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GREENHOUSE IPM: SUSTAINABLE THRIPS CONTROL

PEST MANAGEMENT TECHNICAL NOTES

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Abstract: This publication summarizes IPM for greenhouse thrips on both vegetable and ornamental crops. Monitoring, biological controls, biorational pesticides, and insect growth regulators are discussed. Supplemental tables include information on the newest biopesticides and biological control organisms.

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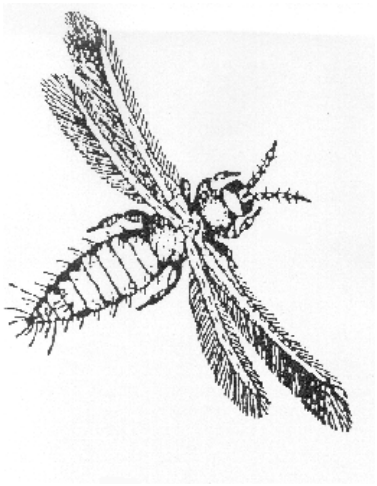
Thrips are one of the most difficult pests to control in greenhouses. Thrips are tiny insects that reproduce rapidly, congregate in tight places that make pesticide coverage difficult, and feed with rasping-piercing-sucking mouth parts, resulting in deformation of flowers and leaves. Tolerance of thrips on floriculture crops is particularly low. In addition, when the Western flower thrips feed on plants infected with the tomato spotted wilt virus (TSWV) or impatiens necrotic spot virus (INSV), the insect vectors these diseases to other plants in the greenhouse. Once plants are infected, it is too late to do anything except dispose of diseased plants. Thus, the best way to prevent virus infection is to control thrips.



What's Inside

Table 1. Main Species of Thrips in Greenhouses

Common Name	Species Name
Greenhouse thrips	*Heliothrips haemorrhoidalis*
Banded greenhouse thrips	*Hercinothrips femoralis*
Flower thrips	*Frankliniella tritici*
Western flower thrips (WFT)	*Frankliniella occidentalis*
Onion or tobacco thrips	*Thrips tabaci*

Table 2. Life Cycle of Adult Thrips

Stage	Duration of Temperatures Between 68° and 98° F
Egg	2–4 days
1st instar	1–2 days
2nd instar	2–4 days
Pre-pupal	1–2 day
Pupal	1–3 days
Adult	30–45 days

Biology and Identification

There are at least 6,000 species of thrips in the world. A few of the main species of thrips known to injure greenhouse crops are summarized in Table 1 above.

It is important to understand the life cycle and behavior of thrips in order to develop an effective control strategy. Knowledge about the weak link in a pest's life cycle can help in choosing the most appropriate control strategy. Table 2 summarizes the life cycle of adult thrips.

As an aid to managing thrips species infesting your greenhouse, you may want to obtain positive identification. Because they are extremely small, the best way thrips can be identified is by a trained entomologist with the aid of a microscope. Plant diagnosis, or identification of insect and disease pests, is usually available through the Cooperative Extension Service.

Crop Scouting and Trapping

To detect early infestations, a crop scouting program that includes both sticky trap cards and visual inspection is critical. Scouting should be done once a week, and more often when an infestation is detected. Regular scouting is also necessary to monitor the efficacy of control measures. A hand lens is a useful tool to detect live thrips as well as signs of thrips activity—e.g., black feces and silvery, flecked areas on leaves. Lightly blowing on blossoms and growing points aids in visual inspection as it causes thrips to become mobile, apparently because of the carbon dioxide contained in exhalation.

Hot-pink sticky cards have been found to be the most attractive color for trapping thrips, though blue is often still used. Sticky traps should be placed 1 to 2 inches above the crop canopy so that the bottoms of the traps are just above the crop, at the rate of one or two per 1,000 square feet.

The economic threshold, or number of thrips found on each trap in relation to crop injury, is not yet available for every greenhouse crop. A threshold level of 20 WFT/trap/week was figured to be appropriate for chysanthemums in Switzerland (1). In contrast, a greenhouse in New Mexico initiates pesticide application when just 5 thrips/trap/week are detected, and chrysanthemums make up 80% of its crop mix (2). When biological control organisms are used to control thrips, they should be released as soon as the first adult thrips have been trapped.

Certain plants are especially appealing to thrips and can be used as "biological indicators" to detect the presence of thrips in the greenhouse. Majestic, Blue Magic, and Calypso petunias are recognized as thrips indicators because they will exhibit viral symptoms of TSWV within just a few days after feeding. Fortunately, the virus remains localized in the plants and does not become systemic, so that spread of this disease from infected petunias to other plants in the greenhouse is not a problem. Symptoms of thrips-vectored TSWV on petunias include a distinct brown rim at the feeding site within three to four days after feeding. This is followed by a localized circular lesion in about a week. Flowers should be removed from the petunias to discourage adult thrips from feeding on the flowers instead of the foliage, because viral lesions will not show up on flowers (3).

Leanne Pundt, Extension Greenhouse IPM specialist with the University of Connecticut, provided the following suggestions on effective integration of sticky cards and indicator plants (4):

- Place sticky cards throughout your operation to detect where thrips are located and to monitor their numbers.
- Place indicator plants among crops at bench or floor level. One plant every 20 to 30 feet seems to work well.
- Place incoming plant material with indicator plants and isolate for at least three to four days to allow thrips scars to develop and show viral lesions.

Dr. Wayne Allen, research pathologist with Agriculture Canada, provided these additional points on use of sticky cards and indicator plants (5):

- Indicator plants are not intended as a substitute for sticky cards, but rather they're an additional component to an effective monitoring system.
- While sticky cards monitor only flight activity and relative population of thrips, indicator plants monitor feeding activity and the presence of virus-carrying thrips near those plants.
- Studies show that attraction to indicator plants can be significantly increased if hot pink or blue insect-monitoring cards, *without adhesive*, are attached to the petunia pots. In addition to increased attractiveness to thrips, the colored cards serve as location markers, and reminders that the plants should be examined frequently.

See Appendix I for a summary of monitoring and scouting techniques for greenhouse insects.

Sanitation

Sanitation is key for controlling pests in greenhouses. The goal of sanitation is to eliminate all possible sources of the pest. Weeds inside and near the outside of the greenhouse can harbor pests. It's best to pull weeds inside the greenhouse rather than spray them, since insects may survive the spray and migrate onto crops. Bag all weeds and dispose of them outside the greenhouse.

In addition, a 10–30 foot vegetation-free zone around the outside perimeter of the greenhouse—especially near vents and openings—can provide a dramatic decrease in pests. A heavy-duty geotextile weed barrier (e.g., DeWitt Sunbelt® Weed Barrier) covered with bark mulch or gravel can provide a pleasant vegetation-free zone, and eliminate the need for herbicides.

Plant debris from previous crops can also be a source of both immature and adult pests. Clean up all debris from previous crops and dispose of infested plants, or any infested growth. Ideally, the greenhouse should be thoroughly cleaned and left empty for one week prior to beginning the next crop. This enables removal of all pest stages, and starves any remaining adults. Closing up the greenhouse when it is empty in summer will increase the temperature and help eradicate pests.

Inside the greenhouse, a clean stock program should be in place. This includes temporary quarantine and inspection of all plants upon arrival from other greenhouses, and regular monitoring of stock plants used for propagation. If a separate section of the greenhouse can't be dedicated to this purpose, flag all incoming plants. All new plant material should be thoroughly inspected (with a 10X hand lens) for the presence of pests to ensure that no infested plants are introduced into the greenhouse. Workers in the greenhouse should avoid wearing yellow clothing, since many pests are attracted to this color and may hitch a ride on the fabric from one greenhouse to the next.

Screening

In the spring, adult thrips migrate from host plants and relocate to new host plants. Though thrips are not strong fliers, they are easily borne by the wind, which facilitates their movement. Prevention of airborne entry of thrips into greenhouses can be greatly aided with the use of an insect screen. Growers in New York, North Carolina, and Florida estimated a 30–70% reduction in pest problems after installation of insect screening (6).

Thrips are so tiny and elusive, that the *brand* of insect screening you choose can make a big difference in how well it excludes thrips. In 1995, researchers from North Carolina reported that 27 types of insect screens were evaluated for thrips exclusion. Only 3 brands (FlyBarr®, BugBed®, No-Thrips®) were effective in preventing the entry of thrips into greenhouses (7).

Cultural Controls

One option to consider is a fallow period in summer. To perform this operation successfully, the grower should first remove all plants, then all weeds, and then heat the greenhouse (either artificially or naturally) until *soil* temperatures reach 60°F. This temperature should be maintained for three weeks. During this time, any thrips eggs will hatch and the nymphs will starve for lack of food. Depending on fuel source and heating systems, the fallow period treatment could cost from five to fifteen cents per square foot, with floor heating being the least costly system.

This strategy has worked for Western flower thrips. Researchers found that an air temperature of 104° F with a relative humidity of 10% was sufficient to kill WFT (an environment that was fatal to plants within 4 days). However, when sufficient water was made available to keep plants alive in the greenhouse (whether weeds or crop plants), mortality of WFT was only 50% (8).

Another recommended strategy for controlling thrips is to remove all flowers and buds, if not crucial to the crop. The flowers and buds should be put into plastic bags, sealed, and disposed of outside the greenhouse.

Plants that Repel Thrips

A large greenhouse grower in The Netherlands found that garlic plants are an effective way to *repel* thrips. He uses three potted garlic plants for every 30 square feet of bench area (9).

Biological Control

Biological control of greenhouse thrips can be achieved through release of biocontrol agents such as predatory mites, lady beetles, and soil-dwelling mites. See Appendix II for a detailed summary of beneficial organisms used in greenhouse IPM. Please note that thrips are listed as target pests for each product in the table. A list of suppliers is also provided.

Certain crops are better adapted to biological control of thrips than others. Greenhouse vegetables, bedding plants, and tropical houseplants are better adapted to biological control than are floriculture crops. Thrips preferentially feed on flowers and leaves and cause little or no damage to fruits themselves. Thus, while fruit-bearing vegetable crops like tomatoes, cucumbers, and peppers are well suited to low populations of prey food (i.e., thrips), tolerance in floriculture crops is greatly reduced because feeding results in cosmetic injury on the marketable portion of the crop. When TSWV or INSV are present, tolerance is nil in either case.

A recent study showed that beneficial insects can control Western flower thrips on bedding plants, even though bedding plants have such a short turnaround time (10). Treatments consisted of BotaniGard™ (a *Beauveria bassiana*-based product) applied at 1 lb./acre, *Neoseiulus cucumeris* mites applied weekly at a rate of 12,000 mites per 3,000 sq. ft. of growing area, and a combination of the two. Plants treated with *B. bassiana* had between .16 and .5 thrips/plant, while plants treated with predatory mites had a maximum of .15 thrips/plant. The untreated control plants had .75 to 1.25 thrips per plant.

Notes on biological control of thrips:

- Release of biocontrol agents should begin as soon as thrips are detected on sticky traps, or even before detection, as part of a planned biocontrol release program on sensitive crops.

- Adult female predatory mites (*Neoseiulus)* consume from 1 to 10 young thrips per day and have a 30-day lifespan. They can also survive on pollen and spider mites in the absence of thrips. Repeat applications of predators must be made to establish a 1:2 ratio of predators to prey. *Neoseiulus* attacks first instar (very young) thrips only and does not move long distances from where it is first placed. They are most often applied in small piles at the base of plants, or in paper bags. Usually, a small hole is made in the bag, and mites move out of the bag slowly.

- Adult pirate bugs (*Orius*) consume 5–20 thrips (all stages) per day. They can survive on pollen in the absence of prey. Both adults and nymphs are predacious. *Orius* is the only predator that attacks thrips in tight places like flower buds. Since *Orius* is a strong flyer, it moves easily throughout the greenhouse.

- Soil-dwelling predacious mites (*Hypoaspsis*) attack thrips in their pre-pupal and pupal stages when they inhabit the soil or growing medium. *Hypoaspis* mites are usually applied only once per crop or season.

- *Thripobius semiluteus* is a parasitoid of greenhouse thrips nymphs.

Biorational Pesticides

While the practices of inspection, sanitation, physical exclusion, and biological control will go a long way towards managing thrips, there may still be instances when pesticides are necessary. Biorational pesticides—also known as least-toxic or "soft" pesticides—are emphasized in biologically intensive IPM programs and by growers depending on organic pest management (OPM) as part of certified organic production.

Thrips control can still be difficult even with the use of biorational pesticides. During much of their life cycle thrips exist as eggs, as pupae in the soil, or as extremely mobile adults. Once thrips infest a crop, the adult females begin feeding and laying their eggs. Thrips usually concentrate on rapidly growing tissues such as young leaves, flowers and terminal buds. This affinity for tight places makes thorough coverage with a pesticide difficult. Just prior to pupation, the larvae move down the plant to pupate in the soil or leaf litter. They are most vulnerable just after hatching and before pupation.

Dr. Richard Lindquist (11), entomologist at Ohio State University, demonstrated biorational control of flower thrips with either: a) M-Pede® insecticidal soap mixed with an emulsified crop oil, or b) weekly applications of neem seed oil (NSO) for four straight weeks. He also found

that the fungus *Paecilomyces fumosoroseus* (PFR), the predatory mite *Neoseiulus cucumeris*, and an azadirachtin insecticide (neem) could be used alone or in combination for control of WFT in greenhouses (12).

New Research with Thrips:

- In laboratory trials and caged rose trials, *Beauveria bassiana* sprays killed up to 82% of the thrips on rose foliage (13). Mortality increased along with humidity. Oil formulations of *B. bassiana* worked more quickly than wettable powders.
- BotaniGard™ and Naturalis-O™, both of which use *Beauveria bassiana*, have been effective on a schedule of three to five applications at three to five-day intervals. The addition of Azatin™ (a neem product) may increase effectiveness (14).
- Dr. Richard Lindquist at Ohio State University found that four applications of Naturalis-O™ over a period of 15 days controlled thrips well on gerbera (15).
- In another study, Lindquist found that Conserve® (a new biopesticide formulated from the soil-inhabiting actinomycete *Saccharopolyspora spinosa*) was significantly better than Orthene™ at controlling Western flower thrips (16). Plants treated with Conserve also had higher numbers of beneficial insects and mites—such as minute pirate bugs, predatory mites, and green lacewing larvae.
- Neem extracts (trade names Azatin™, Neemazad™, and Neemix™) prevent development of flower thrips in the early larval stages, but have no effect on adults. Repeat applications are most effective.
- In 1999, Dr. Dan Gilrein of Cornell Extension tested several biopesticides for their effect on Western flower thrips, including Avid (contains abamectin), Conserve (spinosad), Sanmite (the synthetic chemical pyridaben), BotaniGard (*Beauveria bassiana*), a combination of BotaniGard +Azatin (neem) + M-Pede (insecticidal soap), and Alsa (a garlic product) (17). Although Conserve performed best, other treatments also provided control. The table below is excerpted from an article in the September, 1999 issue of *GMPro*.
- Researchers at Ohio State University are currently testing combinations of *B. bassiana* with the biorationals Azatin, Adept (an insect growth regulator), Conserve, Fulex SO-2000, Hot Pepper Wax, Garlic Barrier, yeast extract, and white sugar (18). So far, they have shown that spray mixes combining *B. bassiana* with Adept, sugar, yeast extract or Azatin produce higher levels of infection and mortality in Western flower thrips. Specifically, white sugar at a rate of 1 lb./100 gallons and yeast extract at a rate of 0.25% wt/volume increased mortality by about 20 percent, presumably due to their ability to induce feeding. The opposite was true for plants treated with Hot Pepper Wax, an

Table 3. Control of Western flower thrips on *Chrysanthemum* 'Linda' after four weekly applications (17).

Treatment	Thrips/plant	Flower damage*
Avid	19.3	0.6
Conserve	3.6	0.6
Sanmite	17.3	0.8
BotaniGard ES	51.4	3
BotaniGard + Azatin + M-Pede	25.2	2.6
Alsa drench 4x rate	43	2.7
Alsa drench 1x rate	43.4	3
Water (control)	47.9	3.7

*Flower damage was based on a 0–5 scale, 0 = no damage and 5 = all flowers entirely brown.

insect repellent and antifeedant. BotaniGard + Azatin showed excellent results: "Inclusion of Azatin at 1/10 or 1/4 the recommended rate led to a 50 and 100% increase, respectively, in infection and mortality" (18).

Biorational pesticides for greenhouse pests are summarized in Appendix III. Please note that thrips are listed as target pests for each product in the table.

Insect Growth Regulators

Insect growth regulators (IGRs) are another least-toxic pesticide control option for pests. IGRs typically kill insects by disrupting their development. They have a complex mode of action that precludes insects from rapidly developing resistance. IGRs can work in one of several ways: 1) they can mimic juvenile hormones, so that insects never enter the reproductive stage of development; 2) they can interfere with the production of chitin, which makes up the shell of most insects; or 3) they can interfere with the molting process.

IGRs usually work through ingestion, so good spray coverage is essential. They generally don't affect non-target species—such as humans, birds, fish, or other vertebrates. For most IGRs there are minimal re-entry restrictions. IGRs typically take several days to have an effect on pest populations. Because IGRs do not affect mature insects, adult beneficials released into the greenhouse after an IGR application are not likely to be affected. Use of IGRs is generally prohibited by organic certification organizations because the products are synthetic.
IGRs can sometimes be used in conjunction with biological control efforts and may provide

Table 4. Selected Insect Growth Regulators

Brand Name	Supplier	Active against:
Adept	Uniroyal Chemicals	Not specifically labeled for thrips, but does seem to be effective when used in combination with *B. bassiana*
Azatin	Hydro-Gardens, Olympic Horticultural Products	whiteflies, leafminers, **thrips**, mealybugs, fungus gnats, aphids, cabbage loopers, diamondback moths, armyworms
Neemazad	Thermo Trilogy	whiteflies, leafminers, **thrips**, mealybugs, fungus gnats, aphids, cabbage loopers, diamondback moths, armyworms
Neemix	Thermo Trilogy	whiteflies, leafminers, **thrips**, mealybugs, fungus gnats, aphids, loopers, diamondback moths, armyworms, cabbage loopers
Precision	Novartis	**thrips**, whiteflies, fungus gnats
Preclude	Whitmire Micro-Gen	whiteflies, **thrips**, scales, aphids

growers with a "safety net" should beneficials fail to keep the pests below economically damaging levels. The table below lists some well-known insect growth regulators.

Summary and Further Resources

Greenhouse thrips are tiny insects, but they demand serious attention on the part of the greenhouse grower. Integrated pest management offers a sustainable approach for dealing with greenhouse thrips, and safer pest control products facilitate the adoption of least-toxic control measures that dovetail very nicely with the IPM philosophy.

For an overview of greenhouse IPM, please see the complementary ATTRA publication *Integrated Pest Management for Greenhouse Crops*. It contains an extensive listing of resources and publications on greenhouse IPM which support many of the concepts and practices outlined in this publication on greenhouse thrips.

In the Resources sections below, growers are provided with a list of key articles on thrips; contacts for IPM specialists in thrips control; biological control suppliers; and tables that summarize monitoring and scouting techniques, biocontrol agents, and biorational pesticides that help to control thrips.

Related Attra Materials

Organic Greenhouse Vegetable Production
Integrated Pest Management of Greenhouse Crops
Greenhouse IPM: Sustainable Aphid Control
Greenhouse IPM: Sustainable Whitefly Control

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Listserver

Thripsnet is an Internet mailing list maintained by Dr. Margaret Skinner at the University of Vermont. There are over 300 participants on the list. To subscribe, contact:

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Biological Control Suppliers

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317-337-7374 fax
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http://www.hortnet.com/olympic

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http://www.lisco.com/soiltech

Thermo Trilogy Corp.
9145 Guilford Rd., Ste. 175
Columbia, MD 21046
800-847-5620
301-604-7015 fax

Whitmire Micro-Gen
3568 Tree Court Ind. Blvd.
St. Louis, MO 63122
800-777-8570
314-225-3739 fax
http://www.wmmg.com

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The electronic version of **Greenhouse IPM: Thrips Control** is located at: http://www.attra.org/attra-pub/gh-thrips.html

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Appendix I: Monitoring and Scouting Techniques for Thrips (and Other Greenhouse Pests)

	Aphids	Plant Bugs	Shore Flies	Fungus Gnats	Leaf-Miners	Mealy-bugs	Broad Mites	Spider Mites	Soft Scales	Armored Scales	Slugs	Thrips	White-flies	Cater-pillars
<u>Scouting:</u>														
Inspect underside of leaf	X					X	X	X	X	X		X	X	
Inspect upper surface for stippling/small white spots								X				X		
Inspect new growth or terminal for feeding	X	X					X					X		
Tap flowers over white surface & look for movement	X							X				X		
White or brown spots on flowers												X		
Dark area on buds that are just opening												X		
<u>Observe for:</u>														
Small black spots on leaves (fecal drops)			X									X		
Chlorotic (yellow) spots on upper leaf surface	X								X	X		X	X	
Buds fail to open or uneven opening of flowers												X		

Appendix II: Beneficial Organisms used in Greenhouses

Organism	Supplier	Pests Controlled	Application/Comments
Chrysopa carnea (predator)	Natural Pest Controls, Beneficial Insectary, Caltec, Arbico, A-1 Unique Insect Control, Praxis, Rincon-Vitova, Hydro-Gardens	aphids, caterpillars, mealybugs, scales, spider mites, **thrips**, whiteflies	1 lacewing/5–30 aphids; 1000 eggs/200 sq. ft. Apply every 1–3 weeks as needed. May arrive as eggs, immatures, or adults.
Chrysoperla rufilabris (predator)	Arbico, Beneficial Insectary, IPM Labs., A-1 Unique Insect Control, Nature's Control, Praxis, Rincon-Vitova	see above	
Chrysoperla spp. (predator)	M&R Durango, Florikan, Green Spot	see above	
Coleomegilla imaculata (pink ladybird beetle)	Arbico	aphids, caterpillars, mites, scales, **thrips**, whiteflies	1/sq. ft.; shipped as larvae and eggs.
Deraeocoris brevis (predator)	Green Spot	aphids, whiteflies, **thrips**	
Heterorhabditis bacteriophora (beneficial nematode)	M&R Durango, Aribco, BioLogic, Hydro-Gardens, Harmony Farm Supply, Plant Health Care, Green Spot	fungus gnats, crown borers, **thrips**, cut-worms, grubs, Jap. beetles, black vine weevil	Application rate varies; 1 million/3000 sq. ft. is suggested. Nematodes need a moist environment to survive and move through soil. Apply in evening directly into growing medium.

Organism	Supplier	Pests Controlled	Application/Comments
Hypoaspis miles (predator)	Florikan, Harmony Farm Supply, Green Spot	**thrips**	100–300/sq. meter
Neoseiulus spp. or *Amblyseius* spp. (predatory mites):			
N. barkeri	IPM Laboratories, Arbico	broad mites, **thrips**	10–30/plant per week.
N. cucumeris	Arbico, Natural Pest Controls, Nature's Control, Intl. Technology Services, Florikan, IPM Labs., Harmony Farm Supply, Hydro-Gardens, Rincon-Vitova, Green Spot	**thrips**, mites	Humidity should be 70–90%, temp. 50–85°F. Introduce at first sign of pests.
N. cucumeris and *N. barkeri*	Hydro-Gardens	**thrips**, aphids, mites	1 predator/sq. ft.; humidity should be moderate, temp. 70°F. Establish population early. Repeat every month during periods of warm, dry weather.
Orius insidiosus (minute pirate bug) (predator)	Florikan, IPM Labs., Harmony Farm Supply, Arbico, Hydro-Gardens, Praxis, Koppert, Intl. Tech. Services, Green Spot	aphids, caterpillars, **thrips**, whiteflies, mites	1/10 sq. ft. (preventive), 1 every 2 sq. ft. when pests are present. Temperature should be 70-90°F. *Orius* are dormant September–April. Re-apply every 2-3 weeks. Very susceptible to pesticides. Works well in combination with *Neoseiulus cucumeris*.
Steinernema spp. (beneficial nematodes)	Hydro-Gardens, Nature's Control	cutworms, **thrips**, white grubs, shore flies, fungus gnats, etc.	1 million/3000 sq. ft.; temperature should be above 55°F. Apply in evening, directly to growing media. Water in after application. Needs moist environment to thrive.
Steinernema spp.and *Heterorhabditis* spp.	Florikan, Green Spot	see above	
Thripobius semiluteus (parasite)	Arbico, Nature's Control	**thrips**	

Appendix III: Biorational Pesticides

Azadirachtin – extract of neem seed; IGR that works through contact or ingestion

Brand Name	Supplier	Pests Controlled	REI	Application/Comments
Azatin	Green Spot	aphids, caterpillars, fungus gnats, leafhoppers, leafminers, Western flower **thrips**, whiteflies, psyllids	4 hours	Apply when pests first appear.
Neemazad	Thermo Trilogy	aphids, caterpillars, **thrips**, greenhouse whitefly, leafminers, sweetpotato whitefly, psyllids, leafhoppers	12 hours	Cannot be applied through irrigation. Low rate can be used as a preventative.

***Beauveria bassiana* – fungus that works through contact; exposure to non-target insects should be avoided**

Brand Name	Supplier	Pests Controlled	REI	Application/Comments
Naturalis-O	SePro	aphids, caterpillars, mites, psyllids, **thrips**, whiteflies	4 hours	Apply when insects first appear and repeat every 7–10 days. Need good spray coverage. Not compatible with other fungicides.
BotaniGard	Mycotech	giant whitefly, green peach aphid, black vine weevil, other aphids and whiteflies, **thrips**, leafhoppers, psyllids, white grubs	12 hours	See above.

Garlic extracts

Brand Name	Supplier	Pests Controlled	REI	Application/Comments
Garlic Gard	Soil Technologies	repels thrips and other insects		
Garlic Barrier	Green Spot	see above	4 hours	Use late in the day. Can be mixed with fish oil or horticultural oil. Do not use in combination with bumblebees or honeybees.

Horticultural oil – includes dormant and summer superior oils

Brand Name	Supplier	Pests Controlled	REI	Application/Comments
All Seasons	Green Spot	aphids, mealybugs, scales, **thrips**, whiteflies, spider mites	4 hours	Use on sunny days to promote rapid drying and decrease chance of phytotoxicity. Not compatible with beneficials.

Hot pepper wax – contains capsaicin, paraffin, and mineral oil

Brand Name	Supplier	Pests Controlled	REI	Application/Comments
Hot Pepper Wax	Green Spot	aphids, loopers, beet army-worms, mites, whiteflies, **thrips**, mealybugs, etc.	4 hours	Also contains herbal essential oils. Not compatible with beneficials.
Hot Pepper Wax	Hot Pepper Wax, Inc.	see above		

Insecticidal soap – contains potassium salts of fatty acids

Brand Name	Supplier	Pests Controlled	REI	Application/Comments
M-Pede	Mycogen	aphids, mealybugs, scales, **thrips**, whiteflies, spider Mites	12 hours	Phytoxicity is often a concern, esp. after repeated applications.
Safer	Green Spot	see above	4 hours	See above.
Insecticidal soap	Olympic	see above		

Neem oil – multi-purpose organic insecticide/fungicide/miticide; kills eggs, larval and adult stages of insects

Brand Name	Supplier	Pests Controlled	REI	Application/Comments
Trilogy 90EC	Thermo Trilogy	greenhouse whitefly, silver-leaf whitefly, sweetpotato whitefly, **thrips**, whiteflies, leafminers, aphids, mites, psyllids, San Jose scale, scale, spider mites, downy mildew, powdery mildew, Alternaria, Botrytis, etc.	4 hours	Apply at first signs of damage. Repeat every 7–10 days as needed.
Triact 90EC	Thermo Trilogy	see above	4 hours	For ornamental crops only.

***Paecilomyces fumosoroseus* (PFR) – expected to become available in 1999; controls whiteflies, Western flower thrips, and spider mites**

***Saccharopolyspora spinosa* – soil-inhabiting actinomycete**

Brand Name	Supplier	Pests Controlled	REI	Application/Comments
Conserve	Dow Agro Sciences	caterpillars, leafminers, **thrips**		