

Fungus gnats

Common pest observed in propagation areas, over-watered crops. FG adults can be confused with shore flies.

Description: Larvae are white and legless, about 1/4 inch long when mature, and have a shiny black head. The adult is mosquito-like in body shape, about 1/8 inch long, with long legs, a clear pair of wings, and long antennae. Fungus gnats are weak fliers and are frequently observed resting on the media in the pot or running over the foliage or other surfaces. The adult fungus gnat is sometimes confused with another small dark-bodied fly called the shore fly. Shore flies have more robust bodies than fungus gnats and their antennae are very short. Their most distinguishing characteristic is the presence of five light-colored spots on each of their dark wings.

Damage: Adults are primarily a nuisance. Larvae feed on plant roots, fungi and decaying organic matter and tunnel into the crown and stems of plants. The feeding damage creates wounds that allow soilborne pathogens to enter and can kill plants. Fungus gnat larvae may also carry some soil-borne pathogens such as *Thielaviopsis* and *Fusarium*. Fungus gnats are a common problem on greenhouse crops growing in media that contains a high percentage of peat moss or compost. Larvae present in infested plants or soil can lead to prolonged emergence of adults.

Life cycle:

The life cycle of fungus gnats is shown in Figure 1. A female fungus gnat may lay up to 300 whitish eggs in clusters of 20 to 30 or more on the surface or in the crevices of moist soil or potting media rich in organic matter. Eggs hatch in about six days. Larvae feed for 12-14 days before changing into a pupa, which is formed inside a silken pupal chamber in the soil. The pupal stage may last 5-6 days and adults live up to 10 days. The life cycle from egg to adult requires approximately 4 weeks depending on temperature; development time decreases as temperatures increase, as is true of most insects.

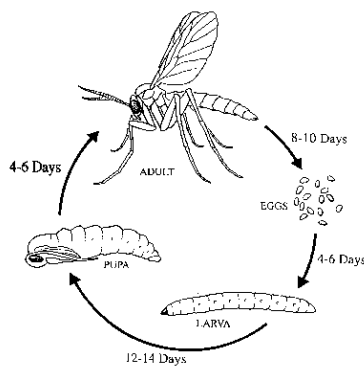


Figure 1. Life cycle of the fungus gnat

Monitoring Fungus gnats, Shore flies:

To monitor for larvae, place raw potato chunks with peel removed on the soil surface. Larvae are attracted to the potato chunks, under which they move and congregate. Check the potato chunks daily for larvae. Potato disks cut one inch in diameter and 1/2 to 1 inch thick work well. Ten potato disks may be sufficient to monitor a 10,000 sq.ft greenhouse.

Monitor adult flies with yellow sticky cards placed at the base of the plant at soil line. Weekly inspections of yellow sticky cards can detect the onset of an infestation, and continued recording of the number of adults per card per week can aid in evaluating the efficacy of control efforts. Place 3" x 5" yellow sticky cards in a horizontal position just above the soil surface, or lay them on the top of the pots, 1-4 per 1,000 sq. ft. throughout the greenhouse. For early detection, position cards near doorways and vents or among new plants being placed in the house. If time permits, check the cards twice weekly particularly when temperatures warm up in the spring.

Managing Fungus gnats and Shore flies

- Sanitation.
- Avoid overwatering.
- Avoid debris under benches.
- Eliminate algae. Algicides: Green-Shield, Physan 20, Triathlon (Quaternary ammonium compounds), ZeroTol (Hydrogen Dioxide)
- Inspect incoming plant material.

Biological Control

Steinernema feltiae -Parasitic nematode, fungus gnat larvae

Trade names: Nemasys, Nemashield, Scanmask, Entonem, Exhibitline

Nematodes are applied as a drench to containers or flats and they can also be applied through drip irrigation systems, however, filters must be removed. Apply nematodes two to three days after inserting cuttings, planting plugs, or starting seeds. To assess the viability of shipments prior to application, place a small quantity of the product in a shallow container with a few drops of tepid water. After a few minutes, look for active nematodes which have a slight 'J' curve at the ends of their bodies.

Repeat applications are usually needed. Growing medium temperatures must be 50-80F with optimum temperatures of 60-70F. Irrigate the growing medium before and after applying nematodes. The nematodes require moisture in order to move within the pores of the growing medium. Apply nematodes in the evening or on cloudy days because the nematodes are extremely sensitive to ultraviolet light desiccation. In general, beneficial nematodes are compatible with most pest control materials except for carbamate and organophosphate pesticides.

Other Biological Control

Microbial insecticide – Gnatrol (bacterium- *Bacillus thuringiensis israelensis*)

Predaceous mite (*Hypoaspis miles* also known as *Stratiolaelaps scimitus*)

Shore fly larvae: *Steinernema carpocapsae* Millenium

Rove beetle for fungus gnats and shore flies (*Atheta coriaria*)

Natural enemy – *Synacra pauperi*, a parasite of fungus gnat larvae that comes into gh from outdoors.

Thrips

Description:

Adult WFT are about 1/16th of an inch long, and are long and narrow shaped, like grass seed. Adults have two sets of narrow, clear, nearly veinless wings that have dark, hairy, fringes. Adult male WFT are light yellow, while adult female WFT is the most prevalent species of thrips in Massachusetts greenhouses. Larvae resemble adults, but are wingless.

- Resistant to many pesticides
- Not many effective pesticides available
- Life cycle – Stages protected from pesticides
- Incoming plant material already has thrips
- Can transmit tospovirus (Impatiens Necrotic Spot Virus, Tomato Spotted Wilt Virus)
- Key to thrips species:
<http://www.entomology.umn.edu/cues/inter/inmine/Thripb.html>

How Thrips Feed and Feeding Damage

- Pierce plant cells and suck out their contents.
- Symptoms of damaged plant cells that collapse: Deformed foliage and flowers, or silvered patches and flecking on expanded leaves.

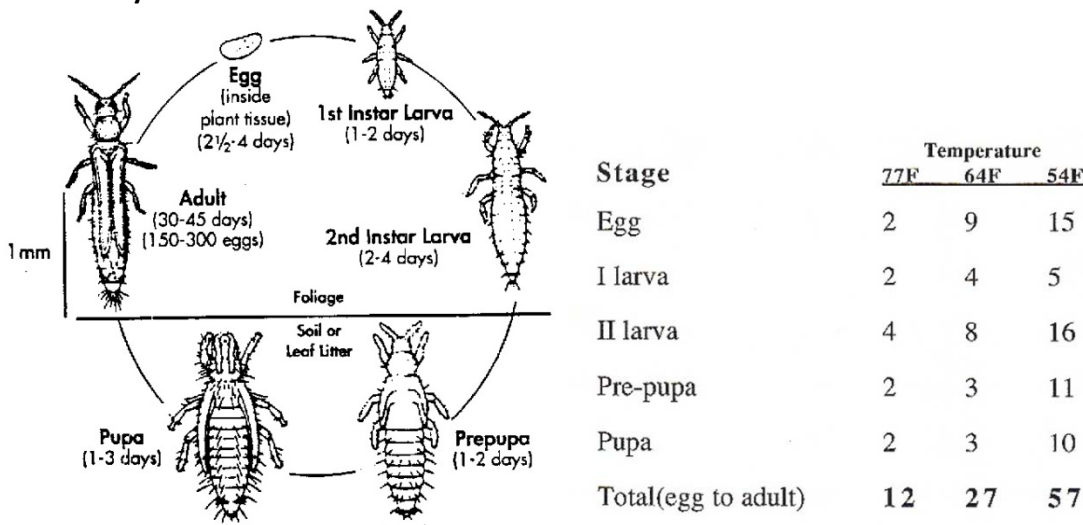
Photos: (Arugula seedling and Dahlia flower)

Be Aware of Virus Symptoms: Impatiens necrotic spot virus, Tomato spotted wilt virus by WFT

- Thrips acquire virus during first instar larvae.
- Must feed on virus-infected plants to acquire the virus.

- Infected thrips are produced in the greenhouse only if infected plants (including weeds), which can support thrips development, are present.
- Winged adult thrips are primarily responsible for viral spread.
- An infected thrips is able to transmit tospoviruses to at least one plant per day until its death.

WFT Life Cycle



Effects of temperature on life cycle of WFT

Monitor for Thrips for Early Detection!

- Traps
 - Over 2000 sq ft use 1 trap/2000 sq ft
 - Under 2000 sq ft use 3 traps
 - Traps overhead and under benches
- Tap foliage, flowers over white paper to dislodge.
- Blow into flowers to activate
- Indicator Plants

Indicator Plants for Virus

- Fava beans, petunia plants
- Show virus symptoms around the thrips feeding scar
- Blue (non-sticky) plate attracts thrips to plants.

On-site Virus Test Kits

Cultural Practices to Manage WFT and Tospoviruses

- Sanitation: Remove old flowers and debris which provide refuge for thrips.
- Keep weeds removed under benches.
- Cull piles away from vents and greenhouses.
- Monitor incoming plant material – prevent infested plants from coming in.
- Rogue out virus infected plants and weeds.
- Avoid growing vegetable plants in same greenhouses as susceptible flowering plants.

Thrips Management: Pesticides

- Treat in early evening (two flights per day, early morning and evening).
- If using oil, be sure there is drying time.
- Treat before you see a peak in adult numbers on yellow sticky cards. Adult thrips numbers on cards tend to peak every two to three weeks. Apply insecticides before this peak, so adults will be killed before they lay eggs.
- Small droplets of pesticide sprays are most effective for coverage.

Pesticides

- Pyridalyl (Overture) and *chlorfenapyr (Pylon). Note: (Overture) is more toxic to second instar nymphs than adults. Also, Overture takes at least seven days to kill a majority of WFT, so do not expect an immediate reduction in populations. Read the label for plant safety. Both of these products have precautions. Both of these products also have translaminar activity.

Examples of Pesticide Rotations to different modes of action to prevent pesticide resistance

Note: Use one material for length of thrips life cycle before rotating to next.

- Spinosad (Conserve, *^oEntrust) (not with resistant populations), Chlorfenapyr (* Pylon), Abamectin (Avid), Pyridalyl (Overture)
- Pyridalyl (Overture), Abamectin (Avid), Chlorfenapyr (Pylon), Spinosad (Conserve, *^oEntrust)
- Novaluron (Pedestal), Note that Pedestal is an insect growth regulator (IGR) labeled for immature stages. Acephate (Orthene), Pyridalyl (Overture), Spinosad (Conserve, *^oEntrust)
- Methiocarb (Mesuroil) Mesuroil has a 24 hour REI plus it may leave an unsightly residue, so it may be best early in the growing season., Abamectin (Avid), Pyridalyl (Overture), Chlorfenapyr (Pylon)
- Pyridalyl (Overture), Novaluron (Pedestal), Chlorfenapyr (Pylon), Spinosad (Conserve, *^oEntrust)
- Other products to include: *Beauveria bassiana* (*BotaniGard/^oMycotrol), *Beauveria* works best with high relative humidities (80%+) for 24-48 hours. Avoid such conditions if *botrytis* or other foliar diseases are present and *Beauveria* works better before plants are in flower.
- Horticultural oil (^oSuffOil-X or *Ultra Pure oil) (Follow label cautions regarding plant safety).
* Vegetables, herbs on label ^oOrganic
For pesticides for vegetable transplants, see : <https://nevegetable.org/>

Organic products for thrips:

- Azadirachtin (Aza-Direct, Azatrol, AzaGuard, Azahar, Molt-X)
- *Beauveria bassiana* (Mycotrol O)
- Horticultural oil (SuffOil-X, TriTek) (apply when it can dry quickly)
- Insecticidal soap (M-Pede)
- *Isaria fumosoroseus* (NoFly WP, Preferal) (insect killing fungus, needs high RH, 80%+)
- *Steinernema feltiae* (Nemasys, NemaShield, Scanmask) (Primarily for thrips pupae)
- Pyrethrins (Pyganic EC 1.4 and 5.0)
- Spinosad (Entrust)

Biocontrol: Incoming Plants and Propagation

- Parasitic nematodes (*Steinernema feltiae*) and /or *beauveria bassiana* (Botanigard) early in crop cycle to minimize problems.
- Pro-actively use on rooted or unrooted cuttings (disease risks using dips)
- As soon as mist is reduced or off, start with other BCA's

Steinernema feltiae- nematodes that carries a bacteria that kills fungus gnats and thrips, used as a spreng or drench.

Neoseilus = Amblyseius cucumeris

- *Amblyseius cucumeris* at time of seeding or as soon as plants are planted in final pot → predatory mite for thrips, breeder piles provide 4-6 weeks of control.
- Note different formulations: (Breeder mix sprinkle/broadcast formulation; controlled release packs (contain various life stages from egg-adult).

Predatory Mites

- Predatory mites eat pollen, fungi and other materials
- Crop plant can influence success or failure.

- Short term crops – no pollen, less successful than longer term crops that contain pollen.
- For example, peppers are a good crop for mites – they feed on pollen and support populations.

Amblyseius swirskii

Amblyseius swirskii (April-May) likes warmer temps, also for whitefly.

Hypoaspis and Atheta

Do not rely on.... *Hypoaspis miles*, a predatory mite, soil dwelling, generalist, but mostly released for fungus gnat control and thrips pupae in soil.

Do not rely on....*Atheta* or Rove beetle, soil dwelling, generalist, released for fungus gnats and thrips pupa

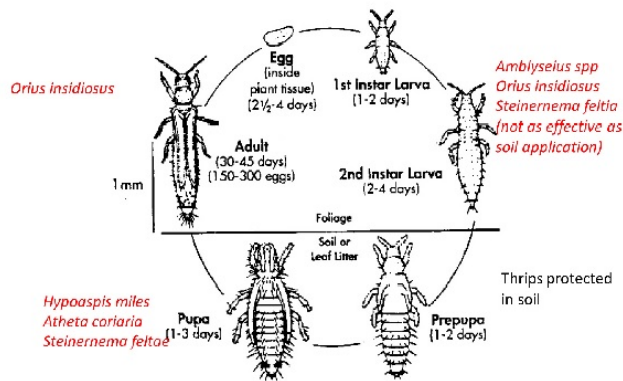
Banker Plants: Purple Flash Peppers and Marigold plants with Orius for Thrips.

- *Orius* – for longer term crops – needs pollen
- Used in banker plant system - peppers ('Black pearl', 'Purple Flash', 'Explosive Ember') or yellow marigolds ('Hero Yellow', 'Bonanza') or 'White Sensation' Cosmos

Orius (Minute Pirate Bugs)

- Released at a rate of 60-80 per pepper plant.
- Lays eggs on the pepper plants in the same area where thrips lay eggs, usually in or near flowers.
- One pepper plant per 1,000 sq. ft. of growing area. As long as the pepper plants are in flower and producing pollen, the minute pirate bugs will reproduce on them.
- Adult *orius* will kill 1st and 2nd instar thrips larvae and adult thrips.
- One release of minute pirate bugs onto the banker plants.
- Remove pepper fruit about once a month from the plants to keep them flowering. Some growers have mentioned that keeping peppers picked off the plants is tedious and time consuming.

Thrips Development and Using Biocontrol



Aphids

- How they feed: Sucking insects, Insert mouthpart into phloem and suck out plant sap.
- Honeydew
- Some transmit viral plant diseases
- Aphids: About 30 different species in greenhouses.
- Most common species - green peach (*Myzus persicae*), melon or cotton (*Aphis gossypii*), potato (*Macrosiphum euphorbiae*), chrysanthemum (*Macrosiphoniella sanborni*) aphids and foxglove.

Green Peach *Myzus persicae* – light green/pink/orange, black tip on cornicles, indentation

- Found on tip growth and populations can explode in spring (March – early June).
- Look for the long cornicles on the rear end with black tips and notch in the antennae.

Melon *Aphis gossypii*– short, black cornicles, no indentation, antennae shorter than body

- Melon aphids start building up on branches in the center of the plant. They accumulate around flowers when the plant matures.

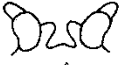
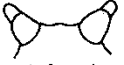

Potato aphids *Macrosiphum euphorbiae* hosts: Potatoes, tomatoes in summer and wild or on lettuce, spinach in the autumn and may overwinter.

- *Aphidius ervi* – parasitic wasp, good for potato aphids.

Foxglove aphids - larger than green peach or melon aphids.

- Pale green to yellow, “shiny” compared to other aphids.
- Two large, dark-green spots at the base of their cornicles.
- Unlike other aphids, foxglove aphid has a toxic saliva, which is injected into the plant as it feeds. The toxin can lead to curled and twisted leaves.
- Found on flower stems, flower petals. So, systemic insecticides (imidacloprid) won’t work well.
- Foxglove Aphid – Growing Cool
- Have more babies at 50-60°F than at 77°F: almost twice as many.
- Foxglove aphid also develops faster than either green peach or melon aphid at 60°F.
- At really warm temperatures, can barely grow and can’t reproduce at constant temperatures of 86°F

Identifying aphids

	Green Peach Aphid	Melon/Cotton Aphid	Foxglove Aphid
Color	light green; occasionally pink to orange	variable from light green, dark green to yellow	pale green
Cornicles (tailpipes)	light green; slightly darker than the body, with black tips	black	green spot at base
Head (use hand lens to profile of top of head)	 ↑ indentation	 no indentation	 ↑ indentation

Pesticides for Aphids

- *Beauveria bassiana* (BotaniGard) and Azadirachtin (Molt-X) mixed together. Azadirachtin slows down molting process so spores can germinate on aphids.
- Pymetrozine (Endeavor) – ornamentals only
- Alternate with Suffoil-X or Pure Spray Horticultural Oil
- Insecticidal soaps and/or horticultural oil may provide control when populations are low. Thorough coverage is needed since these pesticides kill by contact and have minimal residual activity.
- Azadirachtin- Neem-X, Molt-X, Azatin
- Grandevo PTO –bioinsecticide (derived from soil bacteria) (vegetables and ornamentals)
- Neem products such as Aza-Direct and Neemix can also be used for low populations.
- Systemic insecticides: imidacloprid (Marathon and generics), thiamethoxam (Flagship), acetamiprid (TriStar), dinotefuran (Safari). Note that dinotefuran (Safari) is best used for aphids as a soil application
- Selective feeding blockers, pymetrozine (Endeavor), flonicamid (Aria) are also effective.
- Cyantraniliprole (Mainspring) – used early before populations build, new MOA (ornamentals)

Organic Products for Aphids:

- Azadirachtin (Aza-Direct, Azatrol, AzaGuard, Azahar, Molt-X)
- *Beauveria bassiana* (Mycotrol O)

- Horticultural oil (SuffOil-X, TriTek) (apply when it can dry quickly)
- Insecticidal soap (M-Pede)
- *Isaria fumosoroseus* (NoFly WP, Preferal) (insect killing fungus, needs high RH, 80% +)
- Neem oil (Triact 70)
- Pyrethrins (Pyganic EC 1.4 and 5.0)
- *Chromobacterium subtsugae* strain PRAA4-1 (Grandevo) (labeled also for thrips, mites) – veg, herbs

Biocontrol for Aphids

- Start planning a strategy early (months ahead).
- Review the pesticides you are currently using.
- Bio control is a pro-active approach and needs to be executed consistently, talk with your supplier
- Include banker and trap plants where possible
- Look at the complete pest picture. Best results are achieved with minimal pesticide (even ‘compatible’ products) interfere. If needed, try spot application if possible.
- Propagation and incoming plant material impacts overall results. Communicate with your suppliers / propagators / breeders

Banker Plants for Green Peach and Melon Aphids

- Use banker plants (cereals such as barley, wheat or oat) to rear Aphid parasite *Aphidius colemanii* (to manage green peach and melon aphids). Note research has shown barley to work best.
- Purchase starter plants with bird cherry oat aphid (can only survive on monocots).
- Protect cherry oat aphids during rearing
- Supplement starter plants with barley seed in 6-8” pots in Feb or March to get bird cherry oat aphid population established early.
- Aphids are protected on barley plants in cages or grown in a protected place until population is established.
- Once aphids are established, release *Aphidius colemani* on the bird cherry aphids.
- Wait until parasitism occurs, then put plants in greenhouse – *Aphidius* emerges from bird cherry aphids and parasitizes green peach and melon aphids.
- Need to establish wasp early in season before aphids become established.
- If technique is used properly, population of *Aphidius colemanii* is kept high on an ongoing basis. (min. 10 *A. colemanii* / sticky card / wk)

Starting Banker plants for aphids

- Works on melon aphid and green peach aphid
- Depending on greenhouse, 2 banker plants per 1,800 sq.ft has been shown to be effective.
- Do not use if growing lemon grass or lilies (monocots)
- Potato aphid, use *Aphidius ervi*
- For outbreaks, lacewing larvae/each week (1 per plant), release eggs.

Mites

Description: The adult female is oval, approximately 1/50-inch long, greenish to slightly orange, with two dark spots on either side of their body and four pairs of legs.

Mite outbreaks are most severe during hot, dry conditions

- Optimum temperatures for development, between 85 to 95F. Two-spotted mites can complete their development in as little as 8 to 12 days.
- Several generations can develop in a growing season.

Monitoring

Foliar inspection to detect all stages.

- Undersides of leaves along the leaf vein.
- Look for cast skins and empty eggs.
- Because mites are easily carried on workers or their clothing, scout mite-infested areas last.

Bush bean for Mites

- Indicator Plant -beans attract and are used for early detection of spider mites, three or four adult mites on a bean leaf show characteristic yellow speckling feeding damage on top of the leaf.
- Also used to rear spider mite predators. Once the bean plants become infested with spider mites, they are inoculated with the predatory mite *Phytoseiulus persimilis* .
- Scouting tool
- Trap plant – Draws the pest from the crop
- Banker plant – to provide sustained source of beneficials
- Bean plants won't work as trap plants for all ornamental crops. Thunbergia is extremely attractive to two-spotted spider mites and comparable to bean plants in their attraction. In these situations where the ornamental plant is very attractive to spider mites, growers should consider implementing preventive releases of biological control agents. Bean plants are also very attractive to thrips and possibly aphids. Growers who are using biological control agents should release the biologicals on both the bean plants as well as on the ornamental crop being produced.

Look Alike – Ivy Geranium – spider mite damage resembles injury caused by Oedema

Mite Prevention

- Inspect incoming plants for signs of mites or their damage.
- Eliminate weeds in and around greenhouses that can harbor mites.
- Promptly remove unsold or pet plants, as older plants may be a source of mites for younger plants.
- Manage mites at end of crop cycle – do not allow overwintering.

Miticides for Spider mites

- Contact or translaminar miticides. Translaminar - The material penetrates leaf tissues and forms a reservoir of active ingredient within the leaf which provides extended residual activity.
- Translaminar Miticides: abamectin (Avid, Abamectin SPC, Flora-Mek, Lucid, Quali-Pro and others), etoxazole (TetraSan), chlorfenapyr (Pylon), and spiromesifen (Judo).
- Most miticides are not effective against the egg stage, so repeat applications may be needed in 5-7 days.
- Thorough coverage is important for materials with contact activity.
- Contact Miticides: cyflumetofen (Sultan) (compatible with bios), bifenazate (Floramite), SuffOil-X (other horticultural oils), insecticidal soaps and neem oil (Triact 70). Consult label for information on plant safety.
- After treatment, mark several plants.
- Go back and check plants within a few days. Use a 10 to 20X hand lens to look for live and dead mites and eggs.
- Continue to monitor and repeat treatments as needed.

Chemical Control - Mites

- Spot treat locally infested plants instead of the entire greenhouse. Rotate miticides with different modes of actions (i.e. different pesticide classes and work differently).
- Follow long-term rotations and all label restrictions (amount and frequency of use). Some miticides are more selective toward a particular life stage or are more effective when populations are low.
- Regular monitoring, careful timing with more selective miticides.

Organic Products for Two-spotted spider mites:

- Azadirachtin (Aza-Direct, Azatrol, AzaGuard, Azahar)
- *Beauveria bassiana* (Mycotrol O)
- Horticultural oil (SuffOil-X, TriTek) (apply when it can dry quickly)
- Insecticidal soap (M-Pede)
- *Isaria fumosoroseus* (Preferal) (insect killing fungus, needs high RH, 80% +)
- Neem oil (Triact 70)
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- *Chromobacterium subtsugae* strain PRAA4-1 (Grandevo) (product labeled also for thrips, aphids) – veg, herbs

Biological Control Using Predatory mites

- *Phytoseiulus persimilis* feeds on all stages of the two-spotted mites and is the most commonly used in greenhouses.
- *Amblyseius californicus* can be used with *Phytoseiulus*. *A. californicus* can survive without TSSM – so can use preventatively.
- *Feltiella acarisuga* – Predatory midge – mobile, needs hot spot of infestation.

Broad Mites

- Broad mites are too small to be seen without the aid of a microscope.
- Young terminal buds can be killed and leaves turn downward.
- Injury can be confused with thrips damage, herbicide injury, physiological or nutritional disorders.
- Broad mites have a wide host range.
- **Broad Mites Damage:** Bronzed, distorted foliage, russeting on stem, Severe stunting
- Pesticides for Broad Mites– abamectin (Avid, Flora-Mec, etc.), bifenthrin (Talstar), chlorfenapyr (Pylon), fenazaquin (Magus), fenpyroximate (Akari), insecticidal soap (M-Pede), pyridaben (Sanmite), spiromesifen (Judo)
- Biocontrol – *Amblyseius andersoni*, *californicus*, *cucumeris*,