

Pepper

General Information

The most common pests in a greenhouse pepper crop are spider mites, thrips, aphids, fungus gnats, Lepidoptera larvae (e.g. loopers, caterpillars) and Lygus (tarnished plant bug). Historically, whitefly was usually not a problem; however, infestations of both greenhouse whitefly and Bemisia whitefly are now increasing in both damage and frequency. Uncommon pests include broad mite, potato psyllid and pepper weevil. Spider mites, thrips, aphids and whitefly are easily control using an appropriate integrated pest management (IPM) program based on the use of Biological Control Agents (BCA).

Scouting and Monitoring

For monitoring flying insects, we suggest using 25 sticky cards per hectare (=10 cards/acre = 1 card/400m² = 1 card/4000ft²), which should be inspected once a week. Identify, count and record number of all pests and BCA's found on the cards. All counts and observations can be recorded on the Biobest 'Scout-Sheet' or other scouting and monitoring sheets. For non-flying pests such as spider mites, we recommend inspecting weekly 10 to 20 plants per house randomly selected within a row; look at a different row within each house every week. Look for any early symptoms of pests as well as any adults, nymphs or eggs of pests. Identify and record all observations. For more information and pictures to better identify and recognize pest symptoms, you can refer to the Biobest Poster 'Diseases and Pests of Sweet Pepper'.

Pests, Biological Control Agents (BCA) & Control Strategy

Spider mites



The most common spider mite species in pepper crop is the two-spotted spider mite (TSSM, *Tetranychus urticae*), which can successfully be controlled by combining good clean-up practices with the use of BCA's both preventively and curatively. In northern areas, TSSM go into hibernation in the fall. Hibernating TSSM, which can be recognized by their orange to orange-red color, walk off plants to hide in the ground or in cracks and crevices. When temperatures become favorable (spring), TSSM come out of hibernation and quickly re-infest the spring crop. While in hibernation, TSSM are very difficult to kill with clean-up products, pesticides or BCA's. Therefore, in order to start with the lowest TSSM pressure and prevent an early infestation of the pepper crop in the spring, it is extremely important to lower the TSSM population in the fall before they begin to hibernate. The key to control TSSM is prevention and early detection. As preventive measure, when plants reach about 2-ft tall, we recommend introducing the Californicus-System, which contains the predatory mite *Amblyseius Californicus*, on plants located on the perimeter of the greenhouse, in dryer zones (e.g. heating pipes and pumps) and by structural posts. As soon as the first TSSM are found, we suggest introducing the Phytoseiulus-System, which contains the predatory mite *Phytoseiulus persimilis*. In hot-spots, we suggest additional Phytoseiulus-System in combination with the Feltiella-System, which contains the predatory midge *Feltiella acarisuga*. Because TSSM thrive under dry and warm conditions, it is important to monitor closely the balance between populations of BCA's versus TSSM in the top of the plant canopy, and if necessary to replace the Phytoseiulus-System by the Californicus-System. In cool and humid conditions (<25°C; >65% RH), *Phytoseiulus* usually provides a faster control than *A. californicus* but might not show up in the upper canopy in extreme heat and dryness; *Amblyseius californicus* tolerates heat and dryness better than *Phytoseiulus*. (Introduction rates: Tables 1 and 2).

Thrips



In North America, the western flower thrips *Franklinella occidentalis* is the most common thrips in pepper crop. The best line of defence against thrips is to begin a biological program as early as possible. We recommend starting immediately after planting by introducing the Amblyseius-Breeding-System, which contains the predatory mite *Amblyseius cucumeris*, as a small pile of loose

bulk material on every block or pot. When plants are touching, introduce the Swirskii-Breeding-System, which contains the predatory mite *Amblyseius swirskii*, by hanging sachets on plants. When plants are flowering, we recommend introducing the Degenerans-System, which contains the predatory mite *Amblyseius degenerans*. Finally, at about mid-February, introduce the Orius-System containing the predatory bug *Orius insidiosus*. When temperature are above 20°C (<68°F), the Amblyseius-Breeding-System can be replaced by the Swirskii-Breeding-System. This substitution is recommended especially when both thrips and whitefly are expected or usually observed every year.

If a thrips problem develops, we suggest a curative introduction of either the Amblyseius-Breeding-System or Swirskii-System in combination with the Orius-system in and around the infected areas. As a corrective treatment for high levels of thrips, we recommend a foliar application of the Steinernema-System, which contains the nematode *Steinernema feltiae*. (Introduction rates in Table 2)

Aphids



Many aphid species attack greenhouse sweet pepper plants but the most common ones are the potato aphid, the foxglove (or glasshouse potato) aphid, the cotton or melon aphid and the green peach aphid. It is important to identify the aphid species present because some BCA's (e.g. parasitic wasps) can attack some aphid species but not others; therefore, aphid species present in a greenhouse will impact the choice of BCA's used. For a detailed identification key, please consult the 'Aphid Pest-Info Sheet'.

Soon after planting, we recommend preventive introduction of the Aphidius-System, which contains *Aphidius colemani*, a parasitic wasp of the cotton aphid and of the green peach aphid, in combination with the Banker-System. The Banker-System consists of barley plants infested with cereal aphids, which cannot attack pepper plants but can support a population of *A. colemani*; in other words, it is an 'in-house rearing system of aphid enemies'. If hotspots of cotton aphid or green peach aphid develop, we recommend additional introduction of the Aphidius-System. If potato aphid and/or foxglove aphid are found, we recommend curative introduction of the Ervi-System, which contains the parasitic wasp *Aphidius ervi*. To complement control in hotspots (any aphid species), we recommend using the Aphidoletes-System, which contains the predatory midge *Aphidoletes aphidimyza*, and/or the Chrysopa-System, which contains the lacewing *Chrysopa rufilabris*. (Introduction rates: Tables 1 and 2).

Whitefly



The main whitefly species found on pepper is the greenhouse whitefly (*Trialeurodes vaporariorum*) but the silverleaf (tobacco or sweet potato) whitefly (*Bemisia argentifolii* or *B. tabaci*) is another species that may also be found. It is important to identify the whitefly species because BCA's may attack some whitefly species but not others; therefore, whitefly species present in a greenhouse can impact the choice of the BCA's used.

In crops where whitefly is expected to be a problem, we recommend introducing preventively the Swirskii-System, which contains the predatory mite *Amblyseius swirskii*, as soon as the temperature reaches a 24hr average of 20°C. If whitefly becomes out of hands, we recommend curative introduction of the Encarsia-System, which contains the parasitic wasp *Encarsia formosa* either alone or in combination with the Eretmocerus-System, which contain the parasitic wasp *Eretmocerus eremicus*. In case silverleaf whitefly is present, we suggest the Mundus-System, which contain the parasitic wasp *Eretmocerus mundus*; the Mundus-System can be use in combination with the Encarsia-System and/or Eretmocerus-System if both whitefly species are present. For additional control, we suggest curative introduction of the Swirskii-System (Introduction rates: Tables 1 and 2).

Fungus gnat and shore fly:



Fungus gnat is usually a problem during the propagation of young plants but can also cause damage at the planting stage of small plants or even to older plants. Shore flies can be a problem (nuisance) but they do not cause direct damage to plants. We suggest using the Hypoaspis-System, which contains the predatory mite *Hypoaspis miles*, as preventive measure against fungus gnats. We also suggest to introduce the Atheta-System, which contains the predatory rove beetle *Atheta coriaria*, as a preventive measure; this beetle will complement the work of the Hypoaspis-System in controlling fungus gnats but it will also control shore flies. Usually one application soon after seeding and at planting is enough to establish a population and obtain control of fungus gnats and shoreflies. (Introduction rates: Table 1).

Lygus:

Unfortunately there are no BCA's available to control Lygus effectively. Therefore, this pest problem needs to be addressed with selective pesticide when found in the greenhouse. Please contact your Biobest or distributor's IPM consultant to discuss options.

Caterpillars and Loopers:

Caterpillars and loopers can be controlled with B.t.k. (*Bacillus thuringiensis* var. *kurstakii*) products as well as with some pesticides that have no negative effect on the rest of the biological control system and/or on BCA's used. There are some BCA's available commercially for use against caterpillars and loopers; if you are interested in learning more about these BCA's, please your Biobest representative or distributor.

Impact of pesticides on BCA's

- Pesticides (insecticides, nematicides, fungicides, etc.) can have short or long-term negative effects on one or more stages of the BCA's. Therefore, be careful if or when choosing pesticides to apply while using BCA's.
- If buying plants from an outside source, request a record of the pesticides applied on the plant material you are buying. Some pesticides with long-term residuals can have a negative impact on BCA's for many weeks after their application, even if pesticides were applied before the plant material is brought into your greenhouse. Ask your supplier of plant material to incorporate BCA's as much as possible in his pest management program.
- Effects of pesticides on BCA's are listed in the Biobest's publication "Side Effects Manual" or can be found on Biobest's website (www.biobest.ca);

Additional sources of information

- For detailed information on pests and BCA's mentioned above, consult the corresponding "Pest Info-Sheet" or "Beneficial Info-Sheet", which are all contained on the "Biobest Info-System" CD. To obtain a copy of any info-sheet or of the CD, please contact Biobest directly or a Biobest representative.

Miscellaneous

- Introduction rates of BCA's can be influenced by climate, season and location;
- Always use products as soon as possible after receipt. If storage is unavoidable, keep at recommended temperature (indicated on package) for the shortest amount of time possible;
- Always use products before the expiry date stated on the package;
- For additional information, please contact a Biobest supplier or technical advisor.

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Pepper

Table 1: Preventive introduction of BCA's against pests of pepper.

Pest	Product (BCA)	Introduction rate	Timing	Application
	Use the following four products			
Thrips	Amblyseius-Breeder-System (<i>Amblyseius cucumeris</i>)	100 / plant	Once at planting	5ml pile on block
	Swirskii-Breeding-System (<i>Amblyseius swirskii</i>)	1 sachet / 3 m ²	Once when leaves are touching	Hang sachets on plant
	Degenerans-System (<i>Amblyseius degenerans</i>)	0.25 / m ²	Two introductions a week apart when plants are flowering	Sprinkle on leaves
	Orius-System (<i>Orius insidiosus</i>)	0.25 / m ²	Four introduction a week apart starting in February	Sprinkle on leaves
Whitefly	Swirskii-Breeding-System (<i>Amblyseius swirskii</i>)	1 sachet / 3 m ²	Once when temperature >20°C (68°F)	Hang sachets on plant
Spider mite	Californicus-System (<i>Amblyseius californicus</i>)	0.33 / m ²	Three introduction a week apart when crop is 5ft tall	Sprinkle on leaves at perimeter and dry areas of greenhouse
	Use the following two products in combination			
Small aphids	Banker-System (barley plant with cereal aphid)	1 plant / acre	Every 2 weeks, start immediately after planting	Transplant in hanging basket and place in greenhouse
	Aphidius-System (<i>Aphidius colemani</i>)	250 / Banker-System	1 week after introduction of Banker-System	Sprinkle on Banker-System
	Use the following two products in combination			
Fungus gnats	Hypoaspis-System (<i>Hypoaspis miles</i>)	50 / plant	Once at planting	2.5ml Pile on block
	Atheta-System (<i>Atheta coriaria</i>)	2 / m ²	Once at planting	Pile on slab

N.B.: 1 m² = 10 ft²

Table 2: Curative introduction of BCA's against pests of pepper

Pest	Product (BCA)	Introduction rate	Timing	Application
Use one of the first two products; use the third and fourth as needed:				
Thrips	Amblyseius-Breeder-System (<i>Amblyseius cucumeris</i>)	50 / m ²	As necessary	Sprinkle on leaves in hot-spots
	Swirskii-Breeding-System (<i>Amblyseius swirskii</i>)	50 / m ²	As necessary	Sprinkle on leaves in hot-spots
	Orius-System (<i>Orius insidiosus</i>)	10-20 / m ²	As necessary	Sprinkle on leaves in hot-spots
	Steinernema-System (<i>Steinernema feltiae</i>)	250000 / m ²	3 applications a week apart	Spray on plants
Always use first product; second product is optional				
Spider mite	Phytoseiulus-System (<i>Phytoseiulus persimilis</i>)	2 / m ²	Three introduction a week apart when TSSM first detected	Sprinkle on leaves
		10-20 / m ²	As necessary	Sprinkle on leaves in hot-spots
	Feltiella-System (<i>Feltiella acarisuga</i>)	250 / hot-spot	2 introductions a week apart	Open package in hot-spots
Small aphids	Aphidius-System (<i>Aphidius colemani</i>)	0.5 - 2 / m ²	As necessary	Sprinkle on leaves
Large aphids	Ervi-System (<i>Aphidius ervi</i>)	0.5 - 2 / m ²	As necessary	Sprinkle on leaves
Use at least one of the following two products				
All aphids	Aphidoletes-System (<i>Aphidoletes aphidimyza</i>)	0.5 - 1 / m ²	As necessary	Make piles of 250 Aphidoletes near hotspot
	Chrysopa-System (<i>Chrysopa rufilabris</i>)	500 / Acre	As necessary	Open package in hot-spots
Use at least one of the first two products; use third product if silverleaf (<i>Bemisia</i> spp.) whitefly present; fourth product is optional				
Whitefly	Encarsia-System (<i>Encarsia formosa</i>)	4 / m ²	As necessary	Hang cards on plant
	Eretmocerus-System (<i>Eretmocerus eremicus</i>)	3 / m ²	As necessary	Hang cards on plant
	Mundus-System (<i>Eretmocerus mundus</i>)	3 / m ²	As necessary	Hang cards on plant
	Swirskii-Breeding-System (<i>Amblyseius swirskii</i>)	1 sachet / m ²	First sign of whitefly	Hang sachets on plant

N.B.: 1 m² = 10 ft²