

2010 Crop Recommendations Pepper

Overview:

The density and toughness of the leaves makes Pepper a hard crop to monitor. Spider mites can be well established and dispersing before any damage to the leaf can be seen. In the case of whitefly, there are a lot of leaves to look at in a tall crop, so the likelihood of finding the first few whitefly is small. Because of this, Pepper, like no other crop, needs monitoring aids. Every Pepper house should have yellow sticky traps right from the first day of planting out. Eggplants are excellent whitefly trapping plants in a Pepper crop because whitefly prefer Eggplant over Pepper by quite a wide margin. Chronic spider mite areas should have beans grown amongst the Pepper plants in order to see when the mites are returning, and to act as a banker system when the mites have colonized the beans.

The presence of pollen in the Pepper crop allows a broad range of beneficials to be introduced early in the crop, as a preventative step. Prevention is the key to lower cost biological control.

As always, the movement of people in the greenhouse is a major form of dispersal of the crawling pests, such as spider mites. Whenever possible, restrict the movement of people in known hot spots. Enter the hot spots last and then directly leave. Coveralls should be frozen overnight or washed each day, especially for the people that worked in a known infested area.

Prior to Planting Out:

The house should be thoroughly cleaned. Walls, floors, posts, wires etc should be washed with soap or another suitable cleaning product. Whitefly and Aphids will persist in cool greenhouses for well over 1 week without any plant material available, but they will be killed with a thorough cleanup.

If the house has a history of spider mites, they will be hiding in the ground around the posts and the walls. An introduction of *Hypoaspis miles* (250 mites per square meter) at each post and along the walls will help kill the overwintering spider mites.

Discuss with the propagator the presence of pests. Ensure that your plants are clean because of good pest management practices and not because of a chemical insecticide. If an insecticide is used, get all of the details such as rate and date, as well as method of application.

At Planting Out:

Apply *Hypoaspis miles* at a rate of 50 to 100 per square meter. Lower rates can be used on new rockwool or other substrates, but care must be taken to ensure that the *Hypoaspis* is thoroughly mixed. *Hypoaspis* can be diluted with sawdust or vermiculite but it is difficult to maintain an even distribution immediately after the mixing. Skipping plants can work in clean houses, as the *Hypoaspis* will disperse themselves quite well.

Apply *Encarsia Max* at a rate of 0.5 per square meter if no whitefly is detected. At one to two whitefly per yellow card per week increase rate to 1 per square meter. If using regular *Encarsia*, the rate should be doubled. See below; Whitefly Strategy Overview.

At First Flower:

Apply *Amblyseius fallacis* at a rate of 2 mites per square meter. *A. fallacis* is a general predator capable of feeding on all types of spider mites (including Russet mite), whitefly eggs and first instar, thrips larvae, etc., and pollen, which will help them persist in a clean environment.

The *fallacis* will be effective until serious webbing develops in a hot spot, at which time they will leave the webbed area. See below; Spider Mite Strategy Overview.

Apply *Aphidoletes aphidimyza* at a rate of 2000 per hectare per week. The release points must be neutral, away from any known aphids. Any aphid hot spots should be treated with a direct application of *Aphidoletes* or *Aphidius matricariae* (if green peach aphid) at a rate of 1 *Aphidoletes* to 10 aphids. Small hot spots should be treated by releasing some adults from a tray or with *Aphidoletes Max*, a hanging vial that slowly releases *Aphidoletes* over a 1 week period. See below; Aphid Strategy Overview.

Encarsia Max release rate should go to 2 per square meter. Any count over 2 whitefly per week is a serious infestation and should be countered by increasing the rates to 4 per square meter for *Encarsia Max* or 6 per square meter for *Encarsia. Delphastus catalinae* should be applied at a rate of 0.01 per square meter every 2 weeks. The *Delphastus* will scout out new pest sites and has the added ability to find and eliminate any *Bemisia* should they find their way into the house. See below; Whitefly Strategy Overview.

Early Season:

Watch for the return of the spider mites. Returning mites are frequently still “red phased” so are easy to scout unless *Phytoseiulus persimilis* are present. If the house had a problem with spider mites in the previous year, a trap/banker system should be employed. Bush beans should be planted throughout the crop in the areas of previous infestation at a rate of 1 Bush bean for every 20 plants. Supports in the infested areas should have a Pole bean planted at each base. These beans become a monitoring device first, as the damage is very quickly seen and the spider mites will prefer the beans over the Peppers. As soon as spider mites are detected, the bean plants should be treated with *P. persimilis* at a rate of 2 bean leaves per bean plant (if using *P. persimilis* on bean leaves) or 100 *P.persimilis* adults (twice the rate for vermiculite). The trapping bean plants will then become *P.persimilis* bankers, dispersing *persimilis* into the main crop as control is achieved in the beans. These beans should be left as long as possible as the spider mites will often return over a long period of time. Bean leaves that have a good balance of *persimilis* can be pulled off the banker plants and distributed in the crop. See below; Spider Mite Strategy Overview.

Whitefly should never be given a chance to develop. Rates of release for *Encarsia Max* should increase to 3 per square meter and the release of *Delphastus* should be changed to weekly. Eggplant trapping plants should be converted to *Encarsia* and *Delphastus* bankers by concentrating releases onto the Eggplant. See below; Whitefly Strategy Overview.

Watch for Aphids entering the house. Rates of the preventative release should increase to 5000 per hectare per week, as the crop is now much larger. Hot spots should be directly attacked with releases of adult *Aphidoletes*, but control of the Melon aphid will only occur by prevention, as the Melon aphid reproduces and disperses faster than the biocontrols can handle. For major infestations, rates of 8000 per hectare per week should be neutrally released until the numbers are back in manageable levels. In order to achieve quick recovery, the ratio of *Aphidoletes* to aphids must be in the order of 1 to 100. This could require extremely large numbers of *Aphidoletes* for a quick cure or a longer time frame for recovery. All species of aphids are controlled by *Aphidoletes*. *Aphidius matricariae* will easily control and cycle with Green Peach Aphid.

The presence of the “Foxglove” aphid must be dealt with immediately. In addition to the increased release rate of *Aphidoletes*, the Brown Lacewing, *Micromus variegatus* should be released directly in the affected areas at 1 per square meter, every 2 weeks.

Thrips should be dealt with when they arrive. The presence of *A. fallacis* on the crop will help hold back the development of the thrips until *A. cucumeris* can get up and running. *A.cucumeris* at 200 mites per square meter either directly applied or by slow release packs will manage a thrip attack on Peppers. After the middle of March, *Orius* should be introduced at the recommended rate. The *Hypoaspis* in the growing media will prevent any of the soil pupating

thrips from cycling. If a leaf pupating thrip establishes, such as Echinothrips, it is a very serious threat and should be dealt with by doubling the *cucumeris* rate (at least 200 per plant) and by using numerous blue sticky traps with Vanilla extract on them. The vanilla will attract the thrips away from the plant, onto the cards.

Main Season:

Spider mites should be surrounded by *P. persimilis*. The treated area should be the hot spot and then two more unaffected plants, as the spider mites are probably on these unaffected plants. The *persimilis* should be placed low on the treated plants as they instinctively move upwards and high, which will force a better search and reduce the spread of the mites. A ratio of 1 *persimilis* to 100 spider mites will achieve control in 2 weeks. A typical attack on a single plant hot spot would be 1000 *persimilis* on the affected plant, 500 *persimilis* on the immediate adjacent plants, and 200 *persimilis* on all of the plants within the treatment circle. The hot spot should be flagged and traffic should be diverted. If a general spider mite infestation is occurring, also apply *Stethorus punctillum* at a rate of 500 per hectare, every 3 weeks. The *Stethorus* will fly about the greenhouse and have a preventative effect. They find spider mite by smell. See below; Spider Mite Strategy Overview.

Whitefly should be under control based on the preventative releases. But the increased density of the crop should be responded to by doubling the rate of *Encarsia Delphastus catalinae* will remove very large numbers of whitefly eggs and can be used to reduce outbreaks. If *Bemisia* are present, *Delphastus* should be released every two weeks at a rate of 0.1 to 1 per square meter, depending on level of infestation. The banking Eggplants can be vacuumed with a “Dustbuster” or, even better, inoculated with extra *Encarsia* and *Delphastus*. In extremely hot situations (over 30 Celsius) whitefly adults will only live for a few days (instead of months) and will not lay eggs. See below; Whitefly Strategy Overview.

Aphid control should shift entirely to *Aphidoletes*, as *Aphidius* will now be infested with hyperparasites. Any aphid banking system should be converted to *Aphidoletes* by introducing *Aphidoletes* directly onto the bankers. Please note that we do not recommend any Aphid Banking System. See below; Aphid Strategy Overview.

Late Season:

This is the most important time of the year for spider mites. What you do at this time will determine how bad the next year will be. Every effort should be made to eliminate all of the spider mites before the beginning of September. Once the daylength begins to noticeably decrease and the evening temperatures drop, the spider mites begin diapausing. In a diapause state, spider mite are more resistant to chemicals and are not as attractive to the beneficials. If chemicals should be used, it would be at this time. Hopefully the whitefly is under control so a spray of Avid will not cause a whitefly outbreak.

Rates of *Encarsia* should be now at a minimum of 3 per square meter, due to the density of the crop. Adding trap Eggplants will help if the plants are vacuumed daily. The vacuum or the bag must be frozen to kill the whitefly. Adding parasites beyond 6 per square meter will have very little effect, as there are just too many whitefly and the stickiness of the honeydew will begin to impair the movement of all of the parasitoids. *Delphastus* will continue to work at very high whitefly densities but their impact will not be quickly seen, as they will graze on the eggs and the adult whitefly will live on for months.

Aphids must be in good control going into the fall as the *Aphidoletes* may stop cycling due to diapause. Preventative releases will still work, as they are not being asked to cycle. *Aphidius* can work very well in the fall, especially if they were not used in the summer, reducing the pressure of the hyperparasites.

Spider Mite Strategy Overview:

Cleanup is essential. Physical spraying, chemical spraying, and *Hypoaspis* will all have extremely high returns on investment.

The monitor/banker system using beans works very well and should be used if the house has a history of spider mites.

The use of *A. fallacis* was first used to prevent chronic Russet mite problems in New England on Tomatoes. We found that, not only did the *fallacis* eliminate the Russet mite, but the growers who used it had much better spider mite control in the following season. *A. fallacis* will stay in the Peppers at low or no spider mite densities, as they are true generalists and will feed on pollen, whitefly, and any other small eggs. Their Achilles heel is that they can't tolerate webbing, like all other *Amblyseius* species.

P. persimilis is still the main beneficial. The leaf product will work about twice as fast and with half the inoculums.

Whitefly Strategy Overview:

Whitefly is an insidious pest. Low numbers can give the grower a false sense of security. The longevity and fecundity of the whitefly can lead to overwhelming situations very quickly. The only sure way to control whitefly is to start clean and prevent any significant buildup.

Weekly releases of preventative *Encarsia* must be considered similar to an insurance policy. *Encarsia Max* will reduce the weekly cost by allowing you to use very low rates (as low as 0.25 per meter square). *Encarsia Max* live longer, fly farther, and are actually smarter than refrigerated *Encarsia*. All of Applied's *Encarsia* are held above 11 degrees Celcius and are never refrigerated. *Encarsia Max* is guaranteed to be no older than 48 hours from harvest.

Because of the high number of leaves in a Pepper crop, as compared to Tomatoes and Cucumbers, the general rate of release of all Biological Controls should be greater. The minimum release rate of *Encarsia Max* should be 1 per square meter, for every meter in height. Therefore the minimum release rate should start at 1 and increase to 3 per square meter as the crop grows. Correspondingly, if using our regular, fresh *Encarsia*, the rates should vary from 2 to 6 per square meter.

Using Eggplant as a trap/banker can be very effective, although, in our experience, *Encarsia Max*, starting clean, will be all you need. Whitefly have a very advance sense of smell and will move onto the Eggplant in a very profound way.

If *Bemisia* have established, parasitoids are at a disadvantage because they are all reared on Greenhouse whitefly and parasitoids always work best on their established host. All parasitoids will adapt to *Bemisia* and will all host feed aggressively. The use of *Delphastus* will have a major impact on *Bemisia*, and, if started early, will eliminate the *Bemisia* before they move on to the Greenhouse whitefly. *Bemisia* are much harder to monitor because they don't evenly distribute themselves the way Greenhouse whitefly does.

Aphid Strategy Overview:

The increasing occurrences of the Melon aphid has shown us that the old "hot spot" treatment, that worked so well on the Green Peach aphid, is no longer viable. *Aphidoletes* and *Aphidius* can't keep up with the rapid growth rate and dispersal of the Melon aphid if they are applied in the old way.

Aphids such as the foxglove aphid and snapdragon aphid cause severe tissue damage that must be prevented. Both of these aphids have developed evasion tactics for *Aphidius*, which reduces our ability to control them. *Aphidoletes* however, is very effective against them. The Brown Lacewing, *Micromus variegatus*, should be released directly in the affected areas at a rate of 1 per square meter.

Work in Holland with our distributor at Rijn Plant, a major producer of *Anthrimum*, has shown us that *Aphidoletes* is a much better flier than previously thought. They also have a sense

of smell that has not been fully fathomed. Over a 5year period, we were able to develop a preventative release program that prevented aphids from establishing in the house. This technique was adapted to Pepper in 2005 in B.C. The essential components of the program are; regular releases at a “neutral” location (away from known aphid hot spots) and treatment of known “hot spots” with direct releases. All species of aphid will be eliminated at a rate of 8000 per hectare per week and all species will be prevented at a rate of 4000 per hectare per week.

Late in the season, *Aphidius matricariae* will work well because it is not sensitive to day length and not as sensitive as *Aphidoletes* with respect to temperature.

Applied does not recommend the aphid banking system because of its’ cost and the development of hyperparasites during the spring and summer, and the “false” targets that they present for the preventative *Aphidoletes*.

Thrip Strategy Overview:

No screen can prevent a thrip from entering your house. I have witnessed a thrip squeezing through the channeling on the wall of a glass house and emerging on the other side. Thrips are a tropical pest that has adapted very well to our moderate northern climate.

Waves of thrips will invade your house when an upwind hayfield is being cut, or the outside host plants are disturbed in any way.

An invasion should be dealt with severely by introducing *A. cucumeris* and *Orius* as soon as the first thrip is seen. In areas where it is reasonable to assume that thrips are going to be present, a The presence of *A. fallacis* in the crop will help “hold the fort” until the traditional biological controls are present. The presence of *Hypoaspis* in the root zone will also prevent soil-pupating thrips, such as WFT, from cycling in your house.

Thrips are also very fond of vanilla. A drop of vanilla (pure) on a sticky card will increase the trapping of thrips by up to 10 times. In our *persimilis* rearing system, when Onion thrips show up in the summer, we can remove the adults by adding a drop of vanilla to a “bug zapper”, which also attracts thrips by the UV.

Summary:

Spider Mite	First Flower	Early Season	Mid Season	Late Season
<i>A.fallacis</i>	2 per sq. meter			
<i>P.persimilis</i>	As needed	As needed	As needed	As needed
<i>Stethorus punctillum</i>		As needed	As needed	As needed

Whitefly	First Flower	Early Season	Mid Season	Late Season
<i>Encarsia formosa</i> Max weekly	1 per sq. meter	2 per sq. meter	3 per sq. meter	3 per sq. meter
<i>Encarsia formosa</i> weekly	2 per sq. meter	4 per sq. meter	6 per sq. meter	6 per sq. meter
<i>Delphastus catalinae</i>	As needed	0.1 per sq. meter	0.2 per sq. meter	As needed

Aphid	First Flower	Early Season	Mid Season	Late Season
<i>Aphidoletes aphidimyza</i> weekly-preventatively	0.2 per sq. meter	0.4 per sq. meter	0.6 per sq. meter	As needed
<i>Aphidoletes curatively</i>	1 A.a. per 100 Aphids	1 A.a. per 100 Aphids	1 A.a. per 100 Aphids	1 A.a. per 100 Aphids
<i>Aphidius matricariae</i>	As needed	As needed	As needed	0.5 per sq. meter

Thrip	First Flower	Early Season	Mid Season	Late Season
<i>Amblyseius cucumeris</i>	As needed	10 per sq. meter	As needed	As needed
<i>Orius sp.</i>	As needed	As needed	As needed	As needed