

# Pepper Crop Recommendation

By Applied Bio-nomics Ltd.

## OVERVIEW:

Pepper is one of the most welcoming of crops for pests. The leaves are smooth and non-toxic. The climate is warm and humid. People are moving through the crop daily, providing transport for those pests not blessed with wings. Even the glasshouse provides protection from the elements and volunteering beneficials such as *Orius* spp., Ladybugs and Lacewings. For the Grower, pepper is also difficult as the leathery leaves do not show pest damage quickly and the density makes monitoring difficult. Pepper, like no other crop, needs effective monitoring in order to manage the pest population. We urge pepper growers outside of the Mediterranean basin to avoid the use of *Amblyseius swirskii*. Thrips in pepper, while common and frequently overwhelming, are easily controlled by using more benign and cheaper beneficials and seldom cause actual crop damage. Using *swirskii* will not allow you to follow this guideline, as it is extremely detrimental to *Aphidoletes aphidimyza* and can also disrupt *Phytoseiulus persimilis*.

## 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. Whiteflies and aphids will persist in cool greenhouses for well over one month without any plant material available, but can be killed with a thorough cleanup. Before placing any plants in the house, place a test plant (many test plants actually) in the house at least two days before the planting takes place. The best "test" plant is a bush bean. They grow quickly and are very attractive to spider mites, thrips and whiteflies. This will either confirm that you did a good job cleaning up, or it will show you that you have a big, rush job ahead of you. If you don't have time for a clean-up, at least you will be prepared for the battle. 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 *Stratiolaelaps scimitus* (250 mites per 10 square feet) 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 *Stratiolaelaps* at a rate of 50 to 100 per 10 square feet. Skipping plants can work in clean houses, as it will disperse quite well. If the house has a history of whitefly, apply *Encarsia formosa* at a rate of 0.25 per 10 square feet if no whitefly is detected. At 1-2 whiteflies per yellow card, per week; increase rate to 0.5 per 10 square feet. Bush beans grown in a pot should be strategically placed throughout the greenhouse. In the general crop, one bean plant should be used every 500 to 1,100 square feet. More plants should be used where there has been a history of spider mites and in the obvious locations near heating pipes, entrances and perimeter walls. Returning spider mites will be obvious in one or two days on the beans, and will stay there for some time; allowing you time to react with *persimilis*. The beans will also provide you with an early warning system for thrips and whitefly.

## AT FIRST FLOWER

Apply *Amblyseius cucumeris* at a rate of 2 mites per 10 square feet. *Cucumeris* is a general predator capable of feeding on all types of spider mites, whitefly eggs, thrips larvae, and pollen, which will help them persist in a clean environment. The *cucumeris* 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 at a rate of 2,000 per 2.5 acres, per week. The release points must be neutral and away from any known aphids (the same spot every week). 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 or Aphidius to 100 aphids. Small hot spots should be treated by releasing some adults from a tray. Alternatively, Aphidius can be established and will bank themselves in the crop. Care should be taken to not allow them to over-parasitize the site. Once 60 % parasitism is achieved, discontinue Aphidius applications. See below: Aphid Strategy Overview.

Encarsia release rate should go to 0.5 per 10 square feet if whiteflies are present. Any count of over two whiteflies per week is a serious infestation and should be countered by doubling the rates to 1 per 10 square feet. *Delphastus catalinae* should be applied at a rate of 0.01 per 10 square feet 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. The bean plants will show damage very quickly. Be prepared to replace overgrown beans (we recommend a continuous production of bush beans). React by applying persimilis directly to the beans. New hot spots affecting the crop should be dealt with by pushing a bean seed into the substrate at the site. The bean will leaf out in a few days, and the spider mites will leave the pepper plant and move onto the bean. Apply more persimilis directly to the bean as soon as it has leafed out. The trapping bean plants will then become 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 should increase to 1 per 10 square feet, and the release of Delphastus should be changed to weekly if whitefly has established. 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 5,000 per 2.5 acres 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 aphid reproduces and disperses faster than the biocontrols can handle. For major infestations, rates of 8,000 per 2.5 acres per week should be neutrally released until the numbers are back in manageable levels. Hot spots should have Aphidius applied to them directly. Aphidius should be discontinued once parasitism is more than 60%. In order to achieve effective recovery, the ratio of Aphidoletes or Aphidius to aphids must be in the order of 1 to 1,000. 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, as they can have a very negative effect on the pepper crop. The damage goes from leaf distortion to leader damage very quickly. The presence of Aphidoletes will help, and may even prevent the Foxglove, especially if the Green Peach Aphid is being well managed. It is believed that Aphidoletes prefers the Green Peach Aphid because of the higher levels of honeydew produced. Foxglove Aphids tend to be territorial and dispersion is relatively slow, so a focused response can be very effective. Directly release Aphidoletes into the Foxglove site at a rate of 5 per 10 square feet, every two weeks until controlled. If allowed, also release *Micromus variegatus*, the Brown Lacewing at a rate of 1 per 10 square feet (also every two weeks).

Thrips should be dealt with when they arrive, and their arrival will be seen on the bean plants first. Cucumeris can be re-applied at 100 to 200 mites per 10 square feet either directly applied or by slow release packs. After the middle of March, Orius



may be introduced at the recommended rate. The *Stratiolaelaps* in the growing media will prevent any of the soil pupating thrips from cycling. If a leaf pupating thrips 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 (or almond) extract on them. The scent will attract the thrips away from the plant and onto the cards.

### MAIN SEASON

If a general spider mite infestation is occurring, apply *Stethorus punctillum* at a rate of 500 per 2.5 acres, every 3 weeks. The *Stethorus* will fly about the greenhouse and have a preventative effect, as they find spider mites by smell. We frequently find *Stethorus* associated with newly found hot spots. 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* 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 10 square feet, 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 86° F), 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 all *Aphidius* species will now be infested with hyperparasites. Any aphid banking system should be converted to *Aphidoletes* by introducing it 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

day-length begins to noticeably decrease and the evening temperatures drop, the spider mites begin diapausing. In a diapause state, spider mites are more resistant to chemicals and are not as attractive to the beneficials. Rates of *Encarsia* should be now at a minimum of 3 per 10 square feet, due to the density of the crop. Adding parasites beyond 6 per 10 square feet 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 and *Stratiolaelaps* will both have extremely high returns on investment. The monitor/banker system using beans works very well. So well in fact, that spider mites have become a much lower level pest in some of our houses. The use of *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. *Fallacis* will stay in the peppers at low or no spider mite densities, as they are true generalists and will feed on pollen, whitefly, thrips and any other small eggs. Their only downfall is that they can't tolerate webbing, like all other *Amblyseius* species. A few years ago, we substituted cucumeris for *fallacis* in a crop that was under more thrips pressure. We found that cucumeris was almost as good as *fallacis* with spider mites and was considerably better with thrips, not to mention being considerably less expensive. This strategy has become our standard, due to the success of the bush bean system in reducing the impact of spider mites.

*Persimilis* is still the cornerstone of spider mite management, and recommend that it be purchased



on bean leaves. Stethorus has become a standard in some pepper houses. These small black beetles are spider mite specialists. They go after all of the commercially relevant mites, finding them by smell. Introductions once the house has warmed up and some spider mite pressure is seen will have a significant effect. As in all beetles, a thorough clean-up is not expected, as they tend to graze in the most productive spots, laying their eggs in the low density left overs. However, in peppers they are frequently the only control needed, as the delay is usually enough for us or the persimilis to find the spot.

### 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. Peppers in many areas are not normally affected by whitefly, but growers in those areas should never drop their guard. Once again, the bush bean monitors will provide you with a lot of warning. Weekly releases of preventative Encarsia must be considered similar to an insurance policy. Encarsia will reduce the weekly cost by allowing you to use very low rates (as low as 0.25 per 10 square feet). Applied Bio-nomics' Encarsia live longer, fly farther, and are actually smarter than refrigerated Encarsia. All of Applied's Encarsia are held above 52 degrees F and never refrigerated, and also 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 should be 1 per 10 square feet, for about every 3 feet in height. Therefore, the minimum release rate should start at 1 and increase to 3 per 10 square feet as the crop grows. Using eggplant as a trap/banker can be very effective; although in our experience, starting clean with Encarsia will be all you need.


Whitefly has a very advanced 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, meaning parasitoids always

work best on their established host. All parasitoids will adapt to *Bemisia* and will all host feed aggressively. The use of Delphastus, 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

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*) appears to have an affinity for the foxglove aphid, and therefore should be released directly in the affected areas at a rate of 1 per 10 square feet. Work in Holland with our distributor at Rijn Plant (a major producer of Anthurium) has shown us that Aphidoletes is a much better flier and searcher 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 British Columbia. The essential components of the program are: regular releases at a "neutral" location (away from known aphid hot spots, the same spot every week) and treatment of known "hot spots" with direct releases. All species of aphid will be *eliminated* at a rate of 8,000 per 2.5 acres per week, and all species can be *prevented* at a rate of 4,000 per 2.5 acres per week. Burning sulfur for fungus control severely reduces Aphidoletes' ability to work preventatively. Late in the season, as the temperature drops and the days get shorter, Aphidius will work well because as it is not sensitive to day length and not as sensitive as Aphidoletes with respect to temperature. When using Aphidius, care should be taken not to over apply them. They are very efficient and can overrun the aphid population, resulting in a crash that subsequently forces you to start all over again; which is costly and inefficient. We recommend that if Aphidius has parasitized over 40% of the aphids, reduce the introductions. If over 60% are parasitized, immediately stop further releases until





the numbers drop below 50%. Applied Bio-nomics does not recommend the aphid banking system because of its cost, the development of hyperparasites during the spring and summer, and the false targets that they present for the preventative Aphidoletes program.

### THRIPS STRATEGY OVERVIEW

No screen can prevent thrips from entering your house. I have witnessed thrips 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 cucumeris as soon as the first thrips is seen. In areas where it is reasonable to assume that thrips are going to be present, the presence of fallacis in the crop will help “hold the fort” until the traditional biological controls are present. The presence of Stratiolaelaps in the root zone will also prevent soil pupating thrips, such as Western Flower Thrips, from cycling in your house. Healthy, fresh cucumeris will easily handle any thrips invasion in peppers. Thrips are also very fond of vanilla or almond. A drop of either on a cotton ball, stuck on a sticky card can increase the trapping of thrips by up to 10 times.

