Spring crops (Bedding Plants & Hanging Baskets)

General Information

Spring crops, which include bedding plants and hanging baskets represented by a very diverse mix of plant species, varieties and cultivars. Each one of these crops can be sensitive to one or many of a variety of pests such as thrips, spider mite, aphids, fungus gnats, shoreflies, whitefly and leafminers. With this in mind, the easiest way to manage pest problems with an IPM/bio-control program is to have a pro-active approach with mostly preventive introductions of biological control agents (BCA's) against the most common pest. Furthermore, it is a good idea to share your knowledge of your crops with your IPM technical support person. For example, if you know that a certain crop usually has a high risk of thrips problem, it would then be good idea to use a higher rate of thrips predators in that particular crop. The difference between a traditional pest management program and an IPM/bio-control program is timing, i.e. a re-active approach in the traditional program versus a pro-active approach on the IPM/bio-control program. Growers who have successfully used this program often comment that it has relieved them of sprays and stress about pest management in the period of shipping and sales, when they really don't have time for anything else but sales, packing and shipping. This document describes standard guidelines for the use of bio-control agents in an IPM approach for spring related crops such as bedding plants and hanging baskets. This general program will need to be adjusted to address the needs of each individual crop. For example, if a crop is not attacked by thrips, it would not be necessary to introduce BCA's against thrips. To discuss this in detail, please contact a Biobest representative or distributor.

Scouting and Monitoring

Scouting needs to be done on a very regular and consistent basis (weekly on the same day) to monitor pest and BCA populations. An excellent tool for monitoring whitefly, thrips, leafminer, fungus gnat and shore fly populations is the use of sticky cards. We suggest using 10 sticky cards per acre (1 card/4000ft^2) in a production greenhouse, which should be inspected once a week. Identify, count and record number of pests and BCA's found on cards. All counts (and observations) can be recorded on the Biobest 'Scout-Sheet' or other scouting and monitoring sheets. Some pest problems do not show up on sticky cards as they do not fly; two-spotted spider mite and aphids are a good example. Therefore, plants or trays should also be inspected weekly; if any pests and BCA's are found on plants, identify and record observations.

Pests, Biological Control Agents (BCA) & Control Strategy

Thrips:

Thrips originally always has been a major obstacle for a successful bio-control program in spring crops, especially during the last phase of the crop when plants start to flower At that stage, with flowers ripening, the pollen available is a very attractive food source for adult thrips, and thrips always seems to suddenly increase, which can result in serious damage to flowers; this is often the result of adult thrips accumulating during the winter and spring. The western flower thrips *Franklinella occidentalis* is usually the main thrips attacking crops. The best line of defence against thrips is to begin a biological program as early in the crop as possible. If thrips are present in the greenhouse at planting, first instar larva of thrips could be crawling out of the egg within one week after planting; first instar thrips larva is the stage causing most of the damage. The first instar thrips larva is also the stage most sensitive to the attack of the BCA contained in the Amblyseius-Breeding-System (predatory mite *Amblyseius cucumeris*), the main product used against thrips. The basis of thrips control is to start early in order to prevent the first instar larva from reaching later stages, which are more difficult to control thrips.
In the production of spring crops, we recommend to start the bio-control program as soon as the plants are planted in their final pot, container or hanging basket. We suggest introducing the Amblyseius-Breeding-System as a small 'breeder' pile in every pot (or container or hanging basket); the breeder pile will release *Amblyseius cucumeris* for a period of four weeks; introduction should be repeated every 4 to 6 weeks. In cases where plants are stuck in trays that hold 3-inch or 4-inch pots (not spaced afterwards), it is recommended to introduce one breeder pile per tray. Overhead watering does not harm the 'breeder' pile as long as it is gentle watering, i.e. with pressure low enough not to 'blast

apart' the pile. The Amblyseius-Breeding-System is also available in sachets; if these sachets are used, it is important that plants are touching as these predatory mites do not fly and need to walk from plant to plant to provide adequate protection to each plant. In case a hotspot of thrips develops, we recommend doing foliar application of the Steinernema-System, which contains the nematode *Steinernema feltiae*. (Introduction rates: Table 1).
Other products could be used against thrips. First, there is the Swirskii-System (or Swirskii-Breeding-System), which contains *Amblyseius swirskii*, a predatory mite that feeds not only on thrips larva but also on whitefly larva; however, *A. swirskii* requires higher temperature (minimum daily average of 68^{o}F). Therefore, at this time, we suggest the Swirskii-System as a possible substitute to the Amblyseius-Breeding-System only for late season (April-May) and mainly in thrips and whitefly-sensitive crops. There is also the Orius-System, which contains the predatory bug *Orius insidiosus*, but *Orius* usually does not fit well into a short-term crops. However, positive results were achieved recently with the use of banker-plants to establish and sustain an *Orius* population in the greenhouse. If you like to know more about this technique, please contact your Biobest representative or distributor. The Hypoaspis-System and the Atheta-System, which contain the predatory mite *Hypoaspis miles* and the predatory rove beetle *Atheta coriaria* respectively, are normally used for fungus gnat and shore fly control. Both BCA's live in the top layer of the potting media and also prey on thrips pupating in the soil, thus contributing to thrips control. However, the actual contribution of these two BCA's to thrips control is uncertain and it is therefore not recommended to rely only on them to control thrips

Spider mite:

Since two-spotted spider mites (TSSM) are very small and do not fly, they can remain undetected in the crop; so, early detection is important for effective control. Inspect plants on a weekly basis and keep an eye opened for signs of TSSM such as yellowing or spotted leaves. In some greenhouses, bush bean plants (*Phaseolus vulgaris*) are used as a scouting tool to detect TSSM; beans are very attractive to TSSM and the idea is that spider mites prefer the bean plant to the crop itself.
On the first sign of TSSM in the crop, we recommend introducing the Phytoseiulus-System, which contains the predatory mite *Phytoseiulus persimilis*. In crops very susceptible to TSSM, we recommend introducing the Californicus-System, which contains the predatory mite *Amblyseius californicus*, as a complement to the Phytoseiulus-System. Since *A. californicus* can survive for a long period of time without TSSM, it is possible to release it preventively. However, *A. californicus* will only slow down the development of TSSM; only using the Phytoseiulus-System and Californicus-System in combination will provide adequate control of TSSM. The last product that can be used, especially in hotspots, is the Feltiella-System, which contains the predatory midge *Feltiella acarisuga*. This BCA is more mobile than Phytoseiulus but needs a hotspot to get established well since the larva has an enormous appetite. Once *Phytoseiulus* and *Feltiella* are established, spider mite control is achieved for the remaining time of the crop. (Introduction rates: Table 1)

Aphids:

Spring crops are hosts to many aphid species including green peach, melon, potato and foxglove (or glasshouse potato) aphids (for detailed identification key, consult the 'Aphid Pest-Info Sheet'). Reproduction of aphids is very fast as they give birth to live youngs, so aphid population can develop very quickly. Often, when aphids are found in the crop, population has already reached a level that requires an intervention with a pesticide.
As a preventive measure, we suggest using the Aphidius-System, which contains *Aphidius colemani*, a parasitic wasp of the green peach aphid and of melon aphid. We strongly recommend using the 'Aphid Banker-System' to complement the Aphidius-System. The 'Aphid Banker-System' consists of barley plants infested with cereal aphids, which can support a population of *A. colemani*; in other words, it is an 'in-house rearing system of aphid enemies'. The cereal aphid used on the Banker-System attacks monocotyledonous plants only; therefore, the Banker-System should not be used in greenhouse where monocotyledonous plants (e.g. ornamental grasses, lilies) are grown. Upon detection of potato aphid and foxglove/glasshouse potato aphid in the crop, we suggest combining the Ervi-System and the Aphelinus-System, which contains the parasites *Aphidius ervi* and *Aphelinus abdominalis*, respectively. The Aphidoletes-System, which contains *Aphidoletes aphidimyza*, a predatory midge that attacks any aphid species, can be used in hotspots to supplement the work of the parasites. (Introduction rates: Table 1)

Fungus gnat and shore fly

Fungus gnats can be a serious damages during propagation of young plants but also as at the planting stage of small rooted plants. However, occasionally they can also cause damage to older plants, especially if root problems/diseases are an issue. Shoreflies can also be a problem; they do not cause damage to plants but their presence decreases the aesthetic value and marketability of the plant.

We suggest using the Hypoaspis-System, which contains the predatory mite *Hypoaspis miles*, as preventive measure against fungus gnats. We suggest to also introduce the Atheta-System, which contains the predatory rove beetle *Atheta coriaria*, as a preventive measure; this BCA will complement the work of the Hypoaspis-System in controlling fungus gnats and it will also control shoreflies. Usually one application soon after beginning of the crop is enough to establish a population and obtain control of fungus gnats and shoreflies for the whole duration of the crop. In case fungus gnat hot spots develop, we suggest using the Steinernema-System, which contains the parasitic nematode *Steinernema feltiae*, as curative measure. (Introduction rates: Table 1).

Whitefly

Whitefly is a common pest in some spring crops. The most common whitefly species found is the greenhouse whitefly (*Trialeurodes vaporariorum*). Silverleaf (tobacco or sweet potato) whitefly (*Bemisia argentifolii* or *B. tabaci*) is far less common and is generally found in Southern regions, but occasionally shows up in Northern USA and Canada when plant material is imported from Southern regions. 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.
Since greenhouse whitefly is the most common species, we suggest using the Eretmix-System, which contains the BCA's *Encarsia formosa* and *Eretmocerus eremicus*, two parasitic wasps that attack whitefly by parasitization and by feeding on whitefly larva (host-feeding). In the case that silverleaf whitefly is found in the crop, we suggest using the Mundus-System, which contains *Eretmocerus mundus*, a parasitic wasp specialized against silverleaf whitefly. Depending on the crop, it might be useful to also introduce the Swirskii-System, which contains the predatory mite *Amblyseius swirskii*. This predatory mite, which feeds especially on whitefly eggs but also on thrips larva, is very effective, especially when temperatures are higher during the late spring, summer and early fall; discuss if using the Swirskii-System is right for your case with your Biobest representative or distributor.(Introduction rates: Table 1).

Leafminer:

The control of leafminer is one of the most successful biological control systems. However, since spring crops are sold as complete plants, the tolerance for damages (mines) is extremely low.
Therefore, we recommend using the Diglyphus-System, which contain the parasitic wasp *Diglyphus isaea*. Introduction is done on a weekly basis and should start immediately when leafminer is first detected in the crop. *Diglyphus* immediately stops the leafminer larva in the mine, thus preventing further development of the mine. If leafminer level reaches an average of five or more adult leafminers per sticky card per week, we suggest doing a corrective spray with a compatible pesticide to bring leafminer population down. *Dacnusa sibirica* is another parasitic wasp of leafminer but it is not a viable option since it does not "kill" the leafminer larva instantly in the mine. Scouting for adult leafminers is easily done with yellow sticky cards placed horizontally, which can catch at least 10 times more adult leafminer than vertically placed sticky cards. Often, high level of leafminer damage is found along the walkways and gable ends; horizontally-placed sticky cards are also useful to reduce adult leafminer population in such hot spot. We also recommend monitoring parasitism levels on a weekly basis starting at three weeks after 1st introduction of the Diglyphus-System; dissecting mines and larva with the help of a microscope is the best way to determine parasitism levels. (Introduction rates: Table 1).

Lygus:
Unfortunately there are no BCA's available to control the cucumber beetle or Lygus effectively. Therefore, these pest problems need to be addressed with selective pesticide when observed 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 thurgiensis* var. *kurstakii*) products as well as some pesticides with that have no negative effect on the rest of the biological control system and/or 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.

Trap-Plant and Banker-Plant
'Trap plants' are plants other than the crop grown, which are more attractive to certain pests than the crop itself; trap plants help in the early detection of pests. When BCA's are introduced on trap plants, it creates an "in-house" rearing system of BCA's, hence the term 'Banker-Plants'. In spring crops, positive results have been obtained with banker-

plants for aphid control. If you are interested in implementing this technique in your propagation area, please contact a 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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Table 1: introduction of BCA's against pests of spring crops.

Pest	Product (BCA)	Introduction rate	Timing	Application
Thrips	Always use the first product; use second if necessary			
	Amblyseius-Breeding-System (Amblyseius cucumeris)	125 / pot < 8 inches or 250 / pot > 8 inches	Once at beginning of crop, and re-apply every 4-6 weeks	Introduce as breeder pile in pot
	Steinernema-System (Steinernema feltiae)	25000/ft^2	If needed	Spray foliage
	Orius- System (Orius insidiosus)	In combination with banker plants; discuss with technical representative		
Two Spotted Spider Mite	Use following two products in combination; third product is optional			
	Phytoseiulus-System (Phytoseiulus persimilis)	0.4 to 0.6 /ft^2	At least 3 times or until population is established	Sprinkle on plants
	Californicus-system (Amblyseius californicus)	0.2 to 0.4 /m^2	Once, one week after planting	Sprinkle on crop
	Feltiella-System (Feltiella acarisuga)	250 / hot-spot	2 introductions a week apart	Open package in hot-spots
Aphids (green peach, black melon)	Use first two products in combination. Third product is optional			
	Aphidius -System (Aphidius colemani)	0.015/ft^2	Weekly until banker plants are producing or control is achieved	Sprinkle on crop or banker plants
	Aphid Banker Plant (barley plant with cereal aphid)	1 plant / acre	Bi-weekly	Plant in hanging basket and place in greenhouse
	Aphidoletes-System (Aphidoletes aphidimyza)	0.05 to 0.1 /ft^2	Weekly for at least 3 weeks or until control is achieved	Make piles of 250 Aphidoletes near hotspot
Aphids (potato, foxglove)	Use all three products in combination			
	Aphelinus-System (Aphelinus abdominalis)	0.2 to 0.4 /ft^2	Weekly for at least 3 weeks or until control is achieved	Release in crop
	Ervi-System (Aphidius ervi)	0.05 to 0.1 /ft^2	Weekly until control is achieved	Release in crop
	Aphidoletes-System (Aphidoletes aphidimyza)	0.05 to 0.1 /ft^2	Weekly for at least 3 weeks or until control is achieved	Make piles of 250 Aphidoletes near hotspot
Fungus gnats & shore flies	Use first two products in combination as preventive measure; use third if needed as curative measure			
	Hypoaspis-System (Hypoaspis miles)	10/ft^2	Once, after seeding	Sprinkle on soil
	Atheta-System (Atheta coriaria)	0.1/ft^2	Once, after seeding	Sprinkle on soil
	Steinernema-System (Steinernema feltiae)	100000/ft^2	As needed	Drench on soil
Whitefly	Use first product; use second product if Bemisia tabaci is found;			
	Eretmix-System (Encarsia formosa & Eretmocerus eremicus)	0.6/ft^2	Weekly	Hang card on plants
	Mundus-System (Eretmocerus mundus) (if Bemisia is found)	0.3/ft^2	Weekly	Hang cards on plants
	Swirskii-System (Amblyseius swirskii)	Use in whitefly susceptible crops. Discuss options with technical representative		
Leafminers	Diglyphus-System (Diglyphus isaea)	0.01/ft^2	Weekly, until parasitism >75 %	Release on plants