IPM and Biological Control for Ornamental Nursery Pests

The programs that follow are general guidelines that have been used with success in ornamental nurseries in Canada. An IPM program must be custom designed for each different crop and greenhouse or nursery situation. This should be done initially before purchasing the biocontrol products and then in consultation with the biocontrol producer, supplier or IPM advisor. Regular monitoring using sticky traps or other monitoring devices is necessary in any IPM program to provide accurate updates on both pests and native biocontrol. Integrated pest management using biological control requires a knowledge of pest life cycles and threshold levels and modification of spray programs to avoid harm to the biocontrol agent. The rewards of using biological control in IPM programs are better pest control, healthier plants, lower costs, lower pesticide inventories, reduced health and environmental hazards and happier employees.

Fungus Gnats (*Bradysia sp.*)
Root damage by fungus gnats can spread disease to healthy roots and if common can cause losses of 20-40% of plants in early propagation stages. In greenhouses, excellent preventive control of fungus gnats can be obtained with early applications of the predatory mite *Hypoaspis miles*. This predator also feeds on spring tails, thrips, root mealybug mites and other small soil organisms. If fungus gnats are established on the crop and appearing in high numbers, beneficial nematodes or the new fungus gnat strain of *Bacillus thuringiensis* (BtI) may be applied for control of the larval stages. Improve drainage and avoid over watering to limit algal growth and sites for fungus gnat and shore fly breeding. Bleach solutions can be used to help control algae.

Monitoring tips
Monitor plants for adult fungus gnats weekly using 1 yellow sticky trap per every 500 square meters. If adult fungus gnat counts are above 20/trap/week, treat area with parasitic nematodes or fungus gnat Bt formulations using the recommended rates. Repeat these treatments weekly until the adult fungus gnat numbers are below 20/plant. This treatment will not harm other biocontrol agents.

Treatment
Hypoaspis is most effective when applied before fungus gnat population become established or while numbers are still low. One application of *Hypoaspis* per crop cycle is usually sufficient, if used early in the season.

1. **Soil Culture –** Apply 1 L(15,000)/100 m^2 (1000 ft^2) to the soil at the time of planting. Be sure to treat wet, exposed areas of soil, where fungus gnats are likely to breed. Mites can also be applied to propagation media before striking cuttings.

2. **Pot Culture –** Apply 1 L(15,000)/ 100 m^2 (1000 ft^2) of bench area. Treat the floor of the greenhouse if it provides conditions for fungus gnats to breed and occasionally treat the perimeter of the greenhouse.
It is not necessary to apply mites to every pot if applications are done early to allow them two weeks or more to spread (e.g. apply Hypoaspis to every second row of pots).

For Best Results
Do not mix predators into the growth media before potting because many will be killed when mixing.
Apply Hypoaspis shortly after planting and before fungus gnat levels reach more than 20 adults/trap/week.

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To control high numbers of fungus gnats, use of Hypoaspis can be integrated with insect parasitic nematodes (e.g., *Steinernema* spp.) and *Bacillus thurinigiensis ioensis* (BTI) (Vectobac®), both of which control the larval stage of fungus gnats.

Using Pesticides
See compatibility chart for expected effects of pesticides on Hypoaspis. In general, do not apply Hypoaspis to soil that has been treated with lime or residual pesticides (particularly soil treated with diazinon).
Foliar sprays are usually less harmful than soil drenches, depending upon how much pesticide reaches the soil surface. Fungicide drenches containing benzimidazoles are known to reduce reproduction of Hypoaspis. Microbial pesticides, such as Vectobac® (BTI) will not harm Hypoaspis.

Spider Mite
Control of mites has been achieved on many species of woody ornamental shrubs in British Columbia using the predatory mite *Amblyseius fallacis*. Fallacis is used to control two-spotted spider mites and other mites on greenhouse peppers, field strawberries, raspberries, currants and mint. In British Columbia, Washington and Oregon, IPM programs for field berry crops are based on using Fallacis as the primary control for spider mites.
Fallacis is also used on container and field-grown nursery stock. Research in Oregon indicated that Fallacis can control spruce and outher spider mites (*O. ilicis, O. ununguis,* and *T. urticae*) on woody ornamentals (*Thuja, Skimmia, Weigela, Potentilla, Euonymus,* and *Buddleia)*. Fallacis feeds on apple rust mite (*Aculus schlectendali*), cyclamen mite (*Steneotarsonemus pallidus*) and tomato russet mite (*Aculops lycopersici*), however, whether or not it controls these species is not known.
Fallacis is more resistant to pesticides than most biological controls and a strain highly resistant to pesticides is available commercially. Unlike other predatory mites, such as the Persimilis predatory mite, Fallacis can remain in areas with low levels of spider mites; they survive in the absence of mite prey by feeding on other small arthropods and pollen.
Fallacis feeds and reproduces over a wide range of temperatures [9-32°C (48-85°F)]. They do best where there is a dense plant canopy and when relative humidity is over 50%.
Fallacis can reproduce at lower temperatures than other predatory mites (*Phytoseiulus persimilis, Neoseiulus californicus*) and displaces them in the cooler growing areas in Canada and northern USA.
Where there are species of plants that are very attractive to mites the new predatory beetle, *Stethorus punctillum* and the predatory midge, *Feltiella acarisuga* may be released. Release 100 adult beetles or 100 midges into each infested plant site. Make weekly introductions for 3 weeks. These biological controls can fly and feed on all stages of spider mite and will reproduce and remain in the area for more than one season. Feltiella will only establish if humidities are 65% or higher.

Monitoring tips
Use a headband magnifier or 10-15X hand lens. The predators are usually easy to tell from their prey, which are slow-moving. Adult mites often hide under leaf hairs and along the edge of leaf veins. They are most easily seen on parts of the leaf where spider mite numbers are low or around the edges of the main spider mite infestation. Eggs are usually found singly or in pairs in crevices along, or partly under, the leaf midrib or where prey is abundant.
Life Cycle of A. fallacis Predatory Mite
Development from egg to adult takes from 7-9 days at 21°C (70°F) to 3 days at 32°C (85°F). At 26°C (78°F) a fourfold increase in numbers can occur within 4 days; in the field, under optimum conditions, populations can increase from 10 predators/100 leaves to 200-500 predators/100 leaves, in just 2 weeks.

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Adult females lay 1-5 eggs per day, for a total of 26-60 eggs over their 14-62 day life time. The eggs hatch in 2-3 days. Eggs are oval and twice the size of two-spotted mite eggs.
Newly hatched predators do not eat, but later stages and adults feed on all stages of prey. Female Fallacis eat 2-16 spider mites per day.
Adult females enter diapause in response to the short days (daylight of 14 hours or less in Canada) in fall. They stop reproducing and move into sheltered areas, such as under bark or ground cover.

Product Information
Fallacis is available commercially either on bean leaves or in a granular carrier (usually vermiculite or corn grits). Both formulations should be applied as soon as possible. Fallacis packages can be held at 10-15^{o}C (50-60^{o}F), out of direct sunlight, for 1-2 days--but quality and egg laying will be lower.
Two new more mobile mite predators, the beetle *Stethorus punctillum* and midge, *Feltiella acarisuga* are also now available and are being used with Fallacis with good results as both have flying adult stages.

Treatment:
1.Apply Amblyseius fallacis onto all spider mite sensitive ornamental plants during propagation or when setting them out in cold frames or the field. Use a general rate of 3 predators per square meter of infested plant area repeated weekly for 3 weeks if spider mites are present.
2.Monitor these plants weekly to check spider mite levels. If mites are building up or causing webbing apply fenbutatin-oxide (Vendex™, Torque™) through a high volume sprayer. This will not harm predators.

Aphids (many species)

There has been excellent success treating aphid infestations in nurseries with biological control agents. In fact, if biological control agents are introduced in open screen houses and field settings, it is usually unnecessary to apply pesticides for most species of aphids. Unfortunately, protected or gall forming aphids are not controlled by biological control agents that are presently available from commercial suppliers.

Treatment:
1. Before the first sign of aphids, apply the *Aphidoletes* aphid predatory midge preventively, weekly or bi-weekly at the rate of 0.25-0.5 per square meter of planting. Once aphids are detected apply an additional 2 predators per square meter of infested area, repeated weekly for 3 weeks. These biocontrols can fly and feed on all stages of most species of aphids and will reproduce and often over-winter and remain in the area providing control for more than one season.
2. At the first sign of aphids, also apply the aphid parasite, *Aphidius* matricariae at a rate of 1 parasite for every 2 square meters of infested area, repeated weekly for 3 weeks. Three weeks following the release look for signs of parasites in the form of parasitized aphid mummies attached to the leaves.
3. Monitor plants weekly, if aphid hot spots continue to develop and there is plant damage, spot spray with pirimocarb (Pirless™) or Insecticidal Soap. This will cause minimal harm to the biologicals. Avoid the use of other pesticides unless determined to be safe for biological control agents.

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Caterpillars (Lepidopteran larvae)

Caterpillar damage may be controlled by releasing the commercially available moth egg parasite Trichogramma spp. or spraying the spores and insecticidal crystals of strains of *Bacillus thuringiensis* (Bt).

Treatment:

1. Monitor planted area for adult moths using pheromone traps or ultra violet light traps.
2. Release *Trichogramma* egg parasites as soon as adult pest moths are detected at rates of 50,000-100,000/acre or as advised by the supplier.
3. Bt is usually applied as a high volume spray at first sign of larval damage. Follow the formulators recommendations for rates.

Vine Weevil (Otlorhynchus sulcatus)

The vine weevil can cause serious harm to nursery plant roots and the adult also feeds on leaves. Unfortunately these root weevils are all female do not require mating and can lay up to 1000 eggs each! Adults are also flightless, are most active at night and they can walk s far as 1000 meters per day. Adults lay eggs in the root ball and both larvae and adults continue feeding at temperatures as low as 2ºC. As many as 400 weevils have been found in a single 2 gal. container root ball.

A nematode is available as a bilogical control agent of this pest but nematodes are most effective when applied into potted plants under warmer growing conditions in greenhouses or when soil temperatures are greater than 12ºC. Nematodes are mixed with water and applied as a drench. Nematodes in the Heterorhabditis group have been found more effective than other types against vine weevil.

Treatment:

1. Monitor plants weekly for damaged leaves and check the root ball of wilting plants for weevil larvae causing root damage.
2. Apply nematodes to the root zone following label recommendations. Apply 2-3 treatments at weekly intervals. Spring and fall applications are best as most adult weevils are in the soil at this time. Treated plants should be watered before treatment and kept moist as the nematodes can only move through moist substrates. Do not over-water treated plants as this will wash away nematode larvae. Nematode biocontrols are resistant to Orthene and it may be applied as a combined drench where necessary.

Biocontrol of Lygus Bug?

At the moment there is no commercially available biocontrol for Lygus Bug for nurseries and the only control method is excluding by screening vent openings or use of pesticides Cornell University is experimenting with the fungus, *Beauvaria bassiana*, a microbial biocontrol that is now available in the USA. Work is also being done at Simon Fraser University on Lygus attraction or mating disruption pheromones and this may have direct application to nursery IPM. Presently Lygus appear quite sensitive to most pesticides. Endeavor (pymetrozine) has provided some control in greenhouses and still allows biocontrol agents to develop. Low rates of thiodan have also provided control of the mobile stages while allowing some survival of other beneficial parasites and predators in field berry crops in British Columbia.

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IPM SUMMARY FOR NURSERY PESTS

Fungus Gnats	Yellow Sticky Traps	use 1 trap/500m2 for monitoring adults
	Hypoaspis miles	if fly trap counts are below 20/trap/week
	Steinernema feltiae	apply at least 2X at 2 week intervals if fly trap counts are above 20/trap/week rate- 50,000,000/250 m2 or as recommended
	Bacillus thuringiensis ioensis	apply weekly if fly trap counts are above 20/trap/week rate- 4-8 litres/1000 litres of water, or as directed
Spider Mite	Amblyseius fallacis	preventative and low curative 3 predators/m2 repeated weekly for three weeks once mites are detected
	Stethorus punctillum	preventative and low curative 100/hot spot/weekly for 3 weeks
	Feltiella acarisuga	preventative and low curative (requires Rh+70) 100/hot spot/weekly for 3 weeks
	fenbutatin oxide (Vendex 50W™)	500g-1Kg Vendex 50W/1000 litres water
Aphids (many species)	Aphidoletes aphidimiza	preventive 0.5-0.25 predators/m2 of infested area repeated weekly or bi-weekly
	Aphidius spp.	preventative and curative 1 parasite/2m2 of infested area repeated weekly for 3 weeks.
	pirimicarb (Pirliss™ 50DF)	500g Pirliss 50 DF/1000 litres water or as directed moderately harmful to biologicals so apply at low rate to tops of plants only or use only in hot spots.
	insecticidal soap (Safer's Soap™)	1 part soap/100 parts water or use low rate moderately harmful to biologicals so apply to tops of plants only or in hot spots.
Caterpillers	pheromone traps	use 1trap/5000m2 for monitoring adults
	ultraviolet light	or as advised by supplier
	Trichogramma brassiere	egg parasites should be released as soon as pest adult moths are detected, release 50,000-100,000 parasites/acre weekly for 3 weeks or as advised by supplier.
	Bacillus thuringiensis var. kurstaki (Dipel™)	apply as a high volume spray at first sign of larval damage at recommended rates (eg.) 1.2Kg. Dipel/1000 liters water
Vine Weevil	Heterorhabditis megidis (Nemasys™)	soil temperature must be 12°C or greater most effective in pot or container culture apply as a soil drench as directed (eg.) 50,000,000/250 m2

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