Commercially Available* Biological Control Agents for Common Greenhouse Insect Pests

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Commercially Available Biological Control Agents for Aphids

Parasitoids

Predators

Aphelinus abdominalis

Parasitic Wasp

- Parasitizes a wide-range of aphid species.
- Can tolerate higher temperatures than most *Aphidius* species.
- Slower to establish than *Aphidius* species.
- Release 2 to 4 adult wasps per 10 square feet weekly or until 80-90% of the aphids are parasitized.

Aphidius colemani

Parasitic Wasp

- Parasitizes smaller aphids such as green peach and melon aphid.
- Can be reared using banker plants (oat or wheat) infested with bird-cherry oat aphid (use a minimum of 4 banker plants per acre).
- May be sold as a mixture with *Aphidius ervi.*
- Release 400 to 2,000 adults per acre.

Aphidius ervi

Parasitic Wasp

- Parasitizes larger aphids such as foxglove and potato aphid.
- May be sold as a mixture with *Aphidius colemani.*
- Release 400 to 2,000 adults per acre.

Aphidius matricariae

Parasitic Wasp

- Parasitizes green peach aphids.
- Active at cooler temperatures (50°F to 85°F; optimum 77°F) than *Aphidius colemani* (Optimum: 86°F).
- Release 400 to 2,000 adults per acre.

Aphidoletes aphidimyza

Predatory Gall Midge

- Larval stages prey on all aphid species encountered in greenhouses.
- Most effective at temperatures between 68 and 80°F and a relative humidity between 70 and 80%.
- Primarily active at night.
- Mainly used against high aphid populations.

Adalia bipunctata

Ladybird Beetle

- Both larvae and adult feed on many different aphid species.
- Used when aphid populations are high.
- Adults typically attempt to leave the greenhouse after release. Therefore, make releases in the evening.
- Release adults every 2 to 3 weeks.

Chrysopa carnea

Green Lacewing

- Larvae feed primarily on aphids but may also feed on mealybugs.
- Can consume up to 425 aphids per week.
- Release 5 to 10 eggs per plant or 1,000 eggs per 200 square feet.

Chrysoperla ryfilabris

Green Lacewing

- Tolerates a higher relative humidity (>75%) than *Chrysopa carnea.*
- Can consume up to 300 aphids per week.
- Release 5 to 10 eggs per plant or 1,000 eggs per 200 square feet.

Hippodamia convergens

Ladybird Beetle

- Feeds on 2,000 aphids during their lifetime.
- Multiple releases are usually required.
- Most effective when aphid numbers are high.
- Adults typically attempt to leave the greenhouse after release. Therefore, make releases in the evening.
- Release adults every 2 to 3 weeks .

***All release rates are benchmarks – they will vary with crop type and infestation level.**

***Photo credits: [1]Koppert Biological Systems, [2]Bugwood.org or [3]Evergreen Growers Supply.**

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Commercially Available Biological Control Agents for Western Flower Thrips

Predators

Beneficial Nematode

Amblyseius swirskii

Predatory Mite

- Feeds on both 1st and 2nd instar larvae.
- Tolerates higher temperatures than *Neoseiulus cucumeris.*
- Will also feed on the eggs and nymphs of whiteflies.
- Feeds on pollen in the absence of prey.
- More expensive than *Neoseiulus cucumeris.*

Neoseiulus (=*Amblyseius*) *cucumeris*

Predatory Mite

- Most widely used predatory mite for western flower thrips.
- Feeds on the 1st instar larvae.
- Make releases early in the crop production cycle.
- Active at temperatures between 70 and 75 ° F; prefers a relative humidity around 65%.

Orius spp.

Minute Pirate Bug

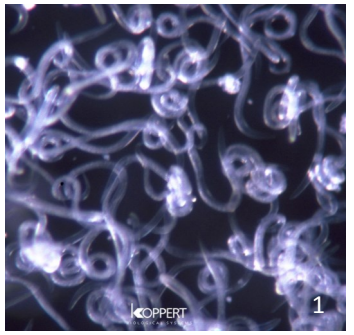
- Feed on larvae and adults of western flower thrips.
- May also feed on aphids and whiteflies.
- Can be used with ornamental pepper plants serving as banker plants (example: 'Purple Flash,' 100 per acre).
- More expensive than using *Neoseiulus cucumeris.*
- Most effective when temperatures are >60° F and day length is >12 hours.
- Release 0.5 to 1 per square foot.

Stratiolaelaps scimitus

Soil-dwelling Predatory Mite

- Adults may kill up to 30 prey, including western flower thrips pupae or fungus gnat larvae, per day.
- Release 1,000 to 2,000 per square foot.

Steinernema feltiae



Beneficial Nematode

- Apply as either a foliar spray or drench to the growing medium. Drench applications target the pupa stage.
- Requires soil temperatures of 50 to 80° F to be effective.
- Apply early in the morning or late in the evening.
- Water crops both before after application to increase efficacy.
- For foliar sprays, apply 50 million per 1,000 square feet.
- Remove screens before making applications.

***All release rates are benchmarks – they will vary with crop type and infestation level.**

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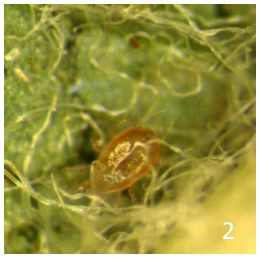
Commercially Available Biological Control Agents for Twospotted Spider Mites

Predators

Amblyseius andersonii



Predatory Mite

- Feeds on alternative prey if twospotted spider mites are absent.
- Active at temperatures between 43 and 46° F.
- Release 10 mites per square foot.

Amblyseius californicus

Predatory Mite

- Slower acting than other predatory mites such as *Phytoseiulus persimilis.*
- More effective at higher temperatures (>80° F) and a lower relative humidity than *Phytoseiulus persimilis.*
- Used for long-term crops under warm, dry conditions.
- Release 10 mites per square foot.

Amblyseius fallacis

Predatory Mite

- Tolerates cooler temperatures than most predatory mites.
- Feeds on pollen in the absence of prey.
- Release 10 mites per square foot.

Feltiella acarisuga

Predatory Gall Midge

- Larvae feed on all life stages of the twospotted spider mite.
- Females lay eggs near colonies of the twospotted spider mite.
- Adults fly around and can spread among a crop.
- Most effective when used in combination with other biological control agents.
- Optimal conditions are 68 to 80° F and a relative humidity >60%.
- Does not perform well when temperatures are >85° F.
- Release 10 adults per square foot.

Galendromus occidentalis

Predatory Mite

- Smaller than *Phytoseiulus persimilis.*
- Most effective at higher temperatures and a relative humidity between 40 and 80%.
- Survives well when twospotted spider mite populations are low.
- Feeds on twospotted spider mite, broad mite and cyclamen mite.
- Release 10 mites per square foot.

Phytoseiulus persimilis

Predatory Mite

- Main predatory mite used against the twospotted spider mite.
- Most effective at temperatures between 70 and 80° F and a relative humidity >60%.
- Does not perform well when temperatures are >85° F.
- At optimal temperatures, develops twice as fast as twospotted spider mite.
- Release 10 mites per square foot.

Stethorus punctillum

Predatory Beetle

- Both larvae and adults feed on all life stages of twospotted spider mites.
- Release 10 adults per square foot.

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***Photo credits: [1]Koppert Biological Systems, [2]Evergreen Growers Supply, [3]Wikimedia Commons or [4]Biobest.**

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Commercially Available Biological Control Agents for Fungus Gnats

Predators

Dalotia coriaria

Predatory Rove Beetle

- Apply directly onto the surface of the growing medium.
- Larvae and adults are predators and highly mobile.
- Both adults and larvae are very sensitive to light.
- Adults can fly and spread within a greenhouse.
- Release 1 adult per 10 square feet.

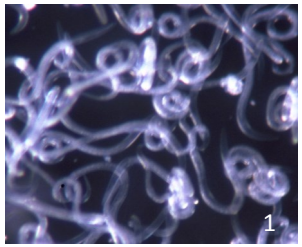
Stratiolaelaps scimitus

Predatory Mite

- Adults may kill 15 to 30 fungus gnat larvae per day.
- Feeds on eggs, larvae and pupae of fungus gnats.
- Apply directly to the growing medium.
- Previously known as *Hypoaspis miles.*
- May be used in combination with *Steinernema feltiae*.
- Release 1,000 to 2,000 mites per square foot.

Beneficial Nematode

Steinernema feltiae



Beneficial Nematode

- May be effective up to 4 weeks.
- Attacks the larval stages of fungus gnats.
- Requires a moist growing medium and growing medium temperature between 50 and 86° F.
- Apply early in the morning or late in the evening.
- Irrigate before and after application.
- Apply 50 million per 1,000 square feet as a drench.

***All release rates are benchmarks -– they will vary with crop type and infestation level.**

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Commercially Available Biological Control Agents for Mealybugs

Parasitoids

Leptomastix dactylopii

Parasitic Wasp

- Females attack only the 3rd and 4th instars of the citrus mealybug.
- Effective at low mealybug populations.
- Release 5 parasitoid adults per 10 square feet.

Anagyrus pseudococci

Parasitic Wasp

- Attacks both vine and citrus mealybugs.
- Females attack 2nd through 4th instars.
- Optimal temperature is around 86° F.

Predators

Cryptolaemus montrouzieri

Predatory Beetle

- Both larvae and adults feed on all mealybug life stages.
- Not effective at temperatures <50° F.
- Most active under warm, sunny conditions.
- Less effective on tomato and other crops with glandular trichomes (hairs).
- Repeated releases (introductions) are usually required.
- Release 1 to 2 larvae or adults per square foot.

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Commercially Available Biological Control Agents for Whiteflies

Parasitoids

Encarsia formosa

Parasitic Wasp

- Most widely used parasitoid for greenhouse whiteflies.
- Most effective at higher temperatures (>70° F).
- May be ineffective on plants with honeydew (clear, sticky liquid).
- Make releases when greenhouse whitefly populations are low.
- Adult females will host feed on nymphs.
- Release parasitoids every 1 to 2 weeks.
- Release 2 wasps per 15 square feet every 1-2 weeks for preventation.

Eretmocerus eremicus

Parasitic Wasp

- Parasitizes sweet potato and greenhouse whitefly.
- Females prefer laying eggs into 2nd or 3rd nymphal instars.
- Tolerates higher temperatures and does more host-feeding than *Encarsia formosa.*

Predators

Amblyseius swirskii

Predatory Mite

- Feeds on the eggs and nymphs of whiteflies and larvae of western flower thrips.
- May also feed on pollen in the absence of prey.

Delphastus catalinae

Predatory Beetle

- Most effective when whitefly populations are high.
- Can feed on >150 whitefly eggs per day.
- Will not attack parasitized whitefly.
- May be sensitive to pesticide residues.

Dicyphus hesperus

Predatory Mirid Bug

- Feeds on greenhouse whitefly.
- Reared on mullein banker plants: requires a minimum of 8 weeks to establish a sufficient population.

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