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Sierra Biological "In Vivo" Entomopathogenic Nematodes

About Sierra Biological Beneficial Nematodes

Entomopathogenic nematodes are extraordinarily lethal to many invasive insect pests yet safe for plants and animals. This high degree of safety means that unlike chemicals (or even *Bacillus thuringiensis*), nematode applications do not require safety equipment. In addition, zero re-entry time, residues, groundwater contamination, chemical trespass, and pollinator issues make them a net benefit when compared with chemicals. Most biologicals require days or weeks to kill, yet nematodes, working with their symbiotic gut bacteria, can kill insects within 24–48 hours.

Sierra Biological produces *in vivo* nematodes, which are much more effective, prolific, and have a superior infestation ratio in comparison to *in vitro* produced nematodes. In fact, *in vitro* producers generally use *in vivo* nematodes as seed stock because of their superior qualities. In addition, *in vivo* nematodes are compatible with organic production, whereas *in vitro* may contain unacceptable residues.

All of our nematodes emerge (*in vivo*) from freshly-killed larvae- rather than (*in vitro*) from a nutrient solution- thus increasing infestation ratios. The small-batch production method also boasts a higher degree of quality control. Sierra's nematodes have been trialed in numerous greenhouses, farms, gardens, and lawns in North America to combat larval stages of over 250 pests.

Sierra In Vivo Nematode Products

1) *Steinernema feltiae* (Sf) is unique in maintaining infectivity in soil temperatures as low as 50°F (10°C). *Sf* has a foraging strategy in between "ambush" and "cruiser" and is effective against immature **dipterous insects** including **mushroom flies, fungus gnats, thrips, and tipulids** as well as some lepidopterous larvae.

2) *Steinernema carpocapsae* (Sc) is the most studied of all entomopathogenic nematodes and most effective between 72–82°F (22–28°C). They can also survive for several months in room-temperature soil. *Sc* is particularly effective against **lepidopterous larvae**, including various **armyworms, cutworms, webworms, girdlers, some weevils, and wood-borers**. A classic sit-and- wait or "ambush" forager, it stands on its tail in an upright position near the soil surface and attaches to passing hosts. Therefore, *Sc* is especially effective against highly mobile surface-adapted insects

Common Targeted Insect List			
Common Name	Scientific Name	Key Crop(s) targeted	Efficacious Nematodes
Artichoke plume moth	<i>Platyptilia carduidactyla</i>	Artichoke	Sc
Armyworms	<i>Lepidoptera: Noctuidae</i>	Vegetables, turf	Sc, Sf, Sr
Banana moth	<i>Opogona sachari</i>	Ornamentals	Hb, Sc
Banana root borer	<i>Cosmopolites sordidus</i>	Banana	Sc, Sf, Sg
Billbug	<i>Sphenophorus</i> spp. (<i>Coleoptera: Curculionidae</i>)	Turf	Hb, Sc
Black cutworm	<i>Agrotis ipsilon</i>	Turf, vegetables	Sc
Black vine weevil	<i>Otiophynchus sulcatus</i>	Berries, ornamentals	Hb, Hd, Hm, Hmeg, Sc, Sg
Borers	<i>Synanthedon</i> spp. and other <i>sesiids</i>	Fruit trees, ornamentals	Hb, Sc, Sf
Cat flea	<i>Ctenocephalides felis</i>	Home yard, turf	Sc
Chinch Bug	<i>Blissus</i> spp.	Home yard, turf	Sc
Citrus root weevil	<i>Pachnaeus</i> spp. (<i>Coleoptera: Curculionidae</i>)	Citrus, ornamentals	Sc, Sf
Codling moth	<i>Cydia pomonella</i>	Pome fruits	Sc, Sf, Sr
Corn earworm	<i>Helicoverpa zea</i>	Vegetables	Hb, Sc
Corn rootworm	<i>Diabrotica</i> spp.	Vegetables	Sc
Cranberry girdler	<i>Chrysoteuchia topiaria</i>	Cranberries	Sc
Crane fly	<i>Diptera: Tipulidae</i>	Turf	Hb, Sr
Diaprepes root weevil	<i>Ctenocephalides canis</i>	Citrus, ornamentals	Sf, Hb
Dog flea	<i>Diaprepes abbreviatus</i>	Home yard, turf	Sc
Fungus gnats	<i>Diptera: Sciaridae</i>	Mushrooms, greenhouse	Sf, Hb
Grape root borer	<i>Vitacea polistiformis</i>	Grapes	Hb, Sc
Iris borer	<i>Macronoctua onusta</i>	Iris	Hd, Sc
Large pine weevil	<i>Hylobius albietis</i>	Forest plantings	Sc, Sf
Leafminers	<i>Liriomyza</i> spp. (<i>Diptera: Agromyzidae</i>)	Vegetables, ornamentals	Sc, Sr, Scap
Love bugs	<i>Plecia nearctica</i>	Home yard, turf	Sf, Sc
Mole crickets	<i>Scapteriscus</i> spp.	Turf	Sc
Navel orangeworm	<i>Amyelois transitella</i>	Nut and fruit trees	Sc
Plum curculio	<i>Conotrachelus nenuphar</i>	Fruit trees	Sr
Root maggots	<i>Delia</i> (genus)	Plant root zones	Sf, Sc
Scarab grubs	<i>Coleoptera: Scarabaeidae</i>	Turf, ornamentals	Hb, Sc, Sg, Ss, Hz
Shore flies	<i>Scatella</i> spp.	Ornamentals	Sc, Sf
Small hive beetle	<i>Aethina tumida</i>	Bee hives	Hb, (Hi, Sr)
Strawberry root weevil	<i>Otiorynchus ovatus</i>	Berries	Hm, Hb
Sweetpotato weevil	<i>Cylas formicarius</i>	Sweet potato	Hb, Sc, Sf
Western flower thrips	<i>Frankliniella occidentalis</i>	Greenhouse crops	Sf, Sc
White grubs (Scarabs)	<i>Scarabaeidae</i> (family)	Home yard, turf	Hb, Sc

3) *Heterorhabditis bacteriophora* (*Hb*) is a warm temperature nematode performing best above 70°F (20°C) soil. *Hb* is among the most economically important entomopathogenic nematodes that possess considerable versatility, attacking **lepidopterous** and **coleopterous insect larvae** among other insects. This “cruiser” species appears quite useful against **root weevils**, particularly **black vine weevil** (though some below-ground insects are also controlled) where it has provided consistently excellent results.

4) ‘Lawn and Garden Blend’ [Hb + Sc blend]

A mixture of *Heterorhabditis bacteriophora* and *Steinernema carpocapsae* optimally formulated for lawn and garden use to combat an array of pests. See Table for a partial listing of targets.

5) ‘Greenhouse Blend’ [Sc + Sf blend]

A mixture of *Steinernema carpocapsae* and *Steinernema feltiae*. The hybrid strain of *Steinernema feltiae*, in particular, has been specifically developed with greenhouse effectiveness in mind such as greater cold-tolerance, humidity tolerance, heat tolerance, longevity, *et cetera*.

Nematode Compatibility

Infective juveniles—the stage of nematodes, which leave the host in search of a new host (see flowchart)—may be compatible with a number of agricultural chemicals under field conditions. For example, compatibility has been tested with over 100 different chemical pesticides and entomopathogenic nematodes were found to be compatible with most chemical herbicides and fungicides as well as many insecticides (such as bacterial or fungal products) (Koppenhöfer and Grewal, 2005). However, specific interactions can vary based on the nematode and host species and application rates. Nematodes are generally compatible with chemical fertilizers as well as composted manure though fresh manure can be detrimental.

Relative Effectiveness

Entomopathogenic nematodes are under-utilized against many soil pests despite remarkable versatility. For instance, we generally focus on pests when they are above the ground and visible to the naked eye. Yet it is the root zone where many pests spend the majority—up to 90%—of their life cycle! Therefore, use of beneficial nematodes targets this root-zone cycle of pests.



Sierra nematodes are delivered on a sterile sponge to be squeezed into reservoir water.



Wax worm cadavers as part of the “in vivo” production.

