Entomopathogenic nematode as biological control of crop pests

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ABSTRACT

Entomopathogenic nematodes are a group of nematodes (thread worms), causing death to insects. The EPNs of the families Heterorhabditidae and Steinernematidae are obligate parasites of insects and have demonstrated to pose a high potential for the agricultural pest control. They can be considered good candidates for integrated pest management and sustainable agriculture due to a variety of attributes. Some species can recycle and persist in the environment; they may have direct and/or indirect effects on populations of plant parasitic nematodes and plant pathogens; can play an indirect role in improving soil quality; and are compatible with a wide range of chemical and biological pesticides used in IPM programs.
Commercially produced EPNs are currently in use for control of Leptidoteran and coleopteran pests

Keywords: Biological control, Crop pest, entomopathogenic nematode, *Heterorhabditis* , *Steinernema*

Introduction

Nematodes that parasitize insects, known as entomopathogenic nematodes (EPNs), have been described from 23 nematode families. Of all of the nematodes studied for biological control of insects, the Steinernematidae and Heterorhabditidae have received the most attention because they possess many of the attributes of effective biological control agents and have been utilized as classical, conservational, and augmentative biological control agents. First discovered in the 1920s, entomopathogenic nematodes (EPNs) received increasing interest starting in the 1950, and their commercialization started in the 1980s. They have been largely excluded from pesticide registration requirements in many countries due to their high level of safety to humans, non-target organisms, and the environment. The symbiotic bacteria of EPNs fall in the genera *Photorhabdus* (*Heterorhabditis* spp.) and *Xenorhabdus* (*Steinernema* spp.). Once members of the family *Enterobacteriaceae*, *Photorhabdus* and *Xenorhabdus* are now seated within the family *Morganellaceae* (Enterobacteriales) along with the type genus *Morganella* and five other genera (Lacey, 2012). Currently, there are 19 species of *Photorhabdus* and 26 species of *Xenorhabdus*. The association between nematode and bacterium is highly specific. In nature, the bacteria have no infective capabilities and cannot persist outside the nematodes or insect host and rely on the nematode to vector them from host to host. However, the bacteria play a major role in killing the insect host through suppression of the immune system causing toxemia and septicemia. They also produce antibiotics that prevent secondary host invasions, a deterrent factor that discourages scavengers from feeding on the host cadaver (*Photorhabdus* spp. only), and serve as a food resource for the nematodes. The exact role of bacteria and nematodes in overcoming the immune response has only been studied in depth in a few nematode-bacteria combinations and in a few host species (Brodie, 2020).

Advantages

1. Highly lethal to important insect pests with least off-target effects.
2. Highly safe to humans and environment.
3. No safety equipment required, no residual effects, no groundwater

contamination and are safe to pollinators.
4. Kills insects within 24-48 hours
5. Easy to mass produce and are compatible with standard agrochemical equipment and irrigation systems for application.
6. little or no registration required

Disadvantages

1. Cost of production
2. Limited shelf life and refrigeration is required
3. Environmental limitations – requirement for adequate moisture and temperature, sensitivity to uv radiation, lethal effect of several pesticides

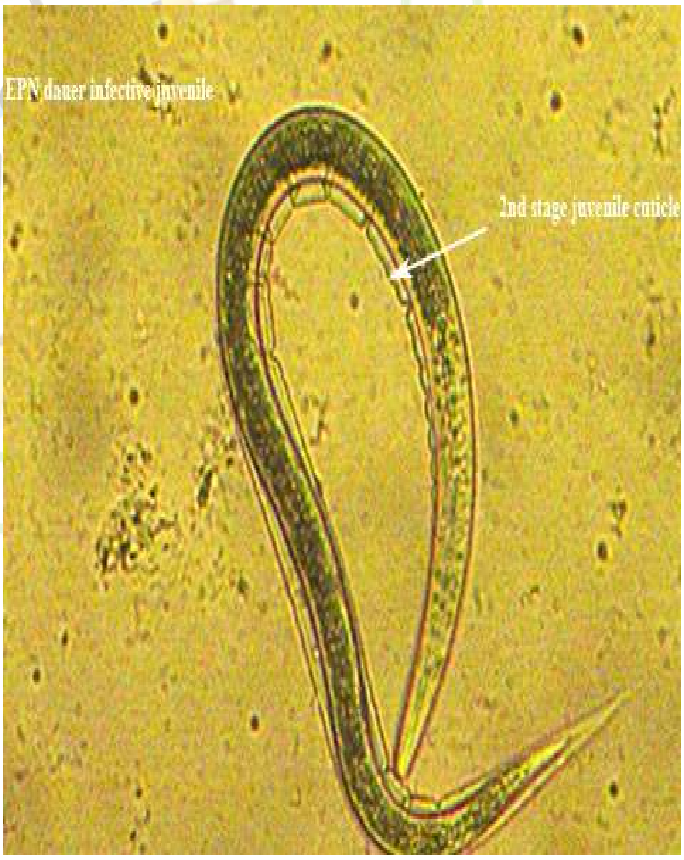
Biology of EPNs

Third stage juvenile of the EPN species are infective. They are free-living, non-feeding and possess highly sensitive chemoreceptors which can detect host cues. When a insect has been located, the nematodes enter into the insect body cavity via natural body openings (mouth, anus, spiracles) or cuticle. After entering the insect haemolymph, bacteria released produced toxins with insecticidal properties and the insect gets killed with 24-48 h due to septicemia (blood poisoning). In the dead insect, nematodes and bacteria feed on insect body contents and reproduce inside the cadaver. After completing several generations, thousands of infective juveniles emerge out of cadaver and search for a fresh host.

Table 1. Commercial use of entomopathogenic nematodes (EPN) *Steinernema* and *Heterorhabditis* as bioinsecticides.

Mass production and Formulations

There are two methods of mass production, *In vivo* and *In vitro* mass production methods s. *In vivo* mass production is done using greater wax moth larvae or rice moth larvae. It is oriented for small scale production.This method is more laborious. *In vitro* mass multiplication is done using solid or liquid media. Bacteria from EPNs is isolated and inoculated in media.After 2 days incubation at 27 degrees, fresh IJ are inoculated. After 2-3 weeks, newly emerged IJs can be harvested through white's trap. This method is used for large scale production (Lacey et al., 2012). Formulation plays a significant role in commercialization of bioagents. EPNs can be formulated either with active nematodes in various substrates or with reduced or arrested mobility (partial of complete anhydrobiosis). A number of formulations are available with good nematode storage and application including activated charcoal, alginate and polyacrylamide gels, baits, clay, paste, peat, polyurethane sponge, vermiculite, and water-dispersible granules. The shelf-life is variable among the formulations and it mainly depends on the activity of infective juveniles. EPNs are highly sensitive to temperature fluctuations and soil moistures in environment. So, researchers have to keep this problem in mind and develop suitable EPN formulations which improves the shelf life and protection from environmental fluctuations under field conditions.



EPN species	Major pest(s) targeted – as recommended by various commercial companies
Steinernema glaseri	White grubs (scarabs, especially Japanese beetle, *Popilli* sp.), banana root borers
Steinernema kraussei	Black vine weevil, *Otiorhynchus sulcatus*
Steinernema carpocapsae	Turfgrass pests- billbugs, cutworms, armyworms, sod webworms, chinch bugs, crane flies. Orchard, ornamenta and vegetable pests - banana moths, codling moths, cranberry girdlers, dogwood borers and other clearwing borer species, black vine weevils, peachtree borers, shor flies (*Scatella* spp.)
Steinernema feltiae	Fungus gnats (*Bradysia* spp.), shore flies, western flowe thrips, leafminers
Steinernema scapterisci	Mole crickets (*Scapteriscus* spp.)
Steinernema riobrave	Citrus root weevils (*Diaprepes* spp.), mole crickets
Heterorhabditis bacteriophora	White grubs (scarabs), cutworms, black vine weevils, fle beetles, corn root worms, citrus root weevils
Heterorhabditis megidis	Weevils
Heterorhabditis indica	Fungus gnats, root mealybugs, grubs
Heterorhabditis marelatus	White grubs (scarabs), cutworms, black vine weevils
Heterorhabditis zealandica	Scarab grubs

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