AGRIALLIS
Science for Agriculture and Allied Sector: A Monthly Magazine
Volume 6, Issue 6
www.agriallis.com

Article Id
AL04354

ENTOMOPATHOGENIC NEMATODES: A SUSTAINABLE SOLUTION FOR PEST MANAGEMENT

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Nematodes, elongated roundworms, come in two types: harmful ones, damaging crops, and beneficial ones, which control soil-borne pests without harming other organisms. Among beneficial nematodes, entomopathogenic ones are widely utilized in various farming systems to control insect pests, offering environmentally safe and sustainable protection for crops. They target a variety of insects including caterpillars, grubs, and beetles. They possess traits making them suitable for commercialization as biological control agents: rapid insect host kill, broad pest host range, active searching behaviour, mass producibility, integration potential in pest management programs, and safety for vertebrates and most non-target invertebrates. These nematodes are environmentally safe and require careful handling for effective use. Understanding their lifecycle, matching them with pests, and applying them correctly are keys to success.

Life Cycle, Mode of Action and Foraging Strategies of EPN

The life cycle of entomopathogenic nematodes (EPNs) consists of several stages: eggs, four juvenile stages, and adults. The third juvenile stage, known as the infective juvenile or dauer stage, is crucial for biological control. These juveniles, which do not feed and have a closed mouth and anus, actively penetrate the insect host's body cavity, where they carry symbiotic bacteria, Xenorhabdus for steinernematids and Photorhabdus for heterorhabditids. These bacteria help the nematodes overcome the insect's immune system, leading to the host's death within 48 hours of infection. The bacteria then degrade the host tissues, providing nourishment for the nematodes. Different symbiotic bacteria cause distinct colour changes in the insect cadaver. After reproduction and nutrient depletion, a high nematode population density triggers their development into infective juveniles again. The life cycle varies with temperature but typically completes within 12-15 days, with an optimum temperature range for growth and reproduction between 25°C and 30°C. EPNs are found worldwide in diverse habitats and form a complex nematode/bacterium unit that cooperatively acts as a biological control to kill insect hosts. Infective juvenile nematodes in the soil locate and penetrate insect pests using two strategies:

- **Ambushers:** Species like *Steinernema carpocapsae* and *Steinernema scapterisci* have low motility and remain near the soil surface. They typically don't respond to volatile or contact host cues unless presented in a specific sequence. Ambushers are effective against mobile hosts near the soil surface, such as codling moth larvae, cutworms, and mole crickets.

- **Cruisers:** Species like *Steinernema glaseri* and *Heterorhabditis bacteriophora* have high motility and are distributed throughout the soil profile. They respond to volatile host cues and switch to a localized search after host contact. Cruisers are well-suited for infecting sedentary hosts like scarab and lepidopterous prepupae and pupae.

Mass Production Methods of EPN

❖ ***In Vivo* Mass Culture:** It involves culturing EPNs within live insect hosts, typically utilizing the white trap method or innovative systems like the LOTEK system. Host selection is crucial, with factors such as susceptibility, multiplication potential, and cost-effectiveness taken into account. Common insect hosts include the greater wax moth (*Galleria mellonella*), silkworm (*Bombyx mori*), and yellow mealworm (*Tenebrio molitor*). Factors such as host size, inoculum dosage, temperature, aeration, and humidity influence production yields. Mechanization and advancements in production methods aimed at applying nematodes through infected host cadavers can enhance efficiency and scalability.

❖ ***In Vitro* Mass Culture:** It involves introducing nematodes to a pure culture of their symbiotic bacteria in a nutritive, non-living medium. The medium must be sterile to avoid contamination, retain specific symbiotic bacteria, and provide necessary nutrients. Techniques range from solid media production to liquid fermentation methods. Solid media production utilizes sterilized media inoculated with bacteria and nematodes, achieving high yields economically. Liquid fermentation techniques, though more complex, can also achieve high yields and have been advanced through various measures including automation and sterile room technology.

Types of EPN Formulations

- **Aqueous Suspension:** This is the most common EPN formulation used for storage, transportation, and application. It typically involves suspending the EPNs in water. However, it requires refrigeration for storage and has limitations regarding survival time and susceptibility to microbial contamination.
- **Synthetic Sponges:** EPNs can be formulated in polyurethane sponges, but this method is mainly suitable for small-scale storage and transport due to refrigeration requirements and labour-intensive release methods.
- **Gels:** Various gel-based formulations have been developed using materials like alginate. These formulations aim to improve survival time and stability at room temperature.
- **Clay and Powder:** EPNs can be encapsulated in clay or powder formulations, but these have faced challenges related to storage stability and application methods.
- **Infected Cadavers:** Another approach involves using infected insect cadavers as a carrier for EPNs. Coatings or packaging methods are used to protect the cadavers during storage and transport.
- **Compatibility with Agrochemicals:** EPNs are shown to be compatible with various agrochemicals, offering a cost-effective alternative to pest control. Their tolerance to chemical pesticides allows for tank-mixing and application together.

Shelf Life and Quality Control of EPN

The shelf life of EPNs is relatively short due to their active metabolic state, unlike some other microbial insecticides with a resting stage that allows for long-term storage. It's recommended to order EPNs only 3-4 days before application and to use them within 1-2 days after arrival. Upon receipt, it's essential to check their viability. Live EPNs should be mobile and exhibit a characteristic shape, such as a resting "J" shape for *S. carpocapsae*, or move in an "S" pattern for other species. If nematodes appear straight and immobile, they are likely dead. Evaluating nematode applications can be challenging, but simple tests using waxworms can assess their efficacy. Two common tests involve placing waxworms in soil either before or after nematode application. Infected waxworms typically change colour, with

Steinernematid infected waxworms turning yellow, tan, or brown, and Heterorhabditid infected waxworms turning pink or purple. These tests help determine if nematodes have successfully reached the soil and targeted pests.

Use of EPN in Different Production Systems

- **In Greenhouse Production:** Fungus gnats, particularly *Bradysia* spp., are significant pests in greenhouse production, and EPNs, especially *S. feltiae*, have shown effectiveness in controlling them. High-volume foliar applications of *S. feltiae* combined with adjuvants have been successful for thrips control in greenhouses.

- **In Mushroom Production:** Sciarid flies (*Lycoriella* and *Bradysia* spp.) are common pests in mushroom production, and *S. feltiae* has been applied directly into or onto casing at casing time to provide control comparable to chemical insecticides.

- **In Orchards:** EPNs have shown effectiveness against soil-dwelling stages of various orchard insect pests such as the false codling moth, plum curculio, and pecan weevil. Different EPN species like *H. bacteriophora* and *S. riobrave* have been successfully utilized, providing significant control rates ranging from 80 to 100 per cent in peach, apple, and cherry orchards.

- **In Small Fruit Production:** Root weevils, such as *Otiorhynchus* species, are major pests of small fruit crops and have been effectively controlled using various EPN species, including *H.* bacteriophora, *H. marelata*, and *S. carpocapsae*. EPN applications have shown promising control rates against cranberry girdler, scarab grubs, and other pests in berries and cranberries.

- **In Maize and Vegetable Production:** EPNs have been researched for managing pests like corn rootworms, corn earworms, and cutworms in corn, vegetable, and tuber crops. *S. riobrave* and *S. carpocapsae* have demonstrated efficacy against corn rootworms and black cutworms, providing control rates ranging from 50% to 95%.

Conclusion

In conclusion, entomopathogenic nematodes (EPNs) represent a promising solution for sustainable pest management across various agricultural systems. Their ability to target a wide range of insect pests while posing minimal risk to non-target organisms makes them an environmentally safe alternative to chemical insecticides. Understanding the life cycle, foraging strategies, and mass production methods of EPNs is crucial for their successful implementation in pest management programs. Additionally, advancements in formulation techniques and compatibility with agrochemicals further enhance their effectiveness and practicality in diverse farming systems. From orchards to greenhouse production and mushroom cultivation, EPNs have demonstrated efficacy against key insect pests, offering growers a valuable tool for integrated pest management. However, ensuring proper handling, application, and quality control measures are essential for maximizing the efficacy of EPN-based pest management strategies. Continued research and development efforts hold the potential to unlock even greater benefits from these beneficial nematodes in the realm of sustainable agriculture.

References

Chitra, P., Sujatha, K and Jeyasankar, A. 2017. Entomopathogenic nematode as a biocontrol agent: recent trends—a review. *International Journal of Advanced Research in Biological Sciences*, 4(1): 9-20.

Cruz-Martínez, H., Ruiz-Vega, J., Matadamas-Ortíz, P.T., Cortés-Martínez, C.I and Rosas-Diaz, J., 2017. Formulation of entomopathogenic nematodes for crop pest control–a review. *Plant Protection Science*, 53(1): 15-24.

Devi, G. 2018. Mass production of entomopathogenic nematodes-A Review. *International Journal of Environment, Agriculture and Biotechnology*, 3(3): 1032-1043.

Koppenhöfer, A.M., Shapiro-Ilan, D.I and Hiltpold, I. 2020. Entomopathogenic nematodes in sustainable food production. *Frontiers in Sustainable Food Systems*, 4: 1-14.

Vashisth, S., Chandel, Y.S and Sharma, P.K. 2013. Entomopathogenic nematodes-A review. *Agricultural Reviews*, 34(3): 163-175.