Review Article

Use of entomopathogenic nematodes for the management of banana rhizome weevil (*Cosmopolites sordidus*): A review

Abstract

Banana production is inhibited by various insect pests. Though chemical insecticides are recommended for control of these pests, use of biocontrol agents are alternative method .One of the biocontrol agents is the entomopathogenic nematodes (EPNs). This review finds the work of some of the successful EPN species or strains from different geographical locations that may affect practical bio control of banana rhizome weevil, a major pest of banana. Emphasis is made on roles of EPNs in reducing banana rhizome weevil (*Cosmopolites sordidus*) and directions of future research in biocontrol programme are presented.

Key words: Banana insect pests, banana rhizome weevil, management of pests, biological control, Entomopathogenic nematodes (EPNs).

Introduction

Banana (*Musa* spp.) is an important fruit crop commonly grown in tropical and subtropical parts of the World. Banana production is inhibited by various pests and diseases. Worldwide, around 180 insect pests have been reported [1]. Balakrishnan and Poorani [2] reported about 50 species of banana pests from India. The common pests are pseudostem weevil (*Odoiporous longicollis*) rhizome (corm) weevil(*Cosmopolites sordidus*), banana aphid (*Pentalonia nigronervosa*), leaf eating caterpillar (*Pericallia ricini*, *Asuraila moore*, *Creatonotus gangis*, *Diacrisia oblique*, *Euproctis fraterma*, *Eupterote geminate*), leaf rollers, bag worms, slug caterpillars and tobacco caterpillar (*Spodoptera litura*), flea beetle, fruit/ leaf scaring beetle (*Nodostoma sabcostatum, N. viridipennis*, *Colapis hypochlora*)[3].Among these pests, banana corm weevil (*Cosmopolites sordidus* Germar (Coleoptera: Curculionidae) remains a major economic pests in sustainable banana production in India and other parts of the world. The pest causes yield losses ranging from 40% to 100% [4] .The species is hardly oligophagous, and all four developmental stages are associated with cultivars of the genus *Musa* (Musaceae). Adults are nocturnally active and attracted to the host plants by volatiles emanating from fresh and decomposing banana materials, very susceptible to desiccation and it rarely flies. The newly emerged adult is red brown but turns black two to three days later. It measures about 12 mm hard shelled and it has a pronounced snout. The beetles feed on tender unfolded leaves and fruits and remain hidden under unfolded leaves. The leaves of central whirl are worst affected. The beetles scratch epicarp of the tender fruits, blemish them and render unmarketable. The beetle destroys the tissue of the corm sometimes followed by secondary infestation by other insects and micro-organisms. The grub develops from the eggs attacks the plant by feeding on the corm portion and thereby making bore holes and tunnels in the corm .The tunneling interferes with root initiation and development, nutrient and water uptake thereby weakening the plant leading to production of a bunch with less

weight or eventual death [5] .Infestation at the early stage reduces the plant vigour. Sick appearance and yellow lines on the top leaves are early symptoms. At advanced stage of infestation, plant show tapering of the stem at crown region, reduction in leaf size, poor bunch formation and choked throat appearance. In addition, the galleries built facilitate the entry of phytopathogens such as fungus that causes the Panama disease, *Fusarium oxysporum* f.sp.*cubense*. The weevil spreads through infested suckers to different places. Banana weevil damage also results in delayed maturity, snapping, toppling, reduced bunch weight, mat die-out and shortened plantation life [6-7].

To minimize the damage caused by corm weevil, use of chemical pesticides, clean planting material from existing fields or tissue culture plants are recommended [6]. Good culturing practices or crop sanitation and pseudostem traps are also recommended. Trapping methods using old pseudo stems to trap the insects with insecticides incorporated in the traps or on the soil have been recommended. Reddy *et al*.[8] suggested that trapping can be intensified during the rainy season when trap catches are improved by the moisture. Pheromone traps for monitoring and control can also be used. A sustainable alternative to minimize the use of pesticides is the use of bio-control agent. Among the most promising biocontrol agents of root pests, entomopathogenic nematodes (EPNs) are the one of them.

EPNs mode of action

EPNs in the families Steinernematidae and Heterorhabditidae are obligate and lethal parasites of a wide range of insects, mainly soil dwelling stages of Lepidoptera, Diptera and Coleoptera. EPNs have received attention as biocontrol agents because of their wide host range, ability to kill host rapidly, can easily be mass produced and applied, and long-term efficacy with no adverse effect on the environment. As EPNs are soil-dwelling organisms, they can be isolated from soil and procured commercially. The third stage infective juveniles, known as dauer juveniles (DJs) search for a suitable insect host in the soil and gain entry through natural openings like the anus, mouth, spiracles and additionally the cuticle for heterorhabditids [9]. Steinernematids and heterorhabditids live in a mutualistic association with bacteria of the genera *Xenorhabdus* [10] and *Photorhabdus* [11] respectively. After penetration of the nematodes, the bacteria are released into the insect hemocoel where they multiply and cause septicemia resulting to death within 48 h. The juvenile develop to adults, reproduce and when nutrients become limiting, produce third stage infective juveniles which are released from the cadaver into the soil ready to infect other hosts. A high virulence of an EPN isolate is one important characteristic required for the successful biological control of a pest [12-13].

EPNs against banana rhizome weevil

Several studies in the laboratory showed the EPNs are potential biocontrol agent against the banana corm weevil [14-16]. Entomopathogenic nematodes are applied in water either around the pseudo stem or in stem traps to control the *C.sordidus*. Entomopathogenic nematodes are sensitive to moisture where nematodes will only survive and their activities are optimal in moist condition. The habits of the banana weevil are characterized by a sheltered lifestyle where the egg, larval and pupal stage all occurs within the host plant or crop residues. The adult weevil feeds on and lives in the crop residues and is sensitive to soil moisture and will commonly die within 72 hours when maintained on dry substrates. Rainfall increase adult activity. Mulch conserves moisture that is critical for the survival of both nematodes and adult weevils. The prevailing conditions and the behavior of the banana weevil ensured their maximum contact for infectivity of nematodes. This survival requirement is important when considering control of

weevils with entomopathogenic nematodes. This combines very well with the habits of the weevils and the environmental requirements of both weevils and nematodes.

The use of EPNs against banana weevil has been explored mainly through laboratory assays. On the Canary Island (Spain), a study on indigenous *H.bacteriophora* (TF19), *S.feltiae* (TF135) at 100 IJs/cm^2 against neonate banana weevil larvae indicated 100% mortality in laboratory sand bioassays [17]. *S.carpocapsae*, *S.glaseri*, and *S.bibionis* by applying 400,4000,40000 nematodes /plant causing 75-100% mortality to 6-7-instar larvae of *C. sordidus* and found to be reduced the number of tunnels made by larvae in plantain corms under greenhouse condition [18]. Field trials in New South Wales, Australia using *S.carpocapsae* All and *S. carpocapsae* NC513 gave acceptable levels of larval and adult *C. sordidus* control [19]. Schmitt *et al.* [20] applied dose of 5×10^6 IJ/m^2 onto split pseudostems and pseudostem stumps as a baiting technique and recorded 70% mortality of adult *C. sordidus* recovered from the traps 7 days after treatment. Application of EPN to pseudostem traps resulted to significantly greater control of weevils than application on the soil around banana. Many studies on the virulence of EPNs on different species of weevil have shown that *Heterorhabditis* species perform much better than *Steinernema* species. Treverrow and Bedding [21] observed 85% infection of *C.sordidus* by *S. carpocapsae* BW under laboratory condition in Australia. Anon [22] found that both adults and larvae of banana weevil were susceptible to attack by infective juveniles of *S.carpocapsae* and *H.bacteriophora*. *Heterorhabditis* isolates MK7BHt and MK7CHt and *Steinernema* isolate MK7ASt and MW8St were found to be virulent (100% mortality at 7 IJ/cm^2) to larval stage of banana weevil, whereas adults appeared resistant to infection [23] . Bortoluzzi *et al.* [24] observed mortality (0-36.7% within 2-7 days) of *C. sordidus* at 100 infective juvenile (IJ)/cm^2 applied on cut pseudostem placed in plastic containers in the laboratory. *Heterorhabditis* spp. isolate IBCBn40 caused highest mortality. *Heterorhabditis* IJs have an interior tooth-like structure that enables enhanced penetration of the larval cuticle [25] .Treverrow and Bedding [21] and Tomalak [26] suggested that the resistance is almost certainly due to the difficulty of nematodes entering the host rather than establishment once infection is successful. Combination of EPNs with insecticide (carbofuran) did not affect viability of IJ, although it caused reduction in infectivity [24,27]. Amador *et al.* [28] evaluated the susceptibility of *C. sordidus* adults and larvae to *H. atacamensis* isolate CIA-NEO7 at different concentrations of 100, 500, and 1000 IJ per insect under laboratory condition. No mortality of adult weevils was observed while LD_{50} value was 52 IJ/larva. When larvae were in the corm, LD_{50} value increased to 375 IJ/larva whereas at 1000 IJ/larva showed 80% mortality 10 days after inoculation. Ndiritu *et al.*,[29] observed that *S.carpocapsae* All, *S.weiseri*, *S.yirgalemense* and *S.* sp. caused over 90% larval mortality within 48 hours, whereas adults were not susceptible to all the nematodes even at higher doses. Mwaniki [30] reported that the local EPNs isolated do not infect adult weevils and therefore no mortality was observed. Although the entire test EPNs caused more than 90% mortality for weevil larvae, *S. carpocapsae* was the most virulent at 300, 400, and 500 IJ/larva. Successful penetration and establishment in the larvae implies a potential for recycling of EPNs in the host environment, thereby increasing the control potential.

Conclusion

EPNs can penetrate *C. sordidus* larval galleries and easily reproduce, while mortality varies with the EPN species and concentration. Adult weevil mortality caused by these pathogens is more effective and enhanced only when they are applied under field conditions on pseudostem traps, disc-on-corm traps, and corm incisions. There is necessary to formulate commercial products from the most effective EPN strains and determine their compatibility with commercial

pesticides so as to integrate with chemical pesticides. However, effectiveness of these EPNs to a particular insect in the field varies with the species or strain, climate, method of application, and duration of storage.

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