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

Abstract

Banana is an important fruit crop which is grown in tropical and subtropical parts of the world. 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 which is grown in tropical and subtropical parts of the World. Banana production is inhibited by various biotic stress including 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 (*Spodoptera litura*), banana thrips (*Cheatanophothrips signipennis*, *Helionothrips kadaliphilus*, *Thrips florum*), banana leaf and fruit scaring beetle (*Nodostoma subcostatum*), banana lacewing bug (*Stephanitis typicus*), hard scale(*Aspidiotus destructor*),fruit fly(*Bactrocera dorsalis*), bag worm(*Kophene cuprea*), and banana scab moth(*Nacoleia octasema*)"[3].

"Among these pests, banana rhizome weevil, *Cosmopolites sordidus* Germar (Coleoptera: Curculionidae) is one of the important pests of banana in India and other parts of the world. The pest causes considerable damage to the crop from the start of rhizome growth up to harvesting of fruit causing yield loss from 40% up to 100%" [4] . "The species is narrowly oligophagous, and all the stages have been observed in cultivars of the genus *Musa* (Musaceae). The grub develops from the eggs are apodous, yellowish white in colour with red head, generally attacks the plant by feeding on the corm and pseudostem portion and thereby making bore holes and tunnels in the corm. Due to tunneling, nutrient and water uptake is not sufficient which weaken the stem leading to production of a bunch with less weight or sometimes death of the plant" [5]. "The pupa is white in colour and found inside the corm. 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. During the day time they hide under debris or in the soil and during night time they are active. They attracted to the host plants by volatiles emanating from fresh and decomposing banana debris. The weevil also feed on tender unfolded leaves and fruits. Infestation at the early stage of the plant reduces the plant vigour. Pale appearance and yellow lines on the top leaves are early symptoms of infestation. The weevils scratch epicarp of the tender fruits, and blemish them. At advanced stage of infestation, plant show thinning of the stem at crown region, reduction in leaf size, poor bunch formation and choked throat appearance. Other symptoms are delayed maturity, cracking or toppling, reduced bunch weight and sizes, mat disappearance and shortened plantation life" [6,7].The weevil destroys the tissue of the corm sometimes followed by secondary infestation by other insects and soil borne fungal disease (Panama disease, *Fusarium oxysporum* f.sp.*cubense*). The weevil spreads to different places through infested suckers. However, pest status may vary with soil type, temperature, moisture, cropping system and agronomic practices.

To minimize the damage caused by rhizome weevil, recommended practices are good culturing practices or crop sanitation and pseudostem traps, use of clean planting material from existing fields or tissue culture plants besides use of chemical pesticides, [6,8]. Trapping methods using old pseudo stems to trap the insects with insecticides incorporated in the traps or on the soil are also good practices. Reddy *et al*.[8] suggested that "trapping can be intensified during the rainy season due to high 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 and use of tolerant/resistant varieties like Poovan, Kadali, Kunnan, Poomkalli [9]. Among the most promising biocontrol agents of root pests, entomopathogenic nematodes (EPNs) are the one of them [10].

EPNs mode of action

"EPNs in the families Steinernematidae and Heterorhabditidae have been reported as obligate and lethal parasites of a wide range of insects, mainly soil dwelling stages of Coleoptera and considered as one of the important biocontrol agent" [11, 12]. "EPNs have a wide host range, they can kill host rapidly, they can easily be mass produced and applied, and they have long-term efficacy with no adverse effect on the environment. The third stage infective juveniles (IJs), 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 as well as the cuticle for heterorhabditids" [13]. Steinernematids and heterorhabditids live in a mutualistic association with bacteria of the genera *Xenorhabdus* [14] and *Photorhabdus* [15], respectively. "After entry into the insect host, the bacteria are released by the nematodes into the insect hemocoel where they multiply and cause septicemia resulting to death of the insect host within 48 h. The juvenile develop to adults, reproduce and when nutrients become restrictive, produce third stage infective juveniles which are on the rampage from the cadaver into the soil ready to infect other hosts. A successful host-parasite relationship is one important characteristic required for the competent biological control of a pest" [16-17].

EPNs against banana rhizome weevil

Most of the research works were confined to the laboratory condition and showed the EPNs are potential biocontrol agent against the banana corm weevil [18-20].However, some of theexperiments under greenhouse condition showed that, when applied in water either around the pseudo stem or in stem traps, EPNs can control the *C.sordidus*. EPNs are sensitive to moisture; their activities are optimal in moist condition. The habits of the banana weevil are characterized by a cryptic lifestyle where the egg, larval and pupal stage all occurs within the host plant or crop residues. The adult weevil is sensitive to soil moisture and will commonly die within 72 hours when maintained on dry substrates. Mulch conserves moisture that is favorable for the survival of both nematodes and adult weevils. Thus the prevailing environmental conditions and the behavior of the banana weevil ensured their maximum contact for penetration and infectivity of nematodes.

Case studies

Various studies documented the success stories of use of EPNs against rhizome weevil. Indigenous isolate of *H.bacteriophora* (TF19), *S.feltiae* (TF135) at the rate of 100 infective juveniles (IJs) /cm^2 against neonate banana weevil larvae indicated 100% mortality in laboratory sand bioassays in Spain, Canary Island [21]. Under greenhouse condition, *S.carpocapsae*, *S.glaseri*, and *S.bibionis* at different doses of 400,4000,40000 IJs / plant causing 75-100% mortality to 6-7-instar larvae of *C. sordidus* and also found to be reduced the number of tunnels made by larvae in plantain corms [22]. Field trials using *S.carpocapsae* All and *S. carpocapsae* NC513 gave higher levels of larval and adult *C. sordidus* control in Australia, New South Wales [23]. Schmitt *et al*. [24] applied a baiting technique at dose of 5×10^6 IJ/m^2 onto split pseudostems and pseudostem stumps and recorded 70% mortality of adult *C. sordidus* 7 days after treatment. Application of EPN to pseudostem traps resulted to significantly greater control of weevils than application on the soil around banana. Treverrow and Bedding [25] observed 85% mortality of *C.sordidus* by *S. carpocapsae* BW under laboratory condition in Australia. Anon [26] 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 [27]. In the laboratory, Bortoluzzi *et al*. [28] 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. Many studies on the virulence of EPNs on different species of weevil have shown that *Heterorhabditis* species perform much better than *Steinernema* species. *Heterorhabditis* spp. IBCBn40 showed highest mortality as the IJs have an interior tooth-like structure that enables enhanced penetration of the larval cuticle [29].Treverrow and Bedding [25] and Tomalak [30] suggested that the resistance is due to the difficulty of nematodes entering the host rather than establishment once infection is successful. Viability of IJ did not affect when ombine with insecticide (carbofuran), although it caused reduction in infectivity [28,31]. Amador *et al*. [32] evaluated “the susceptibility of *C. sordidus* adults and larvae to *H. atacamensis* CIA-NEO7 at different doses of 100, 500, and 1000 IJ per insect under laboratory condition. Adult weevils were not infected, however 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*.,[33] observed that “*S.carpocapsae* All, *S.weiseri*, *S.yirgalemense* and *S*. sp. caused over 90% larval mortality within 48 hours, whereas adults were not infected to all the nematodes even at higher doses”. Mwaniki [34] also 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

At suitable temperature and moisture condition EPNs can penetrate *C. sordidus* larval galleries and easily reproduce. Insect mortality varies with the EPN species and rate of application. Under field conditions EPNs should be applied on pseudostem traps, disc-on-corm traps, and corm incisions for their efficacy.Though pesticides and crop nutrition are important recommended practices, biocontrol with entomopathogenic nematodes are important aspects in sustainable production of banana [35]. There is necessary to formulate commercial products from the most effective and native 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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