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Management of Cutworm by Entomopathogenic Nematodes-A Review

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A B S T R A C T

Cut worm cause extensive damage to many agricultural and horticultural crops. The pests are difficult to control due to larval hiding behavior during the daylight hours. Chemical methods of control are recommended for the management of this pest. One of the promising biological control agents is the entomopathogenic nematodes.

Introduction

Cutworms are smooth caterpillars of several moth species (Lepidoptera: Noctuidae).They are polyphagous and ubiquitous insects and have been recorded as serious pests in the world including India (Gulab *et al*., 2001; Mrowczynski *et al*., 2003; Napiorkowska and Gawowska, 2004). Several species of cutworms, viz., *Agrotis* spp. *Peridroma saucia*, *Amathes c- nigrum*, *Spodoptera frugiperda*, *S. exigua* and *S. litorallis* cause serious problems to agricultural, vegetable and forage crops. These insects cause considerable damage by cutting seedlings at the ground level thereby reducing the yield .The caterpillars emerging from the eggs grow with several moults until they are full size and then pupate in the ground, moths emerge from those pupae. It may take one month or a year to complete the life-cycle depending on the species involved and the weather. The black cutworm, *Agrotis ipsilon* (Hufnagel) is a major pest of over 30 economically important agricultural and horticultural crops in many parts of the world, which makes it survive nearly in every agro ecosystem (Rings *et al*., 1975).Black cutworm larvae vary in size from 3 mm to 50 mm.They are light gray to almost black in colour and have a greasy appearing texture and coarse granules of various sizes that can be seen on their body covering. Moths are attracted to green vegetation for egg laying. Newly hatched larvae feed on weeds or young plants, leaving small irregular holes in the leaves. Larger larvae may notch the stems of seedlings immediately below the soil surface, which can cause plants to wilt and die. They may completely cut through stalks, which can result in severe stand reductions. They usually feed at night or during overcast days. They sometimes drag cut plants under dirt clods or into small holes in the soil to continue their feeding during the daylight hours. More than 80% of the losses occur after reaching the fourth instar of larvae, which cuts several plants overnight (Abdel-Gawaad and El-Shazli 1971 and Capinera 2001). Crop losses were due to its wide host range including weeds, hidden lifestyle, feeding behavior, prolonged egg laying, and its ability for long-distance migration (Ya-Zhong ,1992; Showers *et al*., 1993; Capinera,2001).Chemical control used against *A. ipsilon* larvae is often not effective and remains inadequate for the control of this pest because of its larval hiding behavior during the daylight hours and the resistance to most of the chemicals (Capinera, 2001; Takeda, 2008). Moreover, the negative impact of the chemicals has led researchers to search for new control strategies (Laznik and Trdan, 2012).

Management through biological method

Biological control agents including fly and wasp parasites, disease organisms like granulosis virus, fungi, bacteria and protozoa and predatory beetles reduce cutworm numbers to certain level. But none of them could bring down cutworm population within a short time.

Biological control by entomopathogenic nematodes (EPNs) appears to be one of the sustainable alternatives to manage this pest. An entomopathogenic nematode, *Hexamermis arvalis* (Nematoda: Mermithidae) is known to parasitize up to 60% of larvae in the central USA (Puttler and Thewke, 1971). An ectoparasitic nematode *Noctuidonema guyanense* parasitized the adult stage of fall armyworm (Rogers *et al*., 1991). Entomopathogenic nematodes (EPNs) of the genera *Steinernema* and *Heterorhabditis* are capable of controlling a variety of economically important insect pests (Klein, 1990; Shapiro-Ilan *et al*., 2002). The infective juveniles (IJs) of EPNs enter the host insect and release their symbiotic bacteria (*Photorhabdus* spp. or *Xenorhabdus* spp.), which cause septicemia leading to the death of the insects within 24-48 hrs. Searching ability of the host, high virulence, ease of culturing, safety to nontarget organism have led to successful integration of these nematodes into pest management programme for the control of soil borne pests especially cutworm (Kaya and Gaugler, 1993; Hussaini 2014; Shapiro-Ilan *et al*., 2015).

Case studies of Entomopathogenic nematodes

Many studies have been conducted in order to evaluate the virulence and control potential of entomopathogenic nematodes (EPNs) species or isolates against *A. ipsilon* larvae (Israel *et al*., 1969; Simons and Guys, 1980; Morris,1985; Capinera *et al*., 1988; Georgis *et al*., 1989; Morris *et al*., 1990; Morris and Converse, 1991; Shamseldean *et al*., 1994; Baur *et al.*, 1997; Shamseldean and Ismail, 1997; Shapiro *et al*., 1999; Hussaini *et al*., 2000a, 2000b, 2001, 2002, 2003, 2005; Mathasoliya *et al*., 2004; Kunkel *et al*., 2004; Fetoh *et al*., 2009; Richmond and Bigelow, 2009; Seal *et al*., 2010; Ebssa and Koppenhöfer 2011; 2012; Mantoo *et al*., 2012; Bélair *et al*., 2013; Khattab and Azazy 2013; Lee *et al*., 2013; Han *et al*., 2014; Yan *et al*., 2014; Goudarzi *et al*., 2015; Saleh *et al*., 2015; Hassan *et al*., 2016; Mahmoud *et al*., 2016; Mazurkiewicz *et al*., 2016; Souad, 2016; Vashisth *et al*., 2018; Yuksel and

Canhilal, 2018). Control of *Agrotis segetum* with *Steinernema feltiae* (*Neoplectana bibionis*) in lettuce was equivalent to endosulfan, under field conditions (Lossbroek and Theunissen 1985). *A. ipsilon* has been effectively managed with *S. carpocapsae* on golf course greens. Larvae and pupae of armyworms are very susceptible to entomopathogenic nematodes and can be effectively managed by nematodes (Kaya and Grieve 1982). Chandel *et al*.,(2009) found that 1000 IJs of *Heterorhabditis bacteriophora* per kg soil were found to be sufficient to initiate the infection and kill up to 61.3% of 5th instar larvae of *A. segetum* after 7 days of exposure. Richter and Fuxa (1990) reported 33-43% infection of *S. frugiperda* by *S. carpocapsae* in field corn. They also found that spraying of nematodes onto corn ears reduce damage of *S. frugiperda* up to 71%. Molina-Ochoa *et al.*, (1999) evaluated the susceptibility of *S. frugiperda* to several species of nematodes and found that the LC_{50} ranged from 1.5 to 20.6 and 3.4 to 37.2 nematodes/ml for larvae and prepupae, respectively. They concluded that *S. carpocapsae* All strain, *S. riobrave*, and *H. megidis* have potential for controlling *S. frugiperda*. Shoeb *et al*., (2006) investigated the efficacy of *S. abbasi* and *H. bacteriophora* against the fourth instar larvae of *A. ipsilon* in Petri dishes in the laboratory study at 27 ± 1 °C. They reported that *H. bacteriophora* caused 49, 53, and 73% mortality rates, respectively, at 25, 50, and 100 IJs/larva in the second day after the treatment. Fetoh *et al*., (2009) evaluated the effectiveness of *S. carpocapsae* and *H. bacteriophora* against fourth instar *A. ipsilon* larvae at concentrations of 25, 50, 100 IJs/ml in Petri dish under laboratory conditions. Mortality rates, at the second day after treatment, were found as 70, 85, and 100% for *S. carpocapsae* and 80, 90, and 100% for *H. bacteriophora* at concentrations of 25, 50, and 100 IJs/ml, respectively. Unlu *et al.*, (2007), also compared the efficacy of *S. weiseri* (BEY), *S. feltiae* (TUR-S3), and *S. carpocapsae* (TUR) isolated in Turkey against last instar larva of *A. segetum*. Each nematode species was applied at 10, 25, 50, and 100 IJs per *A. segetum* larva in 10 ml of water. *S. weiseri* was more effective than *S. feltiae* (TUR-S3) at 50 and 100 IJs per larva; however, *S. weiseri* was less effective than *S. carpocapsae*. The efficacy of *S. kraussei* was tested on *Agrotis segetum* larvae at different densities (100, 300, and 500 infective juveniles (IJs) g^{-1} dry sand) in laboratory conditions at 25 °C. The highest mortality (98%) was obtained with 500 IJs g^{-1} dry sand within 7 d after inoculation (Gokce *et al*., 2013).

EPNs can provide excellent control of cutworms (*Agrotis* spp.) in many different field crops, which often exceeds the level of control provided by insecticides. Field application of *S.carpocapsae* reduced the black cutworm (*A.ipsilon*) damage by 50% on maize (Capinera *et al.*, 1988). Levine and Oloumi-Sadeghi(1992) found that a single application of *S.carpocapsae* reduced the number of cut maize plants by 76-83% during the 1-10 days after treatment. Yokomizo and Kashio (1996) reported that a single ground spray of *S.carpocapsae* at 1 billion IJs/ha or two applications of 0.5 billion IJs / ha with an 8 day interval caused 80 and 67% mortality of turnip moth (*Agrotis segetum*) larvae, respectively. To be effective, entomopathogenic nematodes must usually be applied to soil at rates of 2.5×10^9 IJs/ha or higher (Georgis and Hague, 1991; Georgis *et al*., 1995; Shapiro-Ilan *et al*., 2002). In cases where the pest is particularly susceptible or in controlled condition such as in the greenhouse, lower application rates might also be effective. For example, *S. carpocapsae* applied at the relatively low rate of 12.5 IJs/cm^2 reduced black cutworm, *Agrotis ipsilon* (Hufnagel) damage in field corn by more than 75%, which was as effective as or more so than the chemical insecticides tested (Levine and Oloumi-Sadeghi, 1992).

In conclusion, soil type, temperatures and moisture are considered as important physical factors influencing nematode mobility, efficacy, reproduction, development and persistence in the field (Kung, 1990). *S. carpocapsae*, *S.abbasi*, *S.glaseri*, *H.indica*13.3, *H.indica* 6.71 caused absolute mortality of last instar larvae of *Agrotis ipsilon* at 25^{0}C during 48h exposure period (Hussaini *et al*., 2005). Therefore, their populations normally need to be supplemented with accurate virulent strain to realize high levels of parasitism. Nematodes are applied with irrigation and should be done early in the summer season when larvae are most vulnerable. Entomopathogenic nematodes thus offer an ecofriendly and IPM compatible alternative to chemical insecticides for the management of cutworm.

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