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Gitanjali Devi
Department of Nematology, Assam Agricultural University, Jorhat, Assam, India

Mitul Saikia
Department of Plant-Pathology, Assam Agricultural University, Jorhat, Assam, India

Sudhansu Bhagawati
Department of Entomology, Assam Agricultural University, Jorhat, Assam, India

Badal Bhattacharyya
Department of Entomology, Assam Agricultural University, Jorhat, Assam, India

Corresponding Author:
Gitanjali Devi
Department of Nematology, Assam Agricultural University, Jorhat, Assam, India

Bioefficacy of entomopathogenic nematode, *Heterorhabditis bacteriophora* against cutworm, *Agrotis ipsilon* damaging potato under field condition

Gitanjali Devi, Mitul Saikia, Sudhansu Bhagawati and Badal Bhattacharyya

Abstract
A field experiment was conducted at ICR Farm, AAU, Jorhat during the year 2019-20 to evaluate the efficacy of entomopathogenic nematode, *Heterorhabditis bacteriophora* at different application doses against cutworm, *Agrotis ipsilon* on potato. Lowest tuber damage was recorded at 5.0×10^9 IJs/ha followed by at 2.5×10^9 IJs/ha as compared to untreated control. Highest yield was recorded in the treatment at application dose 5.0×10^9 IJs/ha. Cost benefit ratio revealed that application with higher dose of *H. bacteriophora* proved most effective followed by subsequent doses as well as neem pesticide.

Keywords: bioefficacy, entomopathogenic nematodes, *Heterorhabditis bacteriophora*, biopesticide, nimbecidine, chlorpyriphos

Introduction
In Assam, Potato crop is infested by a number of insect pests. Among these pests, black cutworm, *Agrotis ipsilon* (Hufnagel) (Lepidoptera: Noctuidae), is a major pest causing extensive damage from 53.5 to 57.5% of plant and 34.6 to 40.1% of tuber on weight basis [1]. In India, five species of cutworms *viz.*, *Agrotis ipsilon* Hufnagel, *Agrotis interacta* Walk, *Agrotis flammatra* Schiff., *Agrotis spinnifera* Hb. and *Agrotis segetum* Schiff have been reported causing 12-40% loss in tuber yield in different parts [2]. 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 by fourth instar of larvae, which cuts several plants overnight [3-5]. 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 [6]. Moreover, negative impacts have led to the development of alternatives safe control agents and strategies include novel biological control agents. Entomopathogenic nematodes(EPNs) belong to both families of Steinernematidae and Heterohabditidae and their associated symbiotic bacteria, *Xenorhabdus* and *Photorhabdus* spp. are excellent biological control agents of many insect pests [7]. The present study was conducted to evaluate the efficacy of local entomopathogenic nematodes isolate, *Heterorhabditis bacteriophora* compared with chemical insecticide, chlorpyriphos against cutworm under field condition.

Materials and Methods
The isolate of EPN used in the experiment, *Heterorhabditis bacteriophora* was isolated from Majuli, Assam [8]. Enough population of *H. bacteriophora* were reared on last instar larvae of the greater wax moth, *Gallaria mellonella* L. (Lepidoptera: Pyralidade) [9]. The *G. mellonella* larvae were collected from infected hives and reared on an artificial media at 28±2 ºC and relative humidity of 65±5% in the laboratory [10]. The emerging infective juveniles (IJs) were harvested on the White trap [11] and stored in sterilized water at 10ºC for one week and were

permitted to acclimatize at room temperature for 1 h before using as inoculum [12]. The viability of IJs in nematode suspension was assessed by observation of movement under a stereomicroscope.

The field trial was conducted in randomized block design with six treatments including control in ICR Farm of Assam Agricultural University, Jorhat campus during 2019-20. Each treatment was replicated four times. The time of application was furrow application before sowing of the potato tubers and at the time of 1st and 2nd earthing up. The treatments were: T_1: 1.25×10^9 IJs/ha, T_2: 2.5×10^9 IJs/ha, T_3: 5.0×10^9 IJs/ha, T_4: Azadirachtin 0.03% (Nimbecidine) @ 5%, T_5: Chlorpyriphos 20% EC (Tricel) @ 2 ml/l and T6-control(untreated). Kufri pokhraj variety of potato was planted in the first week of November, 2019 in plot size 4×3 meters and spacing 60×20 cms. All the agronomic practices were done as per schedule. Weekly observations were recorded on the incidence of *A. ipsilon* on plant. The crop was harvested in the second week of February, when potato attained full maturity. At the time of harvesting, damage of tubers due to cutworm both by number and weight basis was recorded.

Results and Discussions

The result on the efficacy of different doses of nematode in terms of tuber damage, tuber yield and benefit cost ratio during the period of investigation are presented in table.1. From the data of the table, it is evident that all treatments in respect of hulm cut were significantly lower over the untreated control. The per cent tuber damage (by number and weight) was significantly lower compared to control. There was no significant difference between the treatment with neem pesticide and the treatment with highest dose of *H. bacteriophora* (5.0×10^9 IJs/ha). However, the chemical pesticide, chlorpyriphos shows better results in controlling the pest Levine and Oloumi-Sadeghi [13] 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 [14] reported that a single spray of *S. carpocapsae* at 1 billion IJs/ha or two sprays of 0.5 billion IJs/ha with an 8 day interval caused 80 and 67% mortality of *Agrotis segetum* larvae, respectively. Georgis and Hague [15]; Georgis *et al*. [16] and Shapiro-Ilan *et al*. [17] recommended the effective dose of entomopathogenic nematodes to soil as 2.5×10^9 IJs/ha or higher. In cases where the pest is particularly susceptible or in controlled condition such as in the greenhouse, lower application rates might also be effective. *S. carpocapsae* applied at the relatively low rate of 12.5 IJs/cm^2 reduced black cutworms, *Agrotis ipsilon* damage in field corn by more than 75%, which was as effective as or more than the chemical insecticides tested [13]. The results indicated that application of *H. bacteriophora* at 5.0×10^9 IJs/ha recorded the better yield as compared to untreated control. Though the application of chlorpyriphos shows higher BCR(3.61), the highest BCR (3.42) was recorded with the treatment with *H. bacteriophora* at 5.0×10^9 IJs/ha followed by treatment with Nimbecidine (2.91) The efficacy of chlorpyriphos in reducing the cutworm infestation with subsequent increased in benefit cost ratio have also been documented [18, 19]. Capinera *et al.* [20] observed that under field condition, *A. ipsilon* damage can be reduced up to 50% by application of *S. carpocapsae*.

Table 1: Bioefficacy of entomopathogenic nematode, *Heterorhabditis bacteriophora* against cut worm, *Agrotis ipsilon* hufnagel (Lepidoptera: noctuidae) in potato

Treatment	Initial plant population per plot	Hulm cut (%) 75 DAS*	Tuber damage (%)		Yield (q ha-1)	BCR
			Weight basis	Number basis		
1	148.0	32.8 (34.9) b	32.5 (34.7) b	34.0 (35.6) b	80.0 d	3.23
2	150.2	25.6 (30.3) c	32.0 (34.4) b	33.0 (35.0) b	82.0 cd	3.31
3	146.7	19.2 (25.9) d	20.2 (26.6) c	17.0 (24.3) c	85.2 bc	3.42
4	146.2	19.4 (26.1) d	18.6 (25.5) c	16.8 (24.1) c	89.4 ab	2.91
5	150.7	10.8 (19.1) e	12.8 (20.9) d	12.2 (20.4) d	92.8 a	3.61
6	152.5	39.5 (38.9) a	43.3 (41.1) a	42.8 (40.8) a	84.0 cd	
CD (P = 0.05)	-	(2.3)	(2.0)	(2.1)	5.0	

*DAS: Days after sowing, Figures in parentheses are angular transformed values

Conclusion

From the experiment it can be concluded that entomoapthogenic nematodes are effective against cutworm, *A. ipsilon*. The time of application of the nematode in relation to the period of cutworm infestation in soil is critical for efficacy of control. Thus for an effective control, the application of the nematode must be made before or at the time when majority of larvae are present on the soil.

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