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Reseach Article

Field evaluation of *Beauveria bassiana* and *Metarhizium anisopliae* against the cutworm, *Agrotis ipsilon* (Hufnagel) damaging potato in Uttarakhand hills

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ABSTRACT: Field experiments were conducted at crop research center (Gaja) of College of Forestry and Hill Agriculture, GBPUA&T, Ranichauri during the year 2006-2009 to test the effectiveness of entomopathogenic fungi, *Beauveria bassiana* and *Metarhizium anisopliae* in comparison with an chlorpyriphos against cutworm, *Agrotis ipsilon* on potato. Lowest tuber damage (15.6%) was recorded in treatment of *M. anisopliae* (5.0x10^{11} spores/g) followed by *B. bassiana* (5.0x10^{9} spores/g) with tuber damage of 17.82% as compared to control (31.82%). Highest yield of 126.97 q ha^{-1} was recorded in *M. anisopliae* treatment. However, among all the treatments, chlorpyriphos was found to be the most effective at lowest tuber damage (8.80%) with 142.01 q ha^{-1} yield while in control it was 65.78 q ha^{-1}. Cost benefit ratio also revealed that application of higher dosage of *M. anisopliae* proved most effective followed by *B. bassiana*.

KEY WORDS: *Beauveria bassiana*, *Metarhizium anisopliae*, chlorpyriphos, bio-efficacy, *Agrotis ipsilon*, potato

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INTRODUCTION

The cutworm, *Agrotis ipsilon* (Hufnagel) (Lepidoptera: Noctuidae), which is locally known as "katuwa keet", has become a widespread and destructive insect pest of vegetable crops in Uttarakhand hills. The caterpillars cause severe damage by feeding on the roots zone of almost all agricultural crops from March to September resulting in symptom of wilting and drying of plants. The entomopathogenic fungus, *Metarhizium anisopliae* (Metschn.) Sorokin is widely used as biological control agent against different insect pests. Commercially available product is safe with minimal risks to vertebrates, humans and the environment (Gisbert, 2007). Wraight *et al.* (2010) tested the various isolate of entomopathogenic fungi *B. bassiana* against many lepidopterous insects and found that susceptibility of cutworm is low compared to diamondback moth (*Plutella xylostella* Linnaeus), European corn borer (*Ostrinia nubilalis* Hubner), corn earworm (*Helicoverpa zea* Boddie), fall armyworm (*Spodoptera frugiperda* Smith), beet armyworm (*Spodoptera exigua* Hubner), cabbage worm (*Pieris rapae* Linnaeus) and cabbage looper (*Trichoplusia ni* Hubner)). Susceptibility of the black cutworm (*A. ipsilon*) to the entomopathogenic fungus, *B. bassiana* has been demonstrated by Gosselin *et al.* (2009). However, Bhagat *et al.* (2008) found that bio-agents like *Heterorhabditis indica*, *M. anisopliae, B. bassiana, Steinernema carpocapsae* were less effective against *A. ipsilon* at earlier stages of seedling growth while at later stages of crop proved very effective.

In the light of above facts, field experiment was carried out to evaluate the entomopathogenic fungi, *B. bassiana* and *M. anisopliae* with few insecticides against *A. ipsilon* on potato in Uttarakhand hills.

MATERIALS AND METHODS

Field experiment was conducted at Research Center (Gaja), College of Forestry and Hill Agriculture, GBPUA&T, Ranichauri during three consecutive years from 2006 to evaluate the effectiveness of *B. bassiana* and *M. anisopliae* in comparison with chlorpyriphos against *A. ipsilon,* under rain-fed condition of Uttarakhand hills. Fungal formulations were obtained from National Bureau of Agriculturally Important Insects, Bangalore through the Project Coordinating Cell of All India Network Project on Whitegrubs and Other Soil Arthropods, Agricultural Research Station (Durgapura), Jaipur (Rajasthan). The potato crop was sown in March under rain-fed condition in the plot size of 5 x 5 meters. The seed to seed and line to line distance was maintained 20 cm and 60 cm, respectively. All the agronomical practices recommended for the crop were followed to grow healthy crop. The experiment was conducted under randomized block design with seven treatments which were as under and each treatment was replicated thrice.

The bio-agent of each treatment was mixed up in compost while the chemical insecticide was mixed in pulverized soil separately and this was mixed in respective plots during the earthing time at tuberization stage. At the time of harvesting yield tuber damage and larval population in one square meter area at 20 cm depth were recorded. The data recorded from different treatments were subjected to ANOVA through MSTAT-C computer program.

RESULTS AND DISCUSSION

Perusal of data of year 2006-07, 2007-08 and 2008-09, it was found that there was significant variation in tuber damage, yield and per pit larval population. The tuber damage ranged from 8.80 to 21.10 percent while yield and per pit larval population ranged from 118.21 to 129.95 qha^{-1} and 0.53 to 1.11 larvae, respectively.

Among the treatments, highest tuber damage i.e. 20.46, 25.12 and 18.37 percent was recorded in *M. anisopliae* @ 3 g/m^2 during the all the three years compared to control where the tuber damage was 31.69, 31.28 and 30.86 percent, respectively. The lowest tuber damage (15.53, 15.18 and 16.10%) was recorded during all the years respectively, in treatment with high dose of *M. anisopliae* having $1x10^{11}$ conidia per gram (applied @ 5 g/m^2) with an average tuber damage of 15.6 percent. This was followed by T_4 (*B. bassiana* applied @ 5 g/m^2) where the tuber damage was 16.43, 19.85 and 16.72 percent, respectively, with an average of 17.66 percent tuber damage (Table 1). However, Gosselin *et al.* (2009) reported lower efficacy of *B. bassiana* against cutworm with an estimated LC_{50} of 7×10^7 spores ml^{-1}. Among all the treatments, chlorpyriofos had lowest tuber damage i.e. 8.38, 9.20 and 8.83 percent during the year 2006, 2007 and 2008, respectively, with an average of 8.80 percent tuber damage. At same dosage level i.e. applied @ 3 g/m^2 and 5 g/m^2, *B. bassiana* was found to be most effective by recording 20.25 and 17.66 percent tuber damage as compared to *M. anisopliae* where the damage was 21.31 and 19.14 percent, respectively.

Variation in yield and per pit larval population in different treatments was also recorded which ranged from 52.5 to 167.3 qha^{-1} and 0.53 to 1.11 larvae, respectively. The highest tuber yield i.e. 129.95 was in T_5 ($1x10^{11}$ conidia per gram formulation of *M. anisopliae* applied @ 5 g/m^2) having highest dosage of *M. anisopliae* followed by non-significantly in T_4 (*B bassiana* applied @ 5 g/m^2 of 1.0 x 10^9 conidia per gram formulation) where the yield was 127.95 qha^{-1}. Increasing the dosage of *M. anisopliae* gave better yield as compared to lower dosage of same bio-agent. Present finding was found to be in agreement with Frag (2008), who reported that application of commercially available formulation of *M. anisopliae* and *B. bassiana* @ 2 g/l gave considerable mortality of both, *Spodoptera littoralis* and *A. ipsilon*. However, T_5 was at par with all other bio-agent's treatments except T_1 having lower dosage of *M. anisopliae*. Among the all the treatment, chlorpyriphos 20 EC (0.04%) proved to be best treatment where highest yield i.e. 142.01 qha^{-1} was recorded which was significantly superior than all the treatments as well as with control where the yield was 65.78 qha^{-1}.

At the time of harvesting, the per pit larval population in all the treatments was also recorded which ranged from 0.53 to 1.87 larvae per pit. Lowest larval population per pit was non significantly recorded in T_5 (0.64 larva per pit) followed by T_4 (0.87 larva per pit). However, lowest per pit larval population was recorded in T_6 (applied chlorpyriphos @ 0.04%) which was 0.53 larva per pit as compared to control where it was 1.78 larva per pit. However, all the treatments except T_6 were found to be significantly at par with each other.

Cost-benefit ratio

Cost benefit ratio study revealed that the yield in terms of rupee ranged from Rs. 82,747/- to Rs. 99,407/- with highest net retune of Rs. 80465/- (Table 2). Among the bio-agent treatments, highest net return (Rs. 80465/-) with 73.73 percent gain over control was recorded in T_5 (*M. anisopliae* ($1.0x10^{11}$ spores/g) having highest dosage of *M. anisopliae* (@ $1x10^{11}$). Lowest net return (Rs. 77097/-) with 67.43 percent gain over control was recorded in T_1 (*M. anisopliae* @$1.0x10^9$ spores/g) having lowest dosage of *M. anisopliae*. At same dosage, *B. bassiana* proved to be non-significantly superior by recording highest gain of 73.66 percent while in case of *M. anisopliae* it was 73.15 percent over control. However, chlorpyriphos was found to be superior over all

Table 1. Field evaluation of bio-pesticides applied as soil treatment against cutworm, *Agrotis ipsilon* in potato, 2006-08

Sl. No.	Treatment	Doage*	Mean initial plant population (5.0 x 5.0 m)				Mean % tuber damage (By number)				Marketable tuber yield (q ha^{-1})				Mean no. of larvae/pit (1x1.0m^2)			
			2006	2007	2008	Avg.	2006	2007	2008	Avg.	2006	2007	2008	Avg.	2006	2007	2008	Avg
T_1	*M. anisopliae* (1.0 x 10^9 spores/g)	3g/m^2	75.0	75.0	71.0	73.6	20.46 (26.85)	25.12 (29.60)	18.37 (25.36)	21.31 (27.30)	108.00	136.2	110.42	118.21	1.00	1.0	1.33	1.11
T_2	*M. anisopliae* (1.0 x 10^9 spores/g)	5g/m^2	76.0	76.0	72.0	74.6	16.90 (23.69)	21.54 (27.63)	18.98 (25.77)	19.14 (25.79)	117.33	145.5	118.08	126.97	1.00	1.3	1.33	0.99
T_3	*B. bassiana* (1.0 x 10^9 spores/g)	3g/m^2	71.0	71.0	71.0	71.0	18.98 (25.75)	24.46 (30.07)	17.31 (24.57)	20.25 (26.83)	114.00	132.1	116.67	120.92	1.00	1.00	1.00	1.00
T_4	*B. bassiana* (1.0 x 10^9 spores/g)	5g/m^2	72.0	75.0	75.0	74.0	16.43 (24.25)	19.85 (26.49)	16.72 (24.13)	17.66 (24.95)	121.83	142.2	119.83	127.95	0.33	0.06	1.00	0.87
T_5	*M. anisopliae* (1.0 x 10^{11} spores/g)	5g/m^2	77.0	77.0	73.0	75.6	15.53 (23.20)	15.18 (22.95)	16.10 (23.64)	15.60 (23.26)	119.16	150.6	120.08	129.95	0.66	0.6	0.66	0.64
T_6	Chlorpyriphos 20 EC(foliar spray)	0.2kg	72.0	72.0	75.0	73.0	8.38 (16.82)	9.20 (17.66)	8.83 (17.27)	8.80 (17.25)	129.16	167.3	129.58	142.01	0.33	0.6	0.66	0.53
T_7	Untreated control	–	75.0	72.0	71.0	72.6	31.69 (34.25)	31.28 (34.02)	30.86 (33.70)	31.28 (34.00)	50.33	94.5	52.50	65.78	2.00	1.6	2.00	1.87
	SEm (±)						0.99	1.54	0.98	0.73	4.38	4.38	6.02	3.06	–	–	–	0.14
	C.D. (*P* = 0.05)		NS	NS	NS	NS	3.07	3.35	3.04	2.27	9.54	9.54	8.55	9.43				0.45
	CV (%)						6.92	8.74	6.86	9.45	11.3	11.3	9.54	4.46				15.5

* Desired quantity of insecticides was mixed in pulverized soil and applied on the ridges followed by earthing at tuberization stage.
** Figures in parentheses are the angular transformed values.

Table 2. Cost-benefit ratio of different bio-pesticides at different dosage applied as soil application in potato against *Agrotis ipsilon*

Tr. No.	Treatment	Dosage	Cost of treatment (Rs. ha^{-1})	Production in (Rs. ha^{-1})	Net retune (Rs. ha^{-1})	Gain over control (Rs. ha^{-1})	B/C ratio	Mean cutworm pop. (sq./m^2)
T_1	*Metarhizium anisopliae* (1.0 x10^9 spores/g)	3.0g/m^2	5,650.00	82,747.00	77,097.00	31,051.00 (67.43)	5.49:1	1.11
T_2	*M. anisopliae* (1.0 x10^9 spores/g)	5.0g/m^2	9,150.00	88,879.00	79,729.00	33,683.00 (73.15)	3.68:1	0.87
T_3	*Beauveria bassiana* (1.0 x10^9 spores/g)	3.0g/m^2	5,500.00	84,644.00	79,144.00	33,098.00 (71.88)	6.01:1	1.00
T_4	*B. bassiana* (1.0 x10^9 spores/g)	5.0g/m^2	8,900.00	88,865.00	79,965.00	33,919.00 (73.66)	3.81:1	0.99
T_5	*M. anisopliae* (1.0 x10^{11} spores/g)	5.0g/m^2	10,500.00	90,965.00	80,465.00	34,413.00 (74.73)	3.27:1	0.64
T_6	Chlorpyriphos 20 EC	0.04%	1,600.00	99,407.00	97,807.00	51,761.00 (112.41)	32.35:1	0.53
T_7	Untreated control	–	–	46,046.00	46,046.00	–	–	1.87

* Figures in parentheses are the percent gain over control.

the treatment by recording 112.41 per cent gain over control. Among the treatments, highest benefit cost ratio was recorded in chlorpyriphos 20EC at 800 g a.i. ha⁻ (T_6) (32.35:1) followed by *B. bassiana* (@1.0x10^9 spores/g) (T_3) (6.01:1).

Through *B. bassiana* proved to be most effective bioagent by recording higher yield and net returns in comparison to chlorpyriptos, the effectiveness of bio-agents was found to be lower in respect to per cent tuber damage, yield and larval population per pit.

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