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Efficacy of biopesticides and insecticides in controlling maize cutworm in Jammu

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ABSTRACT: A field trial was laid out during 2004 and 2005 at intermediate zone in Jammu Province to study the efficiency of some biopesticides and insecticides in the management of *Agrotis ipsilon* Hufn. on Pioneer Maize (K-85) under recommended agronomic practices of SKUAST-Jammu. Seed treatment with chlorpyriphos, imidacloprid and insecticidal dust application of chlorpyriphos attributed to higher yield and less plant mortality as compared to other treatments. Use of biopesticides, *viz.*, *Heterorhabditis indica*, *Metarhizium anisopliae*, *Beauveria bassiana*, *Steinernema carpocapsae*, *S. carpocapsae* + *B. bassiana*, *S. carpocapsae* + *M. anisopliae* and *H. indica* + *M. anisoliae* provided less protection at earlier stages of seedling growth, whereas at later stages, they were effective and registered higher yield as compared to control. *H. indica* + *M. anisopliae* treated plots recorded higher yield as compared to other biopesticides.

KEY WORDS: *Agrotis ipsilon*, biopesticides, efficacy, Jammu, maize

INTRODUCTION

Maize (*Zea mays* L.) is an important staple food in many tropical countries in Africa, Asia and Latin America (Paroda and Kumar, 2000) and occupies third place in the world after wheat and rice. Of the 27 maize producing countries of the world, India ranks fifth in terms of area and eighth in production. In India, it is grown in an area of 7.4 million hectares with annual production of 14.7 million tons and average production of 1.98 tons ha^{-1} (Anonymous, 2004a). Jammu and Kashmir is one of the major maize producing states occupying an area of 534 thousand hectares with an average higher production of 1.525 t ha^{-1}, which is (1.829 t ha^{-1}) in Jammu division (Anonymous, 2004b). More than 130 insect pests have been recorded causing damage to maize in India. Among these, cutworms (*Agrotis* spp.), borers (*Chilo* spp.), shoot flies (*Atherigona* spp.) and white grubs (*Holotrichia* spp.) are serious. In particular, maize cutworm causes considerable damage to maize crop in hilly and sub-mountainous regions of Jammu and Kashmir. This paper presents the results of field trials conducted to study the efficacy of biopesticides against *A. ipsilon*.

MATERIALS AND METHODS

A trial was laid out in randomized block design with 14 treatments replicated three times with a plot size of 3mx2.5m for two consecutive years in farmer's field. The plants were spaced 60 cm between and 20 cm within the rows. The trial was laid with Pioneer Maize (K-85) under recommended agronomic practices for Jammu (Anonymous, 2002). Two insecticides, *viz.*, chlorpyriphos 20 EC @ 5 g a.i kg^{-1} seed and imidacloprid 200 SL @ 3.5 g a.i kg^{-1} seed, were used as seed treatments. Chlorpyriphos 1.5% D @ 25 kg ha^{-1}, two entomopathogenic fungi, *viz.*, *Metarhizium anisopliae* and *Beauveria bassiana* @ 1×10^{12} spore ha^{-1}, two entomopathogenic nematodes, viz., *Steinernema carpocapsae* @ 1billion and 2billion IJs ha^{-1} and *Heterorhabtidis indica* @ 1b and 2b IJs ha^{-1} were used as soil treatments. Combinations of each nematode with each entomopathogenic fungus, *viz.*, *S. carpocapsae* + *B. bassiana*, *S. carpocapsae* + *M. anisopliae*, *H. indica* + *B. bassiana* and *H. indica* + *M. anisopliae* @ 0.5b IJs ha^{-1} + 5×10^{11} spores ha^{-1} were also used as soil treatments.

Entomopathogenic fungi, nematodes and chlorpyriphos dust were mixed with sand (25kg ha^{-1}) and then applied in soil at the time of sowing. Seed treatment was done by taking known quantity of seed in a polythene bags and known quantity of chemical was added in it in a slurry form. The bag was swirled gently to provide a uniform coat of insecticide over the seeds. The coated seeds were spread on a plastic sheet and shade dried as per the method of Sahni (1992). The coated seeds were sown in furrows. The viability of the seeds was tested by keeping them in a seed germination chamber in seed testing laboratory, Department of Agriculture, Talab Tillo, Jammu.

The crops were sown on 5th June 2004 and 11th June 2005, respectively. Observations on the plant mortality were taken at different seedling stages. The seedlings started emerging from 5th day after sowing in the respective years. The number of plants cut by cutworm up to coleoptile stage (9 days after sowing), two-leaf stage (10-13 days after sowing), four-leaf stage (14-17 days after sowing) and six-leaf stage (18-21 days after sowing) were recorded separately. The data on the number of plants cut were recorded daily to know the per cent plant mortality. The biological fitness of insecticides and bio-pesticides was judged on the basis of number of plants cut. Weekly sampling was done to know the efficacy of different treatments in reducing cutworm population compared to control. Samples were taken by excavating 8400 cm^3 (20 x 20 x 21 cms) in the field according to the method given by Toba and Turner (1981) at weekly intervals. For each treatment, 10 samples were taken (2 sample/ replication). The number of larvae present per sample was recorded. At the end of the crop season, when cob sheath dried and became brownish they were harvested. The cobs from each plot were bagged separately. They were then dried and shelled. The grains were dried (up to 14 per cent moisture) and yield data was recorded.

Per cent plant mortality by *A. ipsilon* at all seedling stages, *viz.*, from coleoptile to six-leaf stage, was calculated as per the formulae given below:

$$\text{Per cent plant mortality} = \frac{\text{Total no. of plants in previous stage} - \text{Total no. of plants in the succeeding stage}}{\text{Total no. of plants in the previous stage}} \times 100$$

After six-leaf stage, total plant mortality was worked out as follows:

$$\text{Total \% plant mortality} = \frac{\text{Initial plant stand} - \text{Final plant stand}}{\text{Initial plant stand}} \times 100$$

Per cent decrease in plant mortality over control was worked out by the following formula:

% decrease in plant mortality = % plant mortality in control – % plant mortality in treatment

Per cent increase in yield over control was calculated as follows:

$$\text{\% increase in yield over control} = \frac{\text{Yield obtained from treatment plot} - \text{Yield obtained from the control plot}}{\text{Yield obtained from the control plot}} \times 100$$

RESULTS AND DISCUSSION

Good protection was provided at different seedling stages by seed treatment with chlorpyriphos (5g a.i. kg^{-1} seed) followed by imidacloprid 200 SL (3.5g a.i kg^{-1} seed) and soil application of chlorpyriphos 1.5 D (25 kg ha^{-1}) (Table 1). At coleoptile stage, lowest plant mortality (2.30%) was registered in chloropyriphos 20EC treated plots, followed by imidacloprid 200 SL (2.77%) and chlorpyriphos 1.5 D (3.69%) treated plots. Chlorpyripos 20EC was statistically on par with imidacloprid 200SL, but differed significantly from the rest of the treatments. These findings were also supported by the experiments conducted by Thakur and Vaidya (2000), Viji and Bhagat, (2001) and Mishra (2002). They evaluated various insecticides against cutworm and found that the dust application of chlorpyriphos was effective in checking plant mortality and enhancing the yield. Eizaguirre *et al.* (2005) recorded best performance of granular chlorpyriphos against soil pests of maize.

Among the biopesticides, 11.11 per cent plant mortality was recorded in plots treated with *M. anisopliae* @ 1×10^{12} spores ha^{-1}, followed by 11.56, 12.02, 12.50, 12.95, 13.88, 14.88, 15.33, 16.19, and 16.66 per cent plant mortality in *H. indica* + *M. anisopliae*, *S. carpocapsae* + *M. anisopliae*, *H. indica* + *B. bassiana*, *S. carpocapsae* + *B. bassiana*, *B. bassiana*, *H. indica* @ 2 billion and 1 billion IJs ha^{-1}, *S. carpocapsae* @ 2 billion and 1 billion IJs ha^{-1} treated plots, respectively. *M. anisopliae* was statistically on par with *H. indica* + *M. anisopliae* treated plots, but differed significantly from the rest of the treatments, whereas 18.05 per cent plant mortality was recorded in control plots.

At two-leaf stage, lowest plant mortality (2.84 per cent) was recorded with chlorpyriphos 20EC, followed by imidacloprid 200SL (3.80 per cent) and chlorpyriphos 1.5D (3.83 per cent) whereas 7.85, 10.51, 14.28, 14.36, 14.54, 9.89, 14.67, 14.83, 14.91 and 15.00 per cent plant mortality was recorded in *H. indica* + *M. anisopliae, S. carpocapsae* + *M. anisopliae, H. indica* + *B. bassiana, S. carpocapsae* + *B. bassiana, B. bassiana, M. anisopliae, H. indica* (2b and 1b IJs ha^{-1}) and *S. carpocapsae* (2b and 1b IJs ha^{-1}) treated plots. Control plot recorded 16.94 per cent plant mortality. However, imidacloprid 200SL and chlorpyriphos were statistically on par with each other. *H. indica* + *M. anisopliae* recorded the lowest plant mortality among biopesticides (7.85%), but differed significantly from the rest of the treatments. *S. carpocapsae* (1b IJs ha^{-1}) provided minimum protection and was statistically on par with *S. carpocapsae* (1b IJs ha^{-1}), *H. indica* (1b and 2b IJs ha^{-1}), *B. bassiana* which registered 15.00, 14.91, 14.83, 14.67, and 14.54 per cent plant mortality, respectively. Control plots recorded 16.94 per cent plant mortality. At four-leaf stage, lowest plant mortality (2.92 per cent) was recorded in chlorpyriphos 20EC treated plots, which was statistically on par with imidacloprid 200SL (2.97 per cent). Similarly, lowest plant mortality (3.40 per cent) was recorded among biopesticides in *H. indica* + *M. anisopliae* treated plots which were statistically on par with chlorpyriphos 1.5D (3.49 per cent). However, 4.40, 4.45, 6.34, 6.45, 7.54, 9.55

and 11.61 per cent plant mortality was recorded in *H. indica* + *B. bassiana*, *S. carpocapsae* + *B. bassiana*, *M. anisopliae*, *S. carpocapsae* + *M. anisopliae*, *B. bassiana* and *H. indica* (@ 2b and 1b IJs ha^{-1}), respectively. *H. indica* + *B. bassiana* and *S. carpocapsae* + *B. bassiana* were statistically on par with each other. Minimum protection was provided by *S. carpocapsae* (1b IJs ha^{-1}) which was statistically on par with *S. carpocapsae* @ 2b IJs ha^{-1} (12.33 and 12.28 per cent, respectively).

Similarly, at six- leaf stage, minimum mortality (1.16 per cent) was recorded in *H. indica* + *M. anisopliae*, on par with *H. indica* @ 2b IJs ha^{-1}, *M. anisopliae*, *S. carpocapsae* + *M. anisopliae*, which registered 1.66, 1.81, and 1.88 per cent plant mortality, respectively. Chlorpyriphos 20EC was statistically on par with imidacloprid 200SL, *H. indica* + *B. bassiana*, chlorpyriphos 1.5D and *H. indica* (1b IJs ha^{-1}) which registered 2.00, 2.03, 2.04, 2.06, 2.81 per cent plant mortality, respectively. Maximum plant mortality (6.97 per cent) was recorded in control, which was on par with *S. carpocapsae* @ 1b IJs ha^{-1} (6.81 per cent), whereas *S. carpocapsae* + *B. bassiana* and *S. carpocapsae* (2b IJs ha^{-1}) recorded 3.92 per cent and 4.44 per cent plant mortality, respectively, and differed significantly from the rest of the treatments.

M. anisopliae and *B. bassiana* were evaluated against cutworm by Viji and Bhagat (2001) who found that the fungi were effective at later stages and gave good protection to crops. Feng *et al.*(1994) have also portrayed the potential role of *B. bassiana* in the management of insect pests. Mohamed *et al.* (1987) and Quintela and McCoy (1998) discussed similar results and reported that *B. bassiana* and *M. anisopliae* are potential microbial control agents and their high inoculum rates achieved 60 to 70 per cent larval control in the field soil insects. Hussaini *et al.* (2003) also confirmed the efficacy of *S. carpocapsae* and *H. indica* against cutworm and showed that alginate formulations caused maximum mortality (60 to 80 per cent).

The lowest cumulative plant mortality (9.72 per cent) was recorded in chlorpyriphos 20EC reflecting higher yield (2.708t ha^{-1}), followed by imidacloprid 200SL, chlorpyriphos 1.5D, *H. indica* + *M. anisopliae*, *M. anisopliae*, *S. carpocapsae* + *M* . *anisopliae*, *S. carpocapsae* + *B. bassiana*, *B. bassiana*, *H. indica* (@ 2b and 1b IJs ha^{-1}) and *S. carpocapsae* (@ 2b and 1b IJs ha^{-1}) which recorded 22.23, 26.38, 27.77, 31.94, 33.33, 34.72, 36.11, 38.88, 40.27, 43.05 per cent plant mortality, respectively, and corresponding yield obtained was 2.333, 2.208, 2.166, 2.041, 2.000, 1.998, 1.916, 1.833, 1.791 and 1.708 t ha^{-1}. Control recorded maximum plant mortality (44.40 per cent) and lowest yield (1.666 t ha^{-1}). All the treatments significantly differed from each other. Similarly, highest decrease in plant mortality over control and per cent increase in yield over control was recorded in chlorpyriphos 20EC (34.68 and 62.54), followed by imidacloprid 200SL (33.29 and 60.02) and chlorpyriphos 1.5D (31.90 and 57.56), respectively. Lowest decrease in mortality and increase in yield over control (1.35 per cent and 2.52 per cent, respectively) were observed in *S. carpocapsae* (@1b IJs ha^{-1}) treated plots. Bosque *et al.* (1989) recorded average yield loss per plant of 46.0, 65.0, 73.0 and 74.0 per cent when the larvae attacked plants at one-, two-, three- and at four-leaf stage, respectively.

The efficacy of biopesticides and chemicals against larval population is presented in Table 2. After 7 days of sowing, 0.17 larvae (minimum) were recorded in chlorpyriphos 20EC, imidacloprid 200SL and chlorpyriphos 1.5D and differed significantly from the rest of the treatments. *H. indica* + *M. anisopliae*, *B. bassiana*, *M. anisopliae* and *H. indica* (1b and 2b IJ's ha^{-1}) treated plots recorded 0.83 larvae and were statistically on par with *S. carpocapsae* (1b and 2b IJ's ha^{-1}) and *S. carpocapsae* + *M. anisopliae* treated plots (1.00 larvae). *S. carpocapsae* + *B. bassiana*, *H. indica*+ *B. bassiana* and control recorded 1.17 larvae. At 14 days after sowing, minimum larval population (0.17) was recorded after 7 days of sowing in chloropyripos 20EC, imidacloprid 200SL and chlorpyriphos 1.5D, whereas 0.50 larvae were recorded in *H. indica* + *M. anisopliae*, *B. bassiana*, *S. carpocapsae* (2b IJs ha^{-1}), *M. anisopliae*, *H. indica*, (IJs ha^{-1}) and *S. carpocapsae* + *M.*

Table 1. Efficacy of some biopesticides and synthetic insecticides against *Agrotis ipsilon* at different stages of seedling growth (Pooled)

Treatments	Dose	Per cent plant mortality at seedling stage			
		Coleoptile Stage	2- leaf stage	4-leaf stage	6- leaf stage
Steinernema carpocapsae	1 billion I J's ha^{-1}	16.66 (24.09)	15.00 (22.79)	12.33 (20.56)	6.81 (15.13)
Steinernema carpocapsae	2 billion I J's ha^{-1}	16.19 (23.73)	14.91 (22.71)	12.28 (20.51)	4.44 (12.16)
Heterorhabditis indica	1 billion I J's ha^{-1}	15.33 (23.05)	14.83 (22.65)	11.61 (19.92)	2.81 (9.65)
H. indica	2 billion I J's ha^{-1}	14.88 (22.69)	14.67 (22.51)	9.55(18.00)	1.66 (7.40)
Metarhizium anisopliae	1x10^{12} spores ha^{-1}	11.11 (19.47)	9.89 (18.33)	6.34 (14.58)	1.81 (7.73)
Beauveria bassiana	1x10^{12} spores ha^{-1}	13.88 (21.87)	14.54 (22.41)	7.54 (15.94)	3.92 (11.42)
S. carpocapsae + B. bassiana	0.5 b IJ'S ha^{-1} + 5 x 10^{11} spores ha^{-1}	12.95 (21.10)	14.36 (22.27)	4.45 (15.84)	3.34 (10.53)
H. indica + B. bassiana	0.5 b IJ'S ha^{-1} + 5 x 10^{11} spores ha^{-1}	12.50 (20.70)	14.28 (22.20)	4.40 (15.78)	2.04 (8.21)
S. carpocasae+ M. anisopliae	0.5 b IJ'S ha^{-1} + 5 x 10^{11} spores ha^{-1}	12.02 (20.28)	10.51 (18.92)	6.45 (14.71)	1.88 (7.88)
H. indica + M. anisopliae	0.5 b IJ'S ha^{-1} + 5 x 10^{11} spores ha^{-1}	11.56 (19.88)	7.85 (16.27)	3.40 (10.62)	1.16 (6.18)
Chlorpyriphos 1.5D	25Kg ha^{-1}	3.69(11.07)	3.83 (11.28)	3.49 (10.77)	2.06 (8.25)
Imidacloprid 200SL	3.5g a.i. Kg^{-1} Seed	2.77 (9.58)	3.80 (11.24)	2.97 (9.92)	2.03 (8.19)
Chlorpyriphos 20 EC	5g a.i. Kg^{-1} Seed	2.30 (8.72)	2.84 (9.70)	2.92 (9.84)	2.00 (8.13)
Control		18.05 (25.14)	16.94 (24.30)	13.72 (21.74)	6.97 (15.31)
CD at 5 %		0.78	0.50	0.56	0.82

Figures in parentheses are $\sqrt{X + 0.5}$ transformed values.

Table 2. Impact of some biopesticides and insecticides on larval population of cutworm and maize yield (Pooled)**

Treatments	Dose	* Larval population per 8400 cm^3				Per cent Plant mortality	Per cent decrease in plant mortality over control	Yield t ha^{-1}	Per cent increase in yield over control
		7 DAS	14 DAS	21 DAS	28 DAS				
Steinernema carpocapsae	1 billion IJ's ha^{-1}	1.00 (1.21)	0.83 (1.15)	0.50 (1.00)	0.33 (0.91)	43.05 (41.00)	1.35 (6.80)	1.708	2.52
Steinernema carpocapsae	2 billion IJ's ha^{-1}	1.00 (1.21)	0.50 (1.00)	0.50 (1.00)	0.33 (0.91)	40.27 (39.39)	4.13 (11.68)	1.791	7.50
Heterorhabditis indica	1 billion IJ's ha^{-1}	0.83 (1.15)	0.83 (1.15)	0.66 (1.08)	0.17 (0.82)	38.88 (38.57)	5.52 (13.56)	1.833	10.02
H. indica	2 billion IJ's ha^{-1}	0.83 (1.15)	0.50 (1.00)	0.50 (1.00)	0.17 (0.82)	36.11 (36.93)	8.29 (16.74)	1.916	15.00
Metarrhizium anisopliae	$1x10^{12}$ spores ha^{-1}	0.83 (1.15)	0.50 (1.00)	0.33 (0.91)	0.17 (0.82)	26.38 (30.90)	18.02 (25.10)	2.208	32.53
Beauveria bassiana	$1x10^{12}$ spores ha^{-1}	0.83 (1.15)	0.67 (1.08)	0.33 (0.91)	0.33 (0.91)	34.72 (36.10)	9.68 (18.15)	1.958	17.52
S. carpocapsae + *B. bassiana*	0.5 b IJ'S ha^{-1} +5 $x10^{11}$ spores ha^{-1}	1.17 (1.29)	0.83 (1.15)	0.50 (1.00)	0.33 (0.91)	33.33 (35.26)	11.07 (19.46)	2.000	20.04
H. indica + B .bassiana	0.5 b IJ'S ha^{-1} +5 x 10^{11} spores ha^{-1}	1.17 (1.29)	0.50 (1.00)	0.50 (1.00)	0.33 (0.91)	31.94 (34.41)	12.46 (20.70)	2.041	22.50
S. carpocasae+ M. anisopliae	0.5 b IJ'S ha^{-1} +5 x 10^{11} spores ha^{-1}	1.00 (1.21)	0.50 (1.00)	0.33 (0.91)	0.17 (0.82)	27.77 (31.80)	16.63 (24.04)	2.166	30.01
H. indica + M. anisopliae	0.5 b IJ'S ha^{-1} +5 x 10^{11} spores ha^{-1}	0.83 (1.15)	0.50 (1.00)	0.17 (0.82)	0.33 (0.91)	22.22 (28.12)	22.18 (28.11)	2.333	40.03
Chlorpyriphos 1.5D	25 kg ha^{-1}	0.17 (0.82)	0.17 (0.82)	0.33 (0.91)	0.17 (0.82)	12.50 (20.70)	31.90 (34.39)	2.625	57.56
Imidacloprid 200SL	3.5 g a.i. kg^{-1} Seed	0.17 (0.82)	0.33 (0.91)	0.17 (0.82)	0.17 (0.82)	11.11 (19.47)	33.29 (35.24)	2.666	60.02
Chlorpyriphos 20 EC	5 g a.i. kg^{-1} Seed	0.17 (0.82)	0.33 (0.91)	0.17 (0.82)	0.17 (0.82)	9.72 (18.16)	34.68 (36.09)	2.708	62.54
Control		1.17 (1.29)	1.17 (1.29)	1.33 (1.35)	1.17 (1.29)	44.40 (41.78)		1.666	
CD (P = 0.05)		0.27	0.23	0.59	0.17	0.48	0.93	0.29	1.80

*Figures in parentheses are $\sqrt{X + 0.5}$ transformed value; **Figures in parentheses are angular transformed values *anisopliae*, which were on par with *S. carpocapsae* + *B. bassiana, S. carpocapsae* and *H. indica* each @ 1b IJs ha^{-1} (0.83 larvae), whereas control recorded 1.17 larvae which was significantly different from rest of the treatments.

Twenty one days after sowing, 0.17 larvae were recorded in chlorpyriphos 20EC, imidacloprid 200SL and *H. indica* + *M. anisopliae* which were statistically on par with *S. carpocapsae* (1b and 2b IJs ha^{-1}), *H. indica* (1b and 2b IJs ha^{-1}), *M. anisopliae, B. bassiana, S. carpocapsae* + *B. bassiana, H. indica* + *B. bassiana, S. carpocapsae* + *M. anisopliae* and chlorpyriphos 1.5D (0.50, 0.50, 0.66, 0.50, 0.33, 0.33, 0.50, 0.50, 0.33, 0.33 larvae, respectively), whereas 1.33 larvae were recorded in control. Similarly, 28 days after sowing, 0.17 larvae were recorded in chlorpyriphos 20EC, imidacloprid 200SL, chlorpyriphos 1.5D, *S. carpocapsae* + *M. anisopliae, M. anisopliae* and *H. indica* (1b and 2b IJs ha^{-1}), which were on par with *S. carpocapsae* (1b and 2b IJs ha^{-1}), *B. bassiana, S. carpocapsae* + *B. bassiana, H. indica*+ *B. bassiana* and *H. indica*+ *M. anisopliae* (0.33 larvae), whereas 1.17 larvae were recorded in control.

Gaugler (1981) highlighted the considerable role of EPN as biological control agents and alternatives to chemical control of insect pests. Epsky and Capinera (1993), Levine and Sadeghi (1993) and Cabanillas and Raultson (1996) demonstrated well that the black cutworm was susceptible to *S. carpocapsae* in both laboratory and field trials. Baur *et al.* (1997) compared the efficacy of *S. carpocapsae* against *A. ipsilon* and found that all strains infected the cutworm larvae. Similar findings were also reported by Hussaini *et al.* (2003), who found *S. carpocapsae, S. abbasi* and *H. indica* causing 60.0-80.0% mortality against cutworms.

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