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Research Article

Bio-efficacy of microbial insecticides against cabbage butterfly, *Pieris brassicae* (Lepidoptera: Pieridae) in NEH region of India

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ABSTRACT: The field experiments were conducted to study the bio-efficacy of microbial insecticides against *Pieris brassicae* Linnaeus in cabbage crop var. "Green Hero" in NEH region of India. The pooled data of two years indicated that *Metarhizium anisopliae* @ 1500 g/ha proved the most effective treatment in reducing the incidence of *P. brassicae* with a minimum mean leaf damage of 49.93 per cent as against 67.57 per cent in untreated control followed by *Beauveria bassiana* 10 SC @ 1000 ml ha^{-1} and *M. anisopliae* @ 1000 g ha^{-1} with a record of lower mean leaf damage of 51.68 and 51.85 per cent, respectively. The treatment *M. anisopliae* @ 1500 g ha^{-1} recorded maximum cabbage yield of 17.09 t ha^{-1} followed by *B. bassiana* 10 SC @ 1000 ml ha^{-1} treated plots (15.19 t ha^{-1}) and *M. anisopliae* @ 1000 g ha^{-1} (15.02 t ha^{-1}). The minimum yield (12.84 t ha^{-1}) was obtained from the plots treated with Dichlorvos 76 SL @ 500 ml with an increased yield of 3.09 t ha^{-1} over control, but, did not differ significantly from rest of the treatments. The extent of avoidable yield loss due to the incidence of *P. brassicae* was estimated to be 45.98 per cent in untreated control which was reduced to 9.41-28.86 per cent in treated plots. Minimum avoidable yield loss being recorded in *B. bassiana* 10 SC @ 1000 ml ha^{-1} and maximum avoidable yield loss in Dichlorvos 76 SL @ 500 ml ha^{-1} treatments. The net profit of the treatments varied from Rs. 28,350.00 (Dichlorvos 76 SL @ 500 ml ha^{-1}) to Rs. 77,150.00 (*M. anisopliae* @ 1500 gm ha^{-1}) with the cost-benefit ratio of 1:11.12 to 1:13.19 in the treatments. *Beauveria bassiana* 10 SC @ 1000 ml ha^{-1} gave the highest benefit-cost ratio of 1:13.19, while the lowest was in Dichlorvos 76 SL @ 500 ml ha^{-1} with 1:11.12.

KEY WORDS: Bio-efficacy, cabbage butterfly, microbial control, *Pieris brassicae*

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INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata* Linn.) is undoubtedly one of the most popular, oldest and extensively cultivated cole crop. Cabbage is a rich source of vitamins *i.e.,* A, B_1, C and minerals like Ca, P, K, Na & Fe (Yawalkar, 1980). In India, cabbage (*Brassica oleracea* var. *capitata* Linnaeus) is one of the most important cole crops grown throughout the country. It is mostly cultivated during cold seasons. India ranks third in cabbage production in the World. In the country, the crop occupies an area of about 2,45,400 hectares with a production of 56,17,100 tonnes. However, the average productivity of cabbage in India is about 22,890 kg/ ha, which is less than World's productivity of 23,985 kg/ ha. In Manipur, the total area under cabbage is only 1,000 hectares with a production of 10,100 metric tonnes. The productivity is only 10,100 kg/ ha in the State as compared to the national productivity of 22,890 kg per ha (Anon., 2012). In India, a total of 37 (thirty-seven) insect pests have been reported to feed on cabbage, of which the diamondback moth (*Plutella xylostella* Linnaeus), cabbage butterfly (*Pieris brassicae* Linnaeus), cabbage aphid (*Brevicoryne brassicae* Linnaeus) and the mustard aphid (*Lipaphis erysimi* Kaltenbach) are the major limiting factors for profitable cultivation of the crop (Lal *et al*., 2002). But, amongst these insect species, diamondback moth (*Plutella xylostella* Linnaeus), the cabbage butterflies (*P. brassicae*, *P. canidia* and *P. rapae*), the cabbage looper (*Trichoplusia orichalcea*), mustard aphid, *L. erysimi* and the cabbage butterfly, *B. brassicae* are the most important and regular pests of this crop in the State. Out of these pests, *Pieris* spp are considered to be the serious pests of cruciferous crops causing about 20-100 per cent damage (Sachan and Gangwar, 1980). *Pieris brassicae* and *P. canidia* belong to Pieridae family of order Lepidoptera.

Pieris brassicae is the large butterfly which is known as cabbage butterfly or cabbage white butterfly. The eggs appear as yellow and become black and transparent few hours prior to hatching. Large white larvae experience four

moultings with five instars and they are light yellow in colour with distinctive brown heads. Males have white wings with black tips on forewings. Females have two black spots on each forewing. Underside of wing is pale greenish. *Pieris canidia* is the Indian cabbage white butterfly where males have scattered black scales on the base of the forewings while females have more prominent scattered black scales. Several broad-spectrum synthetic organic insecticides are usually recommended for the effective control of these pests (Singh *et al*., 1993; Sonkar and Desai, 1998). However, these compounds are known to evoke multifarious problems including environmental pollution, health hazards, destruction of beneficial fauna like parasitic, predatory and pollinating insects, resistance to insecticides, resurgence of secondary insect pests etc. Moreover, excessive use of such persistent insecticides on vegetables is acquiring a special concern since there is a little time lag between the last application and harvest of the produce. Owing to wide spectral problems with the use of these insecticides, use of eco-friendly insecticides like microbial insecticides is gaining popularity in pest management because of their safety to non – targeted organisms and non-biomagnification in the food chain. Moreover, chemical pesticide residues are the major constraints in the export of vegetables. Therefore, in the present scenario, total reliance on such pesticides is not desirable. Hence, an attempt was made to conduct the present investigation on evaluation of certain microbial insecticides at different doses against the cabbage butterfly.

MATERIALS AND METHODS

Field experiments were conducted during *Rabi* season in in the years 2016-2017 and 2017-18 at the Vegetable Research Farm, College of Agriculture, Central Agricultural University, Iroisemba, Imphal to evaluate the efficacy of two microbial insecticides each at three different doses against *P. brassicae* in cabbage variety "Green Hero". All the recommended agronomic practices were adopted for growing the experimental crop for the experiments under study. For the experiment, seedlings were raised in properly prepared nursery beds. Before sowing, the seeds were treated with Carbendazim 12% + mancozeb 63% 75 W.P. @ 2.00 gm per kg of seed in order to make the seeds disinfected from fungal diseases. The thirty days old seedlings were used for transplantation in the main field. The experiment was laid out in Randomized Block Design (RBD) with cabbage var. "Green Hero". There were 8 (eight) treatments including one untreated control and each treatment was replicated thrice. There were altogether eight treatments comprising of six microbials *viz., Beauveria bassiana* 10 SC @ 500 ml/ha,*Beauveria bassiana* 10 SC @ 1000 ml/ha, *Beauveria bassiana* 10 SC @ 1500 ml/ ha, *Metarrhizium anisopliae* @ 500 ml/ ha, *Metarhizium anisopliae* @ 1000 ml/ha and *Metarhizium anisopliae* @ 1500 ml/ha, one check chemical insecticide (dichlorvos 76 SL @ 500 ml/ha) including one control. Spray solution consisting of different insecticides in desired concentration was prepared separately for each treatment. All the spray treatments were applied by a high volume hand compression knapsack sprayer thrice at ten days intervals commencing from appearance of pests. The volume of the spray liquid was kept at 500 litres/ ha. All the insecticides applied in the evening hours. Care was taken at the time of spraying to avoid drifting of the insecticidal spray solution from one plot to another and to give a thorough coverage of the plants. Plain water was sprayed on the plants of untreated control plots. The relative field efficacy of the test insecticides against *P. brassicae* was determined by recording the per cent leaf damage from five randomly selected plants of each plot. Observations were made at 1 day before, and 3, 5, 7 and 10 days after each application of insecticides. Plot-wise cabbage yield was recorded at harvest of the crop and computed to tonnes per hectare. The cabbage yield obtained from each plots was recorded and converted to tonnes per hectare as follows:

$$\text{Cabbage yield (tonnes/ha)} = \frac{\text{Yield per plot in tonnes}}{\text{Plot size in sq.m}} \times 10{,}000$$

Avoidable yield loss (%) due to pest infestation for all the treatments was computed by using formula suggested by Pawar et al. (1994).

$$\% \text{ avoidable loss} = \frac{T - C}{T} \times 100$$

where,

T= Yield in most effective treatment

C= Yield in respective treatment

The per cent yield increase of different insecticidal treatments over control was also determined by using the following formula:

$$\% \text{ yield increase} = \frac{a - b}{b} \times 100$$

Where,

a = Yield of respective treatment

b = Yield of untreated control

The data obtained from the experiments were computed to determine the mean values. The mean values after suitable transformation were subjected to statistical analysis to test significance as per Analysis of Variance for interpretation of the results.

RESULTS AND DISCUSSION

The salient findings obtained from various field experiments carried out on the comparative bio-efficacy of two microbial insecticides each at three doses against the cabbage butterfly, *Pieris brassicae* and their effect on the yield of cabbage crop revealed that *M. anisopliae* @ 1500 gm/ha found to be the most effective insecticide in suppression of *P. brassicae* population with lowest mean leaf damage of 49.93 % against 67.57% in untreated control. The second most effective treatment was *B. bassiana* 10 SC @ 1000 ml/ha (51.68%) and *M. anisopliae* @ 1000 gm/ha (51.85%) which showed non significant difference with the effectiveness of *M. anisopliae* @ 1500 gm/ha. Beaauveria bassiana10 EC @ 250 ml/ ha exhibited the least effective treatment against P. brassicae with a record of maximum mean leaf damage incidence of 57.11 per cent. Its least effectiveness was on par with *B. bassiana*10 SC @ 1000 ml/ha (55.07%), *M. anisopliae* @ 500 gm/ha (54.84%) and Dichlorvos 76 SL @ 500 ml/ha (54.84%). However, all the insecticidal treatments recorded significantly lower leaf damage as compared to untreated control. Significant reduction of the pest (Table 1).

The results obtained in this experiment on the effectiveness of *M. anisopliae* @ 1500 gm/ ha, *B. bassiana* 10 SC @ 1000 ml/ ha and *M. anisopliae* @ 1000 gm/ ha against *P. brassicae* are in conformity with the findings of Atcha (1998) who stated that the highest dose of 10^9 spores of *B. bassiana* 5653 and *M. anisopliae* 180 caused 53.8 per cent, 50.6 per cent and 20.0 per cent mortality of larvae and pupae of a Lepidopteran pest (*P. xylostella*) on cabbage, respectively. The present findings of *B. bassiana* and *M. anisopliae* are supported by Vodouhe (1999) who tested seven strains of *B. bassiana* and two *M. anisopliae* strains for their virulence on *P. xylostella* and reported that the different strains of both fungus were found to be pathogenic to the larvae of *P. xylostella*. However, the *B. bassiana* strain 5653 caused the highest mortality of 94 per cent with highest sporulation rate of 62 per cent. The reports of Zhao *et al*. (2003) who opined that *M. anisopliae* when applied at a dilution rate of 1:20 gave a control efficacy of 77.48 per cent against *P. xylostella* and 77.73 per cent against *P. rapae*. In Egypt, Sabbour *et al*. (2005) tested some microbial control agents *viz*., *Bacillus thuringiensis, B. bassiana* and *M. anisopliae* under green house and in the field condition and reported that the percentage of infestation reached to 20,15 and 21 per cent of *P. xylostella, Pieris rapae* and *S. exigua,* respectively after 90 days of treatment with *M. anisopliae* and 21, 20 and 21 per cent after treatment with *B. bassiana* after 90 days, which encourage the present findings of *B. bassiana* and *M. anisopliae* in effective control of *P. brassicae.* The present results are in conformity with Godonou *et al.* (2008) who screened 8 isolates of the entomopathogenic fungi for virulence against *P. xylostella*. The *B. bassiana* isolates tested were Bba14, Bba5645, Bba5654, Bba44 and Bba5653 and the *M. anisopliae* isolates were Ma178 and Ma182. Out of different isolates Bba5653 caused 94 per cent mortality of diamondback moth larvae. The less effectiveness of dichlorvos 76 SL @ 500 ml/ ha against *P. brassicae* observed in the present investigation is in agreement with the results of Devjani and Singh (2001) who reported among the different insecticides tested their efficacy against major insect pests of cauliflower in Manipur, dichlorvos showed poor performance against *P. xylostella*. The least effectiveness of the dichlorvos 76 SL @ 500 ml/ ha treatment against *P. brassicae* may be due to their low contact toxic action and minimum residual toxic effect on cabbage plants.

The mean yield data of two experimental years revealed that the minimum yield (9.75 t/ha) was obtained from untreated control, which was significantly lower than that of the yields harvested from the insecticidal treatments (12.84 to 18.05 t/ha). The highest being recorded in *M. anisopliae* @ 1500 gm/ ha treatment and lowest in dichlorvos 76 SL @ 500 ml/ha treatment. The yields obtained from *M. anisopliae* @ 1500 gm/ha was followed by *B. bassiana* 10 SC @ 1000 ml/ha (16.35 t/ha) and *M. anisopliae* (*M. anisopliae*) @ 1000 g/ ha (15.84 t ha^{-1}) which did not differ significantly from each other. The mean yield recorded in the plots of the treatments *viz*., *B. bassiana* 10 SC @ 500 ml/ha, *M. anisopliae* @ 500 gm/ha, *B. bassiana* 10 SC @ 250 ml/ha were found to be at par recording a mean yield of 14.47 t/ha, 14.40 t/ha and 13.07 t/ha, respectively. However, it is amply clear that all the microbial insecticides applied each at three doses were superior in controlling *P. brassicae* in comparison to untreated control. *M. anisopliae* @ 1500 gm/ha treatment showed 85.12 per cent increase in yield over control, which was the highest among all the test insecticides. This was closely followed by *B. bassiana* 10 SC @ 1000 ml/ ha and *M. anisopliae* (*M. anisopliae*) @ 1000 gm/ha with 67.69 and 62.46 per cent, respectively. The standard synthetic organic insecticide (dichlorvos 76 SL) was least effective in reduction of pest incidence with 31.69 per cent increase in yield over control.

The analysis of cost-benefit ratio revealed that the use of *B. bassiana* 10 SC @ 1000 ml/ha recorded higher yield with lower cost of pest control (Rs. 3,600.00/ ha).

The present findings indicated the effectiveness of *B. bassiana* and *M. anisopliae* in reducing the incidence of *P. brassicae* and further increase in the yield of cabbage.

Table 1. Relative effect of microbial insecticides on cabbage butterfly, *P. brassicae* in cabbage during 2016–17

Treatment	Dose in ml or gm per hectare	Mean leaf damage (%)			Pooled Mean	[1]Composite Mean leaf damage(%) over 1st , 2nd and 3rd spray				
		1st spray	2nd spray	3rd spray		1 DBA	3 DAA	5 DAA	7 DAA	10 DAA
T_1= *B. bassiana*	250 ml	64.87	56.71	51.18	57.59	67.57	59.64	57.65	56.86	55.28
T_2= *B. bassiana*	500 ml	65.44	57.78	51.73	58.32	69.40	61.05	58.40	56.72	55.77
T_3= *B. bassiana*	1000 ml	63.07	51.48	44.74	53.10	68.00	55.97	53.02	51.41	50.33
T_4= *M. anisopliae*	500 gm	63.83	56.41	50.36	56.87	65.33	59.33	56.96	55.79	54.88
T_5= *M. anisopliae*	1000 gm	61.43	52.52	45.45	53.13	65.63	55.30	53.74	51.61	50.47
T_6= *M. anisopliae*	1500 gm	61.17	49.89	43.57	51.54	66.20	53.81	52.01	50.54	48.13
T_7= Dichlorvos 76 SL	500 ml	60.77	50.80	46.08	52.55	66.97	54.40	53.25	50.92	49.55
T_8= Control (water)	–	65.17	67.89	68.53	67.20	62.90	66.70	67.21	67.48	68.16
SE(m) ±	–	**1.50**	**1.40**	**1.33**	**2.86**	**1.53**	**3.02**	**2.75**	**2.53**	**2.38**
CD(P=0.05)	–	**3.22**	**3.00**	**2.84**	**6.14**	**NS**	**6.47**	**5.90**	**5.42**	**5.10**

DBA= Days before application; DAA= Days after application; NS= Non significance; [1]Composite means of 3 replications recorded at 3, 5, 7 and 10 DAA

Table 2. Effect of microbial insecticides on the incidence of *P. brassicae* and yield in cabbage during 2016–2017

Treatment	Dose in ml or gm per hectare	[1]Mean leaf damage per cent due to *P. brassicae*	[2]Average cabbage yield (t/ha)
T_1= *B. bassiana*	250 ml	57.59	13.69
T_2= *B. bassiana*	500 ml	58.32	16.79
T_3= *B. bassiana*	1000 ml	53.10	17.51
T_4= *M. anisopliae*	500 gm	56.87	15.85
T_5= *M. anisopliae*	1000 gm	53.13	16.65
T_6= *M. anisopliae*	1500 gm	51.54	19.00
T_7= Dichlorvos 76 SL	500 ml	52.55	13.04
T_8= Control (water)	–	67.20	9.84
SE(m) ±	–	**2.86**	**0.40**
CD(P=0.05)	–	**6.14**	**0.86**

[1]Mean of three sprays based on four time intervals *i.e.* 3, 5, 7 and 10 days after application; [2]Average yield (t/ha) of three replications

Table 3. Relative effect of microbial insecticides on the incidence of cabbage butterfly, *P. brassicae* during Rabi, 2017–18

Treatment	Dose in ml or gm per hectare	Mean leaf damage (%)			Pooled Mean	[1]Composite Mean leaf damage(%) over 1st , 2nd and 3rd spray				
		1st spray	2nd spray	3rd spray		1 DBA	3 DAA	5 DAA	7 DAA	10 DAA
T_1= *B. bassiana*	250 ml	64.55	53.86	42.48	56.63	67.77	56.88	54.41	52.46	49.69
T_2= *B. bassiana*	500 ml	63.85	51.07	40.51	51.81	69.00	55.57	52.44	50.24	47.28
T_3= *B. bassiana*	1000 ml	63.23	49.33	38.18	50.25	69.20	53.97	51.18	48.47	45.38
T_4= *M. anisopliae*	500 gm	63.44	53.14	41.83	52.8	67.87	56.69	54.11	50.58	48.35
T_5=*M. anisopliae*	1000 gm	62.53	49.99	39.16	50.56	67.67	54.06	51.81	48.75	45.91
T_6= *M. anisopliae*	1500 gm	61.55	47.52	35.86	48.31	68.00	51.98	49.43	46.27	43.41
T_7= Dichlorvos 76 SL	500 ml	66.73	55.82	44.07	55.54	69.00	58.83	56.78	53.97	51.81
T_8= Control (water)	_	67.37	67.38	69.04	67.93	67.00	67.96	68.12	67.21	68.56
SE(m) ±	_	**1.31**	**1.36**	**1.59**	**3.68**	**1.15**	**3.66**	**3.63**	**3.57**	**3.37**
CD(P=0.05)	_	**2.80**	**2.92**	**3.42**	**7.90**	**2.47**	**7.85**	**7.78**	**7.66**	**7.22**

DBA= Days before application; DAA= Days after application; NS= Non significance;
[1]Composite means of 3 replications recorded at 3, 5, 7 and 10 DAA

Table 4. Effect of certain microbial insecticides on the incidence of *P. brassicae* and yield in cabbage during 2017–2018

Treatment	Dose in ml or gm per hectare	[1]Mean leaf damage per cent due to *P. brassicae*	[2]Average cabbage yield (t/ha)
T_1= *B. bassiana*	250 ml	56.63	12.45
T_2= *B. bassiana*	500 ml	51.81	12.14
T_3= *B. bassiana*	1000 ml	50.25	15.19
T_4= *M. anisopliae*	500 gm	52.8	12.94
T_5= *M. anisopliae*	1000 gm	50.56	15.02
T_6= *M. anisopliae*	1500 gm	48.31	17.09
T_7= Dichlorvos 76 SL	500 ml	55.54	12.84
T_8= Control (water)	_	67.93	9.66
SE(m) ±	_	**3.68**	**0.41**
CD(P=0.05)	_	**7.90**	**0.88**

[1]Mean of three sprays based on four time intervals i.e., 3, 5, 7 and 10 days after application; [2]Average yield(t/ha) of three replications

Table 5. Relative effect of microbial insecticides on the incidence of *P. brassicae* in cabbage during 2016-2017and 2017–2018

Treatment	Dose in ml or gm per hectare	[1]Mean leaf damage (%) due to *P. brassicae*		[2]Pooled Mean
		2016-2017	2017-2018	
T_1= *B. bassiana*	250 ml	57.59	56.63	57.11
T_2= *B. bassiana*	500 ml	58.32	51.81	55.065
T_3= *B. bassiana*	1000 ml	53.10	50.25	51.675
T_4= *M. anisopliae*	500 gm	56.87	52.8	54.835
T_5= *M. anisopliae*	1000 gm	53.13	50.56	51.845
T_6= *M. anisopliae*	1500 gm	51.54	48.31	49.925
T_7= Dichlorvos 76 SL	500 ml	52.55	55.54	54.045
T_8= Control (water)	_	67.20	67.93	67.565
SE(m) ±	_	**2.86**	**3.68**	**1.47**
CD(P=0.05)	_	**6.14**	**7.90**	**3.47**

[1]Mean leaf damage of three replications; [2]Mean of two years based on three replications

Table 5. Relative effect of microbial insecticides on yield of cabbage during 2016–2017and 2017–2018

Treatment	Dose in ml or gm per hectare	[1]Average cabbage yield (t/ha) during		[2]Pooled yield (t/ha)
		2016-2017	2017-2018	
T_1= *B. bassiana*	250 ml	13.69	12.45	13.07
T_2= *B. bassiana*	500 ml	16.79	12.14	14.47
T_3= *B. bassiana*	1000 ml	17.51	15.19	16.35
T_4= *M. anisopliae*	500 gm	15.85	12.94	14.40
T_5= *M. anisopliae*	1000 gm	16.65	15.02	15.84
T_6= *M. anisopliae*	1500 gm	19.00	17.09	18.05
T_7= Dichlorvos 76 SL	500 ml	13.04	12.84	12.84
T_8= Control (water)	_	9.84	9.66	9.75
SE(m) ±	_	**0.40**	**0.41**	1.03
CD(P=0.05)	_	**0.86**	**0.88**	2.44

[1]Average cabbage yield (t/ha) of three replications; [2]Mean cabbage yield (t/ha) of two years based on three replications

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