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Comparative efficacy of *Beauveria bassiana* and NSKE against diamondback moth (*Plutella xylostella* L.) on cabbage (*Brassica oleracea* L.)

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Abstract
The field experiment was conducted during *Rabi* season of 2014-2015 at the central research farm of Sam Higginbottom Institute of Agriculture Technology and Sciences, Deemed-to-be-University, Allahabad. Evaluated the efficacy of different doses of *Beauveria bassiana* and NSKE against Diamond Back Moth (*Plutella xylostella*). Observed that the maximum reduction per cent of *Beauveria bassiana* 6% (57.79%) as compared to treated (cypermethrin 25 EC) and untreated control (60.85% and 0.00% respectively). The maximum yield and cost benefit ratio was recorded in *Beauveria bassiana* 6% (234.87 q/ha and 1:6.42) as compared to treated and untreated control (258.36 q/ha, 1:6.67 and 98.46 q/ha 1:2.78 respectively).

Keywords: *Beauveria bassiana*, NSKE, cabbage (*Brassica oleracea* L.), cost benefit ratio, percent population reduction

Introduction
Cabbage is the second most important Cole crop, which originated in Europe and in the Mediterranean region after cauliflower. Cabbage is one of the most popular winter vegetables grown in India. Cabbage is being widely cultivated in Uttar Pradesh, Orissa, Bihar, Assam, West Bengal, Maharashtra and Karnataka in India. Area, Production and Productivity of cabbage crop were given below. India is the second largest producer of cabbage in the world after China. India producing 909.2 million tonnes (5.5 per-cent of total vegetable production) in an area of 400.1 ha.(4.3 per-cent of total vegetable area) with a productivity of 22.6 MT/ha. Highest production of cabbage in India is found in West Bengal. Highest Cabbage producing states of India, West Bengal, Orissa and Bihar, 2197.4 tonnes, 1150.9 tonnes and 735.0 tonnes respectively. (Anonymos, 2014) [1].
The cabbage crop is attacked by a number of different insect pests and among them Cabbage caterpillar (*Pieris brassicae* Linnaeus), diamondback moth (*Plutella xylostella* Linnaeus), Cabbage semi-looper (*Thysanoplusia orichalcea* Fabricius and *Autographa nigrisigna* Walker), tobacco caterpillar (*Spodoptera litura* Fabricius), Cabbage leaf webber (*Crocodolomia binotalis* Zeller), cabbage borer (*Hellula undalis* Fabricius) and cabbage flea beetles (*Phyllotreta cruciferae* Goeze, *P. chotanica* Duviv, *P. birmanica* Harold., *P. oncera* Maulik and *P. downesi* Baly) are the pests of major importance (Atwal and Dhaliwal 2002) [3]. The diamondback moth (DBM), *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) is a serious pest and a major constraint in the production of cruciferous crops throughout the world. This pest has been reported to cause more than 90% crop loss in the area of their outbreaks (Verkerk and Wright, 1996) [10].

Materials and Mathods
Experimental site: The field experiment consisted of eight treatments was conducted in the central field of the Department Plant Protection, Sam Higginbottom Institute of Agriculture, Technology and Sciences (Deemed-to-be university) Allahabad during *rabi* season 2014-15. The experiment field was conducted in randomized block design with three replication for each treatment. The site selected was uniform, cultivable with sandy loam soil having good drainage.

Experimental design and treatment: The present investigation was carried out on the Diamond Back Moth (*Plutella xylostella*). Eight different treatments, consisting application of *Beauveria bassiana* 2% (T_1), *Beauveria bassiana* 4% (T_2) *Beauveria bassiana* 6% (T_3) NSKE 2% (T_4), NSKE 4% (T_5), NSKE 6% (T_6), treated (Cypermethrin 25%EC T_7) and untreated control were evaluated against DBM on three replication in randomized block design. Two sprays were applied during the investigation period. The first spray was applied as soon as the pest level crossed the ETL i.e. 4-5 larvae per plant.

Recording of observation (Larval population): To study the relative efficacy of different dose of *Beauveria bassiana* and NSKE against diamondback moth, (*Plutella xylostella*) of cabbage and its population counts were recorded by randomly selecting 5 plants. The population count of diamondback moth larvae was recorded on the day before every spray which served as pre-treatment observation and the subsequent counts were taken on three, seven and ten days after each spray (Post-treatment).

On the basis of population existing earlier (Pre-treatment) and surviving after application on three, seven and ten day, the observation on the larval population were taken preferably during morning hours.

The percent reduction in the population of this pest was worked out by using following formula:

$$P = \frac{T_a - T_b}{T_a} \times 100$$

Where,

P = Percent reduction in the population of pest.

Ta = Number of pest individuals before application (Pre-treatment count).

Tb = Number of surviving pest individuals on particular day after application.

Benefit Cost Ratio: Gross return was calculated by multiplying total yield with the market price of the produce. Cost of cultivation and cost of treatment imposition was deducted from the gross returns, to find out net returns and cost benefit ratio by following formula

$$B: C = \frac{\text{Gross return}}{\text{Cost of treatment}}$$

Were, B: C–Benefit and Cost ratio

Results and Discussion

The results obtained on average per cent reduction of *Plutella xylostella* on cabbage for evaluating each treatment for diamond back moth management. Among the different dose of *Beauveria bassiana* and NSKE used. The observation of larval population reduction per cent of Diamond Back Moth (*Plutella xylostella)* on cabbage revealed that the maximum reduction per cent of *Beauveria bassiana* 6% (57.79%) as compared to treated and untreated control (60.85% and 0.00% respectively) and which was significantly superior over control followed by NSKE 6% (57.25%) *Beauveria bassiana* 4% (53.48%), NSKE 4% (52.06%), *Beauveria bassiana* 2% (46.46%) and NSKE 2% (45.66%) was least effective among all the treatments (Table no. 1).

The yields among the different dose of *Beauveria bassiana* and NSKE were significant. The maximum yield was recorded in *Beauveria bassiana* 6% (234.87 q/ha) as compared to treated and untreated control (258.36 q/ha and 98.46 q/ha). *Beauveria bassiana* 6% was followed by NSKE 6% (218.48 q/ha), *Beauveria bassiana* 4% (197.61 q/ha), NSKE 4% (186.38 q/ha), *Beauveria bassiana* 2% (174.67 q/ha), NSKE 2% (163.24 q/ha). Among the treatments studied, the best and most economical treatment was *Beauveria bassiana* 6% (1:6.42) as compared to treated and untreated control (1:6.76 and 1:2.78 respectively). *Beauveria bassiana* 6% was followed by NSKE 6% (1:5.97), *Beauveria bassiana* 4% (1:1.50), NSKE 4% (1:5.10), *Beauveria bassiana* 2% (1:4.77) and NSKE 2% (1:4.46) (Table no. 1).

Table 1: Evaluated the effect of different dose of *B. bassiana* and NSKE on population reduction of (*Plutella xylostella*).

S. No.	Treatment Name	% Reduction in larval population of DBM 1st spray					% Reduction in larval population of DBM 2nd spray				Mean 1st &2nd spray	B:C ratio
		BS	3DAS	7DAS	10DAS	Mean	3DAS	7DAS	10DAS	Mean		
T_1	*B. bassiana* 2%	4	21.75^{fg} (27.79)*	41.34^{f} (40.01)*	47.02^{f} (43.29)*	36.70^{cf} (37.28)*	40.55^{g} (39.55)*	62.44^{def} (52.20)*	65.72^{df} (54.16)*	56.23^{bcdef} (48.57)*	46.46^{def} (42.97)*	1:4.77
T_2	*B. bassiana* 4%	4.27	26.69^{e} (31.10)*	51.25^{cd} (45.71)*	63.41^{cd} (52.77)*	47.11^{bcd} (43.34)*	46.44^{de} (42.95)*	64.30^{d} (53.30)*	68.83^{bc} (56.06)*	59.85^{bcd} (50.68)*	53.48^{abcd} (46.99)*	1:5.40
T_3	*B. bassiana* 6%	3.80	38.25^{c} (38.20)*	56.18^{b} (48.55)*	66.30^{b} (54.51)*	53.57^{ab} (47.04)*	49.85^{c} (44.91)*	68.14^{ab} (55.63)*	70.50^{ab} (57.10)*	62.83^{ab} (52.43)*	58.20^{ab} (49.63)*	1:6.42
T_4	NSKE 2%	3.53	22.46^{f} (28.28)*	40.76^{fg} (39.67)*	42.35^{g} (40.59)*	35.19^{fg} (36.38)*	45.91^{def} (42.65)*	59.85^{g} (50.68)*	62.66^{g} (52.33)*	56.14^{bcdefg} (48.52)*	45.66^{defg} (42.51)*	1:4.46
T_5	NSKE 4%	3.87	29.16^{d} (32.68)*	49.20^{de} (44.54)*	56.76^{e} (48.88)*	45.04^{bcde} (42.15)*	47.85^{cd} (43.76)*	62.77^{de} (52.39)*	66.67^{de} (54.73)*	59.09^{bcde} (50.23)*	52.06^{de} (46.18)*	1:5.10
T_6	NSKE 6%	4.13	40.19^{b} (39.24)*	52.63^{c} (46.50)*	64.40^{bc} (53.36)*	52.40^{bc} (46.37)*	52.35^{b} (46.34)*	66.38^{abc} (54.56)*	67.61^{d} (55.31)*	62.11^{bc} (52.01)*	57.25^{abc} (49.16)*	1:5.97
T_7	Cypermethrin25C 0.05% (Treated)	3.67	45.50^{a} (42.41)*	60.11^{a} (50.83)*	68.56^{a} (55.89)*	58.05^{a} (49.63)*	56.20^{a} (48.56)*	68.20^{a} (55.67)*	70.85^{a} (57.52)*	65.08^{a} (53.37)*	61.56^{a} (51.68)*	1:6.76
T_0	Untreated /Control	3.73	0.00^{h}	0.00^{h}	0.00^{h}	0.00^{h}	0.00^{h}	0.00^{h}	0.00^{h}	0.00^{h}	0.00^{h}	1:2.78
	F-Test	NS	S	S	S	S	S	S	S	S	S	
	S.Ed(±)	1.05	0.80	1.02	1.0	4.54	0.93	0.87	0.80	3.36	4.71	
	C.D.(P= 0.05)	2.25	1.73	2.18	2.15	9.75	2.01	1.87	1.71	7.22	11.14	

Conclusion

From the critical analysis of the present findings of "Comparative efficacy of *Beauveria bassiana* and NSKE against Diamond Back Moth (*Plutella xylostella* L.) on cabbage *(Brassica oleracea* L.)". It was concluded that among all the treatment *Beauveria bassiana* 6% proved to be the best treatment. NSKE 6%, *Beauveria bassiana* 4% also effective in managing *Plutella xylostella* reduction. *Beauveria bassiana* is a effective entomofagous fungus and safe for environment, human health and hazards. *Beauveria bassiana* and NSKE may be useful in devising proper integrated pest management strategy against diamondback moth.

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