

Original Research Article

Bio-efficacy and economics of Diatomaceous earth against gram pod borer [*Helicoverpa armigera* (Hubner)] in chickpea with combination of *Beauveria bassiana*, *Metarhizium anisopliae* and neem oil.

ABSTRACT

An experiment was conducted during 2021-22 to study the effect of Diatomaceous earth and biopesticides against gram pod borer [*Helicoverpa armigera* (Hubner)] in chickpea at Central Research Farm (CRF), Department of Entomology, SHUATS, Prayagraj during *rabi* season with seven treatments i.e., Diatomaceous earth (T₁), Neem oil 3% (T₂), *Beauveria bassiana* 1.5% L.F (T₃), *Metarhizium anisopliae* (T₄), Diatomaceous earth+neem oil 3% (T₅), Diatomaceous earth+ *B.bassiana* 1.5% L.F (T₆), Diatomaceous earth+ *M. anisopliae* (T₇) and untreated control (T₈) were evaluated against chickpea pod borer (*H.armigera*). Results revealed that, among the different treatments, the highest per cent population reduction of chickpea pod borer was recorded in Diatomaceous earth+neem oil 3% (72.48%) followed by Diatomaceous earth+ *B.bassiana* 1.5% L.F (71.24%), Diatomaceous earth+ *M.anisopliae* (69.40%). It is followed by Diatomaceous earth (66.05%) and neem oil 3% (38.32%), *B.bassiana* 1.5% L.F (36.45%) and *M. anisopliae* (31.94%) was the least effective among all treatments. While, the highest yield 20.55q/ha was obtained from the treatment Diatomaceous earth+neem oil 3% as well as B:C ratio 1:3.58 was obtained high from this treatment. It was followed by Diatomaceous earth+ *B.bassiana* 1.5% L.F (1:3.49), Diatomaceous earth+ *M.anisopliae* (1:3.24), Diatomaceous earth (1:2.96), neem oil 3% (1:2.54), *B.bassiana* 1.5% L.F (1:2.34), *M. anisopliae* (1:2.12), as compared to Control (1:1.39).

KEYWORDS: Bio-efficacy, benefit cost ratio, *Cicer arietinum*, diatomaceous earth, *Helicoverpa armigera*.

INTRODUCTION

Chickpea, [*Cicer arietinum* L.] is the third most important food legume. It is a legume plant of family Fabaceae. It is a herbaceous annual plant with height ranging from 30-70 cm. It has tap root

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system bearing symbiotic nodules with rhizobium bacteria which are capable of fixing atmospheric nitrogen in plant usable form. Chickpea pod borer [*Helicoverpa armigera* (Hubner)] (Lepidoptera: Noctuidae) is a polyphagous pest, Multivoltine and cosmopolitan pest and is reported to feed and breed on 182 species of host plants belonging to 47 families in India, which ~~causes~~ causes severe damage in chickpea (Sithanantham, 1983 and Pawar, 1998). It causes 90 to 95 % of total damage in chickpea. This pest ~~have~~ has high mobility, high reproductive rate and diapause are major factors contributing to its serious pest status (Fitt et al., 1989 and Sharma et al., 2005).

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~~*H. armigera*, which causes severe losses in chickpea. Though,~~ Application of Diatomaceous earths (DE), Neem oil and entomopathogenic fungi with different mode of action at proper crop stage is significant for its management. Diatomaceous earths are a type of naturally occurring soft siliceous sedimentary rock, consisting of the fossilized exoskeleton of unicellular algae. Inert powders are rich in silicon and can prevent the attack of pests and plant diseases. Prolonged activity, along with the difficulty of insects to develop resistance to this type of product, make ~~these~~ them important tools in pest control (Costa et al., 2006), (Korunic et al., 1998), (Lorini et al., 2001). DE kills insects by removing the protective lipid layer of the insect cuticle, leading to death by dehydration. The abrasive activity of DE enhanced the insecticidal efficacy of entomopathogenic fungi. So, Inert dusts synergized the pathogenicity of *B. bassiana* and *M. anisopliae*. (Athanassiou et al., 2006).

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These cues led us to investigate the entomotoxicity of Diatomaceous earth, biopesticides and their combinations against *H. armigera*.

MATERIALS AND METHODS

The experiment was conducted at Central Research Field (CRF), Department of Entomology, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (UP) during 2021-22 during *rabiseason*.

The experiment ~~material consist of~~ was laid out using *pusa 362* variety of chick pea, which ~~is~~ was released from Indian Agricultural research institute New delhi. The experiment was ~~laid out~~ sown in randomized block design with three replications consisting of 7 treatments having one control, Diatomaceous earth, neem oil and two entomopathogenic fungi *Beauveria bassiana* and *Metarhizium anisopliae* were used. Diatomaceous earth (T1), Neem oil 3% (T2), *B. bassiana* 1.5% L.F (T3), *M. anisopliae* (T4), Diatomaceous earth+neem oil 3% (T5), Diatomaceous earth+ *B. bassiana* 1.5% L.F (T6), Diatomaceous earth+ *M. anisopliae* (T7). The seed rate of 80 kg /

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ha was utilized to raise the crop. Plots of size of 2m×2m was made. Sowing was done with 30 cm × 10 cm spacing and applied dose of FYM ~~is~~was 12.5t/ha and N, P, K is 25 kg, 50kg and 25kg/ha respectively. The population of *Helicoverpa armiger* was recorded before 1-day, 3rd day, 7th day and 14th day after insecticidal application. The populations of *H. armiger* was recorded on 5 randomly selected and tagged plants from each plot and then it was converted into percent of reduction by following formula., following formula giving by (Henderson et al., 1955)

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$$\text{Percent reduction} = \frac{\text{Population in control} - \text{Population in treatment}}{\text{Population in control}} \times 100$$

The benefit cost ratio (BCR) was determined by dividing the additional returns with the additional cost of imposing the respective treatment on hectare basis. following formula ~~giving~~by given by (Hossain et al., 2010).

$$B.C.R = \frac{\text{Gross Returns}}{\text{Total Cost of Protection}}$$

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RESULTS AND DISCUSSION

First spray: Per cent population reduction of chickpea pod borer on 3rd, 7th and 14th day revealed that all the treatments were significantly superior over control. Among all the treatments the highest per cent larva reduction was recorded in T₅ - Diatomaceous Earth+Neem oil 3% (71.329%) followed by T₆ - Diatomaceous Earth+ *Beauveria bassiana* 1.5% L.F (69.98%), T₇ - Diatomaceous Earth+ *Metarhizium anisopliae* (68.106%), T₁ - Diatomaceous Earth (63.7699%), T₂ - Neem oil 3% (25.81%), T₃- *B. bassiana* 1.5% L.F (23.94%) and Treatment T₄ - *M. anisopliae* (20.1085%) was reported with minimum per cent larva reduction. (T₄, T₃, T₂,) and (T₁, T₇, T₆, T₅), was found statistically at par with each other.

Second spray: Per cent population reduction of chickpea pod borer on 3rd, 7th and 14th revealed that all the treatments were significantly superior over control. Among all the treatments the highest per cent larva reduction was recorded in T₅(73.766%) followed by T₆ (71.94%), T₇ (71.29%), T₁ (68.40%), T₂ (50.75%), T₃ (48.99%) and Treatment T₄ (43.73%) was reported with minimum per cent population reduction. (T₄, T₃, T₂,) and (T₁, T₇, T₆, T₅) was found statistically at par with each other.

The data on the mean per cent population reduction of first spray and second spray overall mean revealed that all the treatments except untreated control are effective and at par. Among all the treatments highest per cent reduction of chickpea pod borer as well as increasing the yield was recorded in T₅ (72.48%). Similar findings made by Zeni *et al.*, (2021), Constanski *et al.*, (2016), Aniwanou *et al.*, (2020)^{††}. T₆ (71.24%) is found to be the next best treatment which is in line with the findings of Sabbour *et al.*, (2012), Arooni-Hesari *et al.*, (2015), they reported that was found most effective in reducing percent population. T₇ (69.40%) is found to be the next best treatment which is in line with the findings of Sabbour *et al.*, (2012). T₁ (66.05%) is found to be the next effective treatment which is in line with the findings of Gesraha. *et al.*, (2017), Zeni *et al.*, (2021), Ebadollahiet *al.*, (2018), Mucha-Pelzer *et al.*, (2008). T₂ (38.28%) is found to be the next effective treatment which is in line with the findings of Reza *et al.*, (2016), Kumar *et al.*, (2019). The result of T₃ (36.45%) which is at par with T₄ (31.91%) is found to be least effective but comparatively superior over the control, these findings are supported by Singh *et al.*, (2009), Fite *et al.*, (2020), Prasad *et al.*, (2008).

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The yield among the treatments was significant. The highest yield was recorded in Diatomaceous Earth+Neem oil 3% (20.55q/ha) followed by Diatomaceous Earth+ *Beauveria bassiana* 1.5% L.F (19.72q/ha), Diatomaceous Earth+ *Metarhizium anisopliae* (18.88q/ha), Diatomaceous Earth (17.5q/ha), Neem oil 3% (15.55q/ha), *B. bassiana* 1.5% L.F (14.72q/ha), *M. anisopliae* (13.88q/ha), as compared to control plot (9.72q/ha).

When cost benefit ratio was worked out, interesting result was concluded. Among the treatments studied, the best and most economical treatment was Diatomaceous Earth+Neem oil 3% (1:3.58) followed by Diatomaceous Earth+ *Beauveria bassiana* 1.5% L.F (1:3.40), Diatomaceous Earth+ *Metarhizium anisopliae* (1:3.21), Diatomaceous Earth (1:2.96), Neem oil 3% (1:2.49), *B. bassiana* 1.5% L.F (1:2.31), *M. anisopliae* (1:2.12), as compared to Control (1:1.39). The highest yield and cost benefit ratio was recorded in Diatomaceous Earth+Neem oil 3% (20.55q/ha & 1:3.58) followed by Diatomaceous Earth+*B. bassiana* 1.5% L.F (19.72q/ha & 1:3.4).

TABLE1.Effect ofDiatomaceous earth(Inert dust) and biopesticides againstpod borer, *H. armigera* on chickpea during rabi season of 2021-22.

T.No	Treatments	First spray				Second Spray				Over all mean ^{1st and 2nd} spray	Yield q/ha	B:C ratio		
		larval population /5 plants (DBS)	Percentage of reduction of larval population / 5 plants			Mean	larval population /5 plants (DBS)	Percentage of reduction of larval population / 5 plants					Mean	
			3DAS	7DAS	14DAS			3DAS	7DAS					14DAS
T ₁	Diatomaceous Earth	2.8	63.39	65.90	61.79	63.69	1.4	66.17	71.92	67.10	68.40	66.05	17.5	1:2.96
T ₂	Neem oil	3	16.66	26.36	34.40	25.81	2.4	40.93	52.63	58.68	50.75	38.28	15.55	1:2.49
T ₃	<i>Beauveria bassiana</i> 1.5% L.F	2.86	14.58	24.50	32.65	23.91	2.46	39.18	50.87	56.92	48.99	36.45	14.72	1:2.31
T ₄	<i>Metarhizium anisopliae</i>	2.93	10.41	20.69	29.14	20.08	2.6	35.76	42.10	53.33	43.73	31.91	13.88	1:2.12
T ₅	Diatomaceous Earth+ Neem oil 3%	3.06	71.13	73.63	69.10	71.29	1.13	71.44	77.19	72.36	73.66	72.47	20.55	1:3.58
T ₆	Diatomaceous Earth+ <i>B. bassiana</i> 1.5% L.F	2.93	69.17	71.67	69.10	69.98	1.13	71.44	75.43	68.94	71.94	70.96	19.72	1:3.40
T ₇	Diatomaceous Earth+ <i>M.anisopliae</i>	2.867	67.21	69.71	67.25	68.05	1.2	69.59	73.68	70.61	71.29	69.67	18.88	1:3.21
T ₀	Control	3	0.00	0.00	0.00	0.00	3.66	0.00	0.00	0.00	0.00	0	9.72	1:1.39
	F-test	NS	S	S	S	S	S	S	S	S	S	S	-----	-----
	S. Ed (±)	-	2.58	3.47	3.46	4.06	0.13	4.02	4.02	4.25	3.95	3.95	-----	-----
	C.D.(P =0.5)	-	5.95	8.03	8.07	9.18	0.27	9.44	10.09	9.88	8.89	8.89	-----	-----

Comment [D12]: difference between number of larva in before first and second spray is just 1 in the best treatment to kill one larve we need not use such a costly chemical as DE

Comment [D13]: B : C ratio need to be properly worked out

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Comment [D15]: Pest population is very low and below ETL hence Erroneous results are observed in the table



Figure 1 Effect of Diatomaceous earth (Inert dust) and biopesticides against pod borer, *H. armigera* on chickpea during rabi season of 2021-22. (First spray)

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Efficacy of DE was tested against *Helicoverpa armigera*. DE+neem oil was the most effective and achieved the highest percentage of reduction. DE+neem oil and DE+ *Beauveria bassiana* were the highlight treatments against *H.armigera*. Neem oil combining with DE enhance their properties, pursuing better insecticidal performances. Constraints of the use of neem oils, such as their poor penetration, strong odor, lack of persistence and high concentration requirements could be reduced if combined with DE. Neem oil increased the DE efficacy by increasing insect's locomotion activity through the particles and, at the same time, DE reduced the oil concentration for the satisfactory protection. The lowest percentage of reduction was recorded in case of *Metarhizium anisopliae*. The influence of temperature on the insecticidal effect of DE against *H.armigera* has been extensively evaluated. Generally, at the larval stage, the increase of temperature increased DE efficacy, because at higher temperature insects are more mobile, so the possibility of picking up more DE particles increases (Korunic *et al.*, 1998, Subramanyam *et al.*, 2000, Athanassiou *et al.*, 2006).

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Our findings indicated that entomopathogenic fungi have low insecticidal toxicity against *H.armigera*. Application of *B.bassiana* alone is less effective and toxicity increase when combined with DE. Results exalted the suitability of fungi as crop protectants but also pointed out their need for peculiar humid conditions to achieve satisfactory conidial adherence, germination, and penetration through the cuticle. The synergistic effect between DE and entomopathogenic fungi expands the area for fungal spore penetration, increasing insect mycosis. (Zeni *et al.*, 2021). Applications of mixtures with these two ecologically compatible agents is a very appealing approach to IPM in *H.armigera*. The application of DE+ *B. bassiana* combined considerably increased larval percentage of reduction in *H. armigera*, temperature and longer exposure intervals compared with DE+*B. bassiana* and *B. bassiana* alone. Application of DE+*Metarhizium anisopliae* resulted in higher percentage of reduction of the *H.armigera* compared to the efficacies of each compound alone.

CONCLUSION

The need to moderately withdraw from the chemical-based pesticide policies to more sustainable and ecological approaches. Among the treatments studied, Diatomaceous Earth+Neem oil 3% gave the highest cost benefit ratio (1:3.58) and marketing yield (20.55q/ha) followed by Diatomaceous Earth+ *B. bassiana* 1.5% L.F (1:3.40) and 19.722q/ha, Diatomaceous Earth+ *M. anisopliae* (1:3.21 and 18.88q/ha), Diatomaceous Earth (1:2.96 and 17.5q/ha), Neem oil 3% *B. bassiana* 1.5% L.F,

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M.anisopilae respectively as such more trials are required in future to validate the findings. Hence more trails are needed to be conducted in future to validate the findings which can be useful for the farmers in a feasible manner for sustainable production of chickpea and to prevent the losses occurring from this insect pest infesting the crop.

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