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.

Article type: ***Original Research Article***

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 (T_1), Neem oil 3% (T_2), *Beauveria bassiana* 1.5% L.F (T_3), *Metarhizium anisopliae* (T_4), Diatomaceous earth+neem oil 3% (T_5), Diatomaceous earth+ *B.bassiana* 1.5% L.F (T_6), Diatomaceous earth+ *M. anisopliae* (T_7) and untreated control (T_8) was 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% (72.480%) followed by Diatomaceous earth+ *B.bassiana* 1.5% L.F (71.241%), Diatomaceous earth+ *M.anisopliae* (69.400%). It is followed by Diatomaceous earth (66.052%) and neem oil 3% (38.281%), *B.bassiana* 1.5% L.F (36.455%) and *M. anisopliae* (31.911%) 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 (1:3.40), Diatomaceous earth+ *M.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).

KEY WORDS: 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 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 lndia, which cousese severe damage in chickpea **(Sithanantham. 1983 and Pawar. 1998)**. It causes 90 to 95 % of total damage in chickpea. This pest have 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**).

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 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)**

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 *rabi* season.

The experiment material consist of pusa 362 of chick pea, which is released from Indian Agricultural research institute New delhi. The experiment was laid out 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 / 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 12.5t/ha and N, P, K is 25 kg, 50kg and 25kg/ha respectively. The population of *Helicoverpa armigera* was recorded before 1-day spraying and on 3rd day, 7th day and 14th dayafter insecticidal application. The populations of *H. armigera* was recorded on 5 randomly selected and tagged plants from each plot and then it was converted into per cent of reduction by following formula., following formula giving by **(Henderson *et al.*, 1955)**

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

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

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

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 T_5 - Diatomaceous Earth+Neem oil 3% (71.29%) followed by T_6 – Diatomaceous Earth+ *Beauveria bassiana* 1.5% L.F (69.98%), T_7 - Diatomaceous Earth+ *Metarhizium anisopliae* (68.06%), T_1 - Diatomaceous Earth (63.699%), T2 - Neem oil 3% (25.81%), T_3- *B. bassiana* 1.5% L.F (23.91%) and Treatment T_4 – *M. anisopliae* (20.085%) was reported with minimum per cent larva reduction. (T_4, T_3, T_2,) and (T_1, T_7,T_6,T_5), 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 T_5 (73.66%) followed by T_6 (71.94%), T_7 (71.29%), T_1 (68.40%), T2 (50.75%), T_3 (48.99%) and Treatment T_4 (43.73%) was reported with minimum per cent population reduction. (T_4, T_3, T_2,) and (T_1, T_7, T_6, T_5) 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 T_5 (72.48%) . Similar findings made by **Zeni *et al.*, (2021)**,**Constanski *et al.*, (2016), Aniwanou *et al.*, (2020)**[1]. T_6 (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. T_7(69.40%) is found to be the next best treatment which is in line with the findings of **Sabbour *et al.*, (2012)**. T_1 (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), Ebadollahi *et al*.,(2018), Mucha-Pelzer *et al*.,(2008) .** T_2 (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 T_3 (36.45%) which is at par with T_4(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).**

The yields among the treatments were 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.anisopilae* (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) .

TABLE 1. Effect of Diatomaceous earth(Inert dust) and biopesticides againist pod 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	*Beauveria bassiana* 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	*Metarhizium anisopliae*	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+ *B. bassiana* 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+ *M.anisopliae*	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	------	------

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

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 infuence 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**).

Our findings indicated that entomopathogenic fungi have low insecticidal toxicity againist *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* (1:3.21and 18.88q/ha), Diatomaceous Earth (1:2.96 and 17.5q/ha), Neem oil 3% *B. bassiana* 1.5% L.F, *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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