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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

Christeena Benny [a*#] and Ashwani Kumar [a†]

[a] *Department of Entomology, Faculty of Agriculture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, 211007, Uttar Pradesh, India.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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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* $1x10^8$ CFU/ml (T3), *Metarhizium anisopliae*$1x10^8$ CFU/ml (T4), Diatomaceous earth+neem oil 3% (T5), Diatomaceous earth+ *B.bassiana* $1x10^8$ CFU/ml (T6), Diatomaceous earth+ *M. anisopliae*$1x10^8$ CFU/ml (T7) and untreated control (T8) 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% (74%) followed by Diatomaceous earth+ *B.bassiana*$1x10^8$CFU/ml (73%), Diatomaceous earth+ *M.anisopliae* $1x10^8$CFU/ml (72%). It is followed by Diatomaceous earth (68%) and neem oil 3% (42%),

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[#] *M.Sc. Scholar,*
[†] *Associate Professor,*
**Corresponding author: E-mail: christeenabenny092@gmail.com;*

B.bassiana 1x10^{8}CFU/ml (40%) and *M. anisopliae* 1x10^{8}CFU/ml (36%) was the least effective among all treatments. While, the highest yield 23.2q/ha was obtained from the treatment Diatomaceous earth+neem oil 3% as well as B:C ratio 1:4.1. It was followed by Diatomaceous earth+ *B.bassiana*1x10^{8}CFU/ml (1:3.8), Diatomaceous earth+ *M.anisopliae*1x10^{8}CFU/ml (1:3.7), Diatomaceous earth (1:3.5), neem oil 3% (1:2.4), *B.bassiana*1x10^{8}CFU/ml (1:2.3), *M. anisopliae* 1x10^{8}CFU/ml (1:2.1), as compared to Control (1:0.9).

Keywords: Bio-efficacy; benefit cost ratio; Cicer arietinum; diatomaceous earth; Helicoverpa armigera.

1. 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 India, which causes severe damage in chickpea [1,2]. *H.armigera* causes 90 to 95 % of total damage in chickpea. This pest has high mobility, high reproductive rate and diapause are major factors contributing to its serious pest status [3,4].

Application of Diatomaceous earth (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 them important tools in pest control [5-7]. Diatomaceous earth 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* [8].

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

2. 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 was laid out using pusa 362 variety of chick pea, which was released from Indian Agricultural research institute New Delhi. The experiment was sown in randomized block design with three replications consisting of 7 treatments having one absolute 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* 1x10^8 CFU/ml (T3), *M. anisopliae*1x10^{8}CFU/ml (T4), Diatomaceous earth+neem oil 3% (T5), Diatomaceous earth+ *B. bassiana* 1x10^{8}CFU/ml (T6), Diatomaceous earth+ *M. anisopliae* 1x10^{8}CFU/ml (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 farm yard manure was 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 day after 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 given by Henderson et al. [9].

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

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,

$$B.C.R = \frac{Net\ Returns}{Total\ Cost\ of\ cultivation}$$

Table 1. Details of biopesticides

T. no	Treatment	Quantity/doses(ha)
T_1	Diatomaceous Earth	7.5 kg/ha
T_2	Neem oil	10ml/lit
T_3	*Beauveria bassiana* 1x10^8 CFU/ml	5ml/lit
T_4	*Metarhizium anisopliae*	2.5gm/lit
T_5	Diatomaceous Earth+ Neem oil 3%	2g/lit+10ml/lit
T_6	DiatomaceousEarth+ *B.bassiana* 1x10^8 CFU/ml	5kg/ha+2500gm/ha
T_7	DiatomaceousEarth+*M.anisopliae*1x10^{8}CFU/ml	5kg/ha+2500gm/ha

3. RESULTS AND DISCUSSION

3.1 Efficacy of Diatomaceous Earth (Inert Dust) and Biopesticides against *H. armigera* on Chickpea

3.1.1 First spray

The result of effectiveness of different insecticidal treatments against gram pod borer, *H. armigera* showed that all the treatments were significantly superior over control in terms of mean reduction of gram pod borer larvae (Table 2) Among all the treatments the highest per cent larvae reduction was recorded in T_5 - Diatomaceous Earth+Neem oil 3% (71.3%) followed by T_6 – Diatomaceous Earth+*Beauveria bassiana* 1x10^{8}CFU/ml (70%), T_7 - Diatomaceous Earth+ *Metarhizium anisopliae*1x10^8 CFU/ml (68%), T_1 - Diatomaceous Earth (63.7%), T2 - Neem oil 3% (25.8%), T_3- *B. bassiana* 1x10^8 CFU/ml (23.9%) and Treatment T_4 – *M. anisopliae*1x10^8 CFU/ml (20.1%) 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.

3.1.2 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 in terms of mean reduction of *H.armigera* larvae (Table 3). Among all the treatments the highest per cent larva reduction was recorded in T_5(77.54%) followed by T_6 (76.55%), T_7 (75.03%), T_1 (73.18%), T2 (57.93%), T_3 (56.41%) and Treatment T_4 (51.99%) 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 (Table 4) 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 (74.41%). Similar findings made by Zeni et al. [10],Constanski et al. [11], Aniwanou et al. [12]. T_6 (73.26%) is found to be the next best treatment which is in line with the findings of Sabbour et al. [13], Arooni-Hesari et al. [14]. T_7 (71.54%) is found to be the next best treatment which is in line with the findings of Sabbour et al. [13]. T_1 (68.44%)is found to be the next effective treatment which is in line with the findings of Gesraha et al. [14], Zeni et al. [10], Ebadollahi et al. [16], Mucha-Pelzer et al. [17]. T_2 (41.86%) is found to be the next effective treatment which is in line with the findings of Reza et al. [18], Kumar et al. [19]. The result of T_3 (40.16%) which is at par with T_4(36.03%) is found to be least effective but comparatively superior over the control, these findings are supported by Singh et al. [20], Fite et al. [21], Prasad et al. [22].

3.2 Economics of Treatments

The yields among the treatments were significant. The highest yield was recorded in Diatomaceous Earth+Neem oil 3% (23.2q/ha) followed by Diatomaceous Earth+ *Beauveria bassiana* 1x10^8 CFU/ml (21.8q/ha), Diatomaceous Earth+ *Metarhizium anisopliae*1x10^8 CFU/ml (21q/ha), Diatomaceous Earth (20q/ha), Neem oil 3% (15.55q/ha), *B. bassiana* 1x10^8 CFU/ml (14.72q/ha), *M.anisopliae*1x10^8 CFU/ml (13.88q/ha), as compared to control plot (8q/ha).

The highest cost benefit ratio (1:4.1) was found in Diatomaceous Earth+Neem oil 3% treated plots followed by Diatomaceous Earth+ *Beauveria bassiana*1x10^8 CFU/ml (1:3.8), Diatomaceous Earth+ *Metarhizium anisopliae* 1x10^8 CFU/ml (1:3.7) and Diatomaceous Earth (1:3.5), Neem oil 3%, *B. bassiana* 1.5% L.F, *M.anisopilae* 1x10^8 CFU/ml was also found effective as well as economical with cost : benefit 1:2.49, 1:2.31 and 1:2.12 as compared to Control

(1:0.9). The highest yield and cost benefit ratio was recorded in Diatomaceous Earth+Neem oil 3% (23.255q/ha & 1:4.1) followed by Diatomaceous Earth+*B.bassiana*1x10^8 CFU/ml (21.8 q/ha & 1:3.8).

4. DISCUSSION

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*1x10^8 CFU/ml 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 attaches to insect cuticle cusing death through desiccation and, at the same time, DE reduced the oil concentration for satisfactory reduction of larvae. The lowest percentage of reduction was recorded in case of *Metarhizium anisopliae* 1x10^8CFU/ml. 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 [6,23,8].

Table 2. Effect of diatomaceous earth (Inert dust) and biopesticides againist pod borer, *H. armigera* on chickpea after 1st spray during *rabi* season of 2021-22

T. no	Treatment	PTP/5 plants	Mean reduction (%) Days after 1st spray			
			3DAS	7DAS	14DAS	Mean
T_1	Diatomaceous Earth	2.8	63.39	65.90	61.79	63.69
T_2	Neem oil	3	16.66	26.36	34.40	25.80
T_3	*Beauveria bassiana* 1x10^8 CFU/ml	2.86	14.58	24.50	32.65	23.91
T_4	*Metarhizium anisopliae*	2.93	10.41	20.69	29.14	20.08
T_5	Diatomaceous Earth+ Neem oil 3%	3.06	71.13	73.63	69.10	71.28
T_6	Diatomaceous Earth+ *B. bassiana* 1x10^8 CFU/ml	2.93	69.17	71.67	69.10	69.98
T_7	Diatomaceous Earth+ *M.anisopliae* 1x10^8 CFU/ml	2.867	67.21	69.71	67.25	68.05
T_0	Control	3.3	0.00	0.00	0.00	0.00
	F-test	NS	S	S	S	S
	S. Ed (±)	-	2.58	3.47	3.11	4.06
	C.D. (P = 0.5)	-	5.54	7.44	6.67	8.70

**PTP- Pretreatment population ** DAS- Day after spray*

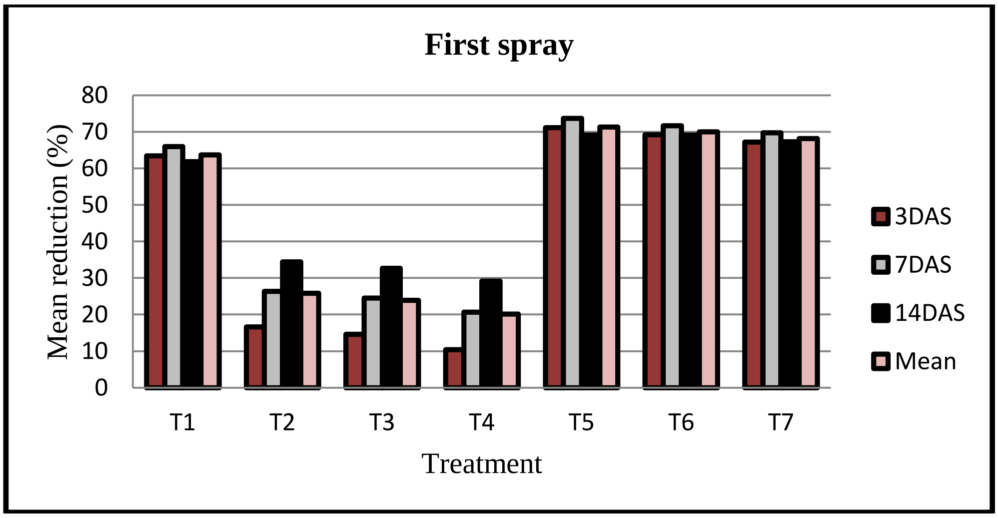

Fig. 1. Graphical representation of effect of Diatomaceous earth(Inert dust) and biopesticides againist pod borer, *H. armigera* on chickpea after 1st spray during *rabi* season of 2021-22

Table 3. Effect of Diatomaceous earth (Inert dust) and biopesticides against *H. armigera* on chickpea after 2nd spray during *rabi* season of 2021-22

T. No	Treatment	PTP/5 plants	Mean reduction (%) Days after 1 st spray			
			3DAS	7DAS	14DAS	Mean
T_1	Diatomaceous Earth	1.4	70.41	76.21	72.94	73.18
T_2	Neem oil	2.4	48.41	59.68	65.70	57.93
T_3	*Beauveria bassiana* $1x10^8$ CFU/ml	2.46	46.82	58.16	64.25	56.41
T_4	*Metarhizium anisopliae*	2.6	43.72	50.79	61.47	51.99
T_5	Diatomaceous Earth+ Neem oil 3%	1.13	74.96	80.56	77.11	77.54
T_6	Diatomaceous Earth+ *B. bassiana* $1x10^8$ CFU/ml	1.13	74.96	79.05	75.66	76.55
T_7	Diatomaceous Earth+ *M.anisopliae* $1x10^8$ CFU/ml	1.2	73.37	77.53	74.21	75.03
T_0	Control	4.06	0.00	0.00	0.00	0.00
	F-test	S	S	S	S	S
	S. Ed (±)	0.13	3.44	3.62	3.48	3.61
	C.D. (P = 0.5)	0.27	7.38	7.76	7.46	7.74

**PTP- Pretreatment population ** DAS- Day after spray*

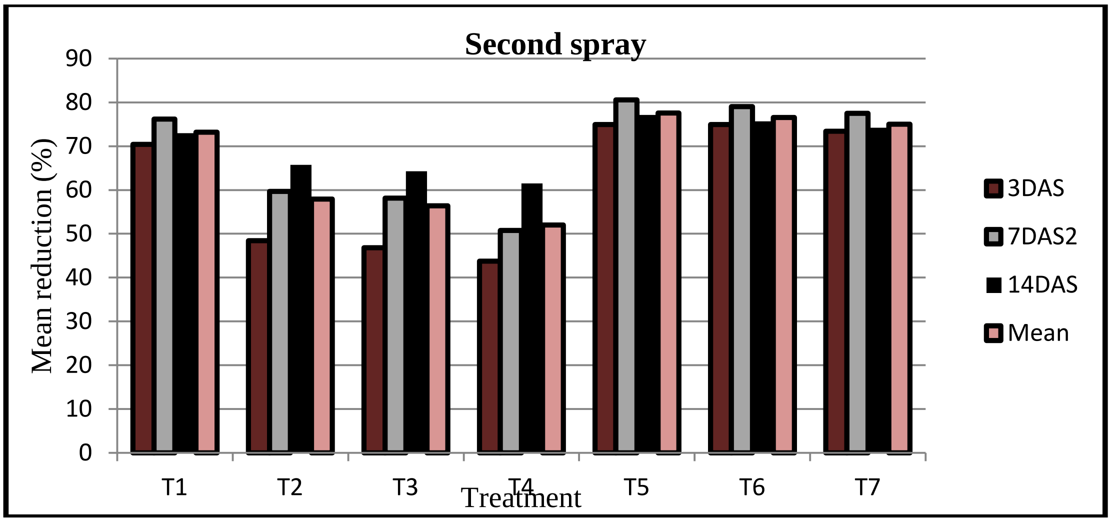

Fig. 2. Graphical representation of effect of Diatomaceous earth(Inert dust) and biopesticides againist *H. armigera* on chickpea after 2nd spray during *rabi* season of 2021-22

Table 4. Effect of Diatomaceous earth(Inert dust) and biopesticides against *H. armigera* on chickpea over all mean during *rabi* season of 2021-22

T. no	Treatment	1st spray mean	2nd spray mean	Over all mean
T_1	Diatomaceous Earth	63.69	73.18	68.44
T_2	Neem oil	25.80	57.93	41.86
T_3	*Beauveria bassiana* $1x10^8$ CFU/ml	23.91	56.41	40.16
T_4	*Metarhizium anisopliae*$1x10^8$ CFU/ml	20.08	51.99	36.03
T_5	Diatomaceous Earth+ Neem oil 3%	71.28	77.54	74.41
T_6	Diatomaceous Earth+ *B. bassiana* $1x10^8$ CFU/ml	69.98	76.55	73.26
T_7	Diatomaceous Earth+ *M.anisopliae*$1x10^8$ CFU/ml	68.05	75.03	71.54

Table 5. Yield and economics of cultivation

T. no	Treatments	Yield q/ha	Market price (q/ha) (□)	Gross return(□)	Net return	Total cost(ha)	B:C ratio
T_1	Diatomaceous Earth	20	5500	110000	85,720	24280	1:3.53
T_2	Neem oil	15.55	5500	85555.58	61,056	24500	1:2.49
T_3	*Beauveria bassiana* $1x10^8$ CFU/ml	14.72	5500	80972.21	56,552	24420	1:2.31
T_4	*Metarhizium anisopliae* $1x10^8$ CFU/ml	13.88	5500	76388.89	51,909	24480	1:2.12
T_5	Diatomaceous Earth+ Neem oil 3%	23.2	5500	127600	102,960	24640	1:4.1
T_6	Diatomaceous Earth+ *B. bassiana* $1x10^8$ CFU/ml	21.8	5500	119900	95,300	24600	1:3.8
T_7	Diatomaceous Earth+ *M.anisopliae* $1x10^8$ CFU/ml	21	5500	115500	90,880	24620	1:3.69
T_0	Control	8	5500	44000	21,680	22,320	1:0.9

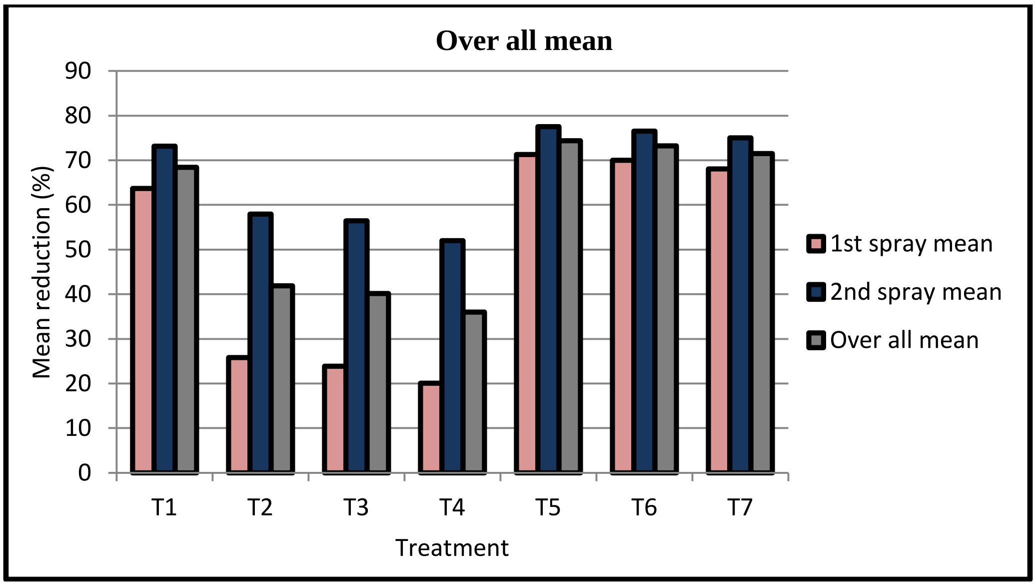

Fig. 3. Graphical representation of effect of diatomaceous earth (Inert dust) and biopesticides againist *H. armigera* on chickpea over all mean during *rabi* season of 2021-22

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 [10]. 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*1x10^8CFU/ml combined considerably increased larval percentage of reduction in *H. armigera*, temperature and longer exposure intervals compared with DE+ *B. bassiana*1 x10^8CFU/ml and *B. bassiana*1x10^8CFU/ml alone. Application of DE+ *Metarhizium anisopliae*1 x10^8CFU/ml resulted in higher percentage of reduction of the *H.armigera* compared to the efficacies of each compound alone.

5. CONCLUSION

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* 1x10^8CFU/ml (1:3.40)and 19.722q/ha), Diatomaceous Earth+ *M. anisopliae*1x10^8CFU/ml (1:3.21and 18.88q/ha), Diatomaceous Earth (1:2.96 and 17.5q/ha), Neem oil 3% *B. bassiana* 1x10^8 CFU/ml and *M. anisopilae*1x10^8CFU/ml 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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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sithanantham S, Rao VR, Ghaffar MA. International review of crop losses caused

by insects on chickpea. In Proceedings of the National Seminar on Crop Losses due to Insect Pests. 1983;7(9):269-283.
2. Pawar VM. Microbial control of Helicoverpa sp. on pulse crops. IPM System in Agriculture. 1998;4:55-78.
3. Fitt GP. The ecoloa of Heliolhis in relation to ago-ecosystems. Annual review of Entomology. 1989;34:17-52.
4. Sharma HC, Stevenson PC, Gowda CLL. Heliothis/ helicoverpa management emerging trends and strategies for future research. Oxford and IBH Publishers. 2005;81(204):453 – 462.
5. Costa RR, Moraes JC. Efeitos do ácido silícico e do acibenzolar-s-methyl na resistência de plantas de trigo ao *Schizaphis graminum* (Rondani) (Hemiptera: Aphididae). Neotropical Entomology, Londrina. 2006;35(6):834-839.
6. Korunic. Diatomaceous earths, a group of natural insecticides. Journal of Stored Products Research, Philadelphia. 1998;4(2):87-97.
7. Lorini I, Ferreira Filho A, Barbieri I, Demaman NA, Martins RR, Dalbello O. Terra de diatomáceas como alternativa no controle de pragas de milho armazenado em propriedade familiar. Agroecologia e Desenvolvimento Rural e Sustentável, Porto Alegre. 2001;2(4):32-36.
8. Athanassiou CG. Influence of instar and commodity on insecticidal effect of two diatomaceous earth formulations against larvae of *Ephestia kuehniella* (Lepidoptera: Pyralidae). Journal of Economic Entomology. 2006;99(5):1905-1911.
9. Henderson CF, Tilton EW. Tests with acaricides against the brown wheat mite. Journal of Economic Entomology. 1955; 48(2):157-161.
10. Zeni V, Baliota GV, Benelli G, Canale A, Athanassiou CG. Diatomaceous earth for arthropod pest control: Back to the future. Molecules. 2021;26(24):74-87.
11. Constanski KC, Zorzetti J, Santoro PH, Hoshino AT, Neves PMOJ. Inert powders alone or in combination with neem oil for controlling *Spodoptera eridania* and *Spodoptera frugiperda* (Lepidoptera: Noctuidae) larvae. Semina: Ciencias Agrárias. 2016;37(4):1801-1810.
12. Aniwanou CT, Sinzogan AA, Deguenon JM, Sikirou R, Stewart DA, Ahanchede A. Bio-efficacy of diatomaceous earth, household soaps, and neem oil against *Spodoptera frugiperda* (Lepidoptera: Noctuidae) larvae in Benin. Insects. 2020;12(1):18.
13. Sabbour M, Abd-El-Aziz S, Sherief M. Efficacy of three entomopathogenic fungi alone or in combination with diatomaceous earth modifications for the control of three pyralid moths in stored grains. Journal of Plant Protection Research. 2012;52(3): 360-363.
14. Arooni-Hesari M, Talaei-Hassanloui R, Sabahi Q. Simultaneous use of entomopathogenic fungus Beauveria bassiana and diatomaceous earth against the larvae of Indian Meal Moth, Plodia interpunctella.Advances in Bioscience and Biotechnology. 2015;6(08):501.
15. Gesraha MA, Ebeid AR, Salem NY, Abdou WL. Comparative study on some biological indices of *Agrotis ipsilon* (Lepidoptera: Noctuidae) larvae treated with three control agents under laboratory conditions. Annual Research & Review in Biology. 2017;21(6):1-8.
16. Ebadollahi A, Sadeghi R. Diatomaceous earth and kaolin as promising alternatives to the detrimental chemicals in the management of *Spodoptera exigua*. Journal of Entomology. 2018;15(2):101-105.
17. Mucha-Pelzer T, Debnath N, Goswami A, Mewis I, Ulrichs C. Bekämpfung von *Epilachna vigintioctopunctata* (F.) und Spodoptera litura (F.) mit Silikaten. Gesunde Pflanzen. 2008; 60(1):23-28.
18. Reza ME, Islam MAMIM, Roy HP. Ecofriendly management of chickpea pod borer. 2016;9(06):29-34.
19. Kumar A, Tripathi MK, Chandra U, Veer R. Efficacy of botanicals and bio-pesticide against *Helicoverpa armigera* in chickpea. Journal of Entomology and Zoology Studies. 2019;7(1):54-57.
20. Singh H, Singh HR, Yadav RN, Yadav KG, Yadav A. Efficacy and economics of some bio-pesticide in management of *Helicoverpa armigera* (Hub) on chickpea. Pestology. 2009;33(7):36-37.
21. Fite T, Tefera T, Negeri M, Damte T, Sori W. Evaluation of *Beauveria bassiana, Metarhizium anisopliae,* and *Bacillus thuringiensis* for the management of *Helicoverpa armigera* (Hubner) (Lepidoptera:Noctuidae) under laboratory

and field conditions. Biocontrol Science and Technology. 2020;30(3):278-295.

22. Prasad J. Efficacy of Metarhizium anisopliae and Beauveria bassiana against *Helicoverpa armigera* in Chickpea, under Field Conditions in Nepal Formosan Entomo. 2008;28:249-258.
23. Subramanyam B, Roesli R. Inert dusts. In Alternatives to pesticides in stored-product IPM. 2000;321-380.

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