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Biorational Management of Gram Pod Borer, *Helicoverpa armigera* (Hubner) Infesting Chickpea

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ABSTRACT: Chickpea is susceptible to a wide variety of insect pests, among which the gram caterpillar *Helicoverpa armigera* is a prominent adversary. Presently, farmers predominantly depend on pesticides as their primary method of controlling this pest. As pesticides are associated with numerous environmental risks, there is a growing emphasis on the significance of biorational products. The study aimed to evaluate the effectiveness of various biorational insecticides in controlling the infestation of the gram pod borer (*Helicoverpa armigera*, Hubner) in chickpea crop. As pesticides result in many environmental hazards, biorational products are given importance. In this study Malathion 50 EC (standard check), Spinosad 45 SC, Emamectin benzoate 5 SG, Neem oil 1%, Karanj oil 1%, NSKE 5%, Azadirachtin 0.03 EC, *HaNPV* 250LE, and Papaya leaf extract 5%5% were evaluated against *H. armigera* in chickpea in 2021-22. Incidence of *H. armigera* was significantly less in Malathion 50 EC (91.94%) followed by Spinosad 45 SC (82.24%), and Emamectin benzoate SG (78.75%). However, the Papaya leaf extract 5%treatment was the least effective options, showing a significantly lower reduction in larval population compared to other insecticides. The maximum seed yield of 15.78 q/ ha was recorded in Malathion 50 EC followed by Spinosad 45 EC and Emamectin benzoate 5 SG, 14.97, 13.94 q/ ha, respectively. Among these biorationals Spinosad 45 SC, Emamectin benzoate 5 SG provided the best result with the highest mean percentage larvae reduction and revealed the highest efficacy compared to other treatments, suggesting both Spinosad 45 SC and Emamectin benzoate 5 SG both might be used to manage *H. armigera* borer effectively.

Keywords: Bioefficacy, Biorational, Gram pod borer, *Ha*NPV 250LE, Karanj oil, NSKE 5%, Spinosad 45 SC.

INTRODUCTION

Chickpea (*Cicer arietinum*) is an important *rabi* pulse crop in India, known as Bengal gram or chana and grown widely in the world. It originated from South Western Asia and considered as the 'King of Pulses.' With high protein quality, it is the third most significant pulse crop globally. Chickpeas are rich in nutrients, including protein (21.5%), carbohydrates (64.5%), fats (4.5%), calcium, iron, niacin, vitamin B, and Vitamin C. They also provide more calcium and phosphorus than other legumes and even more calcium than whole cow's milk (Lamesgen Yegrem, 2021). During 2021-22 (fourth estimate), chickpea production of India was 13.75 million tonnes from an acreage of 10.91 million ha with a productivity of 12.6 q./ha (DES 2023, MOAF&W, GoI). Chickpea solely contributes nearly 50% of the Indian pulse production. States like Maharashtra (25.97% contribution to national production), Madhya Pradesh (18.59%), Rajasthan (20.65%), Gujarat (10.10%) and Uttar Pradesh (5.64%) are major chickpea producing states of India. Rajasthan is one of the major states which occupies 2.25 million hectares area with production of 26.60 lakh tonnes and 1177 kg/hectare productivity (E&S Division, DA&FW 2022).

It is an important pulse crop world-wide andthere are many constraints in the production of the crop, of which pod borer, *Helicoverpa armigera* (Hubner) is the notorious one which causes both quantitative and qualitative loss. In India, this pest has been observed on a variety of crops such as cotton, pigeon pea, sunflower, corn, chilli, tomato, okra, and chickpeas (Wubneh, 2016; Patil *et al.*, 2017). The larvae of *H. armigera* feed on different parts of plants, including leaves, flowers, and pods of chickpeas, leading to substantial losses of up to 90% (Ahmad *et al.*, 2015). The heavy infestation of *H. armigera* has a significant impact on chickpea production (Chaudhary and Sharma 1982; Russel *et al.*, 1999; Sarwar *et al.*, 2009; 2011).

To *manage H. armigera*, there has been a widespread use of chemical insecticides and farmers generally rely on it for management that leads to various problems, *viz*., resistance development, pest resurgence and residue problem along with environmental degradation. Unfortunately, the uncontrolled use of these insecticides' harms not only the target pest but also pollinators, natural predators, and human health (Mesnage and Seralini 2018). It led to the development of resistance also (Kranthi *et al.*, 2002; Yang *et al.*, 2013; Bird, 2018). However, a more thoughtful approach involving the integration of biocontrol agents into pest management programs can effectively address this issue. The utilization of biocontrol agents to regulate *H. armigera* populations has proven to be both efficient and environmentally friendly (Abid *et al.*, 2020). Prioritizing biorational approaches those spare beneficial organisms like parasitoids and predators is crucial in achieving successful pest management while maintaining ecological balance.

MATERIALS AND METHODS

The field experiment was carried out during the *rabi* season of 2021-22 at the Agronomy farm S.K.N. College of Agriculture, Jobner (Rajasthan) in a simple randomized block design (RBD) with 10 treatments and three replications for evaluating the relative efficiency of biorational insecticides against. The plot size was 3.0 × 3.0 m^2 with a row-to-row distance of 30 cm and a plant-to-plant distance of 10 cm. The chickpea variety RSG-902 was sown on last week of October, and recommended practices were followed for crop management. Ten treatments including control, i.e., Malathion 50 EC (0.05%), Spinosad 45 SC (0.01 %), Emamectin benzoate 5 SG, Neem oil 1%, Karanj oil 1%, NSKE 5%, Azadirachtin 0.03 EC, *HaNPV* 250LE, and Papaya leaf extract 5%were selected for experimentation. Application of the respective treatments was carried out by means of sprays using a knapsack hand sprayer equipped with a hollow cone nozzle. To prevent any unintended drift of insecticides, a protective polythene sheet screen was placed around each plot during the spraying process. Pest sampling was initiated upon the appearance of larvae on the plants and continued until the crop's harvest. The sprays were conducted during the early morning hours. A total of two sprays were administered: the first was administered after evaluating the economic threshold level, and the second spray was conducted after a fifteen-day interval following the initial spray. For data collection, pre-treatment pod borer larval populations were observed on ten randomly chosen and tagged plants per plot, a day prior to the application of insecticides. Post-treatment larval population data were collected at intervals of 1, 3, 7, and 14 days subsequent to the insecticide application. The observations of the larval populations were subjected to angular transformation for analysis.

RESULTS AND DISCUSSION

The bio-efficacy of the treatments against *H. armigera*, based on mean percentage larval population reduction, is as follows in decreasing order: Malathion 50 EC (87.45%), Spinosad 45 SC (81.14%), Emamectin benzoate 5 SG (77.20%), Neem oil 1% (73.79%), NSKE 5% (71.68%), Karanj oil 1% (66.03%), Azadirachtin 0.03 EC (61.11%), HaNPV 250LE (48.50%), and Papaya leaf extract 5% (32.03%). These results were recorded after the first spray of the insecticides. After 15 days from the first spray, a second spray was given, and the results showed that the insecticides were significantly superior to the control in reducing gram pod borer infestation. Based on the overall efficacy of treatments at one, three, seven, and fourteen days after the spray against *H. armigera*, Malathion 50 EC proved to be the most effective, followed by Spinosad 45 SC and Emamectin benzoate 5 SG. The treatments of Neem oil, NSKE 5%, Karanj oil, and Azadiractin 0.03EC fell in the middle range of effectiveness, with Papaya leaf extract 5%being the least effective treatment. All the insecticidal treatments resulted in higher seed yields and were found to be significantly superior to the control. The maximum seed yield of 15.78 q/ha was recorded in Malathion 50 EC, followed by Spinosad 45 EC, Emamectin benzoate 5 SG, Neem oil, NSKE 5%, Karanj oil 1%, Azadirachtin 0.03 EC, and HaNPV 250LE at 14.97, 13.94, 13.05, 12.96, 12.05, 11.49, and 10.09 q/ha, respectively. The least seed yield, at 10.09, was recorded in the Papaya leaf extract 5% treatment. The maximum total increase in yield, 7.16 q/ha, and the percentage increase in yield over the control (83.06%) were recorded in the plot treated with Malathion 50 EC, followed by Spinosad 45 EC (6.35 q/ha and 73.66%). Emamectin benzoate SG showed a total increase in yield of 5.32 q/ha and a percentage increase in yield of 61.71% over the control, followed by Neem oil 1%(4.43 q/ha and 51.39%) and NSKE 5% (4.34 q/ha and 50.34%).The total increase in yield and percentage increase in yield over control were recorded in the plots treated with Karanj oil 1% (3.88 q/ha and 45.01%), followed by Azadirachtin 0.03 EC (3.34 q/ha and 38.74%), *Ha*NPV 250LE (2.87 q/ha and 33.29%), and Papaya leaf extract 5% (2.28 q/ha and 26.45%).The maximum net profit of Rs. 35446/ha was obtained in the treatment of Malathion 50 EC, followed by Spinosad 45 SC (Rs. 25830/ha). The minimum net profit of Rs. 18368/ha was obtained in the treatment of Neem oil 1%, followed by NSKE 5% (Rs. 17898/ha), while Emamectin benzoate SG 5 (Rs. 17523/ha). In the treatments of Karanj oil 1%, Azadirachtin 0.03 EC, *Ha*NPV 250LE, and Papaya leaf extract 5%, the net profit was Rs. 14892, 12248, 10260, and 6824/ha, respectively. The maximum cost-benefitratio of 17.35 was obtained in the treatment of Malathion 50 EC, followed by Neem oil 1% (1:3.8) and NSKE 5% (1:3.7), while Spinosad 45 SC (1:3.5), Karanj oil 1%

(1:2.7), Azadirachtin 0.03 EC (1:2.3), *Ha*NPV 250LE (1:2.1), and Emamectin benzoate SG 5 (1:1.7). The minimum benefit-cost ratio was found in Papaya leaf extract 5% (1:1.3). The B:C ratio in the effective treatments of Spinosad 45 EC and Emamectin benzoate 5 SG is slightly low due to their high cost.

The present results are supported by the observations of Gautam *et al.* (2018). Similarly, Yadav *et al.* (2022) found that the larval population of *H. armigera* was lowest in Spinosad 45 SC (0.6 ml/lit. water), followed by Emamectin benzoate 5 SG (0.5 g/lit. water), Neem oil 1% (3.75 ml/lit. water), and NSKE 5%. According to Anandhi *et al.* (2011), Spinosad and Neem seed kernel extract 5% were the best treatments. Similarly, the maximum percentage reduction of the larval population was recorded in Spinosad 45 SC (89.40%) by Lakshmikanth and Kumar (2018); Gayatri and Kumar (2021). The next most effective treatment was Neem oil 1% (85.74%). Gautam *et al.* (2017) results showed that NSKE 5% was the most effective, followed by Karanj oil 1% and Papaya leaf extract 5%, which aligns with the present findings. Bhagat *et al.* (2017) also found NSKE 5% to be the most effective against *H. armigera*, followed by Karanj oil 1% and Papaya leaf extract 5%, but the present investigation's results contradicted those of Goutham *et al.* (2018), Konda *et al.* (2022), and Yerrabala *et al.* (2021), who found Karanj oil 1% to be the most effective, followed by NSKE 5% 5%. Konda *et al.* (2022) observed that the percentage reduction of the larval population was higher in the treatment of Spinosad 45 SC, followed by Neem oil 1%. Singh *et al.* (2018) recorded that NSKE 5% and Azadirachtin 0.03 EC were the most effective in reducing the larval population of *H. armigera*, followed by *Ha*NPV (250 LE/ha), supporting the present findings. According to Moorthy *et al.* (2011), the insecticide NSKE 5% (5.0 ml/lit.) was observed to be more effective than Azadirachtin 0.03 EC (5.0 ml/lit.) against *H. armigera*. The spray of NSKE5% was reported to be moderately effective, partially corroborating the present findings. Onkar (2006); Chandra (2010); Singh *et al.* (2012) reported NSKE 5% and Azadirachtin 0.03 EC as the least effective in reducing the larval population of *H. armigera*, providing conformity to the results of the present investigation.

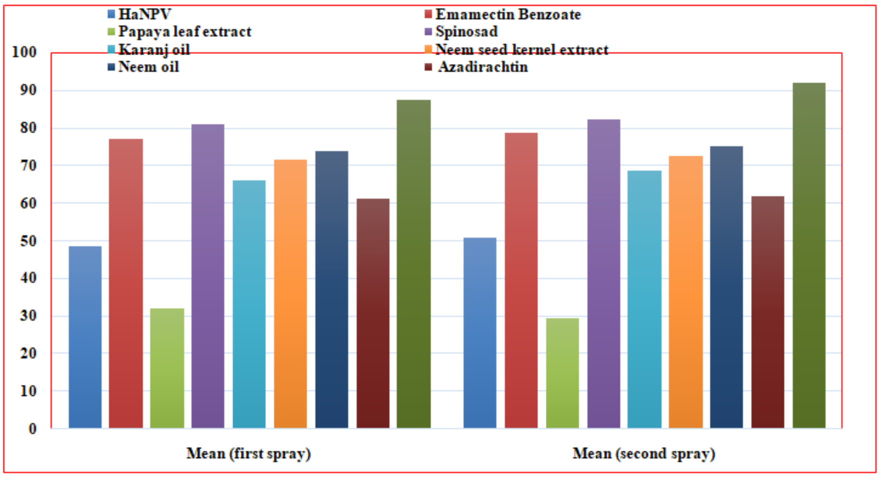

Table 1: Bioefficacy of biorational insecticides against *H. armigera* on chickpea during *Rabi* 2021-22.

Sr. No.	Name of insecticide	Conc. (%)	PTP	Mean percent reduction of larval population days after first spray				Mean	Mean percent reduction of larval population days after second spray				Mean
				Day 1	Day 3	Day 7	Day 14		Day 1	Day 3	Day 7	Day 14	
1.	*HaNPV 250LE*	250LE	2.68	41.91 (40.32)	54.98 (47.83)	56.74 (48.8)	40.38 (39.43)	48.50 (44.11)	42.95 (40.93)	58.47 (49.85)	59.47 (50.44)	42.86 (40.87)	50.93 (45.52)
2.	Emamectin benzoate 5 SG	200 gm/l	2.1	80.43 (63.74)	81.24 (64.30)	74.62 (59.72)	72.53 (58.37)	77.20 (61.53)	81.92 (64.82)	82.67 (65.38)	76.49 (61.00)	73.93 (59.27)	78.75 (62.60)
3.	Papaya leaf extract 5%(Lab. prepared)	5	2.26	36.94 (37.41)	34.24 (35.79)	30.98 (33.80)	25.98 (30.62)	32.03 (34.41)	37.89 (37.97)	32.46 (34.71)	25.85 (30.54)	21.48 (27.59)	29.42 (32.71)
4.	Spinosad 45 SC	0.01	2	81.65 (64.61)	83.59 (66.14)	80.43 (63.72)	78.92 (62.68)	81.14 (64.26)	82.96 (65.63)	84.27 (66.68)	81.94 (64.84)	79.82 (63.28)	82.24 (65.07)
5.	Karanj oil	1	2.28	63.78 (52.98)	67.84 (55.43)	70.81 (57.27)	61.71 (51.75)	66.03 (54.35)	64.34 (53.31)	68.47 (55.82)	71.49 (57.71)	70.54 (57.10)	68.71 (55.98)
6.	NSKE 5% (Lab. prepared)	5	2.48	66.19 (54.98)	72.42 (58.30)	74.86 (59.90)	73.25 (58.83)	71.68 (57.85)	68.47 (55.83)	73.49 (58.98)	74.84 (59.88)	72.94 (58.63)	72.43 (58.32)
7.	Neem oil	1	2.29	68.49 (55.84)	74.82 (59.86)	76.54 (61.01)	75.34 (60.20)	73.79 (59.22)	69.79 (56.64)	75.61 (60.38)	78.49 (62.36)	76.5 (60.99)	75.09 (60.08)
8.	Azadirachtin 0.03 EC 0.03 EC	5 ml/l	2.36	59.89 (50.68)	61.30 (51.51)	63.20 (52.63)	60.05 (50.77)	61.11 (51.40)	60.98 (51.32)	62.94 (52.47)	64.87 (53.63)	58.37 (49.80)	61.79 (51.80)
9.	Malathion 50 EC (Check)	0.05	2.35	94.34 (76.36)	92.54 (74.12)	82.61 (65.36)	80.32 (63.65)	87.45 (69.82)	96.84 (79.73)	94.54 (76.70)	91.02 (72.55)	85.36 (67.47)	91.94 (74.04)
10.	Untreated	-	2.96	0	0	0	0	0	0	0	0	0	0
S.Em. ±	-	-	-	0.81	0.56	0.82	0.48	1.45	0.71	0.79	0.70	0.51	1.49
CD at 0.05	-	-	-	2.44	1.69	2.45	1.46	4.25	2.14	2.37	2.10	1.55	4.35

Figures in parentheses are angular transformed values

Table 2: Effect of biorational insecticides on the pod damage and seed yield of chickpea during *Rabi*, 2021-22.

Sr. No.	Name of insecticide	Pod damage (%)	Seed yield (q ha^{-1})	Total increase in yield over control (q/ha)	Return of increased yield (Rs*)	Expenditure (Rs. **)	Net profit (Rs. ha^{-1})	B:C Ratio
1.	*HaNPV 250LE*	15.94 (23.52)	11.49	2.87	15010	4750	10260	2.16
2.	Emamectin benzoate 5 SG	4.02 (11.56)	13.94	5.32	27823	10300	17523	1.70
3.	Papaya leaf extract 5%(Lab. prepared)	16.36 (23.84)	10.09	2.28	11924	5100	6824	1.33
4.	Spinosad 45EC	3.86 (11.32)	14.97	6.35	33210	7380	25830	3.50
5.	Karanj oil	11.58 (19.88)	12.5	3.88	20292	5400	14892	2.75
6.	NSKE 5% (Lab. Prepared)	9.64 (18.07)	12.96	4.34	22698	4800	17898	3.72
7.	Neem oil	6.85 (15.16)	13.05	4.43	23168	4800	18368	3.82
8.	Azadirachtin 0.03 EC 0.03 EC	15.89 (23.48)	11.96	3.34	17468	5220	12248	2.34
9.	Malathion 50 EC (check)	1.59 (7.24)	15.78	7.16	37446	2040	35406	17.35
10.	Untreated	35.86 (36.77)	8.62	0	-	-	-	-
Figures in parentheses are angular transformed values								

*Minimum support price of chickpea at the current season was 5230/-per quintal
**Includes the cost of the biorationals and Laboure charges

CONCLUSIONS

The maximum seed yield (Table 2) was obtained in the treatment of Malathion 50 EC (15.78 q ha^{-1}), followed by Spinosad 45 EC (14.97 q ha^{-1}). The higher seed yield was also obtained in the treatment of Emamectin benzoate 5 SG (13.94 q ha^{-1}), followed by Neem oil 1% (13.05 q ha^{-1}) and Karanj oil 1% (12.96 q ha^{-1}). The minimum seed yield of 12.50 q ha^{-1} and 11.96 q ha^{-1} was obtained in the treatments of NSKE 5% and Azadirachtin 0.03 EC, respectively. The least seed yield of 11.49 q ha^{-1} was obtained in the treatment of *Ha*NPV 250LE, followed by Papaya leaf extract 5% (10.09 q ha^{-1}).

FUTURE SCOPE

The excessive use of synthetic pesticides has placed human health, the environment, and the emergence of resistant insect and pathogen strains at risk. As a result, it is crucial to assess the effectiveness and importance of biorational pesticides in the management of agricultural pests, given their renewable nature and their positive impact on human health and the environment. The scope of biorational management for gram pod borers is broad and encompasses a range of strategies that are environmentally friendly, economically viable, and sustainable. By reducing the reliance on synthetic chemical pesticides and promoting natural and ecological approaches, biorational management contributes to healthier ecosystems and safer agricultural practices.

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Conflict of Interest. None.

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