International Journal of All Subject Studies
www.allstudiesjournal.com
ISSN: 3107-541X
Received: 04-07-2025, Accepted: 20-07-2025, Published: 06-08-2025
Volume 1, Issue 2, Jul-Sep, 2025, Page No. 1-3

Effect of different treatments on larval population, per cent pod damage by *Helicoverpa armigera* and its effect on yield of gram

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Abstract
Gram pod borer, *Helicoverpa armigera (*Hubner) is the serious pest of chickpea in Indian Agriculture. It is polyphagous and widely distributed in the world. Productivity of gram crop is strongly affected by *Helicoverpa armigera* which damage up to 90-95 per cent crop during favorable weather condition. A single larva of *Helicoverpa armigera* can damage 25-30 pods of gram in its life span. The research experiment was carried out at Insectary Field of Department of Entomology, College of Agriculture, Nagpur to evaluate the various HaNPV concentrations in combination with Neem seed extract and Quinolphos against *Helicoverpa armigera* on gram with nine treatments replicated thrice in Randomized Block Design. Results revealed that, treatment T_6 (HaNPV @ 500 LE ha^{-1} + Quinolphos 25 EC @ 0.05%) was found most superior amongst all the treatments and recorded 0.22 L mrl^{-1} lowest larval population of *H. armigera* at 14 DAS of second spraying with minimum pod damage of 10.35 per cent and produced highest grain yield 18.30 q ha^{-1} of gram. Second best treatment was T_5 (HaNPV 400 LE ha^{-1} + Neem seed extract 5%) and found at par with T_6. The maximum larval population (1.80 L mrl^{-1}) with highest pod damage (24.15%) and lowest grain yield (8.14 q ha^{-1}) was recorded in control. Thus, there is possibility of alternating HaNPV with chemical insecticides for the effective management of pod borer *H. armigera* in gram.

Keywords: HaNPV, *Helicoverpa armigera*, chickpea, neem, quinolphos

Introduction
India is the biggest consumer and producer of chickpea in the world and occupies 7.1 million hectares with a production of 5.75 million tones accounting for 30.9% and 39.9% of total pulse areas and production, respectively (Kumar *et al.*, 2018) [6]. Gram pod borer, *Helicoverpa armigera (*Hubner) is the serious pest of chickpea in Indian Agriculture; it is polyphagous and widely distributed in the world. In India, it has been observed to feed on 181 cultivated and uncultivated species belonging to 45 families. Productivity of gram crop is strongly affected by *H. armigera* which damage up to 90-95% crop during favorable weather condition. A single larva of *H. armigera* can damage 25-30 pods of gram in its life span. It feeds on tenders shoots and young pods. It makes holes in pods and inserts its half body in to pod and eat the developing seeds (Gautam *et al.*, 2018) [3]. Today crop pest have become a major concern for the farmers across the world. Regular and indiscriminate use of chemical insecticides and the misuse of synthetic pesticides on the crop have led to development of insecticide resistance in target pests, pest resurgence, secondary pest outbreaks, loss of bio-diversity, environmental pollution, residual toxicity and occurrence of human health hazards. This has promoted the necessity for seeking natural resource based new, safer, biodegradable insecticides that could be feasible and effective for insect pest management. This has low environmental risk, specificity, safety to non-target organism and low risk of resistance development in insect pests. HaNPV and neem are ideal for integrated pest management (IPM) program because they are relatively safe to use and have a narrow spectrum of toxicity against human and animals than chemical insecticides. Keeping in view the seriousness of the pest, economic importance of this crop and hazardous of insecticides the present study was carried out to evaluate natural resource based HaNPV and neem with insecticide against gram pod borer, *Helicoverpa armigera* (Hubner).

Material and Methods
The research experiment was conducted at Insectary Field of Department of Entomology, College of Agriculture, Nagpur, Maharashtra with nine treatments replicated thrice in Randomized Block Design. Treatments comprised of T_1- HaNPV (1x109 POB ml^{-1}) 500 LE $ha^{-1,}$ T_2- HaNPV (1x109 POB ml^{-1}) 400 LE ha^{-1}, T_3- Neem seed extract 5%, T_4- HaNPV (1x109 POB ml^{-1}) 500 LE ha^{-1} + Neem seed extract 5%, T_5- HaNPV (1x109 POB ml^{-1}) 400 LE ha^{-1} + Neem seed extract 5%, T_6- HaNPV (1x109 POB ml^{-1}) 500 LE ha^{-1} + Quinolphos 25 EC @ 0.05%, T_7- Neem seed extract 5% + Quinolphos 25 EC @ 0.05%, T_8- Quinolphos 25 EC @ 0.05%, T_9- Control (Water spray). The gram cultivar Jaki-9218 was sown by dibbling method. From the commercial solution, the quantity of the insecticide was worked out and used for spray. Fresh spray solution of Quinolphos 25 EC @ 0.05%, HaNPV (1x109 POB ml^{-1}) 400 LE ha^{-1}, 500 LE ha^{-1} was prepared at the time of application of spray and Neem seed extract 5% were prepared in separate containers day before the sowing. The first treatment spray was given when pest crossed ETL after emergence of crop. Second spray was given at an interval of 15 days. Average larval population of *Helicoverpa armigera* $meter^{-1}$ row length was worked out and further calculations were done for working out per cent pod dsamage. The data recorded in the various treatments were subjected to statistical analysis after suitable transformation by following standard procedures of Randomized Block Design experiment (Gomez and Gomez, 1984) [4].

Results and Discussion (Table 1)

Larval population of *H. armigera*

Larval population of *H. armigera* at 14th days after first spray The treatment T_6 was found to be significantly most effective with minimum larval population of *H. armigera* (0.65 L mrl^{-1}) and was statistically at par with T_7 (0.67 L mrl^{-1}) and followed by T_4 (1.06 L mrl^{-1}) which was also at par with T_5 (1.09 L mrl^{-1}), T_8 (1.10 L mrl^{-1}), T_1 (1.15 L mrl^{-1}), T_2 (1.21 L mrl^{-1}) and T_3 (1.28 L mrl^{-1}) except Control (3.27 L mrl^{-1}).

Larval population of *H. armigera* at 14th days after second spray, treatment T_6 was found significantly effective in recording minimum larval population of *H. armigera* (0.22 L mrl^{-1}) and was statistically at par with T_7 (0.27 L mrl^{-1}) followed by T_8 (0.36 L mrl^{-1}); T_4 (0.53 L mrl^{-1}) at par with T_5 (0.58L mrl^{-1}), T_3 (0.70 L mrl^{-1}), T_1 (0.77 L mrl^{-1}) and T_2 (0.83 L mrl^{-1}). Significantly maximum larval population of *H. armigera* was recorded in Control (1.80 L mrl^{-1}). It is seen from the above results, treatment T_6 and T_7 found significantly effective in order of merit in keeping the larval population of *H. armigera* at lower level at 7th and 14th days after second spray. The findings are in line with the results of Munni *et al.* (2011) [9]. Allah Ditta Abid *et al*. (2020) [1] mixed HaNPV with two insecticides, spinetoram and emamectin benzoate in various combinations and applied to larvae of *H. armigera* in laboratory conditions and recorded that, there was synergistic effect of HaNPV @ 0.5 × 109 PIB ml^{-1} × Spinetoram @ 40, 20, 10 ml 100 L^{-1} of water. In case of emamectin benzoate, synergistic effects were recorded at 1 × 109 PIB ml-1 HaNPV × emamectin benzoate @ 100 ml 100 L-1 of water. However, 0.5 × 109 PIB/ ml-1 HaNPV has synergistic effects with all three doses of emamectin benzoate. Similarly, Reddy *et al*. (2010) [12] reported maximum and highest larval reduction with NSKE 1.66% + HaNPV 250 LE ha^{-1} + Endosulphan 0.023% at 15 days interval in chickpea. Whereas, Gowda and Yelshetty (2007) [5] evaluated the different emulsifiable concentrations and dusts in rainfed chickpea ecosystem against *H. armigera* and recorded that, Chloropyriphos 20 EC @ 250 g a.i. ha^{-1}, Quinolphos 1.5 D @ 375 g a.i. ha^{-1} and Malathion 5D @ 1250 g a.i. ha^{-1} emerged as superior treatments resulting per cent larval reduction over initial population, a day after treatment. Kumawat *et al*., (2023) [7] reported that, 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 whereas, Parmar *et al*., (2024) observed that, natural resource based bioagents were found significantly effective to minimize the population density of gram pod borer larvae. The HaNPV + Bt treatment was found most effective in reducing larval population of *H. armigera*.

Table 1: Effect of various treatments on larval population of *H. armigera*, per cent pod damage and grain yield of gram

Tt	Treatment Details	Larval Pre-treatment count*	Larval Population at First Spray*		Larval Population at Second Spray*		Per cent Pod Damage #	Gain Yield (q ha^{-1})
			7 DAS	14 DAS	7 DAS	14 DAS		
T_1	HaNPV 500 LE ha-1	s3.73 (1.93)	2.41 (1.55)	1.15 (1.07)	0.95 (0.97)	0.77 (0.87)	18.10 (4.25)	12.90
T_2	HaNPV 400 LE ha-1	2.53 (1.59)	2.50 (1.58)	1.21 (1.10)	0.96 (0.97)	0.83 (0.91)	19.75 (4.44)	12.40
T_3	Neem Seed Extract 5%	3.85 (1.96)	2.51 (1.58)	1.28 (1.13)	0.98 (0.98)	0.70 (0.83)	19.88 (4.46	12.05
T_4	HaNPV 500 LE ha-1 + Neem Seed Extract 5%	3.00 (1.72)	1.50 (1.22)	1.06 (1.03)	0.88 (0.93)	0.53 (0.72)	15.85 (3.94)	13.80
T_5	HaNPV 400 LE ha-1 + Neem Seed Extract 5%	3.13 (1.77)	1.73 (1.31)	1.09 (1.04)	0.90 (0.94)	0.58 (0.76)	16.04 (4.00)	13.10
T_6	HaNPV 500 LE ha-1 + Quinolphos 25 EC @ 0.5%	2.64 (1.62)	0.96 (0.97)	0.65 (0.80)	0.47 (0.68)	0.22 (0.46)	10.35 (3.22)	18.13
T_7	Neem Seed Extract 5%+ Quinolphos 25 EC @ 0.5%	2.87 (1.69)	0.98 (0.98)	0.67 (0.81)	0.53 (0.73)	0.27 (0.51)	10.70 (3.27)	17.30
T_8	Quinolphos 25 EC @ 0.5%	3.27 (1.80)	1.75 (1.32)	1.10 (1.04)	0.94 (0.96)	0.36 (0.60)	16.10 (4.01)	13.00
T_9	Control- Water spray	3.70 (1.92)	3.85 (1.96)	3.27 (1.80)	2.00 (1.41)	1.80 (1.34)	24.15 (4.91)	8.14
'F' Test		NS	Sig	Sig	Sig	Sig	Sig	Sig
S.E. (m) ±		-	0.07	0.05	0.06	0.03	0.20	0.7
C.D. at 5%		-	0.22	0.17	0.18	0.10	0.61	2.1

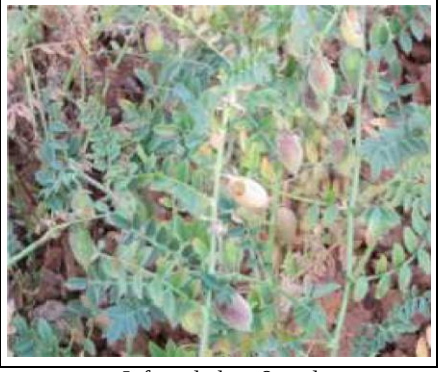
*Figures in parenthesis are square root transformed values

#Figures in parenthesis are angular transformed values

Per cent pod damage at harvest

The treatment T_6 was found significantly most effective in recording minimum pod damage (10.35%) and was found superior over all other treatments whereas, the next effective treatment was T_7 (10.70%). The remaining treatment in descending order of effectiveness were T_4 recorded comparatively minimum pod damage (15.85%) followed by T_5 (16.04%), T_8 (16.10%), T^1 (18.10%), T_2 (19.75%) and T_3 (19.88%). Significantly maximum pod damage was recorded in Control (24.15%). Babar *et al*. (2012) and Patil [11] *et al*. (2007) reported minimum pod damage on chickpea and are in line with present results. Parmar *et al*., (2024) noticed that, natural resource based bioagents were found significantly effective in reducing the pod damage inflicted by gram pod borer, *H. armigera* and pod damage varied from 3.05 to 5.04%. The HaNPV + Bt. was found most effective and had minimum (3.05%) pod damage.

Infested pod at an experimental plot



Infested plant & pod

Pod borer larva on chickpea plant

Grain yield

Treatment T_6 found most effective in recording highest yield of chickpea (18.13 q ha^{-1}) and was at par with T_7 (17.30 q ha^{-1}). The second-best effective treatment was T_4 (13.80 q ha^{-1}) and at par with T_5 (13.10 q ha^{-1}), T_8 (13.00 q ha^{-1}), T_1 (12.90 q ha^{-1}), T_2 (12.40 q ha^{-1}) and T_3 (12.05 q ha^{-1}) whereas, lowest yield of 8.14 q ha^{-1} was recorded in Control. Similar findings were also reported by Yadav *et al*. (2007) and Bhalkare *et al*. (2007) [14, 2]. Singh *et al*. (2013) and Lingappa *et al*. (2000) [13, 8] also studied the efficacy of insecticides and bio-pesticides against *H. armigera* on chickpea with maximum yield. Kumawat *et al*., (2023) [7] suggested Spinosad 45 SC and Emamectin benzoate 5 SG both might be used to manage *H. armigera* borer effectively for maximum yield. Parmar *et al*., (2024) [4] reported that, all the natural resource based bioagents were effective to more yield in comparison to control treatments, among which two sprays of NPV+Bt reveals maximum yield.

Conclusions

Findings indicated the possibility of alternating NPV with chemical insecticides to manage the *H. armigera* infestation in chickpea ecosystem.

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