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Population fluctuation and management of gram pod borer, *Helicoverpa armigera* (Hubner) infesting chickpea in new alluvial zone of West Bengal, India

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Abstract
The present investigation was conducted at District Seed Farm, Bidhan Chandra Krishi Vishwavidyalaya, Kalyani, for consecutive two *Rabi* season 2017-18 & 2018-19. Gram pod borer, *Helicoverpa armigera* larval population first appeared in the field during 5rd SMW and maintained same trend of population up to 7th SMW. However, it reached its peak population in 11th SMW with a population load 18 larvae/ 10 plants. Correlation coefficient of *H. armigera* with various abiotic factors, maximum temperature (r = 0.76) and bright sunshine hours (r =0.574) was exhibited significant positive correlation whereas minimum temperature (r = - 0.391) was found negative correlation with *H. armigera* larval population. So far as the management of *H. armigera* by used new molecule along with bio-pesticide, Cyclaniliprole 10% DC @ 350 ml/ha gave highest mortality followed by Cyclaniliprole 10% DC @ 300 ml/ha. The highest yield was obtained from Cyclaniliprole 10% DC @ 350 ml/ha treated plots (14.30 q/ha) which was statistically at par with the treatment of Cyclaniliprole 10% DC @ 300 ml/ha (13.67 q/ha).

Keywords: Chickpea, gram pod borer, population fluctuation, abiotic factors, new insecticide

Introduction
Chickpea (*Cicer arientinium* Linn.) is one of the most important pulse crop grown approximate 9 million hectares of land all over the world out of which 70% grown in India [5]. In India context, total food production was about 209 million tonnes in the year 1999-2000, among that only 13.4 million tonnes was contributed by pulse crops. Chick pea covers near about 38 per cent of cultivable land under pulse crops and give 50 per cent yield of the total pulses production. It is not only used for human consumption but also use feeding to cattle animals which have been considered as a 'king of Pulses'. It contains 25% proteins and 61.1% carbohydrates [11]. Nowadays, various constraints like diseases, pests and weeds are found that interrupted successful chickpea cultivation in India. Among them gram pod borer, *Helicoverpa armigera* (Hub) infestation is the serious concern which turns low crop production [10]. It is considered as damaging pest and has assumed as a national pest due its high fecundity, high adaptation to adopt diverse agro-climatic conditions, migratory behaviour and development of resistance capability against various insecticides. In India, the extent of losses due to *H. armigera* is up to 27.9% in North West Plain Zone, 13.2% in North East Plain Zone, 24.3% in Centre Plain Zone and 36.4% in South Plain Zone [6]. To combat this notorious pest, major thrust was given mainly use of chemical insecticide, however, the knowledge on the seasonal fluctuation of gram pod borer may be supporting in formulating the insect pest management strategies. Intervention of microbial pesticides like nuclear polyhedrosis virus (HaNPV), entomopathogenic fungi (viz. *Hirsutella*, *Metarhizium*, *Nomuraea*, *Beauveria*) *Bacillus thuringiensis*, entomopathogenic nematodes (Steinernematidae and Heterorhabditidae) and plant products such as neem, custard apple and pongamia kernel extracts have been shown promising against *H. armigera* [8]. HaNPV has been found a sustainable option to manage *H. armigera* in chickpea [3]. Hence, the present experiment was carried out to understand the population fluctuation of gram pod borer and its suitable management by using new insecticide including bio-pesticide.

Materials and Methods

To study the population fluctuation of *Helicoverpa armigera*, chickpea seed was sown in line with a spacing 30 cm X 10 cm in five different plots measuring about 5m X 5m at District Seed Farm, Bidhan Chandra Krishi Vishwavidyalaya, Kalyani, Nadia, West Bengal (22^{0}58'52" N; 88^{0}26'30"E, 10 m above sea level) for consecutive two years (*Rabi* 2017-18 and 2018-19). One of the popular variety 'KWR108' was selected for whole experiment and standard agronomic practices as per the recommendations were followed. Data was collected at seven days interval from ten randomly selected plants of each plot.

To manage of *Helicoverpa armigera* (Hub.) field experiments was conducted at District Seed Farm, BCKV, Kalyani (22^{0}58'52" N; 88^{0}26'30"E, 10 m above sea level), Nadia, West Bengal. The experiment was conducted for two consecutive *Rabi* seasons 2017-18 and 2018-19 in randomized block design (RBD) with six treatments including an untreated control with four replications in a plot size of 25 m^2. Four different insecticides including bio-pesticide (*Beauveria bassiana* 1.50% LF, entomopathogenic fungus) were applied at different dosages at 15 days interval. Two spraying were done starting after showing natural infestation during dawn and dusk. All the precautions were taken before and during spraying so the product should reach the target pest. The observations were recorded on randomly selected five plants in each replication marked with tags. The data on the number of larval population on five plants were noted before spray and 1, 3, 7, 10 days after spray. Spraying was done twice in a season. At harvest, the yield of chickpea was noted separately in each treatment and yield data was cumulated for statistical analysis.

Statistical analysis

The influence of different weather factors like maximum temperature (^{0}C), minimum temperature (^{0}C), maximum relative humidity (RH), minimum relative humidity (RH) and bright sunshine hours on population fluctuation of *H. armiger* had been investigated by means of correlation study through Pearson's correlation method. The data were subject to analysis after making necessary transformation and expressed on the basis of percent reduction of pest population.

Results and Discussion

Population fluctuation of *Helicoverpa armigera* infesting chickpea

The seasonal fluctuation of gram pod borer, *H. armigera* in chickpea was monitored under field condition at District Seed farm, BCKV Kalyani, during *Rabi* 2017-18 and 2018-19 and presented in table 1 and figure 1. It is evident from the table and figure that the *H. armigera* larval population started its appearance in chickpea from 5th standard meteorological week and maintained same trend of population up to 7th SMW (standard meteorological week). However, it reached its peak in 11th SMW with a population 18 larvae/ 10 plants. Then the population gradually dwindled onwards 13th SMW when the crop reached near senescence stage and this population was found below the economic injury level. The present finding is agreed with author Borah and Dutta 2004 who reported that the larval population first appeared in end of January and reached its peak during end of March and thereafter population was declined. Correlation coefficient of *H. armigera* population with various abiotic factors viz. maximum temperature (r = 0.76) and bright sunshine hours (r = 0.574) was exhibited significant positive correlation, minimum temperature (r =-0.391) found negative correlation with *H. armigera* whereas, maximum relative humidity (r = 0.077) and minimum relative humidity (r = 0.12) was found non-significant but positive correlation with *H. armigera* larval population. The present findings are in conformity of earlier authors Shinde, *et al*. (2013) [9], Spoorthi, *et al*. (2017) [12] and Waseem & Thakur (2019) [15] reported that larval population had showed a positive correlation with maximum temperature and bright sunshine hours whereas, negative correlation was build up with maximum relative humidity and total rainfall. The result of the same trend had been found in the second year experiment (table no. 2 & figure no. 2).

Table 1: Correlation between *H. armigera* population with weather factors during *rabi* 2017-18.

Weather factors	Correlation co-efficient(r)	co-efficient of determination ($R^{2)}$	Regression Equation
Max. Temperature (^{0}C)	0.760*	R^2= 0.578	y= 0.406x^2+ 26.27x +411.54
Min. Temperature (^{0}C)	(-) 0.391	R^2= 0.153	y= -0.113x^2+ 4.240x - 27.62
Max. Relative Humidity (%)	(-) 0.077	R^2= 0.006	y= 0.017x^2-3.188x -156.53
Min. Relative Humidity (%)	0.012	R^2= 0.016	y= 0.005x^2-0.55x +24.70
Bright sunshine (hrs)	0.574	R^2= 0.330	y= 0.427x^2-3.97x +13.07

*Significance at 5% level of significance

Table 2: Correlation between *H. armigera* population with weather factors during *rabi* 2018-19.

Weather factors	Correlation co-efficient (r)	co-efficient of determination ($R^{2)}$	Regression Equation
Max. Temperature (^{0}C)	0.741*	R^2= 0.412	y= 0.107x^2+ 7.824x –128.98
Min. Temperature (^{0}C)	(-) 0.77	R^2= 0.605	y= -0.332x^2+ 11.868x – 90.53
Max. Relative Humidity (%)	0.431	R^2= 0.191	y= 0.044x^2-8.553x +424.59
Min. Relative Humidity (%)	0.570	R^2= 0.326	y= -0.0197x^2+1.354x -9.25
Bright sunshine (hrs)	0.491	R^2= 0.242	y= -0.154x^2+2.924x -0.673

*Significance at 5% level of significance

Table 3: Efficacy of Treatments on Mean population of gram pod borer larvae/ 5 plants during 2017-18.

Treatments	Dosagem l/ha	Pre-treated pop./5plants	% mortality of gram pod borer after 1st round spray					% mortality of gram pod borer after 2nd round spray				
			1 DAS	3 DAS	7 DAS	10DAS	Mean	1DAS	3DAS	7 DAS	10 DAS	Mean
T_1= Cyclaniliprole 10% DC	300	5.33	60.39 (51.29)*	81.33 (64.77)	84.43 (66.37)	76.92 (61.20)	75.76	80.84 (64.40)	87.57 (69.79)	89.08 (71.17)	83.48 (66.41)	83.64
T_2= Cyclaniliprole 10% DC	350	6.46	63.96 (53.40)	85.28 (67.84)	87.53 (69.76)	80.19 (63.93)	79.24	82.66 (65.78)	89.06 (71.15)	92.23 (74.36)	88.92 (71.02)	87.21
T_3= Chorantraniliprole 18.5%	125	5.88	57.35 (49.52)	73.01 (59.02)	81.03 (64.55)	74.39 (59.92)	71.44	76.86 (61.58)	81.07 (64.57)	84.84 (67.49)	83.23 (66.21)	81.11
T_4= Novaluron 10% EC	750	6.07	53.90 (47.52)	74.38 (59.92)	85.73 (68.22)	76.61 (61.42)	72.65	79.51 (63.44)	87.65 (69.86)	89.53 (71.59)	84.12 (66.91)	84.64
T_5= *B. bassiana* 1.50% LF	1500	6.27	12.28 (20.95)	28.36 (32.49)	35.46 (37.44)	42.07 (41.31)	29.79	45.23 (40.82)	49.33 (44.90)	59.21 (50.02)	64.02 (52.84)	54.44
T_6= Untreated control	--	5.97	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	----	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	--
CD (0.05)	--		5.47	5.36	5.45	6.06		4.02	5.45	6.76	6.16	--
SEm±			1.23	1.12	1.09	1.33		0.98	1.36	1.63	1.54	--

Table 4: Efficacy of Treatments on Mean population of gram pod borer larvae/ 5 plants during 2018-19.

Treatment	Dosage ml/ha	Pre-treated pop./5 plants	% mortality of gram pod borer after 1st round spray					% mortality of gram pod borer after 2nd round spray				
			1 DAS	3 DAS	7 DAS	10DAS	Mean	1 DAS	3 DAS	7 DAS	10DAS	Mean
T_1= Cyclaniliprole 10% DC	300	5.63	62.16 (52.33)*	79.56 (63.48)	83.37 (66.32)	78.48 (62.71)	75.89	82.58 (65.71)	84.34 (67.09)	86.64 (68.98)	85.33 (67.88)	84.20
T_2= Cyclaniliprole 10% DC	350	4.71	63.72 (53.26)	81.61 (64.98)	85.81 (68.29)	81.00 (64.53)	78.63	84.85 (67.49)	86.97 (69.27)	88.72 (70.83)	86.79 (69.12)	86.40
T_3= Chorantraniliprole 18.5%	125	4.92	52.46 (46.69)	71.55 (58.08)	77.16 (61.79)	71.92 (58.32)	68.27	76.45 (61.31)	78.39 (62.64)	80.48 (64.14)	79.91 (63.73)	78.66
T_4= Novaluron 10% EC	750	5.13	46.70 (43.39)	74.05 (59.70)	79.50 (63.44)	73.75 (59.50)	68.50	79.70 (63.58)	81.68 (65.03)	84.18 (66.96)	81.62 (64.98)	81.42
T_5= *B. bassiana* 1.50% LF	1500	5.33	14.25 (22.57)	26.46 (31.28)	38.26 (38.50)	43.27 (41.42)	30.56	44.13 (41.92)	51.33 (46.05)	57.26 (49.46)	59.12 (50.55)	52.96
T_6= Untreated control	----	4.75	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)		0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	--
CD (0.05)		--	6.34	5.12	5.76	5.10		5.44	5.12	6.05	5.32	--
SEm±			1.54	1.38	1.42	1.23		1.26	1.26	1.33	1.27	--

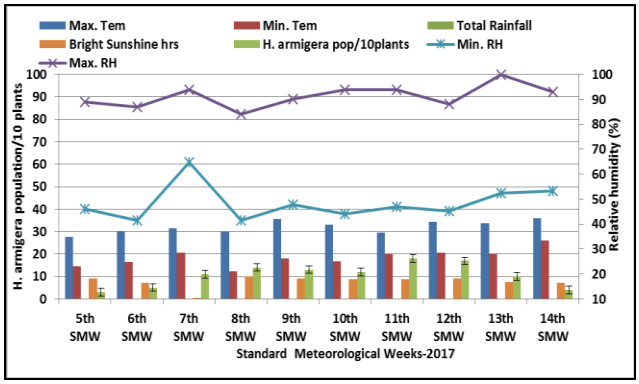

Fig 1: Population fluctuation of gram pod borer infesting chickpea during *rabi* season 2017-18.

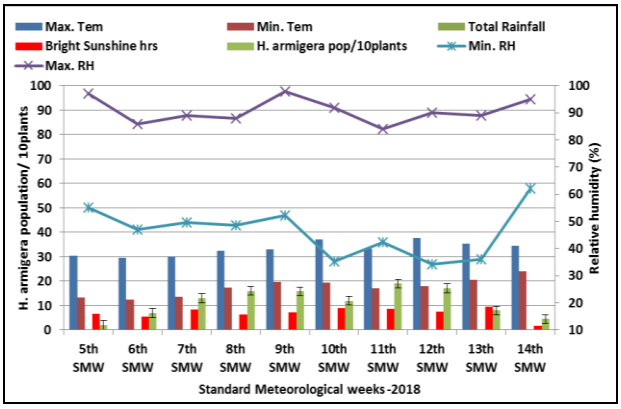

Fig 2: Population fluctuation of gram pod borer infesting chickpea during *rabi* season 2018-19.

Bio-efficacy of insecticides against *H. armigera* infesting chickpea during *Rabi* 2017-18

Different pests attacked in chickpea during the period of investigation, among them gram pod borer, *Helicoverpa armigera* (Hub.) was the most dominating and notorious one. One day before spray, pod borer population ranged from 5.33 to 6.46 per 5 plants and it was statistically non-significant showing equal distribution in the experimental plots (Table 3). One day after spray, highest mortality of pod borer (63.96%) was noticed from the treatment T_2 i.e. Cyclaniliprole 10% DC @ 350 ml/ha but this treatment was statistically at par with T_1 i.e. Cyclaniliprole 10% DC @ 300 ml/ha with 60.39% mortality followed by T_3 (57.35) and T_4 (53.90) though these treatments were statistically at par with each other. On the 3rd day of spray, maximum mortality was recorded from the plots treated with T_2 and registered 85.28% mortality followed by T_1 (81.33%) though these treatments were statistically at par. The treatment T_4 i.e. Novaluron 10% EC @ 750 ml/ha was rendering satisfactory result securing 74.38% mortality which was statistically at par with the treatment T_3 (Chorantraniliprole 18.5% SC @ 125ml/ha) with 73.01% mortality. The Similar trend of observation was recorded on 7th and 10th days of spray. However, 7 days after spray highest mortality was observed from the treatment T_2 = Cyclaniliprole 10% DC @ 350ml/ha (87.53%) followed by T_1 (84.43%) and T_4 (85.73%) whereas, the less mortality percentage was observed from the treatment T_5 (35.46%). After 10 days of treatment, maximum mortality was recorded with the treatment T_2 (80.19%) followed by T_1 (76.92%), T_4 (76.61%), and T_3 (74.39%) though these treatments were statistically at par with each other. Lowest mortality per cent

of *H. armigera* (42.07%) was recorded in the treatment *Beauveria bassiana* 1.50% LF @1500 ml/ha treated plots. The significance efficacy of Chlorantraniliprole 18.5 SC, Novaluron 10 EC and *Beauveria bassiana* 1.50% LF @1500 ml/ha against gram pod borer was reported by Bala and Sarkar (2017) [2], Chitralekha *et al*. (2018) [4], Patel *et al*. (2016) [7] and Sreekanth & Seshamahalakshmi 2012 [13]. Since, Cyclaniliprole 10% DC is new molecule and there are lacks of available supporting literatures regarding bio-efficacy against gram pod borer. Howevr, Cyclaniliprole 10% DC @ 300 ml/ha or Cyclaniliprole 10% DC @ 350 ml/ha could be good and alternative option for management of gram pod in chickpea in new alluvial zone of West Bengal. Similar trend of results had been found in second round of spray in the first year experiment.

Efficacy of insecticides against gram pod borer *H. armigera* during *Rabi* 2018-19

Pre-treatment population of gram pod borer ranged from 4.71 to 5.63 per 5 plants and it was statistically non significant showing equal distribution (Table 4). However, one day after spray (DAS) highest mortality of pod borer (63.72%) was recorded in the treatment T_2 (Cyclaniliprole 10% DC @ 350 ml /ha) but this treatment was statistically at par with T_1 i.e. 300 ml/ha accounting 62.16% mortality and lowest mortality of pod borer (14.25%) was recorded in *Beauveria bassiana* 1.50% LF @ 1500 ml/ha treated plots. Three days after spraying, maximum mortality was recorded from the plots treated with T_2 and registered 81.61% mortality followed by T_1 (79.56%) though these treatments were statistically at par with each other. The treatment T_4 (Novaluron 10% EC @ 750 ml/ha) was received satisfactory result recorded 74.05% mortality which was statistically at par with the treatment T_3 i.e. Chorantraniliprole 18.5% SC @ 125ml/ ha (71.55%). The Similar trend of observation was recorded after 7th and 10th days of spray as well as second round spray in the second year experiment (Table 4).

Plate 1: Symptom of gram pod borer damage caused by *H. armigera* in chickpea.

Yield of Chickpea

Yield of chickpea revealed that all the treatments were significantly superior over untreated control (Table 5). However, the plots treated with Cyclaniliprole 10% DC @ 350 ml/ha produced highest yield (14.82 q/ha) followed by T_1 i.e Cyclaniliprole 10% DC @ 300 ml/ha (13.67 q/ha), T_3 Chorantraniliprole @ 125 ml/ha (13.77 q/ha) and T_4 Novaluron 10% EC @ 750 ml/ha (12.30 q/ha) which was statistically at par with each other. Similar trends of observed was recorded in successive year. The present findings are partially in line with the authors Chitralekha, *et al*. (2018) [4] and Singh & Verma, 2006, they observed that lower pod damage and maximum yield was recorded in Novaluron 50 EC and Chlorantraniliprole 15.5 SC treated plots.

Table 5: Effect of insecticides on Cumulative yield of chickpea in q/ha.

Treatments	Dosage (ml /ha)	Yield of chickpea Q/ha	
		1st Season	2nd Season
T_1= Cyclaniliprole 10% DC	300	13.67	13.20
T_2= Cyclaniliprole 10% DC	350	14.30	15.06
T_3= Chlorantraniliprole 18.5%	125	13.77	12.55
T_4= Novaluron 10% EC	750	12.30	13.23
T_5= *B. bassiana* 1.50% LF	1500	9.33	9.75
T_6= Untreated control	-	6.73	6.80
CD (0.05)	-	2.06	1.79
SEm±		0.64	0.48

Conclusion

From the critical investigation of the present findings it was concluded that fluctuation of gram pod borer dependant on weather factors. However, *H. armigera* larval population first appeared in the field during 5rd SMW and maintained its population up to 7th standard meteorological week and then reached its peak in 11th SMW with a population load 18 larvae/10 plants, thereafter population gradually dwindled when the crop was reached in senescence stage. So far as management of gram pod borer in chickpea, it was established that chemical management was found more effective as compared to bio pesticide. However, the new molecule Cyclaniliprole 10% DC @ 350 ml/ha and Cyclaniliprole 10% DC @ 300 ml/ha was found equal effective in controlling *H. armigera* larval population, reduce pod infestation and produced maximum grain yield.

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