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Surveillance of pod borer, *Helicoverpa armigera* (Hubner) and its natural enemies on chickpea at Sahaspur Lohara blocks

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Abstract
Experiments on incidence of *Helicoverpa armigera* and its natural enemies in chickpea was studied during 2016-17 and 2017-18 at the area of Kabirdham districts of Chhattisgarh at blocks *viz.,* sahaspur-Lohara and in each block fields were selected during 2016-17 and 2017-18. On the basis of pooled mean various abiotic parameters *viz.,* the population of *H. armigera* larva Showed non-significant and negative correlation with maximum temperature (^{0}C) (r = - 0.448) but minimum temperature (^{0}C) (r = - 0.540*) negative significant correlation with *H. armigera* and regression line was worked out for no. of *H. armigera* larvae Y_1= -0.274 X_2+ 5.940 R^2 0.29. Rain fall (r = 0.204), wind velocity (r = - 0.329) and sunshine hours (r = 0.013) are positive non-significant but relative humidity (r = 0.845**) highly positive significant correlation with *H. armigera* larva population and regression line was worked out for no. of *H. armigera* larvae Y_1 = 0.143 X_3 - 8.564, R^2 0.71. Pooled mean data, the ento-pathogenic virus NPV infected larvae was Showed non-significant and negative correlation with maximum temperature (^{0}C) (r = - 0.506), minimum temperature (^{0}C) (r = - 0.473) and sunshine hours (r = 0.123). Rain fall (r = 0.231), wind velocity (r = 0.424) positive non-significant correlation was observed but morning relative humidity (r = 0.812**) highly positive significant correlation with NPV infected larvae and regression line was worked out for no. of NPV infected larvae Y_2 = 0.011 X_3 - 0.752, R^2 0.71. Basis of pooled mean data, the larval parasitoid, *Campolestis chlorideae* was showed non-significant and negative correlation with maximum temperature (^{0}C) (r = - 0.430), minimum temperature (^{0}C) (r = - 0.511) and Sunshine hours (r = - 0.108). Rain fall (r = 0.003), Wind velocity (r = 0.435) are non-significant and positive correlation but Relative humidity (r = 0.746**) is highly significant positive correlation and regression line was worked out for no. of *Campolestis chlorideae* parasitoid larvae Y_3 = 0.016 X_3- 0.990, R^2 0.55.

Keywords: abiotic factors, correlation, non-significant, chickpea, surveillance

1. Introduction
Chickpea (*Cicer arietinum* L.) is the most important pulse crop grown in India. It is commonly recognized by the name 'Chickpea' or Bengal or Chana and belongs to leguminoseae family. It is probably originated from South Eastern Turkey and from there it spread to other countries of the world therefore it is known as 'King of Pulses'. It is a helpful source of vitamin K, foliate, phosphorus, zinc and protein too It is also very rich in dietary fiber and hence a healthy source of carbohydrates for a person suffering with insulin sensitivity or diabetes. Among all the pulse crops, the maximum content of protein *i.e.* 25% is provided by Chickpea and a carbohydrate is about 61.1%. It contains certain dietary minerals such as iron, phosphorus and thiamine (Jukanti *et al*., 2012) [7]. It has protein digestibility corrected amino acid score of about 0.76, which is higher than many other (Khatoon and Prakash, 2004) [9].
This pest starts infesting the shoot/tips few weeks after crop emergence and feed on buds, flowers and pods till harvesting, causing heavy yield losses. Larvae of *H. armigera* (Hubner) are prodigious foliar feeder as early instars and later move to the developing seeds and fruits leading to drastic reduction in yield. A single larva can consume upto 30-40 pods in its life cycle (Taggar and Singh, 2012) [18]. *H. armigera* in chickpea causes yield loss may range from 70 to 95 per cent (Prakash *et al*., 2007) [13]. The major factors contributing to the serious pest status of *H. armigera* (Hubner) are high polyphagy, mobility and fecundity.
The seasonal information of the pod borer activity is required to manage the pest timely and in an effective way (Singh *et al*., 2005; Jadhav *et al*., 2010) [15, 16, 6]. The life cycle of *H. armigera* passes through egg, larva, pupa and adult stages within 28-30 days. Adults are nocturnal and respond to light radiations at night and can be monitored through light traps (Hardwick, 1965) [5].

2. Methods and Material
Fixed plot survey study was conducted for the surveillance of chickpea pod borer, *Helicoverpa armigera* (Hubner) and its natural enemies in Kabirdham districts of Chhattisgarh at blocks *viz.,* sahaspur-Lohara and in each block fields were selected during 2016-17 and 2017-18.

2.1. Observations recorded

For the study of surveillance of pod borer, the number of larva per meter row length was observed at weekly interval from five randomly selected spot at each location. Similarly, its natural enemies (parasitoids) were observed at weekly interval from five randomly selected spot at each location and percent parasitization was calculated by using the formula given blow –

$$\text{Parasitization (\%)} = \frac{\text{Number of Parasitized larvae}}{\text{Number of total larvae observed}} \times 100$$

3. Results and Discussion

The surveillance of *Helicoverpa armigera* and their natural enemies on chickpea crop at sahaspur lohara blocks during *rabi* 2016-17 and 2017-18. Surveillance of pod borer and its natural enemies (parasitoids) per meter row length was observed at weekly interval from five randomly selected spot at each location. During the course of study one natural enemies Larval parasitoid, *Campolestis chlorideae* and one Ento-pathogenic virus nuclear polyhedrosis virus (NPV) observed during the period of study. The present finding of Suganthy *et al*. (2003) [17] who reported that peak activity of pest was observed in first fortnight of December, January and February when the crop was at peak podding stage and decline in population gradually towards the maturity of the crop. Chatar *et al*. (2010) [2] regarding the appearance of gram pod borer in chickpea is also similar to the present studies. Dubey *et al.* (1995) [3] who studies the population dynamics of gram pod borer and peak activity in February of gram pod borer.

3.1. Chickpea pod borer, *Helicoverpa armigera* (Hubner)

The population of *Helicoverpa armigera* was in the range of 0.34 to 4.49 and 0.24 to 4.12 per meter row length during *rabi* 2016-17 and 2017-18, respectively (Table 4.1 Fig.4.1).

During *rabi* 2016-17, the *Helicoverpa armigera* larvae first appeared in 51th SMW (third week of December) (1.65 *H. armigera* larvae/mrl). The maximum no. of *H. armigera* larvae (4.49 larvae/mrl) were noticed during 5th SMW fifth week of January, (Table 4.1) During this period rainfall, maximum and minimum temperature, relative humidity, wind velocity and bright sunshine hours were recorded 0.0 mm, 29.2 ^{0}C and 13.4 ^{0}C, 77 percent, 3.80 kmph and 9.20 hours/day, respectively. Thereafter, the no. of *H. armigera* larvae gradually decreased 0.34 during 11th SMW (second week of March).

During *rabi* 2017-18, *H. armigera* larvae was first noticed in 51th SMW (third week of December) (1.72 *H. armigera* larvae/mrl). The maximum no. of *H. armigera* larvae (4.12 larvae/mrl) were noticed during 6th SMW (first week of February). During this period rainfall, maximum and minimum temperature, relative humidity, wind velocity and bright sunshine hours were recorded 0.0 mm, 30.9 ^{0}C and 13.4 ^{0}C, 81 percent, 1.80 kmph and 9.20 hours/day, respectively. Thereafter, the no. of *H. armigera* larvae gradually decreased 0.24 during 11th SMW (second week of March).

During the two years 2016-17 and 2017-18 basis of pooled mean data, The no. of *H. armigera* larvae first appeared in 51th SMW third week of December with (1.69 larvae/mrl).The maximum no. *H. armigera* larvae (3.92 larvae/mrl) were noticed during 5th SMW (fifth week of January), During this period pooled weather parameters rainfall, maximum and minimum temperature, relative humidity, wind velocity and bright sunshine hours were recorded 0.00 mm, 29.2 ^{0}C and 12.35 ^{0}C, 79.50 percent, 3.30 kmph and 8.80 hours/day, respectively. Thereafter, the no. of *H. armigera* larvae gradually decreased 0.29 during 11th SMW (second week of March).

Suganthy *et al*. (2003) [17] reported similar findings with the present investigation that peak activity of pest was observed in first fortnight of December, January and February when the crop was at peak podding stage and decline in population gradually towards the maturity of the crop. The findings of Chatar *et al*. (2010) [2]. Regarding the appearance of gram pod borer in chickpea is also similar to the present studies. Dubey *et al.* (1995) [3] studied the population dynamics of gram pod borer and peak activity in February and March of gram pod borer.

Table 3.1: Surveillance of pod borer, *Helicoverpa armigera* (Hubner) at block- SAHASPUR LOHARA during 2016-17 to 2017-18

SMW	DATE	Pod borer and their natural enemies/mrl								
		Pod borer			NPV infected larvae			*Campolestis chlorideae*		
		2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
50	10-16 Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	17-23 Dec	1.65	1.72	1.69	0.00	0.00	0.00	0.00	0.00	0.00
52	24-31 Dec	1.74	1.55	1.65	0.00	0.11	0.06	0.13	0.25	0.19
1	01-07 Jan	2.61	1.42	2.02	0.13	0.15	0.14	0.11	0.34	0.23
2	08-14 Jan	3.87	1.54	2.71	0.17	0.19	0.18	0.16	0.42	0.29
3	15-21 Jan	3.31	2.62	2.97	0.16	0.26	0.21	0.24	0.55	0.40
4	22-28 Jan	4.10	2.75	3.43	0.22	0.28	0.25	0.36	0.58	0.47
5	29Jan-04 Feb	4.49	3.35	3.92	0.26	0.22	0.24	0.45	0.47	0.46
6	05 -11 Feb	3.13	4.12	3.63	0.23	0.31	0.27	0.37	0.32	0.35
7	12-18 Feb	2.86	3.26	3.06	0.16	0.25	0.21	0.26	0.17	0.22
8	19-25 Feb	2.57	2.81	2.69	0.00	0.14	0.07	0.15	0.31	0.23
9	26 Feb-04 March	1.43	1.61	1.52	0.00	0.00	0.00	0.18	0.12	0.15
10	05-11 March	1.30	1.44	1.37	0.00	0.00	0.00	0.11	0.15	0.13
11	12-18 March	0.34	0.24	0.29	0.00	0.00	0.00	0.00	0.00	0.00
12	19-25March	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seasonal Mean		**2.23**	**1.90**	**2.06**	**0.09**	**0.13**	**0.11**	**0.17**	**0.25**	**0.21**

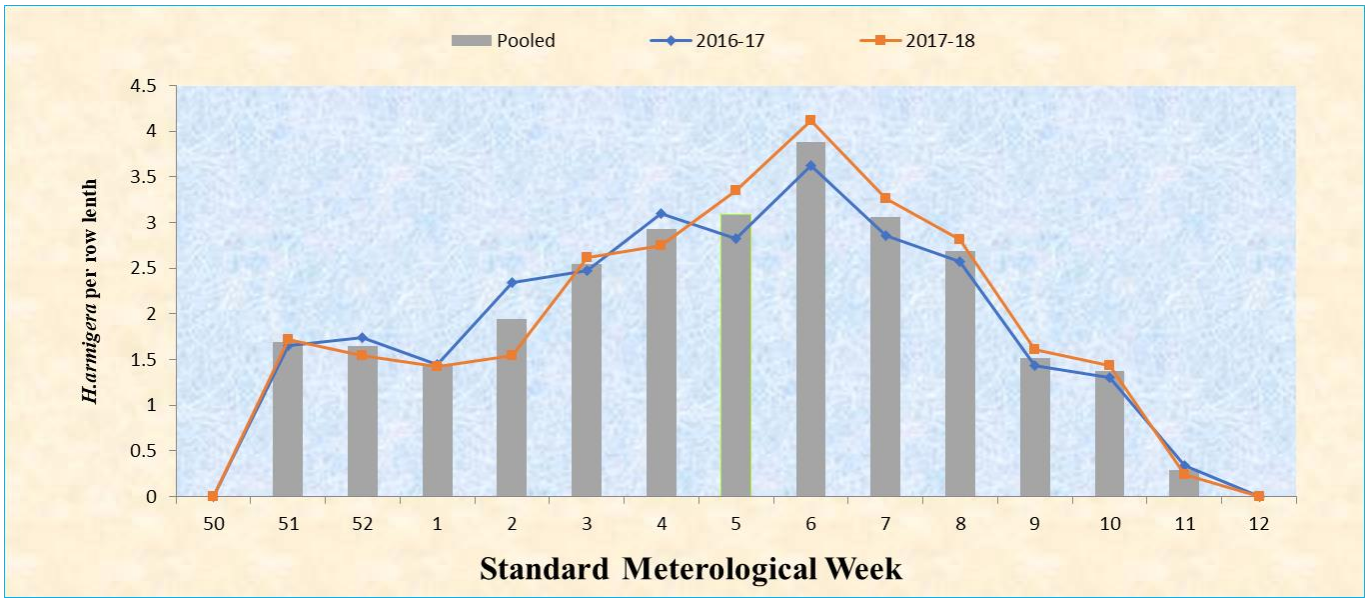

Fig 3.1: *Helicoverpa armigera* population on chickpea during 2016-17 and 2017-18 pooled mea

3.2. Ento-pathogenic virus nuclear polyhedrosis virus (NPV)

The population of ento-pathogenic virus NPV infected larvae was in the range of 0.13 to 0.26 larvae/mrl and 0.11 to 0.31 larvae per meter row length during *rabi* 2016-17 and 2017-18, respectively. Table 4.1 Fig 4.2.

During *rabi* 2016-17, the ento-pathogenic virus NPV infected larvae was first appeared in 1st SMW (first week of January) (0.13 larvae/mrl). The maximum NPV infected larvae (0.26 larvae/mrl) were noticed during 5th SMW (fifth week of January). During this period rainfall, maximum and minimum temperature, relative humidity, wind velocity and bright sunshine hours were recorded 0.0 mm, 29.2 ^{0}C and 13.4 ^{0}C, 77 percent, 3.80 kmph and 9.20 hours/day, respectively. There after the no. of NPV infected larvae gradually decreased 0.16 during 7th SMW (second week of February).

During *rabi* 2017-18, the ento-pathogenic virus NPV infected larvae was first noticed in 52th SMW fourth week of December (0.11 larvae/mrl). The maximum NPV infected larvae (0.31 larvae/mrl) were noticed during 6th SMW (first week of February), During this period rainfall, maximum and minimum temperature, relative humidity, wind velocity and bright sunshine hours were recorded 0.0 mm, 30.9 ^{0}C and 13.4 ^{0}C, 81 percent, 1.80 kmph and 9.20 hours/day, respectively. There after the no. of NPV infected larvae gradually decreased 0.0.14 during 8th SMW (third week of February).

During the two years 2016-17 and 2017-18 basis of pooled mean data, NPV infected larvae was first appeared in 52th SMW fourth week of December (0.06 larvae/mrl). The maximum NPV infected larvae (0.27 larvae/mrl) were noticed during 6th SMW (first week of February), During this period rainfall, maximum and minimum temperature, relative humidity, wind velocity and bright sunshine hours were recorded 0.00 mm, 30.85 ^{0}C and 14.25 ^{0}C, 82 per cent, 2.30 kmph and 9.40 hours/day, respectively. There after the no. of NPV infected larvae gradually decreased 0.07 during 8th SMW (third week of February).

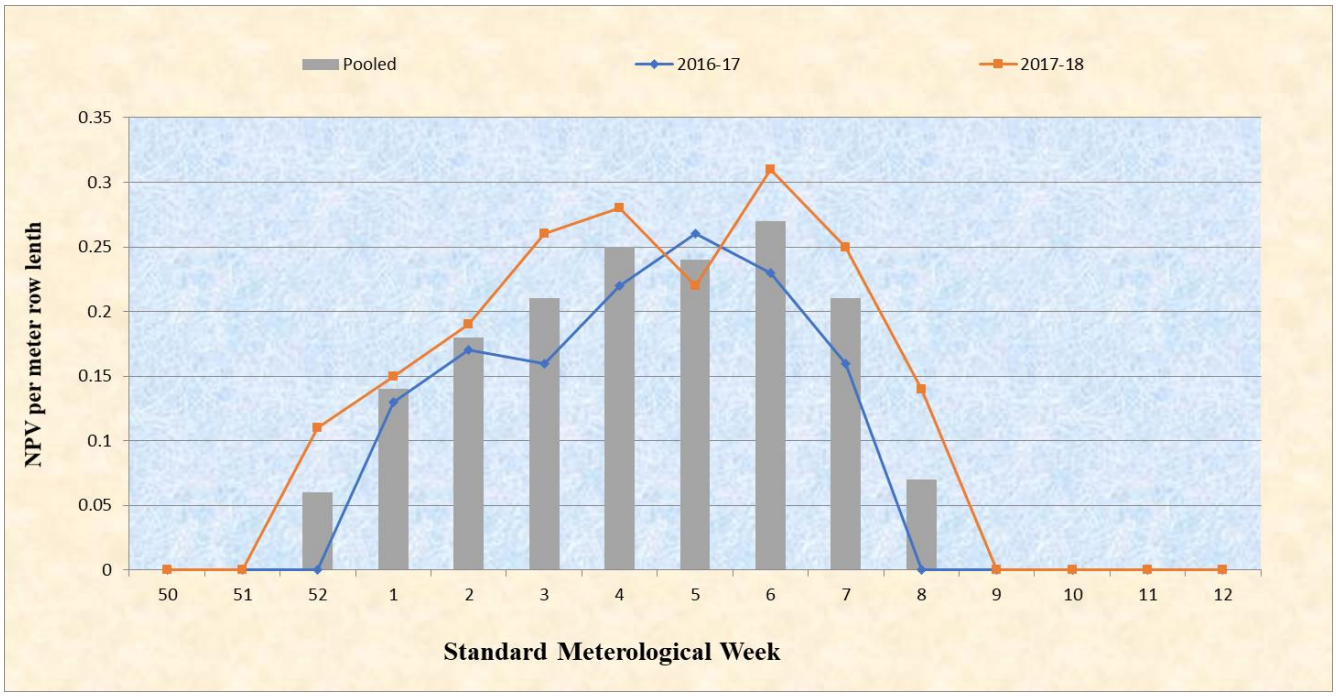

Fig 3.2: NPV population on chickpea during 2016-17 and 2017-18

3.3. Larval parasitoid, *Campolestis chlorideae*

The observation on larval parasitoid, *Campolestis chlorideae* on chickpea are presented in Table 4.1 depicted in Fig. 4.3. The population of larval parasitoid, *Campolestis chlorideae* was in the range of 0.11 to 0.45 larvae/mrl and 0.12 to 0.58 larvae per meter row length during *rabi* 2016-17 and 2017-18, respectively.

During *rabi* 2016-17, The population of larval parasitoid, *Campolestis chlorideae* was first appeared in 52th SMW fourth week of December (0.13 larvae/mrl). The maximum parasitoid larvae (0.45 larvae/mrl) were noticed during 5th SMW (fifth week of January), During this period rainfall, maximum and minimum temperature, relative humidity, wind velocity and bright sunshine hours were recorded 0.0 mm, 29.2 ^{0}C and 13.4 ^{0}C, 77 percent, 3.80 kmph and 9.20 hours/day, respectively. There after the no. parasitoid larvae gradually decreased (0.11 larvae/mrl) during 10th SMW (first week of March).

During *rabi* 2017-18, The population of larval parasitoid, *Campolestis chlorideae* was first appeared in 52th SMW fourth week of December (0.25 larvae/mrl). The maximum parasitoid larvae (0.58 larvae/mrl) were noticed during 4th SMW (fourth week of January). During this period rainfall, maximum and minimum temperature, relative humidity, wind velocity and bright sunshine hours were recorded 0.0 mm, 27.8 ^{0}C and 11.1 ^{0}C, 88 percent, 2.80 kmph, and 6.40 hours/day, respectively. There after the no. parasitoid larvae gradually decreased (0.15 larvae/mrl) during 10th SMW (5-11 march).

During the two years 2016-17 and 2017-18 basis of pooled mean data, the population of larval parasitoid, *Campolestis chlorideae* was first appeared in 52th SMW fourth week of December (0.19 larvae/mrl). The maximum parasitoid larvae (0.47 larvae/mrl) were noticed during 4th SMW (fourth week of January). During this period rainfall, maximum and minimum temperature, relative humidity, wind velocity and bright sunshine hours were recorded 0.00 mm, 28.50 ^{0}C and 13.05 ^{0}C, 87.50 percent, 4.15 kmph and 7.20 hours/day, respectively. There after the no. parasitoid larvae gradually decreased (0.13 larvae/mrl) during 10th SMW (first week of March).

The findings in relation to population of pupae of *C. chlorideae* on chickpea are pursuant to the observations recorded by Pandey and Kumar (2006) who reported that *Campolestis chlorideae* parasitoid preferred the late instars or early 2nd instars host larvae for parasitisation and pupated outside the host in the form of cocoon within a week. Singh and Ali (2006) who reported seasonal activity of gram pod borer, *Helicoverpa armigera* and its parasitoid, *Campolestis chlorideae*, on chickpea cv. K-850. The maximum parasitisation by *C. chlorideae* was observed in 4th standard weeks. Kaur *et al* (2000) found that the larval parasitoid *C.chloridae* was the most important mortality factor for the larvae of *H. armigera* parasitim due to *C.chlorideae* throughout the crop season. Sharma *et al*. (2008) who reported that parasites *C. chlorideae* was found to parasitize the *H. armigera* larvae from vegetative to pod initiation stage. *H. armigera* laval parasitisation by *C. chloridae* ranges from 3.69 to 14.83%, maximum parasitization was observed during 4th SMW *i.e.* vegetative stage.

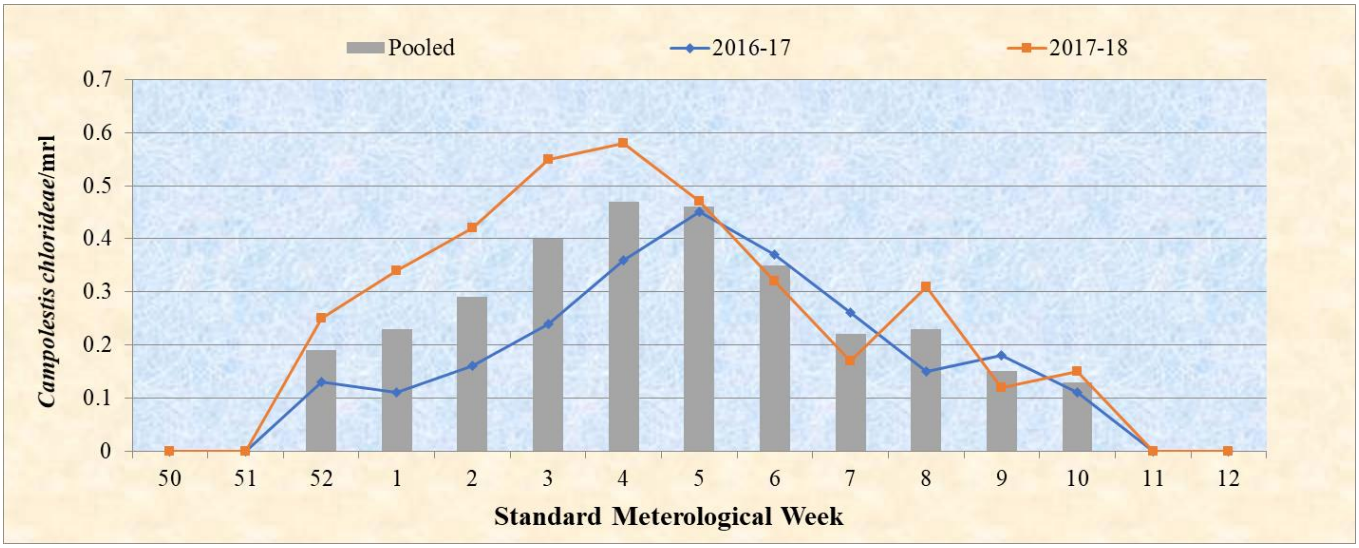

Fig 3.3: *Campolestis chlorideae* population on chickpea during 2016-17 and 2017-18 pooled mean

3.4. Correlation and Regression studies:- Correlation of pod borer, *Helicoverpa armigera* (Hubner) and its natural enemies on chickpea crop in relation to weather parameters at Sahaspur Lohara Blocks during 2016-17 and 2017-18.

3.4.1. Chickpea pod borer, *Helicoverpa armigera* (Hubner)

The correlation coefficient was worked out between population of *H. armigera* larva and abiotic factors during *rabi* 2016-17 and 2017-18 of both year on chickpea crop and presented Table 4.2.

During *rabi* 2016-17, The population of *H. armigera* larva Showed non-significant and negative correlation with maximum temperature (^{0}C) (r = - 0.471), minimum temperature (^{0}C) (r = - 0.340) and sunshine hours (r = - 0.234). Rain fall (r = 0.087) and wind velocity (r = 0.324) positive non-significant but relative humidity (r = 0.564*) positive significant correlation with *H. armigera* larva population and regression line was worked out for no. of Y1 = -0.2690+685x, R^2 0.31'Y_1' was estimated number of *H. armigera* larvae which explained by regression equation for any value of independent variable X_2= Relative humidity (RH) and R^2 was number of *H. armigera* larvae population which explained by regression equation where, 'Y' was no. of larvae and X was prevailing weather parameters.

During *rabi* 2017-18, The population of *H. armigera* larva Showed non-significant and negative correlation with

maximum temperature (^{0}C) (r = - 0.363), wind velocity (r = - 0.014) but minimum temperature (^{0}C) (r = - 0.545*) negative significant correlation with *H. armigera* and regression line was worked out for no. of *H. armigera* larvae Y_1 = -0.224 X_2 + 4.89 R^2 0.29 (Fig. 4.5). Rain fall (r = 0.298) and sunshine hours (r = 0.200) are positive non-significant but relative humidity (r = 0.780**) highly positive significant correlation with *H. armigera* larva population and regression line was worked out for no. of *H. armigera* larvae Y_1 = 0.080 X_3 - 3.83, R^2 0.60 (Fig. 4.6).

During 2016-17 and 2017-18 basis of pooled mean data, the population of *H. armigera* larva Showed non-significant and negative correlation with maximum temperature (^{0}C) (r = - 0.448) but minimum temperature (^{0}C) (r = - 0.540*) negative significant correlation with *H. armigera* and regression line was worked out for no. of *H. armigera* larvae Y_1= -0.274 X_2+ 5.940 R^2 0.29 (Table 4.2 Fig. 4.7). Rain fall (r = 0.204), wind velocity (r = - 0.329) and sunshine hours (r = 0.013) are positive non-significant but relative humidity (r = 0.845**) highly positive significant correlation with *H. armigera* larva population and regression line was worked out for no. of *H. armigera* larvae Y_1 = 0.143 X_3 - 8.564, R^2 0.71 (Table 4.4).

Similar kind of work was done and observation had been recorded by Ganguli *et al.,* (1998) [4] and Babu *et al.,* (2009) [1] reported a negative correlation with minimum temperature. Kumar and Durairaj (2012) [10] also reported that the emergence of *H. armigera* adults had a significant negative association with minimum temperature. Patel and Koshiya (1999) [12] found negative association of maximum and minimum temperatures with *H. armigera.*

3.4.2. Ento-pathogenic virus nuclear polyhedrosis virus (NPV)

The correlation of Ento-pathogenic virus nuclear polyhedrosis virus (NPV) with weather parameters was worked out to estimate correlation coefficient (r) during *rabi* 2016-17 and 2017-18 and pooled mean of both year on chickpea crop and presented.

During *rabi* 2016-17, the ento-pathogenic virus NPV infected larvae was Showed non-significant and negative correlation with maximum temperature (^{0}C) (r = - 0.429), minimum temperature (^{0}C) (r = - 0.216) and sunshine hours (r = - 0.280). Rain fall (r = 0.146) and wind velocity (r = 0.312) positive non-significant but relative humidity (r = 0.657**) highly positive significant correlation with *H. armigera* larva population and regression line was worked out for no. of Y_2 = 0.009X_2 - 0.64, R^2 =0.43.

During *rabi* 2017-18, the ento-pathogenic virus NPV infected larvae was Showed non-significant and negative correlation with maximum temperature (^{0}C) (r = - 0.560*) but minimum temperature (^{0}C) (r = - 0.651**) highly negative significant correlation with *H. armigera* and regression line was worked out for no. of *H. armigera* larvae Y_2 = -0.021 X_1 + 0.77, R^2 0.31 and Y_2 = -0.025 X_2 + 0.47, R^2 0.42 (Fig. 4.10). Rain fall (r = 0.280), wind velocity (r = 0.056), sunshine (r = 0.054) positive non-significant correlation was observed but in case of morning relative humidity (r = 0.636*) positive significant correlation was observed with NPV infected larvae and regression line was worked out for no. of NPV infected larvae Y_2 = 0.006 X_3 - 0.32, R^2 0.40 (Fig. 4.4).

During 2016-17 and 2017-18 basis of pooled mean data, the ento-pathogenic virus NPV infected larvae was Showed non-significant and negative correlation with maximum temperature (^{0}C) (r = - 0.506), minimum temperature (^{0}C) (r = - 0.473) and sunshine hours (r = 0.123). Rain fall (r = 0.231), wind velocity (r = 0.424) positive non-significant correlation was observed but morning relative humidity(r = 0.812**) highly positive significant correlation with NPV infected larvae and regression line was worked out for no. of NPV infected larvae Y_2 = 0.011 X_3 - 0.752, R^2 0.71 (Table. 4.5).

3.4.3. Larval parasitoid, *Campolestis chlorideae*

The correlation of larval parasitoid, *Campolestis chlorideae* with weather parameters was worked out to estimate correlation coefficient (r) during *rabi* 2016-17 and 2017-18 and pooled mean of both year on chickpea crop and presented (Table 4.3).

During *rabi* 2016-17, The larval parasitoid, *Campolestis chlorideae* was Showed non-significant and negative correlation with maximum temperature (^{0}C) (r = - 0.162), minimum temperature (^{0}C) (r = - 0.074) and Rain fall (r = 0.154), Relative humidity (r = 0.446), wind velocity(r = 0.383) and sunshine hours (r = 0.080) are positive non-significant correlation with larval parasitoid, *Campolestis chlorideae*.

During *rabi* 2017-18, The larval parasitoid, *Campolestis chlorideae* was Showed non-significant and negative correlation with Rain fall (r = - 0.108), Sunshine hours (r = - 0.117) but significant negative correlation with maximum temperature (^{0}C) (r = - 0.564*) and highly significant negative correlation with minimum temperature (^{0}C) (r = - 0.730**) regression line was worked out for no. of larval parasitoid, *Campolestis chlorideae* Y_3 = -0.036 X_1 + 1.34, R^2 0.31 and Y_3 = -0.049 X_2 + 0.90, R^2 0.53 (Fig. 4.13). Wind velocity (r = 0.013) are positive non-significant correlation but Relative humidity (r = 0.530*) is significant positive correlation and regression line was worked out for no. of *Campolestis chlorideae* parasitoid larvae Y_3 = 0.008 X_3 - 0.38, R^2 0.28 (Table. 4.4).

During 2016-17 and 2017-18 basis of pooled mean data, the larval parasitoid, *Campolestis chlorideae* was showed non-significant and negative correlation with maximum temperature (^{0}C) (r = - 0.430), minimum temperature (^{0}C) (r = - 0.511) and Sunshine hours (r = - 0.108). Rain fall (r = 0.003), Wind velocity (r = 0.435) are non-significant and positive correlation but Relative humidity (r = 0.746**) is highly significant positive correlation and regression line was worked out for no. of *Campolestis chlorideae* parasitoid larvae Y_3 = 0.016 X_3- 0.990, R^2 0.55 (Table. 4.5).

Table 3.2: Correlation coefficient on Pod borer, *Helicoverpa armigera* (Hubner) and their natural enemies with weather parameters during 2016-17 to 2017-18 block:-Sahaspur-Lohara

Weather Parameters	Pod borer			NPV infected larva			*Campolestis chlorideae*		
	2016-17	2017-18	pooled	2016-17	2017-18	pooled	2016-17	2017-18	pooled
Maximum Temperature (^{0}C)	-0.471	-0.363	-0.448	-0.429	-0.560*	-0.506	-0.162	-0.564*	-0.430
Minimum Temperature (^{0}C)	-0.340	-0.545*	-0.540*	-0.216	-0.651**	-0.473	-0.074	-0.730**	-0.511
Rain fall (mm)	0.087	0.298	0.204	0.146	0.280	0.231	0.154	-0.108	0.003
Relative humidity (RH)	0.564*	0.780**	0.845**	0.657**	0.636**	0.812**	0.446	0.530*	0.746**
Wind velocity (km/h)	0.324	-0.014	0.329	0.312	0.056	0.424	0.383	0.013	0.435
Sunshine hours (hours)	-0.234	0.200	0.013	-0.280	0.054	-0.123	0.080	-0.117	-0.108

*****: Significant (5%) = 0.514

******: Highly significant (1%) = 0.641

Table 3.3: Regression line analysis for *Helicoverpa armigera* and its natural enemies with Weather parameters during 2016-17 sahaspur-lohara

Regression equation			R^2		
H.armigera	NPV	*Campolestis chlorideae*	*H.armigera*	NPV	*Campolestis clorideae*
$Y_1 = 0.685X_2 - 0.26$	$Y_2 = 0.009X_2 - 0.64$	-	0.31	0.43	-

Y_1= Estimated of *H.armigera*, Y_2=NPV, Y_3= *Campolestis clorideae*
X1= Maximum Temperature
X2= Relative humidity (RH)
R^2= Coefficient of Determination

Table 3.4: Regression line analysis for *Helicoverpa armigera* and its natural enemies with Weather parameters during 2017-18 sahaspur-lohara

Regression equation			R^2		
H. armigera	NPV	*Campolestis clorideae*	*H.armigera*	NPV	*Campolestis clorideae*
-	$Y_2 = -0.021\ X_1 + 0.77$	$Y_3 = -0.036\ X_1 + 1.34$	-	0.31	0.31
$Y_1 = -0.224\ X_2 + 4.89$	$Y_2 = -0.025\ X_2 + 0.47$	$Y_3 = -0.049\ X_2 + 0.90$	0.29	0.42	0.53
$Y_1 = 0.080\ X_3 - 3.83$	$Y_2 = 0.006\ X_3 - 0.32$	$Y_3 = 0.008\ X_3 - 0.38$	0.60	0.40	0.28

Y_1= Estimated of *H.armigera*, Y_2=NPV, Y_3= *Campolestis clorideae*
X1= Maximum Temperature
X2= Minimum Temperature
X3= Relative humidity (RH)
R^2= Coefficient of Determination

Table 3.5: Regression line analysis for *Helicoverpa armigera* and its natural enemies with Weather parameters during 2016-17 to 2017-18 pooled sahaspur-lohara

Regression equation			R^2		
H. armigera	NPV	*Campolestis clorideae*	*H. armigera*	NPV	*Campolestis clorideae*
$Y_1 = -0.274\ X_2 + 5.940$	-	-	0.291	-	-
$Y_1 = 0.143\ X_3 - 8.564$	$Y_2 = 0.011\ X_3 - 0.752$	$Y_3 = 0.016\ X_3 - 0.990$	0.713	0.659	0.556

Y1 =Estimated of *H. armigera*, Y_2=NPV, Y_3= *Campolestis clorideae*
X1= Maximum Temperature
X2= Minimum Temperature
X3= Relative humidity (RH)
R^2= Coefficient of Determination

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