Journal of Entomology and Zoology Studies
Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2017; 5(1): 636-642

Received: 24-11-2016
Accepted: 26-12-2016

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Impact of abiotic and biotic factors on population dynamics of *Helicoverpa armigera* Hubner (Noctuidae: Lepidoptera) in chickpea

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Abstract
To determine the impact of abiotic factors and parasitization by *Campoletis chlorideae* on population dynamics of *Helicoverpa armigera,* investigations were undertaken in chickpea during winter 2010-11 and 2011-12. Weekly observations were recorded regarding abiotic factors in relation to larval intensity, larval parasitization, and rate of larval multiplication in field or lab conditions. It was concluded that during February month, the larval population had the highest peaks as 8.93 & 7.93 larvae m^{-1} row along with the highest multiplication rate as 0.44 & 0.33 larvae/day. The natural parasitization was the maximum during December month as 51.67 & 56.67%. Simple correlation coefficient (r) of temperature (maximum and minimum), wind speed, and evaporation rate had reflected positive values when relative humidity (morning and evening), rainfall and larval parasitization played a negative role on the pest population.

Keywords: population dynamics, *Helicoverpa armigera*, abiotic factor, *Campoletis chlorideae*, chickpea, larval parasitization

1. Introduction
Among all the pulses, the Chickpea (*Cicer arietinum* L.) which is commonly known as Gram or Bengal gram is the most important pulse crop of India. However, the productivity is not quite good as a large number of insect-pests have been recorded while feeding on chickpea. Among them the *Helicoverpa armigera* Hubner (Noctuidae: Lepidoptera) has attained status of the most serious pest in recent years in terms of economic damage caused to different agricultural crops throughout India including chickpea (Davies and Lateef and Lal *et al.*) [4, 10]. The extent of losses caused by *H. armigera* varies from region to region and depends upon climate and crop intensity. However, a monetary loss of 203 crore rupees annually is estimated (CAB International) [6].
The pest lays eggs on chickpea seedlings at second and third leaf stages of the crop in Orissa, India (Patnaik and Senapati) [12]. Its larvae appeared on chickpea crop after 15 days of germination at Dharwad, Karnataka, India (Kambrekar) [8]. Singh and Ali [20] found active *H. armigera* larvae throughout the chickpea crop period at Faizabad, Uttar Pradesh, India. The single larva of the pest has ability to destroy 30-40 pods in its lifetime and due to *H. armigera*, around 80% pod damages have been reported from India and Pakistan. The ecological factors, temperature (14-45 ^{0}C), photoperiod (10-14 hrs), relative humidity (15-95%) coupled with optimum and intermittent rainfall were found to affect the population build-up, adult emergence and fecundity of the female moths of *H. armigera* (Tripathi and Singh) [23].
Natural enemies are major biotic constraints to the population build-up of *H. armigera* in crops (Singh *et al.*) [18]. The early stage larvae of the pest are found to be parasitized by *Campoletis chlorideae* (Uchida) (Bilapate *et al.* [1] and Kaur *et al.*) [9]. This parasitoid has been observed to cause 80.5 per cent parasitization of *H. armigera* larvae in chickpea ecosystem (Pandey *et al.*) [11]. The parasitic activity was noticed higher at minimum temperature 9.7 ^{0}C and was also ceased at maximum temperature more than 40 ^{0}C in chickpea ecosystem in Himachal Pradesh, India (Gupta and Desh Raj) [5].
Monitoring of the larval population and extent of larval parasitization of *H. armigera* in the field is a prerequisite for successful pod borer management. Perusal of literature reveals that very little research works have been done in this region (Bihar, INDIA) regarding population dynamics of *H. armigera* in relation to abiotic and biotic factors. Therefore, in order to design a superior pest management model for the crop in this region, the present research study was

undertaken to know the population dynamics of *H. armigera* larvae in relation to abiotic (Maximum and minimum temperature, relative humidity during morning & evening hours, wind velocity, evaporation rate and rainfall) factors and biotic factor (natural parasitization by *Campoletis chlorideae* Uchida) under chickpea field conditions.

2. Materials and Methods

2.1 Conduction of field experiments: The chickpea variety (KPG-59, *Uday*) was sown on 2nd November 2010 and 7th November 2011 following the recommended agronomical practices of Bihar Agricultural University (Sabour, India). The plot size was 4X4m for every treatment and the path of 1.0m width was maintained around each plot. Trials were conducted in Randomized Block Designs in 3 replications during both the years. During the experiment, the crop was left as untreated and population dynamics in relation to abiotic factors (maximum & minimum temperature, % relative humidity in morning & evening, evaporation, wind speed and rainfall) and natural parasitization of *H. armigera* by its parasitoid (*Campoletis chlorideae* Uchida) was recorded. In all experiments, 2nd instar larval population of *H. armigera* were counted as per linear meter row.

2.2 Meteorological observations: Observations regarding temperature (maximum & minimum), relative humidity (morning & evening), wind speed, evaporation and rainfall were recorded from the Meteorological observatory of the India Meteorological Department at Patna. Data so obtained were finally computed together to obtain the total mean of weather parameters at weekly intervals for entire cropping period from 2nd week of November to 2nd week of April during 2010-11 & 2011-12.

2.3 Observations on population dynamics and parasitisation of *H. armigera*: For determining the intensity of the pest in chickpea, the 2nd instar larval population was recorded in one meter linear row of the crop at 5 random places at weekly intervals, started after a fortnight upon germination and continued till maturity of the crop.

For observation of larval parasitisation in untreated plots, 20 1st and 2nd instar larvae were collected randomly and observed in Entomological laboratory (Bihar Agricultural University, Sabour, India) at weekly intervals. The data on larval intensity m^{-1} row and natural parasitisation (by *Campoletis chlorideae* Uchida) were computed and correlated with prevailing abiotic (maximum & minimum temperature, % relative humidity in morning & evening, evaporation, wind speed and rainfall) factors. The rate of multiplication of the pest intensity was calculated as means of 3 replications by subtracting the values of current larval intensity from previous work in subsequent weeks. The subtracted values were divided by the number of days (7) of the week and those values were taken as the rate of multiplication per day. The per cent parasitization was calculated by using this formula suggested by Chaudhary and Sharma [3]:

$$\textbf{Per cent parasitization} = \frac{\text{Number of parasitized larvae}}{\text{Number of total reared larvae}} \times 100$$

Correlation and regression of the abiotic factors on *H. armigera* were worked out by using the formula as suggested by Snedecor and Cochran [22]. For analysis of variance, the data were subjected to statistical analysis after tabulation in to transformed values. The population data of larvae were transformed to $\sqrt{X + 0.5}$, while data in percentages were transformed to their angular values. The data so obtained were analysed by using the analysis of variance techniques. The significance among different treatment means was judged by critical difference (C.D) at 5% & 1% levels of significance for comparison among the treatments, for which the marginal means of each treatment was considered.

3. Results and Discussion

3.1 Effect of abiotic factors on pest population during 2010-11 and 2011-12:

Maximum temperature (Degree Celsius): During 14th Standard Week (SW) in April 2011 and 15th SW (Apr.12), it was noted the highest as 38.19 & 35.68 ^{0}C and larval parasitization, larval intensity and larval multiplication were 1.67 & 0.0%, 0.67 & 0.33m^{-1} row and -1.0 & -0.15/day respectively. The lowest temperature recorded during 1st SW (Jan. 11) and 52nd SW (Dec.11) was as 13.03 & 18.31 ^{0}C with larval parasitization, larval intensity and larval multiplication as 31.67 & 33.33%, 0.26 & 0.33m^{-1} row and 0.0 & -0.06/day respectively. [Table-1 and Figure-1 near here].

Minimum temperature (Degree Celsius): During 14th SW in April 2011 and 15th SW (Apr.12), it was noted the highest as 18.91 & 20.31 ^{0}C and larval parasitization, larval intensity and larval multiplication were 1.67 & 0.0%, 0.67 & 0.33m^{-1} row and -1.0 & -0.15/day respectively. The lowest temperature recorded during 48th SW (Nov. 10) and 52nd SW (Dec.11) was as 4.43 & 7.66 ^{0}C with larval parasitization, larval intensity and larval multiplication as 33.33 & 33.33%, 1.47 & 0.33 m^{-1} row and 0.11 & -0.06/day respectively.

Relative humidity percentage in morning: During 52nd SW (Dec.10) and 6th SW (Feb.12), it was noted the highest as 95.57 & 94.71% and larval parasitization, larval intensity and larval multiplication were 28.33 & 31.67%, 0.26 & 4.60 m^{-1} row and -0.03 & 0.30/day respectively. The lowest relative humidity recorded during 14th SW (Apr. 11) and 49th SW (Dec.11) was as 54.86 & 20.14% with larval parasitization, larval intensity and larval multiplication as 1.67 & 43.33%, 0.67 & 2.13 m^{-1} row and -1.0 & 0.04/day respectively.

Relative humidity percentage in evening: During 8th SW (Feb.11) and 5th SW (Jan.12), it was noted the highest as 85.71 & 78.57% and larval parasitization, larval intensity and larval multiplication were 21.67 & 26.67%, 7.67 & 2.53m^{-1} row and 0.44 & 0.27/day respectively. The lowest relative humidity recorded during 13th SW (Mar. 11) and 14th SW (Mar.12) was as 29.14 & 19.43% with larval parasitization, larval intensity and larval multiplication as 1.67 & 0.0%, 7.67 & 1.40m^{-1} row and 0.13 & -0.56/day respectively. [Table-2 and Figure-2 near here].

Wind speed: During 10th SW (Mar.11) and 15th SW (Apr.12), it was observed the highest as 7.49 & 7.07Km/hour and larval parasitization, larval intensity and larval multiplication were 23.33 & 0.0%, 6.47 & 0.33m^{-1} row and -0.35 & -0.15/day respectively. The lowest wind speed was witnessed during 46th SW (Nov.10) and 46th SW (Nov.11) as 1.10 & 2.03 Km/hour and larval parasitization, larval intensity and larval multiplication were observed as the nil growth.

Evaporation: During 12th SW (Mar.11) and 15th SW (Apr.12), it was observed the highest as 6.89 & 8.20 mm/week and larval parasitization, larval intensity and larval multiplication were 6.67 & 0.0%, 6.73 & 0.33m^{-1} row and

0.29 & -0.15/day respectively. The lowest evaporation rate was observed during 52nd SW (Dec.10) and 52nd SW (Dec.11) as 0.09 & 0.66 mm/week and larval parasitization, larval intensity and larval multiplication were 28.33 & 33.33%, 0.26 & 0.33m^{-1} row and -0.03 & -0.06/day respectively.

Rainfall: During 52nd SW (Dec.10) and 14th SW (Mar.12), it was observed the highest as 36.0 & 11.70 mm/week with larval parasitization, larval intensity and larval multiplication were 28.33 & 0.0%, 0.26 & 1.40 m^{-1} row and -0.03 & -0.56/day respectively. The lowest rainfall was observed during 5th SW (Jan.11) and 13th SW (Mar.12) as 3.78 & 0.50mm/week and larval parasitization, larval intensity and larval multiplication were 11.67 & 1.67%, 1.0 & 5.33m^{-1} row and 0.05 & -0.13/day respectively.

3.2 Population dynamics of *H. armigera* larvae (2010-11 and 2011-12)

Regarding initiation of *H. armigera* infestation on chickpea during 2010-11, initially the pest intensity was 0.73 larvae m^{-1} row during 47th SW (Nov.10), which fluctuated intermittently and reached to high as 1.73 larvae m^{-1} row until 49th SW (Dec.10) and thereafter declined to a low level of 0.26 larvae m^{-1} row until 52nd SW (Dec.10), and remained constant until 1st SW (Jan.11). Singh and Ali [20] reported similar activities of *H. armigera* larvae on chickpea crop at Kumarganj, Faizabad, India. [Figure-3 near here].

The pest manifested its activity in increasing trend from 2nd SW (Jan.11) with 0.33 larvae m^{-1} row and reached to high as 8.93 larvae m^{-1} row until 9th SW (Feb.11). Thereafter, it started to decline intermittently and before the maturity of the crop (14th SW, Apr.11), the larval population was decreased up to 0.67 larvae m^{-1} row. Similar trends on associations of temperature and relative humidity with the population build-up of the larvae of *H. armigera* were reported by earlier workers from varied agro-ecological regions as Shahzad *et al.* [16], Shah *et al.* [14] and Shah *et al.* [15] from Faisalabad, Pakistan and Singh *et al*. [18] from North West Rajasthan, India.

Similar trend on larval population of *H. armigera* was noticed during the 2nd year (2011-12), as there was an initial population of 0.26 larvae m^{-1} row during 47th SW (Nov.11) which fluctuated intermittently until 52nd SW (Dec.11) as 0.33 larvae m^{-1} row, thereafter, it remained constant until the end of 1st SW (Jan.12). Such activity was noticed again from 2nd SW (Jan.12) and it gradually increased until 10th SW (Mar.12) and showed a heavy flush of the pest with a maximum population of 7.93 larvae m^{-1} row, thereafter, it was gradually declined up to 15th SW (Apr.12) as 0.33 larvae m^{-1} row. Singh [18] similarly reported a sudden rise in larval populations with rise in minimum temperature during 6th standard week.

During 2010-11, natural parasitisation of *H. armigera* by *Campoletis chlorideae* was maximum (48.33-51.67%) between 49th (Dec.10) to 50th (Dec.10) standard weeks during main activity period of the pest and thereafter it gradually declined with the season until 5th SW (Jan.11) as 11.67%. it was high again during 6th SW (Feb.11) as 18.33%, thereafter, it fluctuated intermittently and declined up to 1.67% during 14th SW (Apr.11, maturity of the crop). Similar trend on naural parastization was observed during 2011-12 as maximum (43.33-56.67%) between 49th (Dec.11) to 50th (Dec.11) standard weeks and thereafter it fluctuated intermittently and declined to the lowest as 1.67% during 13th SW (Mar.12, maturity of the crop). Such observations are in conformity with the reports of (Gupta and Desh Raj [5], Pandey *et al.* [11] and Chandel *et al*. [2]).

During 2010-11, rise in minimum temperature above 7.69 ^{0}C from 2nd SW (Jan.11) favoured the rate of larval multiplications of *H. armigera* and it was the highest as 0.44 larvae/day during 8th SW (Feb.11). Where exceeded maximum temperature as 38.19 ^{0}C, minimum temperature as 18.91 ^{0}C, lowest relative humidity in morning as 54.86% had reduced the larval population to the lowest as -1.0 larvae/day. Similarly during 2011-12, rise in minimum temperature above 9.93 ^{0}C from 3rd SW (Jan.12) favoured the rate of larval multiplications of *H. armigera* and it was the highest as 0.33 larvae/day during 7th SW (Feb.12). Vishwadhar *et al.* [24] also reported that a sudden rise in the minimum temperature above 7.5 ^{0}C around 7-8 standard weeks shown a major rise in pest population. When exceeded maximum temperature as 35.46 ^{0}C, the lowest relative humidity in evening as 19.43%, highest rainfall as 11.70 mm/week, drastically declined the multiplication of the pest to its lowest level as -0.56 larvae/day.

3.3 Correlation of meteorological factors with the larval parasitization of *H. armigera*

During 2010-11, Simple correlation coefficient (r) of all the abiotic factors with larval population evidenced that minimum temperature (r=0.62), evaporation rate (r=0.71) had reflected highly significant positive values followed by maximum temperature (r=0.57) and wind speed (r=0.53). Reddy *et al.* [13] similarly found that the population has significantly positive correlation with both minimum and maximum temperature and the correlation coefficient being 0.71 and 0.82, respectively. Though, the relative humidity in morning (r= -0.49), relative humidity evening (r= -0.37), rainfall (r= -0.27) and parasitization (r= -0.37) played a negative role on larval population. [Table-3 and Figure-4 near here].

In the subsequent year (2011-12), almost similar relationships were found except the rainfall. Simple correlation coefficient (r) of all the abiotic factors with larval population evidenced that maximum temperature (r=0.32), minimum temperature (r=0.42), evaporation rate (r=0.27), wind speed (r=0.51) and rainfall (r=0.066) reflected a positive relationship, however, relative humidity in morning (r=0.11), relative humidity evening (r=0.22) and parasitization (r= -0.164) were played a negative role on larval activities. Yadav and Jat [25], Shinde *et al.* [17] and Jagdish and Agnihotri [7] have also confirmed that maximum and minimum temperatures had a significant positive correlation with larval population whereas relative humidity and rainfall had no effect on population fluctuation.

Table 1: Impact of abiotic and biotic factors on population dynamics of *Helicoverpa armigera* in chickpea (2010-11)

Standard Weeks		Abiotic Factors							Biotic Factor	Mean* larval intensity (m^{-1} row)	Mean* rate of increase in larval population/day
		Max. Temp. (Deg. Cel.)	Min. Temp. (Deg. Cel.)	% R.H. (Mor.)	% R.H. (Eve.)	Wind Speed (Km/H)	Evaporation (mm/week)	Rainfall (mm/ week)	Mean* parasitization (%) By *C. Chlorideae*		
Nov. 10	46	27.37	10.57	91.29	45.29	1.10	1.97	0.0	0.0	0.0	0.0
Nov. 10	47	26.63	10.00	90.43	48.29	3.33	1.71	0.0	21.67	0.73	0.10
Nov. 10	48	25.03	4.43	92.43	50.14	1.1	1.17	0.0	33.33	1.47	0.11
Dec. 10	49	24.79	6.14	89.57	44.29	2.6	1.09	0.0	48.33	1.73	0.04
Dec. 10	50	27.23	9.86	90.86	52.43	2.53	1.86	0.0	51.67	1.23	-0.07
Dec. 10	51	20.13	9.33	95.29	66.14	1.63	1.44	0.0	43.33	0.50	-0.10
Dec. 10	52	14.66	7.43	95.57	85.00	4.30	0.09	36.0	28.33	0.26	-0.03
Jan. 11	01	13.03	5.64	93.00	79.71	2.89	0.26	0.0	31.67	0.26	0.0
Jan. 11	02	17.14	7.69	95.57	74.71	4.51	0.56	0.0	30.0	0.33	0.01
Jan. 11	03	18.94	9.81	95.00	74.57	4.21	0.60	0.0	26.67	0.50	0.02
Jan. 11	04	17.77	9.69	90.43	77.14	5.79	0.69	33.6	16.67	0.67	0.02
Jan. 11	05	19.59	8.64	89.29	74.29	6.01	2.91	3.78	11.67	1.0	0.05
Feb. 11	06	23.11	7.76	91.86	81.86	4.76	2.69	0.0	18.33	1.67	0.10
Feb. 11	07	25.2	10.27	95.00	80.29	3.61	2.59	0.0	23.33	4.60	0.42
Feb. 11	08	27.74	12.90	94.29	85.71	5.43	2.97	0.0	21.67	7.67	0.44
Feb. 11	09	25.61	13.26	73.57	42.57	5.89	3.83	0.0	20.0	8.93	0.14
Mar.11	10	29.54	14.16	76.14	39.86	7.49	5.29	0.0	23.33	6.47	-0.35
Mar.11	11	32.94	16.01	85.57	42.43	3.46	3.86	0.0	10.0	4.73	-0.25
Mar.11	12	36.09	18.81	69.14	32.57	6.50	6.89	0.0	6.67	6.73	0.29
Mar.11	13	36.31	17.50	63.14	29.14	4.36	6.57	0.0	1.67	7.67	0.13
Apr. 11	14	38.19	18.91	54.86	30.70	3.76	5.77	0.0	1.67	0.67	-1.0

Note: * Mean of 3 replications.

Table 2: Impact of abiotic and biotic factors on population dynamics of *Helicoverpa armigera* in chickpea (2011-12)

Standard Weeks		Abiotic Factors							Biotic Factor	Mean* larval intensity (m^{-1} /row)	Mean* rate of increase in larval population/day
		Max. Temp. (Deg. Cel.)	Min. Temp. (Deg. Cel.)	% R.H. (Morning)	% R.H. (Evening)	Wind Speed (Km/H)	Evaporation (mm/week)	Rainfall (mm/week)	Mean* parasitization (%) by *C. Chlorideae*		
Nov. 11	46	29.89	12.23	85.71	56.71	2.03	2.26	0.0	0.0	0.0	0.0
Nov. 11	47	28.46	13.36	92.29	53.43	2.06	2.0	0.0	36.67	0.26	0.04
Nov. 11	48	27.90	14.16	92.23	62.57	3.17	2.0	0.0	50.0	1.87	0.23
Dec. 11	49	25.83	11.54	20.14	55.14	3.73	1.91	0.0	43.33	2.13	0.04
Dec. 11	50	24.51	10.07	89.86	64.29	2.77	1.23	0.0	56.67	1.33	-0.11
Dec. 11	51	21.71	11.50	90.14	74.71	3.73	0.96	0.0	41.67	0.73	-0.09
Dec. 11	52	18.31	7.66	92.57	59.00	4.59	0.66	0.0	33.33	0.33	-0.06
Jan. 12	01	22.49	11.31	88.00	60.00	5.09	1.86	5.40	26.67	0.33	0.0
Jan. 12	02	22.30	8.93	90.86	54.29	4.31	2.26	0.50	23.33	0.26	-0.01
Jan. 12	03	22.04	9.93	89.00	58.14	5.06	1.60	2.50	31.67	0.33	0.01
Jan. 12	04	19.37	8.26	92.29	63.14	5.61	2.34	6.20	30.0	0.67	0.05
Jan. 12	05	20.89	9.46	94.57	78.57	4.0	1.46	9.20	26.67	2.53	0.27
Feb. 12	06	23.34	10.20	94.71	74.14	5.20	1.94	0.0	31.67	4.60	0.30
Feb. 12	07	27.11	13.96	88.43	54.57	6.43	3.69	0.0	36.67	6.93	0.33
Feb. 12	08	24.31	11.54	82.71	55.57	6.36	3.60	0.0	35.0	7.93	0.14
Feb. 12	09	28.20	13.36	79.86	44.29	7.03	4.0	0.0	21.67	6.33	-0.23
Mar.12	10	30.71	17.90	81.00	46.43	6.34	3.0	3.70	16.67	7.93	0.12
Mar.12	11	29.20	15.36	87.29	50.00	4.47	2.71	7.50	16.67	5.73	-0.21
Mar.12	12	34.37	18.59	74.71	34.71	4.24	5.09	0.0	8.33	6.27	0.08
Mar.12	13	33.86	17.31	57.86	27.43	5.70	5.97	0.50	1.67	5.33	-0.13
Mar.12	14	35.46	17.14	45.71	19.43	5.26	6.97	11.70	0.0	1.40	-0.56
Apr.12	15	35.68	20.31	46.86	28.30	7.07	8.20	0.0	0.0	0.33	-0.15

Note: * Mean of 3 replications.

Table 3: Correlation of meteorological factors with the larval parasitization of *H. armigera* (2010-11 & 2011-12)

Meteorological factors	Year 2010-11		Year 2011-12	
	C. chlorideae (Mean)†	*H. armigera* (Mean)†	*C. chlorideae* (Mean)†	*H. armigera* (Mean)†
Temp. Max. (Deg. Cel.)	-0.52*	0.57*	0.66*	0.32**
Temp. Min. (Deg. Cel.)	-0.70*	0.62*	-0.63*	0.42*
R.H. (%) Morning	00.63*	-0.49*	0.077	0.11NS
R.H. (%) Evening	00.31	-0.37**	00.75*	0.22NS
Wind speed (Km/hr)	-0.45*	0.53*	-0.32**	0.51*
Evaporation (mm/week)	-0.68*	0.71*	-0.76*	0.27NS
Rainfall (mm/week)	-0.078	-0.27 NS	0.33**	0.066
Parasitization (%)	0.0	-0.37**	0.0	-0.164

Note: † Mean of 3 replications, Simple correlation coefficient (r) at * 5% and ** 1% level of significance, NS=Non-significant.

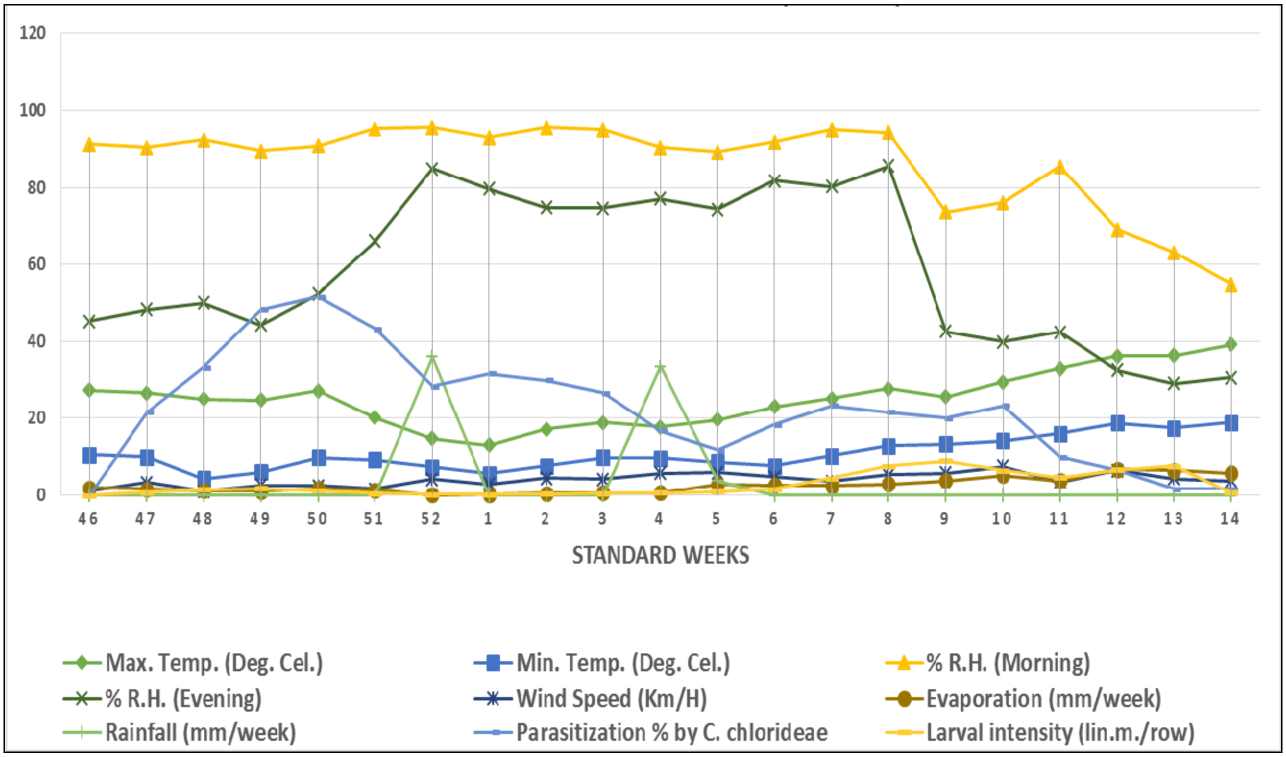

Fig 1: Population dynamics of *h. armigera* larvae with meteorological factors (2010-11)

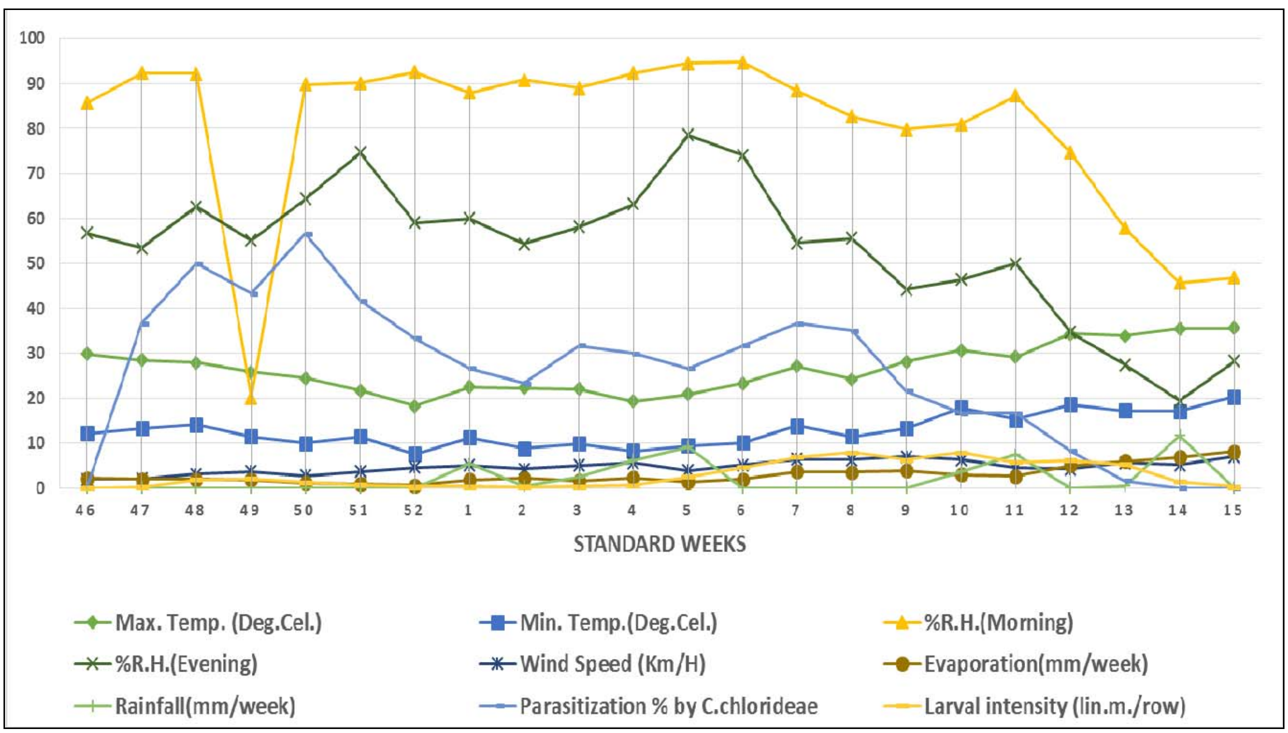

Fig 2: Population dynamics of *h. armigera* larvae with meteorological factors (2011-12)

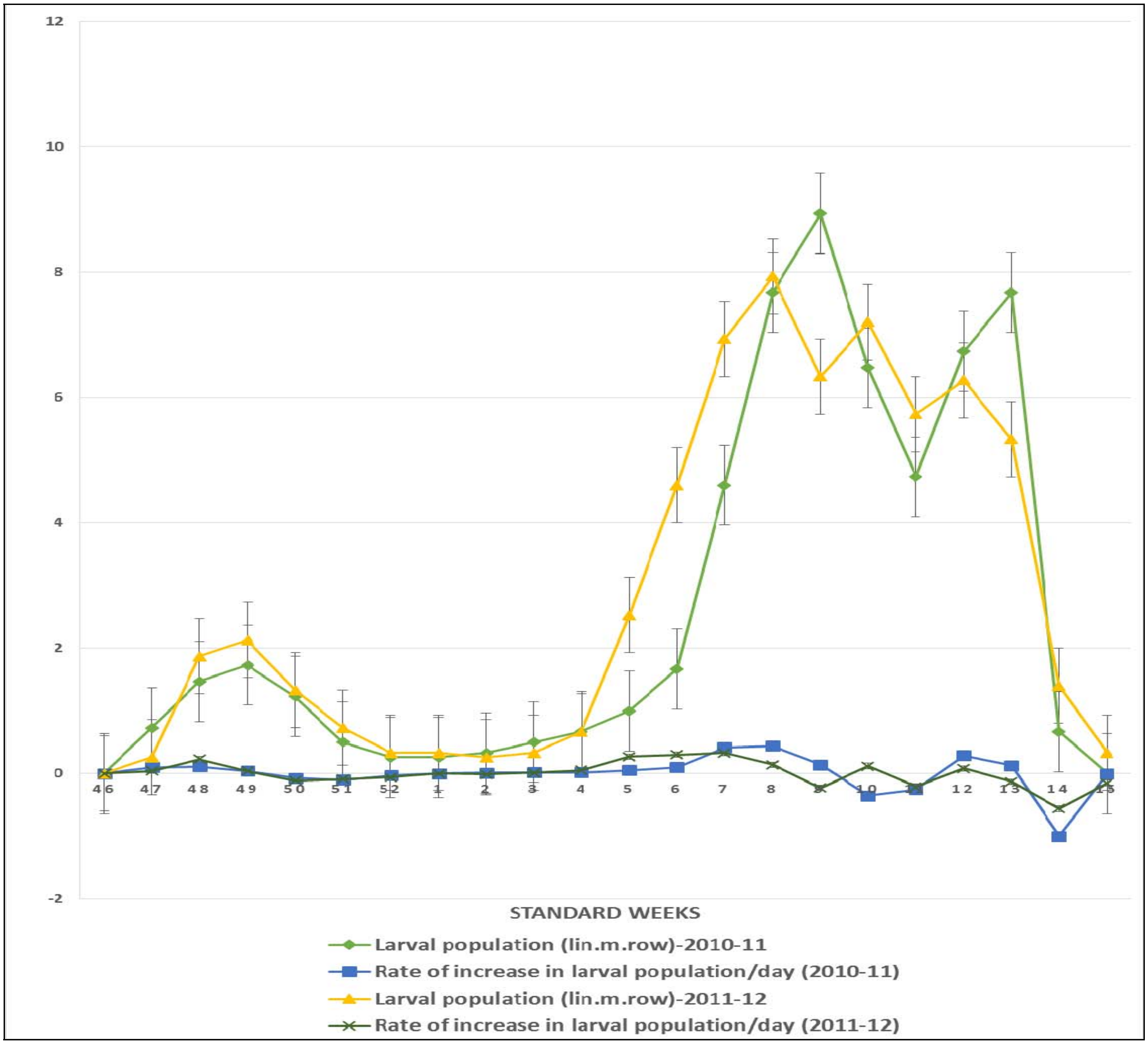

Fig 3: larval population of *h. armigera* in two consequent cropping seasons (2010-11 & 2011-12)

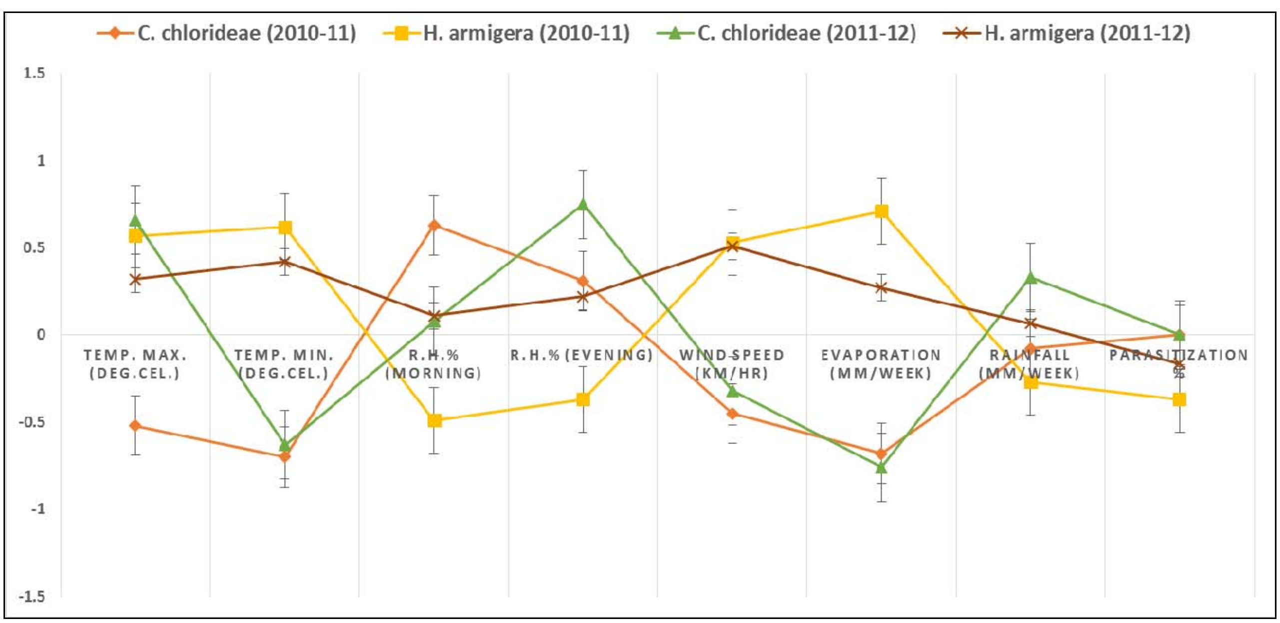

Fig 4: correlation of abiotic & biotic factors with h. armigera (2010-11 & 2011-12)

4. Conclusion

It was concluded that during February month, due to increase in minimum temperature above 7.69 ^{0}C, the larval population of the pest had the highest peaks as 8.93 & 7.93 larvae m^{-1} row along with the highest multiplication rate as 0.44 & 0.33 larvae/day, thereafter, during April month, due to the exceeded maximum temperature (38.19 & 35.46^{0}C), it declined to 0.67 & 0.33 larvae m^{-1} row and -1.0 & -0.56 larvae/day respectively. The natural parasitization was the maximum during December month as 51.67 & 56.67%, thereafter, it declined to the lowest level as 1.67 & 0.0% during April month. Simple correlation coefficient (r) of abiotic factors revealed that the minimum temperature (r=0.62 & 0.42), evaporation rate (r=0.71 & 0.27), maximum temperature (r=0.57 & 0.32) and wind speed (r=0.53 & 0.51) had reflected significant positive values when rainfall reflected negative relationship (r= -0.27) during 2010-11 and in 2011-12, it had positive impact as (r=0.066). The relative humidity in morning (r= -0.49 & 0.11), relative humidity evening (r= -0.37 & 0.22), and parasitization (r= -0.37 & -0.164) played a negative role on larval population both the years.

5. Acknowledgements

Senior author thanks to the Head, Department of Entomology, Bihar Agricultural University, (Sabour, INDIA) for providing necessary facilities towards this research study.

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