Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

Journal of Entomology and Zoology Studies

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(5): 693-697

Received: 29-07-2018
Accepted: 30-08-2018

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Studies on insect diversity in chickpea (*Cicer arietinum* Linnaeus) ecosystem

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Abstract
A study on the insect diversity in chickpea and mustard ecosystem was carried out in the field at Student Instructional Farm, C.S.A.U.A&T, Kanpur during winter of 2015-2016. Altogether four insect-pests *Helicoverpa armigera* (Hubner), *Agrotis ipsilon* (Hufnagel), *Spodoptera litura* (Fabricius) *and Odontotermes obesus* (Rambur)} and two natural enemies of chickpea pod borer *Trichogramma chilonis* (Ishii) *and Campoletis chlorideae* (Uchida) have been recorded in the chickpea. Among these pests of chickpea, gram pod borer were found as key pest in the field, respectively. It was appeared first in the 51st SW (Standard week) during mid-December with its initial intensity of 0.25 larvae m^{-1} row which increased in subsequent weeks up to 8th SW and touched the peak population of 13.00 larvae m^{-1} row during 9th SW. It showed positive correlation with respect to maximum temperature while negative correlation with minimum temperature, relative humidity and rainfall. Larval parasitization of *H. armigera* by the parasitoid, *C. chlorideae* was observed predominantly in chickpea ecosystem as compared to egg parasitoid, *T. chilonis*. Host population and weather factors played significantly positive role in the parasitization. It was observed that 7th SW with maximum temperature of 30.4 °C, minimum temperature of 11.7 °C and RH of 75.0 per cent was observed as was the most conducive period for the larval parasitization. As regards the biotic factors of gram pod borer, *H. armigera* exhibited a significant positive correlation with *T. chilonis*, which indicate an important role in suppressing the pest population to some extent.

Keywords: *H. armigera, T. chilonis, C. chlorideae*, *Campoletis chlorideae* and Chickpea

1. Introduction
Pulses are an important source of protein and oil respectively in the Indian dietary cuisine. Pulses are major source of vegetable protein containing essential amino acids, (methionine, cysteine and tryptophan) required to the proper growth and development of the human body. These are the cheapest source of protein, constituting about 27 per cent of total dietary in our country. Pulse crops residues are nutritious feed for livestock and also provide added advantage to the poor farm families. Henceforth, Indian Council of Medical Research (ICMR) has recommended pulse intake of 80 g/capita/day. Among the pulses chickpea (*Cicer arietinum* L.), a member of family Leguminaceae and subfamily Papilinioceae, is an important self-pollinated leguminous crop. There are two types of gram, one is the 'Kabuli' white and another is 'Desi' brown. India ranks first in the world in respect of production as well as acreage of chickpea crop followed by Pakistan. In India, pulses occupy an area of a 25.45 million hectare with production of 17.38 million tones and average yield of 789 kg/hectare. Chickpea finds a pride place among the pulse grown in our country. It occupies about 37 per cent of the area under pulses and it contributes about 43 per cent of the total pulses production in India. In India Chickpea occupying an area of 9.98 million hectare with 7.59 million tones production and average yield is 958 kg/hectare. In India Uttar Pradesh ranks first in gram/chickpea production (596.7lakh tones), with an area of 589 lakh hectare and average yield of 1013 kg/hectare [1]. Nearly 60 insect species are known to feed on chickpea. In central Uttar Pradesh the major insect pests which attack on chickpea crop are mainly *H. armigera, S. litura* F., *A. ipsilon, Plusia orichalsia* (Fab.) *and Bemisia tabaci.* Among these, the chickpea pod borer (*H. armigera*) is the most destructive pest of this crop. The young larvae feed upon the tender portion of foliage before attacking the fruiting bodies, causing heavy losses to the crop. Sometime the crop faces failure due to severe infestation by *H. armigera* [2]. The biological control through parasites and predators holds promise for effective population

suppression of insect pests of chickpea [3]. However, studies have been suggested that many natural enemies occur on chickpea crop [4]. Looking into the importance of chickpea crop, the present studies were therefore carried out to record and identify the natural enemies present in chickpea ecosystem.

2. Materials and Methods

A. Experimental site and location: The field experiment was conducted during *Rabi* season 2015-2016 at Student Instructional Farm (SIF), Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh). It lies between 25° 26`- 28° 58` N latitude 79° 31`- 80° 34` E longitude at an altitude of 125.9 meter above mean sea level. The climate of the district is subtropical, semi arid with hot dry summers and severe cold winters. Average rainfall is about 351.6 mm through summer monsoon during July to October, there being hardly 39.8 mm rain fall in winters.The experiment was laid out in Randomized Block Design with four replications. 'Radhey' is a variety. Total area for the experiment was 360 square meter. Crop was sowing in 4 plots of 40 square meter (10x4 meter) size was selected for each replication.

B. Observation: Observations were regularly monitored at weekly intervals for recording the different insects. The diversity of insects was recorded on 5 randomly selected plants from each plot by following mode of observations as follows: *H. armigera*, *A. ipsilon* and *S. litura (*Number of larvae on 5 randomly selected plants m^{-1} row/plot) and *Odontotermes obesus* (Number of nymph in m^{-1} row/plot). Population of natural enemies was recorded by five randomly selected plants by visual count and sweep net. Here eggs and larvae of *H. armigera* collected from the field and reared in the laboratory. Parasites that emerged out from eggs and larvae were counted. For sweep net method about 5 strokes of sweeping were made. After each strokes, the predators caught in the net were counted.

C. Identification: Identification of the insect-pests, predator and parasitoid through specific literature and taxonomists in Department of Entomology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (UP).

D. Determination of correlation coefficient: The data recorded on the density of insects in chickpea crop were statistically analyzed in order to determine the correlation coefficient between population dynamics of different insects and their correlation with their natural enemies

3. Results

A. Insect-pest and natural enemy's complex of chickpea

The observations were taken on insect pest of chickpea right from the time of sowing till the harvest. Various insect-pests were appeared at different stages of the crop growth, causing damage to chickpea variety "Radhey". There are four insect-pests *i.e., H. armigera, A. ipsilon, S. litura and O. obesus* have been recorded at different growth stages of crop. The attack of *H. armigera* started on the tender foliage and on developing buds and pods of chickpea while *A. ipsilon, S. litura* and *O. obesus* population was very low in field. *H. armigera* was considered as a major pest followed by cutworm. Two natural enemies of chickpea pod borer *T. chilonis and C. chlorideae* were noted in the laboratory. Among them population of *C. chlorideae* was significantly highest.

(i). Population dynamics of gram pod borer, *H. armigera Hub.* on chickpea crop

The incidence of *H. armigera* was recorded for the 1st time in a 51st standard week with the maximum temperature of 23.8 °C, minimum temperature of 0.8 °C, RH of 63.5 per cent and nil rainfall, later on larval population fluctuated slightly and reached as high as 1.25 larvae m^{-1} row during the first week of January and zeroed in a 4th standard week at the max. temperature of 28 °C, minimum temperature of 7.5 °C, RH (67.0%) and rainfall of 0.0 mm respectively. The larval population increases with increase in temperature during 4th to 9th standard week. The maximum population of 13.00 larvae m^{-1} row was recorded in the 9th standard week at a maximum temperature of 33.2°C, minimum temperature of 16.6 °C, RH of 77.5 per cent with no rainfall. Thereafter, the larval population declined gradually in subsequent weeks and reached up to its minimum level of 0.25 larvae m^{-1} row in 11th standard week at maximum temperature of 32.3 °C, minimum temperature of 13.0 °C, RH of 76.5 per cent with no rainfall (Table 1).

Table 1: Population dynamics of gram pod borer, *H. armigera* in chickpea in relation to abiotic factors during *Rabi* 2015-2016.

SW	Larval Population m^{-1} row	Weather parameters			
		Temperature(°C)		RH	Rainfall
		Max.	Min.	(%)	(mm)
51	0.25 (0.86)	23.8	0.8	63.5	0.0
52	0.25 (1.32)	25.4	1.6	60.0	0.0
1	1.25 (1.32)	28.0	7.5	67.0	0.0
2	2.00 (1.58)	25.4	4.3	69.0	0.0
3	2.75 (1.80)	20.2	3.8	74.0	1.2
4	4.25 (2.21)	27.2	5.5	61.5	1.6
5	5.00 (2.78)	27.0	6.5	81.5	0.0
6	7.25 (2.78)	26.8	9.2	84.5	3.6
7	8.75 (3.04)	30.4	11.7	75.0	0.0
8	10.75 (3.35)	32.4	13.7	65.5	2.2
9	13.00(3.67)	33.2	16.6	77.5	0.0
10	3.00(1.87)	32.0	13.8	82.5	1.7
11	0.25(0.86)	32.3	13.0	76.5	0.0

SW (Standard Week), Figures within parentheses $\sqrt{x+0.5}$ are transformed values.

(ii). Correlation between larval population of *H. armigera* and abiotic factors.

Correlation between larval population and weather parameters *viz.*, maximum temperature, minimum temperature, RH and rainfall has been given in (Table 2).

Table 2: Correlation coefficient and regression between larval population of *H. armigera* Hub. and abiotic factors.

Insect	Physical parameters	r	Regression equation
	Max. Temp.	0.5268	Y= (-10.768) + (0.5498) x
Gram pod borer	Min. Tem	-0.6586 *	Y= (0.1498) + (0.5352) x
	R.H.	-0.2962	Y= (-6.1063) +(0.1484)x
	Rainfall	-0.3018	Y= (3.7521) + (1.0654)x
Gram pod borer + Max. Temp + Min. Temp. + R.H. + Rainfall		R = 0.7193	Y= a+b+c+d+ ex Y= (-0.6190) + (1.1096) + (-0.1427) + (0.4625) + (0.1727) x

* Test of significance at 5% level (Y= a + bx)

As regards the impact of environmental factors, simple correlation coefficient (r) of all the abiotic factors with larval population had non-significant positive correlation (r = 0.5268) with a maximum temperature while significant negative correlation with respect to a minimum temperature (r = -0.6856), and non-significant positive correlation with relative humidity (r = -0.2962) and rainfall (r = -0.3018). As regard the impact of abiotic factors minimum temperature was the key factor in regulating the gram pod borer larval population.

(iii). Incidence of natural enemies of gram pod borer, *H. armigera*: Total two parasitoid *viz.*, *T. chilonis* (egg parasitoid) and *C. chlorideae* (larval parasitoid) was recorded in chickpea ecosystem. The populations of parasitoids are being portrayed in (Table 3).

(iv). Incidence of egg parasitoid, *T. chilonis:* The population was fluctuating with weather parameters as indicated in (Table 3), it was appears in 1st SW and reached to maximum population in 4th SW at maximum temperature of 27.2°C, minimum temperature of 5.5°C, RH of 61.5 per cent and rainfall of 1.6 mm. Again population was reached to maximum in 7th SW corresponding to the higher incidence of pod borer.

(v). Incidence of larval parasitoid, *C. chlorideae*: As (Table 3) indicated that larval parasitization by *C. chlorideae* was first observed in 52nd SW with 20 per cent parasitization as per visual observation. Highest population was recorded in 7th SW with 8.75 larvae m^{-1} row of gram pod borer. The maximum temperature during this period of 30.4°C, minimum temperature of 11.7 °C, RH of 75.0 per cent with no rainfall was recorded. After this the population of *C. chlorideae* was declined and it was nil in 11th SW when the maximum temperature of 32.3°C, minimum temperature of 13.0 °C and 76.5 of per cent RH was recorded.

Table 3: Incidence of natural enemies of Gram Pod Borer, *H. armigera.*

SW	No. of larvae m^{-1} row	Parasitoid		Weather Parameters			
		T. chilonis	*C. chlorideae*	Temp. (°C)		RH (%)	RF (mm)
				Max.	Min.		
51	0.25	0	0	23.8	0.8	63.5	0.0
52	1.25	0	1	25.4	1.6	60.0	0.0
1	1.25	1	1	28.0	7.5	67.0	0.0
2	2.0	1	2	25.4	4.3	69.0	0.0
3	2.75	0	1	20.2	3.8	74.0	1.2
4	4.25	2	2	27.2	5.5	61.5	1.6
5	5.0	0	3	27.0	6.5	81.5	0.0
6	7.25	1	2	26.8	9.2	84.5	3.6
7	8.75	2	4	30.4	11.7	75.0	0.0
8	10.75	0	1	32.4	13.7	65.5	2.2
9	13.0	2	3	33.2	16.6	77.5	0.0
10	3.0	1	2	32.0	13.8	82.5	1.7
11	0.25	0	0	32.3	13.0	76.5	0.0

(vi). Correlation coefficient between gram pod borer *H. armigera* Hub, and its natural enemies

It is evident from (Table 4), that gram pod borer population showed significant positive correlation with its egg parasitoid, *T. chilonis* (r = 0.627648) and non-significant positive correlation with its larval parasitoid, *C. chlorideae* (r =0.472365). Maximum eggs and larval parasitization (30%) was observed on 1st to 2nd SW as per visual counts. The parasitization by *C. chlorideae* was found to be increase in the end of January and early February.

Table 4: Correlation coefficient and Regression between Gram Pod Borer, *Helicoverpa armigera* Hub. and its Natural Enemies.

Insect	Parasitoid	r	Regression equation
	T. chilonis	0.627648*	Y= (2.006231) + (1.179743) x
	C. chlorideae	0.472365	Y= (0.40135) + (1.676114)x
Gram pod borer + *T. chilonis* + *C. chlorideae*		R = 0.630394	Y= (0.892264) + (1.754989) x

* Test of significance at 5% level (Y= a + bx)

4. Discussion

Four insect pests *viz., H. armigera, A. ipsilon, S. litura and O. obesus* and two natural enemies *T. chilonis and C. chlorideae* of gram pod borer wars recorded. Similar to the present findings the predators coccinellids, *Geocoris* spp. *Qriussp, Chrysoperla* spp. and the parasitoids *i.e., T. chiloris, c. chloridae, Telonomussp,* attacked the eggs and larvae of cut worms on chickpea crop by Nizamani [4]. The larvae *H. armigera* was noticed for the first time in a 51st SW at the minimum temperature of 0.8 °C, maximum temperature of 23.80 °C, RH of 63.5 per cent and nil rainfall and maximum population of 13.00 larvae m^{-1} row in 9th standard week at a minimum temperature of 16.6 °C, maximum temperature of 33.2 °C, RH of 77.5 per cent and 0.0 mm rainfall. Thereafter, there was a decline in number of larval population recorded in subsequent weeks, and reached to its minimum *i.e.,* 0.25 larvae m^{-1} row in the 11th standard week at minimum temperature of 13.0 °C, maximum temperature of 32.3 °C, RH of 76.5 per cent, rainfall 0.0 mm when crop was ready to harvest. Present findings agreement with Vishwa *et al.* [5] sudden rise in minimum temperature were associated with a considerable pest population during 5 and 7th SW which triggered a major rise in the pest population. Similar results was obtained from Shah and Shahzad [6] population was low during 49th to 6th SW but increased from 7th SW onward and declined again at 14th SW. Singh *et al.* [7] reported that population increase from mid February (1.0-1.8 larvae/m^2) till the second week of April (8.0-10.8 larvae/m^2) and then declined abruptly by and larval again population *H. armigera* was maximum during 12th SW by Reddy *et al.* [8]. The larval population had non-significant positive correlation (r=0.5268) with maximum temperature while significant negative correlation with respect to minimum temperature (r=-0.6856) and had negative correlation with relative humidity (r=-0.2962) and rainfall (r=-0.3018). Present results agreement with Shahzad and Shan [9] and Singh [10] significant positive correlation with temperature and negative correlation with morning-evening relative humidity and sunshine on larval population. Reddy *et al.* [8] and Baijya [11] reported that positive correlation with minimum and maximum temperature, while negative correlation with RH, however minimum temperature, rainfall, vapor pressure and relative humidity in the morning and evening were positively correlated with increase in *H. armigera* population.

Larval parasitization by the parasite, *C. chlorideae* was observed predominantly in chickpea ecosystem which appeared in 52nd SW while egg parasitoid, *T. chilonis* was first observed in 1st SW. Emergence of *T. chilonis* from parasitized egg was maximum two in number in 4th SW. Larval parasitoid, *C. chlorideae* was first emerged in 52nd SW. Highest population of *C. chlorideae* was in 7th SW against 8.75 larvae m^{-1} row. Among 100 parasitoid species on the *H. armigera*, 70 belong to the order Hymenoptera, *C. chlorideae* found a promising species among them for the management of the pest by Nakim and Gaikwad [12]. The maximum population of *C. chlorideae* as larval parasitoid on *H. armigera*. in March by Ravi and Verma [13]. The monitored population of *H. armigera* through light and pheromone traps and seasonal activity of their natural enemies in Madhya Pradesh. They found that the level of attack by the larval parasitoid, *C. chlorideae* and a Dipteran pupal parasitoid varied from 4.8 to 27.3 per cent and 2.9 to 20.1 per cent under laboratory condition, respectively. Both these parasitoids were quite active in chickpea field from January to March on *H. armigera* by Bhatnagar *et al.* [14]. Most important natural enemy of *H. armigera, C. chlorideae* with maximum incidence during first and second week of April by Devi *et al.* [15].

The eggs and larval population of *H. armigera* showed significant positive correlation with its egg parasitoid, *T. chilonis* (0.627648) and non-significant positive correlation with its larval parasitoid, *C. chlorideae.* The parasitization of eggs and larvae occurred at the slower rate in 52nd SW. It was 1st to 2nd SW in which eggs and larval parasitization was highest in the eggs and larvae collected from chickpea field. The parasitization was found to increase up to the end of January or early February. It was observed that 7th SW with maximum temperature of 30.4 °C, minimum temperature of 11.7 °C and RH of 75.0 per cent was most conducive period for the larval parasitization by *C. chlorideae.* Parasitization decreased gradually towards the end of February. *C. chlorideae* parasitized maximum number of *Helicoverpa* larvae in the field. The density of parasites is dependent on its host. When egg and larval population increased in the field their natural enemies were also increased in same manner and parasitized several larvae of gram pod borer. The extent of natural parasitization by *C. chlorideae* of *H. armigera* on chickpea in Uttar Pradesh, during 1995- 96 and 1996-97 varied between 12.69 and 56.28 per cent during 1995-96 and 3.57 and 80.64 per cent during 1996-97. The peak parasitism was observed during January at temperature of 25 °C-26 °C in both the years by Sachan and Bhaumik [16].

5. Conclusion

In view of the vast array of biotic and abiotic factors affecting pests and natural enemies of chickpea. The development of integrated pest management based system is imperative. For this identification of superior natural enemy is important tactic. Understand the complex interactions among the prey, pest, augmentive entomophage and their biotic and abiotic environment provides a framework for better understanding of ecosystem. The present investigations will definitely throw a light on potential egg parasites, *Trichogramma chilonis*, larval parasite, *Campoletis chlorideae*, as biological control agents of *H. armigera* under IPM and crop management strategy to procure economic production of affected commodities.

6. Acknowledgement

The authors are thankful to Department of Agricultural Entomology, C.S.A. University of Agriculture and Technology-Kanpur for their support and for providing the facilities.

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