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Research Article

Biology and relative parasitization of larval endoparasitoid *Campoletis cholrideae* Uchida on *Heliocoverpa armigera* Hübner under sole and chickpea-coriander intercropping system

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ABSTRACT: The *Campoletis cholrideae* Uchida is a single most prominent parasitoid in chickpea for major pest *Heliocverpa armigera* Hubner under natural ecosystem. The purpose of present study was to investigate how weather parameters and cropping system influence on the biology, per cent parasitization in sole and intercropping system under laboratory and field conditions. In sole crop, mean parasitism by *C. chlorideae* on the larvae of *H. armigera* during 2013 and 2014 was 60.61 %, 44.66 %, respectively. Egg-larval and cocoon formation to adult emergence periods 10.16± 0.215, 4.25±2.02 days, respectively and female and male parasitoid could survive with a mean longevity of 4.50 ± 2.012 and 3.25 ± 1.85 days, respectively. Higher parasitism of 76.67% occurred on 8th collection of 11th S.W March and 60.67% on 1st collection of 11th S.W of March for respective years. The progeny of sex-ratio varied in two seasons, the mean sex ratio (M:F) were 1:1.62; 1:1.07 respective years in sole crop. In intercropping ecosystem, the overall mean parasitism by *C. chlorideae* on larvae of *H. armigera* during 2013 and 2014 with 76.96 % , 66.67 % respectively. Higher parasitism was observed (90 %) on 6th collection of 11th S.W March and 80 % on 1st collection of 11th S.W of March for respective years. However, there was steep escalation in female sex ratio in chickpea-coriander cropping system when compared with sole crop. The overall mean sex ratio were (M:F) is 1:1.90; 0.98:1.0 respective years in chickpea-coriander intercropping. A correlation with abiotic factors revealed a non-significant positive correlation with maximum temperature, evening relative humidity (RH), rain fall and sunshine hours. There was a negative correlation between parasitism and minimum temperature and morning RH in respective years under sole crop. In case of intercropping system, the result elucidated that a significant positive correlation exist with evening RH and rainfall ($r= 0.951^*$; $r= 0.900^*$ and $r= 0.926^*$; $r= 0.931^*$) in respective years. These results suggested that different parameters, especially cropping system and temparture, were very important for the parasitism of *C. chlorideae* on *H. armigera*.

KEY WORDS: Chickpea, coriander, intercrop, *Campoletis cholrideae, Heliocverpa armigera*

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INTRODUCTION

Gram pod borer, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae), is an international pest and polyphagous in nature. It causes economic damage at reproductive stages, primarily on pods, highly mobile and nocturnal in nature spread speedily in wide areas, and causes damage to several cultivated crops *viz*., chickpea, pigeonpea, tomato, chilli, okra, etc in India. Its larvae appeared on chickpea crop after 15 days of germination (Kambrekar, 2005). The *H. armigera* larvae found active throughout the chickpea crop (Singh and Ali, 2006). The ecological parameters *viz*., temperature (14-45^{o}C), photoperiod (10-14 hrs), relative humidity (15-95%) coupled with optimal and intermittent rainfall were found to influence the population buildup, adult emergence and maximum fecundity of the female moths of *H. armigera* (Tripathi and Singh, 1993). The pest could be managed naturaly under field conditions by larval parasitoid *Campoletis chlorideae* Uchida (Hymenoptera: Ichneumonidae) in chickpea ecosystem, causes up to 78% parasitisation of early instars under natural conditions (Agnihotri *et al.,* 2011). However, activity of the parasitoid occurs only during November to March, coinciding with the vegetative stage of the crop and winter season. Host searching behaviour is considered to be an important component of parasitoid biology, often influencing the success of inoculative biological control (Gross *et al.,* 2005). The activity of parasitoid was reported higher at minimum temperature

9.7^{o}C and also ceased when temperature was more than 40^{o}C in chickpea ecosystem in Himachal Pradesh (Gupta and Desh Raj, 2003). How to minimize the mortalities caused by larval cannibalism is a big problem for rearing large quantities of standardized and normalized *H. armigera*, and information about the factors that influence the cannibalistic behavior would help to solve this problem. However, such kind of information is still very limited. The parasitoid is basically male biased in nature. Considering these factors, effect of intercropping pattern influence for the enhancement of activity and sex ratio of *C. chlorideae* under chickpea-coriander intercropping system and the impact of weather parameters on pest and *C. chlorideae* population for two consecutive years *i.e*., *rabi* season 2012-13 and 2013-14 was studied and reported in this article.

MATERIAL AND METHODS

Site of experiment

The field experiments were conducted at the crop research center (CRC), G B. Pant University of Agriculture & Technology, Pantnagar, situated (29^{0}N, 79$^{0.}$29' E at an elevation of 243.8 m. above mean sea level) in the District U. S. Nagar (Uttarakhand) during rabi season of 2012 and 2013. The soil of experimental field having slightly clay loam. The laboratory experiments were carried out in the Department of Entomology, College of Agriculture, at GBPUAT, Pantnagar, U.S.Nagar (Uttarakhand).

Biological attributes of the parasitoid

The field collected cocoons of *C. chlorideae* were reared in the laboratory (22 ± 28°C, 70 ± 10% RH and 10:14 h (L:D) photoperiod) and used for biology studies of *C. chlorideae.* The *C. chlorideae* culture was maintained on early instars (2nd instar) of *H. armigera* under laboratory conditions. Males and females of similar age were kept in plastic cages (10 cm height and 6 cm diameter) for mating for two days, and fed on 10% honey solution. For oviposition, a mated *C. chlorideae* was released in 25 ml plexi glass containing 25 neonate larvae of *H. armigera.* After parasitization, *H. armigera* larvae were placed on artificial diet/fresh chickpea leaves for parasitoid development. Ten *H. armigera* larvae were maintained for each replication, and there were four replications in a completely randomized design. Observations were recorded only on the biological attributes such as larval, pupal periods of *C. chlorideae* larvae and adult emergence.

Studies on percent parasitization and sex ratio in sole and chickpea-coriander intercropping system

The observations were recorded in sole and chickpea-coriander intercropping system. The larvae of *H. armigera* were collected twice or thrice weekly intervals from two untreated sole and chickpea-coriander intercropping ecosystem and the collected larvae were brought to the laboratory in 25ml plexi glass vials and reared individually in laboratory till the adult emergence of the parasitoids. Observations were recorded on number of adult parasitoids emerged from *H. armigera* larvae and calculate percent parasitization and sex ratio.

Meteorological observations

Pantnagar has humid sub-tropical climate with hot dry summer, hot and wet rainy season and cold winters. It is situated near the foot hills of shivalik range of central kumaon Himalayas. It is part of *Tarai* regions. The minimum and maximum temperatures, R.H. and rainfall during the period of experimentation from December to May 2012-13 and 2013-14 at University Meteorological Observatory Unit was recorded and used for statistical analysis.

RESULT AND DISCUSSION

Growth and development of *Campoletis chlorideae* on early instars of *Helicoverpa armigera*

In the present investigation, the egg-larval period ranged from 9-12 days. The study of biology and growth of *C. chlorideae* has been reported by various workers. Gupta, *et al.* (2007) revealed that the egg-larval and pupal period was 13.5 ± 0.45 and 7.0 ± 0.44 days, respectively. Single mated female *C. chlorideae* laid on an average 13.40 ± 3.02 and 42.00 ± 2.21 eggs after throughout its life span, respectively. The emergence rate varied from 78.3 to 85.2%. The sex ratio of male:female in mated progeny was 1: 3.15 ± 0.62. Adult longevity increased when provided with food source. Similarly, Sharma and Dhillon (2005) also reported that the eggs of *C. chlorideae* hatch in 1.0–1.5 days, total egg + larval development period completed in 7–8 days. On completion of larval development, the *C. chlorideae* larva emerges from the host larva. It weaves a cocoon around itself and the pupal period extends for about 6 days. Post-embryonic development of *C. chlorideae* was completed in about 13–14 days (Dhillon and Sharma, 2007). Data from longevity experiment suggested that *C. chlorideae* survived for longer period when provided with food compared to without food. The use of peculiar host species for rearing as well as the presence of honey affects longevity of *C. chlorideae* (Murugan *et al.,* 2000).

Table 1. Biology of larval endo parasitoid *Campoletis chlorideae* on *Helicoverpa armigera*

S.No	Attributes	Range	Mean±SE
1	*Development stage(days)		
	Egg-larval	9-12	10.16±0.215
	Pupal to adult period	3-5	4.25±2.02
	Total development period	18-21	18.41±0.209
2.	**Adult longevity	3-4	4.00±1.67
	Male without food	1-3	1.8±0.24
	Male with food	3-5	3.25 ± 1.85
	Female without food	2-3	2.3 ± 0.28
	Female with food	4-6	4.50 ± 2.012

Values are expressed as mean values of three replications ± standard deviation *Mean of four replicates- each replicate having ten early instar larave ** Mean of five replicates –each replicate having six early instar larvae

Seasonal parasitization and sex ratio in chickpea sole and chickpea-coriander intercropping ecosystem

The data on seasonal parasitism and sex-ratio studies of *H. armigera* by *C. chlorideae* in sole and chikcpea-coriander intercropping ecosystem, during the post-rainy season of two consecutive years (2013 and 2014) are presented (Table 2, 3). The occurrence and percentage parasitism varied in both years. The parasitism remained almost nil up to the end of February and was observed only in the first week of March to third week of March. It was reported that in both years the occurrence of parasitoid activity were started on 9th S.W and 11th S.W respectively years. However, the activity of parasitoid was less during 2013-14, it was hardly observed for 15-17 days for the (11th-13th S.W). The activity of *C. chlorideae* completely declined after 13th standard week in both years. The activity of parasitoid, coincided with flowering and pod formation stage of the crop. As the high activity of *C. chlorideae* was only for few weeks, so the larvae were collected two days once and brought to the laboratory for studying percent parasitsm. In present study, it was reported that *C. chlorideae* is male biased. Similar trend of seasonal parasitization of *H. armigera* by *C. chlorideae* has also been reported Gupta and Desh Raj (2003), Chandel *et al.* (2005), Singh and Ali (2006), Nikoshe *et al.* (2014) and Singh *et al.* (2015).

It was recorded that mean parasitism by *C. chlorideae* on larvae of *H. armigera* during 2013 and 2014 with 60.61 % , 44.66 % respectively. Higher parasitism of (76.67% and 60.67%) occurred on 11th S.W March in both the years. The lowest percent parasitism recorded was 30.67 and 30.00 on 11th and 12th S.W of in both the years. The progeny sexratio were varied in both years, the mean sex ratio (M:F) were 1:1.62; 1:1.07 respectively for 2012-13 and 2013-14 in sole crop. Singh *et al.* (2015) reported that maximum parasitization (90%) of *H. armigera* by *C. chlorideae* was recorded on early instars larvae in chilly January, which exerted pressure on the initial pest population. Maximum prevalence of *H. armigera* larvae was noticed at podding stage of chickpea with abrupt temperature rise by 5°C in February. Temperature (maximum and minimum) exhibited a significant positive role on population build up of both the pest and its parasitoid.

The per cent parasitization in intercropping ecosystem revealed that the overall mean parasitism by *C. chlorideae* on larvae of *H. armigera* during 2013 and 2014 with 76.96 % , 66.67 % respectively. Higher parasitism was recorded with 90% occurred on 11th S.W and 80% on 11th S.W for

Table 2. Seasonal incidence of *Campoletis chlorideae* on *Helicoverpa armigera* in chickpea crop during *Rabi*, 2012-13

Date of collection	Parasitism (%) in		Sex ratio		Max Temp	Min Temp	RH Morning	RH Evening	Rainfall (mm)	wind velocity	Sun Shine Hr
	Chick pea sole crop	Chick pea-corinder inter crop	Chick pea sole crop	Chick pea-corinder inter crop							
3/3/13	56.67	73.33	1:1.42	1:1.2	24.5	11.4	97	45	0.0	3.5	6.9
5/3/13	53.33	70.00	1:1.66	1:1.1	28.0	13.0	92	47	0.0	3.0	9.0
7/3/13	60.00	73.33	1:1.57	0.9:1	30.0	11.0	93	49	0.0	4.2	9.4
9/3/13	66.67	80.00	1:1.85	1:1.81	29.2	13.4	93	44	0.0	1.7	8.9
11/3/13	60.00	80.00	1:1.71	1:1	28.9	13.9	86	45	0.0	6.0	8.0
13/03/13	73.33	90.00	1:1.62	0.92:1.0	29.0	11.0	90	46	0.0	2.4	7.1
15/03/13	66.67	86.67	1:1.85	1:1.16	29.8	14.8	91	50	13.4	2.9	7.8
17/03/13	76.67	83.33	1:1.87	0.92:1	29.5	11.4	90	39	0.0	3.9	9.6
19/3/13	73.33	86.67	1:1.44	1:1.16	27.8	13.5	93	50	0.0	8.1	9.3
21/3/13	43.33	73.33	1:1.60	1:1.2	30.0	14.4	93	46	0.0	1.4	5.7
23/3/13	36.67	50.00	1:1.20	1:14	29.2	15.1	90	37	0.0	1.6	8.0
Mean	60.61	76.96	1:1.62	1:1.07							

Table 3. Seasonal incidence of *Campoletis chlorideae* on *Helicoverpa armigera* in Chickpea and chickpea-coriander intercrop during *Rabi*, 2013-14

Date of collection	Parasitism (%) in		Sex ratio		Max Temp	Min Temp	RH Morning	RH Evening	Rainfall (mm)	wind velocity	Sun Shine Hr
	Chick pea sole crop	Chick pea-corinder inter crop	Chick pea sole crop	Chick pea-corinder inter crop							
13/03/14	66.67	80.00	1:2.33	1:1.18	29.0	11.0	90	46	0.0	2.4	7.1
15/03/14	46.67	66.70	1:2.50	1:1.22	29.8	14.8	91	50	13.4	2.9	7.8
17/03/14	40.00	63.30	1:2.00	0.9:1.0	29.5	11.4	90	39	0.0	3.9	9.6
19/3/14	40.00	66.70	1:1.40	0.6:1.0	27.8	13.5	93	50	0.0	8.1	9.3
21/03/14	30.00	60.00	1:1.25	1.0:1.0	30.0	14.4	93	46	0.0	1.4	5.7
Mean	44.66	67.33	1:1.90	0.98:1.0							

2012-13 and 2013-14 respectively. The lowest parasitism reocrded of 50.00% and 60.00% on 12th S.W of March for respective years two years. The progeny sex ratio varied in both years, However there was steep escalation in female sex ratio in chickpea-coriander cropping system when compared with sole crop. The overall mean sex ratio were (M:F) is 1:1.90; 0.98:1.0 respectively for 2012-13 and 2013-14 in chickpea-coriander intercropping system presented in (Table 2 & 3).

Earlier studies indicated that *C. chlorideae* is an effective parasitoid in different ecosystems (Kaur *et al.,* 2000 and Gupta *et al.,* 2007).

In North India, *C. chlorideae* is the most efficient parasitoid of *H. armigera* in chickpea, and it preferentially attacks early instars (second and third instar larvae) which feed mostly on leaves (Dhillon and Sharma, 2009). The present investigation revealed that *C. chlorideae* was quite active in chickpea cropping ecosystems between 11th S.W of March and 14th S.W of end of March, conforming earlier results obtained by Ravi and Verma (1997).

Crop diversification in terms of intercropping of chickpea with coriander significantly recorded higher parasitic activity of *C. chlorideae* (Turkar *et al.,* 2000). Reena, *et al*. (2009) reported that parasitization by *C. chlorideae* did not vary with the intercrops during pre-winter months of rabi while parasitization was higher in chickpea + linseed**.** Bisane *et al*. (2013) reported that under chickpea ecosystem, *Eriborus argenteopilosus* 16.1% parasitized *H. armigera* and *C. chlorideae* registered parasitization up to 14.3 per cent and neither larval incidence of *H. armigera* nor the parasitization by natural enemies were found to have consistent significant relationship with the weather parameters. In the present study *H. armigera* incidence was more closely associated with host phenology rather than the weather parameters and the parasitization showed density dependent relationship.

Use of *C. chlorideae* was also helpful in reducing the use of synthetic insecticides and thus it plays a vital role in conservation of natural resources. Sujata *et al*. (2002) reported the incidence of *C. chlorideae* from the last week of March during 1998 and 2000 with parasitism of 3.80 and 1.18%, respectively. The peak of parasitism with 23.81 and 10.34% was observed during second and third week of April in 1998 and 1999, respectively. Hem Saxena *et al.* (2012) studied on seasonal parasitism of *Habrobracon hebetor* (Say) on *H. armigera* in chickpea for three consecutive years. The result showed that, parasitism by *H. hebetor* on larvae of *H. armigera* reached 12.3%. Parasitoid developmental time was longest in fifth instar (9.1 days) compared to other instars (8.1-8.9 days). Fifth instar larvae resulted in highest numbers of cocoons and adult emergence. Singh and Battu (2006) also investigated that *C. chlorideae* was the only parasitoid causing 20.9 ± 2.9, 24.9 ± 1.8, 20.0 ± 2.3 and 25.9 ± 2.6 per cent natural mortality of *H. armigera* larvae on from chickpea, Egyptian clover, sunflower and tomato crops, respectively. In intercropping system Pandey *et al*. (2010) reported maximum larval parasitization of 39.86% in chickpea+coriander (2:1) and minimum of 17.5 % in chickpea+barley (6:1) and 19.5% in chickpea sole crop. Similar results also confounded by Ram *et al.* (2010) in tomato with varied intercrops, with the maximum parasitization recorded coriander 22.57% followed by fenugreek 15.67% and mustard 13.79% as compared to sole crop of tomato 09.09%.

In present study, it was reported that *C. chlorideae* is male biased, confirming earlier results of Dhillon and Sharma, (2011) who reported sex-ratio of the progeny from females that had mated twice was male biased. Females mated with males from the unmated females produced significantly less numbers of females than those mated with males from the mated females, indicating genetic regulation of sex-ratio in *C. chlorideae.* Field utilization of this parasitoid is severely limited due to the lack of effective mass production techniques and the highly male-biased sex ratio as per results obtained from National bureau of agricultural important insect, Bengaluru. Nikhil Kumar *et al.* (2000) observed that sex ratio of *C. chlorideae* was female-biased showing a linear decrease with increasing parasitoid density at fixed host densities. To obtain a female-biased sex ratio, a low density of parasitoids should be released at a recommended site.

Influence of weather parameters on per cent parasitization in *H. armigera* in sole crop

It was clearly revealed that during 2012-13, there was a non-significant positive and negative correlation was observed for weather parameters (Table 5). The regression revealed that the various abiotic factors were found to be most influencing factor, which contributed (R^2 = 0.602) 60.2 per cent variation in *C. chlorideae* population (Table 6).

Y = 214.673-0.827(TMAX)-4.908(TMIN)-1.371 (RHM)+0.665(RHE)+ 1.069(RF)+3.385(S

During 2013-14, it was observed that a non-significant correlation with morning RH and sunshine hours. A significant positive correlation were observed with evening RH and rainfall (r= 0.951*, r = 0.900*) respectively. The non-significant negative correlation were respectively for Maximum temperature and minimum temperature (Table 5). The regression revealed that the various abiotic factors were found to be most influencing factor, which contributed (R^2 = 0.892) 89.2 per cent variation in *C. chlorideae* population (Table 4).

Y = - 229.045+1.72 (RHM)+ 1.893 (RHE)+ 0.660 (RF)+3.675(SSH)

Influence of weather parameters on per cent parasitization in *H. armigera* in chickpea coriander intercropping system

It was clearly revealed that during 2012-13, there was a non-significant positive and negative correlation with weather parameters presented in Table 5. The regression revealed that the various abiotic factors were found to be most influencing factor, which contributed (R^2 = 0.602) 60.2 per cent variation in *C. chlorideae* population (Table 5).

Y = 205.060-0.209(TMAX)-3.673(TMIN)-1.457(RHM)+1.348(RHE)+0.751(RF)-0.345(SSH)

During 2013-14, it was noted that a non-significant positive correlation with morning RH and sunshine hours. A positive significant correlation were observed with evening RH and rainfall (r= 0.926*, r = 0.931*) respectively. The regression confirmed that the various abiotic factors were found to be most influencing factor, which contributed (R^2 = 0.792) 79.2 per cent variation in *C. chlorideae* population (Table 5).

Y = - 52.586+1.029 (RHM)+ 0.731 (RHE)+ 0.683 (RF)-0.562(SSH)

The result is partially cogent with Halder *et al.,* (2013), who reported that, total parasitization was nega-

Table 4. Correlation of weather parameters on the incidence of *Campoletis chlorideae* under sole and chickpea-coriander intercrop system

Year	Cropping system	Temperature (^{0}C)		Relative humidity (%)		Rainfall (X_5)	Sunshine hours (X_7)
		Max. (X_1)	Min. (X_2)	7: 12 am (X_3)	14:12 pm (X_4)		
2012-13	Sole crop	0.006	-0.506	-0.088	0.308	0.159	0.457
	Chickpea-coriander intercrop	0.059	-0.341	-0.083	0.548	0.290	0.089
2013-14	Sole crop	-0.182	-0.572	0.127	0.951*	0.900*	0.158
	Chickpea-coriander intercrop	-0.030	-0.619	0.165	0.926*	0.931*	-0.024

Table 5. Regression between weather parameters and population of *Campoletis chlorideae* sole and chickpea-coriander intercrop system

Year	Cropping system	Regression Equation	R^2 value
2012-13	Sole crop	$Y = 67.349 – 0.323 (X_4) – 0.696 (X_5) – 3.803 (X_6) + 0.784 (X_7) – 1.680 (X_8) – 6.245 (X_9)$	0.602
	Chickpea-coriander intercropping system	$Y = 628.902 – 9.682 (X_4) + 5.108 (X_5) – 49.726 (X_6) + 2.284 (X_7) – 13.304 (X_8) – 29.866 (X_9)$	0.892
2013-14	Sole crop	$Y = - 41.399 + 0.343 (X_5) + 3.210 (X_7) + 6.059 (X_8) – 3.317 (X_9)$	0.602
	Chickpea-coriander intercropping system	$Y = - 66.484 - 0.019 (X_5) + 5.663 (X_7) + 0.134 (X_8) + 7.984 (X_9)$	0.792

tively correlated with the mean temperature during the crop growth period and the corresponding r-values were -0.56, -0.21 and -0.095, respectively. Present study revealed that the *H. armigera* incidence was more closely associated with host phenology rather than weather parameters and the parasitization showed density dependent relationship. Gupta and Raj (2003) who elucidated that, the activity of the *C. chlorideae* ceased when the mean maximum temperature reached above 40°C and a significant positive correlation with total rainfall was observed.

The present investigation explores the possibilities that how *C. chlorideae* can suitably increase in there population when chickpea-coriander intercropping system. The intercropping pattern infulence in maximising the activity of parasitoid, which indirectly help in increasing the parasitization of *H. armigera* under natural ecosystem. The progeny sex ratio also positively towards female baised ratio in intercropping system. Hence, there is scope for adopting intercropping of chickpea-corriander for not reducing pod borer population but also get additional income from coriander.

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REFERENCES

Agnihotri M, Gairola SC, Basera A. 2011. Seasonal incidence of *Campoletis chloridae* Uchida, A larval parasitoid of *Helicoverpa armigera* (Hubner) in chickpea. *J Insect Sci.* **24**(4): 362–366.

Bisane KD, Wadaskar KM, Deotale. 2013. Tritrophic interaction of *Helicoverpa armigera* (Hubner) in major pulses ecosystem. *Legume Res.* 36(2).

Chandel SF, Singh PK, Ahmad R. 2005. Population dynamics of *Helicoverpa armigera* (Hubner) and *Campoletis chlorideae* on different crops. *Annals Pl Prot Sci.* **13**: 379–383.

Dhillon MK, Sharma HC. 2007. Survival and development of *Campoletis chlorideae* on various insect and crop hosts: Implications for *Bt*-transgenic crops. *J App Entomol*. **131**(3): 179–185.

Dhillon MK, Sharma HC. 2009. Temperature influences the performance and effectiveness of field and laboratory strains of the ichneumonid parasitoid, *Campoletis chlorideae. Bio Control* **54**: 743–750.

Dhillon MK, Sharma HC. 2011**.** Effect of mating and parasitism regimes on progeny production and sex-ratio of *Campoletis chlorideae* Uchida. *Indian J Exp Biol*. **49**: 786–790.

Gross P, Hawkins BA, Cornell HV, Hosmane B. 2005**.** Using lower trophic level factors to predict outcomes in classical biological control of insect pests. *Basic Appl Ecol.* **6**: 571–584.

Gupta RK, Raj D, Devi N. 2007. Biological and impact assessment studies on *Campoletis chlorideae* Uchida: A promising solitary larval endoparasitiod of *Helicoverpa armigera*(Hubner). *J Asia-Pacific Entomol*. **7**(2): 239–247.

Gupta RK, Raj D. 2003**.** Extent of parasitism and seasonal activity of *Campoletis chlorideae* Uchida in chickpea ecosystem of lower hills of Himanchal Pradesh. *Indian J Pl Prot.* **31**: 5–8.

Pandey R, Ujagir R. 2009. Effect of intercropping on *Campoletis chloridae* Uchida, a larval parasitoid of *Helicoverpa armigera* (Hübner) in chickpea. *J Insect Sci*. **22**(3): 227–231.

Saxena H, Ponnusamya D, Iquebal MA. 2012**.** Seasonal parasitism and biological characteristics of *Habrobracon hebetor* (Hymenoptera: Braconidae), a potential larval ectoparasitoid of *Helicoverpa armigera* (Lepidoptera: Noctuidae) in a chickpea ecosystem. *Biocont Sci Tech.* **22**(3): 305–318.

Kambrekar DN. 2005**.** Managing chickpea pod borer. The Hindu, Science and Technology, February, 3.

Kaur S, Barar KS, Sekhon BS, Joshi N, Shenmar M, Singh J. 2000**.** Role played by *Campoletis chlorideae* Uchida in natural mortality of *Helicoverpa armigera* (Hubner) on chickpea in Punjab. *J BioI Control* **14**: 51–54.

Murgan K, Senthil Kumar N, Jeybalan D, Senthil Nathan S, Sivaramakrishanan S, Swamippan M. 2000. Influence of *H. armigera* diet on its parasitoid *Campoletis chlorideae* Uchida. *Insect Sci Appl.* **20**: 23–31.

Kumar N, Kumar A, Tripathi CPM. 2000. Sex ratio of *Campoletis chlorideae* Uchida in response to *Helicoverpa armigera* (Hübner) density. *Int J Trop Insect Sci.* 20(1): 73–76.

Nikoshe AP, Zala MB, Bharpoda TM. 2014. Relative impact of insecticidal applications on the parasitization activity of *Campoletis chloridae* Uchida, a parasitoid of *Helicoverpa armigera* in chickpea. *Int J Pl Prot*. **7**(1): 260–262.

Ravi G, Verma S. 1997**.** Seasonal incidence of chickpea pod borer, *Helicoverpa armigera* and its larval parasitoid on chickpea crop. *Indian J Entomol.* **59**(4): 359–361.

Ram S, Singh S, Mall P. 2010. Effect of intercrops on the temporal parasitization of *Helicoverpa armigera* (Hub.) by larval parasitoid, *Campoletis chlorideae* Uchida in tomato. *Env Ecol.* **28**(4A): 2485–2489

Reena R, Singh SK, Sinha, BK, Jamwal BS. 2009. Management of gram pod borer, *Helicoverpa armigera* (Hubner) by inter-cropping and monitoring through pheromone traps in chickpea. *Karnataka J Agric Sci.* **22**(3): 215–219.

Sharma HC, Dhillon MK. 2005. *Archival report 2005.* Global Theme-Biotechnology, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India.

Singh D, Singh SK, Venilla S. 2015. Weather parameters influence population and larval parasitization of *Helicoverpa armigera* (Hübner) in chickpea ecosystem. *Legume Res*. **38**(3): 402–406.

Singh R, Ali S. 2006**.** Seasonal incidence of *Helicoverpa armigera* and *Campoletis chlorideae* on chickpea. *Annals Pl Prot Sci.* **14**: 234–235.

Singh S, Battu GS. 2006**.** Potential of *Campoletis chlorideae* Uchida in the natural control of *Helicoverpa armigera* (Hubner) infesting various crops at Ludhiana, Punjab. *Agric Sci Digest* **26**(2): 126–128.

Tripathi SR, Singh R. 1993**.** Seasonal bionomics of *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) in the Tarai belt on north eastern Uttar Pradesh. *Insect Sci Applic.* **14**: 439–444.

Turkar KS, Gupta R, Banerjee SK, Wanjari RR. 2000. Influence of intercropping chickpea with coriander on parasitisation of *Heliothis armigera* (Hubner) by *Campoletis chlorideae* Uchida. *J Entomol Res*. **24**(3): 279–281.