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Relationship of abiotic factors and the copiousness of larval parasitoid, *Campoletis chlorideae* on pod borer, *Helicoverpa armigera* under sole and chickpea-coriander ecosystem at Pantnagar, Uttarakhand

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Abstract
The pod borer, *Helicoverpa armigera* is a conundrum pest of chickpea in Uttarakhand, India. One of the best ways to overcome the attack of this pest is to destroy its initial stage of the life cycle by larval endo parasitoid *Campoletis chlorideae*. The seasonal incidence and simple statistical tool were used for studying the relationship between percent parasitization and weather parameters in sole and chickpea-coriander intercropping systems. The results revealed that in both cropping systems higher parasitism were recorded on 11th Standard Week (March) in both consecutive years. In sole crop, parasitism of 76.67% and 60.67%; and in intercropping system higher parasitism were recorded with 90%; 80% for respective years. 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 negative correlation observed with minimum temperature and morning RH in respective years under sole crop. In case of intercropping system, the result elucidated that a significant positive correlation was observed with evening RH and rainfall (r= 0.951*; r= 0.900* and r= 0.926*; r= 0.931*) in respective years under intercropping system.

Keywords: *Campoletis chlorideae*, correlation, temperature and relative humidity

Introduction
Worldwide changes are in charge of extensive variety of human movement and normal environmental variation [1]. These climatic and climate changes influence the status of insect pests as well as influence their populace dynamics, distribution, abundance, intensity and feeding behavior [2]. Force of progress in worldwide climatic biological community has demonstrated an immediate and circuitous impact on prey and host relationship, their safe reactions and rate of improvement, their fruitfulness and assorted physiological capacities [3]. The pulse crop, chickpea (*Cicer arietinum* L.) is the third most essential grain vegetable on the planet after dry beans (*Phaseolus* spp.) and field pea (*Pisum sativum* L.). It is a critical wellspring of protein, minerals, and vitamins in the diets of millions of people residing in semi-dry tropics. India is the largest producer of chickpea of around 67% of the worldwide production.

It involves about 31% of aggregate pulse region in the nation and contributes more than 37% to the national pulse eneration production [4]. The chickpea for the year 2013-14 denoted a noteworthy increment in area of 9.96 million ha and with a production of 9.92 million tons [5]. There are numerous limitations which influence the production of chickpea among which are insect pests, especially the major one gram pod borer *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) [6]. Among the common natural enemy of *H. armigera* recorded in chickpea biological ecosystem, *Campoletis chlorideae* Uchida (Hymenoptera: Ichneumonidae) is a vital larval endoparasitoid that causes up to half parasitisation under natural ecosystem [7]. Nonetheless, movement of the parasitoid happens just amid November to February, matching with the vegetative phase of the crop. In North India, amid March to April, *H. armigera* damage concurs with the fruiting phase of chickpea causing overwhelming losses [8]

It was asserted that, the explore of a potential parasitoid coinciding with the fruiting stage of chickpea and recorded a gregarious larval ectoparasitoid *Habrobracon hebetor* (Say)

(Hymenoptera: Braconidae) on *H. armigera* in chickpea fields in Kanpur district, Uttar Pradesh [9]. The knowledge on the seasonal incidence of larval endo parasitoid will certainly found to be helpful in formulating the insect pest management strategies for *H. armigera* at Pantnagar conditions. Therefore, an attempt has been made to understand the seasonal parasitism and the effect of different abiotic factors on parasitism of *C. chlorideae* on *H. armigera* in sole chickpea and chickpea-coriander ecosystem.

Materials and Methods

A field experiments were conducted at Crop Research Centre (CRC), G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India during, 2012-13 and 2013-14 (17° 20' N, 78° 30'). The chickpea, *C. arietinum* (variety PG 186) and the coriander (variety Haritha) was sown in 5x4 m plot size and the ratio with intercrops was 4 (chickpea):2(coriander) under chickpea- coriander intercropping system during 2012-13 and 2013-14. Row spacing was maintained by 30cm. In order study the, effect of weather parameters on the percent parasitization of larval parasitoid *C. chloridae* under sole and chickpea-coriander cropping systems. Thirty larvae of *H. armigera* (first and second instars) were collected randomly at daily basis from untreated chickpea crop and chickpea-coriander intercrop ecosystems. The collected larvae were brought to the laboratory in plastic vials and reared individually in laboratory till the adult emergence of the parasitoids. Observations were recorded on number of adult parasitoid emerged from parasitized larvae *H. armigera* and percent parasitisation was calculated. The percent parasitisation data were correlated with weather parameters *viz.*, maximum and minimum temperature and maximum and minimum relative humidity.

Results and Discussion

In the present study the seasonal incidence and percent parasitization by *C. chlorideae*, in two cropping systems were studied and the results have been presented in Table 1-4

Seasonal parasitism of *C. chlorideae* on H. armigera in sole chickpea and chickpea-coriander intercropping ecosystem

The data on seasonal parasitism of *H. armigera* by *C. chlorideae* in sole chickpea and chikcpea-coriander intercropping ecosystem, during the post-rainy season for two consecutive years (2013 and 2014) are presented in table 1-4. The occurrence and percentage parasitism varied in both years. In both years, the parasitoid remained almost nil up to the end of February and parasitism was observed only in the first week of March to third week of March. The maximum parasitiod activity, at temparture between 15-28 ^{o}C. It was reported that, in both years the occurrence of parasitoid activity were started on 9th S.W and 11th S.W for the respective years. The however the activity of parasitoid was very less in during 2013-14, it may hardly observed for 15-17 days (11th -13th S.W). The activity of *C. chlorideae* completely decline after 13th standard week in both year as it concurance with the crop maturity and raise in temparure. The activity of parasitoid, coinciding with flowering and pod formation stage of the crop. As the high activity of *C. chlorideae* were only for few weeks, hence, larvae were collected at two days intervals and brought to labraotry for studying percent parasitsm.

Percent parasitization of H. armigera in chickpea sole crop

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% occurred on 11th S.W March and 60.67 on 11th S.W for 2012-13 and 2013-14 respective years. The lowest parasitism of 30.67 and 30.00 was recorded on 11th and 12th S.W for respective years under sole crop is presented in Table 1 and 3.

Percent parasitization of *H. armigera* in chickpea- coriander intercropping system

The percent parasitization in intercropping ecosystem was recorded in both consecutive years, the result revealed that, the overall mean parasitism by *C. chlorideae* on larvae of *H. armigera* was 76.96% and 66.67% during 2013 and 2014, respectively. Higher parasitism of 90% and 80% was recored on 11th S.W for 2012-13 and 2013-14, respectively. The lowest parasitism of 50.00% and 60.00% was reocrded on 12th S.W of March for respective two years in chickpea- coriander intercropping system presented in Table 2 and 4

In the present study, the *C. chlorideae* is the most predominant and promising larval endo parasitoid causing up to 80% parasitism in different ecosystems [10, 11]. 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 [12]. These results suggested that *C. chlorideae* was quite active in chickpea cropping ecosystems between 11th and 14th S.W of March. The comparable outcomes were acquired [13], they reported that the occurrence of *H. armigera* began from first seven day stretch of January and achieved its peak by March. Parasitoid population pursued the host population and declined after 9th S.W. Crop diversification in term of intercropping of coriander with chickpea significantly recorded higher parasitic movement of *C. chlorideae* [14, 15] reported, most astounding chickpea equivalent grain yield was recorded in chickpea + mustard (6:2) trailed by chickpea + grain (4:2) amid rabi 2004-05.

Pod damage by *H. armigera* was highest in chickpea sole crop. Parasitization by *C. chlorideae* did not vary with the intercrops during pre-winter months of rabi 2004-05 while, parasitization was higher in chickpea + linseed during rabi 2006-07. [16] who reported that, under chickpea ecosystem, *Eriborus argenteopilosus* parasitized *H. armigera* larvae up to 16.1 percent and *C. chlorideae* registered parasitization up to 14.3 percent, whereas, Tachinid fly could inflict parasitization to the tune of 10.0 and 33.3 percent in late larval and pupal stages, respectively.

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

The correlation co-efficient was worked out between the percent parasitization and weather parameters during 2012-13 and 2013-14 are presented in Table 1 and 3

It was clearly revealed that during 2012-13, there was a non-significant positive correlation with maximum temperature (r = 0.006), evening RH (r = 0.308), Rain fall (r = 0.159) and sunshine hours (r = 0.457). There was negative correlation was observed in minimum temperature and morning RH with (r =-0.506, r = 0.088, respectively).

During 2013-14, it was observed that a non-significant correlation with morning RH and sunshine hours with (r = 0.127, r = 0.158) respectively. A positive significant correlation were observed with evening RH and rainfall (r=

0.951*, r = 0.900*, respectively). The non-significant negative correlation was observed with maximum and minimum temperature (r = - 0.182, r = - 0.572), respectively.

Influence of weather parameters on percent parasitization in *H. armigera* in chickpea-coriander intercropping system

The correlation co-efficient was worked out between percent parasitization and weather parameters during 2012-13 and 2013-14 are presented in Table 2 and 4.

It was clearly revealed that during 2012-13, there was a non-significant positive correlation with maximum temperature (r = 0.059), evening RH (r = 0.548), Rain fall and sunshine hours (r = 0.290, r = 0.089, respectively). Negative correlation was observed in minimum temperature and morning RH (r =- 0.341, r = -0.083, respectively.

During 2013-14, it was ascertained that a non-significant positive correlation with morning RH and sunshine hours with (r = 0.165). A positive significant correlation were observed with evening RH and rainfall (r= 0.926*, r = 0.931*) respectively. The non-significant negative correlation were observed (r = - 0.030, r = - 0.619, respectively) for Maximum temperature and minimum temperature.

The result is partially cogent with Halder *et al*., 2013 [17], who reported that, total parasitization was negatively 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 [18] 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 (Table 5).

Table 1: Seasonal incidence of larval endo parasitoid *C. chlorideae* on *H. armigera in Chickpea* crop during *Rabi*, 2012-13

Collection	Date of collection	No. of larvae collected	No. of parasitized	% parasitism	Max Temp	Min Temp	RH Morning	RH Evening	Rainfall (mm)	wind velocity	Sun Shine Hr
1st	3/3/13	30	17	56.67	24.5	11.4	97	45	0	3.5	6.9
2nd	5/3/13	30	16	53.33	28	13	92	47	0	3	9
3rd	7/3/13	30	18	60.00	30	11	93	49	0	4.2	9.4
4th	9/3/13	30	20	66.67	29.2	13.4	93	44	0	1.7	8.9
5th	11/3/13	30	18	60.00	28.9	13.9	86	45	0	6	8
6th	13/03/13	30	22	73.33	29	11	90	46	0	2.4	7.1
7th	15/03/13	30	20	66.67	29.8	14.8	91	50	13.4	2.9	7.8
8th	17/03/13	30	23	76.67	29.5	11.4	90	39	0	3.9	9.6
9th	19/0.3/13	30	22	73.33	27.8	13.5	93	50	0	8.1	9.3
10th	21/03/13	30	13	43.33	30	14.4	93	46	0	1.4	5.7
11th	23/3/13	30	11	36.67	29.2	15.1	90	37	0	1.6	8
MEAN				60.61							

Table 2: Seasonal incidence of larval endo parasitoid *C. chlorideae* on *H. armigera in* Chickpea - coriander intercropping system during *Rabi*, 2012-13

Collection	Date of collection	No. of larvae collected	No. of parasitized	% parasitism	Max Temp	Min Temp	RH Morning	RH Evening	Rainfall (mm)	wind velocity	Sun Shine Hr
1st	3/3/13	30	22	73.33	24.5	11.4	97	45	0	3.5	6.9
2nd	5/3/13	30	21	70.00	28	13	92	47	0	3	9
3rd	7/3/13	30	22	73.33	30	11	93	49	0	4.2	9.4
4th	9/3/13	30	24	80.00	29.2	13.4	93	44	0	1.7	8.9
5th	11/3/13	30	24	80.00	28.9	13.9	86	45	0	6	8
6th	13/03/13	30	27	90.00	29	11	90	46	0	2.4	7.1
7th	15/03/13	30	26	86.67	29.8	14.8	91	50	13.4	2.9	7.8
8th	17/03/13	30	25	83.33	29.5	11.4	90	39	0	3.9	9.6
9th	19/0.3/13	30	26	86.67	27.8	13.5	93	50	0	8.1	9.3
10th	21/03/13	30	22	73.33	30	14.4	93	46	0	1.4	5.7
11th	23/3/13	30	15	50.00	29.2	15.1	90	37	0	1.6	8
Mean				76.96							

Table 3: Seasonal incidence of larval endo parasitoid *C. chlorideae* on *H. armigera in Chickpea* crop during *Rabi*, 2013-14

Collection	Date of collection	No. of larvae collected	No. of parasitized	% parasitism	Max Temp	Min Temp	RH Morning	RH Evening	Rainfall (mm)	wind velocity	Sun Shine Hr
1st	13/03/14	30	20	66.67	29	11	90	46	0	2.4	7.1
2nd	15/03/14	30	14	46.67	29.8	14.8	91	50	13.4	2.9	7.8
3rd	17/03/14	30	12	40.00	29.5	11.4	90	39	0	3.9	9.6
4th	19/03/14	30	12	40.00	27.8	13.5	93	50	0	8.1	9.3
5th	21/03/14	30	9	30.00	30	14.4	93	46	0	1.4	5.7
Mean				44.66							

Table 4: Seasonal incidence of *H. armigera* and larval endo parasitoid *C. chlorideae* on Chickpea- coriander intercrop system during *Rabi*, 2013-14

Collection	Date of collection	No. of larvae collected	No. of parasitized	% parasitism	Max Temp	Min Temp	RH Morning	RH Evening	Rainfall (mm)	wind velocity	Sun Shine Hr
1st	13/03/14	30	24	80.0	29	11	90	46	0	2.4	7.1
2nd	15/03/14	30	20	66.7	29.8	14.8	91	50	13.4	2.9	7.8
3rd	17/03/14	30	19	63.3	29.5	11.4	90	39	0	3.9	9.6
4th	19/03/14	30	20	66.7	27.8	13.5	93	50	0	8.1	9.3
5th	21/03/14	30	18	60.0	30	14.4	93	46	0	1.4	5.7
Mean				67.33							

Table 5: Influence of weather parameters on the incidence of *C. 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

Conclusion

The present investigation results would be benefit for *Terai* farming community through adaptation of chickpea- coriander intercropping system as it splendidly enhance activity of *C. chlorideae* and thereby influencing natural control of early instar *H. armigera* under field condition. The farmers also get additional income from coriander along with main crop. It also helpful to know the effect of weather parameter for the population buildup of larval parasitoid.

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