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Comparative parasitisation of *Helicoverpa armigera* (Hubner) [Lepidoptera: Noctuidae] by *Campoletis chlorideae* Uchida [Hymenoptera: Ichneumonidae] on some chickpea varieties

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ABSTRACT: Chickpea varieties, commonly recommended for cultivation in Rajasthan, were screened for their preference by the pod borer, *Helicoverpa armigera* (Hubner), under natural infestation and the parasitisation efficacy of the larval parasitoid, *Campoletis chlorideae* Uchida. The variety Pratap Chana was most preferred by the pod borer, as it harboured the maximum numbers of eggs (15.85), larvae (19.05) and damaged pods (41.44); whereas, variety GNG 1581 was least preferred for egg laying (4.79); GNG 663 had lowest larval population (5.50); and RSG 888 had lowest numbers of damaged pods (4.19). The larval parasitoid, *C. chlorideae* was active from 15thDecember, 2014 to 26th January, 2015; but, the maximum parasitisation varied on different varieties. The observed abundance of the parasitoid, *C. chlorideae* was significantly more (10.47 per 4-m row) on chickpea variety Pratap Chana, while observed parasitisation (34.84%) was more on variety GNG 663. The coefficient of correlation between pod borer and its parasitoid was significant (r = +0.83) only for chickpea variety GNG 1581. The prevailing abiotic factors of the environment did not evince any significant effect on the population of pod borer and its larval parasitoid.

KEY WORDS: Chickpea, *Helicoverpa armigera*, parasitisation, *Campoletis chlorideae*

INTRODUCTION

Chickpea (*Cicer arietinum* L.), also known as Bengal gram, gram or *chana* is an important *rabi* pulse crop of India and is infested by several species of insects and other arthropods; however, the major pest of chickpea is the gram pod borer, *Helicoverpa armigera* (Hubner), which is a polyphagous, multivoltine and cosmopolitan pest, known to feed on 182 species of plants belonging to 47 families in India (Sithanantham, 1987 and Panwar, 1998). High polyphagy, mobility, reproductive rate and diapause are major factors contributing to its serious pest status (Fitt, 1989 and Sharma *et al.,* 2005). Over 250 natural enemies have been recorded on *H. armigera* (Romeis and Shanower, 1996) in different agro-ecosystems, however, the activity and abundance of natural enemies varies across crops (Pawar *et al.,* 1986), and different genotypes of the same crop (Romeis and Shanower, 1996; Sharma *et al.,* 2003; Dhillon and Sharma, 2007). Host plant selection by the female parasitoids, involves a series of complex responses in a non-random manner to a hierarchy of physical and/or

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chemical stimuli that lead them to their potential hosts (Vet and Groenewold, 1990; Lewis *et al.,* 1991; Tumlinson *et al.,* 1993). Parasitoids also respond to the volatiles emanating from both undamaged (McAuslane *et al.,* 1990; Li *et al.,* 1992; Turlings and Tumlinson, 1992; Udayagiri and Jones, 1992) and damaged (Whitman, 1988; Turlings *et al.,* 1990, 1995; Mattiaci *et al.,* 1994; de Moraes *et al.,* 1998; War *et al.,* 2011) plants. Genotypic resistance has a considerable influence on parasitism of insect pests in different crops. The nature of influence depends on the insect pest, natural enemy, and the crop (Sharma *et al.,* 2003). In chickpea, parasitisation of *H. armigera* larvae by *C. chlorideae* ranged from 8.33 to 28.00 per cent (Gupta and Raj, 2003), and varied considerably across genotypes (Kaur *et al.,* 2004); however, there is no information on genotypic effects on the activity and abundance of natural enemies in chickpea.

MATERIALS AND METHODS

A field experiment was conducted at the Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur, during *rabi* 2014-15. Six varieties recommended for the zone Pratap Chana, RSG-902, GNG-469, GNG-663, GNG-1581, RSG-888 were evaluated for their preference by the gram pod borer. The experiment was laid out in RBD with six treatments and four replications in plots of size 4m x 3m; planting the seed on 4th November, 2014 maintaining a spacing of 30cm x 10cm. All recommended agronomic practices including hoeing, weeding and irrigation were performed as and when needed following the package of practices for cultivation of chickpea.

During early hours of the day (7 to 9 am) observations on the number of eggs per plant as an evidence of preference for egg laying by *H. armigera* on the different gram varieties was recorded from 5 plants selected at random and tagged replicate-wise in each treatment (variety). Record of the total numbers of plants with egg laying per replicate for each variety screened was made and expressed as a percentage of plants harbouring *H. armigera* eggs in the different varieties for comparison. Similarly, observations for *H. armigera* larvae infesting the crop were taken along the 4-metre-row, selecting 3 rows from each plot/ replicate for each variety. From the same rows observed for the pest, the numbers of parasitized larvae were field collected and brought to the laboratory. Particular care was taken to record the influence of variety on parasitoid abundance and efficacy, for which, the field-collected parasitized larvae were maintained in glass jars of 500ml capacity separately until adult parasitoid emergence. The glass jars were covered with muslin cloth and fastened with rubber bands. The parasitoids were preserved for further study. The effective parasitisation (%) was computed using the methodology adopted by Tian *et al* (2008):

$$\text{Effective Parasitisation (\%)} = \frac{\text{Number of larvae parasitized}}{\text{Number of larvae effectively parasitized} + \text{Number of healthy larvae}} \times 100$$

Morphological characterization of the parasitoid was done using photographs of significant taxonomical characters taken under the stereozoom binoculars Stemi 2000 C of Carl Zeiss make. Necessary line drawings at a magnification of 7-X, for clarity, were drawn with the help of a drawing tube under the stereozoom binoculars Nikon SMZ 1500. The parasitoids collected were identified using standard references and internet sources (NBAIR, Bangalore).

RESULTS

From the Table (1) it can be observed that variety Pratap Chana was the most preferred variety of the pod borer as, on this variety, significantly the maximum mean numbers of eggs were laid (15.85 eggs per 4-m row), the maximum mean numbers of larvae were recorded (19.05 caterpillars per 4-m row) and the maximum damage to pods was also observed (41.44 pods per 4-m row). On the other hand, variety GNG 1581 happened to be the

Table 1. Screening of chickpea varieties against the gram pod borer during *rabi*, 2014-15

Gram Varieties	Egg-laying preference by pod borer (Mean ¹/row	Larval population of pod borer (Mean ¹/row)	Pod borer damaged Pods (Mean ¹/row)	Yield (Kg/plot) [Plot 12m^2]	Yield (Kg/ha)
Pratap Chana	1.20^{f}{15.85}	1.08^{d}{19.05}	41.44^{d}	2.39^{ab}	1993.54
RSG 902	0.92^{b}{8.32}	0.73^{c}{8.32}	15.19^{c}	2.96^{b}	2463.75
GNG 469	1.10^{e}{12.60}	0.66^{b}{7.24}	9.64^{b}	2.20^{ab}	1834.79
GNG 663	1.07^{d}{11.75}	0.59^{a}{5.50}	5.81^{a}	2.41^{a}	2010.42
GNG 1581	0.68^{a}{4.79}	0.58^{a}{5.75}	5.74^{a}	1.75^{a}	1460.63
RSG 888	1.03^{c}{10.72}	0.73^{c}{7.94}	4.19^{a}	1.78^{a}	1480.00
S. Em. +	0.006	0.016	0.854	0.254	——
C.D. (5%)	0.018	0.049	2.572	0.765	——

Note: *Figures in* { } *are retransformed antilog values*

least preferred variety, as it harboured significantly the lowest numbers of eggs (4.79 eggs per 4-m row), lesser numbers of larvae (5.75 caterpillars per 4-m row) and also lower numbers of damaged pods (5.74 pods per 4-m row), however, variety GNG 663 harboured the least numbers of larvae (5.50 caterpillars per 4-m row) and variety RSG 888 had the lowest numbers of damaged pods (4.19 pods per 4-m row). When the yield parameters obtained from 12m^2 plots were compared, the lowest yield was recorded for variety GNG 1581 (1.75 kg/plot), though it was least preferred by the pod borer, being at par with that of Pratap Chana, GNG 469, GNG 663 and RSG 888. The variety RSG 902 significantly yielded the maximum (2.96 kg/plot). Based on the yield attributes the varieties RSG 902, GNG 663, Pratap Chana and GNG 469 yielded relatively more than varieties GNG 1581 and RSG 888.

Natural parasitisation of *H. armigera* by the Ichneumonid parasitoid, *C. chlorideae* (Table: 2) indicated that parasitisation was significantly more on varieties GNG 663 (34.84 %), GNG 469 (33.16 %) and RSG 902 (30.27%); however, the numerical abundance of the parasitoid was significantly more on the variety Pratap Chana in terms of numbers (10.47) and mean parasite count (17.93). On the different varieties, the mean numbers of caterpillars in a 4-m row ranged from 5.50 (GNG 663) to 19.05 (Pratap Chana); the observed parasitoid abundance ranged from 2.74 (GNG 1581) to 10.47 (Pratap Chana); per cent parasitisation ranged from 24.74 (RSG 888) to 34.84 (GNG 663); and the mean parasite count ranged from 4.43 (GNG 1581) to 17.93 (Pratap Chana). From the Table (3) it is conspicuous that the effective parasitisation, as per method suggested by Tian *et al* (2008), was the maximum on variety GNG 469 (65.15 %), followed by that on Pratap Chana (61.40 %), while it was the minimum on RSG 888 (44.10 %). The seasonal parasitisation trend as given in Table (4) shows that irrespective of chickpea variety, natural field parasitisation was noted from 15th December, 2014 onwards that gradually increased in the subsequent weeks with a significant variation continuing up to the last week of January, 2015. The per cent parasitisation evaluated in the different varieties ranged from 18.97 to 32.63 for Pratap Chana; 20.30 to 46.40 for RSG 902; 20.70 to 41. 44 for GNG

Table 2. Natural parasitisation of *H. armigera* on different gram varieties during *rabi*, 2014-15

Gram Varieties	Larval population of pod borer (Mean No/row)	Observed Parasitoid* *C. chloridae*		Mean parasite count (No)
		Abundance (No)	Parasitization (%)	
Pratap Chana	1.08^{d}{19.05}	3.31^{c}[10.47]	31.26^{ab}(26.93)	1.2536^{b}{17.93}
RSG 902	0.73^{c}{8.32}	2.27^{ab}[4.65]	33.38^{abc}(30.27)	0.9340^{ab}{8.59}
GNG 469	0.66^{b}{7.24}	2.52^{b}[5.85]	35.16^{bc}(33.16)	1.0251^{ab}{10.59}
GNG 663	0.59^{a}{5.50}	1.89^{a}[3.06]	36.18^{c}(34.84)	0.7213^{a}{5.26}
GNG 1581	0.58^{a}{5.75}	1.80^{a}[2.74]	31.58^{ab}(27.42)	0.6461^{a}{4.43}
RSG 888	0.73^{c}{7.94}	1.90^{a}[3.11]	29.83^{a}(24.74)	0.6609^{a}{4.58}
S. Em. +	0.016	0.200	1.393	0.135
C.D. (5%)	0.049	0.602	4.197	0.405

**Figures in* () *are retransformed per cent values; Figures in* [] *are retransformed square values*; *Figures in* {} *are retransformed antilog values*

*Parasitoid abundance is on the basis of 7 observations during the season; the pod borer, *H. armigera* was parasitized by *C. chloridae*

Table 3. Effective parasitisation of *H. armigera* by *C. chlorideae* on different chickpea varieties during 2014-15 (as per method of Tian *et al.*, 2008)

Dates of Observation	Chickpea Varieties/parasitisation			Chickpea Varieties/ parasitisation					
	Atm. Temp. (°C)	R. H. (%)	Sunshine (hrs)	Pratap Chana	RSG 902	GNG 469	GNG 663	GNG 1581	RSG 888
15/12/2014	16.01	54.30	7.10	18.26	15.09	27.76	25.00	32.45	18.95
22/12/2014	13.59	57.70	7.70	42.51	54.78	60.01	47.26	36.40	42.61
29/12/2014	14.54	53.00	8.70	60.61	60.02	79.54	52.26	44.44	53.33
05/01/2015	14.80	72.00	3.90	55.40	45.05	70.07	36.97	42.19	52.22
12/01/2015	17.20	54.00	8.70	67.07	43.76	67.34	38.76	63.29	58.57
19/01/2015	14.70	65.00	7.60	92.38	92.34	73.53	81.47	75.19	0.00
26/01/2015	16.20	73.00	4.02	93.60	92.59	77.82	89.09	87.98	82.99
Seasonal Mean	15.29	61.29	6.82	61.40	57.66	65.15	52.97	54.56	44.10
r - value for mean Temp. & parasitisation				0.13	-0.18	-0.16	-0.08	0.41	0.31
r- value for mean R. H. & parasitisation				0.55	0.55	0.41	0.55	0.52	0.27
r- value for mean S-shine & parasitisation				-0.21	-0.21	-0.13	-0.25	-0.26	-0.39

Table 4. Seasonal parasitisation trend of gram pod borer by *C.chloridae* on different varieties of chickpea

Dates of Obser-vation	Mean Abiotic Factors			Chickpea Varieties/ parasitisation					
	Mean Atm. Temp. (C)	Mean R. H. (%)	Mean Sunshine (hrs)	Pratap Chana	RSG 902	GNG 469	GNG 663	GNG 1581	RSG 888
01/12/2014	21.62	52.00	8.90	2.79	1.27	0.96	1.27	0.83	0.71
08/12/2014	18.86	48.60	8.60	4.71	3.00	2.31	1.85	1.60	2.96
15/12/2014	16.01	54.30	7.10	7.83 (18.97)	2.81 (20.30)	2.60 (26.27)	1.50 (26.44)	2.60 (28.25)	3.21 (21.92)
22/12/2014	13.59	57.70	7.70	4.40 (28.90)	2.27 (39.27)	1.83 (38.50)	1.40 (40.12)	1.75 (32.04)	2.02 (29.11)
29/12/2014	14.54	53.00	8.70	3.25 (32.63)	0.83 (30.55)	0.71 (41.44)	0.69 (34.05)	0.31 (21.03)	1.31 (29.28)
05/01/2015	14.80	72.00	3.90	2.42 (28.00)	0.92 (24.31)	0.75 (33.24)	0.85 (27.40)	0.69 (22.07)	0.92 (28.47)
12/01/2015	17.20	54.00	8.70	1.23 (26.13)	0.64 (22.42)	0.73 (32.71)	0.79 (29.48)	0.44 (27.57)	0.71 (26.97)
19/01/2015	14.70	65.00	7.60	0.17 (29.06)	0.21 (46.40)	0.27 (30.87)	0.23 (45.90)	0.17 (28.47)	0.21 (12.86)
26/01/2015	16.20	73.00	4.02	0.10 (25.53)	0.06 (30.87)	0.14 (20.70)	0.12 (41.71)	0.10 (33.33)	0.10 (26.44)

* Figures in parentheses are percent values of parasitisation

469; 26.44 to 45.90 for GNG 663; 21.03 to 33.33 for GNG 1581 and 12.86 to 29.28 for RSG 888.

The abiotic factors of the environment did not significantly affect the effective parasitisation (%) of *H. armigera* by *C. chlorideae*; however, atmospheric temperature had a variable response among the chickpea varieties; relative humidity was uniformly positively correlated to parasitisation across the varieties and sunshine showed a negative correlation with parasitisation for all the varieties evaluated (Table: 3). The observed numerical abundance of the larval parasitoid of the pod borer showed significant negative correlation with the mean atmospheric temperature only on chickpea variety RSG 902 ($r = - 0.78^*$); while, on other varieties the correlation coefficients for different factors of the environment had no significant relationship. Likewise, the population of *H. armigera* had a negative correlation with the mean relative humidity that was significant only on chickpea variety GNG 663 ($r = - 0.71^*$). The relationship between pod borer and its parasitoid evinced a significant positive correlation ($r = 0.83^*$) only on the chickpea variety GNG 1581 (Table: 5).

The larval parasitoid of *H. armigera* was identified as *Campoletis chlorideae* Uchida (Hymenoptera: Ichneumonidae) with the help of identification key provided by NBAIR, Bangalore (URL: www.nbair.res.in, 2013) and has been presented in Plate I along with the life stages of the pod borer, *Helicoverpa armigera* (Hubner). As per key, the important taxonomic features observed for the species include: areolet in forewing receiving second recurrent vein a little before middle and the

Table 5. Impact of abiotic/ biotic factors on the gram pod borer and its parasitoid on different gram varieties

Dates of Observation	Mean Abiotic Factors			Population of the pod borer, *H. armigera* and larval parasitoid, *C. chloridae* (¹/row)											
	Atm. Temp. (°C)	R. H. (%)	Sun-shine (hrs)	Pratap Chana		RSG 902		GNG 469		GNG 663		GNG 1581		RSG 888	
				H	**C**	**H**	**C**	**H**	**C**	**H**	**C**	**H**	**C**	**H**	**C**
01/12/14	21.62	52.00	8.90	2.79	—	1.27	—	0.96		1.27	—	0.83	—	0.71	—
08/12/14	18.86	48.60	8.60	4.71	—	3.00	—	2.31		1.85	—	1.60	—	2.96	—
15/12/14	16.01	54.30	7.10	7.83	1.75	2.81	0.50	2.60	1.00	1.50	0.50	2.60	1.25	3.21	0.75
22/12/14	13.59	57.70	7.70	4.40	3.25	2.27	2.75	1.83	2.75	1.40	1.25	1.75	1.00	2.02	1.50
29/12/14	14.54	53.00	8.70	3.25	5.00	0.83	1.25	0.71	2.75	0.69	0.75	0.31	0.25	1.31	1.50
05/01/15	14.80	72.00	3.90	2.42	3.00	0.92	0.75	0.75	1.75	0.85	0.50	0.69	0.50	0.92	1.00
12/01/15	17.20	54.00	8.70	1.23	2.50	0.64	0.50	0.73	1.50	0.79	0.50	0.44	0.75	0.71	1.00
19/01/15	14.70	65.00	7.60	0.17	2.00	0.21	2.50	0.27	0.75	0.23	1.00	0.17	0.50	0.21	0.00
26/01/15	16.20	73.00	4.02	0.10	1.50	0.06	0.75	0.14	0.50	0.12	1.00	0.10	0.75	0.10	0.50
Correlation for Atm. Temp. with H/C				0.04	-0.52	0.17	**-0.78***	0.12	-0.60	0.37	-0.58	0.05	0.23	0.05	-0.32
Correlation for RH with H/C			-0.56	-0.43	-0.62	-0.03	-0.60	-0.49	**-0.71***	0.19	-0.46	-0.22	-0.59	-0.49	
Correlation for sunshine with H/C				0.26	0.42	0.33	0.30	0.31	0.43	0.44	0.03	0.18	-0.01	0.29	0.29
Correlation between pest and parasitoid				—	0.12	—	0.05	—	0.25	—	-0.21	—	**0.83***	—	0.43

* Indicates t-value being significant at P=0.05; H = *H. armigera* , C = *C. chloridae*

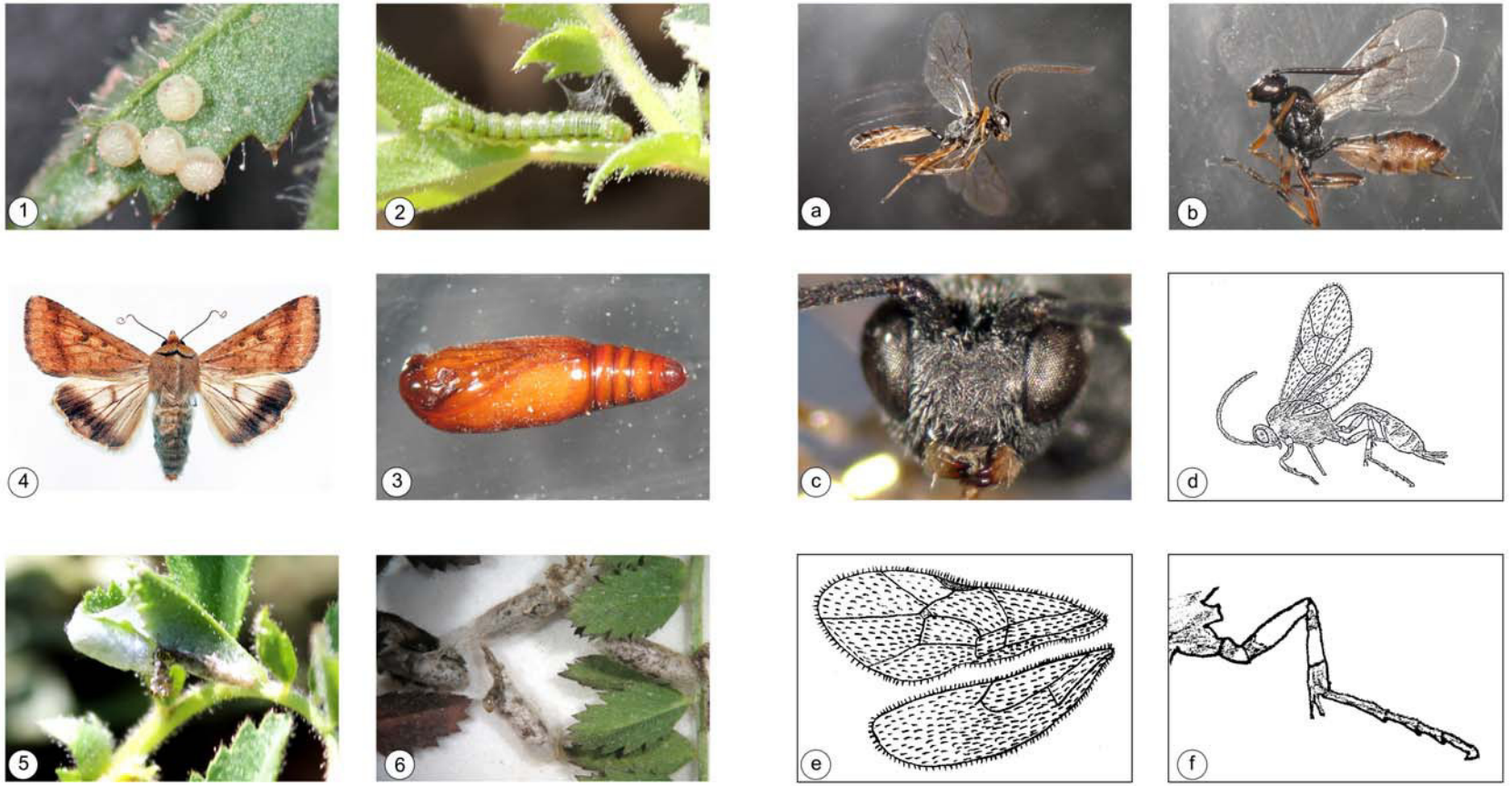

Plate: I Life cycle of *H. armigera* and morphological characterization of the larval parasitoid, *C. chlorideae*

1. Eggs; 2. Caterpillar; 3. Pupa; 4. Adult – *Helicoverpa armigera* (Hubner); 5. Field parasitization of *H. amigera*; 6. Cocoon of *C. chlorideae*

a. *C. chlorideae* (♂); b. *C. chlorideae* (♀); c. Clypeus with median tooth ; d. Female diagram lateral view; e. Areolet in forewing; f. Two segmented hind trochanter

apical margin of clypeus with an obtuse median tooth.

DISCUSSION

The entire collection of 362 parasitoids happened to be males and females of *Campoletis chlorideae* Uchida (Hymenoptera: Ichneumonidae). The overall assessment indicated that variety Pratap Chana was most preferred by the pod borer and the associated parasitoid was also the maximum on this variety; while, the variety GNG 1581 was least preferred by the pod borer and was also least visited by the parasitoid, defining the density-dependent activity of the parasitoid. Earlier, Ramegowda *et al* (2007) observed that of the 24 genotypes screened against *H. armigera*, ICC 506 (resistant control) and A1 (local control), BG-1039, P-1772 B, L-550 and 86019 had minimum ova load and were at par with ICC-506 and superior to A1, which recorded 2.70 ova per plant. Deshmukh *et al* (2010) reported chickpea genotypes BG-372, HC-1, SAKI-9516, Vijay and Avrodhito to be comparatively less susceptible as they harboured lower larval population (1.07 to 1.32 larvae/ plant) and had lower damage to pods (11.41 to 14.16%). Likewise, the mean larval population was lowest (<4.75 larvae/5 plants) on RSG-931 and GNG-1488, which were categorized as the least susceptible to the gram pod borer under hyper arid partial irrigated western plain zone of Rajasthan (Chandra and Nanda, 2013).

Earlier reports indicate that the egg parasitoid, *Trichogramma* spp. and the larval parasitoids, *Campoletis chlorideae* Uchida (Hymenoptera: Ichneumonidae), *Carcelia illota* Curran, *Palexotista* spp., and *Goniozus* spp. are predominant parasitoids of *H. armigera* in different agro-ecosystems. It has also been observed that the activity and abundance of natural enemies varies across crops (Pawar *et al.,* 1986), and different genotypes of the same crop (Romeis and Shanower, 1996; Sharma *et al.,* 2003; Dhillon and Sharma, 2007). In chickpea, parasitism of *H. armigera* larvae by *C. chlorideae* ranged from 8.33 to 28.00 per cent (Gupta and Raj, 2003), and varied considerably across genotypes (Kaur *et al.,* 2004). Studies were undertaken to identify pigeonpea, *Cajanus cajan* (L.) and the wild relative of pigeonpea, *Cajanus scarabaeoides* (L.) (Accession ICPW 125) genotypes that are hospitable to the pod borer, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) and the larval parasitoid, *Campoletis chlorideae* Uchida (Hymenoptera: Ichneumonidae) for the management of this pest in pigeonpea based cropping systems. Percentage parasitisation of *H. armigera* larvae by *C. chlorideae* females was greater under no-choice conditions than under multi-choice conditions because of forced parasitisation under no-choice conditions. Lowest parasitisation was recorded on the wild relative, ICPW 125, which may be due to long non-glandular hairs and low survival of *H. armigera* larvae. Parasitisation of *H. armigera* larvae was greater under no-choice, dual-choice and/or multi-choice conditions on ICPL 87, ICPL 87119 and ICPL 87091, which are susceptible to *H. armigera*, than on the pod borer-resistant genotypes ICPL 332WR, ICPL 84060 and ICPB 2042; while survival and development of the parasitoid was better on *H. armigera* larvae fed on ICPL 87, ICPL 87119, LRG 41, ICP 7035 and ICPL 87091 than on ICPL 332WR, ICPL 84060, ICPB 2042 and ICPW 125. The genotypes ICPL 87, ICPL 87119, LRG 42 and ICPL 87091 that are hospitable to *C. chloridae*, are better suited for use in integrated pest management to minimize the losses due to *H. armigera* in pigeonpea (Hugar *et al.,* 2014). It thus becomes increasingly clear that germplasm susceptible to pest attack happen to attract more parasitoids leading to higher parasitisation.

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