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RESEARCH ARTICLE :

Effect of different sowing dates on expression of resistance to *Helicoverpa armigera* in different genotypes of chickpea across four plantings using diet incorporation assay under laboratory conditions

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SUMMARY : It is difficult to compare genotypic resistance to insects across seasons and locations because of the variation in the onset and severity of insect infestation. Therefore, in this study, we used artificial diet incorporation assays for evaluating chickpea genotypes for resistance to *Helicoverpa armigera* (L.) across sowing dates. The larval weight was more in insects reared on the crop sown in November than in insects reared on the crop sown in December. Pupal weight was greater on the crop sown in October than on the crop sown in December. Pupation, adult emergence and fecundity were high, whereas larval period was shorter on the crop sown in January, There were no significant differences in survival and development of *H. armigera* across sowing dates. The pupal weight and fecundity were greater, and larval period was shorter on ICC 3137, contributing to its susceptibility to *H. armigera*. On ICCV 10, the pupal weight was lower in the crop sown in October, but similar to that on ICC 3137 in the January sown crop, which is susceptible. Different genotypes behaved differently across sowing dates, suggesting differential effect of climatic factors on expression of resistance to *H. armigera*.

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BACKGROUND AND OBJECTIVES

Chickpea (*Cicer arietinum* L.) also known as Bengal gram or gram, is the second most important food legume in Asia, North Africa, and Mexico. Recently, it has also become an important grain legume crop in North USA, Canada and Australia. It is grown on 13.5 million hectares worldwide, with an average production of 8.8 million tonnes. India is the largest producer of chickpea in the world sharing 71.0 and 67.2% of the total area (9.6 m ha) and production (8.8 mt), respectively (FAOSTAT, 2013). Several biotic and abiotic constraints limit the production and productivity of chickpea, of insect pests are a major constraint to increase the production and productivity of chickpea (Sharma 2005;Yadav *et al*., 2006 and Sharma *et al.*, 2012). Losses due to insect pest damage are likely to increase as a result of changes in cropping patterns, and global warming. The pod borer, *Helicoverpa armigera* (Hubner), is one of the most important constraints in chickpea production (Sharma, 2005). Its population peaks generally correspond to the fullbloom and pod formation stage of the crop in the post rainy season.Therefore, this study was undertaken to study the expression of resistance to *H. armigera* in different genotypes of chickpea.

RESOURCES AND METHODS

H. armigera culture:

The larvae of *H. armigera* used in the bioassays were maintained in the laboratory at ICRISAT, Patancheru, Telangana State, India. The *H. armigera* larvae were reared on chickpea based artificial diet (Armes *et al*., 1992) at 27 ± 2°C (Table A and Table B). The neonates were reared for 5 days in groups of 200 to 250 in 200 ml plastic cups having a 2 to 3 mm layer of artificial diet on the bottom and sides of the cup. Thereafter, the larvae were transferred individually to six cell-well plates (each cell-well measured 3.5 cm in diameter and 2 cm in depth) to avoid cannibalism. Each cell-well had a sufficient amount of the artificial diet (7 ml) to support larval development until pupation. The pupae were removed from cell-wells, sterilized with 2% sodium hypochlorite solution (with 4% available chlorine), and kept in groups of 50 in plastic jars containing moistened vermiculite. Upon emergence, 10 pairs of adults were released in an oviposition cage (30 x 30 x 30 cm). Adults were provided with 10% sucrose or honey solution (Girijan Co-operative Ltd., Visakhapatnam, India) on a cotton swab for feeding. Liners having a rough surface, were provided as a substrate for egg laying. The liners were removed daily, and the eggs were sterilized in 2% sodium hypochlorite solution. The liners were then dried and placed inside the plastic cups. After 4 days, the liners were removed. Freshly emerged neonate larvae were used for bioassays using detached leaf assay and diet impregnation assay (Sharma *et al*., 2005).

Table A : Artificial diet composition

Ingredients	Quantity
Chickpea flour	75.0 g
L-ascorbic acid	1.175 g
Sorbic acid	0.75 g
Methyl -p- hydroxy benzoate	1.25 g
Aureomycin	2.875 g
Yeast	12.0 g
Formaldehyde (40%)	1.0 ml
Vitamin stock solution	2.5 ml
Water	112.5 ml
Agar-agar solution	
Agar-agar	4.325 g
Water	200 ml

Table B : Composition of vitamin stock solution (500 ml)

Ingredients	Quantity
Nicotinic acid	1.528 g
Calcium pantothenate	1.528 g
Riboflavin	0.764 g
Aneurine hydrochloride	0.382 g
Pyridoxine hydrochloride	0.382 g
Folic acid	0.382 g
D-Biotin	0.305 g
Cyano cobalamine	0.003 g
Water	500 ml

Five chickpea genotypes (Two resistant ICCL 86111 and ICCV 10, Two commercial JG 11 and KAK 2 and one susceptible ICC 3137) were sown across four planting dates between October to January at monthly intervals during 2012 - 13 post rainy seasons under field conditions. The experiment was laid out in Randomized Block Design (RBD) with three replications for each genotype, in a plot of four rows with a spacing of 60 cm between rows and 10 cm between plants with in a row.

Diet incorporation assay :

The survival and development of *H. armigera* was studied on chickpea genotypes under laboratory conditions. The chickpea terminals/branches with tender green leaves were collected from the field at 30 days after seedling emergence and placed in an icebox. The leaves were shade-dried and powdered in a mixer grinder and incorporated into the artificial diet. To study antibiosis to *H. armigera* in chickpea, 20 g dried powder of chickpea leaves (as a replacement for part of the chickpea flour) was incorporated into the artificial diet for rearing of *H. armigera* (Table C). The artificial diet (7 ml) was poured into each cell - well in a 25 - cell -

Table C: Composition of artificial diet for rearing *H. armigera* larvae having lyophilized leaf powder

Ingredients	Quantity
Chickpea flour	55 g
Chickpea leaf powder	20 g
L-ascorbic acid	1.175 g
Sorbic acid	0.75 g
Methyl p hydroxy benzoate	1.25 g
Aureomycin	2.875 g
Yeast	12 g
Formaldehyde (40%)	1.0 ml
Vitamin stock solution	2.5 ml
Water	112.5 ml
Agar-agar solution	
Agar-agar	4.325 g
Water	200 ml

well plate. The neonate larvae were released individually into the cell - wells and kept at 27 ±2°C. There were three replications for each genotype with 25 larvae in each replication in a CRD.

Data were recorded on larval weight, larval survival, larval and pupal period, pupation, adult emergence, adult longevity and fecundity. Data on larval weights were recorded on 10th day after initiating the experiment. For recording larval weights the larvae were removed from the cell wells, cleaned, weighed and then placed back in the respective cell wells. The pupal weights were recorded one day after pupation. Pupae from each replication were placed in a 1 L plastic jar containing moist vermiculite. Percentage of larval survival on 10th day, and pupation and adult emergence were computed in relation to number of neonate larvae released in each replication. Data were also recorded on larval and pupal periods. The adults were collected from the jars and three pairs of adults that emerged on the same day on a particular genotype were placed inside a plastic cage and the numbers of eggs laid were counted. There were three replications for each genotype, and the experiment was laid out in a (CRD).

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Larval weight :

There were significant differences in the larval weight across sowings in 2012 - 13, and the highest (178.0 mg larva^{-1}) was recorded in the crop sown in November and the lowest in the January sown crop (118.0 mg larva^{-1}). On the contrary, in 2013 – 14, the highest larval weight was recorded in January sown crop (243.8 mg larva^{-1}) and the lowest in October sown crop (190.4 mg larva^{-1}). There were no significant differences in larval weight across the sowings across seasons.

Among the genotypes tested, highest (161.8 mg larva^{-1}) larval weight was recorded on ICC 3137 in 2012 – 13, and the lowest in ICCV 10 (128.4 mg larva^{-1}). In 2013 -14 and across the seasons there were no significant differences

Table 1 : Expression of resistance to *H. armigera* in different genotypes of chickpea across four plantings using diet incorporation assay: (2012/13 and 2013/14 post rainy season, ICRISAT, Patancheru, Telangana, India)

Genotype	Mean larval weight (mg) (2012 - 2013)					Mean larval weight (mg) (2013 - 2014)					Mean larval weight (mg) (pooled)				
	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean
ICC 3137	178.7	201.8	138.9	127.6	161.8^{c}	181.0	186.0	237.7	271.8	219.1^{b}	179.9	193.9	188.3	199.7	190.4
ICCL 86111	132.7	216.5	110.9	114.0	143.5^{b}	158.8	203.4	217.2	229.0	202.1^{a}	145.7	210.0	164.1	171.5	172.8
ICCV 10	125.6	164.0	118.1	105.9	128.4^{a}	221.4	202.2	197.7	240.4	215.4^{ab}	173.5	183.1	157.9	173.1	171.9
JG 11	201.9	170.3	122.9	133.1	157.0^{c}	211.4	204.0	237.4	209.1	215.5^{ab}	206.6	187.2	180.2	171.1	186.3
KAK 2	149.3	137.4	118.2	109.7	128.6^{a}	179.0	203.5	202.0	268.8	213.3^{ab}	164.2	170.4	160.1	189.3	171.0
Mean	157.6^{b}	178.0^{c}	121.8^{a}	118.0^{a}	143.9	190.4^{a}	199.8^{a}	218.4^{b}	243.8^{c}	213.1	174.0	188.9	170.1	180.9	178.5
	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)	Fp	Vr	S.E.±	LSD (P=0.05)	CV (%)	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)
Genotype G)	<0.001	16.8	3.8	10.9		0.211	1.5	5.2	NS		0.521	0.8	10.2	NS	
Sowing (S)	<0.001	72.6	3.4	9.7	9.1	<0.001	25.4	4.7	13.4	8.5	0.481	0.8	9.1	NS	27.9
G x S	<0.001	7.5	7.6	21.7		<0.001	4.9	10.5	29.9		0.851	0.6	20.3	NS	

Figures followed by the same letter within a column or row are not significantly different at P ≤ 0.05 NS= Non-significant

between the genotypes tested and larval weight.

The interaction effects were significant in 2012 - 13 and the highest larval weight was recorded on ICC 3137 (201.8 mg larva^{-1}) in the crop sown in November and the lowest on ICCV 10 (105.9 mg larva^{-1}) in the crop sown in January. In 2013 - 14, the highest larval weight was recorded on ICC 3137 (271.8 mg larva^{-1}) in the crop sown in January, and the lowest (158.8 mg larva^{-1}) on ICCL 86111 crop sown in October (Table 1).

Larval survival :

The larval survival was significantly higher in the crop sown in January (82.4%), as compared to the crop sown in November (72.0%), in 2013-14. There were no significant differences in the larval survival in 2012 - 13 and across seasons. There were no significant differences across the genotypes in both the seasons as well as across the seasons on larval survival (Table 2).

Larval period :

There were significant differences in the larval period of *H. armigera* across seasons. The larval period was longer on the crop sown in October (21.5 days in 2012-13, 19.5 days in 2013 - 14, and 20.5 days across

Table 2: Expression of resistance to *H. armigera* in different genotypes of chickpea across four plantings: Larval survival (diet incorporation assay) (2012/13 and 2013/14 post rainy season, ICRISAT, Patancheru, Telangana, India)

Genotype	Larval survival (%) (2012 - 2013)					Larval survival (%) (2013 - 2014)					Larval survival (%) (pooled)				
	30^{th} Oct.	30^{th} Nov.	30^{th} Dec.	30^{th} Jan.	Mean	30^{th} Oct.	30^{th} Nov.	30^{th} Dec.	30^{th} Jan.	Mean	30^{th} Oct.	30^{th} Nov.	30^{th} Dec.	30^{th} Jan.	Mean
ICC 3137	68.3	83.3	73.3	70.0	73.8	82.7	66.7	72.0	86.7	77.0	75.5	75.0	72.7	78.3	75.4
ICCL 86111	76.7	70.0	75.0	73.3	73.8	84.0	65.3	77.3	81.3	77.0	80.3	67.7	76.2	77.3	75.4
ICCV 10	68.3	80.0	80.0	63.3	72.9	88.0	69.3	68.0	72.0	74.3	78.2	74.7	74.0	67.7	73.6
JG 11	70.0	71.7	65.0	73.3	70.0	82.7	72.0	72.0	88.0	78.7	76.3	71.8	68.5	80.7	74.3
KAK 2	68.3	71.7	70.0	73.3	70.8	57.3	86.7	82.7	84.0	77.7	62.8	79.2	76.3	78.7	74.3
Mean	70.3	75.3	72.7	70.7	72.3	78.9^{b}	72.0^{a}	74.4^{a}	82.4^{b}	76.9	74.6	73.7	73.5	76.5	74.6
	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)
Genotype(G)	0.416	1.0	1.7	NS		0.316	1.2	1.5	NS		0.932	0.2	1.7	NS	
Sowing (S)	0.102	2.2	1.5	NS	8.3	<0.001	12.8	1.3	3.7	6.5	0.464	0.9	1.5	NS	11.0
G x S	0.019	2.4	3.5	9.9		<0.001	11.4	2.9	8.3		0.001	3.0	3.3	9.4	

Figures followed by the same letter within a column or row are not significantly different at P ≤ 0.05 NS= Non-significant

Table 3 : Variation in larval period of *H. armigera* on different genotypes of chickpea across four plantings (diet incorporation assay) (2012/13 and 2013/14 post rainy season, ICRISAT, Patancheru, Telangana, India)

Genotype	Larval period (days) (2012 - 2013)					Larval period (days) (2013 - 2014)					Larval period (days) (pooled)				
	30^{th} Oct.	30^{th} Nov.	30^{th} Dec.	30^{th} Jan.	Mean	30^{th} Oct.	30^{th} Nov.	30^{th} Dec.	30^{th} Jan.	Mean	30^{th} Oct.	30^{th} Nov.	30^{th} Dec.	30^{th} Jan.	Mean
ICC 3137	21.3	20.0	20.0	17.3	19.7	19.3	18.7	17.0	15.3	17.6^{a}	20.3	19.3	18.5	16.3	18.6
ICCL 86111	22.7	20.0	21.3	17.0	20.3	20.7	18.0	17.7	16.3	18.2^{bc}	21.7	19.0	19.5	16.7	19.2
ICCV 10	21.0	19.7	20.3	16.7	19.4	19.0	18.3	18.0	16.0	17.8^{ab}	20.0	19.0	19.2	16.3	18.6
JG 11	21.0	21.0	19.3	16.3	19.4	19.0	21.0	17.0	16.3	18.3^{c}	20.0	21.0	18.2	16.3	18.9
KAK 2	21.3	20.3	20.3	17.7	19.9	19.3	19.3	17.0	15.7	17.8^{ab}	20.3	19.8	18.7	16.7	18.9
Mean	21.5^{c}	20.2^{b}	20.3^{b}	17.0^{a}	19.7	19.5^{d}	19.1^{c}	17.3^{b}	15.9^{a}	18.0	20.5^{d}	19.6^{c}	18.8^{b}	16.5^{a}	18.8
	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)
Genotype(G)	0.110	2.0	0.3	NS		0.005	4.5	0.1	0.4		0.500	0.8	0.3	NS	
Sowing (S)	<0.001	73.4	0.2	0.6	4.4	<0.001	168.2	0.1	0.4	2.7	<0.001	54.4	0.2	0.7	6.8
G X S	0.221	1.4	0.5	NS		<0.001	8.2	0.3	0.8		0.122	1.5	0.5	NS	

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the seasons), as compared to that on the January sown crop(17 days in 2012-13, 15.9 days in 2013-14, 16.5 days across seasons). There were no significant differences in the larval period in 2012 - 13, and across the seasons. In 2013-14, the larval period was longer on JG 11 (18.3 days) than on ICC 3137 (17.6 days) (Table 3).

Pupal weight:

Sowing dates exhibited significant influence on pupal weight in both the seasons. Pupal weight was lowest on the January sown crop (289.5 mg $pupa^{-1}$) and the highest on the October sown crop (333.6 mg $pupa^{-1}$) in 2012-13. In 2013-14, the pupal weight was highest on the November sown crop (377.7 mg $pupa^{-1}$) and lowest on

Table 4: Variation in weights of *H. armigera* pupae on different genotypes of chickpea across four plantings (diet incorporation assay) (2012/13 and 2013/14 post rainy season, ICRISAT, Patancheru, Telangana, India)

Genotype	Mean pupal weight (mg) (2012 - 2013)					Mean pupal weight (mg) (2013 - 2014)					Mean pupal weight (mg) (pooled)				
	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean
ICC 3137	328.3	288.6	324.3	316.1	314.3^{bc}	383.7	374.6	347.8	349.7	363.9^{bc}	356.0	331.6	336.1	332.9	339.1^{b}
ICCL 86111	337.8	309.5	294.3	265.4	301.8^{ab}	387.4	374.5	351.8	366.7	370.1^{c}	362.6	342.0	323.0	316.1	335.9^{ab}
ICCV 10	318.8	295.6	277.3	271.6	290.8^{a}	316.7	373.6	301.8	372.1	341.0^{a}	317.7	334.6	289.6	321.9	315.9^{a}
JG 11	342.8	316.0	315.6	306.1	320.1^{c}	359.6	396.8	345.9	378.4	370.2^{c}	351.2	356.4	330.7	342.3	345.2^{b}
KAK 2	340.3	297.4	288.7	288.3	303.7^{ab}	340.0	369.2	348.8	383.9	360.5^{b}	340.2	333.3	318.8	336.1	332.1^{ab}
Mean	333.6^{b}	301.4^{a}	300.0^{a}	289.5^{a}	306.1	357.5^{b}	377.7^{d}	339.2^{a}	370.2^{c}	361.1	345.5^{b}	339.6^{b}	319.6^{a}	329.8^{ab}	333.6
	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)
Genotype (G)	0.002	5.3	5.0	14.2		<0.001	25.7	2.4	6.8		0.1	2.1	7.6	21.2	
Sowing (S)	<0.001	18.4	4.5	12.7	5.6	<0.001	63.5	2.1	6.1	2.3	0.0	2.8	6.8	18.9	11.1
G X S	0.074	1.9	9.9	28.5		<0.001	15.6	4.7	13.5		0.9	0.5	15.1	42.4	

Figures followed by the same letter within a column or row are not significantly different at P ≤ 0.05

Table 5: Variation in pupation of *H. armigera* larvae reared on artificial diets with leaf powder of different chickpea genotypes across four plantings (2012/13 and 2013/14 post rainy season, ICRISAT, Patancheru, Telangana, India)

Genotype	Pupation (%) (2012 - 2013)					Pupation (%) (2013 - 2014)					Pupation (%)(Pooled)				
	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean
ICC 3137	56.7	60.0	56.7	60.0	58.3	60.0	54.7	53.3	69.3	59.3^{c}	58.3	57.3	55.0	64.7	58.8
ICCL 86111	50.0	56.7	56.7	58.3	55.4	52.0	52.0	54.7	66.7	56.3^{a}	51.0	54.3	55.7	62.5	55.9
ICCV 10	48.3	66.7	56.7	60.0	57.9	53.3	53.3	56.0	62.7	56.3^{a}	50.8	60.0	56.3	61.3	57.1
JG 11	48.3	60.0	56.7	58.3	55.8	57.3	52.0	62.7	65.3	59.3^{a}	52.8	56.0	59.7	61.8	57.6
KAK 2	50.0	63.3	58.3	58.3	57.5	54.7	56.0	61.3	66.7	59.7^{c}	52.3	59.7	59.8	62.5	58.6
Mean	50.7^{a}	61.3^{b}	57.0^{b}	59.0^{b}	57.0	55.5^{ab}	53.6^{a}	57.6^{b}	66.1^{c}	58.2	53.1^{a}	57.5^{b}	57.3^{b}	62.6^{c}	57.6
	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)
Genotype (G)	0.687	0.6	1.7	NS		0.027	3.1	1.0	2.8		0.363	1.1	1.1	NS	
Sowing (S)	<0.001	8.9	1.5	4.4	10.5	<0.001	40.5	0.9	2.5	5.8	<0.001	14.6	1.0	2.9	9.7
G X S	0.835	0.6	3.4	NS		0.034	2.2	1.9	5.6		0.410	1.1	2.3	NS	

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the December sown crop (339.2 mg pupa^{-1}). Across seasons, the highest pupal weight was recorded on the October sown crop (345.5 mg pupa^{-1}) and the lowest on the December sown crop (319.6 mg pupa^{-1}).

There were significant differences in pupal weight among chickpea genotypes in both the seasons. The highest pupal weight was recorded on JG 11 (320.1, 370.2 and 345.2 mg pupa^{-1} in 2012-13, 2013-14 and across the seasons, respectively) and the lowest on ICCV 10 (290.8, 341.0, 315.9 mg pupa^{-1} in 2012-13, 2013-14 and across the seasons, respectively).The interaction effects were significant in 2013-14, and the highest larval weight was recorded in JG 11(396.8 mg pupa^{-1}) and the lowest (301.8 mg pupa^{-1}) was recorded on ICCV 10 in December sown crop (Table 4).

Pupation :

There were significant differences in pupation across different sowings, in both the seasons. The highest pupation was observed on the crop sown in November in 2012-13 (61.3%) and in January sown crop (66.1%) in 2013-14, and across the seasons (62.6%). The lowest pupation was observed in the October sown crop in 2012-13 (50.7%) and across the seasons (53.1%), and in the November sown crop (53.6%) in 2013-14. There were no significant differences in pupation across the genotypes and the interaction effects were non-significant (Table 5).

Pupal period :

The pupal period was longest in insects fed on the crop sown in November (14.5 days) in 2013 -14. Pupal period was longer on JG11 and KAK 2 (14.7 days) than on ICCL 86111 (12.9 days). Across seasons, longest pupal period was recorded on JG 11 (14.1 days) and the shortest on ICCL 86111 (12.5 days).

Across seasons significantly, the longest pupal period was recorded on KAK 2 (15 days) in the crop sown in December and the shortest on ICCV 10 (11.5 days) in the crop sown in December (Table 6).

Adult emergence :

There were significant differences in the adult emergence across sowings, in both the seasons. In 2012 - 13, the highest adult emergence was recorded in the November sown crop (53.0%) and the lowest in the December sown crop (48.7%). On the contrary, in 2013 - 14, the lowest adult emergence was recorded in the November sown crop (47.7%) and the highest in the January sown crop (58.4%). Across sowings, the highest adult emergence was recorded in the crop sown in January (54.7 %).

Among the genotypes tested, the highest adult emergence was recorded on ICC 3137 (54.7%) and the lowest on ICCL 86111 (49.8%) in 2013 – 14. In 2012-13, and across seasons, there were no significant differences across the genotypes and the interaction effects were also non significant (Table 7).

Table 6 : Variation in pupal period of *H. armigera* reared on artificial diets with leaf powder of different chickpea genotypes across four plantings (2012/13 and 2013/14 post rainy season, ICRISAT, Patancheru, Telangana, India)

Genotype	Pupal period (days) (2012 - 2013)					Pupal period (days) (2013 - 2014)					Pupal Period (days) (pooled)				
	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean
ICC 3137	12.3	12.0	13.0	12.7	12.5^{a}	12.3	13.3	13.0	13.3	13.0^{ab}	12.3	12.7	13.0	13.0	12.8^{a}
ICCL 86111	12.3	11.3	11.3	13.7	12.2^{a}	12.3	14.0	12.0	13.3	12.9^{a}	12.3	12.7	11.7	13.5	12.5^{a}
ICCV 10	13.7	12.7	11.7	13.3	12.8^{ab}	13.7	15.0	11.3	14.0	13.5^{b}	13.7	13.8	11.5	13.7	13.2^{a}
JG 11	14.3	13.0	13.3	13.7	13.6^{b}	14.3	14.3	16.0	14.0	14.7^{c}	14.3	13.7	14.7	13.8	14.1^{b}
KAK 2	13.7	13.3	13.7	12.7	13.3^{b}	13.7	15.7	16.3	13.0	14.7^{c}	13.7	14.5	15.0	12.8	14.0^{b}
Mean	13.3^{b}	12.5^{a}	12.6^{ab}	13.2^{b}	12.9	13.3^{a}	14.5^{b}	13.7^{a}	13.5^{a}	13.8	13.3	13.5	13.2	13.4	13.3
	Fp	Vr	S.E. ±	LSD (P= 0.05)	CV (%)	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)
Genotype (G)	0.004	4.7	0.3	0.8		<0.001	21.5	0.2	0.5		<.001	11.5	0.2	0.6	
Sowing (S)	0.048	2.9	0.2	0.7	7.2	<0.001	9.5	0.2	0.5	4.7	0.707	0.5	0.2	NS	7.8
G X S	0.121	1.6	0.5	1.5		<0.001	9.8	0.4	1.1		<.001	4.1	0.4	1.2	

Figures followed by the same letter within a column or row are not significantly different at P $\leq$ 0.05 NS= Non-significant

Fecundity :

There were no significant differences in fecundity across the sowings. The genotypes tested exhibited significant influence on fecundity in 2013 -14, and across the seasons. The highest fecundity was recorded in insects reared on ICC 3137 (328.2 eggs/female) and the lowest on ICCL 86111 (271.6 eggs/female) in 2013 -14. Across the seasons, the highest fecundity was recorded on ICC 3137 (322.9 eggs/female). The interaction effects were not significant (Table 8).

The larval weight was more in insects reared on the crop sown in November than in insects reared on the crop sown in December. Pupal weight was greater on the crop sown in October than on the crop sown in December. Pupation, adult emergence and fecundity were high, whereas larval period was shorter on the crop sown in January suggesting that increase in temperatures, during plant growth in the late sown crops favoured the growth and development of the *H. armigera*. There were no significant differences in the larval survival and the pupal period across the sowing dates. There were no significant differences in the larval weight, larval survival, larval period, adult emergence and pupation on different chickpea

Table 7: Variation in adult emergence of *H. armigera* reared on artificial diets with leaf powder of different chickpea genotypes across four plantings. (2012/13 and 2013/14 post rainy season, ICRISAT, Patancheru, Telangana, India)

Genotype	Adult emergence (%) (2012 - 2013)					Adult emergence (%) (2013 - 2014)					Adult emergence (%) (pooled)				
	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean
ICC 3137	48.3	55.0	48.3	51.7	50.8	57.3	52.0	49.3	60.0	54.7^{c}	52.8	53.5	48.8	55.8	52.8
ICCL 86111	41.7	48.3	53.3	51.7	48.8	51.3	42.7	48.0	57.3	49.8^{a}	46.5	45.5	50.7	54.5	49.3
ICCV 10	43.3	51.7	45.0	51.7	47.9	52.0	46.7	49.3	57.3	51.3^{ab}	47.7	49.2	47.2	54.5	49.6
JG 11	38.3	55.0	48.3	50.0	47.9	53.3	46.7	54.7	58.7	53.3^{bc}	45.8	50.8	51.5	54.3	50.6
KAK 2	43.3	55.0	48.3	50.0	49.2	50.7	50.7	53.3	58.7	53.3^{bc}	47.0	52.8	50.8	54.3	51.3
Mean	43.0^{a}	53.0^{c}	48.7^{b}	51.0^{bc}	48.9	52.9^{c}	47.7^{a}	50.9^{b}	58.4^{d}	52.5	48.0^{a}	50.4^{a}	49.8^{a}	54.7^{b}	50.7
	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)
Genotype (G)	0.622	0.7	1.5	4.2		<0.001	6.9	0.7	2.1		0.193	1.6	1.1	3.1	
Sowing (S)	<0.001	10.7	1.3	3.8	10.4	<0.001	47.4	0.7	1.9	4.8	<0.001	8.3	1.0	2.8	10.7
G X S	0.474	1.0	3.0	8.4		0.017	2.5	1.5	4.2		0.500	1.0	2.2	6.2	

Figures followed by the same letter within a column or row are not significantly different at P ≤ 0.05

Table 8: Variation in fecundity of *H. armigera* reared on artificial diets with leaf powder of different chickpea genotypes across four plantings. (2012/13 and 2013/14 post rainy season, ICRISAT, Patancheru, Telangana, India)

Genotype	Fecundity (egg laying/ female) (2012 - 2013)					Fecundity (egg laying/ female) (2013 - 2014)					Fecundity (egg laying/ female) (pooled)				
	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean	30th Oct.	30th Nov.	30th Dec.	30th Jan.	Mean
ICC 3137	279.3	313.3	321.0	356.7	317.6^{b}	338.7	330.3	301.0	342.7	328.2^{c}	309.0	321.8	311.0	349.7	322.9^{b}
ICCL 86111	259.0	246.7	282.0	286.0	268.4^{a}	281.3	281.3	257.3	266.3	271.6^{b}	270.2	264.0	269.7	276.2	270.0^{a}
ICCV 10	269.7	309.0	257.0	271.3	276.8^{a}	274.3	183.7	267.7	242.3	242.0^{a}	272.0	246.3	262.3	256.8	259.4^{a}
JG 11	268.3	231.0	301.0	310.7	277.8^{a}	295.0	279.3	275.0	262.7	278.0^{b}	281.7	255.2	288.0	286.7	277.9^{a}
KAK 2	253.0	192.7	277.7	335.7	264.8^{a}	271.0	288.0	297.7	306.3	290.8^{b}	262.0	240.3	287.7	321.0	277.8^{a}
Mean	265.9^{a}	258.5^{a}	287.7^{ab}	312.1^{b}	281.1	292.1	272.5	279.7	284.1	282.1	279.0^{ab}	265.5^{a}	283.7^{ab}	298.1^{b}	281.6
	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)	Fp	Vr	S.E.±	LSD (P= 0.05)	CV (%)
Genotype(G)	0.014	3.6	11.1	31.9		<0.001	11.3	9.3	26.7		<0.001	8.6	8.3	23.2	
Sowing (S)	0.002	5.9	10.0	28.5	13.7	0.421	1.0	8.3	23.9	11.4	0.024	3.3	7.4	20.8	14.4
G X S	0.067	1.9	22.3	63.8		0.123	1.6	18.6	53.3		0.509	0.9	16.5	46.4	

Figures followed by the same letter within a column or row are not significantly different at P ≤ 0.05

genotypes, however, the pupal weight and fecundity was higher, and larval period was shorter on ICC 3137 contributing its susceptibility to *H. armigera*. Different genotypes behaved differently across sowing dates indicating differential effect of climate on expression of resistance to *H. armigera*. On ICCV 10 the pupal weight was lower in the crop sown in October but similar to that on ICC 3137 in the January sown crop which is susceptible. Narayanamma *et al*. (2008) reported that larval weights were significantly lower in larvae reared on leaves/pods of ICC 12475, ICC 12476, ICC 12477 and ICCV2 as compared to those reared on the susceptible check, ICCC 37. Pupal weights were lower in insects reared on ICC 12476, ICC 12478, ICCV 2 and ICC 506EB as compared to the insects reared on ICCC 37. There were considerable differences in numbers of *H. armigera* larvae on different genotypes under field conditions (Lateef, 1985 and Lateef and Sachan, 1990). Antibiosis to *H. armigera* in chickpea is expressed in terms of larval mortality, decreased larval and pupal weights, prolonged larval and pupal development, failure to pupate and reduced fecundity and egg viability (Yoshida *et al*., 1995 and Cowgill and Lateef, 1996). Growth inhibitor and/or antifeedant substances in chickpea leaves/pods might contribute to antibiosis to *H. armigera* in chickpea (Yoshida and Shanower, 2000). Temperature has a direct influence on the phenology, life cycle, growth and developmental rates as well as on the distribution of insects among plants, and geographic locations (Bale *et al*., 2002). Increase in temperatures resulted in a decrease in female fecundity, and pupal weight (Buse *et al*., 2006), shorter developmental times (Johns and Hughes, 2002., Williams *et al*., 2003; Johns *et al*., 2003; Chong *et al*., 2004) and increased survival (Chong *et al*., 2004) of insects reared on plants at elevated temperature. Studies on the effect of the environmental factors on plant - herbivore associations is mediated by secondary metabolites.

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