Tolerance to *Helicoverpa armigera* damage in chickpea genotypes under natural infestation

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Abstract

Host plant resistance is one of the important components for minimizing the damage by the pod borer, Helicoverpa armigera. *To develop cultivars with stable resistance to insect pests, there is a need to identify genotypes with different mechanisms of resistance for gene pyramiding. Therefore, we studied the tolerance component of resistance to* H. armigera *damage in a diverse array of chickpea genotypes under natural infestation in the field. The chickpea genotypes ICC 506 EB, ICCC 37, ICC 12478, and ICC 12479 recorded high grain yield under unprotected conditions, of which ICC 506 EB and ICC 12478 showed lower reduction in grain yield under un-protected conditions as compared to ICC 3137, ICC 4918, and ICCC 37. Significant and negative correlations were observed between yield plant^{-1} and pod borer damage under unprotected conditions. The genotypes ICC 12478, ICC 12479 and ICC 506 EB, showing tolerance to* H. armigera *damage can be used for chickpea improvement.*

Keywords: *Helicoverpa armigera*, tolerance, chickpea, recovery resistance

Introduction

Chickpea, *Cicer arietinum* (L.) is the third most important grain legume in the world, after dry beans and peas. It is cultivated in over 42 countries in South Asia, East Africa, North and Central America, Mediterranean Europe, Australia, and North America. Globally, chickpea is grown in 10.2 million ha with an average production of 7.9 million tons, and an average productivity of 770 kg ha^{-1} (FAO, 2005). Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops of India (Bhatt and Patel, 2001). India has more than 80% of the world's chickpea area (10.6 million ha), and ranks fifth in area and fourth in production among the food grains (Chabhra *et al.*, 1990). It is a source of high quality protein for the people in many developing countries, including India. Its average yield is 773 kg per ha, which is far lower than its potential (up to 4 t ha^{-1}) yield (Ali and Kumar, 2001). There has been no significant increase in chickpea yield as compared to the cereal crops, because of several biotic and abiotic constraints. Among the biotic factors responsible for low yield, damage due to insect pests is the major limiting factor (Sharma, 2005; Bhagwat *et al.*, 1995). Chickpea is attacked by nearly 57 species of insect pests in India (Lal, 1992). Amongst them, pod borer, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is most important, and accounts for about 90 to 95% of the total damage caused by all the insect pests (Sachan and Katti, 1994).

Insecticide application for pod borer control is uneconomical under subsistence farming, and is beyond the means of resource poor farmers in the semi-arid tropics. Host plant resistance (HPR) can play a major role in controlling *H. armigera* damage in combination with other methods of pest control. Several chickpea genotypes with less susceptibility to *H. armigera* or the genotypes that have the capability to recover from pod borer damage have been identified in the past (Dua *et al.*, 2005; Sharma *et al.*, 2005).

In view of limited success in developing crop cultivars with resistance to this pest, there is a need to identify genotypes with different mechanisms of resistance. Resistance genes from diverse sources need to be combined (gene pyramiding) to increase the levels and diversify the bases of resistance to this pest. Chickpea plants damaged during the vegetative, flowering, and early podding stage have a remarkable capacity to recover from *H. armigera* damage by producing more vegetative growth and through a second flush of flowers and pods, a situation quite prevalent in South Central India. However, there is limited scope for compensation for loss in pods damaged by *H. armigera* in situations of limited moisture availability. The present studies were therefore

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carried out to assess the ability of chickpea genotypes to recover from *H. armigera* damage and their ability to produce grain under unprotected conditions.

Materials and methods

To study the tolerance component of resistance in chickpea to pod borer, *H. armigera,* we evaluated a diverse array of nine chickpea genotypes nine chickpea genotypes (8 *Desi* and one *Kabuli* type), which were selected based on earlier evaluation of these genotypes under field conditions (Lateef, 1985; Sharma *et al.*, 2005). The test genotypes included ICC 506EB (resistant), ICC 12476, ICC 12477, ICC 12478, and ICC 12479 (moderately resistant), ICCC 37 (ICC 12426), ICC 3137, ICCV 2 (ICC 12968), and ICC 4918 (susceptible) (Table 1). Tolerance to *H. armigera* damage was measured by comparing leaf/pod damage and grain yield under insecticide protected and unprotected conditions. There were three replications in a randomized complete block design, with plot size of four rows of 2 m long (4 ´ 2 m), planted at 60 ´ 10 cm row-to-row and plant-to-plant spacing. The crop was raised under irrigated conditions during the post-rainy season (November - March). The protected plots were sprayed at 25, 43, 55, 61, 68, and 89 days after seedling emergence with Acephate (@ 500 g a.i. ha^{-1}), when there were more than one egg/larva per meter row. Data were also recorded for days to 50 % flowering, days to maturity, pod damage, 100 seed weight, pods per plant, and grain yield per plant. Grain yield was recorded after harvest. Loss in grain yield due to *H. armigera* damage was calculated by using the following formula.

$$\text{Loss in grain yield (\%)} = \frac{[\text{Yield in protected plot} - \text{Yield in unprotected plot}]}{\text{Yield in protected plot}} \times 100$$

The data were subjected to analysis of variance. The significance of difference between the genotypes was judged by F-test, while the treatment means were compared using least significant difference (LSD) at $P < 0.05$. Correlations were computed between grain yield and pod borer damage.

Results and discussion

The test material took longer time to flowering under unprotected conditions (57 days) as compared to that under protected conditions (54 days) because of *H. armigera* damage during the vegetative phase (Table 2). The plants needed some time to recover from damage by *H. armigera* during the vegetative phase. Similarly, the test genotypes took 4 days longer for maturity under unprotected conditions than under protected conditions. The numbers of pods $plant^{-1}$ were lower under unprotected conditions (81 pods $plant^{-1}$) as compared to that under protected conditions (107 pods $plant^{-1}$). However, the reduction in number of pods was less in case of ICC 506 EB, ICC 12477, and ICC 12478 as compared that in ICC 3137, ICC 12476, ICCV 2, and ICCC 37 (Table 2). The 100-seed weight was more under unprotected conditions (18.44 g) as compared to that under protected conditions (17.2 g) probably because of reduced

Table 1. Characteristics of chickpea genotypes evaluated for tolerance to pod borer, *H. armigera* under natural infestation (ICRISAT, Patancheru, post-rainy season, 2003-05)

Genotype	Pedigree	Days to 50 % F	Days to maturity	Seeds pod^{-1}	100 seed wt. (g)
Desi					
ICC 3137	P-3659-2	64.3	119.2	1.10	25.3
ICC 4918	ICC 4918	50.9	107.0	1.19	19.9
ICC 12426	ICC 12426 (P 481 X (JG X P-1630) (ICCL 80074)	54.6	102.0	1.36	19.2
ICC 12475	BEG 78	55.4	104.4	1.21	16.1
ICC 12476	ICC 6663 HR (NEC-764)	67.1	114.7	1.19	15.8
ICC 12477	ICC 10460 HR (RPSP-194)	54.2	110.4	1.17	12.9
ICC 12478	ICC 10667 HR (62-10-3)	58.1	114.9	1.09	15.0
ICC 12479	ICC 10619 HR (G 130)	59.5	109.4	1.11	14.8
Kabuli					
ICC 12968	ICCL-82001 (OCCX-752770-13P-2P-BP-BP-BP) (K-850 X GW-5/7) X P-458) X L-550 X Guamuchil	34.1	94.0	1.10	23.95

F = Flowering (Source : ICRISAT, Chickpea breeding) sink size under protected conditions (Table 3). Seed size of ICC 3137, ICCV 2, ICC 4918 and ICCC 37 (18.17 to 23.86 g per 100 grains) was better as compared to that of ICC 12476, ICC 12477, ICC 12478, ICC 12479 and ICC 506 EB (12.06 to 15.38 g) under protected conditions. Reduction in grain yield per plant was less than five grams in case of ICC 12476, ICC 12477, ICC 12478, ICC 12479, ICCV 2, and ICC 506 EB as compared to 7.42 g in ICC 3137. The resistant check, ICC 506 EB recorded higher grain yield (19.79 g plant^{-1}) under unprotected conditions as compared to protected conditions (17.88 g plant^{-1}).

Pod borer damage was greater under unprotected conditions (5.52% in ICC 506 EB to 40.33% in ICC 3137) as compared to that under protected conditions (0.39% in ICC 506 EB to 7.72% in ICC 3137) (Table 4). The resistant check, ICC 506 EB recorded the lowest pod borer damage both under protected and unprotected conditions. The genotypes, ICCC 37, ICC 4918 and ICC 3137 suffered more pod damage (19.24 to 40.33%) than in ICC 506 EB, ICC 12476, ICC 12478, ICC 12479 (5.52 to 12.18%) under unprotected conditions. The susceptible cultivar, ICC 3137 suffered 40.33 % pod damage under unprotected conditions, and had green pods for a longer period of time. The length of poding period is one of the factors influencing genotypic susceptibility to *H. armigera*. Genotypes with shorter poding period have low pod damage as this shortens the effective period for which the pods are susceptible to damage by *H. armigera* larvae (Sharma *et al.*, 2005).

Table 2. Agronomic performance of chickpea genotypes under protected and unprotected conditions (ICRISAT, Patancheru, 2003-05 post rainy season)

Genotype	Days to 50% flowering		Days to maturity		Pods plant^{-1}	
	P	UP	P	UP	P	UP
ICC 3137	68	71	118	125	105	57
ICC 12476	64	67	109	114	112	76
ICC 12477	58	58	105	109	126	125
ICC 12478	53	56	105	109	104	95
ICC 12479	63	65	107	112	106	78
ICCV 2	33	33	96	97	98	68
ICC 4918	48	52	106	110	102	70
Control						
ICC 506 EB (R)	50	55	107	109	92	86
ICCC 37 (S)	53	57	106	109	121	75
Mean	54	57	106	110	107	81
Fp	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.001
SE ±	54.2	46.3	35.6	42.1	10.5	10.3
LSD (at 5%)	4.8	4.3	4.3	3.6	30.1	20.1

P = Protected; UP = Unprotected; R = Resistant check; S = Susceptible check

Table 3. Grain yield per plant and seed weight of chickpea genotypes under protected and unprotected conditions ((ICRISAT, Patancheru, 2003-05 post rainy season)

Genotype	100-seed weight (g)		Grain yield Plant^{-1} (g)	
	P	UP	P	UP
ICC 3137	23.19	27.19	17.64	10.22
ICC 12476	15.03	14.97	22.38	17.42
ICC 12477	12.06	12.14	21.45	17.89
ICC 12478	13.33	14.91	19.55	18.47
ICC 12479	15.04	15.83	20.36	18.37
ICCV 2	23.86	24.78	15.54	11.05
ICC 4918	18.78	20.69	23.65	17.84
Control				
ICC 506 EB (R)	15.38	16.32	17.88	19.79
ICCC 37 (S)	18.17	19.16	26.96	18.42
Mean	17.2	18.44	20.60	16.61
Fp	< 0.001	< 0.001	0.01	0.015
SE ±	4.6	0.8	44.5	41.02
LSD (at 5%)	8.6	3.8	128	19.2

P = Protected; UP = Unprotected; R = Resistant check; S = Susceptible check

Grain yield of ICC 3137, ICC 12476, ICC 12477, ICC 12479, ICC 4918, and ICCC 37 was quite high under protected conditions (1949 to 2358 kg ha^{-1}) (Table 3). Under unprotected conditions, grain yield of ICC 12477, ICC 12477, ICC 12478, ICC 12479, ICC 506 EB and ICCC 37 was higher (1635 to 1862 kg ha^{-1}) than that of ICC 3137 (989 kg ha^{-1}). Mean loss in grain yield due to *H. armigera* damage across genotypes was 24.84 %. Highest yield reduction in grain yield was recorded in ICC 3137 (51.87 %), followed by ICC 12476 (31.82 %), ICC 4918 (27.17 %), ICCV 2 (26.95 %), and ICCC 37 (26.66 %) (Table 4).

Tolerance provides plants the ability to produce satisfactory yield in the presence of a pest population that would otherwise result in a significant reduction in yield in the susceptible plants. Cultivars with tolerant mechanism of resistance do not exert a selection pressure on the pest population. Cultivars with tolerance mechanism of resistance have a great value in pest management as such cultivars prevent the evolution of new insect biotypes capable of feeding on resistant cultivars. Breakdown of antixenotic or antibiotic mechanisms of resistance can be delayed or minimized by combining them with tolerance component of resistance (Tingey, 1981). Lateef and Sachan (1990) suggested that some of the chickpea lines suffered considerably less borer damage than others due to tolerance to pod borer. This has necessitated the need for selecting genotypes with greater ability to tolerate or recover from the pod borer damage (Lateef, 1985; Srivastava and Srivastava, 1989).

Grain yield and pod borer damage (r = -0.74* and -0.81* under un-protected and protected conditions, respectively), grain yield plant^{-1} and leaf damage (r = -0.76* under un-protected conditions), and grain yield plant^{-1} and pod damage (r = -0.91** under un-protected conditions) were significantly and negatively correlated (Table 5). Significant association has earlier been reported between yield and pod damage by Gowda *et al.* (1983), Singh and Singh (1995),

Table 4. Pod damage and loss in grain yield due to *Helicoverpa armigera* damage in nine chickpea genotypes (ICRISAT, Patancheru, post-rainy season, 2003/04 to 2004/05)

	Pod damage (%)		Yield (Kg/ha)		Loss in grain
Genotype	P	UP	P	UP	yield (%)
ICC 3137	7.72	40.33	1949	989	51.87
ICC 12476	1.48	12.18	2112	1480	31.82
ICC 12477	1.43	13.90	2168	1635	26.52
ICC 12478	0.76	8.43	1772	1691	6.59
ICC 12479	2.30	11.44	2055	1651	22.21
ICCV 2	1.63	15.38	1706	1267	26.95
ICC 4918	1.35	26.65	2157	1634	27.17
Control					
ICC 506 EB (R)	0.39	5.52	1927	1862	3.77
ICCC 37 (S)	1.73	19.24	2358	1780	26.66
Mean	2.09	17.01	2023	1554	24.84
Fp	< 0.001	< 0.001	< 0.001	< 0.001	
SE	1.13	2.09	218.7	227.9	
LSD (at 5%)	1.70	6.15	628.6	654.9	

P = Protected; UP = Unprotected; R = Resistant check; S = Susceptible check

Table 5. Correlations between pod borer damage and yield components in chickpea under Protected and un-protected conditions (ICRISAT, Patancheru, post-rainy season, 2003-05)

Yield and damage parameters	Correlation coefficient	
	Protected	Unprotected
Yield (Kg/ha) and borer damage (%)	-0.81*	-0.74*
Larvae and eggs	0.89**	0.94**
Pod damage and eggs	0.62	0.84*
Leaf damage and larvae	0.75	0.85*
Pod damage and larvae	0.91**	0.89**
Yield/plant and leaf damage	0.42	-0.76*
Yield/plant and pod damage	0.63	-0.91**

* significantly different at p = 0.05; ** significantly different at p = 0.01

and Sreelatha (2003). Significant and positive correlation was recorded between larvae and eggs (0.89** and 0.94** under protected and un-protected conditions respectively), pod damage and larvae (0.91** and 0.89** under protected and un-protected conditions respectively), under protected and un-protected conditions respectively), pod damage and eggs (0.84*) and leaf damage and larvae (0.85*) under un-protected conditions. Significantly positive correlations between number of pods per plant and grain yield have been reported by Bejiga *et al.*, (1991), Chhina *et al.*, (1991), and Abdali (1992). An understanding of the contribution of different components of resistance will be helpful in developing proper strategies for improvement of grain yield in chickpea. Development of chickpea cultivars combining antixenosis, antibiosis, and tolerance mechanisms to *H. armigera* would increase the resistance levels and slowdown the breakdown of chickpea resistance to this pest for sustainable crop production.

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