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Tolerance as Mechanism of Resistance to *Helicoverpa armigera* (Hub.) in Chickpea (*Cicer arietinum* Linn.)

E. SREE LATHA, H.C. SHARMA AND C.L.L. GOWDA

International Crops Research Institute for the Semi-Arid Tropics, Patancheru

ABSTRACT

To study the tolerance component of resistance in chickpea to pod borer, *H. armigera,* field experiment was conducted at ICRISAT, Patancheru. The loss in yield of 18 chickpea genotypes (ICC 12475, ICC 12476, ICC 12477, ICC 12478, ICC 12479, ICC 12490, ICC 14876, ICC 4918, ICC 12426, ICC 3137,ICC12491, ICC 12492, ICC 12493, ICC 12494, ICC 12495, ICC 12968, ICC 4973 and ICC 4962) was studied by comparing the grain yield under protected and unprotected crops. Under protected conditions except ICC 12494 and ICC 3137 all the genotypes were on par with the resistant check ICC 12475 for pod borer damage. Under unprotected conditions ICC 12479 (12.3%) and ICC 12493 (11.6%) were on par with the resistant check, ICC 12475. This study indicated presence of tolerance mechanism in chickpea to *H. armigera* damage. Reduction in grain yield was lowest in ICC 12475 followed by ICC 4918, ICC 12490, ICC 12493 and ICC 12476 indicating tolerance to pod borer damage. CC 12477 and ICC 12968 were highly tolerant as there was an increase in yield under infected conditions.The lines showing high and stable resistance to *H. armigera* can be used in chickpea improvement programs.

Key words *Helicoverpa armigera,* tolerance, mechanism of resistance, chickpea

Tolerance provides plants the ability to produce satisfactory yield in the presence of a pest population that would otherwise result in significant damage in the susceptible plants. Tolerant cultivars do not suppress pest populations, and thus do not exert a selection pressure on the pest population. Effects of tolerance are cumulative as a result of interacting plant growth responses, such as plant vigour, inter and intra plant growth compensation, mechanical strength and organism, and nutrient and growth regulation and partitions. Plants with tolerance mechanism of resistance have a great value in pest management; as such plants prevent the evolution of new insect biotypes capable of feeding on resistant cultivars. The antixenotic or antibiotic mechanisms of resistance can be delayed or minimized by using tolerance as a polygenic resistance (Tingey, 1981).

Singh *et al*., (1985) estimated the grain yield loss due to *H. armigera* using chemical protection method. The mean reduction in the pest population in the protected crop over the unprotected one ranged from 61.1 to 81.1%. Yelshetty*et al*., (1996) compared the percentage pod damage at maturity of each trial with that of the control and converted to pest susceptibility rating (PSR) on a scale of 1 to 9) as suggested by Lateef and Sachan (1990). The lower PSR values indicated the lower level of pod borer attack on genotypes and better tolerance to pod borer.

During the course of evolution, plants acquire several defense mechanisms against insect pests to reduce the damage. The major mechanisms are antixenosis (non-preference), antibiosis, tolerance and escape potential (Painter, 1951). To date more antibiosis, than antixenosis or tolerance has been reported in legume crops (Clement *et al.,* 1994).The study is conducted to understand more of tolerance mechanism of resistance to pod borer in chickpea.

MATERIALS AND METHODS

To study the tolerance component of resistance in chickpea to pod borer, *H. armigera,* field experiment was conducted at ICRISAT, Patancheru. The loss in yield of 18 chickpea genotypes (ICC 12475, ICC 12476, ICC 12477, ICC 12478, ICC 12479, ICC 12490, ICC 14876, ICC 4918, ICC 12426, ICC 3137,ICC12491, ICC 12492, ICC 12493, ICC 12494, ICC 12495, ICC 12968, ICC 4973 and ICC 4962) was studied by comparing the grain yield under protected and unprotected crops. The two treatments with respect to larval population and various components of yield were compared by using split plot analysis (P = 0.05). Trial was conducted with three replications; plot size was four rows of 2 m long (2.4 x 2 m) planted at 30 x 10 cm row-to-row and plant-to-plant spacing.

The egg and larval counts were taken during vegetative stage and continued at weekly intervals until harvest of the crop. Data were recorded for pod damage (%), yield per plant, 100 seed weight, and seeds per pod on ten tagged plants in the middle two rows. Seed yield per plot was recorded after harvest. Avoidable loss due to *H. armigera* damage was calculated (Taneja and Nawanze, 1989).

To provide protection from *H. armigera* damage insecticide application was under taken as and when needed. Egg and larval counts were recorded on 10-tagged plants in the middle two rows 1 day before, and 1 and 3 days after spraying in the protected plots, the following spray schedule was under taken.

Table 1. Spray schedule in protected plots for *H. armigera* tolerance studies

Date of spray	Chemical	Quantity of chemica/plot	Quantity of Water used /plot
21/11/2001	Acephate:Sandovit	100 mg:100ml	40 l
05/12/2001	Acephate: Sandovit	100 mg:100ml	40 l
20/12/2002	Acephate: Sandovit	100 mg:100ml	40 l
31/12/2001	Acephate	150 mg	60 l
16/01/2002	Acephate	150 mg	60 l
06/02/2002	Acephate	150 mg	60 l

Sandovit was used as adjuvant to facilitate uniform application.

Acephate 75 SP was applied @ 0.5 kg (0.37 kg a.i) in 200 l / ha during vegetative stage.

Acephate 75 SP was applied @ 0.75 kg (0.55 kg a.i) in 300 l / ha during flowering and poding stage.

Table 2. Yield components of eighteen chickpea genotypes under protected and unprotected conditions to *H. armigara*, ICRISAT, Patancheru, 2001-2002.

	100 seed weight (g)			Seeds pod^{-1}			Yield plant^{-1} (g)		
Genotype	Protected	Unpro-tected	Mean	Protected	Unpro-tected	Mean	Protected	Unpro-tected	Mean
ICC 12476	11.61^a	12.63^a	12.12	1.354^a	1.343^a	1.349	16.72^a	10.15^b	13.72
ICC 12477	11.78^a	12.21^a	11.99	1.072^a	1.149^a	1.111	13.96^a	12.05^a	13.06
ICC12478	13.74^a	14.57^a	14.15	1.040^a	1.156^a	1.098	16.72^a	12.92^a	14.87
ICC 12479	12.84^a	13.81^a	13.32	1.126^a	1.115^a	1.120	17.04^a	10.11^b	14.03
ICC 12490	10.80^a	12.01^a	11.4	1.459^a	1.511^a	1.485	17.98^a	9.50^b	14.33
ICC 14876	14.35^a	14.64^a	14.50	1.202^a	1.32^b	1.261	18.78^a	10.85^b	14.95
ICC 12426	17.35^a	18.38^a	17.86	1.202^a	1.405^b	1.304	15.76^a	12.25^a	14.32
ICC 3137	20.94^a	26.43^b	23.68	1.078^a	1.099^a	1.088	13.04^a	7.45^b	11.15
ICC 12491	16.32^a	18.8^b	17.56	1.098^a	1.253^b	1.175	15.08^a	9.40^b	12.45
ICC 12492	14.37^a	15.98^a	15.18	1.198^a	1.273^a	1.235	15.97^a	11.13^b	13.61
ICC 12493	12.83^a	14.20^a	13.51	1.189^a	1.228^b	1.208	12.92^a	10.18^a	11.64
ICC 12494	14.30^a	16.72^b	15.51	1.206^a	1.339^b	1.273	13.00^a	10.69^a	12.25
ICC 12495	20.81^a	22.77^b	21.79	1.063^a	1.085^a	1.074	17.82^a	9.62^b	13.99
ICC 12968	15.08^a	20.45^b	17.76	1.031^a	1.118^a	1.074	5.44^a	9.84^a	7.65
ICC 4973	16.78^a	19.17^b	17.98	1.182^a	1.209^a	1.195	20.16^a	13.41^b	17.06
ICC 4962	17.21^a	21.86^b	19.54	1.440^a	1.270^b	1.355	18.06^a	10.10^b	14.36
Checks									
ICC 12475 (R)	15.38^a	15.7^a	15.54	1.128^a	1.135^a	1.131	14.9^a	14.28^a	14.63
ICC 4918 (S)	17.84^a	18.85^a	18.34	1.109^a	1.210^b	1.155	16.73^a	11.74^a	14.48
Mean	15.24	17.18	16.21	1.18	1.23	1.21	15.56	10.87	13.48
	F (5%)	LSD		F (5%)	LSD		F (5%)	LSD	
Treat	0.033	1.5508		0.035	0.0471		0.001	0.777	
Genotype	<.001	1.1112		<.001	0.0672		<.001	2.906	
Treat.Geno	<.001	1.7126		<.001	0.0946		0.001	4.009	
CV%	6.0			4.8			18.7		

R-Resistant check, S-Susceptible check.

Table 3. Loss in yield due to *H armigera* damage in eighteen chickpea genotypes under protected and unprotected conditions, ICRISAT, Patancheru, 2001-02.

	Yield kg ha^{-1}				Pod borer damage (%)						Loss in grain weight (%)		
					Actual			Angular transformed					
Genotype	Actual in protec-ted	Expec-ted in protec-ted	Unpro-tected	Mean	Prote-cted	Unpro-tected	Mean	Prote-cted	Unpro-tected	Mean	Protec-ted	Unpro-tected	Avoid-able loss (%)
ICC 12477	1677^{a}	1691	2162^{a}	1927	0.9^{ab}	15.7^{cd}	8.3	5.1	23.3	16.7	0.828	-27.85	-28.9
ICC 12478	2392^{a}	2405	1742^{b}	2073	0.6^{a}	14.4^{bcd}	7.5	4.4	22.2	15.5	0.541	27.57	27.1
ICC 12479	2189^{a}	2253	1792^{a}	2022	1.1^{ab}	12.3^{abc}	6.7	6.1	20.2	16.1	2.841	20.46	18.1
ICC 12490	2443^{a}	2549	1517^{b}	2033	2.8^{ab}	17.0^{de}	9.9	9.4	24.3	21.6	4.158	40.49	37.9
ICC 14876	2165^{a}	2194	1657^{a}	1926	1.4^{ab}	15.7^{cd}	8.5	6.6	23.3	18.2	1.322	24.48	23.4
ICC 12426	2341^{a}	2429	1681^{b}	2055	3.9^{ab}	21.2^{g}	12.5	11.3	27.3	25.0	3.623	30.79	28.1
ICC 3137	1976^{a}	2257	800^{b}	1528	13.5^{c}	33.7^{j}	23.6	20.2	35.5	38.0	12.45	64.55	59.5
ICC 12491	2123^{a}	2181	1226^{b}	1704	2.7^{ab}	27.1^{i}	14.9	9.1	31.3	24.8	2.659	43.79	42.2
ICC 12492	2623^{a}	2641	2107^{a}	2374	0.7^{a}	15.2^{bcd}	8.0	4.8	22.9	16.2	0.682	20.22	19.6
ICC 12493	1964^{a}	1992	1415^{a}	1703	1.3^{ab}	11.6^{ab}	6.4	6.2	19.8	16.0	1.406	28.97	27.9
ICC 12494	2242^{a}	2389	1343^{b}	1866	6.1^{bc}	23.8^{h}	15.0	12.9	29.2	27.5	6.153	43.78	40.1
ICC 12495	2303^{a}	2358	1115^{b}	1736	3.0^{ab}	12.4^{abc}	7.7	9.9	20.5	20.1	2.332	52.71	51.5
ICC 12968	859^{a}	863	1000^{a}	932	0.5^{a}	14.2^{b}	7.3	3.3	22.0	14.3	0.463	-15.87	-16.1
ICC 4973	2470^{a}	2535	1618^{b}	2077	2.9^{ab}	15.9^{bcd}	9.4	9.7	23.4	21.4	2.564	36.17	34.4
ICC 4962	2580^{a}	2659	1202^{b}	1930	3.1^{ab}	19.7^{efg}	11.4	10.0	26.1	23.1	2.971	54.80	53.4
Checks													
ICC 12475 (R)	2454^{a}	2465	2383^{a}	2424	0.4^{a}	9.4^{a}	4.9	3.5	17.8	12.4	0.446	3.33	2.89
ICC 4918 (S)	2295^{a}	2362	2258^{a}	2310	2.9^{ab}	20.9^{fgh}	11.9	9.7	27.1	23.2	2.836	4.40	2.60
Mean	2174	2240	1584	1912	2.8	17.6	10.2	8.5	24.5	20.7	2.864	26.738	27.4
	F(Prob.. at 5%)	LSD			F(Prob. at 5%)	LSD		F(Prob . at 5%)	LSD				
Treat	0.025	453.7			<.001	3.3		<.001	2.0				
Geno	<.001	428.4			<.001	3.8		<.001	2.0				
Treat.Geno	<.001	627.8			<.001	5.4		<.001	3.3				
CV %	19.4				31.9			19.7					

R – Resistant check; S – susceptible check.

RESULTS AND DISCUSSION

100-seed weight : Mean 100 seed weight was significantly high (17.18 g) under unprotected conditions compared to protected conditions (15.24 g). In ICC 3137, ICC 12491, ICC 12494, ICC 12495, ICC 12968, ICC 4973 and ICC 4962 (because of compensation) significantly high 100 seed weight was recorded under unprotected conditions (Table 2).

Seeds per pod : Significantly high number of seeds per pod were recorded under unprotected conditions in ICC 12426, ICC 3137, ICC 12493, ICC 12494, ICC 12495 and ICC 4918 whereas significantly high number of seeds per pod under protected conditions were recorded in ICC 4962. Mean number of seeds per pod were high under unprotected conditions (1.23) compared to protected conditions (1.18) but not significant (Table 2).

Yield per plant : In ICC 12476, ICC 12479, ICC 12490, ICC 12426, ICC 3137, ICC 12491, ICC 12492, ICC 12495, ICC 4973, ICC 4962 and ICC 4918 significantly high yield per plant was recorded under protected conditions. Mean yield per plant under protected conditions (15.56 g) was greater as compared to yield per plant under unprotected conditions (10.87 g) (Table 2).

Yield loss (%): Tolerance index was recorded based on yield loss (%). ICC 12475 (3.3 %) was the most tolerant genotype followed by ICC 4918 (4.4%), ICC 12490 (18.1%), ICC 12493 (19.7%), and ICC 12476 (26.1%). Highest yield reduction was recorded in ICC 3137 (59.5%) and ICC 4962 (53.4%), which were highly susceptible to *H. armigera* damage. Mean loss in yield was 26.7 % under unprotected conditions and 2.8 % under protected conditions (22.2)(Table 3).

The larvae of *H. armigera* appeared on chickpea 15 days after sowing when the crop was at vegetative stage. When the crop reached pod formation stage, larvae damaged pods by feeding on the developing grains. There was a significant and positive correlation between the larval population and pod damage (r_g = 0.198). The damage with respect to yield parameters was significantly lower in unprotected crop as compared to the crop protected with chemical insecticides.

Significantly high grain yield was recorded in ICC 12478, ICC 12490, ICC 12426, ICC 3137, ICC 12491, ICC 12493, ICC 12494, ICC 12495, ICC 4973 and ICC 4962 under protected conditions. High yield was recorded under unprotected conditions in ICC 12477 and ICC 12968 but the differences were not significant.

Pod damage in unprotected crop was 20.9 % compared to 2.9 % pod damage in the protected crop. Significantly high pod damage was recorded in all the genotypes under unprotected conditions. High pod damage was recorded in ICC 3137 in both protected and unprotected conditions. The pod damage in ICC 3137, which is medium-duration genotypes was extremely high. ICC 3137 started poding earlier than the other medium-duration genotypes and retained green leaves and pod formation as late as the other late duration genotypes. Longer poding period resulted in prolonged exposure to *H. armigera*. The length of poding period may therefore to be one of the factors associated with resistance to *H. armigera*. Genotypes with shorter poding period are preferred and have low pod damage, especially in the medium -duration genotypes (Yoshida, 1997).

Under protected conditions except ICC 12494 and ICC 3137 all the genotypes were on par with the resistant check ICC 12475 for pod borer damage. Under unprotected conditions ICC 12479 (12.3%) and ICC 12493 (11.6%) were on par with the resistant check, ICC 12475. This study indicated presence of tolerance mechanism in chickpea to *H. armigera* damage. Reduction in grain yield was lowest in ICC 12475 followed by ICC 4918, ICC 12490, ICC 12493 and ICC 12476 indicating tolerance to pod borer damage. CC 12477 and ICC 12968 were highly tolerant as there was an increase in yield under infected conditions.

The increase in number of seeds per pod under unprotected conditions in genotypes, ICC 14876, ICC 12426, ICC 12491, ICC 12493, ICC 12494, ICC 4962 and susceptible check ICC 4918 and increase in 100 seed weight in genotypes, ICC 3137, ICC 12491, ICC 12494, ICC 12495, ICC 12968, ICC 4973 and ICC 4962 indicates the tolerence mechanism of resistance *H. armigera* damage. To compensate the loss in seed number by *H. armigera* damage in these genotypes the seed weight and seeds per pod was increased.

Many morphological characteristics or non-preference tactics have been used to breed for resistance to *H. armigera* to reduce pest abundance and damage. Multiple types of resistance (tolerance, antixenosis and escape) are reported in chickpea (Clement *et al*., 1992). Several morphological and phenological traits such as shape of the pod, pod wall thickness, foliar colour and crop duration seems to influence the *H. armigera* infestation in chickpea (Ujagir and Khare 1987a and 1987b).

Several lines were shown to have good levels of resistance/tolerance to *H. armigera* and were incorporated in breeding programs to enhance the levels of borer resistance and high yielding capacity in the progenies. Since 1980, the resistant/tolerant selections and breeding lines have been assessed for their performance along with the borer tolerant selections identified by AICPIP-Entomologists in different agroecological zones in India. ICC 506 and ICCV 7 were consistently found resistant to *H. armigera*across agroecological zones (Lateef and Sachan, 1990).

Studies on yield loss under protected and unprotected conditions revealed tolerance as one of the mechanism of resistance to *H. armigera* in chickpea. Reduction in grain yield was lowest in ICC 12475 followed by ICC 4918, ICC 12491, ICC 12493 and ICC 12476 indicating tolerance to pod borer damage. With chemical insecticide protection in chickpea 2.9% (ICC 12475) to 59.5% (ICC 3137) yield loss can be avoided.The chickpea genotypes identified as stable in resistance to *H. armigera* damage can be used in further breeding programs to develop resistant varieties. The mechanisms of resistance to *H. armigera* in less susceptible chickpea genotypes can be exploited to develop resistant varieties.

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