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POPULATION DENSITY AND DAMAGE BY POD BORERS, *HELICOVERPA ARMIGERA* AND *SPODOPTERA EXIGUA* IN A DIVERSE ARRAY OF CHICKPEA GENOTYPES UNDER NATURAL INFESTATION IN THE FIELD

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ABSTRACT

Host plant resistance is one of the important components of resistance to insects, and hence, we evaluated a diverse array of chickpea genotypes for resistance to pod borers, *Helicoverpa armigera* and *Spodoptera exigua* under field conditions. Data were recorded on *S. exigua* egg masses and larvae, *H. armigera* eggs and larvae, plant damage at the vegetative, flowering and podding stages, and grain yield at crop harvest. During the vegetative stage, significantly lower numbers of *H. armigera* and *S. exigua* larvae were recorded on ICC 10393, ICCL 86111, ICC 12475 and RIL 20; while leaf damage was significantly lower on ICC 12475, ICC 10393, ICCV 10, and RIL 25 as compared to that on ICC 3137. During the flowering stage, leaf damage was significantly lower on ICC 12475, RIL 20, RIL 25, ICC 10393, ICCL 86111, KAK 2, and ICCV 10 than on ICC 3137; of which the numbers of *H. armigera* larvae were significantly lower on ICCL 86111, RIL 20, ICC 10393, RIL 25 and ICC 12475 than on ICC 3137 in one or both sowings/seasons. During the podding stage, the *H. armigera* and/or *S. exigua* larval densities were significantly lower on ICC 12475, ICC 10393, RIL 25, ICCV 10, and RIL 20; of which EC 583264, ICC 10393, ICC 12475, ICCL 86111, ICCV 10, RIL 20 and RIL 25 ~~than~~ in ICC 3137. The grain yield of these genotypes was also significantly greater than that of ICC 3137 ~~one~~ or both sowings/seasons, and these genotypes can be used for improving chickpea to pod borer resistance for sustainable crop production.

Key words: Chickpea, pod borers, *Spodoptera exigua*, *Helicoverpa armigera*, plant resistance, pest management.

Chickpea (*Cicer arietinum* L.) is an important grain legume in Asia and parts of East and North Africa, Mediterranean Europe, Australia, Canada and USA (Kelly *et al*. 2000). Nearly 60 insect species are known to damage chickpea, of which black cut-worm, *Agrotis ipsilon* (Hfn.), leaf miner, *Liriomyza cicerina* (Rondani), aphid, *Aphis craccivora* Koch, pod borer, *Helicoverpa armigera* (Hubner), and the bruchid, *Callosobruchus chinensis* L. are the major pests worldwide (Reed *et al*. 1987; Sharma *et al*. 2007; Chen *et al*. 2011), among which the pod borer, *H. armigera* is the major constraint to chickpea production (Sharma 2005).

The beet armyworm, *Spodoptera exigua* (Hubner) (Noctuidae: Lepidoptera) is emerging as an important pest of chickpea, especially in South central India. The young larvae of *S. exigua* initially feed gregariously on chickpea foliage. As the larvae grow, they become solitary and continue to feed on the foliage and produce large, irregular holes on the leaf (Ahmed *et al*. 1990; Sharma *et al*. 2007). As a leaf feeder, beet armyworm consumes much more chickpea tissues than the chickpea pod borer, *H. armigera*, but it has not been reported as a serious pest on pods. Development of crop cultivars with resistance or tolerance to pod borers, *H. armigera* and *S. exigua* has a major potential for use in integrated pest management. Recombinant inbred lines (RILs) developed from a cross between FLIP 84 – 92C (susceptible) and PI 599072 (resistant) have earlier been evaluated for resistance to *S. exigua*, and nine lines have been identified to be resistant to this pest under greenhouse conditions (Clement *et al*. 2010). However, there is no systematic evaluation of germplasm and breeding lines for resistance to *S. exigua*. The use of resistant varieties is an ideal component of pest management as it involves, no additional cost to the farmers, and does not result in environmental pollution. Therefore, the present studies

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were undertaken to screen a diverse array of chickpea genotypes for resistance to pod borers, *S. exigua* and *H. armigera* across sowing dates and seasons under natural infestation in the field.

MATERIALS AND METHODS

The chickpea genotypes were sown in the field during the 2010-12 postrainy seasons. The experiment was laid in a randomized complete block design (RCBD) with three replications. Each entry was sown in 2 rows, 2 m long, (60 x 10 cm, row-to-row and plant-to-plant spacing). There were two sowings at 30 days interval (early sown crop in Nov and late sown crop in Dec). One set of plot was kept insecticide free, while the other set was protected with insecticides to record the grain yield potential of different genotypes. Data were recorded on numbers of *H. armigera* and *S. exigua* larvae on five randomly selected plants in each replication during the seedling, vegetative, flowering and podding stages. The pod borer damage (*H. armigera* and *S. exigua*) to the leaves and pods was evaluated visually on a 1 - 9 rating scale (1 = <10% leaf ~~area~~ damaged, and 9 = >80% leaf ~~area~~ damaged) at the seedling, vegetative, flowering and podding stages. At harvest, data were also recorded on proportion of pods damaged by *S. exigua* and *H. armigera* in five plants selected ~~at yield~~ was also recorded at each plot at harvest.

The data were subjected to analysis of variance by using GENSTAT 14.0. The significance of difference between the genotypes was measured by F-test, whereas the treatment means were compared by using the least significant difference LSD at P ~~d"0.05~~.

RESULTS AND DISCUSSION

November 2011 postrainy season sowing, there were no significant differences in numbers of *S. exigua* egg masses and larvae, and *H. armigera* eggs and larvae among the test genotypes (Table 1). Numerically, lower *S. exigua* larval density was recorded (24.6 - 31.0 larvae per 5 plants) on ICCV 10, RIL 25, and ICC 10393 as compared to that on ICC 3137 (63.3 larvae per 5 plants). There were 0.0 – 2.0 *H. armigera* eggs per five plants on ICC 3137, ICC 10393, RIL 20, RIL 25, ICCL 86111, ICCV 10, EC 583260, and ICC 12475 as compared to 5.0 eggs per 5 plants on KAK 2. Numerically, the numbers *H. armigera* larvae were lower (<1.6 larvae per 5 plants) on ICCV 10, RIL 20, ICC 10393 and ICC 12475 as compared to 3.3 larvae per 5 plants on RIL 25. The total numbers of pod borer larvae were lower (~~– 32.6~~ larvae per 5 plants) on ICCV 10, RIL 25, and ICC 10393 as compared to 66.0 larvae per 5 plants on ICC 3137. Leaf feeding damage rating was significantly lower (DR 1.6 - 2.6) on ICC 12475, RIL 20, RIL 25, ICCV 10 and ICC 10393 as compared to that on ICC 3137 (DR 4.6) (Table 1).

During the December sowing, there were no significant differences in number of eggs laid and the larval density of *S. exigua* and *H. armigera* between test genotypes. Oviposition by *S. exigua* was very low. Numbers of *S. exigua* larvae were numerically lower (2.3 - 5.7 larvae per 5 plants) on KAK 2, ICC 10393, and RIL 20 than on ICC 3137 (9.0 larvae per 5 plants). Numbers of *H. armigera* larvae were lower (3.3 - 6.3 larvae per 5 plants) on KAK 2, ICCV 10, RIL 25, ICC 12475 and ICC 10393 than on ICC 3137 (9.7 larvae per 5 plants). The total number of pod borer larvae were lower (5.7 - 15.7 larvae per 5 plants) on KAK 2, ICC 10393, RIL 20, RIL 25, and ICC 12475 as compared to that on ICCL 86111 (24.3 larvae per 5 plants) (Table 1).

Larval incidence and damage by *H. armigera* and *S. exigua* in chickpea at the vegetative stage

During the November 2011 sowing, there were significantly lower numbers of *S. exigua* larvae (0.0 – 0.3 larvae per 5 plants) on EC 583264, ICC 3137, ICCL 86111, ICCV 10, KAK 2, RIL 20, EC 583260 and ICC 12475 than on RIL 25 (2.3 larvae per 5 plants) (Table 2). There were no significant differences in *H. armigera* egg and larval numbers between the genotypes tested. Numerically lower numbers (4.0 - 6.0 larvae per 5 plants) of *H. armigera* larvae were recorded on ICC 10393, ICC 12475 and ICCL 86111 as compared to that on KAK 2 (9.0 larvae per 5 plants). Lower numbers (5.0 - 6.3 larvae per 5 plants) of total pod borer larvae were recorded on ICC 10393, ICCL 86111, ICC 12475 and RIL 20 as compared to that on RIL 25 (9.3 larvae per 5 plants). Leaf damage was significantly lower (DR 1.3 - 3.3) on ICC 12475, ICC 10393, ICCV 10, RIL 25, KAK 2, RIL 20, and ICCL 86111 as compared to that on ICC 3137 (DR 5.6). During the December sowing, incidence of *S. exigua* was quite low (Table 2). There were no significant differences in *H. armigera* eggs and larvae between the genotypes tested. However, numerically lower numbers of pod borer larvae were recorded on ICCV 10, ICC 10393 and ICC 12475 (Table 2).

Table 1. Expression of resistance to pod borers, *H. armigera* and *S. exigua* at the seedling stage under natural infestation in the field (ICRISAT, 2011 postrainy season)

Genotype	1st sowing (7-11-2011)						2nd sowing (16-12-2011)				
	S. exigua egg masses/5 plants	*S. exigua* larvae/5 plants	*H. armigera* eggs/5 plants	*H. armigera* larvae/5 plants	Total pod borer larvae/5 plants	Pod borer DR[1]	*S. exigua* egg masses/5 plants	*S. exigua* larvae/5 plants	*H. armigera* eggs/5 plants	*H. armigera* larvae/5 plants	Total pod borer larvae/5 plants
EC 583260	0.0 (1.0±0.0)	59.6 (7.6±0.8)	1.6 (1.4±0.4)	2.0 (1.6±0.3)	61.6 (7.8±0.7)	4.0[cd]	0.3 (1.1±0.1)	13.3 (3.6±0.7)	0.0 (1.0±0.0)	10.0 (3.1±0.6)	23.3 (4.8±0.2)
EC 583264	0.0 (1.0±0.0)	39.3 (6.3±0.2)	2.3 (1.7±0.3)	2.6 (1.8±0.3)	42.0 (6.5±0.3)	3.3[bcd]	0.0 (1.0±0.0)	10.7 (3.0±1.0)	0.0 (1.0±0.0)	8.0 (2.9±0.4)	18.7 (4.2±0.9)
ICC 10393	0.0 (1.0±0.0)	31.0 (5.6±0.2)	0.3 (1.1±0.1)	1.6 (1.5±0.2)	32.6 (5.7±0.2)	2.6[abc]	0.0 (1.0±0.0)	3.3 (1.9±0.5)	1.3 (1.4±0.2)	6.3 (2.4±0.7)	9.7 (3.2±0.2)
ICC 12475	0.0 (1.0±0.0)	34.6 (5.8±0.7)	2.0 (1.5±0.5)	1.6 (1.4±0.4)	36.3 (5.9±0.8)	1.6[a]	0.3 (1.1±0.1)	9.7 (3.0±0.8)	0.0 (1.0±0.0)	6.0 (2.6±0.1)	15.7 (4.0±0.5)
ICC 3137	0.3 (1.1±0.1)	63.3 (7.5±1.9)	0.0 (1.0±0.0)	2.6 (1.7±0.4)	66.0 (7.7±1.7)	4.6[d]	0.0 (1.0±0.0)	9.0 (3.1±0.1)	0.7 (1.2±0.2)	9.7 (3.1±0.5)	18.7 (4.4±0.3)
ICCL 86111	0.3 (1.1±0.1)	47.6 (6.8±1.0)	0.6 (1.2±0.2)	2.3 (1.7±0.2)	50.0 (7.0±0.9)	6.3[e]	0.0 (1.0±0.0)	14.0 (3.6±0.8)	0.0 (1.0±0.0)	10.3 (3.2±0.4)	24.3 (4.9±0.8)
ICCV 10	0.0 (1.0±0.0)	24.6 (5.0±0.3)	1.0 (1.3±0.3)	1.0 (1.3±0.2)	25.6 (5.1±0.4)	2.6[abc]	0.0 (1.0±0.0)	12.3 (3.4±0.7)	0.0 (1.0±0.0)	4.3 (2.2±0.3)	16.7 (4.1±0.3)
KAK 2	0.3 (1.1±0.1)	39.6 (6.3±0.4)	5.0 (2.2±0.7)	2.0 (1.7±0.1)	41.6 (6.4±0.5)	3.0[abc]	0.0 (1.0±0.0)	2.3 (1.6±0.4)	0.0 (1.0±0.0)	3.3 (1.9±0.4)	5.7 (2.3±0.7)
RIL 20	0.0 (1.0±0.0)	40.3 (6.2±1.0)	0.3 (1.1±0.1)	1.3 (1.4±0.2)	41.6 (6.3±1.1)	2.3[ab]	0.0 (1.0±0.0)	5.7 (2.4±0.5)	0.0 (1.0±0.0)	7.0 (2.7±0.4)	12.7 (3.6±0.4)
RIL 25	0.3 (1.1±0.1)	25.6 (5.0±0.7)	0.6 (1.2±0.1)	3.3 (1.9±0.4)	29.0 (5.3±0.7)	2.3[ab]	0.0 (1.0±0.0)	8.0 (2.9±0.4)	0.0 (1.0±0.0)	5.3 (2.5±0.0)	13.3 (3.7±0.3)
Vr (9,18)	0.7	0.9	1.0	0.3	1.0	7.7	0.8	1.2	2.1	0.8	2.1
SE±	0.1	1.0	0.4	0.3	0.9	0.4	0.1	0.6	0.1	0.5	0.5
LSD (P 0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	1.4**	N.S.	N.S.	N.S.	N.S.	N.S.

[1] = 1, <10 % leaf area damaged, and 9 = > 80 % leaf area damaged. Figures in parenthesis are square root transforme($\sqrt{x+1}$) values. NS = Nonsignificant.
** = F-test significant at P 0.01. Figures followed by the same letter within a column are not significantly different by Duncan's multiple range test at $P \leq 0.05$.

Table 2. Expression of resistance to pod borers, *H. armigera* and *S. exigua* at the vegetative stage under natural infestation in the field (ICRISAT, 2011 postrainy season)

Genotype	1st sowing (7-11-2011)					2nd sowing (16-12-2011)			
	S. exigua larvae/5 plants	*H. armigera* eggs/5 plants	*H. armigera* larvae/5 plants	Total pod borer larvae/5 plants	Pod borer DR[1]	*S. exigua* larvae/5 plants	*H. armigera* eggs/5 plants	*H. armigera* larvae/5 plants	Total pod borer larvae/5 plants
EC 583260	0.3 (1.1±0.1)^{a}	0.3 (1.1±0.1)	6.6 (2.7±0.2)	7.0 (2.8±0.2)	5.0^{de}	0.3 (1.1±0.1)	1.0 (1.3±0.2)	7.7 (2.9±0.1)	8.0 (2.9±0.0)
EC 583264	0.0 (1.0±0.0)^{a}	0.0 (1.0±0.0)	8.3 (3.0±0.2)	8.3 (3.0±0.2)	4.0^{cd}	7.0 (2.2±1.2)	4.0 (2.0±0.6)	5.7 (2.5±0.2)	12.7 (3.4±1.0)
ICC 10393	1.0 (1.3±0.2)^{ab}	0.0 (1.0±0.0)	4.0 (2.2±0.2)	5.0 (2.4±0.1)	2.0^{a}	0.0 (1.0±0.0)	0.0 (1.0±0.0)	3.0 (1.8±0.4)	3.0 (1.8±0.4)
ICC 12475	0.3 (1.1±0.1)^{a}	0.6 (1.2±0.2)	5.6 (2.5±0.1)	6.0 (2.6±0.1)	1.3^{a}	0.0 (1.0±0.0)	0.0 (1.0±0.0)	4.0 (2.0±0.5)	4.0 (2.0±0.5)
ICC 3137	0.0 (1.0±0.0)^{a}	0.6 (1.2±0.2)	8.6 (3.0±0.3)	8.6 (3.0±0.3)	5.6^{e}	0.0 (1.0±0.0)	0.3 (1.1±0.1)	12.3 (3.6±0.3)	12.3 (3.6±0.3)
ICCL 86111	0.0 (1.0±0.0)^{a}	0.3 (1.1±0.1)	6.0 (2.6±0.1)	6.0 (2.6±0.1)	3.3^{bc}	0.0 (1.0±0.0)	0.7 (1.2±0.2)	5.7 (2.5±0.2)	5.7 (2.5±0.2)
ICCV 10	0.0 (1.0±0.0)^{a}	0.3 (1.1±0.1)	8.6 (3.0±0.4)	8.6 (3.0±0.4)	2.0^{a}	0.0 (1.0±0.0)	0.0 (1.0±0.0)	3.0 (1.9±0.1)	3.0 (1.9±0.1)
KAK 2	0.0 (1.0±0.0)^{a}	0.3 (1.1±0.1)	9.0 (3.1±0.3)	9.0 (3.1±0.3)	2.3^{ab}	0.0 (1.0±0.0)	0.3 (1.1±0.1)	6.3 (2.6±0.4)	6.3 (2.6±0.4)
RIL 20	0.0 (1.0±0.0)^{a}	0.3 (1.1±0.1)	6.3 (2.7±0.1)	6.3 (2.7±0.1)	2.3^{ab}	0.0 (1.0±0.0)	0.3 (1.1±0.1)	7.0 (2.7±0.3)	7.0 (2.7±0.3)
RIL 25	2.3 (1.7±0.3)^{b}	1.6 (1.6±0.1)	7.0 (2.7±0.2)	9.3 (3.1±0.4)	2.0^{a}	0.0 (1.0±0.0)	1.0 (1.3±0.2)	7.7 (2.9±0.1)	7.7 (2.9±0.1)
Vr (9,18)	2.8	1.6	1.1	0.8	17.3	1.0	1.6	2.2	1.5
SE±	0.1	0.1	0.3	0.3	0.3	0.4	0.2	0.4	0.5
LSD (P 0.05)	0.44*	N.S.	N.S.	N.S.	1.0**	N.S.	N.S.	N.S.	N.S.

[1] = 1, <10 % leaf area damaged, and 9 = > 80 % leaf area damaged. Figures in parenthesis are square root transforme(√x+1) values. *, ** F-test significant at P 0.05 and 0.01, respectively. Figures followed by the same letter within a column are not significantly different by Duncan's multiple range test at P ≤ 0.05.

Larval incidence and damage by *H. armigera* and *S. exigua* in chickpea at the flowering stage

In the November 2010 sowing, leaf feeding damage was significantly lower (DR: 1.0 – 1.6) on ICC 12475, RIL 20, RIL 25, ICC 10393, ICCL 86111, KAK 2, and ICCV 10 than on ICC 3137 (DR 4.3) (Table 3). The numbers of *H. armigera* and *S. exigua* larvae did not differ significantly between the genotypes tested. In the December sowing of significantly higher numbers of *H. armigera* larvae were observed on ICC 3137 (9.3 larvae per 5 plants) than on ICCL 86111, RIL 20, ICC 10393, EC 583264, EC 583260, ICCV 10, RIL 25 and ICC 12475 (1.6 - 4.3 larvae per 5 plants). The incidence of *S. exigua* was very low (0.0 - 2.3 larvae per 5 plants). Total pod borer larvae were significantly lower (1.6 - 3.0) on ICC 12475, RIL 25, ICCV 10, and ICC 10393 as compared to that on ICC 3137 (9.3 larvae per 5 plants) (Table 3). Though incidence of pod borers was quite high during December sowing in 2010 postrainy season, the leaf damage could not be recorded because of heavy rainfall received during the observation period, which later resulted in better recovery in the vegetative growth.

During the 2011 postrainy November sowing, there were no significant differences in *S. exigua* larval numbers across genotypes at the flowering stage. The *H. armigera* larval numbers were significantly lower (8.6 - 10.6 larvae per 5 plants) on ICC 10393, ICCV 10, and ICC 12475 as compared to ICC 3137 (38.6 larvae per 5 plants). The total numbers of pod borer larvae were significantly lower (8.6 – 16.6 larvae per 5 plants) on ICC 10393, ICCV 10, ICC 12475, RIL 25, RIL 20, and ICCL 86111 than on ICC 3137 (38.6 larvae per 5 plants). The leaf damage was significantly lower (DR 3.0 – 4.3) on ICC 12475, ICCV 10, RIL 25, ICC 10393, and RIL 20 than on ICC 3137 (DR 7.3) (Table 4).

In the 2011 December sowing, the differences between the genotypes in leaf damage and *H. armigera* larval numbers were significant (Table 4). ICC 12475, EC 583264, RIL 20, and RIL 25 had significantly lower numbers (2.0 - 5.6 larvae per 5 plants) of *H. armigera* larvae as compared to that on ICC 3137 (9.3 larvae per 5 plants). Leaf damage rating was significantly lower (DR 3.3 - 5.3) on ICC 10393, ICC 12475, RIL 20, RIL 25, ICCV 10, KAK 2, and EC 583260 as compared to ICC 3137 (DR 8.0) (Table 4). At the flowering stage, *H. armigera* was predominant, and the genotypes ICC 10393, ICC 12475 and ICCV 10 were least susceptible to pod borer damage in both the seasons.

Larval incidence and damage by *H. armigera* and *S. exigua* in chickpea at the podding stage

In the November sowing of 2010 postrainy season, the *H. armigera* larval density was significantly lower (2.0 - 5.0 larvae per 5 plants) at the podding stage on ICC 12475, ICC 10393, RIL 25, ICCV 10, and RIL 20 as compared to that on ICC 3137 (12.0 larvae per 5 plants) (Table 5). The *S. exigua* incidence was negligible. Total numbers of pod borer larvae were significantly lower (2.0 - 2.6 larvae per 5 plants) on ICC 12475 and ICC 10393 as compared to that on ICC 3137 (12.0 larvae per 5 plants). The genotypes ICC 10393, ICC 12475, RIL 20, ICCV 10, RIL 25 and EC 583264 suffered significantly ~~lowerdamage~~ (DR 3.3 - 4.0) than ICC 3137 (DR 8.3).

In the 2010 December sowing, there were significant differences in *H. armigera* larval population between the genotypes tested. The numbers of *H. armigera* larvae were significantly lower (4.6 – 13.6 larvae per 5 plants) on ICC 12475, ICC 10393, EC 583260, and RIL 25 than on ICC 3137 (24.6 larvae per 5 plants). The *S. exigua* incidence was negligible. Significantly lower numbers (4.6 – 13.6 larvae per 5 plants) of total pod borer larvae were recorded on ICC 12475, ICC 10393, EC 583260, and RIL 25 than on ICC 3137 (25.6 larvae per 5 plants). The damage was significantly lower (DR 3.3 - 4.3) on ICC 12475, ICCV 10, RIL 20, RIL 25, ICCL 86111, and ICC 10393 as compared to ICC 3137 (Table 5).

Pod damage by *H. armigera* and *S. exigua* in chickpea genotypes under natural infestation in the field

There were significant differences in pod damage among the genotypes tested (Table 6). Significantly lower pod damage (5.8 - 15.9%) was recorded on EC 583264, ICC 12475, ICC 10393, ICCL 86111, ICCV 10, RIL 20, and RIL 25 than in ICC 3137 (39.3%) in early sowing of 2010 postrainy season, of which EC 583264, ICC 12475, RIL 20, and RIL 25 also suffered significantly lower pod damage (8.2 – 14.0%) than ICC 3137 (38.3%) in December sowing. During the 2011 post rainy season, the genotypes EC 583264, ICC 10393, ICC 12475, ICCL 86111, RIL 20, and RIL 25 suffered significantly lower pod damage than ICC 3137 (23.6%) in both the sowings.

Table 3. Expression of resistance to pod borers, *H. armigera* and *S. exigua* at the flowering stage under natural infestation in the field (ICRISAT, 2010 postrainy season)

Genotype	1st sowing (6-12-2010)				2nd sowing (30-12-2010)		
		H. armigera larvae/5 plants	*S. exigua* larvae/5 plants	Total pod borer larvae/5 plants	*H. armigera* larvae/5 plants	*S. exigua* larvae/5 plants	Total pod borer larvae/5 plants
EC 583260	3.0[c]	1.6 (1.6±0.2)	2.0 (1.6±0.3)	3.6 (2.1±0.3)	2.3 (1.8±0.2)[a]	2.3 (1.6±0.4)	4.6 (2.3±0.2)[ab]
EC 583264	2.6[bc]	0.6 (1.2±0.2)	0.0 (1.0±0.0)	0.6 (1.2±0.2)	2.6 (1.8±0.2)[a]	1.3 (1.5±0.1)	4.0 (2.2±0.2)[ab]
ICC 3137	4.3[d]	1.6 (1.6±0.1)	0.0 (1.0±0.0)	1.6 (1.6±0.1)	9.3 (3.2±0.1)[c]	0.0 (1.0±0.0)	9.3 (3.2±0.1)[c]
ICC 10393	1.3[a]	0.6 (1.1±0.1)	0.6 (1.2±0.2)	0.6 (1.3±0.2)	3.0 (1.9±0.1)[ab]	0.0 (1.0±0.0)	3.0 (1.9±0.1)[a]
ICC 12475	1.0[a]	0.3 (1.2±0.2)	0.0 (1.0±0.0)	0.3 (1.2±0.2)	1.6 (1.6±0.1)[a]	0.0 (1.0±0.0)	1.6 (1.6±0.1)[a]
ICCL 86111	1.3[a]	0.3 (1.1±0.1)	0.3 (1.1±0.1)	0.6 (1.2±0.2)	4.3 (2.2±0.2)[ab]	0.0 (1.0±0.0)	4.3 (2.2±0.2)[ab]
ICCV 10	1.6[ab]	2.6 (1.8±0.2)	0.0 (1.0±0.0)	2.6 (1.8±0.2)	2.3 (1.8±0.0)[a]	0.0 (1.0±0.0)	2.3 (1.8±0.0)[a]
KAK 2	1.3[a]	2.3 (1.7±0.2)	0.0 (1.0±0.0)	2.3 (1.7±0.2)	6.0 (2.6±0.2)[b]	0.3 (1.1±0.1)	6.3 (2.6±0.2)[ab]
RIL 20	1.0[a]	0.6 (1.2±0.2)	0.3 (1.1±0.1)	1.0 (1.3±0.3)	3.3 (2.0±0.1)[ab]	0.0 (1.0±0.0)	3.3 (2.0±0.1)[ab]
RIL 25	1.0[a]	1.0 (1.3±0.3)	0.3 (1.1±0.1)	1.3 (1.4±0.4)	2.0 (1.6±0.3)[a]	0.0 (1.0±0.0)	2.0 (1.6±0.3)[a]
Vr (9, 18)	7.7	1.4	1.6	1.2	5.1	2.2	4.5
SE ±	0.4	0.2	0.2	0.3	0.2	0.2	0.2
LSD (P 0.05)	1.2**	N.S.	N.S.	N.S.	0.7**	N.S.	0.7**

= 1, <10% leaf area damaged, and 9 = > 80% leaf area damaged. Figures in parenthesis are square root transformed (√x+1) values. ** F-test significant at P 0.01. NS = Nonsignificant. Figures followed by the same letter within a column are not significantly different by Duncan's multiple range test at P ≤ 0.05

Table 4. Expression of resistance to pod borers, *H. armigera* and *S. exigua* at the flowering stage under natural infestation in the field (ICRISAT, 2011 postrainy season)

Genotype	1st sowing (7-11-2011)				2nd sowing (16-12-2011)	
	S. exigua larvae/5 plants	*H. armigera* larvae/5 plants	Total pod borer larvae/5 plants	Pod borer DR[1]	*H. armigera* larvae/5 plants	Pod borer DR[1]
EC 583260	0.3 (1.1±0.1)	39.0 (6.3±0.1)^{d}	39.3 (6.3±0.1)^{c}	6.3^{c}	8.3 (3.0±0.0)^{bc}	5.3^{ab}
EC 583264	0.3 (1.1±0.1)	19.6 (4.5±0.3)^{bc}	20.0 (4.5±0.3)^{ab}	4.6^{b}	5.3 (2.5±0.0)^{abc}	7.6^{c}
ICC 10393	0.0 (1.0±0.0)	8.6 (3.0±0.2)^{a}	8.6 (3.0±0.2)^{a}	3.6^{ab}	6.3 (2.6±0.1)^{bc}	3.3^{a}
ICC 12475	0.0 (1.0±0.0)	10.6 (3.3±0.3)^{a}	10.6 (3.3±0.3)^{a}	3.0^{a}	2.0 (1.7±0.0)^{a}	3.6^{ab}
ICC 3137	0.0 (1.0±0.0)	38.6 (6.2±0.2)^{d}	38.6 (6.2±0.2)^{c}	7.3^{c}	9.3 (3.1±0.4)^{cd}	8.0^{c}
ICCL 86111	0.0 (1.0±0.0)	16.6 (4.1±0.3)^{abc}	16.6 (4.1±0.3)^{a}	4.6^{b}	9.0 (3.1±0.1)^{cd}	5.6^{b}
ICCV 10	0.0 (1.0±0.0)	9.3 (3.0±0.7)^{a}	9.3 (3.0±0.7)^{a}	3.0^{a}	6.3 (2.6±0.2)^{bc}	4.6^{ab}
KAK 2	5.3 (2.0±1.0)	23.0 (4.8±0.2)^{c}	28.3 (5.3±0.6)^{bc}	6.6^{c}	12.6 (3.6±0.1)^{d}	5.3^{ab}
RIL 20	0.0 (1.0±0.0)	14.3 (3.9±0.1)^{abc}	14.3 (3.9±0.1)^{a}	4.3^{ab}	4.6 (2.3±0.2)^{ab}	4.3^{ab}
RIL 25	0.0 (1.0±0.0)	14.0 (3.8±0.5)^{ab}	14.0 (3.8±0.5)^{a}	3.3^{ab}	5.6 (2.5±0.1)^{abc}	4.0^{ab}
Vr (9,18)	0.9	11.5	8.9	10.6	6.0	5.5
SE±	0.3	0.4	0.4	0.4	0.2	0.6
LSD (P 0.05)	N.S.	1.0**	1.2**	1.4**	0.7**	1.9**

[1] = 1, <10 % leaf area damage, and 9 = > 80% leaf area damaged. Figures in parenthesis are square root transformed ($\sqrt{x+1}$) values. ** F-test significant at P 0.01.
NS = Nonsignificant. Figures followed by the same letter within a column are not significantly different by Duncan's multiple range test at $P \leq 0.05$.

Table 5. Expression of resistance to pod borers, *H. armigera* and *S. exigua* at maturity under natural infestation in the field (ICRISAT, 2010 postrainy season)

Genotype	1st sowing (6-12-2010)				2nd sowing (30-12-2010)			
	H. armigera larvae/5 plants	*S. exigua* larvae/5 plants	Total pod borer larvae/5 plants	DR[1]	*H. armigera* larvae/ 5 plants	*S. exigua* larva/5 plants	Total pod borer larvae/5 plants	Pod borer DR[1]
EC 583260	7.3 (2.8±0.3)[b]	0.0 (1.0±0.0)	7.3 (2.8±0.3)[b]	5.6[cd]	12.6 (3.6±0.0)[bc]	0.0 (1.0±0.0)	12.6 (3.6±0.0)[bc]	7.0[c]
EC 583264	6.0 (2.6±0.0)[ab]	0.6 (1.2±0.2)	6.6 (2.7±0.1)[ab]	4.0[ab]	15.6 (4.0±0.2)[bcd]	0.0 (1.0±0.0)	15.6 (4.0±0.2)[bcd]	5.05[c]
ICC 3137	12.0 (3.5±0.2)[c]	0.0 (1.0±0.0)	12.0 (3.5±0.2)[c]	8.3[e]	24.6 (5.0±0.0)[e]	1.0 (1.3±0.3)	25.6 (5.1±0.0)[e]	6.6[c]
ICC 10393	2.6 (1.8±0.4)[a]	0.0 (1.0±0.0)	2.6 (1.8±0.1)[a]	3.3[a]	8.6	0.0 (1.0±0.0)	8.6 (3.1±0.0)[ab]	4.3[ab]
ICC 12475	2.0 (1.7±0.1)[a]	0.0 (1.0±0.0)	2.0 (1.7±0.4)[a]	3.3[a]	4.6	0.0 (1.0±0.0)	4.6 (2.3±0.0)[a]	3.3[a]
ICCL 86111	7.3 (2.7±0.5)[b]	0.0 (1.0±0.0)	7.3 (2.7±0.5)[b]	4.6[bc]	15.3 (3.9±0.4)[bcd]	0.0 (1.0±0.0)	15.3 (3.9±0.4)[bcd]	4.0[ab]
ICCV 10	4.6 (2.3±0.0)[ab]	0.0 (1.0±0.0)	4.6 (2.3±0.0)[ab]	3.6[ab]	20.6 (4.6±0.1)[de]	0.0 (1.0±0.0)	20.6 (4.6±0.1)[de]	3.6[ab]
KAK 2	7.3 (2.8±0.1)[b]	0.0 (1.0±0.0)	7.3 (2.8±0.1)[b]	6.0[d]	16.6 (4.1±0.2)[cd]	0.0 (1.0±0.0)	16.6 (4.1±0.2)[cd]	6.6[c]
RIL 20	5.0 (2.4±0.1)[ab]	0.0 (1.0±0.0)	5.0 (2.4±0.1)[ab]	3.3[a]	17.3 (4.2±0.4)[cd]	0.0 (1.0±0.0)	17.3 (4.2±0.4)[cd]	4.3[ab]
RIL 25	4.6 (2.3±0.3)[ab]	0.0 (1.0±0.0)	4.6 (2.3±0.3)[ab]	4.0[ab]	13.6 (3.8±0.2)[bcd]	0.0 (1.0±0.0)	13.6 (3.8±0.2)[bcd]	4.0[ab]
Vr (9, 18)	4.2	1.0	4.0	22.7	8.5	1.0	8.8	8.6
SE±	0.3	0.1	0.3	0.3	0.3	0.1	0.3	0.5
LSD (P 0.05)	0.8**	N.S.	0.8**	1.0**	0.8**	N.S.	0.8**	1.4**

[1] = 1, <10 % damage, and 9 = > 80% ~~damaged~~. Figures in parenthesis are square root transform $\sqrt{x+1}$ values. ** F-test significant at P 0.01. Figures followed by the same letter within a column are not significantly different by Duncan's multiple range test at $P \leq 0.05$.

Grain yield ~~of~~ potential of chickpea genotypes under natural infestation of *H. armigera* and *S. exigua* under field conditions

There were significant differences in grain yield among the genotypes tested (Table 6). ICCV 10 recorded highest grain yield (2505.9 kg ha^{-1}), followed by RIL 25 (1926.1 kg ha^{-1}), and ICCL 86111 (1876.5 kg ha^{-1}) during the November 2010 postrainy season; while EC 583264, ICC 10393, ICC 12475, ICCV 10, RIL 20, and RIL 25 yielded >1,000 kg ha^{-1} in the late sown crop in Dec 2010. During ~~2011~~ postrainy season, ICC 12475, ICC 10393, ICCL 86111, RIL 20, RIL 25, and ICCV 10 registered a grain yield of 2773.6 - 4105.5 kg ha^{-1} as compared to 700.0 kg ha^{-1} in EC 583260 (Table 6). In the late sown crop during Dec 2011, the genotypes ICC 12475, ICCL 86111, ICCV 10, RIL 20, and RIL 25 yielded >1,000 kg ha^{-1} as compared to 697.2 kg ha^{-1} in ICC 3137.

The differences in *S. exigua* and *H. armigera* egg laying and larval density, and numbers of total pod borer larvae were nonsignificant among the genotypes tested in one or both sowings, except a few exceptions. The leaf damage was significantly lower on ICC 12475 as compared to that on ICCL 86111 at the seedling stage, although both are resistant to *H. armigera* (Narayanamma *et al*. 2007), and this may be because of insensitivity of *S. exigua* to leaf surface exudates, and or slow growth of this genotypes during the seedling stage. The *S. exigua* larval incidence was greater at 10 - 30 days after seedling emergence, but declined thereafter in comparison to that of *H. armigera*. It might be due to accumulation of organic acids with an increase in plant age (Yoshida *et al*. 1997; Narayanamma *et al*. 2013).

The total numbers of pod borer larvae were lower on ICC 10393, ICC 12475, ICCL 86111, and RIL 20 as compared to ICC 3137 during the vegetative stage, while leaf damage was significantly lower on ICC 12475, RIL 25, ICCV 10 and ICC 10393 as compared to that on ICC 3137 in the Nov sowing. During the December sowing, the differences in *H. armigera* eggs and larvae between the genotypes tested were non-significant. However, lower numbers of pod borer larvae were recorded on ICCV 10, ICC 10393 and ICC 12475 as compared to that on ICC 3137.

During the flowering stage, leaf feeding damage was significantly lower on ICC 12475, RIL 20, RIL 25, ICC 10393, ICCL 86111, KAK 2 and ICCV 10; while the numbers of *H. armigera* larvae were significantly lower on ICCL 86111, RIL 20, ICC 10393, EC 583264, EC 583260, ICCV 10, RIL 25 and ICC 12475 than on ICC 3137 in one or both sowings/seasons. During the podding stage, the *H. armigera* and *S. exigua* larval density was significantly lower on ICC 12475, ICC 10393, RIL 25, and ICCV 10; while ICC 10393, ICC 12475, RIL 20, ICCV 10, RIL 25, and EC 583264 suffered significantly lower ~~damage~~ than ICC 3137 in one or both seasons. Pod damage was significantly lower on EC 583264, ICC 10393, ICC 12475, ICCL 86111, ICCV 10, RIL 20 and RIL 25 than in ICC 3137; their grain yield potential was significantly greater than that of ICC 3137 in one or both sowings/seasons.

Clement *et al*. (2010) identified nine chickpea lines as resistant and 25 lines moderately resistant to beet armyworm, *S. exigua*. The chickpea accessions belonging to *Cicer bijugum*, *C. Judaicum*, *C. cuneatum* and *C. microphyllum* have been identified with high levels of resistance to *H. armigera* (Sharma *et al*. 2002; 2005a). Bhagwat *et al*. (1995) reported that minimum larvae of *H. armigera* and pod damage on ICC 506 EB. Hossain *et al*. (2008) reported that the *H. armigera* population was higher in the early sown crops. November sown crops suffered less pod damage than the December sown crop (Begum *et al*. 1992). Chickpea germplasm accessions with resistance to *H. armigera* have been identified by several workers (Lateef 1985; Chhabra *et al.* 1990; Singh and Yadav 1999). The genotype ICC 16374 exhibited good resistance/tolerance against *H. armigera* (Patil *et al.* 2007). The genotypic responses have been found to be quite variable across seasons and locations (Sharma *et al*. 2003). ICC 506EB, ICC 12476, ICC 12477, ICC 12478 and ICC 12479 recorded minimum oviposition, lower leaf damage (Narayanamma *et al.* 2007). Patil *et al*. (2007) recorded highest grain yield in the genotype ICCC 37. The genotypes ICC 12475, ICC 10393, RIL 20, and EC 583264 showed resistance to pod borers, while ICCV 10 recorded highest grain yield under unsprayed conditions, and these genotypes can be used for improving chickpea to pod borer resistance for sustainable crop production.

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Table 6. Pod damage by *H. armigera* and *S. exigua* and grain yield in a diverse array of chickpea genotype under unprotected conditions in the field (ICRISAT, 2010 and 2011 postrainy seasons)

Genotype	2010				2011			
	1st sowing (6-12-2010)		2nd sowing (30-12-2010)		1st sowing (7-11-2011)		2nd sowing (16-12-2011)	
	Pod damage (%)	Grain yield (kg/ha)	Pod damage (%)	Grain yield (kg/ha)	Pod damage (%)	Grain yield (kg/ha)	Pod damage (%)	Grain yield (kg/ha)
EC 583260	19.7 (4.3±0.8)^{bc}	740.0^{b}	17.5 (4.2±0.2)^{ab}	337.3^{a}	43.7 (6.5±0.7)^{c}	700.0^{a}	11.8 (3.3±0.8)^{ab}	645.8^{a}
EC 583264	15.9 (4.1±0.0)^{abc}	1418.3^{bc}	8.2 (3.0±0.3)^{a}	1070.2^{c}	10.3 (3.3±0.1)^{ab}	1981.9^{b}	6.3 (2.5±0.6)^{a}	798.6^{a}
ICC 3137	39.3 (6.3±0.3)^{d}	920.9^{ab}	38.3 (6.2±0.5)^{c}	497.3^{ab}	23.6 (4.9±0.2)^{b}	2104.1^{bc}	20.04 (4.5±0.3)^{b}	697.2^{a}
ICC 10393	13.0 (3.9±0.5)^{abc}	1706.9^{c}	15.3 (4.0±0.2)^{ab}	1093.2^{c}	11.8 (3.5±0.2)^{ab}	2840.2^{cd}	7.9 (2.9±0.3)^{ab}	876.3^{ab}
ICC 12475	14.8 (3.7±0.2)^{abc}	700.6^{a}	11.8 (3.4±0.5)^{a}	1129.2^{c}	7.5 (2.8±0.2)^{a}	2773.6^{cd}	2.9 (1.8±0.4)^{a}	1198.6^{bc}
ICCL 86111	12.6 (3.6±0.5)^{ab}	1876.5^{c}	17.6 (4.2±0.4)^{ab}	961.3^{bc}	16.2 (4.1±0.3)^{ab}	2922.2^{de}	9.5 (3.2±0.2)^{ab}	1268.0^{c}
ICCV 10	11.7 (3.5±0.3)^{ab}	2505.9^{d}	17.8 (4.3±0.3)^{ab}	1408.5^{c}	16.8 (4.2±0.0)^{ab}	4105.5^{f}	19.0 (4.4±0.0)^{b}	1313.8^{c}
KAK 2	23.0 (4.8±0.2)^{c}	1027.5^{ab}	28.1 (5.2±0.9)^{bc}	282.2^{a}	20.8 (4.6±0.3)^{ab}	2133.3^{bc}	15.2 (3.9±0.7)^{ab}	659.7^{a}
RIL 20	5.8 (2.6±0.1)^{a}	1873.8^{c}	13.9 (3.8±0.3)^{ab}	1330.1^{c}	11.6 (3.5±0.2)^{ab}	3455.5^{def}	13.5 (3.7±0.5)^{ab}	1252.7^{c}
RIL 25	10.3 (3.3±0.2)^{ab}	1926.1^{c}	14.0 (3.8±0.0)^{ab}	1106.4^{c}	16.1 (4.1±0.3)^{ab}	3665.2^{ef}	12.4 (3.6±0.1)^{ab}	1191.6^{bc}
Vr (9, 18)	8.3	11.2	1.4	533.4	7.4	16.9	2.7	6.4
SE±	0.4	180.7	0.5	178.1	2.6	239.5	3.4	110.3
LSD (P 0.05)	1.0**	541.0**	3.9**	5.1**	7.8**	717.0**	10.2*	330.3**

Figures in parenthesis are square root transformed (√x+1) values. ** F-test significant at P 0.05 and 0.01, respectively. Figures followed by the same letter within a column are not significantly different by Duncan's multiple range test at P ≤ 0.05.

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