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Screening for host plant resistance to *Helicoverpa armigera* (Lepidoptera: Noctuidae) in selected chickpea (*Cicer arientinum* L.) genotypes in Kenya

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Abstract

Helicoverpa armigera is a major pest on the chickpea (*Cicer arientinum*) world. In Kenya, it causes up to 80% yield losses of the crop. Control measures include application of pesticides and cultural methods which have become less feasible due to their associated costs. Host plant resistance can offer long-term benefits in managing this pest. The objective of this study was to screen and identify chickpea genotypes that are tolerant to *Helicoverpa armigera* infestation under field conditions. Thirty chickpea genotypes were screened at Agricultural Training Centre, Koibatek under field conditions for two seasons in RCBD design in 3 replicates. Data on larval densities, percent pod damage, and amount of leaf consumed were transformed using angular transformation and then subjected to ANOVA, while treatment means separated using Duncan's Multiple Range Test at $P \leq 0.05$. Correlation analysis between larval densities, yield and yield components was done using Genstat 12. The genotypes were classified into various categories of resistance and susceptibility on a visual leaf damage rating scale of 1-9. The results showed that there was significant variation in larval densities among the genotypes. At vegetative stage, mean larval densities ranged from 0.15 to 1.2 Genotypes EC583250 and EC583264 had lowest larval densities while ICC4973 and ICC3137 had highest densities. Larval densities increased from 0.3 to 1.97 during flowering stage. The larvae population increased drastically to a mean of 3.58 at podding. Genotype EC583260 had the least larval density of 2.2. The genotypes, EC583318, EC583250, EC583260 and EC583264 were least infested by the larvae with percent pod damage ranged from 3% on EC583264 with high yields while ICC3137 had highest pod damage of 20.2%. EC583260 was found to be low yielding (1051kg ha^{-1}) while ICC4958 was the high yielding

(2205kg ha^{-1}). Genotypes EC58318, ICCV10, ICC14831, EC583260, EC583264, and EC583250 had high resistance and could be exploited to chickpea breeding programmes as source to resitance.

Keywords: Chickpea, *Helicoverpa armigera*, larval density, resistance, germplasm.

Introduction

Chickpea is the third most important legume crop in the world after beans and peas. In Asia, chickpea is second in importance to rice (ICRISAT, 2005). The global annual production of chickpea is 10.46 Metric tonnes grown on 11.55 million hectares with average yields of 905.6 Kg/ha (FAOSTAT, 2009). About 90% of the global area and 88% of production is concentrated in Asia. India is the leading chickpea growing country with over 60% share in acreage and production. In Africa, the annual production is approximately 320,000 tons, which accounts for about 5% of global production. The leading producers are Ethiopia (268,000 tons), Malawi (37,000), Tanzania (31,000 tons) Sudan (12,000), and Kenya (<10,000 tons) (ICRISAT, 2012). In Kenya, recent reports indicate that chickpea was introduced in Kenya in 1980s in Eastern province and in Rift valley (Bomet and Njoro area) in early 1990s (ICRISAT, 1989; Metto, 2002), but a recent survey (Kaloki, 2009) indicates that local accessions have been in existence under cultivation in coastal and Eastern parts of Kenya for the last 40 years. Since then, the crop has since spread in Kenya and is currently adapted to varied agro-ecological zones such as dry highlands (Naivasha, Njoro, Nakuru, Uasin Gishu and Timau), medium altitudes (Bomet, Kabete, Mbeere) and also in dry lowlands (Baringo, Kerio valley, Machakos and Koibatek) with annual rainfall range of 250-550 mm per annum (Jaetzold and Schmidt, 1983, Kibe and Onyari, 2007, Onyari *et al*., 2010).

The crop that is currently expanding to new areas from the original semi arid areas to the Rift Valley highlands and mid altitudes as a relay crop during the short rains (Kimurto *et al.,* 2010; Mulwa *et al.,* 2010). Currently chickpea has been introduced in dry highlands like Bomet, Koibatek, Naivasha and Nakuru as relay crop after harvesting cereals and in dry low lands like Baringo and Kerio valley during the short rains (Kimurto *et al.,* 2010). To date 4 chickpea varieties (LTD068-ICCV00108, LTD064-ICCV00305, EU-Chania Desi 1-ICCV97105 and SAINA-K1-ICCV95423) have been released for commercial production by 3 research institutions (KARI, Leldet Seed Company and Egerton University) (KEPHIS, 2010, 2012). They are grown extensively specifically in Mbeere, Koibatek and Bomet districts (Kaloki,

2010). Previous work at KARI Naivasha (dry lowland) also reported mean yields of 1604 and 1894 kg ha^{-1} during the short and long rains (late sowing) respectively from Kabuli 95423 (Onyari *et al*. 2010). Growing chickpea in relay with wheat has the potential to contain the current threat of ug99 strain of wheat stem rust since could break the lifecycle of the pathogen. Work done recently in dryland areas has shown that several varieties (ICCV92944, ICCV 92318, ICCV 96329, ICCV 97037, ICCV10 and ICCV 97126) are well adapted with yields ranging between 1.5-3.2 tons ha^{-1} (Kimurto *et al*, 2008; ICRISAT, 2005; Kimurto *et al*., 2009; Thagana *et al*., 2009). This indicates that Kenya, like many African countries has a high potential for chickpea production and export to deficit countries such as India, China, and Pakistan.

In spite of this, *Helicorverpa armigera* remains the single most serious insect pest that causes significant yield losses of up to 80% due to its mobility, high polyphagy, short generation duration, and high reproductive rate (Suma *et al*., 2009). Currently, the application of chemical spray insecticides is the most common method of controlling this pest on crops including chickpea (Sharma *et al*., 2007). However, *H. armigera* is known to have developed resistance to almost all insecticides used for its control (Kranthi *et al*., 2002). The chemical sprays are also of environmental concern and are responsible for human health problems. Limited success has been attained in the development of cultivars with tolerance to pod borers and its control has relied heavily on the use of chemicals. Chickpea pod borer causes yield losses of over US $2 billion in the semi-arid tropics despite application of insecticides costing $ 500 million annually (ICRISAT, 1992; Sharma *et al.,* 2005).

H. armigera has developed resistance to several pesticides, especially synthetic organophosphates, carbamates, and organ chlorines insecticides (Harender, 2003), leading to excessive use of more chemicals, which also leads to environmental pollution. Use of insecticides also increases cost of production for the small-scale farmers, since they are not affordable and are increasingly becoming less feasible. Biological control methods such as *Bacillus thuringiensis* (Bt) toxin, *H. armigera* polyhedrosis virus and Entomopathogenic fungi have been developed but they are not stable (Lewis, 1997; Ranga-Rao and Shanower, 1999). Weeding as a cultural control where is effective for avoiding oviposition of *H. armigera* eggs, and biological control with egg parasitoids from *Trichogramma* is used for inoculative and inundative releases against the pest. Genetic transformation with the Bt genes has been developed in India, however the deployment of transgenic crops for pest management is raising concerns and may take time to be fully integrated

in cultivation. Thus, host plant resistance (HPR) along with natural enemies and cultural practices remain the backbone of pest management systems favourable to most agro-ecosystems (Sharma, 2007). Despite the importance of HPR in integrated pest management, breeding for plant resistance to insect pests has not been in rapid development as the case may be in disease–resistance. With the development of *H. armigera* resistance to insecticides, there is an urgent need to develop chickpea cultivars with native resistance to the pest. Thus this work was aimed at investigating and identifying chickpea germplasm with host plant resistance to *H. armigera*.

Materials and Methods

This study was conducted at the Agricultural Training Centre (ATC) Koibatek, in the Rift Valley of Kenya. The site lies in Agro-ecological zone between UM2 and UM3 with an average annual rainfall of 767 mm and mean annual minimum and maximum temperatures of 10.9^0C and 28.8^0C respectively. The soils are vitric, well drained, deep to very deep, brown to dark loams, sandy to clay loam andosol (Jaetzold *et al.,* 2007).

Thirty chickpea genotypes comprising one known tolerant check (ICC506) and a test susceptible commercial check (ICC4973) were evaluated. The experiment was conducted for two seasons; short rains (Nov 2008-March 2009) and long rains (April -August 2009) to ensure that material with good levels of resistance was identified under the different environmental conditions. During planting, no fertilizer was applied to the experimental plots. The plots were kept weed free throughout the season by manual weeding. The crop was protected against fungal diseases such as *Aschochyta* blight and *Fusarium* wilt with occasional sprays of Ridomil® at rates of 2.5g/litre of water.

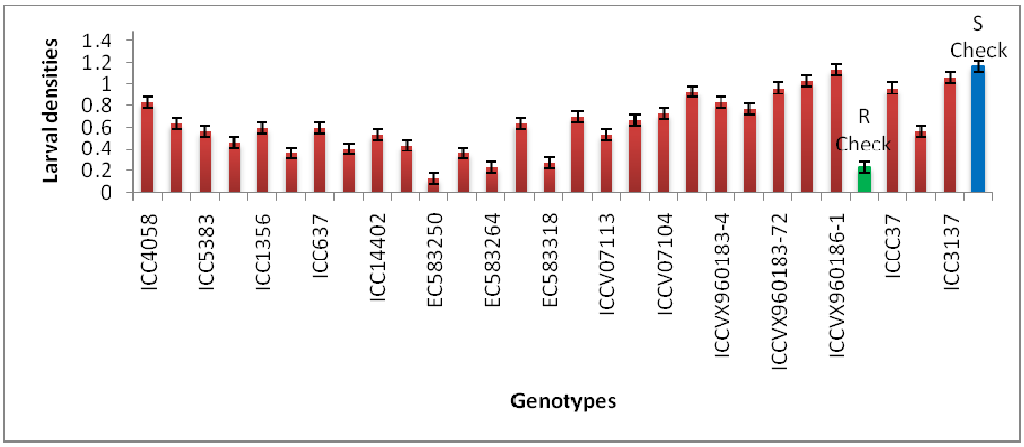
Data collected included number of larvae per plant (larvae density) at the vegetative, flowering and podding stages, total number of pods and the damaged pods per plant at podding stage. Leaf feeding damage, rated visually on a 1 to 9 scale, where 1 = <10% while 9 = >80% leaf area damage was determined. The data on leaf damage scores was used as a resistance rating for the genotypes where a score of 1 stood for very high resistance with leaves free from any damage and 9 representing very high susceptibility with >90% of leaves damaged (Singh and Weigand, 2004). Additionally, the number of days to 50% flowering, number of days to maturity, plant height (cm), biomass (kg/ha), 100-kernel weight (g), grain yield (kg/ha) and harvest index (HI) were measured.

Data were subjected to analysis of variance (ANOVA) using the GenStat Release 12.1 software (2009) and means separated using the Duncan's multiple range test (DMRT) at $P \leq 0.05$. Data on larval densities and percent pod damage were transformed using angular transformation, before analysis. Correlation analysis was done to determine the relationship between the *H. armigera* damage at various crop phenological stages, yield components and overall crop yield.

Results

Herlicoverpa Infestation Vegetative Stages

The 30 genotypes screened showed significant variability ($P<0.05$) to *H. armigera* infestation at this stage in the two seasons. Genotype EC583250 was least infested by *H. armigera* with larval density of 0.133 in season I compared to a larval density of 0.233 recorded on the resistant check (ICC506). Similarly, low infestation densities of 0.23 and 0.27 were observed in genotypes EC583264 and EC583318 in season I, respectively. These genotypes were not significantly different from the resistant check (Figure 1).



Key:

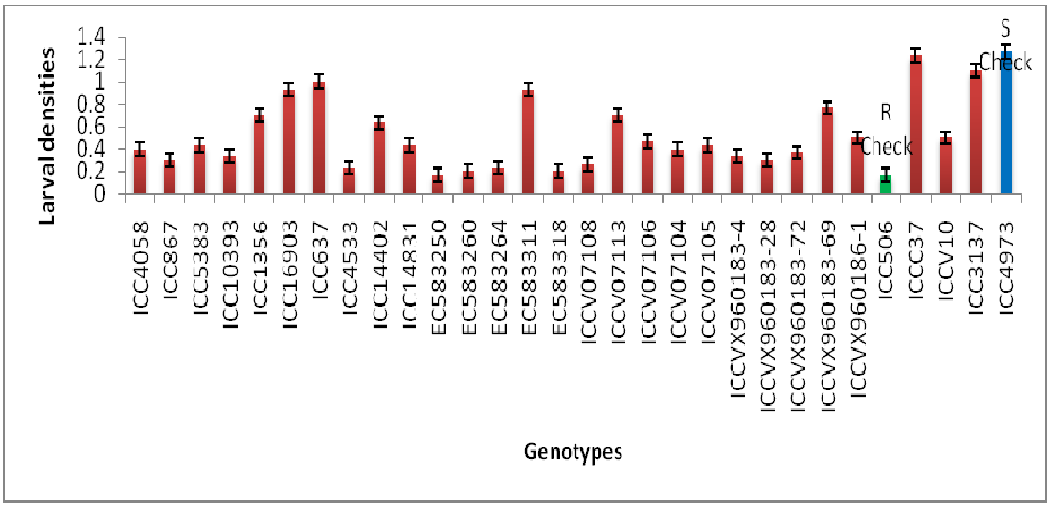
Resistant check Susceptible check

Test genotypes

Figure 1: Larval densities at vegetative stage in season I. Bars show standard errors

The highest larval density of 1.13 was recorded on genotype ICCVX960186-1 while the susceptible check; ICC4973 was heavily infested, recording a density of 1.17. Genotypes ICC4058, ICCV07105, ICCVX960183-72, ICCVX 960183-69, ICCVX960186-1, and ICC3137 were also not significantly different from the susceptible check with larval densities ranging from 0.13 on EC583250 to 1.13 on ICCVX960186-1 in season I (Figure 1).

In season II, the levels of infestation were comparatively higher at vegetative stage than in season I. Infestations ranged from 0.167 on EC583250 to 1.233 on ICCC37 (Figure 2). Genotypes ICC4533, EC583250, EC583260, EC583264 and EC583318 posted an average larval density of 0.2 against a density of 0.167 in the resistant check (Figure 2). Larval densities of more than 1.0 were observed in genotypes ICCC37, ICC3137 and ICC637.



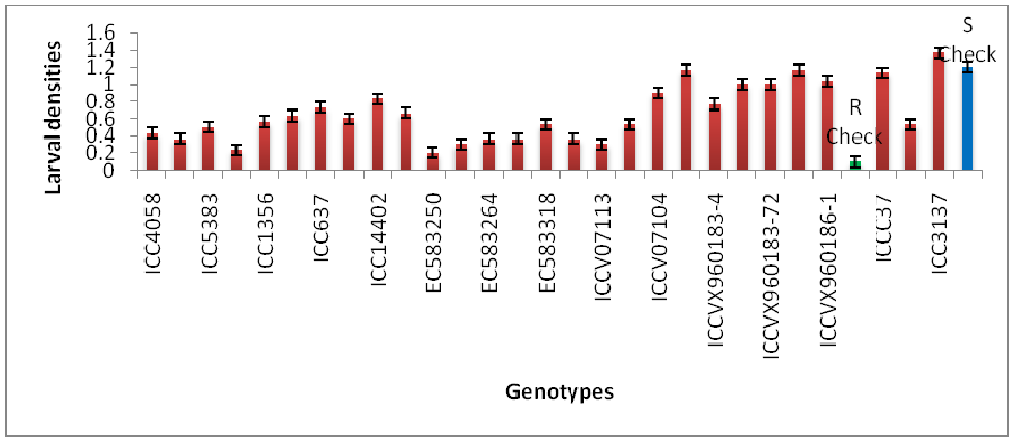
Key:

Resistant check Susceptible check Test genotypes

Figure 2: Larval densities at vegetative stage in season II. Bars show standard errors

Infestation at Flowering Stage

The second instar larvae were common and fed on the flowers, flower buds and foliage. There was no much variation on the mean larval density recorded between the vegetative and flowering stages in season I. A mean larval density of 0.663 was recorded at this stage as compared to 0.646 at vegetative stage. The larval density ranged from 0.2 on EC583250 to 1.367 on ICC3137. The density of larvae decreased drastically on the resistant check from 0.2 at vegetative stage to 0.1 at flowering stage. Larvae densities increased from vegetative on genotypes EC583250, EC583318, EC583264, ICC14402, ICC4958, ICCVX960183-28 and ICCV07105. The genotypes ICCC37, ICC3137, ICC07105, 1CCVX960183-72 maintained an average of 1.0 larval density between vegetative and flowering stages. The genotypes ICC10393, EC583250 had the least larval density and were not significantly different from the resistant check at this stage (Figure 3).

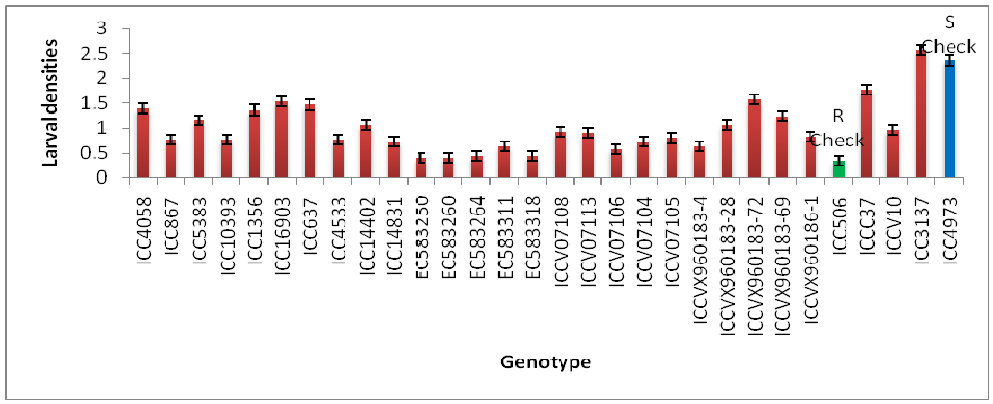


Key:

Resistant check genotypes | Susceptible check | Test

Figure 3: Larval densities at flowering stage in season I. Bars show standard errors

The insect infestation levels increased especially in season II from a mean density of 0.531 at vegetative stage to 1.02 at flowering stage. There was a high population build up of larvae between the two phenological stages as compared to season I. In season II, the larval density varied from 0.4 on genotypes EC583250 and EC583260 to 2.567 on ICC3137. The genotype ICC506 (check) had the least larval density of 0.333. The genotypes EC583250, EC583260, EC583264, EC583318, ICCV07106 and ICCCVX960183-4 did not differ significantly on supporting the average larval density of 0.42, which was the lowest at this stage (Figure 4).



Key:

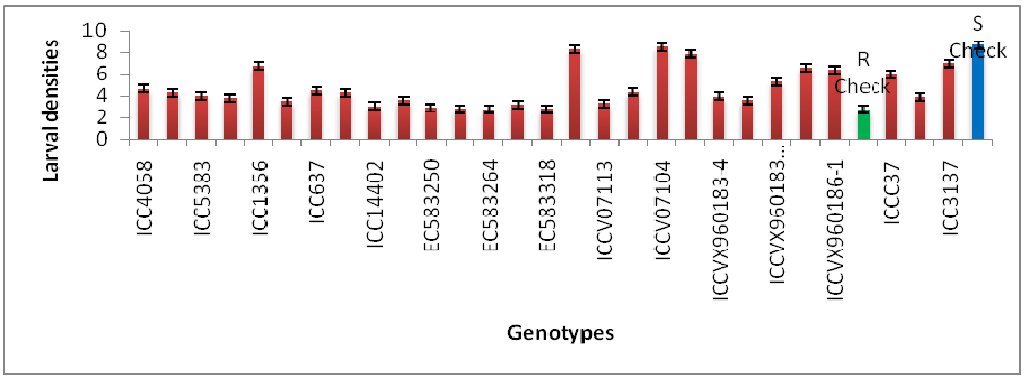
Resistant check genotypes | Susceptible check | Test

Figure 4: Larval densities at flowering stage in season II. Bars show standard errors

Infestation at Podding Stage

In both seasons, the density of the larvae increased drastically at this stage. A grand mean larval density of 4.763 and 2.388 was obtained in season I and II respectively. There was significant variation among the 30 genotypes in response to insect larvae infestation levels in the two seasons at P≤0.05. In season I, the larval density increased from a mean of 0.663 at flowering to 4.763 at podding whereas in season II it increased from 1.02 at flowering to 2.388 at podding stages. The fourth and fifth instars were common and found chewing veraciously on buds, flowers and pods, leaving characteristic round holes on the chickpea pods and feed on developing grain.

In season I, the lowest larval density of 2.733 was recorded on genotype EC583264. The same density of larvae was recorded on the resistant check (ICC506). The larval density ranged from 2.733 on the genotype EC583264 to 8.467 on ICC07104. The genotypesEC583250, EC583260, EC583264, EC583318, and ICC14402 were not significantly different in supporting the larvae at this stage of plant growth (Figure 5). The genotypes ICCV07108, ICCV07104, and ICCV07105 were not significantly different from the susceptible check (ICC4973) and an average larval density of 8.0 and were the heavily infested genotypes at this phenological stage of plant growth (Figure 5).

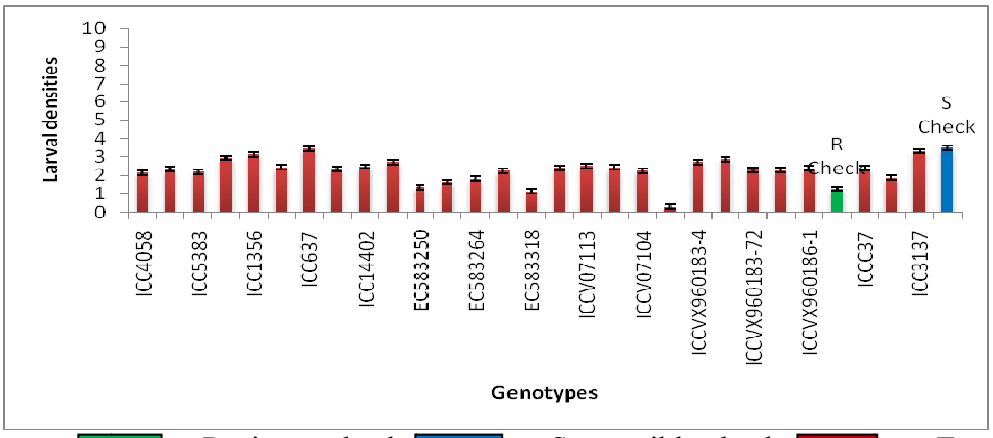


Key: Resistant check Susceptible check Test genotypes

Figure 5: Larval densities at podding stage in season I. Bars show standard error

In season II, the genotype ICCV07105 had the lowest larval density of 0.30 while the resistant check, ICC506 had 1.267. The genotypes EC583250, EC583260, EC583264, and ICCV10, were not significantly different in

supporting the larval densities and had an average density of 1.67 larvae. The highest larval density of 3.433 was recorded on genotype ICC637, while the susceptible check had larval density of 3.5. The genotypes, ICC3137 and ICC637 were not significantly different from the susceptible check (Figure 6).

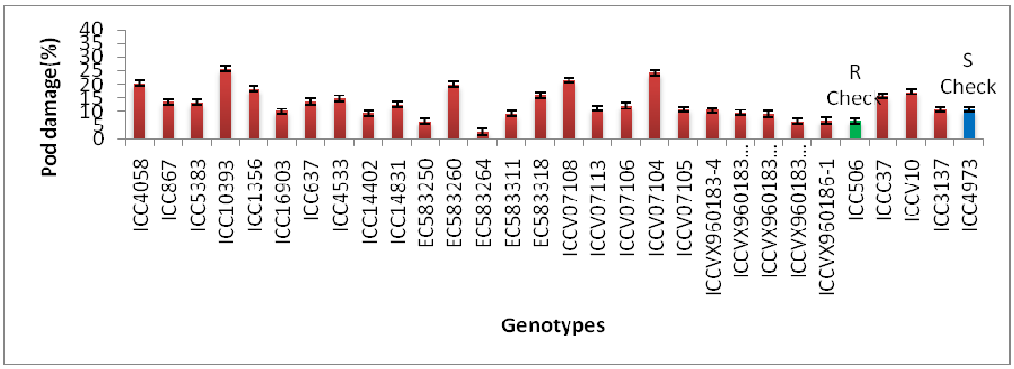


Key: Resistant check Susceptible check Test genotypes

Figure 6: Larval densities at podding stage in season II. Bars show standard errors

Pod Damage

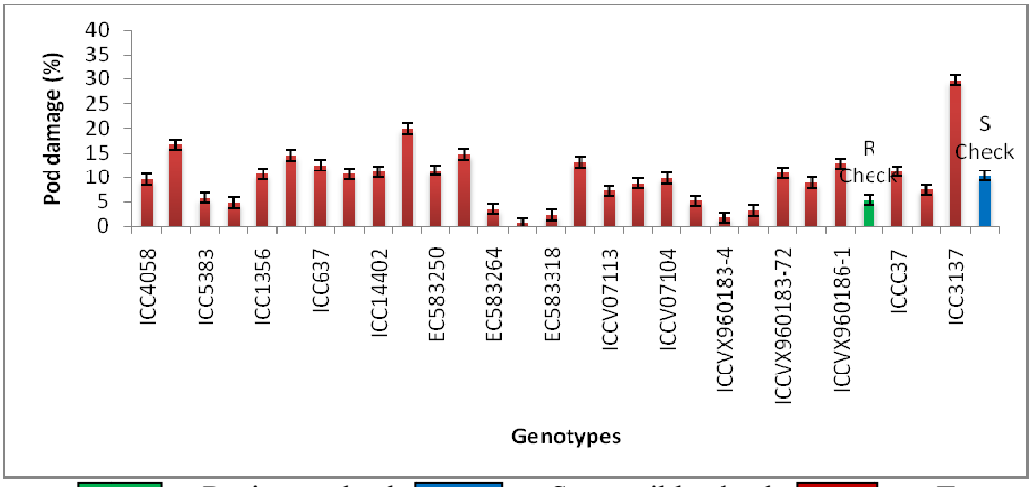
The *Helicoverpa* damaged pods turned whitish due to drying and can easily be distinguished from undamaged pods. In season I, mean pod damage of 12.95 percent was obtained as compared to 9.78 percent recorded in season II. The pod damage ranged from 2.53 percent on genotype EC583264 to 25.6 percent on ICC10393 (Figure 7). The resistant check recorded 6.57 % pod damage while the susceptible check had 10.73 percent pod damage. The genotypes ICC10393 and ICCV07104 recorded the highest pod damage of 25.6 and 24.17 percent respectively. The genotypes EC583250, ICCVX960183-69, ICCVX960186-1 were not significantly different from resistant check. ICC16903, ICC14402, ICCV07113, ICCV07106, ICC3137 and the susceptible check were not significantly different in pod damage percent obtained (Figure7).



Key: Resistant check Susceptible check Test genotypes

Figure 7: Percentage larval pod damage in season I. Bars show standard errors

In season II, the mean damage percent decreased by 3.17 as compared to season I. The pod damage percentage ranged from 0.57 on the genotype EC583311 to 29.7 on ICC3137, EC583311 and ICCVX960183-4 had the lowest pod damage percent recorded. The genotypes EC583264, EC583318 and ICCVX960183-28 were not significantly different in terms of pod damage percent obtained and recorded low pod damage percent as compared to resistant check, ICC506 (Figure 8).



Key: Resistant check Susceptible check Test genotypes

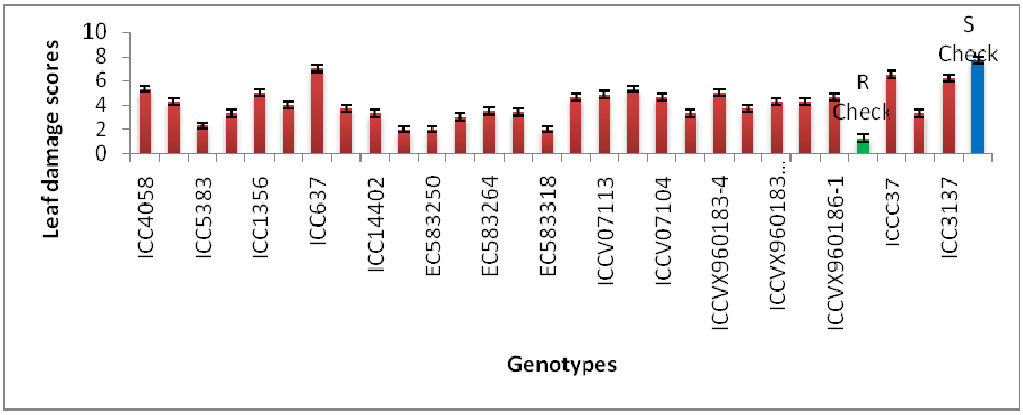
Figure 8: Percentage larval pod damage percent in season II. Bars show standard errors

Leaf Damage

The 30 genotypes showed high variability to leaf damage by the pod borer larvae. General observations indicated that genotypes with light coloured foliage and more spread were preferred by the pest than those with deep green colour and having a compact canopy structure. These genotypes also tended to be more hairy. Genotypes displaying these traits included EC583318, ICC506, EC583260, ICCV10, and EC583264. To the touch, genotype EC583260, had tough, hard leaflets and was found to be the least preferred by the pest. The pest preferred genotypes (ICC4973, ICCC37, ICC1356, and ICC3137) also had large leaflet area and soft leaves. The lowest leaf damage score of 1.3 was recorded on the resistant check, ICC506. Genotypes ICCV07113, ICC14831, EC583250, and EC583318 were not significantly variable in terms of leaf damage, recording the same leaf damage score (Figure 9). Genotypes ICC4058, ICC1356, ICC07106, ICCVX960183-4, ICCC37, and ICC3137 averaged 5.0 on leaf damage score while the susceptible check ICC4973 registered the highest leaf damage score of 7.7 (Table 1).

Table 1: Classification of the 30 genotypes by their resistance/ susceptibility to the pod borer

Genotypes	Category reactions
ICC506	Very highly resistant
EC583250, EC583318, ICC14831, ICC5383	Highly resistant
EC583260, EC583264, EC583311, ICC14402, ICCV10, ICCV07105, ICC10393	Resistant
ICC16903, ICC4533, ICC867, ICCVX960183-72, ICCVX960183-69, ICC867	Moderately resistant
ICCV07104, ICCV07108, ICCV07106, ICC4058, ICCVX960186-1, ICCV07113	Intermediate
ICC1356, ICCVX960183-4	Moderately susceptible
ICC3137, ICCC37, ICC637	Susceptible
ICC4973	Highly susceptible



Key: Resistant check Susceptible check Test genotypes

Figure 9: Leaf damage in the field. Bars show standard errors

Correlation Analysis of Larval Density, Yield Components and Yields

Results of the correlation analysis indicated a significant positive correlation of larval densities at vegetative, flowering, and podding stages of the chickpea crop in both seasons I and II. In season I, the pod damage percentage was positively correlated to larval densities at vegetative, podding stages but negatively correlated at flowering stage (Table 2). Larval densities at vegetative, flowering, and podding stages were positively correlated with plant height. The larval densities at podding stage were positive and significantly correlated to harvest index and plant height. The number of days to 50% flowering was significant and positively correlated to yield while the number of days to maturity was negatively correlated to the realized yield. Plant vigour was significant and positively correlated to the yield obtained and the number of larvae at vegetative and podding stages, but negatively correlated to 50% flowering. Plant biomass and kernel weight were positively correlated to plant vigour (Table 2).

Table 2: Correlation coefficients of *H. armigera* larvae infestation at vegetative, flowering, podding, pod damage percent, yield and yield components. (Season 1)

	LCV	LCF	LCP	PDP	BIO	HI	KWT	DF	DM	PHGT	PV
LCV	1										
LCF	0.76**	1									
LCP	0.65**	0.54**	1								
PDP	0.07	-0.10	0.18	1.00							
BIO	0.10	0.08	0.06	-0.07	1.00						
HI	0.03	-0.05	0.24*	0.05	-0.10	1.00					
KWT	0.16	-0.09	0.18	0.24*	0.06	-0.03	1.00				
DF	0.07	0.16	-0.13	-0.17	0.12	-0.57**	-0.17	1.00			
DM	0.14	0.14	-0.02	-0.17	0.18	-0.28*	0.02	0.26*	1.00		
PHGT	0.22*	0.33*	0.28*	0.08	0.10	0.01	0.15	-0.13	-0.11	1.00	
PV	0.17	-0.04	0.15	-0.06	0.26*	0.12	0.22*	-0.02	-0.08	0.16	1.00
Y/HA	0.06	-0.02	0.18	-0.02	0.70**	0.62**	0.01	-0.35**	-0.2	0.08	0.27**

Key: LCV-larval counts at vegetative stage, LCF-larval counts at flowering stage, LCP -larval counts at podding stage, PDP-pod damage percent, BIO-plant biomass, HI- harvest index, KWT-kernel weight, DF-days to 50 % flowering, DM- days to 75 % physiological maturity, PHGT-plant height, PV-plant vigour, Y/HA-yield per hectare, *-significant at $P \leq 0.05$ and **-significant at $P \leq 0.001$

In season II, the pod damage percentage had a positive and significant correlation to larval density at vegetative, flowering and podding stages of plant growth (Table 3). Biomass was significantly correlated to larvae density at podding stage and negatively correlated to the density of larvae at vegetative and flowering stages. Harvest index had a positive significant correlation with larvae density at vegetative and flowering stages; however, the correlation was not significant with larval density at podding stage and pod damage percentage. Plant height was positively correlated with larval density at flowering, but was negatively correlated with the number of days to flowering.

The yield obtained per hectare in season II correlated positively with biomass, harvest index, plant vigour, kernel weight and days to maturity. The yield also positively correlated with larval density at the vegetative and flowering stages but was negatively correlated at the podding stage. Though not significant the pod damage percentage was negatively correlated to the yield realized in the two seasons; in season I it was significantly correlated to harvest index (Table 3).

Table 3: Correlation coefficients of *H. armigera* larvae infestation at vegetative, flowering, podding, pod damage percent, yield and yield components. (Season II)

	LCV	LCF	LCP	PDP	BIO	HI	PV	KWT	DF	DM	PHGT	Y/HA
LCV	1											
LCF	0.6114**	1										
LCP	0.4907**	0.5985**	1									
PDP	0.2788**	0.4273**	0.2641*	1								
BIO	-0.1719	-0.1624	-.2238*	-0.0687	1							
HI	0.2561*	0.2213*	0.0647	0.1966	-0.0186	1						
PV	-0.0409	-0.1086	-0.1552	-0.0014	-0.1133	-0.0423	1					
KWT	0.0095	0.0089	-0.0708	0.0418	0.1842	-0.0996	0.0991	1				
DF	0.0112	-0.1032	-0.1463	.4165**	0.0082	0.065	-0.1457	-0.0127	1			
DM	-0.4115**	-0.0444	-0.0317	0.0527	-0.0359	-0.1025	-0.0779	0.0162	-0.0368	1		
PHGT	0.0975	0.2087*	0.1589	0.1865	-0.124	-0.1365	0.3098*	0.1147	-0.4045*	0.0488	1	
Y/HA	0.0847	0.1634	-0.057	-0.0052	.2182**	.6518**	.6518*	0.3098*	0.1147	-.4045**	0.0488	1

Key: LCV-larval counts at vegetative stage, LCF-larval counts at flowering stage, LCP -larval counts at podding stage, PDP-pod damage percent, BIO-plant biomass, HI- harvest index, PV-plant vigour, KWT-kernel weight, DF-days to 50 % flowering, DM- days to 75 % physiological maturity, PHGT-plant height, Y/HA-yield per hectare , *-significant at P≤0.05 and **-significant at P≤0.001.

Discussion

Field screening of *Helicoverpa armigera*

The field studies have shown that the chickpea selections have variable response to levels of infestation in the field and damage by *Helicoverpa armigera* larvae. The variability in the infestation levels per genotype can be attributed to varying amounts of chickpea foliar secretions containing high concentrations of malic acid. These volatiles from the plants play an important role for host location. This explains the observed patterns of variability in the larval counts per genotype. The genotypes, ICCV10, EC583318, EC583260, EC583311 and EC583264 attracted fewer larvae as compared to ICCC37, ICC1356, ICC4973 and the difference could be explained by the varying amounts of foliar volatiles. The pest can therefore be controlled by selection of these genotypes which are believed to release low foliar concentrations of malic acid. The preference or non-preference for a given genotype is because of difference in canopy structure of the plant (Muhammed *et al.,* 2009). The genotypes, EC583318, EC583260, ICCV10, ICC14831, EC583311 and EC583264 with a dense kind of canopy, which influences the movement and feeding of the borer's larvae and as result low larval density was recorded on these genotypes. These genotypes were also associated with smaller leaflets and high density of trichomes per unit leaf area. The higher trichome density has a role in imparting resistance /tolerance against chickpea pod borer (Girija *et al*., 2008). Other resistance mechanism as exhibited by EC583260 could be hardiness of the leaves due to high contents of lignin, hemicellulose and cellulose. The low infestation of larvae in this genotype can be attributed to pod borers' inability to chew this genotype with ease and non-preference for this genotype. The genotypes such as ICC3137, ICC1356, ICCC37, ICC637, ICCVX960183-4 and ICC4973 had spread pattern of canopy structure with large soft leaflets and were more preferred by the pest. These genotypes tended to be susceptible by supporting high a population of the pod borers in the two seasons.

The larval counts increased with crop growth in the field by 346 and 175 per cent in both Seasons II and I respectively from vegetative to podding stage. The amount of foliar exudate and the concentration of malic acid depend on temperature, growth stage and has been shown to increase at the reproductive stages of the plant (Muhammed *et al.,* 2009). This gives a reason why there were high larval counts during podding stage as compared to vegetative and flowering stages. The population fluctuations of *H. armigera* on the chickpea can also attributed to the weather patterns during the cropping season. The important factors indicating the probability of population build up were high temperatures and low rainfall. In season II, occasional heavy torrents of rain

over the growing period, tended to wash and destroy the noctuid eggs on the plant and led to breakdown of pupation chambers in the soil preventing the adult emergency resulting to low population over the cropping season.

The genotypes having light green colour foliage (ICC4973, ICC1356, ICC37 and ICC637) were preferred by the pest and had high larval counts. The difference in foliage colour is a good criterion for the determination of resistance in chickpea against gram pod borer (Susanne, 1990). The colour changes or difference unveils the role of the plant constituents in its formation, which could act as anti-feedants to the insect larvae. The genotypes EC583250, EC583260, ICCV10, ICC14402 and EC583311 with deep green colour were non-preferred and attracted low larval counts. The possible mechanisms of resistance could be physical factors/morphology of the leaflets (hardiness, hairiness and size), composition and amount of leaf exudates.

Conclusion

The chickpea genotypes EC583250, EC583318, EC583260, ICCV10, ICC14831 and EC583264 were identified to have resistance to *H. armigera* with comparable yields. We therefore recommend them for use in chickpea breeding programmes to confer resistance to the susceptible and high yielding varieties. Specifically, genotype EC583264 showed high resistance to *Helicoverpa* larvae and possesses other outstanding desirable traits such as high yields, biomass and harvest index and can be advanced as a variety for release to farmers**.**

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