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Genotypic response of chickpea (*Cicer arietinum* L.) for resistance against gram pod borer (*Helicoverpa armigera*)

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Abstract:

Background: Chickpea is an important pulse crop of Pakistan. The pod borer, *Helicoverpa armigera* (Hubner), is the major pest in most of the chickpea growing areas of the country. A field trial was carried out at Entomological Research Area, Ayub Agriculture Research Institute (AARI), Faisalabad, during growing season of 2012-13 to evaluate the resistance of chickpea genotypes against gram pod borer (*Helicoverpa armigera*).

Methods: Experiments were conducted in randomized complete block design (RCBD) with four replications having plot size of 3 ft × 20 ft. Morphological characters of chickpea like pod trichome, pod wall thickness, pod length, pod breadth, pod area and number of pods per plant were measured. The pod borer larval population/pod infestation was recorded from fifteen randomly selected plants per plot after ten days interval.

Results: It was found that the genotypes which had higher trichomes length and density and pod wall thickness were more resistant against *Helicoverpa* infestation. Significant genetic variation for resistance against *Helicoverpa armigera* attack was found in chickpea and variety K-70005 showed resistant behavior followed by K-08004 and K-60062.

Conclusions: It was concluded from prescribed study that the most susceptible genotypes were K-70005, K-08004 and K-70008 for the attack of *Helicoverpa armigera* to reduce grain yield.

Key words: Chickpea, Genetic variation, *Helicoverpa armigera*, Pod borer, Resistance

Introduction

Chickpea is considered to be the third most important grain legume in the world being extensively grown in almost 45 countries of the world [1]. It is also grown over large acreage in northwestern USA, Australia, and the Mediterranean basin [2]. It is not only an important source of feed and food, but it also adds nitrogen to soil which increases soil richness [3]. Chickpea is a crop of sandy soils but for the last few years it is being grown on irrigated lands after the harvesting of rice as cereal-legume rotation for reducing the exhaustion of rare soil nutrients [4].

Chickpea comprises 17.2% protein, 5.4% fat and 3.0% minerals wherein the nutrition vitality is about 1507 kJ. The dependable values for de-husked splitting chickpea are 21.8%, 5.8% and 2.9% respectively. They are also a source of high-quality protein, so known as “a poor man’s meat” [5]. Chickpea is a cool dry season crop, mostly grown in rain-fed areas of Pakistan [6]. Chickpea is the main grain legume of Pakistan, cultivated over 1.05 mha covering 75 percent of the total area under pulses. Total production of the chickpea in Pakistan was 291,000 tons [7]. Over the time, progress in chickpea production and grain yield is low in comparison with rest of the world and latent production of chickpea strains. High nutritional value, low water and nutrients requirements and fertility restoration are the significant features of the chickpea crop [8-10].

Among the key yield regulating components of chickpea; insects, pests and diseases cause severe damage to the crop. Chickpea pod borer (CPB), *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is the utmost damaging pest of the chickpea (*Cicer arietinum* L.) and it is one of the main threatening factor for its production all over the world that caused great yield losses [11-14]. Latent yield of chickpea crop is very low in Pakistan mostly due to the lack of improved varieties appropriate for cultivation both in irrigated as well as rain-fed areas. This problem can be stunned by developing high yielding genotypes to improve the living style of chickpea growing farmers [15,16]. The significance of large sized seed as an essential yield contributing factor in chickpea is well known by chickpea breeding programs in the world [17-20]. Upadhyaya *et al.*, [21] indicated large seed size as skill related trait and component of yield and adaptation in chickpea. Host plant resistance bids a real implement in integrated pest management [22] for control of pest as compared to many other control methods [23,24]. Although, this pest can be controlled by using different integrated methods but host plant resistance is very effective and economical method to control CPB [25,26]. Considering the above factors, the present research was conducted to determine resistance/susceptibility of chickpea varieties against *Helicoverpa armigera* under field conditions.

Methods

This research was conducted at Ayub Agriculture Research Institute (AARI), Faisalabad during the growing season of 2012-13. The K-60062, K-08003, K-08004, K-06005, K-70005, Ks-06006 and K-70008 chickpea varieties were used to assess the resistance potential of chickpea against *Helicoverpa armigera* infestation in relation to pod morphological traits. The experiment was laid out in a randomized complete block design (RCBD) with four replications. The treatments were randomly allotted to each block. The seeds of respective varieties/lines were sown on November 22, 2012 in rows with spacing of 30 cm and plant to plant distance of 15 cm. The gross plot size was maintained 3 ft × 20 ft. All other agronomic factors except the factor under study were kept constant. Usual cultural practices were adopted to maintain a good crop. The observations regarding the pod damage were recorded at the time of pest appearance by counting the total number of pods and number of pods damaged by the pest from 15 randomly selected plants from each plot at 10 days interval up to maturity. Recommended agronomic practices were carried out through the growing season.

Statistical Analysis

The data was statistically analyzed following Fisher’s analysis of variance technique and least significant difference [27] test was used to compare the treatments’ means at 5% probability level.

Results

Analysis of variance reveals significant differences among the comparative performance of different chickpea varieties against all studied traits, presented in (Tables 1 & 2).

Effect of pod borer damage on pod length

The recorded observation showed that K-70005 performed better and highest pod length (2.05/cm) was observed for K-70005. The second highest pod length (1.84/cm) was found in variety K-08004 following the varieties K-06006 (1.79/cm), K-06005 (1.76/cm) and K-60062 (1.69/cm). The lowest pod length was found for K-70008 (1.49/cm) which was statistically similar to variety K-08003 (1.53/cm) (Fig 1a).

Figure 1: Performance of varieties against the attack of pod borer for pod length (a), pod breadth (b), pod area (c) and pod wall thickness (d)

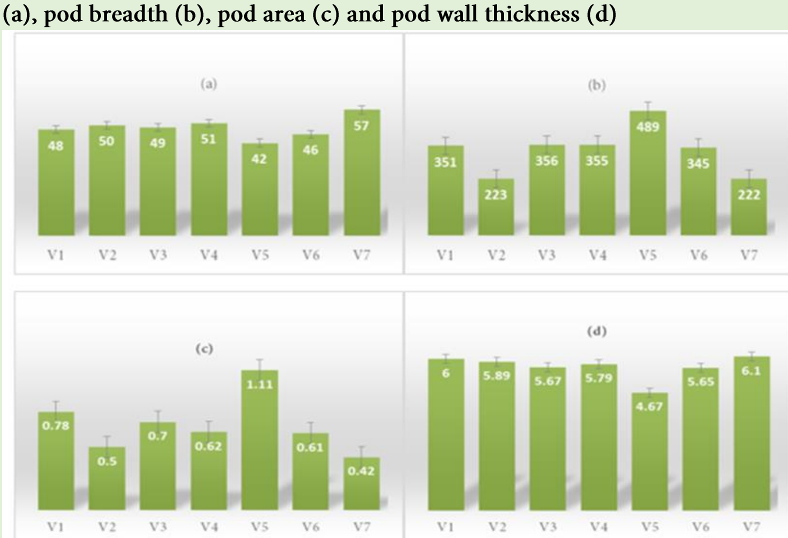

Figure 2: Performance of varieties against the attack of pod borer for pod trichome length (a), pod trichome density (b), no. of pods/ plant (c) and Pod infestation %age after 10 days (d)

Effect of pod borer damage on pod breadth

The recorded observation showed that K-70005 (1.06) performed better as compared to other varieties. The lowest pods breadth was recorded (0.71) for variety K-70008 which was statistically at par with K-08003 (0.74) (Fig 1b).

Effect of pod borer damage on pod area

The maximum pods area (2.02/sq.cm) was recorded for K-70005 following by K-08004 (1.92/sq.cm), K-60062 (1.91/sq.cm) and K-06005 (1.83/sq.cm). The lowest pod area was (1.57/sq.cm) was noted for the variety K-70008 which was statistically same to K-08003 (1.59) (Fig 1c).

Effect of pod borer damage on pod wall thickness

The recorded observation showed that K-70005 performed better and highest pod wall thickness (0.14 /mm) was observed for K-70005. The second maximum and statistically same pod wall thickness was attained for K-60062 (0.13/mm) and K-08004 (0.13/mm). The least pod wall thickness was found for K-70008(0.10/mm) which was statistically similar to K-08003 (0.11/mm) (Fig 1d).

Effect of pod borer damage on pod trichome length

Recorded observation showed that K-70005 performed better and premier pod trichomes length (1.12/mm) was observed for K-70005. The second uppermost pod trichomes length (0.76/mm) was obtained for K-60062 following the variety K-08004 having the value (0.69 /mm). The lowest pod trichome length recorded for K-70008 (0.47/mm) was statistically similar to K-08003 (0.48/mm) (Fig. 2a).

Effect of pod borer damage on pod trichome density

The recorded observation showed that K-70005 performed better and highest pod trichome length (483.75/sq.cm) was observed for K-70005. Trichome density of pods (359.50/sq.cm) was found highest for K-08004 followed by K-06005 (352.50/sq.cm), K-60062 (351.50/sq.cm) and K-06006 (351.25/sq.cm). The lowest pod trichome density found for K-70008 was 239.50 /sq.cm, which was statistically similar to K-08003 (245.75/sq.cm) (Fig. 2b).

Effect of pod borer damage on No. of pods/ plant

The recorded observation showed that K-70008 performed better and gave more number of pods per plant (60.00) in chickpea and statically at par with the results of variety K-08003 which produce 56.25 pods per plant. Both varieties K-08003 and K-70008 have more number of pods per plant than all others (Fig. 2c).

Pod infestation %age after 10 days

The maximum pod-infestation after 10 days was recorded to be 6.38% on genotype K-70008 followed by K-08003 (6.03%) and K-60062 (5.98%). The variety K-70005 performed better against the infestation of gram pod borer when data of pod infestation was taken at 10 days interval. Pod infestation for K-70005 appeared to be 4.88%. This was the least infested variety among all seven varieties and showed maximum resistance against chickpea pod borer (Fig. 2d).

Pod infestation %age after 20 days

The maximum pod-infestation was recorded to be 7.59% on genotype K-70008 followed by K-08003 (7.48%), K-06006 (7.16%) and K-08004 having the pod infestation 6.93%. The variety K-70005 performed better against the infestation of gram pod borer and minimum pod infestation was recorded for this having the pod invasion 6.32% which did not differ significantly from 6.38% recorded on variety K-06005 (Fig. 3a).

Pod infestation %age after 30 days

The maximum pod-infestation after 30 days was recorded to be 8.95% on genotype K-70008 followed by K-08003 (8.93%) and K-60062(8.59%). The variety K-70005 performed better against the infestation of gram pod borer when data of pod infestation was taken at 30 days interval. Minimum pod infestation (6.98%) was recorded for this variety which was statistically similar to K-08004 having pod infestation 7.82% (Fig. 3b).

Pod infestation %age after 40 days

The maximum pod-infestation after 40 days was recorded to be 10.84 % on genotype K-70008 followed by K-08003 (10.63 %) and K-06005 (9.57%). The variety K-70005 performed better against the infestation of gram pod borer when data of pod infestation was taken at 40 days interval. The pod infestation was recorded as 8.98% which was statistically similar to K-08004 (9.10%) followed by K-60062 (9.47%) and K-06006 (9.50%) as shown in Fig. 3c.

Pod infestation %age after 50 days

The maximum pod-infestation after 50 days was recorded to be 10.11% on genotype K-70008 followed by K-08003 (10.07%) and K-06005 (8.92%). The variety K-70005 was proved to be resistant against the pod borer as it showed pod infestation of only 8.38%. This data was statistically similar to the variety K-08004 (8.49%) followed by K-60062 (8.83%) and K-06006 (8.87%) as shown in Fig. 3d.

Figure 3: Pod infestation %age after 20 days (a), Pod infestation %age after 30 days (b), Pod infestation %age after 40 days (c) and Pod infestation %age after 50 days (d)

Source	D.f	Pod length	Pod breadth	Pod area	Pod wall thickness	Pod trichome length	Pod trichome density
Block	3	0.097	0.013	0.054	2.36E-05	0.004	823.1
Treat	6	0.151**	0.053**	0.122**	0.0008**	0.189**	26960.5**
Error	18	0.015	0.003	0.027	1.13E-04	0.003	550.5
Total	27						

Table 1. ANOVA for various traits of chickpea against attack of pod borer

Source	D.f	Pods/plant	Pod infection % 10 days	Pod infection % 20 days	Pod infection % 30 days	Pod infection % 40 days	Pod infection % 50 days
Block	3	44.036	0.54893	0.15492	0.40889	1.89573	1.55082
Treat	6	308.417	0.9175	1.03863	1.91826	2.09532	2.00906
Error	18	20.702	0.28782	0.22435	0.48739	0.75942	0.67868
Total	27						

Table 2. ANOVA for various traits of chickpea against attack of pod borer

Discussion

The results regarding the pod length showed that higher pod length had received lower pod damage and this result is correlated with the findings of the Clement *et al.* [28] who reported that several characters like pod length, trichomes length of pods and pod wall thickness give resistance against Helicoverpa. While Hossain *et al.* [29] reported that outcomes of genotypes of chickpea which have greater pod length have lesser pod borer damage. According to the results (Fig. 1c) the chickpea genotype containing the larger pod area expected inferior pod borer damage and genotypes having lower pods area suffered higher pod borer damage. The results given above in the table correlates to Hossain *et al.* [29] who reported that area of particular genotypes exhibited substantial result in developing tolerance mechanism against pod borer damage. Relationship learning presented an adverse association amongst, pod breadth, pod length and area to pod borer damage. The pods showing greater length, breadth and area are least effected by the gram pod borer. The recorded observation showed that the variety K-70005 performed better having value 1.06/cm (Fig. 1a,b,c). This result showed negative insignificant relation with the pod borer damage. The Variety K-70005 had more pod breath therefore it received low pod borer damage as compared to other varieties. This result correlates with Hossain *et al.* [30] who reported that association study also showed negative irrelevant relationship ($y = -23.337x + 34.985$; $R2=1.002$) between pod breadth and pod borer damage. These conclusions showed that the genotypes of chickpea bearing more pod breadth received inferior pod borer damage. These results are also in accordance with Ali *et al.* [31] who reported that correlation studies of biomass per plant, pod breadth, number of pods per plant, number of secondary branches per plant, number of seeds per pod and 100-seed weight were optimistic and important at genotypic level but positive and extremely significant at phenotypic level which specified that choice for high yielding genotypes can be made on the base of these qualities.

According to the results (Fig. 1c) the chickpea genotypes having larger pod area received minor pod borer damage and genotypes having lower pod area suffered higher pod borer damage. The results given above in the table correlates to Hossain *et al.* [30] who reported that area of individual genotypes revealed major influence to produce resistance against chickpea pod borer damage. parallel studies presented a negative association between pod breadths, pod length and pod area against pod borer damage. The pods having higher length, breadth and area are not desired by the pod borer. Results (Fig. 1d) showed that due to increase in the pod wall thickness, less pod borer damage was recorded on the genotypes. This result is in line with the results of Ujagir and Khare [32] and Shanower *et al.* [33], they have recognized pod wall thickness as a resistance mechanism against pod borer damage.

Results showed that with the increase in pod trichome length less pod infestation was recorded (Fig. 2a). These results correlate with the findings of Peter *et al.* [34] and Romies *et al.* [35] who stated that the length and density of trichomes on the pods of pigeonpea plant have the ability to develop resistance in host plant against the attack of *H. armigera*. Such findings have also been reported by Jeffree [35]; David and Easwaramoorthy [35,36] and Hossain *et al.* [27-28] in which they reported that different types of trichomes and their coordination, length and density are associated with reduction to destruction in numerous crops by the insect. According to the present study the increase in pod trichomes density, less pod infestation was recorded (Fig. 2b) [32-33]. Some other researchers have also described that in pigeonpea crop, pods having the higher length and density of pod trichomes had delivered great potential resistance in the host plant against the pod infestation. Density of pod trichomes observed in our results are also similar with the results of Shanower *et al.* [31] who observed that trichomes present on pods of Cajanus spp. had provided a resistance to the attack of gram pod borer. They suggested that by increasing the viscosity of non-glandular trichomes in pigeonpea, pods could diminish devastation and losses due to pod invasion affected by chickpea pod borer. Several morphological features which give anti-xenosis had been used for breeding the varieties to produce resistant mechanism against *H. armigera* damage.

According to the results shown in Fig. 2c, the genotypes of chickpea presenting more number of pods per plant potentiality got damage caused by gram pod borer and those genotypes which have lesser number of the pods per plant suffered lower injury caused by chickpea pod borer. These results correlates with the results of Hossain *et al.* [29] who described that pod borer damage was positively influenced by number of pods per plant i.e. the chickpea varieties exhibiting greater number of pods potentiality received higher damage caused by pod borer. Different chickpea genotypes displayed imperative difference in podding potential. The occurrence of injuries caused by pod borer was also affected by number of pods per plant. The maximum damage caused by chickpea pod borer was perceived in the varieties generating maximum number of pods per plant. This happened generally because more pods were available to the gram pod borer for feeding with making less movement. This was generally similar to the results of Melchinger *et al.* [37] who identified positive relationship between the pod borer damage and number of pods per plant.

All the varieties of chickpea such as K-60062, K-08003, K-08004, K-06005, K-70005, K-06006 and K-70008 performed differently against the attack of *H. armigera* in terms of pod length, pod breath, pod area, pod wall thickness, pod trichomes length, pod trichome density and number of pods/plant that exhibit resistance to pod borer attack. The variety K-70005 showed great resistance against pod infestation 8.38% (Fig. 3) through the experiment due to having better morphological characters linked to resistance followed by K-08004 (8.49%) and K-60062 (8.83%). The most susceptible variety was K-70008 having higher pod infestation (10.11%) which was statistically at par with K-08003 (10.07%). Such genotypic variation in chickpea for resistance against pod borer was also reported by Jeffree [35]; Ali Q *et al.* [38]; Peter *et al.* [31]; Ujagir and Khare [30]; Hossain *et al.* [26]. So, this genotypic variation can be exploited in future breeding programmes to make pod borer resistance chickpea varieties.

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