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Integrated management of *Helicoverpa armigera* on different genotypes of Kabuli chickpea in Punjab, Pakistan

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Abstract

Gram Pod borer (*Helicoverpa armigera* Hubner) is the most imperative constraint in chickpea (*Cicer arietinum* L.) production causing severe losses or there may be complete crop failure in spite of several rounds of insecticidal applications. The present study was designed to investigate the effect of neem application in controlling Pod borer on six different genotypic varieties (AZ-CM2, AZ-CM4, AZ-CM6, AZ-CM10, AZ-CM12 and Noor-91). The experiment was designed in a Split-Plot Design with three replicates. Different agronomic traits were recorded such as plant population, plant height, percentage flowering, physical maturity, number of pod per plant, infestation of pod borer and yield of chickpea. The results showed that plants treated with neem have high population (maximum in Noor-91 with 16.8 plants/m^2 and minimum in AZ-CM12 with 2.9 plants/m^2, plant height (46.7 cm in AZ-CM4 and 34.7cm in Noor-91), flowering (AZ-CM10 gave 50% flowers after 100.3 days), physical maturity (AZ-CM4 took maximum time (139.7 days) to attain 90% physical maturity while AZ-CM2 and AZ-CM4 took only 136.0 days to attain 90% physical maturity), average number of pods (Noor 91 has higher 19.4 and AZ-CM2 has lowest 12.1). Infestation of pod borer and % damage was found lower in neem sprayed plant. Overall highest yield was observed in plants treated with neem as compared to control and genotype dependent. It is concluded from the results that neem application has a significant effect in controlling pod borer and this effect varies genotype to genotype. Noor-91 was found to be more resistant towards pod borer.

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Introduction

Chickpea (*Cicer arietinum* L.) is ranking the second main legume food obtained by resource-poor cultivars in the arid and semi-arid regions of the world. The genus *Cicer* was originated in South-Eastern Turkey and reached to other regions of world. It is adapted to comparatively cooler climates. Globally, cultivation of chickpea in 45 countries of the world including all the continents and occupied 12.14 million hectares cultivated area with the production, of 11.3million tones (Kumar and Abbo, 2001).

The largest area of adaptation where much production occurs is the Indian sub-continent Chickpeas are categorized into two distinct types: the small-seeded 'desi' with brown-coloured seed coat accounts 90% and the large-seeded cream or beige-coloured 'kabuli' accounts up to 10%. Kabuli chickpeas are cultivated mostly in Pakistan, Turkey, Ethiopia, Syria, Spain, Canada, the United States, Mexico and Portugal (Krishnamurthy *et al.,* 2013).

Chickpea seeds are very nutritious, comprising ~25-29% protein (Hulse, 1989) while 4-10% fat, 52-71% carbohydrate, and 10-23% fiber, minerals and vitamins (Jukanti *et al.*, 2012). Additionally, the seed protein containing necessary amino acids such as lysine, methionine, threonine, valine, isolucine and leucine to provide necessary components of human diet which are useful for maintains of health and fix atmospheric nitrogen and improve the soil fertility. It is a crop with self-pollination having a basic chromosome number 8 and a 739-Mb genome size (Varshney *et al.*, 2014).

Due to rapid increase in population with the passage of time, demands for food grains and usual proliferation efforts require to be supplemented by genomics-assisted breeding (GAB) (Varshney *et al.*, 2013). Agricultural practice improved genotypic traits which ensure survival of chick pea has been functional in plant reproduction which incorporate reserve remobilization (Blum, 2005). It is estimated from throughout about 90% total yield of chick pea is obtained from rain-fed areas including arid and semi-arid regions (Kumar *et al.,* 2001).

In drier and warmer regions of semi-arid tropics of East Africa, Chickpea is considered as a chief protein source for the population in arid and semi-arid world (Kimurto *et al.*, 2013).

Chickpea is cultivated in 45 countries of the world and covers an area of 11 m ha with yield of 9 million tones. Kabuli chickpea is generally cultivated in temperate and subtropical regions and it covers nearly 10% of the total production of the world. Chickpea was considered to be an orphan legume for only a few years ago due to insufficient genomic assets for implementing GAB. Yet, the accessibility of chickpea genome sequence information (Varshney *et al.*, 2013) and extensive genomic resources (Varshney *et al.*, 2013) have changed the crop into a resource rich crop like any other main crop species.

H. armigera (Hubner) (Lepidoptera: Noctuidae) which is Chickpea pod borer (CPB), the main notorious pest of chickpea which destroy the crop on large scale. It is one of the most important limiting factors for its production many regions of the world (Sharma *et al.*, 2005). *H. armigera* also causes productivity losses in many vegetables and crops such as cotton, okra, tomato. About 50-60 % damage was recorded in chickpea due to *H. armigera* (Verma *et al.*, 2015).

Larvae of *H. armigera* causes serious damage to chickpea crop during the fruiting stage, originally by appearing on new leaves then shifting to flowers, young shoots and as a final point entering the pods. A single larva can damage many pods before reaching the pupal stage. It is another factor that *H. armigera* has developed resistance against conventional insecticides due to overuse (Kranthi *et al.*, 2002). Large genetic variation for the different traits has been reported and the breeder can make use of it to evade the damage caused by the *H. armigera* in crop of chickpea. Therefore, the breeding target should be identified, characterized and develop genetic mechanism that confers durable resistance to *H. armigera* (Dua *et al.*, 2001).

Improvement of farmers with resistance to *H. armigera* might provide a valuable approach in integrated pest management (IPM) to reduce the productivity losses of chickpea (Sharma *et al.*, 2005). The use of pheromone trap + BT + Ha NPV effectively control pod borer (*H. armigera*) in chickpea (Kumari *et al.*, 2015). Studies have been conducted by a number of researchers on screening of chickpea varieties for resistance and tolerance against *H. armigera* (Rashid *et al.*, 2003; Shafique *et al.*, 2009; Ali *et al.*, 2016).The aim of the present study was to control the damage caused by *H. armigera*on important crop chickpea by applying integrated management to improve the yield of chickpea.

Materials and methods

Site description

The control experiment was conducted at the research farm, University of Agriculture Faisalabad, while repeated field experiment and survey was conducted in Thal Desert in Punjab, Pakistan. Thal desert is located in District Layyah of Province Punjab, Pakistan has 305.71 Km length and 112.63 Km breadth near Jhelum and Indus river sites and goes up to North in Potohar Plateau.

Climate of Thal is extremely hot during summer season and temperature rises up to 51.6°C temperature of arid region and has brown color soil. The study area is approximately barren and consists of sandy dunes and forest. Average rainfall is 128 mm to 178 mm but sometime there is too much less rainfall and ranges from 2 to 4 years. Therefore, there is scanty of water in Thal at the depth of 25-90m. Study area is actually a Rakh under control of Forest Department.

Preparation of neem extract

Neem Seed Kernel Extract (NSKE 5%), 5 kg of Neem Seed Kernel (well dried) was ground into powder form and soaked overnight in 10 liters of water. Next morning, the solution was stirred with a wooden plank till it became milky white and was, filtered through double layer of muslin cloth. The volume now made up to 100 liters. Thus, the 5% concentrated solution of NSKE was ready to be sprayed in the fields (Verma *et al.*, 2015).

Field Survey

A field survey was conducted of Thal. The collection was mainly done to check the presence of *H. armigera* on different hosts and how it shifts from one host to other hosts (Phenology).

Crops like Peas, Cauliflower, Brinjal, Cabbage and Chickpea. Weeds like Bathu, Senjietc were also been observed there but no *H. armigera* was found there. Upon digging of soil diapa using pupae of *H. armigera* were observed and collected for the laboratory studies but no active stage of *H. armigera* was observed.

From this survey, it can be inferred that the active stages of *H. armigera* are absent during that time and the pupae of *H. armigera* goes into diapauses due to low temperature and coldness.

Agronomic Practices

Six genotypes of chickpea viz. Noor-91, AZ-CM-2, AZ-CM-4, AZ-CM-6, AZ-CM-10, AZ-CM-12 were sown with hand drill. Land preparation was done by two cultivations followed by planking.1.5 bags of MAP (mono-ammonium phosphate) and 1 bag of Urea was applied as fertilizer. Irrigation was applied 5 days before crop sowing.

The varieties were sown in a Split-plot Design with three replications. In one plot the Neem application would be done and in other plot there would be no Neem application. The plot size of each replication was maintained at 20 m x 24.0m (Hossain *et al.*, 2009). Two light traps and 4 pheromone traps were installed near the field to trap *H. armigera* (Hübner) and other Noctuidae pests.

Estimation of H. armigera Damage

Crop pest scouting was done regularly after 3-4 days and 10 plants were examined thoroughly from each plot to check the damage per plant by recording population per m^2, plant height (cm), flowering (percentage), average number of pods, physical maturity (percentage), infestation of pod borer (percentage) and percentage damage.

Results

Different field observations are represented in Fig. 1 to 6. Plant population per meter square of different chickpea cultivars in Neem sprayed and unsprayed cultivars was recorded and maximum plant population per m^2 was observed in Noor-91 with 16.8 plants/m^2. AZ-CM10 had population of 14.7 plants/m^2 followed by AZ-CM6 with 14.2 plants/m^2.

There was no statistical difference of neem application on the emergence of chickpea plants. But, generally high emergence was observed in neem treated plots (Fig.7).

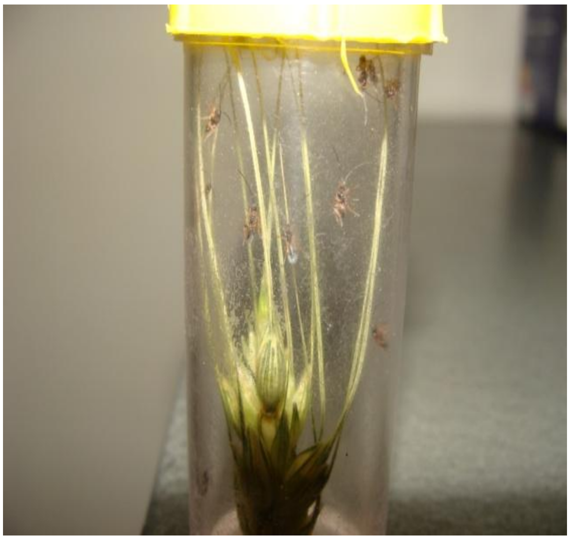

Fig. 1. Pheromone trap installed in IPM Plot.

Fig. 2. Plant Affected by *Ascochyta* Blight.

Fig. 3. Chickpea Plant in IPM Plot released.

Fig. 4. Brachonid Wasps.

Fig. 5. Chickpea Plot.

Fig. 6. Damage by Pod Borer.

Maximum height was obtained by AZ-CM4 (46.7 cm) followed by AZ-CM12 which is 44.9 cm. The lowest height was attained by Noor-91 (34.7 cm). There was no significant difference was observed of neem application on the heights of chickpea cultivars (Fig. 8). Earliest 50 percent flowering was observed in AZ-CM10. In AZ-CM 10 the 50 percent flowering was observed in 100.3 days after sowing of crop.

The differences among the days to 50 percent flowering were non-significant among the cultivars (Fig. 9). The comparison of 90 percent physical maturity of different chickpea cultivars in neem treated and untreated plots.

The differences among the cultivars of chickpea in neem treated and untreated plots were found non-significant. AZ-CM4 took maximum time (139.7 days) to attain 90 percent physical maturity, while AZ-CM2 and AZ-CM4 took only 136.0 days to attain 90 percent physical maturity.

There was no significant difference was observed of neem application on physical maturity (Fig. 10). Highest average number of pods were found on Noor-91 (19.4) followed by AZ-CM12 (18.4) and AZ-CM6 (14.7), also indicating that there are significant difference in pod number in neem treated and untreated plots (Fig. 11).

Highest population per plant were observed in AZ-CM12 (3.0 larva) followed by AZ-CM2 (2.2 larva) and AZ-CM 4 (2.1 larva). There was a significant impact of neem application in reducing the population of pod borer (Fig. 12). Most susceptible variety against the infestation of pod borer was Noor-91 (34.3 percent). After Noor-91 the highest infestation was observed in AZ-CM6 (29.1 percent) followed by AZ-CM12 (26.1 percent). The lowest infestation was observed in the AZ-CM10 (19.0 percent).

There was a significant reduction of infestation in Neem implicated plots (Fig. 13). Highest yield was obtained from Noor-91 at the rate of 1115.4 kg per ha. AZ-CM12 showed good potential and had an estimated yield of 1073.6 kg per ha.

The lowest yield was obtained in AZ-CM2 654.0 kg per ha. There was a significant decrease in yield in all the varieties were Neem was not applied (Fig. 14). This study will be continuing around the year to monitor their population and behavior.

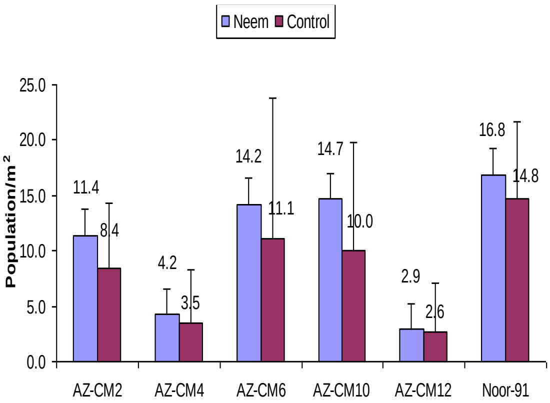

Fig. 7. A Comparison of Plant Population of different cultivars of chickpea in Neem treated and untreated plots.

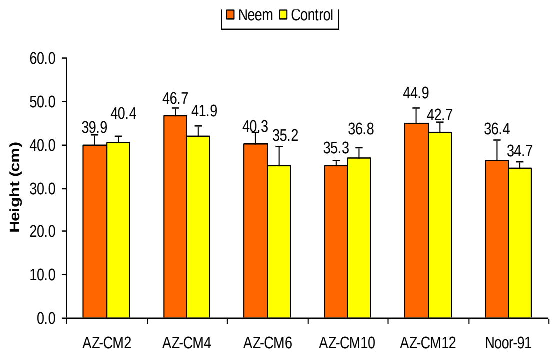

Fig. 8. A comparison of plant height of different cultivars of chickpea in Neemtreated and untreated plots.

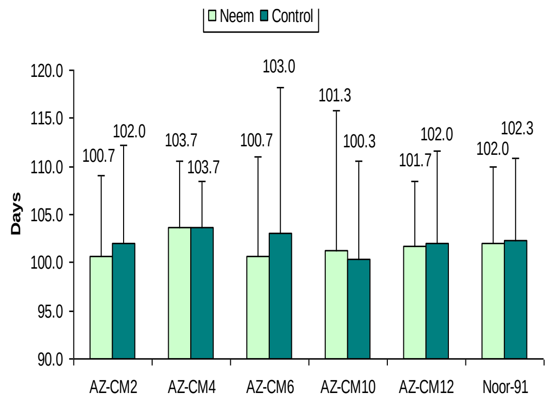

Fig. 9. A comparison of Days to 50% flowering of different chickpea cultivars in Neem treated and untreated plots.

Table 1. Population of *H. armigera* during different weeks of three months of 2010.

Months/Weeks	*H. armigera*	*H. armigera*
Jan-10		
1st week	0	0
2nd week	0	0
3rd week	0	0
4th week	0	0
Feb-10	*H. armigera*	*H. armigera*
1st week	0	0
2nd week	0	0
3rd week	0	0.15
4th week	0	0
Mar-10	*H. armigera*	*H. armigera*
1st week	0	0.28
2nd week	0.7	0.57
3rd week	5.1	0.28
4th week	11.3	5

Discussion

Chickpea, *C. arietinum* L. is an important pulse crop in Pakistan, it is mostly grown in rainfed and irrigated areas of the Punjab and covers an area of 1.11 m ha with a grain production of 475 thousand tons per annum (Anonymous *et al.*, 2008). Pod borer, *H. armigera* (Hub.) is a key pest and a prominent limiting factor in the successful cultivation of chickpea (Lateef *et al.*, 1985). The financial loss due to *H. armigera* harm was expected up to 2030 million rupees per annum in chickpea (Lal *et al.*, 1985). Controlling type of harmful pest of chickpea has proved to be very intricate; mainly in the most recent decade as insecticide resistance has increased (Armes *et al.*, 1993).

The application of neem extract increased the emergence of chickpea plants as compared to control. Among the genotypes, Noor-91 has maximum population with16.8 plants/m^2. Similarly height of the plant was also found higher in neem treated plants. Preliminary outcome propose that there are high levels of preservative genetic variation for the capability to nourish on the moderately resistant chickpea being maintained in the population as presented by (Fitt and Cotter, 2005). Though the modes of resistance or vulnerability might be genotype based. Different nutritive values of host plants may also manipulate the rate of growth of *H. armigera* larvae, thus affecting the population dynamics of this pest.

The given research exactly matches with the findings of (Hemati, Naseri, Ganbalani, Dastjerdi, and Golizadeh, 2012). Earliest 50% flowering was observed in Noor-91 after 102.3 days comparison to other genotypes. The results were in agreement with consequences obtained in 28 diallel trials conducted at ICRISAT representing that days to 50% flowering was mostly under additive inheritance and highly predictable (Singh *et al.* 1992a). In neem applied plant, earliest 90% physical maturity was seen and among the varieties, AZ-CM2 90% matured after 136.3 days. Our results relates with the findings of Yelshetty *et al.* (1996) who compared the percentage pod damage at maturity of each trial with that of the control and transformed to pest susceptibility rating (PSR) on a scale of 1 to 9). The lower PSR values represented the lower level of pod borer attack on genotypes and better tolerance to pod borer. There was a significant impact of neem application in reducing the population of pod borer. On an average, 30 to 40 percent pods were found to be damaged by pod borer with an average of 400 kg/ha grain loss. In favorable condition, pod damage goes up-to 90-95 percent.

Earlier reports representing the significance of variances for number of pods per plant relates with the investigations made (Singh *et al.* (1992b) and Yoshida and Shanower (2000) who recommended that a growth inhibitor or anti-feadent material or both existed in the resistant genotypes.

The larval survival, larval weight, pupal weights, pupation and adult appearance were constantly lower in the resistant genotypes than the vulnerable ones and the standard diet.

Overall yield of chickpea was found to be higher in neem treated plants as compared to control. There was a significant decrease in yield in all the varieties were neem was not applied. In spite of the pest hit in the season, there was an improvement in production when genotypes with resistance modes were planted. The seasonal discrepancies in yield losses pragmatic may also be credited to pest prevalence and genetic composition of arrays such type of attempts agreed with the results of Hossain(2009) and Rajput *et al.*, 2003).

Orientation and settling, feeding, metabolism of ingested food, growth, survival, fecundity, oviposition and hatching of eggs are the most important response categories of insects that determine their successful invasion and utilization of host plants [Saxena, 1969]. The establishment of insects and their consequential damage on the host plant may be reduced or affected by disruption of one or more of these important responses. Dried neem leaves and seed cakes were used for long time in India to protect crops from pests. Previous studies reported natural plant products which possess multitudes of effects such as repellence, feeding deterrence, growth and development inhibitory and other effects have some potential for the management of pests (Klocke *et al.*, 1989).

Nardo *et al.* (1997) reported that the substance in aqueous extracts of leaves and neem seeds inhibit the development of larvae, egg fertility and exerts repellent or toxic effect on B. tabaci. According to Viňuela *et al.* (2003), azadirachtin has effects similar to that of diflubenzuron (DIMILIN 25 WP, Agr Evo, Valencia, Spain) with similar actions in juvenile hormone blocking insect metamorphosis. It inhibits the growth that affects spawning (Bruce *et al.*, 2004) and molting and larval development (Islam *et al.*, 2007).

Grain productivity was mainly under the control of dominant gene action which have a tendency to enhance or reduce grain production are more or less present in equal frequency in parents of the early maturity group while in medium and late maturity groups they were relatively in imbalanced frequency (Gowda, Ramesh, Chandra, and Upadhyaya, 2005). Preservative gene action governed the inheritance of resistance to *H. armigera* whereas non-additive type of gene action was main for inheritance of antibiosis constituent of resistance (larval survival and larval weight) and grain yield (Narayanamma *et al.*, 2013).

The presented consequences were in agreement with (Kumar *et al.*, 2001) who reported that non-additive genetic effects are of chief import for yield. Moreover plant resistance to pests is an economically and ecologically favorite option to other pest management strategies. Host plant resistance is simple, expedient and contemptible and generally works well in arrangement with new forms of pest management while it can have severe implications for the effectiveness of some alternative pest management strategies.

In some cases, serious inappropriateness does occur between natural plant resistance and other pest management approaches, consequently there is a great need to realize completely the mechanisms concerned in resistance to guarantee that antagonistic effects can be avoided (Stevenson *et al.*, 2005). Farmers mainly rely on insecticides for the management of *H. armigera*.

The chickpea genotypes identified as constant in resistance to *H. armigera* harm can be used in further breeding programs to develop resistant varieties. Diallel analysis revealed the gene action for *H. armigera* resistance and suitable breeding technique can be preferred to develop resistant varieties. The main point of view of given research was to assess the relative importance of various Genomic traits that might add to yield stability for further breeding efforts in chickpea.

The results support to conclude safely that the pod infestation, larval population and grain yield could be used as selection criteria of a resistant genotype as the fundamental part of management program against *H. armigera*.

Conclusion

Several studies have been conducted and valuable information has been generated for a targeted chickpea breeding program to improve the productivity. Very little effort had been made toward identification of other potentially important traits apart from the root traits yield improvements in chickpea. Such type of researches mainly focused on a single or a few target genomic traits from the last decade. Consequently such genotypes have a valuable resource of borer resistance that could be utilized either as varieties or by using them in hybridization to develop high yielding and pod borer resistant variety as an element of integrated pest management strategy. To attain this, training in modern plant breeding skills and development integrated breeding strategies and sharing of information and capability among mutual associates, particularly in developing countries with inadequate infrastructure and human resources are the necessitate of the age.

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