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Exploration on resource of resistance in chickpea (*Cicer arietinum* L.) genotypes to gram pod borer *Helicoverpa armigera* (Hubner) (Lepidoptera)

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This study observed resource of resistance in chickpea (*Cicer arietinum* L.) genotypes to its principal insect pest gram pod borer *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae). For this purpose, the susceptibility or resistance of 26 chickpea genotypes was checked at the farm conditions on the basis of combinations of different selected criteria (pod borer's population, percentage of pod damage and grain yield). No any of protective measures were implemented to control insect pest spreading on crop. Data on numbers of *H. armigera* population per plant along with its damage were collected during seedling and pods formation stages, whereas, at crop maturity after harvesting determined seed yield to analyze statistically. Generally, pod borers infestations on different chickpea genotypes remained variable throughout cropping season. Similarly, grain yield of various genotypes also differed due to variable pest intensity and genetic diversity. Considering overall performance amongst the trial material, genotypes CM-24-2/02, CM-210/01, CH-53/99, and CC-94/99 proved the most stable for lessening pest population density and damage, and enhancing grain yield. This was almost certainly due to high potential of resistant chickpea genotypes for pest tolerance and yield enhancement; therefore, genotypes CM-24-2/02, CM-210/01, CH-53/99, and CC-94/99 may be used as resistant donors in the crossing program to evolve pod borer tolerant varieties of chickpea. On the other hand, genotype CM-86-3/02 appeared awkward because of highly affected in its survival against insect pest and poorest yield performance. Consequently, host plant resistance could be regarded as the most important sustainable approach to reduce losses due to insect pests.

Key words: *Cicer arietinum,* resistance, *Helicoverpa,* pod borer, chickpea.

INTRODUCTION

Among the grain legumes, chickpea or gram (*Cicer arietinum* L.) is the premier pulse crop and has occupied a prominent position. It is primarily consumed as green grain, dry whole seed, decorticated split cotyledons and flour (Sarwar, 2013). Chickpea seed is recognized as a valuable source of dietary proteins (18 to 22%), carbohydrate (52 to 70%), fat (4 to 10%), minerals (calcium, phosphorus, iron) and vitamins. Its straw has also good forage value (Shrestha et al., 2011). At 21% protein (range 17 to 26%), chickpea seed is a protein-rich supplement to cereal-based diets, especially critical in developing countries where people either cannot afford animal protein or are vegetarian by choice. In addition to its importance in human food and animal feed, chickpea

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plays an important role in sustaining soil fertility by fixing up to 140 kg N ha-^{1} year-^{1} (Rupela, 1987). The production and productivity of chickpea have been experienced drastically because of biotic and abiotic stresses. It is vulnerable to a broad range of pathogens and the mainly severe pest being gram pod borer *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae).

The four major characteristics which contribute to *Helicoverpa* species pest status are polyphagy, high mobility, high fecundity and facultative diapauses, which are argued extensively (Fitt, 1989). The preference of *H. armigera* to feed on the harvestable parts of host plants, along with its high polyphagy and mobility, broad geographical variety, migratory potential, facultative diapause, high fecundity, and tendency to develop resistance to insecticides have led to its status as an important crop pest (Zalucki, 1991). Increases in intensive crop production technologies and concomitant insecticide resistance due to use of broad spectrum insecticides, as well as continuous accessibility of preferred food plants have favored *H. armigera* to become a major pest (Fathipour and Naseri, 2011). Gram pod borer *H. armigera* is the most important biotic constraint, which at times causes 90 to 95% damage (Singh et al., 1985). Sarwar et al. (2009, 2011) reported 26.01 to 40.08% and 10.53 to 39. 14% crop losses on susceptible and tolerant genotypes, respectively, due to *H. armigera* from early vegetative to pod formation stage in chickpea. As a result, over the past so many years, the productivity of chickpea crop has not witnessed any significant increase as compared to the cereal crops, because such constraints limit its production on the farmer's fields. Past efforts have been rewarding in insulating chickpea varieties against biotic stresses by way of standardization of screening techniques.

Modification of crop plants to improve their suitability for cultivation has been practiced since the dawn of civilization. Early cultivated chickpea has limited source of genetic variability, but wild species of *Cicer* have many economically important traits like resistance to diseases and pests. The pre fertilization and post fertilization cross ability barriers prevented the utilization of wild species in breeding program (Ahmad et al., 2006). Momentous advancement has been made to improve production and protection technologies of chickpea to enhance productivity, improve seed size, reduce crop duration, minimize adverse impact of biotic stresses, and expand its cultivation, development and identification of improved and productive varieties. This has helped to stabilize chickpea production in the country. The present research was carried out in order to identify alternative methods of chemical control for *H. armigera.* Thus, at no extra price and free from environmental contamination trouble, the exploitation of resistant varieties can be an idyllic part of pest management. Information on mechanisms and inheritance of resistance is critical to plan an effective strategy to breed crop for resistance to insect pests. Therefore the implications of the inheritance pattern of pod borer resistance and grain yield are argued in the context of strategies to enhance pod borer resistance and grain yield in chickpea genotypes.

MATERIALS AND METHODS

Field trial and crop management

Twenty-six promising chickpea genotypes were assessed for resistance to *H. armigera* under un-protected field conditions during 2005 to 2006 crop seasons. The experiments were laid at Nuclear Institute of Agriculture, Tandojam, Sindh, Pakistan. Seeds of all test genotypes included; CM-2100/96, CM-3821/97, CM-3837/97, CM-4068/97, CM-1223/98, CH-31/99, CH-53/99, CH-58/99, CH-65/99, CH-38/00, CC-94/99, CC-98/99, CM-2983/00, CM-1589/01, CM-210/01, CM-1616/01, CM-98, CM-24-2/02, CM-36-1/02, CM-54-1/02, CM-86-3/02, CM-86-4/02, CM-914-1/02, CM-914-6/02, CM-914-3/02, and CM-72/02 which were taken from Nuclear Institute for Agriculture and Biology, Faisalabad.

The test genotypes were evaluated using a randomized complete block design (RCBD) with 3 replications. The test treatments were randomly allotted in each block. Each test genotype was sown in November 2005, and each experimental replicate consisted of four rows of 3 m^2 length. Every chickpea entry was raised in a spacing of 30 cm between the rows and 10 cm between the plants within a row with one meter as gap in every replication. The seeds were drilled into the furrows at 5 cm soil depth. During the entire crop season, all the recommended agronomic practices were adopted according to the crop requirements under pesticide free conditions. The crop was kept weeds free manually and the test material received no fertilizer or irrigation. All the cultural practices were performed uniformly in each replicate.

Data collection of trial

The test genotypes were strictly scrutinized for pest appearance at weekly interval beginning from the germination to harvest. The pod borer's resistant and susceptible lines were identified based on examining larval number and pod damage as a measure of insect damage. Agronomic characteristic of the chickpea genotypes used for studying their tolerance action was grain yield at crop maturity. Observations on the incidence of pod borer were recorded from one meter plant row randomly taken per genotype per replicate. Pod borer damage was estimated as percentage of total number of pods under natural infestation. The percentage pod damage data were recorded one week prior to crop harvesting and used for ranking pest damage. Pod damage was recorded from each replicate by counting the total number of pods and number of damaged pods by the pest from five randomly selected plants. The percent (%) of pod damage was calculated by dividing number of damaged pods with total number of pods and multiplying the whole value by 100. Chickpeas were harvested as soon as they matured (required about 100 days to reach harvest) as pods might fall if harvest is delayed. The plants were harvested manually using a sickle. The grains obtained after pods threshing, were then cleaned and dried in the bright sunshine. Threshing was done by beating the plants with sticks and grain yield per replicate was recorded and converted into yield per 3 m^2 (g).

Biometric data analyses

Finally, the mean values of the data recorded on sampled plants for *H. armigera* density, damage and grain yield were used for statistical analysis using Statistix 8.1 software. The data were analyzed following analysis of variance (ANOVA) to test the

Table 1. Field testing of various chickpea genotypes against gram pod borer *H. armigera* under natural conditions in the field.

S/N	Name of genotypes	Larval population/1 m row	Pod infestation (%)	Yield/plot (3 m^2) (g)
1	CM-2100/96	1.77[ab]	15.32[ab]	117.3[j]
2	CM-3821/97	1.33[ab]	13.00[ab]	177.0[e]
3	CM-3837/97	1.99[ab]	17.22[a]	101.0[kl]
4	CM-4068/97	1.88[ab]	15.63[ab]	107.3[k]
5	CM-1223/98	1.55[ab]	13.37[ab]	156.0[g]
6	CH-31/99	1.44[ab]	13.29[ab]	156.7[g]
7	CH-53/99	1.10[b]	11.40[ab]	197.7[c]
8	CH-58/99	1.77[ab]	14.87[ab]	124.3[j]
9	CH-65/99	2.22[ab]	20.57[a]	72.67[n]
10	CH-38/00	1.44[ab]	13.12[ab]	167.7[f]
11	CC-94/99	1.11[b]	11.79[ab]	188.7[d]
12	CC-98/99	1.66[ab]	14.54[ab]	145.0[h]
13	CM-2983/00	2.10[ab]	19.49[a]	81.67[m]
14	CH-65/99	2.21[ab]	15.96[ab]	72.33[n]
15	CM-210/01	0.88[b]	10.40[ab]	206.7[b]
16	CM-1616/01	1.66[ab]	14.38[ab]	151.7[gh]
17	CM-98	1.44[ab]	13.07[ab]	168.3[f]
18	CM-24-2/02	0.88[b]	4.067[b]	218.3[a]
19	CM-36-1/02	1.88[ab]	16.21[ab]	101.7[kl]
20	CM-54-1/02	2.10[ab]	17.49[a]	95.00[l]
21	CM-86-3/02	2.74[a]	22.37[a]	61.67[o]
22	CM-86-4/02	1.77[ab]	14.72[ab]	136.3[i]
23	CM-914-1/02	1.77[ab]	15.32[ab]	118.3[j]
24	CM-914-6/02	1.32[ab]	12.29[ab]	186.7[d]
25	CM-914-3/02	1.55[ab]	14.02[ab]	153.3[gh]
26	CM-72/02	2.10[ab]	19.72[a]	75.00[mn]
LSD value		1.26	10.72	8.44

Means within columns with different letters are significantly different at the 0.05 probability level.

significance of differences among the each test entry at the 0.05 probability level.

RESULTS

Among the insect pests, pod borer (*H. armigera*) was the most important and severe yield reducer of chickpea in experimental area. The pest was vigorous during the whole time of crop season; however damage to gram caused by larvae was through feeding on the leaves and destroying the seedlings at the vegetative growth phase. During the reproductive phase, the caterpillars damaged on flowers, and to pods at green pod and maturity stages by feeding on the developing seed after making a hole in the pods. The data on response of 26 genotypes of chickpea to the incidence of pod borer *H. armigera* depending on the palatability of the test lines are presented in Table 1.

Larval population

There were significant differences among the test genotypes for survival of *H. armigera* larvae, justifying the selection of parents for this study (Table 1). In general, the mean larval survival was lower on CM-24-2/02, CM-210/01, CH-53/99, and CC-94/99 (0.88, 0.88, 1.10 and 1.11) larvae per m plant row, respectively and rated as resistant, clearly indicating the preponderance of the inheritance of antibiosis component under field conditions. For the genotype CM-86-3/02, greater magnitude of mean larval survival (2.74 larvae per m plant row) was noted which suffered high pest injuries showing significant and negative effects for resistance to pod damage by *H. armigera*. It is remarkable to note that, the remaining genotypes showed significant and negative effects for antibiosis resistance to *H. armigera* ranging from 1.32 to 2.22 larval populations per 1 m row.

Pod damage

There were significant differences among the test genotypes for resistance to pod borer *H. armigera* damage, under field conditions (Table 1). In general, the mean pod borer damage was lower in CM-24-2/02 (4.067%); this genotype was statistically different from others and rated as resistant. The most susceptible genotypes rated were CM-86-3/02, CH-65/99, CM-72/02, CM-2983/00, CM-54-1/02 and CM-3837/97 harboring 22.37, 20.57, 19.72, 19.49, 17.49, and 17.22% pod damage, respectively. The left behind genotypes were categorized as moderately resistant or moderately susceptible harboring 10.40 to 16.21% pod damage. The lesser pest damage indicated the lower level of pod borer attack on genotypes, indicating better tolerance to pest.

Grain yield

The analysis of variance of seed yield revealed significant differences among the genotypes for grain produced (Table 1). The highest mean grain yield (218.3 g per 3 m^2) was recorded in CM-24-2/02 that was significantly higher than the other genotypes. This genotype showed first-rate resistance/tolerance against *H. armigera* and ultimately gave an excellent yield to use for general cultivation by the farmers. The results of analysis of variance for yield noted the decreased values from large to medium progressively in CM-210/01, CH-53/99 and CC-94/99 producing 206.7, 197.7 and 188.7 g seed per 3 m^2, respectively and differences among genotypes were significant. The average grain yield between the test genotypes CM-86-3/02, CM-1589/01 and CH-65/99 was noted lowest (61.67, 72.33 and 72.67 g per 3 m^2) due to susceptibility. This was for the reason of podding potentiality, pod size, seed size and seed weight that differed broadly within the genotypes.

DISCUSSION

Overall, 26 chickpea genotypes were screened for resistance to gram pod borer, *H. armigera* under natural field conditions; four genotypes, which included, CM-24-2/02, CM-210/01, CH-53/99 and CC-94/99 recorded less pod damage compared to the rest of entries. The mean pod damage among the test entries ranged from 4.067 to 22.37%. These results were highly significant and in agreement with those of early workers, but the range of damage recorded by earlier researchers varied greatly that is, 19.53 to 40.83% (Parvez et al., 1996); 12.63 to 33.05% (Sarwar et al., 2009); 11.55 to 48.11% (Khan et al., 2009); 13.24 to 38.0% (Sarwar et al., 2011); and 12.18 to 23.12% (Sarwar, 2013).

These deviations in pod damage may be conceivably owing to variations in local climatic conditions and the type of genotypes tested. The results demonstrated the potentials of host plant resistance in the management of *H. armigera.* Plant materials CM-24-2/02, CM-210/01, CH-53/99, and CC-94/99 exhibited least pod damage and harbored slightest larvae on plants and were designated as least susceptible, whereas, CM-86-3/02 showed most pod damage and number of larvae and categorized as most susceptible. Although the modes of resistance or susceptibility of these arrays are not yet clear, it might be genotype based. Different nutritive values of host plants may also influence the rate of development of *H. armigera* larvae, thus affecting the population dynamics of this pest (Hemati et al., 2012). In spite of the pest hit in the season, there was an enhancement in yield when genotypes with resistance modes were planted. The seasonal discrepancies in yield losses observed may also be accredited to pest incidence and genetic makeup of arrays (Rajput et al., 2003; Hossain, 2009).

It may be accomplished that, varieties with the highest amount of tolerance should be developed to compete the increasing alarm of gram pod borer resistance against pesticides due to which every year new pesticides are being imported which not only pollute our environment but are also hazardous to crops and ultimately the consumers. On the basis of the previous research carried out in the quest of biochemical which determined the magnitude of the resistance in chickpea against gram pod borer, an understanding of mechanism of resistance is essential. According to Cotter and Edwards (2006), plants use a number of resistance mechanisms that can affect insect feeding, including physical factors such as leaf toughness or trichome density, or chemical factors such as toxic allelochemicals and proteinase inhibitors.

In a study, a low amount of acidity in the leaf exudates (21.1 and 41.9 meq./100 g) of susceptible genotype was found to be associated with susceptibility to *H. armigera* (Bhagwat et al., 1995). In *H. armigera*, experience with a plant increases the possibility that a female will choose that host to lay eggs in the future. It has also been suggested that, preference is strongly influenced by host abundance, with the relative attractiveness of a host for oviposition increases due to its abundance in the environment (Cunningham et al., 1999; Cunningham and West, 2001). Therefore, it seems likely that, females encountering a large patch of host plants, as would occur in an agricultural situation, would oviposit regardless of the genotype present as long as that genotype did not have strong antixenotic properties. Further investigational information on biochemical factors of miscellaneous chickpea genotypes is mandatory to find out adequately the key mechanism concerned and to know fully the specific basis for the resistance against *H. armigera*. The understanding of the mechanisms underlying the ability of *H. armigera* to feed on particular hosts may help in the development of crop cultivars to which resistance is needed to develop in the field. To this end, work is currently underway to map the genes responsible for *H. armigera* ability to feed on chickpea.

Inheritance of resistance to pod borer and grain yield were different in some chickpea types under unprotected conditions. An understanding of inheritance of resistance is essential for a systematic and efficient approach for genetic enhancement of pod borer resistance in chickpea. Preliminary results suggest that there are high levels of additive genetic variation for the ability to feed on the moderately resistant chickpea being maintained in the population (Fitt and Cotter, 2005). By understanding the genetic variation present in the insect population to overcome plant resistance mechanisms, predictions can be made about the potential for those genes to spread. Several studies have been made to estimate combining ability and to unravel the genetics of resistance to *H. armigera* and grain yield in chickpea. The additive component of genetic variance was important in early maturity, and dominance component was predominant in medium maturity group, while in the late maturity group, additive as well as dominance components were equally important in the inheritance of pod borer resistance.

Grain yield was predominantly under the control of dominant gene action and dominant genes, which tend to increase or decrease grain yield are more or less present in equal frequency in parents of the early maturity group, while in medium and late maturity groups, they were comparatively in unequal frequency (Gowda et al., 2005). Additive gene action governed the inheritance of resistance to *H. armigera*, while non-additive type of gene action was predominant for inheritance of antibiosis component of resistance (larval survival and larval weight) and grain yield (Narayanamma et al., 2013). The discrepancies between the different chickpea genotypes for larval population of pest, pods infestation and the grain yield, confirmed in current study, are indication that the host plant resistance may possibly be successfully utilized in the integrated management of *H. armigera.*

Conclusion

The present study concludes that, in spite of the high variations among the chickpea genotypes, results support that the pod infestation, larval population and grain yield could be used as selection criteria of a resistant genotype as the integral part of management program against *H. armigera*. It also provides useful information on antibiosis mechanism of resistance to *H. armigera*. On the basis of percent pod damage and pest inclusion ratings, genotypes CM-24-2/02, CM-210/01, CH-53/99 and CC-94/99 may be used as resistant donors in the crossing program to evolve pod borer tolerant varieties.

The reality that, the highest resistant genotype gave the highest grain yield may be attributed to the genetic differences of these arrays. On the other hand, CM-86-3/02 appeared awkward because of its survival against insect pest and poorest yield performance. Therefore, tolerant genotypes possess a valuable source 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.

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