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Comparative Development, Survival and Fecundity of *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) on Different Chickpea Cultivars

Rabia Ali, Humayun Javed and Asim Gulzar*
Department of Entomology, Pir Meher Ali Shah Arid Agriculture University, Rawalpindi

ABSTRACT

The development, body weight, survivorship, and reproduction of the gram pod borer, *Helicoverpa armigera* (Hũbner), were evaluated in the laboratory at 25±5°C, 65±5% R. H. and a light : dark cycle of 16:8 h on six different cultivars of chickpea. The larval period ranged from 16.41 to 22.71 days on cultivars CMC-211s and Pb-2008 respectively. Similarly the larval period ranged 9.50 to 14.01 days on CMC-211s and Pb-2008 respectively. The average number of eggs oviposited by adults reared on Pb-2008, Bittal-98, Parbat, CM-2000, Dasht and CMC-211s were 299.68, 323.66, 353.36, 462.84, 492.28 and 522.54 respectively. The survival percentage survival of all larval instars of *H. armigera* ranged from 73% on comparatively resistant cultivars to 93% on susceptible cultivars of chickpea. Dasht, CM-2000, Parbat and Bittle-98 showed intermediate trend. Cultivar Pb-2008 was resistant as compared to other cultivars.

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Key words
***Helicoverpa armigera*, host plant resistance, chickpea cultivars, gram pod borer.**

INTRODUCTION

Chickpea (*Cicer arietinum*) is the third most important grain legume of the World (Sharma *et al*., 2005; Sarwar *et al*., 2011). It is a major source of protein for the poor people of Pakistan. Its protein value ranges from 25.3 to 28.9% (Hulse, 1991; Shrestha *et al*., 2011; Sarwar, 2013). In Pakistan, it is mainly grown in rainfed and irrigated areas of the Punjab and covers an area of 1.11 m ha with a grain yield of 475 thousand tons (Anonymous, 2008). Production constraints in chickpea primarily include insect pests and diseases (Nadeem *et al*., 2011). Among the insect pests, *Helicoverpa armigera* (Hũbner) (Lepidoptera: Noctuidae) is the major constraint in the production of crop worldwide (Sharma *et al.*, 2005; Shafique *et al*., 2009).

H. armigera is highly polyphagous, cosmopolitan, devastating and worldwide distributed pest (Sharma *et al*., 2005; Sarwar *et al.*, 2009). It causes yield losses in cotton, okra, tomato and in few other crops and vegetables (Saleem and Yunus, 1982). Yield losses due to this pest in chickpea may range from 70 to 95% (Prakash *et al.*, 2007). Its larvae causes serious damage to this crop during the fruiting stage. A single larva can consume many pods before reaching the pupal stage (Nadeem *et al*., 2010). In different areas of Pakistan, 3-34% pod damage to important cultivars of chickpea was recorded (Ahmed and Hashmi, 1976).

Chemical control is a primary management tactic to control the *H. armigera*. However, the reliance on insecticides had resulted into many problems like pest resurgence, outbreak of secondary pests, environmental pollution and insecticide resistance (Kranthi *et al*., 2002). It is reported that this pest has developed resistance to pyrethroids, organophosphates, organochlorines, and carbamates (Ahmed *et al.*, 1997, 2001). Resistance of *H. armigera* to the major classes of insecticides is threat to grain legume production in Asia (King and Sawicki, 1990). Therefore, an integrated approach for managing this pest is needed.

Host plant resistance (HPR) as one of the important component of integrated pest management, can play major role in management of *H. armigera* (Sharma *et al*., 1999; Sarwar *et al*., 2011; Sarwar and Sattar, 2013). It is economically reliable, ecologically safe and compatible with other IPM strategies (Sharma *et al*., 1999, Li *et al.*, 2004; Nadeem *et al*., 2010). HPR helps in developing cultivars that give stability to host plants against different insects. This stability is important in terms of growth, development and behavior of herbivorous insects (Umbanhowar and Hastings, 2002; Awmack and Leather, 2002).

Antixenosis and antibiosis are the mechanisms that confer resistance in plants. Antibiosis mechanism of plants may cause reduction in insect size, weight, survival, longevity, reproduction and may be resulted in long developmental time (Sarfraz *et al.*, 2006). Resistant chickpea plants were reported to show non-preference for oviposition and larval feeding by *H. armigera (*Lateef, 1985). Host plant resistance in Chicpea against *H.*

* Corresponding author: asim@uaar.edu.pk
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armigera was studied by many researchers (Wakil *et al*., 2005; Shafique *et al*., 2008; Sarwar *et al*., 2009; 2011; Nadeem *et al*., 2010, 2011).

The objectives of this research were: (1) to investigate the preference/non preference of *H. armigera* larvae towards different chickpea cultivars. (2) to study the effect of different cultivars on the development, survival and fecundity of *H. armigera.*

MATERIALS AND METHODS

Collection and rearing of H. armigera

A field population of *H. armigera* (third to fifth instar larvae) was collected from tomato fields of National Agriculture Research Center Islamabad and cultured at 25±2°C, 60±5% RH with 16:8 (light :dark) cycle. The larvae were reared on artificial diet until pupation and then transferred to a plastic box lined with tissue paper. On adult emergence, individuals were transferred to transparent rearing jars and fed with 10% sugar solution. Nappy liner strips were provided for egg laying and eggs were collected on daily basis. The insects were continuously fed on the artificial diet for three generations before testing to reduce the possible influence of the host source of the tested insect population.

Development H. armigera *fed on different chickpea cultivars*

The seeds of following six different chickpea cultivars *viz.*, Bittal-98, Pb-2008, Parbat, CMC-211s, Dasht, CM-2000, were obtained from National Agriculture Research Center Islamabad. These seeds were sown in plastic pots of 16 cm diameter having sand, soil and farm yard manure in 1:1:1 ratio.

The neonates hatched on the same day (< 24 h old) were divided into six groups (as six cultivars) and randomly transferred to Petri dishes (one larval per Petri dish to prevent cannibalism). All treatments were reared at 25°C with a photoperiod of L:D 16:8 and provided with pods of one of the six cultivars. The pods were provided to larvae until pupation. Larvae were examined daily and the development time and weight of each larval instar was recorded. Total developmental time from neonate to pupation was observed. Pupal weight was recorded one day after pupation with sex determination of each insect. The pupae were placed individually in 250 ml plastic cups covered with white netting secured by a plastic band. The number of adults emerged was recorded daily and the proportion that emerged successfully was also recorded together with the total developmental time from neonate to adult.

Reproductive capacity of H. armigera

Adults that emerged from larvae reared on each cultivar were allowed to mate and then transferred to the 250 ml cups for egg laying. (One pair per cup, 10 pairs) supplied with 10% honey solution as food source. When a female started egg laying, the insect pair was transferred to a new cup every 48 h until they died. Data regarding number of eggs laid per female, pre oviposition, oviposition, and post oviposition period was recorded.

Feeding preference of H. armigera

Pods of different cultivars were placed in each Petri dish (diameter 16 cm). Fifteen Larvae were released in centre of each Petri dish. The experiment was replicated five times. After 24 hours, the feeding preference of these larvae was recorded by observing the number of larvae attracted to different pods.

Statistical analysis

Developmental time, body weight, pre-oviposition time, oviposition time, post oviposition time, fecundity and feeding preference of *H. armigera* reared on different host plants were analyzed with analysis of variance (ANOVA) by using M-STAT, and means were separated least significance difference at $p<0.05$.

RESULTS

Development of H. armigera *on different chickpea cultivars*

The mean larval duration (neonate to pupation) of *H. armigera* was significantly differ ($F_{5,29}$=1452.07, P<0.01) on the six test cultivars of chickpea (Table I). The mean development time of *H. armigera* larvae was longest on Pb-2008 with 22.71 days and shortest on CMC-211s with 16.41 days. Test cultivars had significant effect on the development time of 1st instar larvae of *H. armigera* ($F_{5,29}$=169.54, P< 0.01). Maximum duration of 1st instar larvae was 2.75 days on Pb-2008. While minimum duration was 2.17days on CM-211s (Table I). There was significant differences among the development time of 2nd instar larvae on selected cultivars ($F_{5,29}$=226.35, P< 0.01). 2nd instar larvae reared on CMC-211s developed slowly (2.31 days) as compare to other cultivars. Maximum larval duration of 3rd instar was observed on Pb-2008 (3.53 days) followed by Bittle-98 (3.1 days) and Parbat (3.08 days) while Bittle-98 and Parbat were statistically similar to each other. Minimum larval duration of 3rd instar was observed on CMC-211s (2.62 days) followed by Dasht (2.74 days) and CM-2000 (2.84 days) ($F_{5,29}$=346.09, P< 0.01) (Table I). Cultivars

Table I.- Mean development time of larvae and pupae (days ± SE) of *H. armigera* on different chickpea cultivars.

Cultivar	1st instar	2nd instar	3rd instar	4th instar	5th instar	6th instar	Total time	Pupa
Pb-2008	2.75±0.01 a	2.96±0.02 a	3.53a±0.04 a	3.91± 0.03 a	4.50±0.03 a	5.05±0.04 a	22.71±0.05 a	14.01±0.01 b
Bittal-98	2.54±0.03 b	2.73±0.04 b	3.1±0.03 b	3.52±0.03 b	3.92±0.02 b	4.33±0.03 b	20.24±0.21 b	13.25±0.05 b
Parbat	2.47±0.05 c	2.66±0.04 c	3.08±0.05 b	3.46±0.03 c	3.73± 0.03 c	4.22±0.04 c	19.66±0.11 c	13.03±0.50 b
CM-2000	2.33±0.07 d	2.63±0.05 c	2.84±0.04 c	2.97±0.06 d	3.50±0.05 d	3.92±0.08 d	18.08±0.34 d	11.52±0.03 c
Dasht	2.23±0.03 e	2.52±0.02 d	2.74±0.04 d	2.92± 0.03 e	3.43± 0.03 e	3.74±0.03 e	17.59±0.04 e	10.29±0.15 d
CMC-211s	2.17±0.05 f	2.31±0.02 e	2.62±0.07 e	2.81±0.04 f	3.17±0.05 f	3.32±0.01 f	16.41±0.05 f	09.50±0.02 e
LSD	0.05	0.04	0.05	0.04	0.05	0.04	0.21	

The means followed by different letters in the same columns are significantly different ($P < 0.05$, least significant difference).

Table II.- Mean larval (1st to 6th instar) and pupal weight (mg ± SE) of *Helicoverpa armigera* on different chickpea cultivars

Cultivar	1st instar	2nd instar	3rd instar	4th instar	5th instar	6th instar	Pupa
Pb-2008	0.13±0.00 f	2.52±0.10 f	17.31±0.07 e	58.34±0.20 f	290.47±0.62 f	503.85±0.01 f	163.53±0.63 b
Bittal-98	0.18±0.00 e	3.36±0.02 e	17.88±0.06 d	64.19±0.51 e	293.29±0.56 e	505.29±0.02 e	175.85±0.74 ab
Parbat	0.19±0.01 d	4.34±0.03 d	18.22±0.03 c	66.48±0.18 d	295.05±0.24 d	507.04±0.03 d	180.83±0.45 ab
CM-2000	0.25±0.00 c	6.12±0.04 c	19.52±0.13 b	73.52±0.14 c	298.64±0.34 c	513.66±0.08 c	157.32±3.21 b
Dasht	0.28±0.00 b	6.65±0.10 b	20.56±0.03 a	75.26±0.08 b	303.26±0.41 b	515.71±0.03 b	198.74±0.23 ab
CMC-211s	0.33±0.00 a	7.32±0.15 a	20.64±0.02 a	78.09±0.08 a	305.02±0.24 a	518.20±0.01 a	212.08±1.33 a
LSD	0.00	0.11	0.09	0.29	0.65	0.72	3.92

The means followed by different letters in the same columns are significantly different ($P < 0.05$, least significant difference).

differ significantly with respect to development time of 4th instar larvae ($F_{5,29}$=1119.64, P<0.01). Larvae reared on cultivar Pb-2008 had longest development time with 3.91 days (Table I). Minimum duration of 5th instar was recorded on CMC-211s with 3.17 days, followed by Dasht and CM-2000 with 3.43 and 3.50 days respectively ($F_{5,29}$=857.18, P< 0.01). Chickpea cultivars differed significantly in larval duration of 6th instar of *H. armigera* larvae ($F_{5,29}$=1452.07, P<0.01). The mean pupal development time of *H. armigera* was significantly differ ($F_{5,29}$=464.86, P< 0.01) on chickpea cultivars (Table I). The percentage survival (Table III) of larvae of *H. armigera* was minimum 73% on cultivar Pb-2008 and was maximum 93% on cultivar CMC-211s and differ significantly in all the test cultivars ($F_{5,29}$=30.62, P< 0.01). The percent adult emergence of *H. armigera* was significantly different in all the test cultivar *(*$F_{5,29}$=79.41, P< 0.01).

Table III.- Percentage survival (Mean ± SE) of larvae and pupae of *Helicoverpa armigera* on different chickpea cultivars

Cultivar	Larva	Pupa
Pb-2008	73.00 ±0.02 [d]	78.06±3.17 [d]
Bittal-98	78.00±0.71 [c]	81.00±0.65 [c]
Parbat	79.00±1.07 [c]	80.96±0.95 [c]
CM-2000	87.00±0.08 [b]	87.37±2.05 [b]
Dasht	88.00±0.52 [b]	88.63±0.35 [b]
CMC-211s	93.00±0.64 [a]	94.52± 0.15 [a]
LSD	1.01	1.03

The means followed by different letters in the same columns are significantly different (*P* < 0.05, least significant difference).

Body weight

The results of weight of *H. armigera* on different chickpea cultivars are given in Table II. The mean larval weight of 1st instar ($F_{5,29}$=3978.06, P<0.01), 2nd instar ($F_{5,29}$=2823.83, P<0.01), 3rd instar ($F_{5,29}$=1903.71, P<0.01), 4th instar ($F_{5,29}$=5560.56, P<0.01), 5th instar ($F_{5,29}$=660.62, P< 0.01) and 6th instar ($F_{5,29}$=589.08, P<0.01) of *H. armigera* were significantly different in all the test cultivar. Maximum weight of 1st instar larvae was 0.33 mg on CMC-211s (Table II). The 2nd instar larvae reared on CMC-211s had maximum weight (7.32 mg), followed by Dasht and CM-2000. Larvae of 3rd instar reared on CMC-211s were heavier (20.64 mg) and lighter on Pb-2008 (17.31 mg) as compared to other cultivar. The 4th instar larvae had maximum weight (78.09 mg) and when reared on CMC-211s minimum weight (58.34 mg) cultivar Pb-2008. The 5th instar larvae maximum weight (303.02 mg on CMC-211s, followed by Dasht and CM-2000. The 6th instar larvae was 518.20 mg on CMC-211s and was 503.85 mg on Pb-2008.

The mean pupal weight of *H. armigera* did not differ significantly in all the test cultivars ($F_{5,29}$=2.20, P> 0.05). Maximum pupal weight was 212.08 mg on CMC-211s which was statistically similar to pupal weight on Dasht (198.74 mg), Parbat (180.83 mg) and Bittle-98 (175.85 mg).

Fecundity of H. armigera *on different chickpea cultivars*

There was significant difference in fecundity of *H. armigera* on different chickpea cultivars ($F_{5,29}$=589.26, P< 0.01). The total number of eggs laid were highest by the females of *H. armigera* larvae reared on CMC-211s (522.54 eggs) while there was significant reduction in number of eggs laid by the females of the larvae developed on PB-2008 (299.68 eggs) (Table IV).

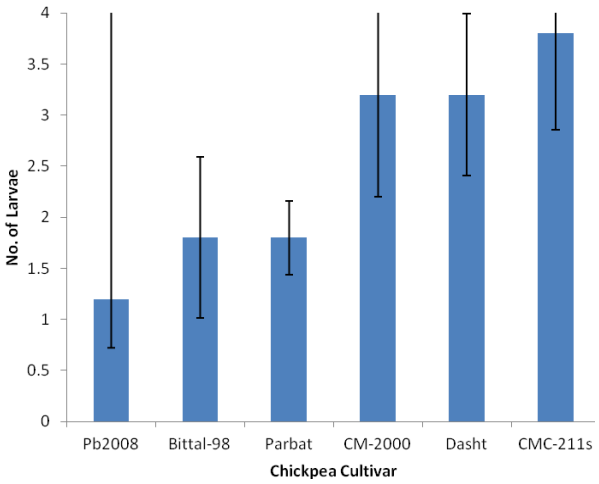

Fig. 1. Preference/non-preference of *Helicoverpa armigera* larvae toward different chickpea cultivar.

Effect of different chickpea cultivars on feeding behaviour of H. armigera

The feeding preference of *H. armigera* were significantly different among all the treatments ($F_{5,29}$=8.66, P<0.01). The maximum larvae were recorded on CMC-211s (3.8) while minimum larvae were recorded on Pb-2008 (1.2) (Table IV).

DISCUSSION

Plant species differ greatly in suitability as hosts for specific insects when measured in terms of survival, development and reproductive rates. Prolonged

Table IV.- The mean pre, post-oviposition , oviposition periods (Days ± SE) and fecundity (Number of eggs/ female) of *Helicoverpa armigera* emerging from larvae reared on different chickpea cultivars.

Cultivar	Pre oviposition period	Oviposition period	Post oviposition period	Fecundity
Pb-2008	3.12±0.08 [a]	6.14±0.04 [a]	2.06±0.04 [a]	299.68±1.73 [f]
Bittal-98	2.93±0.03 [b]	5.81±0.02 [b]	1.92±0.01 [b]	323.66±1.69 [e]
Parbat	2.88±0.05 [b]	5.33±0.10 [c]	1.73±0.00 [c]	353.36±1.15 [d]
CM-2000	2.63±0.02 [c]	4.93±0.03 [d]	1.42±0.02 [d]	462.84±2.77 [c]
Dasht	2.42±0.02 [d]	4.71±0.06 [e]	1.31±0.01 [e]	492.28±2.27 [b]
CMC-211s	2.18±0.05 [e]	4.25±0.11 [f]	1.22±0.03 [f]	522.54±2.31 [a]
LSD	0.05	0.17	0.03	2.57

The means followed by different letters in the same columns are significantly different ($P < 0.05$, least significant difference).

development time on particular species of host means longer life cycle and slower population growth (Singh and Parihar, 1988). Larval stages of *H. armigera* when prolonged may augment the efficacy of its management tactics by using insecticides and natural enemies (Du *et al.*, 2004). In the present study *H. armigera* completed its larval development in six instars which have been reported previously by Goyal and Rathore (1988) and Borah and Duttta (2002).

Development time of 1st instar larvae was longest on Pb-2008 (2.75 days) and shortest on CM-211s (2.17days). These results are in contradiction with Fathipour and Naseri (2011), who reported the development time of 1st instar of *H. armigera* larvae from 17.30 to 26.20 days on soybean cultivars. This variation in results might be associated with food quality of the host species.

The larval periods ranged from 19.66 days on Parbat to 22.71 days on Pb-2008. Whereas Naseri *et al.* (2009) reported total development time of *H. armigera* larvae from 17.30 to 26.20 days on different soybean cultivars. A possible explanation of variations in results may be due to difference in the nutritional value of the host species tested. Body weight is an important indicator of fitness of an insect, which can be measured easily (Liu *et al.*, 2004). Host plants have great influence on the body weight of an insect species. This is evident from Sharma *et al.* (1999) that larvae reared on resistant cultivars had considerably lower weight than reared on susceptible cultivars. This is in agreement with our finding. Pupal weight of *H. armigera* was maximum on CMC-211s (212.08 milligram) while minimum on cultivar CM-2000 (157.32milligram). Whereas, Srivastava and Srivastava (1990) reported pupal weight from 231 to 310 milligram on different chickpea genotypes. The difference in the results is might be due to the physiological differences present in host plants.

The survival of *H. armigera* larvae differed significantly on different cultivars of chickpea. The survival percentage of all larval instars of *H. armigera* ranged from 73% on comparatively resistant cultivars to 93% on comparatively susceptible cultivars of chickpea. These results are in partial agreement to those of Srivastava and Srivastava (1990) who reported 77-90 % survival of larvae of *H. armigera* on different chickpea cultivar.

Many factors affect host suitability, including nutrient content and secondary substances of the host (Liu *et al*., 2004). The exact cause of the differences found among host plants in larval growth rates, mortality, adult fecundity and survival remains unknown (Liu *et al*., 2004). However, it is reported that the presence of secondary plant substances or poor food quality in wild varieties while malic acid and oxalic acid are the principal components of resistance to *H. armigera* in the cultivated chickpea, which result in oviposition nonpreference and antifeedant effects on *H. armigera* (Yoshida *et al*., 1995). It is also reported that antibiosis seems to be the major component of resistance in the wild relatives of chickpea (Sharma *et al*., 2005). There is evidence of substances (flavonoids) present in some chickpea cultivars responsible for antifeedant activity against the *H. armigera* larvae (Simmonds and Stevenson, 2001). In the present study, preference of larval feeding of *H. armigera* revealed significant difference. The maximum larvae were recorded on CMC-211s (3.8) while minimum larvae were recorded on Pb-2008 (1.2). The differences in larval attraction towards cultivars might be attributed to differences in primary or secondary compounds or physiological characteristics present in different cultivar pods (Sharma *et al*., 2005).

There was significant difference in fecundity of *H. armigera* on different chickpea cultivar. The total number of eggs laid were highest by the females developed from larvae reared on CMC-211s (522.54 eggs) while there was significant reduction in number of eggs laid by the

females developed on PB-2008 (299.68 eggs). These results are in accordance with the Narayanamma *et al.* (2007), who reported lower fecundity on resistant chickpea parent hybrids as compared to susceptible parent hybrids. In conclusion, the more body weight, faster development, highest survival percentage and highest fecundity of *H. armigera* suggested that cultivar CMC-211s was susceptible as compared with the other cultivars. Cultivar Pb-2008 was resistant as compare to other cultivars. Dasht, CM-2000, Parbat and Bittle-98 showed intermediate trend.

The development of new chickpea resistant varieties is being recommended to enhance crop protection and ultimately crop production. The development of cultivars with resistance would provide an effective complementary approach in integrated pest management to minimize the extent of losses due to this pest (Sharma *et al*., 2005).

REFERENCES

Ahmed, M. and Hashmi, A. A., 1976. Assessment of pod borer (*Heliothis armigera*) damage to different varieties of chickpea in the Punjab. *J. agric. Res.,* **14**:82-86

Ahmad, M., Arif, M.I. and Attique, M. R., 1997. Pyrethroid resistance of *Helicoverpa armigera* (Lepidoptera: Nocutuidae) in Pakistan. *Bull. entomol. Res.,* **87**: 343-347

Ahmad, M., Arif, M. I. and Ahmad, Z., 2001. Resistance to carbamate insecticides in *Helicoverpa armigera* (Lepidoptera: Noctuidae) in Pakistan. *Crop Protec.,* **20**: 427-432.

Anonymous, 2008. *Agricultural Statistics of Pakistan.* Government of Pakistan, MINFAL, Economic trade and investment wing, Islamabad., pp. 22.

Awmack, C. S. and Leather, S. R., 2002. Host plant quality and fecundity in herbivorous insects. *Annu. Rev. Ent*., **47**: 817-844.

Borah, S. R. and Dutta, S. K., 2002. Biology of gram pod borer, *Helicoverpa armigera* (Hub.) on pigeon pea. *J. agric. Sci. Soc. N. E. India,* **15**:34-37.

Du, L., Ge, F., Zhu, S. and Parajulee, M. N., 2004. Effect of cotton cultivar on development and reproduction of *Aphis gossypii* (Homoptera: Aphididae) and its predator *Propylaea japonica* (Coleoptera: Coccinellidae). *J. econ. Ent.,* **97**: 1278-1283.

Fathipour, Y. and Naseri, B., 2011. Soybean cultivars affecting performance of *Helicoverpa armigera* (Lepidoptera: Noctuidae). In: *Soybean - Biochemistry, chemistry and physiology* (ed. T.B. Ng) In Tech, Rijeka, Croatia, pp. 642.

Goyal, S. P. and Rathore, V. S., 1988. Patterns of insect-plant relationship determining susceptibility of different hosts to *Heliothis armigera* (Hubner). *Indian J. Ent.,* **50**:193-201.

Hulse, J. H., 1991. Nature, composition and utilization of grain legumes. In: *Uses of tropical legumes.* Proceedings of a consultants meeting, 27-30 March 1989, ICRISAT, Patancheru, A.P. 502 324, India, pp.11-27.

King, A.B.S. and Sawicki, R. M., 1990. Insecticide resistance of *Helicoverpa* and its management. In: *Chickpea in the nineties*: Proc. 2nd Int. Workshop on Chickpea Improvement, on 8 Dec. 1989, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, pp. 195-201.

Kranthi, K. R., Jadhav, D. R., Kranthi, S., Wanjari, R. R., Ali, S.S. and Russell, D. A., 2002. Insecticide resistance in five major insect pests of cotton in India. *Crop Protec*., **21**: 449-460.

Lateef, S.S., 1985. Gram pod borer (*Heliothis armigera*) (Hub.) resistance in chickpeas. *Agric. Ecol. Environ.,* **14**: 95-102.

Li, Y., Hill, C. B. and Hartmen, G. L., 2004. Effect of three resistant soybean genotypes on the fecundity, mortality and maturation of soybean aphid (Homptera:Aphidae). *J. econ. Ent.,* **97**: 1106-1111.

Liu, Z., Li, D., Gong, P. Y. and Wu, K. J., 2004. Life table studies of the cotton bollworm, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae), on different host plants. *Environ. Ent.,* **33**: 1570-1576.

Nadeem, S., Shafique, M., Hamed, M., Atta, B. M. and Shah, T. M., 2010. Evaluation of advanced chickpea genotypes for resistance to pod borer, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae). *Pak. J. agric. Sci.,* **47**: 132-135.

Nadeem, S., Hamed, M., Shafique, M., Atta, B. M. and Shah, T.M., 2011. Evaluation for resistance in Kabuli chickpea genotypes against chickpea pod borer, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) under field conditions. *Songklanakarin J. Sci. Technol.,* **33**, 291-294.

Narayanamma, V. L., Sharm, H. C., Gowda, C.L.L. and Sriramulu, M., 2007. Mechanisms of resistance to *Helicoverpa armigera* and introgression of resistance genes into F_1 hybrids in chickpea. *Arthro. Pl. Interact.,* **1**: 263-270.

Naseri, B., Fathipour, Y., Moharramipour, S. and Hosseininaveh, V., 2009. Comparative life history and fecundity of *Helicoverpa armigera* (Hubnes) (Lepidopeia; Noctuidae) on different soybean varieties. *Ent. Sci.,* **12**: 147-154.

Prakash, M.R., Ram, U. and Tariq, A., 2007. Evaluation of chickpea (*Cicer arietinum* L.) germplasm for the resistance to gram pod borer, *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae). *J. entomol. Res.,* **31**: 215-218.

Saleem, M. and Yunus, M., 1982. Host plant and nature and extent of damage of *Heliothis armigera* (Hubner). *Pak. J. agric. Res.,* **3**: 54-58.

Sarfraz, M., Dosdall, L.M. and Keddie, B.A., 2006. Diamondback moth-host plant interactions: implications for pest management. *Crop Protec.,* **25**: 625-636.

Sarwar, M., 2013. Exploration on resource of resistance in

chickpea (*Cicer arietinum* L.) genotypes to gram pod borer *Helicoverpa armigera* (Hubner) (Lepidoptera). *Afr. J. agric. Res*., **8**: 3431-3435.

Sarwar, M. and Sattar, M., 2013. Varietals variability of winter rapes (*Brassica napus* L.) for their susceptibility to green aphid, *Myzus persicae* (Sulzer) (Homoptera: Aphididae). *Pakistan J. Zool*., **45**: 883-888.

Sarwar, M., Ahmad, N. and Tofique, M., 2009. Host plant resistance relationships in chickpea (*Cicer arietinum* L.) against gram pod borer (*Helicoverpa armigera*) (Hubner). *Pak. J. Bot.*, **41**: 3047-3052.

Sarwar, M., Nazir, N. and Toufiq, M., 2011. Identification of susceptible and tolerant gram *(Cicer arietinum)* genotypes against gram pod borer (*Helicoverpa armigera* Hubner). *Pak. J. Bot.*, 4**3**: 1265- 1270.

Shafique, M., Nadeem, S., Hamed, M., Atta, B. M. and Shah, T. M., 2008. Screening of kabuli chickpea recombinants for resistance to pod borer (*Helicoverpa armigera* Hub.) under natural field conditions. *Pak. Entomol*., **30**: 169-173.

Shafique, M., Nadeem, S., Hamed, M., Atta. B. M. and Shah, T. M., 2009. Performance of some advance desi chickpea genotypes against pod borer, *Helicoverpa armigera* (Hubner) resistance. *Pakistan J. Zool*., **41**: 277-280.

Sharma, H. C., Pampapathy, G., Lanka, S.K. and Ridsdill-Smith, T. J., 2005. Antibiosis mechanism of resistance to pod borer, *Helicoverpa armigera* in wild varieties of chickpea. *Euphytica*, **142**: 107-115.

Sharma, H. C., Singh, B. U., Hariprasad, K.V. and Bramel-Cox, P. J., 1999. Host-plant resistance to insects in integrated pest management for a safer environment. *Proc. Acad. environ. Biol.*, 8: 113–136.

Shrestha, R., Neupane, R.K. and Adhikari, N.P., 2011. Status and Future Prospects of Pulses in Nepal. Paper presented at Regional Workshop on Pulse Production held at Nepal Agricultural Research Council (NARC), Kathmandu, Nepal, from 24-25 October, 2011.

Simmonds, M.S.J. and Stevenson, P.C., 2001. Effects of isoflavonoids from Cicer on larvae of *Helicoverpa armigera*. *J. chem. Ecol*., **27**: 965-977.

Singh, O.P. and Parihar, S.B.B., 1988. Effect of different hosts on the development of *Heliothis armigera* Hub. *Bull. Ent*., **29**:168-172.

Srivastava, C.P. and Srivastava, R. P., 1990. Antibiosis in chickpea (*Cicer arietinum L.*) to gram pod borer, *Heliothis armigera* (Hubner) (Noctuidae: Lepidoptera) in India. *Entomon*, **15**:89-93.

Umbanhowar, J. and Hastings, A., 2002. The impact of resource limitation and the phenology of parasitoid attack on the duration of insect herbivore outbreaks. *Theor. Popul. Biol.*, **62**: 259–269.

Wakil, W., Ashfaq, M., Hassan, M. and Javed, A., 2005. Evaluation of different chickpea (*Cicer arietinum* L.) genotypes against *Helicoverpa armigera* (Hub.) in Rawalpindi. *Pak. Entomol*., **27**: 37-40.

Yoshida, M., Cowgill, S.E. and Wightman, J.A., 1995. Mechanisms of resistance to *Helicoverpa armigera* (Lepidoptera: Noctuidae) in chickpea – role of oxalic acid in leaf exudates as an antibiotic factor. *J. econ. Ent*., **88**: 1783–1786.