Pak. J. Bot., 41(1): 421-428, 2009.

ANALYSIS OF HOST PLANT RESISTANCE IN SOME GENOTYPES OF MAIZE AGAINST *CHILO PARTELLUS* (SWINHOE) (PYRALIDAE: LEPIDOPTERA)

MUHAMMAD AFZAL*, ZAHID NAZIR, MUHAMMAD HAMID BASHIR AND BILAL SAEED KHAN

Department of Agriculture Entomology, University of Agriculture, Faisalabad, Pakistan.
**University College of Agriculture, University of Sargodha, Sargodha, Pakistan*

Abstract

Twenty available genotypes of maize were screened for resistance to *Chilo partellus* in the field. The genotype Sahiwal 2002 was found to be most susceptible while DK-6525 was most resistant. Maximum infestation was observed at the end of April while the minimum in the last week of March. Significant variations were observed in all the plant characters viz., number of nodes per plant, plant height, cob height, stem diameter, length of central spike, cob length, leaf length, leaf width, leaf trichomes and 100 grains weight. All these characters had negative and significant correlation with the infestation of *Chilo partellus* except number of nodes per plant, plant height, cob height and length of central spike which had negative but non significant results. The R^2 values computed for multiple linear regression indicated that leaf trichomes contributed for the maximum 41.6% individual role followed by stem diameter alone contributed 32.7% towards resistance to *Chilo partellus.* Overall contribution of significant factors was observed 84.8% which was resulted from the combined effect of stem diameter, cob length, leaf length, leaf width, leaf trichomes and 100 grains weight.

Introduction

Maize is a multipurpose crop, providing food and fuel for human beings, feed for animals, poultry and livestock. Maize grains have great nutritional value and are used as raw material for manufacturing many industrial products. In Pakistan, maize is grown over an area of 1022 thousand hectares with an average production of 3483 kg/ha (Anon., 2006), which is very low as compared to other countries. There are many factors for this low yield. Among these factors, insect pests are most important. Maize plant is attacked by 140 species of insects causing varying degree of damage. Out of these, only 10 species cause serious damage from sowing till storage (Arabjafari & Jalali, 2007). Maize is most vulnerable to *Chilo partellus* Swinhoe (Lepidoptera: Pyralidae) which causes severe losses to it (Songa *et al*., 2001). A loss of 24-75% has been reported by the attack of this pest alone (Kumar & Mihm, 1995, 1996; Kumar, 2002). It is an important pest in Asian and African countries like Afghanistan, Bangladesh, East Africa, Iraq, Japan, Indonesia, Nepal, Malawi, Pakistan, India, Sudan, Taiwan, Thailand and Uganda (Siddiqui & Marwaha, 1993; Arabjafari & Jalali, 2007).

Nature of damage and behaviour of this pest makes it very difficult to control by conventional insecticides and biological control agents. Because once the pest enters the plant tissue, it becomes almost impossible for biological control agents and pesticides to reach the target. Moreover the indiscriminate use of the pesticides has caused many problems like eradication of natural enemies and polluting the environment along with the resistance in the pest. Keeping in view the above mentioned obstacles and the

*Corresponding author E-mail: chafzal64@yahoo.com; Phone: +92 321 6650959

consumer pressure to reduce the chemical inputs, the use of resistant varieties is environmentally safe, economically feasible and socially acceptable as a tactic of pest management. Host plant resistance against various pests including insects has remained a reliable source for pest management since the advent of modern agriculture. Its importance has further enhanced after the realization of the detriment of environment caused by pesticides in general and sanitary and phytosanitary measures applied by WTO, in specific.

There are many plant characters, which are responsible for host plant resistance. The plant structures may influence positively as well as negatively on herbivours and their natural enemies (Krips *et al*., 1999; Afzal & Bashir, 2007). These characters may be divided into morphological and biochemical. Morphological characters are most important in host plant resistance for *Chilo partellus* (Parvez, 1990). These characters are known to contribute a lot towards the host plant resistance (Woodhead & Taneja, 1987; Patel & Sukhani, 1990; Kumar, 1992, 1997; Rebe *et al*., 2004). In maize these characters are responsible for suitability of a cultivar for feeding, oviposition and development. Trichome densities and surface waxes are considered to have negative effect on the oviposition and development of *Chilo partellus* (Kumar, 1997). Plant height and length of internodes have negative correlation with the infestation of *Chilo partellus*. Tunnel length, stem thickness, plant height and length of 3^{rd} internodes at crop maturity have found to have negative effect on the infestation of this pest (Ahmad *et al*., 1990).

Keeping in view the importance of *Chilo partellus* in the region, research was planned with an objective to screen out the resistant varieties from majority of the available material in Pakistan and to study the role of morphological plant characters as mechanism of resistance to this pest.

Materials and Methods

Varietals screening trial: Screening of 20 available genotypes of maize including 8 commercial hybrids (32-F-10, 32-W-86, 34-N-43, Hicorn 11, NK-8441, P-3335, DK-6124 and DK-6525) 6 local hybrids (DTC, EV-1097, EV-5098, EV-6098, FHY-421 and FHY-845) 2 composite varieties (C-20 and C-78) and 4 synthetic genotypes (Sahiwal-2002, Golden, Agati-2002 and Pak Afgoyee) was undertaken during spring season 2004 at the farmer's field at Chak No.254/R.B., Faisalabad following R.C.B.D., replicated thrice in plots measuring 3.5x 5 m^2. The percent plant infestation was recorded from 20 plants randomly selected for maize borer from each plot at weekly interval. The data were analyzed statistically and two entries each showing comparatively resistant, intermediate and susceptible responses based on plant infestation were selected for further investigations.

Selected varieties trial: These selected entries including DK-6525, 32-W-86, EV-6098, 32-F-10, 34-N-43 and Sahiwal-2002 were sown in the farmer's field at Chak No.254/R.B., Faisalabad during spring season 2005. The percent plant infestation was recorded from 20 plants randomly selected for maize borer from each plot at weekly interval. These genotypes were further studied in details for morphological characters for resistance against *Chilo partellus* (Swinhoe).

Table 1. Means comparison of the data regarding plant infestation (%) caused by *Chilo partellus* (Swinhoe), on various genotypes of maize crop, during 2004.

Genotypes	Means (**)
Sahiwal 2002	10.94 a
34-N-43	8.68 b
Golden	8.67 b
EV-1097	8.29 bc
Agati-2002	7.08 bcd
P-3335	7.02 bcd
Hicorn 11	6.48 cde
C-78	6.33 de
DTC	6.29 de
EV-6098	6.24 de
32-F-10	6.02 de
FHY-421	5.94 def
Pak. Afgoyee	5.51 def
EV-5098	5.30 def
DK-6124	5.23 def
C-20	5.22 def
FHY-845	5.07 def
NK-8441	5.01 def
32-W-86	4.61 ef
DK-6525	3.92 f

** = Significant at $p \leq 0.01$.
LSD = 1.76
Means sharing similar letters are not significantly different by DMR Test at P = 0.05.

Morphological plant characters studies: The morphological plant characters were recorded from 5 randomly selected plants per treatment. These included number of nodes per plant, plant height (cm), cob height (cm), stem diameter (mm), length of central spike (cm), cob length (cm), leaf length (cm), leaf width (cm), leaf trichomes (cm^{-2}) and 100 grains weight (gm). The 1st node above ground was taken as node one. Total number of nodes was recorded starting from node one. Above ground plant height was recorded with the help of a measuring tape while the cob height was taken as the distance between node one and cob node. The stem diameter was taken with the help of a Vanier caliper by measuring from the center of the 3rd inter node. Leaf length and leaf width were taken from the leaf at cob node with the help of a measuring tape. Leaf trichomes were counted under a binocular microscope from an area of 1 cm^2 at three different points of a leaf selected randomly. Hundred grains weight was recorded from 5 randomly selected cobs. After sun drying the grains were separated and 100 grains were weighed with electronic balance.

The data were analyzed statistically to screen out the resistant varieties and determine the role of morphological plant characters under study in host plant resistance.

Results and Discussion

Preliminary screening trial: The study was conducted to screen 20 available genotypes of maize based on plant infestation percentage caused by *C. partellus* under field conditions during spring 2004. The data regarding percentage of infestation of plants caused by *C. partellus* in various genotypes of maize during spring 2004 are given in Table 1. The results reveal highly significant differences. The genotype Sahiwal-2002 showed maximum infestation (10.94%). The genotypes 34-N-43, Golden, EV-1097, Agati-2002 and P-3335 showed statistically non significant differences with 8.68, 8.67, 8.29, 7.08 and 7.02% plant infestation, respectively. The minimum plant infestation recorded was 3.92 on genotype DK-6525 which was statistically at par with those of 4.61, 5.01, 5.07, 5.22, 5.23, 5.30, 5.51 and 5.94% on 32-W-86, NK-8441, FHY-845, C-20, DK-6124, EV-5098, Pak. Afgoyee and FHY-421, respectively. The genotype EV-6098 and 32-F-10 showed 6.24 and 6.02% plant infestation which ranked as intermediate and did not show significant differences with those of 6.33, 6.48, 7.02 and 7.08 on C-78, Hicorn 11, P-3335 and Agati-2002, respectively. From these results 6 genotypes were selected showing comparatively susceptible (Sahiwal-2002 and 34-N-43), resistant (DK-6525 and 32-W-86) and intermediate (EV-6098 and 32-F-10) responses for further studies.

Selected varieties trial: The data regarding percentage infestation of *C. partellus* on selected genotypes of maize crop at various dates of observation during 2005 reveals that significant difference of infestation on selected genotypes and dates of observation existed (Table 2). The maximum plant infestation caused by *C. partellus* recorded was 13.71% on Sahiwal-2002 which differed significantly from those of recorded on all other genotypes, whereas minimum infestation was 7.31% on DK-6525 and did not show significant variation with that found on 32-W-86 i.e., 8.21%. The genotype EV- 6098, 32-F-10 and 34-N-43 showed 10.05, 9.21 and 9.80% plant infestation, respectively and showed non-significant difference with one another. From these results it was concluded that the genotype Sahiwal-2002 was comparatively susceptible while DK-6525 showed resistant trend. These results can't be compared with those of Sharma & Chatterji (1972), Khaliq & Mahmood (1991), Ajala & Saxena (1994), Panwar *et al*., (2000), Awan & Khaliq (2003) and Khan & Monobrullah (2003) because they used different varieties of maize other than used in this study, but they found significant differences in infestation level of *Chilo partellus*.

Period of infestation fluctuation: The results presented in Table 2 revealed that the plant infestation appeared on March 26 i.e., 1.68%. The infestation increased consequently on the subsequent dates of observation and reached to a peak of 23.51% on April 23, 2005. A significant decreasing trend was observed thereafter and up to May 14, i.e., 2.22%. From these results it was observed that the 3rd week of April was the most favourable for the pest as per time and growth stage of the crop.

Morphological plant characters: Significant variations were observed in all the morphological plant characters recorded from different genotypes of maize (Table 3). The maximum number of nodes per plant was 16.07 in genotype EV-6098 while minimum number of nodes was recorded from 34-N-43 (12.93). 15.00, 15.07 and 14.94 number of nodes was recorded in genotypes DK-6525, 32-W-86 and 32-F-10, respectively which did not show significant difference with each another. Sahiwal-2002 showed 14.13 numbers of nodes per plant which also differed significantly from those of recorded in all other genotypes.

The maximum plant height recorded was 255.77 cm in genotype 32-W-86 followed by 244.50, 244.30, 214.03, 213.93 and 192.93 in DK-6525, EV-6098, 32-F-10, Sahiwal-2002 and 34-N-43, respectively.

Table 2. Means comparison of the data regarding percent infestation in plants caused by *Chilo partellus* (Swinhoe) in various selected genotypes of maize during 2005.

Dates	Genotypes X Dates						Means** LSD = 1.96
	DK-6525	**32-W-86**	**EV-6098**	**32-F-10**	**34-N-43**	**Sahiwal-2002**	
March 19	0.00	0.00	0.00	0.00	0.00	0.00	0.00 h
March 26	1.67	0.00	1.67	1.67	1.67	3.42	1.68 gh
April 02	3.17	3.42	6.93	3.51	7.41	10.92	5.89 f
April 09	8.51	8.60	12.28	10.72	12.58	18.96	11.94 d
April 16	11.84	14.23	18.13	18.23	19.28	26.91	18.10 b
April 23	18.95	20.37	24.51	24.23	25.49	27.52	23.51 a
April 30	12.48	14.52	15.36	15.14	15.84	19.77	15.52 c
May 07	7.31	9.07	9.58	7.52	5.90	12.01	8.56 e
May 14	1.85	3.71	1.96	1.85	0.00	3.92	2.22 g
Means ** LSD = 1.60	**7.31 d**	**8.21 cd**	**10.05 b**	**9.21 bc**	**9.80 bc**	**13.71 a**	

** = Significant at $p \leq 0.01$.

Means sharing similar letters are not significantly different by DMR Test at P = 0.05

Table 3. Quantum of morphological plant characters in various selected genotypes of maize crop (75 days old plants).

Name of factor	Genotypes						LSD value
	DK-6525	**32-W-86**	**EV-6098**	**32-F-10**	**34-N-43**	**Sahiwal-2002**	
No. of nodes /plant	15.00 b	15.07 b	16.07 a	14.94 b	12.93 d	14.13 c	(**) 0.21
Plant height (cm)	244.50 b	255.77 a	244.30 b	214.03 c	192.93 d	213.93 c	(**) 3.43
Cob height (cm)	101.30 b	108.53 a	103.83 b	95.63 c	84.67 d	104.13 b	(**) 3.91
Stem diameter (mm)	21.73 b	21.47 c	23.23 a	21.50 c	19.73 d	18.80 e	(**) 0.15
Length of central spike (mm)	26.20 b	28.73 a	29.93 a	29.17 a	20.27 c	20.90 c	(**) 1.23
Cob length (cm)	21.17 d	26.63 a	21.97 c	24.03 b	19.83 e	18.83 f	(**) 1.36
Leaf length (cm)	86.19 b	91.43 a	87.27 b	91.23 a	76.87 c	76.93 c	(**) 1.35
Leaf width (cm)	9.00 b	9.30 a	9.40 a	9.17 ab	8.33 c	7.93 d	(**) 0.24
Leaf trichomes (cm^{-2})	85.50 a	81.60 b	57.70 e	76.90 c	67.20 d	40.63 f	(**) 2.64
100 grains weight (gm)	21.07 c	20.90 c	19.07 d	26.27 a	23.20 b	16.10 e	(**) 0.63

** = Significant at $p<0.01$

Means sharing similar letters in rows are not different by DMR Test at P = 0.05.

Significant variations were found to exist among genotypes regarding cob height. The genotype 32-W-86 possessed the maximum cob height i.e., 108.53 cm which showed significant differences from those recorded on all other genotypes. The minimum cob height was recorded to be 84.67 cm in genotype 34-N-43. The cob height recorded on DK-6525 (101.30 cm), EV-6098 (103.83 cm) and Sahiwal-2002 (104.13 cm) were statistically similar.

The genotype EV-6098 showed maximum stem diameter i.e., 23.23 mm while minimum diameter was recorded 18.80 mm in genotype Sahiwal-2002. The genotypes DK-6525 and 34-N-43 with 21.73 mm and 19.73 mm stem diameter differed significantly with one another. The stem diameter i.e., 21.47 mm and 21.50 mm found in genotypes 32-W-86 and 32-F-10 did not show significant difference with one another.

The maximum length of central spike was recorded to be 29.93 mm on genotype of EV-6098 while minimum was observed 20.27 mm on genotypes 34-N-43.

The data regarding the cob length showed significant difference among each other. The maximum cob length was found in 32-W-86 (26.63 cm) while minimum cob length was observed in Sahiwal-2002 (18.83 cm). These genotypes also showed significant differences from those of recorded on all other genotypes DK-6525, EV-6098, 32-F-10 and 34-N-43 which had 21.17, 21.97, 24.03 and 19.83 cm cob length, respectively.

Maximum leaf length of 91.43 cm was recorded in 32-W-86 which was statistically similar to that of 32-F-10 with leaf length of 91.23 cm, where as genotypes DK-6525 and EV-6098 showed statistically similar leaf length with 86.19 and 87.27 cm respectively. Genotype 34-N-43 showed minimum leaf length (76.87) but statistically at par to that of Sahiwal-2002 with mean leaf length of 76.93 cm.

The maximum leaf width recorded was 9.40 cm in genotype EV-6098 followed by 9.30 cm in 32-W-86, 9.17 cm in 32-F-10, 9.00 cm in DK-6525, 8.33 in 34-N-43 and 7.93 cm in Sahiwal-2002.

The maximum trichomes were observed on DK-6525 i.e. 85.50 cm^{-2} and showed significant variation from those of observed on all other genotypes. The minimum trichomes were recorded were 40.63 cm^{-2} on Sahiwal- 2002. The trichome density i.e., 81.60, 76.90, 67.20 and 57.70 cm^{-2} on 32-W-86, 32-F-10, 34-N-43 and EV-6098, respectively differed significantly from one another and as well as from those of observed on other genotypes.

The maximum 100 grains weight 26.27 gm was recorded on 32-F-10 and showed significant difference from those of found in all other genotypes. The minimum weight of 100-grains was observed on genotype Sahiwal-2002 which was 16.10 gm. EV-6098, DK-6525 and 32-W-86 had 19.07, 21.07 and 20.90 gm 100-grain weight respectively.

These results can be compared with those of Sharma & Chatterji (1971a, b), Woodhead & Taneja (1987), Kishore (1991), Rao & Panwar (2000), Rebe *et al.*, (2001), Das *et al*., (2006) and Arabjafari & Jalali (2007) who had discussed the role of morphological plant characters towards resistance/ susceptibility of *Chilo partellus* on maize.

Correlation of morphological plant characters with infestation of *Chilo partellus*: The results regarding the correlation coefficient values between infestation of plants caused by *C. partellus* and morphological plant characters is given in Table 4. These results revealed that stem diameter, cob length, leaf length, leaf width, leaf trichome and 100 grains weight exerted significant and negative correlation with the plant infestation showing r-values of -0.572**, -0.545**, -0.542*, -0.620**, -0.880** and -0.559**, respectively. Number of nodes per plant, plant height, cob height and length of central spike showed non significant correlation with the plant infestation, however the response was found to be negative on the infestation of plants caused *by C. partellus*.

Multiple linear regression models among morphological plant characters and plant infestation: The role of various morphological plant characters showing significant correlation with plant infestation were worked out by processing the data into multiple linear regression analysis (Table 5). It is evident from the results that leaf trichomes contributed the maximum individual effect of 41.6% followed by stem diameter which contributed 32.7% towards infestation of pest. The overall contribution of 84.8% towards the infestation of *Chilo partellus* was obtained by the combination of all the significant characters including stem diameter, cob length, leaf length, leaf width, leaf trichomes and 100 grain weight. From these results it was observed that leaf trichome was the most important plant characters followed by stem diameter contributing towards resistance against *Chilo partellus* in maize crop.

Table 4. Correlation coefficient values between infestation (%) of *Chilo partellus* (Swinhoe) and morphological plant characters.

Plant characters	r-value
No. of nodes/plant	-0.268 ns
Plant height (cm)	-0.434 ns
Cob height (cm)	-0.023 ns
Stem diameter (mm)	-0.572 **
Length of central spike (mm)	-0.271 ns
Cob length (cm)	-0.545 **
Leaf length	-0.542 *
Leaf width (cm)	-0.620 **
Leaf trichomes (cm^2)	-0.880 **
100 grains weight (gm)	-0.559 **

ns = Non-significant
** = Significant at $p \leq 0.01$.

Table 5. Multiple linear regression models along with coefficients of determination between infestation (%) of *Chilo partellus* (Swinhoe) and various morphological plant characters in maize crop during spring 2005.

	Regression equation	R^2	$100R^2$	Difference
**	Y = 8.8971–1.2323 ** X1	0.327	32.7	32.7
*	Y = 8.9593–0.8354 X1–0.4013 X2	0.399	39.9	7.2
*	Y = 8.3705–1.2044 X1–0.7517 X2+0.4292 X3	0.419	41.9	2.0
ns	Y = 8.8760–0.8283 X1–0.6537 X2+0.4459 X3–0.9386 X4	0.422	42.2	0.3
**	Y = 5.1499–1.4962 X1–0.3735 X2 + 0.4522 X3+1.629 X4–0.2938** X5	0.838	83.8	41.6
**	Y = 4.8024–1.3769 X1–0.3496 X2+0.4511 X3+1.4279 X4–0.3238 X5+0.1191 X6	0.848	84.8	1.0

(**)= Significant at $p \leq 0.01$, (*)= Significant at $p \leq 0.05$, ns= Non-significant, R^2= Coefficient of Determination
X1= Stem diameter, X2= Cob length, X3= Leaf length, X4= Leaf width, X5= Leaf trichomes, X6= 100-grain weight

References

Afzal, M and M.H. Bashir. 2007. Influence of certain leaf characters of some summer vegetables with incidence of predatory mites of the family Cunaxidae. *Pak. J. Bot*., 39(1): 205-209.

Ahmad, M., M.R. Khan and M. Rafiq. 1990. Biological characters in relation to resistance against *Chilo partellus* (Swinhoe) in some inbred lines and hybrids of maize. *Pak. Entomol*., 12(1-2): 1-6.

Ajala, S.O. and K.N. Saxena. 1994. Interrelationship among (*Chilo partellus* Swinhoe) damage parameters and their contribution to grain yield reduction in maize (*Zea mays* L.). *Appl. Entomol. Zool*., 29(4): 469-476.

Anonymous. 2006. Area and production of other major kharif and rabi crops. *Agricultural statistics of Pakistan 2005-06*. Govt. Pak., Min. Food Agric. Livestock, (Econ. Wing) Islamabad, pp. 15.

Arabjafari, K.H. and S.K. Jalali. 2007. Identification and analysis of host plant resistance in leading maize genotypes against spotted stem borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae). *Pak. J. Biol. Sci*., 10(11): 1885-1895.

Awan, N.A. and A. Khaliq. 2003. Tassel Infestation and dead hearts formation due to maize stem borer (*Chilo partellus*) attack in maize varieties. *Pak. J. Biol. Sci*., 6(3): 191-194.

Das, S., J.C. Mehla, R.K. Moudgei, K.S. Dhanju, D. Pal, D.P. Singh and V. Kumar. 2006. Identification of morphological traits in maize for its least susceptibility to *Chilo partellus*. *Ann. Pl. Protec. Sci*., 14(1): 33-37.

Khaliq, A. and K. Mahmood. 1991. Studies on relative resistance of six maize varieties to *Chilo partellus* at Rawalakot. *Pak., Entomol*., 13(1-2): 91-92.

Khan, M. S. and M. Monobrullah. 2003. Preliminary screening of maize germplasm against stem borer *Chilo partellus* (Swinhoe) at intermediate zone rajouri (J&K). *Insect Environ*., 9(1): 45-46.

Kishore, P., 1991. Morphological factor responsible for conferring resistance in sorghum cultivars to the stem borer, *Chilo partellus* (Swinhoe). *J. Entomol. Res*., 15(3): 163-168.

Krips, O.E., P.W. Kleijn, P.E.L. Willems, G.J.Z. Gols and M. Dicke. 1999. Leaf hairs influence searching efficiency and predation rate of the predatory mite *Phytoseiulus persimilis* (Acari; Phytoseiidae). *Exp. Apl. Acarol*., 23(2): 119-131.

Kumar, H. 1992. Inhibitional of ovipositional responses of *Chilo partellus* (Lepidoptera: Pyrallidae) by the trichomes on the lower leaf surface of maize cultivar. *J. Econ. Entomol*., 85(5): 1736-1739.

Kumar, H. 1997. Resistance in maize in *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae): an overview. *Crop Prot*., 16(3): 243-250.

Kumar, H. 2002. Resistance in maize to larger grain borer, *Prostephanus truncates* (Horn) (Coleoptera: Bostrichidae). *J. Stored Prod. Res*., 38: 267-280.

Kumar, H. and J.A. Mihm. 1995. Antibiosis and tolerance to fall armyworm, *Spodoptera frugiperda* (J.E. Smith), southwestern corn borer, *Diatraea grandiosella* Dyar and sugarcane borer, *Diatraea saccharalis* Fabricius in selected maize hybrids and varieties. *Maydica,* 40: 245-251.

Kumar, H. and J.A. Mihm. 1996. Resistance in maize hybrids and inbreds to first-generation southwestern corn borer, *Diatraea grandiosella* (Dyar) and sugarcane borer *Diatraea saccharalis* Fabricius. *Crop Prot.*, 15: 311-317.

Panwar, V.P.Z., B.K. Mukherjee and V.P. Ahuja. 2000. Maize inbreds tolerant to tissue borers, *Chilo partellus* and *Atherigona* spp. *Indian J. Genet. Pl. Breed*., 60(1): 71-75.

Parvez, I. 1990. *Factors effecting resistance of different maize cultivars against Chilo partellus (Swinhoe)*. Ph.D. Thesis, Deptt. Agri. Ento., Univ. Agric., Faisalabad.

Patel, G.M. and T.R. Sukhani. 1990. Some biophysical plant characters associated with stem borer resistance in sorghum genotypes. *Indian J. Entomol*., 52(33): 452-455.

Rebe, M., J. Van Den Berg and M.A. McGeoch. 2004. Colonization of cultivated and indigenous graminaceous host plants by *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae) and *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) under field conditions. *African Entomol*., 12(2): 187-199.

Rao, C.N. and V.P. Panwar. 2000. Morphological plant characters effecting resistance to *Chilo partellus* in maize. *Ann. Pl. Protec. Sci*., 8(2): 145-149.

Sharma, V.K. and S.M. Chatterji. 1971 a. Pereferential oviposition and antibiosis in different maize germplasms against *Chilo partellus* (Swinhoe) under cage conditions. *Indian J. Ent*., 33: 299-311.

Sharma, V.K. and S.M. Chatterji. 1971 b. Screening of some maize germplasms against *Chilo zonellus* (Swinhoe) and some varietal plant characters (physical) in relation to their differential susceptibility. *Indian J. Ent*., 33: 279-290.

Sharma, V.K. and S.M. Chatterji. 1972. Screening of some maize germplasms against *Chilo partellus* (Swinhoe) and some varietal plant characters (Physical) in relation to their differential susceptibility. *Indian J. Ent*., 33(3): 279-290.

Siddiqui, K.H. and K.K. Marwaha. 1993. *The vistas of maize entomology in India*, Kalyani Publishers, New Delhi, India, 135 pp.

Songa, J.M., G. Zhou and W.A. Overholt. 2001. Relationship of stem borer damage and plant physical condition to maize yield in a semi arid zone of Eastern Kenya. *Ins. Sci. Applic*., 21(3): 243-249.

Woodhead, S. and S.L. Taneja. 1987. The importance of behaviour of young larvae in sorghum resistance to *Chilo partellus. Entomologia Experimentalis et Applicata*, 45(1): 47-54.

(Received for publication 3 May 2008)