Journal of Entomology and Zoology Studies
Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2015; 3 (2): 246-250

Received: 12-04-2015
Accepted: 30-04-2015

Amjad Ali
Entomological Research Institute, Ayub Agricultural Research Institute, Faisalabad – Pakistan.

Nazia Khalil
Department of Zoology, GC University, Faisalabad – Pakistan.

Muneer Abbas
Entomological Research Institute, Ayub Agricultural Research Institute, Faisalabad – Pakistan.

Ruba Tariq
Department of Zoology, GC University, Faisalabad – Pakistan.

Zia-ullah
Entomological Research Institute, Ayub Agricultural Research Institute, Faisalabad – Pakistan.

Dilbar Hussain
Entomological Research Institute, Ayub Agricultural Research Institute, Faisalabad, Punjab, Pakistan.

Correspondence:
Muneer Abbas
Entomological Research Institute, Ayub Agricultural Research Institute, Faisalabad – Pakistan.

Plant traits as resistance influencing factors in maize against *Chilo partellus* (Swinhoe)

Amjad Ali, Nazia Khalil, Muneer Abbas, Ruba Tariq, Zia-ullah, Dilbar Hussain

Abstract
Ten maize genotypes {seven hybrid (FH-292, FH-810, FH-793, FH-930, FH-949, FH-963 and FH-985) and three commercial (Agaiti-2002, Com-6625, and Com-32F-10)} were tested for resistance/susceptibility against *Chilo partellus* (Swinhoe) with respect to physico-chemical plant traits. The results revealed that the genotype Com-6625 was found resistant, having minimum level of infestation (5.63%) followed by Agaiti-2002 (5.69 %) and FH-810 (6.06 %) while FH-949 proved more susceptible with maximum infestation (19.45 %) followed by FH-963 (15.21 %) and FH-985 (12.10 %). The trend in pest infestation was continuously increased and reached to a maximum peak (21.43%) on 28 April 2010. Number of nodes, cob length, trichome density, 100-grain weight and manganese contents showed significant ($P \leq 0.01$) and negative correlation with the pest infestation, whereas, stem diameter, total minerals, nitrogen and protein had positive and significant ($P \leq 0.01$) correlation. Stem diameter and total minerals were the most important characters which contributed maximum role i.e., 34 and 45.6 percent in per unit change in infestation, respectively and the impact of these factors were positive and significant ($P \leq 0.01$) Commercial genotypes were found to be more resistant than hybrids.

Keywords: Resistance, physico-chemical characters, maize borer.

Introduction
Maize (*Zea mays* L.), a multipurpose crop, provides food, feed and fuel. On the other hand, it was proved as susceptible host for many insect pests during the whole cropping season. Amongst insect pests, maize and jowar borer (*Chilo partellus,* Swinhoe) is the most important and serious one, which attacks and damages all parts of the maize plants except roots. In heavy infestation, the insect damages up to 50% of the maize crop which is liable to secondary attack by other pathogen [11, 12]. De-Groote [8] estimated 12.9% losses in yield with an estimated value of US$ 76 million. Resistant maize can be a safe solution for minimizing the pesticide use and may prove effective in improving natural balance along with enhancing the activity of bio-control agents. It can also reduce the cost of production. CM132, CM137 and PMZ103 showed the highest level of resistance, from 26 tested genotypes [4]. Physico-morphic characteristics contributed a lot in level resistance and positive correlation found with Leaf Injury Score (LIS) and Stem Diameter (SD) in field (0.111) as well as in greenhouse (0.521). Among twenty tested genotypes, Afzal *et al*. [1] found Sahiwal 2002 as most resistant against *C. partellus*.
The physical and chemical plant characteristics of the host plants may also influence the nutrition of the insect by limiting the amount of feeding due to shape, color or texture which may limit the ingestion of the nutritive material and influence the digestibility and utilization of food by the insect. Afzal *et al.* [1] observed significant variations among genotypes 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 *C. 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 regressions indicated that leaf trichomes contributed for the maximum 41.6% individual role followed by stem diameter alone contributed 32.7% towards resistance to *C. partellus*. The contribution of significant factors was observed to be 84.8% resulted from the combined effect of stem diameter, cob length, leaf length, leaf width, leaf trichomes and 100-grains weight. Chattha [6] reported that cob height, stem diameter and leaf trichomes exerted negative and significant correlation with the insect pest under test. Whereas number of nodes per plant,

plant height, length of central spike and cob length did not show significant correlation but the response of these characters was found to be negative on the pest infestation.

Rao and Panwar [17] observed the bio-chemical plant factors in seven maize genotypes comprising resistant, moderately resistant and highly susceptible to *C. partellus* at 20 and 30 days after emergence. They found that leaf chlorophyll, carotenoid, nitrogen, protein and moisture contents were distinctly low in resistant cultivars compared to susceptible ones. The correlation between leaf injuries due to *C. partellus* with these bio-chemical factors individually was positive.

Keeping in view the above facts, the study was conducted on 7 hybrid and 3 commercial genotypes of maize with the objective to find the role of various physico-chemical plant factors contributing resistance/susceptibility against the pest.

Materials and Methods

Seven hybrid maize (FH-793, FH-810, FH-292, FH-930, FH-949, FH-963, FH-985) and three commercial (Com-6625, Com-32F-10 and Agaiti-2002) genotypes were sown on well prepared ridges with R x R and P x P distance of 75-cm and 22.86-cm, respectively in the experiment area of Maize and Millet Research Station, Ayub Agricultural Research Institute, Faisalabad during 2010. Randomized Complete Block Design replicated thrice was followed. No plant protection coverage was applied to the test materials to create the optimum condition for pest multiplication. All the recommended agronomic practices were adopted during the experimentation. The data regarding plant infestation caused by the *C. partellus* were recorded on the basis of dead hearts by selecting 10 plants randomly from each plot at weekly interval.

Physical Plant Characters

The data on number of nodes per plant above soil level, plant height cob height, length of central spike, cob length, stem diameter, leaf trichomes and number of trichomes, were recorded from the sample of 10 randomly selected plants from each plot. Stem diameter was recorded from 3rd internodes above ground level, with the help of a vernier caliper whereas leaf trichomes were recorded from the specific leaf emerging from cob node by placing a one square cm grid under a binocular microscope of 10X magnification. However, number of trichomes was counted from leaf lamina at three positions and average was worked out. Hundred (100) grains from each treatment after harvest were counted and weighed. Complete plants were randomly selected from each treatment and chopped and thoroughly mixed. Approximately 500 gram material in a paper bag was put in a drying oven at 80 ºC. Percent dry matter contents were calculated with the following formula.

Weight of paper bag = W_1 (g)
Weight of sample material in bag = W_2 (g)
Weight of dried sample in bag = W_3 (g)

Calculations

$$\text{Dry matter content (\%)} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Chemical Plant Characters

Sample Preparation

Samples weighing 500g of green leave of each from top (leaves of 5 to 7 days age) and middle + bottom (full grown leaves) portions of the plants from each plot were taken separately. These samples were brought into the laboratory, washed with distilled water and kept in open air under shade for 3 hrs. The leaves were then, dried oven at 70 $\pm$ 5 ºC for 12 hrs. The dried material was cut into pieces, ground and passed through 1mm sieve.

Total Minerals (%)

Weighed 2g of dry ground leaf tissue, from each sample, and put in a boron free fused silica crucible. The samples thus, treated were burnt to ashes in the Muffle Furnace at 600 ºC for five hrs. The material after combustion was weighed and again put at the same temperature till it was completely burnt to white/grayish white ashes, and its weight became constant. The total minerals were calculated as follows [15].

$$\text{Total mineral percentage} = \frac{\text{Wt. of the ash}}{\text{Wt. of dried leaves}} \times 100$$

Nitrogen (%)

Kjeldahl Method was used to determine the total nitrogen. The percentage nitrogen was calculated given as under [18].

$$\text{Nitrogen percentage} = \frac{\text{N of acid x 14.0067 x [ml of titrant for sample – ml of titrant for blank]}}{\text{Wt. of sample (grams) x 10}}$$

Protein (%)

The protein was calculated by the formula followed by Winkleman *et al*. [18] given as under:

Protein % age = Nitrogen % x 6.25

Total Lipids (%)

The total lipids were estimated by weighing 8-gms of dry leaves-tissues from each sample, as followed by Pearson [13].

Calculations:

$$\text{Lipid contents percentage} = \frac{\text{Lipids (g)}}{\text{Wt. of dry matter (g)}} \times 100$$

Reducing Sugars (%)

The reducing sugar was determined by weighing 2g of dry leaves tissues from each sample, as prescribed by AOAC [3].

Macro-nutrients (Sample Digestion)

One gram of leaves material from each sample was weighed for determination of macro-nutrients, and digested in a 10 ml of conc. Nitric acid (HNO_3) and an equal quantity of 72% perchloric acid ($HClO_4$). The volume when reduced to 3 ml and the sample became colorless it was cooled and transferred to volumetric flask. The volume was increased and made to 100 ml by adding the requisite quantity of distilled water. The samples were then filtered and stored in plastic tubes for further analysis.

Magnesium and Phosphorus (%)

These elements were determined by using the digested materials from previous section of samples following method 56 and 61, respectively on Photoelectric Calorimeter using 470 mm wavelength as the characteristic band [3].

Calcium and Potassium (%)

These were determined by using the digested materials and following Method 55a, 58a and 57a, respectively on Gallen Kamp Flame Photometer [3]

Micro-nutrients

Copper, Manganese and Zinc were determined from the solution with the Atomic Absorption Spectro-photometer against the following settings.

Element	Wave Length	Lamp Current	Flame	Slit Width
Cu	324.80 nm	4 mA	Air/acetylene	0.5 nm
Mn	279.5 nm	5 mA	Air/acetylene	0.2 nm
Zn	213.86 nm	5 mA	Air/acetylene	1.0 m

The data were analyzed statistically following RCBD using M-Stat package through IBM Compatible Computer. The correlation between physico-chemical plant characters with the infestation of maize borer was calculated. Multivariate regression models were also developed to find the role of physico-chemical plant characters in infestation fluctuation of the pest.

Results and Discussion

The results (Table 1) reveal that genotypes differed significantly regarding plant infestation caused by *C. partellus*. The genotype FH-949 appeared as susceptible showing maximum plant infestation i.e., 19.45 percent whereas V-6625 was comparatively resistant with minimum plant infestation i.e., 5.63 percent. The genotypes ranked under descending order are FH-949 > FH-963> FH-985 > FH-930 > 32F-10 > FH-793 > FH-292 > FH-810 > Agaiti-2002 > and V-6625. In the course of this experiment, an increasing trend in pest infestation was observed throughout the crop season and the infestation level in the month of March ranged from 0.33 to 3.19 % whereas sharp peaks found in the month of April (ranged 8.69 to 21.43). Previous researchers [1, 2, 3, 4] performed the similar kind of studies with different ecological conditions but recorded the same trend of population infestation during the months of March (minimum) and April (maximum).

In the present study, all the physical (Table 1) and chemical plant characters (Table 2) differed significantly among various genotypes. Number of nodes, cob length, trachoma's density and 100-grain weight showed significant but negative correlation with the pest infestation, whereas stem diameter had positive and significant correlation (Table 3). Furthermore, plant height, cob height and length of central spike had non-significant correlation with the pest infestation. Trichome density contributed in the resistance against borers [9]. Dass *et al*. [7] while working in India, found partially confirmatory results that plant height and number of infested nodes was adversely affected by *C. partellus* under severe infestation conditions but we examined non significant results but the trend shows positive effect on the plant height in contrast with infested nodes. In Pakistan, Rafique [14] and Ahmad *et al*. [2] showed statistically positive and significant correlation of pest infestation with stem diameter.

In the present study, total minerals, nitrogen and protein showed positive and significant correlation (Table 4) with r-values of 0.676, 0.606 and 0.479, respectively with the plant infestation caused by *C. partellus* whereas, manganese had negative and significant correlation with the pest infestation showing r-value of 0.437. Total lipids, reducing sugars, zinc and copper contents showed non-significant correlation with the plant infestation caused by *C. partellus*. The multiple linear regression analysis reveals that total minerals were the most important character which contributed maximum towards infestation fluctuation i.e., 45.6 percent followed by manganese (9.8%) and nitrogen content (8.6 %) role. The impact of total minerals and nitrogen was positive whereas manganese exerted negative impact. The overall contribution of all the chemical plant characters when computed together showed 64.3 percent contribution in the fluctuation of pest infestation.

The multiple linear regression analysis between physical plant characters and plant infestation (Table 5) caused by *C. partellus* revealed that stem diameter contributed 34 percent role in infestation fluctuation followed by number of nodes (26.4%) and trichomes density (22.1%). The 100-R^2 value was obtained 82.6%, in all the physical plant characters computed together.

On an overall basis, maize commercial varieties are more resistant *C. partellus* (with 5.63 to 8.53% infestation) but on the other hand hybrids showed a large variation in percent infestation ranging 6.58 to 19.45. These results are in accordance with Kanta and Sekhon [10] and Biradar *et al*. [5] who recorded large variation in maize hybrids. Number of trichomes of each genotype is responsive for preference of *C. partellus* in our studies but number of trichome with its density constitute a proper means of hindrance in the consumption preference or feeding or infestation of genotype [16]. This indicated that more depth studies has been needed to add some additional physical parameters like trichome density, leaf width, leaf thickness and internode distance.

Conclusion

It is concluded that commercial are better ones than hybrids but needs good agronomic practices with keen pest scouting for proper and timely indication of pest situation. On the other hand, hybrids are available but showed a large variation in pest infestation. Total minerals have positive influence in the onset of *C. partellus* than individuals (nitrogen, protein and lipids etc.). In future, research is needed to correlate the weather factors such as temperature, relative humidity, rainfall, wind speed, wind direction and water evapo-transpiration, to the population of *C. partellus*.

Table 1: Plant Infestation (%) and various Physical plant characters in different genotypes of maize

Name of Genotype	Plant infestation (%)	Number of Nodes /plant	Plant Height (cm)	Cob Height (cm)	Stem Diameter (cm)	Length of Central Spike (cm)	Cob Length (cm)	Leaf Trichomes (cm^{-2})	100- Grain Weight (gms)
FH-793	7.54 de	13.93 e	215.70 f	102.40 c	19.40 e	20.40 g	23.50 e	68.06 e	20.18 d
FH-810	6.06 e	13.20 g	219.33 e	100.30 d	20.13 d	24.10 e	22.90 f	70.73 d	22.90 c
FH-292	6.58 e	14.93 bc	234.73 c	99.26 d	21.46 c	26.40 d	21.80 h	76.40 c	24.11 b
FH-930	11.46 c	50 d	200.54 g	95.46 e	21.46 c	30.20 a	25.60 b	44.93 i	18.58 ef
FH-949	19.45 a	13.00 g	226.43 d	105.33 b	22.90 a	29.46 b	19.60 i	41.60 j	16.57 g
FH-963	15.21 b	13.50 f	229.40 d	89.00 g	21.96 b	20.56 g	22.10 g	48.73 h	18.92 e
FH-985	12.10 c	13.93 e	235.36 c	102.33 c	21.60 c	22.40 f	18.86 j	53.66 f	17.90 f
Com 6625	5.63 e	15.06 b	252.93 a	108.00 a	18.90 f	28.30 c	26.33 a	84.73 a	25.49 a
Com-32 F-10	8.73 d	15.86 a	245.70 b	104.53 b	20.36 d	26.30 d	24.60 d	81.50 g	19.18 d
Agaiti-2002	5.69 e	14.80 c	247.53 b	91.63 f	19.20 e	21.96 f	25.10 c	79.73 b	24.57 b
LSD at 5%	2.036	0.23	3.04	1.86	0.276	0.539	0.195	2.135	0.800
SE	± 0.728	0.07	1.02	0.0626		0.1816	0.0658	0.718	0.269
F Ratio	40.83**	139.55**	245.78	95.14	201.69	402.87	464.58	437.49	134.29
CV (%)	36.28	0.95	0.77	1.09	0.78	1.26	0.49	2.01	2.23

Table 2: Chemical plant characters in different genotypes of maize

Name of Genotype	Total Minerals (%)	Nitrogen (%)	Proteins (%)	Total lipids (%)	Reducing sugar (%)	Zinc contents (%)	Copper contents (%)	Manganese contents (%)	Phosphorous contents (%)	Potassium (%)	Magnesium (%)	Calcium Contents (%)
FH-793	8.76 c	1.81 cd	11.30 cd	5.72 ef	3.50 d	14.78 e	105.09 b	32.49 d	0.12bc	1.75d	0.28f	3.14b
FH-810	8.26 d	1.99 d	11.20 d	6.34 def	2.54 e	17.39 d	56.48 f	45.47 b	0.14ab	1.81c	0.29ef	3.34a
FH-292	10.17 a	1.89 b	11.81 b	11.13 a	4.98 ab	13.96 e	78.02 e	58.95 a	0.13abc	1.83ab	0.48a	3.38a
FH-930	9.66 b	1.87 bc	11.69 bc	11.75 a	4.61 bc	28.64 a	27.27 h	46.16 b	0.12bc	1.69ef	0.28f	2.97c
FH-949	10.37 a	1.77 a	12.33 a	9.71 b	5.32 a	17.62 d	114.77 a	26.59 e	0.12c	1.68f	0.31d	2.71e
FH-963	10.23 a	1.87 bc	11.69 bc	6.52 de	4.79 b	24.46 c	39.53 g	32.33 d	0.12bc	1.60g	0.47a	2.78d
FH-985	9.94 ab	1.84 bcd	11.54 bcd	8.28 c	2.68 e	26.55 b	94.23 cd	47.66 b	0.12c	1.75d	0.37c	2.95c
Com 6625	8.75 c	2.80 d	11.24 cd	6.66 d	5.30 a	30.01 a	91.35 d	28.60 e	0.14ab	1.81bc	0.30de	3.37a
Com-32 F-10	10.01 ab	1.83 bcd	11.43bcd	11.09 a	3.42 d	25.94 b	97.64 c	37.40 c	0.13abc	1.70e	0.18a	3.14b
Agaiti-2002	7.54 e	2.13 bcd	11.47 bcd	5.61 f	4.31 c	18.88 d	40.92 g	59.49 a	0.14a	1.84a	0.44b	3.39a
LSD at 5%	0.391	0.054	0.398	0.770	0.416	1.436	5.306	2.441	0.017	0.017	1.71	0.018
SE	±0.1316	±0.018	±0.134	±0.259	±0.140	±0.483	±1.785	±0.821	±0.0057	±0.0057	±0.0057	±0.054
F. Ratio	55.01	6.20	6.24	88.12	54.95	150.80	302.54	209.72	17.68**	44.25**	180.25**	181.42**
CV (%)	2.42	2.00	2.00	5.42	5.86	3.84	4.15	3.43	3.04	1.17	3.09	1.05

Means sharing similar letters are not significantly different by DMR Test.

Table 3: Correlation between Plant Infestations caused by C. *partellus* and various Physical Plant Characters

Characters	r-values ± S.E
Number of nodes	- 0.514 ± 0.101**
Plant height	-0.294 ± 0.035 ns
Cob height	-0.071 ± 0.005 ns
Stem diameter	0.686 ± 0.120**
Length of central spike	0.160 ± 0.003 ns
Cob length	-0.585 ± 0.105**
Trichomes density	-0.866 ± 0.029**
100- grain weight	-0.677 ± 0.083**

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

Table 4: Correlations between Plant Infestations caused by C. *partellus* and various Chemical Plant Characters

Characters	r-values ± S.E
Total Minerals	0.676 ± 0.017**
Nitrogen	0.606 ± 0.016**
Protein	0.479 ± 0.051**
Total Lipids	0.304 ± 0.018 ns
Reducing Sugars	0.240 ± 0.042 ns
Zinc	0.073 ± 0.009 ns
Copper	0.092 ± 0.008 ns
Manganese	-0.437 ± 0.129*

ns = Non-significant ** = Significant at $P \leq 0.01$ * = Significant at $P \leq 0.05$.

Table 5: Multiple Linear Regression Analysis between Infestation and Physical Plant Characters along with Coefficient of Determination

	Regression Equation	R2	100R^2	Impact (%)	F. Value ± SE
**Y =	15.024-3.095**X1	0.264	26.4	26.40	10.07 ±0.607
**Y=	-7.192-2.257**X1+2.573**	0.604	60.4	34.00	20.59 ±0.454
**Y=	0.5079-2.096*X1+2.471X2-0.1500 nsX3	0.605	60.5	0.10	13.29 ±0.461
**Y=	13.069-0.976 nsX1+0.065 nsX2-0.488 nsX3-0.524X4	0.826	82.6	22.10	29.62 ±0.313
**Y=	13.120-0.932 nsX1+0.0426 ns X2-0.482 nsX3-0.520**X4-0.0391 nsX5	0.826	82.6	0.00	22.78 ±0.319

Where:

X1 = Number of nodes
X2 = Stem diameter
X3 = Cob length
X4 = Trichomes density
X5 = 100-grain weight
NS = Non-significant
** = Significant at $P \leq 0.01$.
* = Significant at $P \leq 0.05$.
R^2 = Coefficients of determination

Table 6: Multiple Linear Regression Analysis between Infestation and Chemical Plant Characters along with Coefficient of Determination

	Regression Equation	R^2	100R^2	Impact (%)	F-Value SE
**Y =	-6.275+3.007**X_1	0.456	45.6	45.60	23.50 ±0.522
**Y=	-21.866+2.193**X_1+11.877X_2	0.542	54.2	8.60	15.95 ±0.488
**Y=	-22.062+2.192**X_1+11.50 nsX2-1.330 nsX3	0.545	54.5	0.30	10.38 ±0.495
** Y=	-20.792+1.691**X1+21.213**X_2-3.488 nsX_3-0.2625**X_4	0.643	64.3	9.80	11.27 ±0.447

Where:

X_1 = Total minerals (%)
X_2 = Nitrogen (%)
X_3 = Protein (%)
X_4 = Manganese (ppm)
ns = Non-significant
** = Significant at $P \leq 0.01$.
R^2 = Coefficient of determination

References

1. Afzal M, Nazir Z, Bashir MH, Khan BS. Analysis of host plant resistance in some genotypes of maize against *Chilo partellus* (Swinhoe) (Pyrallidae: Lepidoptera). Pak. J. of Biol 2009; 41(1):421-428.
2. Ahmad M, Khan MR, Rafiq M. Biological characters in relation to resistance against *Chilo partellus* (Swinhoe) in some inbred lines and hybrids of maize. Pak. Entomol 1990; 12(1-2):1-6.
3. AOAC. Official methods of analysis. 12 ED. Benjamin Franklin Station, Washington 1975, 34-48.
4. Arabjafari KH, Jalali SK. Identification and analysis of host plant resistance in leading maize genotypes against spotted stem borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae). Pak. J. of Biol. Sci 2007; 10(11):1885-1895.
5. Biradar SR, Kotikal YK, Balikai RA, Biradar DP. Comparative performance of maize hybrids against major insect pests. Karnataka J. of Agric. Sci 2011; 24(4):540-541.
6. Chattha AA. Screening of some new hybrid genotypes of maize against *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) and *Atherigona soccata* (Rondani) (Diptera: Muscidae). M.Sc. (Hons). Thesis. Deptt. Agri. Entomol., Univ. Agri., Faisalabad, 2010.
7. Dass S, Mehla JC, Moudgal RK, Dhanju KS, Pal DM, Singh DP *et al*. Identification of morphological traits in maize for its least susceptibility to *Chillo partellus*. Annals of Pl. Prot. Sci 2006; 14(1):33-37
8. De-Groote H. Maize yield losses from *C. partellus* in Kenya. Insect Science and its Application 2002; 22(2):89-96.
9. Javed HI. Studies on the resistance in maize against *Chilo partellus* (Swinhoe), Pyralidae: Lepidptera. Ph.D Thesis. Deptt. Ento, Univ. Arid Agri. Rawalpindi, Pakistan, 2005, 176.
10. Kanta U, Sekhon SS. Location of sources of resistance amongst different maize varieties and inbred to *Chilo partellus* (Swinhoe). J. of Entomological Res 1994; 18:157-162.
11. Lisowiez F. Maize protection against aphids and the European corn borer. Ochrona Roslin 2000; 44(3):35-36.
12. Panwar VPS, Singh NN, Vasal SK, Bergvinson D. Resistance of exotic germplasm to the Asian maize stock borer, *Chilo partellus* (Swinhoe). Ind. J. of Genetics and Pl. Breeding 2001; 61(4):356-357.
13. Pearson D. The chemical analysis of food. Oil and Fats. 7^{th} Ed, 1976, 488-518.
14. Rafique M. Biochemical characters in relation to resistance of some inbred lines and hybrid of maize against *Chilo partellus* (Swinhoe). M.Sc. (Hons.) Thesis, Uni. of Agri. Faisalabad, 1986.
15. Ranganna S. Manual of analysis of fruit and vegetable products. Cent. Food. Tech. Res. Instt., Mysore. Tata McGraw Hill Publ. Co. Ltd., New Delhi, 1977, 16-18.
16. Rao CN, Panwar VPS. Morphological plant characters affecting resistance to *Chilo partellus* in maize. Annals of Pl. Prot. Sci 2000; 8(2):145-149.
17. Rao CN, Panwar VPS. Bio-chemical plant factors affecting resistance in *Chilo partellus* (Swinhoe) in maize. Annals of Pl. Prot. Sci 2002; 10(1):28-30.
18. Winkleman, GR, Amin R, Rice WA, Tahir MB. Methods: Manual Soils Laboratory, Barani Agricultural Research and Development Project, Pak. Agric. Res. Coun. Islamabad (Pakistan), 1986; 30-33.