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Appraisal of Different Wheat Genotypes Against Angoumois Grain Moth, *Sitotroga cerealella* (Oliv.)

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Abstract.- Wheat is one of the most important cultivated crops in all almost all countries of the world. Hybrids have significantly increased the productivity and quality of this major crop. The aim of this study was to evaluate wheat genotype resistance to Angoumois grain moth, *Sitotroga cerealella* (Oliv.) (Lepidoptera: Gelechiidae). Twelve wheat genotypes were tested against *Sitotroga cerealella* at 28±2°C, relative humidity 65±5% and photoperiod L: D 12: 12 hours in the laboratory. The results, evaluated on the basis of percent weight loss, damage, grain size and chemical composition of the grains, revealed that none of the genotypes was completely resistant to the infestation by this pest. However, their response varied significantly. Genotype IBW -97103 (weight loss, 12.19%) had significant resistance followed by IBW-97083 (17.43%), Bakhtawar-92 (19.48%), F-Sarhad (19.66%), IBW-97406 (27.19%), IBW-97114 (27.32%), IBW-97259 (29.40%), IBW-97110 (29.70%), IBW-96405 (30.94%), IBW-97366 (31.02%), IBW-97112 (36.14%) and WS-94194 (40.93%). The coefficient of correlation between percent weight loss and other parameters was significant, except for grain size. The coefficient of correlation between weight loss and chemical constituents was also significant, except for ash content. From the study it was concluded that prolonged storage of the most susceptible genotypes to *S. cerealella* should be avoided and the most resistant varieties, namely BW-97103< IBW-97083< Bakhtawar-92, should be cultivated.

Key word: Wheat genotype, angoumois grain moth, chemical analysis of grains, resistance to moth, *Sitotroga cerealella*.

INTRODUCTION

Wheat, *Triticum aestivum* L. is the most important and widely cultivated plant in the world today, and the major cereal used world wide for making bread (Hudson *et al.*, 1981). *Sitotroga cerealella* is one of the most serious pests of stored wheat throughout the world. In Pakistan, 10-15 % post production losses of wheat occurred every year. Live adult insects were present in about 75 % of the samples taken; the most common species were *S. cerealella*, *Tribolium castaneum* and *Rhyzopertha dominica* and *Sitophilus* spp. The depth of infestation of stored wheat, maize and sorghum by Angoumois grain moth, *Sitotroga cerealella*, was investigated in the laboratory in Nigeria. Infestation decreased with depth on all grains, but the pattern of penetration differed between the 3 grain types (Mahihu, 1984). Arthropods were sampled from stored products at five locations in Romania. Of the 16 arthropods species recorded, *Sitophilus granarius*, *S. oryzae. Tribolium confusum*, and *T. castaneum*, *Oryzaephilus surinamensis*, *Rhyzopertha dominica*, *Plodia interpundella*, *S. cerealella* and *Acaru sito* were the most harmful (Ghizdavu and Deac, 1994).

A survey was conducted in Sindh and Punjab, Pakistan to assess the quality characteristics of wheat grains to compare them with the existing Fair Average Quality (FAQ) standards. It indicated that the current FAQ standards did not describe the wheat produced, and new grading system was suggested (Ahmed *el al.,* 1992). Data collected in wheat stores in two villages in Pakistan showed five pests including *S. cerealella* (Irshad, 1997). Similarly, Irshad and Talpur (1993) studied the interaction between *R. dominica, S. cerealella* and *T. castaneum* and found that maximum loss of 2.5% was recorded in combined infestation of wheat by these three pests. The susceptibility of different wheat cultivars to *S. cerealella* was also studied under controlled laboratory conditions. The results

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revealed that none of the cultivars was completely immune to the attack of this pest (Khattak *et al*., 1991, 1996).

The rearing of *S. cerealella* was studied on wheat, maize and rice grains to assess the effect of rearing media on progeny production (Ashraf *et al.*, 1994). The results indicated that more progeny was produced when *S. cerealella* was reared on wheat. The present study was undertaken to determine the response of different wheat genotypes against *S. cerealella* with the objectives to investigate their susceptibility response and to recommend the most insect tolerant cultivars for safe storage to reduce pest and economic losses.

MATERIALS AND METHODS

Wheat genotypes

The study was undertaken to assess twelve different wheat genotypes against Angoumois grain moth, *Sitotroga cerealella*. Wheat genotypes IBW-97110, IBW-97083, IBW-97114, IBW-97259, IBW-97366, B-92, IBW-97I12, IBW-96405, IBW-97103, IBW97406, WS-94194 and Sarhad were obtained from the mutation breeding division of NIFA, Peshawar. All varieties were conditioned prior to the investigation for a period of 15 days at 5°C.

Appraisal of resistance of wheat genotypes against Angoumois grain moth

There were twelve treatments; each treatment was replicated forty times in a Completely Randomized Design (CRD). A control was allotted to each treatment. Initially, grain from each variety was placed in 10 x 5 cm glass jars. Fifty eggs near to hatch (red colour) were confined in these jars and kept at 28±2 °C and 60±5 %. R.H with a photoperiod of L:D 12:12, in the laboratory. The date of egg seeding was recorded for each replicate. Developmental period i.e., number of days from date of seeding to first adult emergence was recorded for each replicate. Data were recored for first generation adult emergence after their oviposition. For this purpose, ten days grace period is given to complete their emergence. Counting of these adults was done by immobilizing them, using chloroform impregnated cotton plugs. Since these adults have already laid eggs, therefore these were discarded. . The experiment was continued up to two generations, and the data of two generations of adults were combined and considered as a progeny. At the termination of the experiment, each sample was passed through a 60-mesh sieve for separation of the frass and grains. The dust passed was discarded while the remaining material was weighed. The grains containing holes were separated from the sound grains and weighed. These grains were termed damaged grain. The percent damage and the percent loss were calculated according to the following formulae of Khattak *et al*. (1987):

% damage = Weight of control sample-Weight of sound grains in test sample x 100 /Wt. of control sample

% weight loss = Wt. of control sample–(Wt. of sound grain + Wt. of damaged grain in test sample) x 100/ Wt. of control sample

Data recorded for developmental period, percent damage, percent weight loss and progeny were subjected to statistical analysis by analysis of variance and means with standard error compared by using LSD test (Steel and Torrie, 1980). Coefficient of correlation between percent weight loss and other parameters including chemical composition were also determined.

Chemical analysis of the grains

Proximate composition of the grains (*i.e.* determination of moisture, crude protein, crude fat, crude fiber, ash and carbohydrates) were performed in accordance with the standard method of Association of Official Analytical Chemists Washington, DC, USA632 A.O.A.C. (1990).

Moisture determination

Moisture was determined by oven drying. One gram of each sample was accurately weighed in a Petri dish (W1). The dish was placed in an oven at 105°C for 6-12 h, then placed in a desiccator for 30 min to cool. After cooling, it was reweighed (W2) and percent moisture calculated as:

% Moisture = (W1 – W2) x 100 / sample Wt

Determination of ash

Clean empty crucibles were placed in a muffle furnace at 660 °C for an hour, cooled in desiccators and then the weight of empty crucible was noted (W1). One gram of each sample was placed in designated crucibles (W2). The samples were then charred over the burner with the help of blowpipe. The crucibles were then placed in a muffle furnace at 550 °C for 6- 8 hours. After the complete ignition the furnace was turned off. The crucibles were cooled and re-weighed (W3). Percent Ash was calculated as follows:

% Ash = (W3-W1) x 100/ sample Wt

Crude protein determination

In 250 ml s-digestion flask 0.5 g of each sample was mixed with 2 g of digestion mixture i.e. K_2SO_4: $CuSO_4$ (8:1) and 7 ml of concentrated H_2SO_4. These flasks were swirled in order to mix the contents thoroughly. Digestion was carried out by heating the mixture till the mixture became clear. After cooling, the digest was then transferred to 100 ml volumetric flask and volume was made up to the mark by the addition of distilled water. Distillation of the digest was performed in a Markham still distillation apparatus. Ten ml of digest was introduced in the distillation tube through the funnel. Then 10 ml of 0.5 N NaOH was gradually added the same way. Distillation was continued for at least 10 min and NH_3 produced was collected as NH_4OH in a conical flask containing 20 ml of 4% boric acid solution with few drops of modified methyl red indicator. The tip of condenser was washed in the flask with distilled water. During distillation yellowish color appeared due to presence of ammonium hydroxide. The distillate was then titrated against the standard 0.1 N HCl solution till the appearance of pink color. A blank was also run through all the steps as above. Percent crude protein was calculated using the formula given below:

%Crude protein = 6.25 x %N

%N = (S-B) x N x 0.014 x D x 100 / Wt. of sample x V

S, sample titration reading; B, blank titration reading; N, normality of HCl; D, dilution of sample after digestion; V, volume taken for titration, and 0.014, milliequivalent wt of nitrogen.

Crude fat determination

Crude fat was determined by ether extract method using Soxhlet apparatus. One gram of each moisture-free sample was wrapped in filter paper, placed in thimble and then introduced in the extraction tube. Weighed, cleaned and dried receiving beakers were one-third filled with petroleum ether and fitted into the apparatus. Extraction was done to complete drying of the solvent.

The percentage crude fat was determined by using the following formula:

%Crude fat = wt. of ether extract x 100/wt. of sample

Crude fiber determination

The weighed sample was first digested with acid and then with alkali. For acid digestion one gram of each fat-free sample was first boiled with 200 ml 2.5% HCl solution on a steam bath at 90-95 °C for about 2 h. It was filtered through linen cloth and the filtrate was washed with hot distilled water until it became acid free. The residue was transferred to another beaker for alkali digestion.

For alkali digestion 200 ml of 2.5% NaOH solution was added to the filtrate and digested again on steam bath for 2 h. It was filtered through linen and then washed thoroughly with hot water (50ml), alcohol and ether (25 ml) to make it alkali free. The crucible was then dried in an oven at 110-120°C, cooled in a desiccator and weighed (W1). The residue was then ignited in furnace at 600°C till a gray white ash appeared. After cooling in a desiccator, it was re-weighed (W2). Percent crude fiber was calculated as:

% crude fiber = loss in weight on ignition x 100 – crude fat weight / wt. of sample

Crude carbohydrates

Carbohydrate contents were determined by calculating the difference of the total of percentages of protein, crude oil and ash from 100.

RESULTS

The results for multiple comparisons of the means of developmental period and number of progeny of *S. cerealella* are presented in Table I. The developmental period was prolonged (23.25 days) in IBW-97103, while it was shortest (21.25 days) in WS-94194. However, there was no significant difference in the developmental period between any of the twelve treatments. A significantly lower progeny was recorded in mutant IBW-97103 (83.25 adults) and IBW-97083 (102.25 adults) as compared with all other test cultivars. On the basis on their performance with respect to this parameter, these two genotypes could be categorized as resistant to this pest.

Table I.- Developmental period and progeny number of *Sitotroga cerealella* recorded in twelve wheat genotypes.

Genotypes	Developmental period (days)	Progeny No.
IBW-97I10	21.75±0.32	314.50±1.04 abc
IBW -97083	22.50±0.54	102.25±1.03 g
IBW-97 I 14	22.25±0.60	197.00±1.29 def
IBW-97259	22.25±0.75	239.75±0.85 cde
IBW-97366	22.00±0.41	268.00±1.29 bcd
Bakhlawar-92	22.00±0.91	170.25±1.32 efg
IBW-97112	22.00±1.08	336.50±0.96 ab
IBW-96405	22.00±0.41	382.25±1.18 a
IBW-97103	23.25±0.48	83.25±1.11 g
IBW-97406	22.00±0.91	279.75±0.63 bcd
WS-94 I 94	21.25±0.85	337.75±0.85 ab
Fakhr-e-Sarhad	22.75±0.85	134.00±0.7 f[illegible]

Mean values in the same column carrying similar letters do not differ significantly al 5 % level of probability using LSD test.

The results of percent damage and weight lost (Table II) showed that IBW-97103 and IBW-97083 had significantly lower damage *i.e.*, 19.28 % and 22.72% respectively. Genotype IBW-97103 had significantly lower weight loss (12.19%) compared with all other mutants.

The results of the [illegible] size and proximate analysis (Table III) showed significant variations. Significant variations were also found in the grain size (No. of grains/ 45g) of all the treatments. The largest [illegible] in weight was observed in IBW-97112 (1048.75) followed by IBW-97110 (1481.25) and WS-94194, while the number of grains / 45 was more in IBW-96405. The protein content was highest (13.62%) in IBW 97083 followed by (13.56%) in IBW-97103 and Fakhr-e-Sarhad (12.97%), IBW-97110 (12.43%), IBW-97114 (12.43%), IBW-97114 (12.43%) and Bakhtawar-92 (12.1%), while it was lower (7.98%) in WS-94l94 followed by IBW-97ll2 (8.77%), IBW-97336 (10.37%), IBW-97406 (11.39%) and IBW-96405 ([illegible]74%). The crude fiber was found higher (3.86 %) in Fakhr-e-Sarhad, followed by IBW -97103 ([illegible]02%) while it was recorded lower (2.02%) in WS-94194. Also the crude fat content was found higher (3.625%) in IBW-97406, while it was lower (2.125%) in IBW-97114. Percent ash content was found higher (2.25%) in IBW-97103, while it was lower (0.88%) in IBW-97110.

Table II.- Percent damage and percent weight loss recorded in twelve wheat genotypes.

Mutants/ Cultivars	Percent damage	Percent weight loss
IBW-97110	49.60±0.63 abc	29.70±0.59 e
IBW-97083	22.72± 0.93 f	17.43±0.86 de
IBW-97114	35.89±1.03d e	27.32±1.13 c
Il3W -97259	36.23±0.86 de	29.40±0.89c
IBW -97366	44.09±1.14 bcd	31.02±1.77 be
Bakhtawar-92	37.24±0.85 de	I 9.48±0.63 d
IBW-97112	54.95±0.69 a	36.14±0.87 ab
IBW -96405	50.95±1.33 ab	30.94±0.68 bc
IBW-97103	19.28±0.63 f	12.19±1.04 e
IBW-97406	39.94±0.41 cd	27.19±0.86 c
WS-94194	58.28±0.83 a	40.93±0.68 a
Fakhr-e-Sarhad	[illegible]±0.41 [illegible]	19.66±0.78 d

Mean values in the same column carrying similar letters do not differ significantly at 5 % level of probability using LSD test

The results on co-efficient of correlation (Table IV) indicated that correlation between progeny and percent damage, progeny and weight loss was highly significant and positive, while the correlation between progeny and developmental period was highly significant but negative. The correlation between progeny and grain size was non-significant. The correlation of progeny with crude proteins, and crude fiber was significant and negative, while the correlation of progeny with fats, moisture and carbohydrates was significant and

Table III.- Grain weight and chemical composition of twelve wheat genotype.

Mutants/ Cultivars	Grain weight No./ 45g	Ash (%)	Crude fat (%)	Crude protein (%)	Moisture (%)	Crude fiber (%)	Total carbohydrate (%)
IBW-97110	1065.25±1.65 j	0.88±0.01 c	2.50±0.02 c	12.45± 0.32 bc	8.00±0.71def	2.21±0.01 e	73.95±0.69 ab
IBW -97083	1238.00±1.08 g	1.38±0.03 b	2.37±0.01 c	13.62± 0.63 a	7.75±0.63fg	3.463±0.02 ab	71.41±0.98 bc
IBW-97114	1384.75±0.48 c	1.50±0.03 b	2.12±0.02 c	12.50± 0.65 bc	7.37±0.55g	3.340±0.03 ab	73.14±2.14 abc
IBW -97259	1365.50±1.26 cd	1.25±0.03 b	3.25±0.01 ab	12.76± 0.49 abc	8.50±0.65c	3.850±0.03 a	70.39±1.56 c
IBW -97366	1355.00±1.23 d	2.13±0.02 a	3.00±0.13 b	10.37± 0.38 e	8.37±0.37cd	3.110±0.04 be	73.01±1.47 abc
Bakhtawar-92	1322.25±0.85 e	1.50±0.01 b	2.50±0.03 c	12.34± 0.53 bcd	7.87±0.66ef	2.450±0.03 de	73.33±0.85 abe
IBW-97112	1048.75±2.06 j	1.25±0.01 b	3.25±2.01 ab	8.77± 0.63 f	9.50±0.45b	2.920±0.02 bed	74.31±0.62 ab
IBW -96405	1481. 75±1.38 a	2.13±0.01 a	3.00±0.07 b	11. 74± 0.85 cd	8.25±0.49cde	2.590±0.01 cde	72.29±0.63 bc
IBW-97103	1279.50±2.22 f	2.25±0.03 a	2.50±0.05 c	13.56± 0.33 a	6.25±0.48'h	3.470±0.01 ab	71.97±0.38 be
IBW-97406	1451.75±1.44 b	2.25±0.03 a	3.62±0.03 a	11.39± 0.57 de	7.62±0.63fg	2.960±0.02 bed	72.15±0.78 bc
WS-94194	1094.25±2.32 i	1.25±0.01 b	3.25±0.02 ab	7.98± 0.41 f	10.0±0.41a	2.020±0.02 e	75.50±0.87 a
Fakhr-e-Sarhad	1165.50± 1.32 h	1.38±0.01 b	2.25±0.04 c	12.97± 1.06 ab	8.00±0.71def	3.860±0.02 a	71.54±1.31 be

Mean values in the same column carrying similar letters do not differ significantly at 5% level of probability using LSD test

positive; however, it was non-significant and negative between progeny and ash.

The correlation of percent damage and percent weight loss was highly significant (0.932) and positive, while the correlation between percent damage and grain size was non significant and positive. A highly significant negative correlation was found in percent damage and developmental period . The correlations of percent damage with moisture, fats and total carbohydrates were all highly significant and positive, while for ash, proteins and crude fiber they were highly significant and negative.

The correlation of [illegible]ent weight lo[illegible]ith ash was non-significant. The correlation of weight loss with crude protein and crude fiber was highly significant and negative, while the correlation of weight loss with crude fat, moisture and total carbohydrates was highly significant and positive. The correlation between grain size and developmental period was non significant and positive. The correlation of grain size with crude proteins, crude fats and crude fiber was non-signifi[illegible] and positive. While the correlation between grai[illegible]ze and total carbohydrates were significant and negative. The correlation between grain size and moisture was significant and negative. While the correlation between grain size and ash was highly significant and positive.

The correlation of developmental period with moisture was significant and negative. The correlation of developmental period with crude protein and crude fiber was highly significant and positive while the correlation of developmental period and total carbohydrates was highly significant and negative.

It is concluded from the above results that considering percent weight as a main factor of susceptibility response in the twelve genotypes against *S. cerealella,* Mutant IBW-97103 emerged as a significantly resistant genotype, while WS-94194 was the most susceptible one. Also the mutant IBW-97083 showed good resistance to the pest and have bright future prospects. These mutants, if developed into commercial varieties, could be stored safely with least inputs to ensure less reliance on pesticidal fumigants.

Table IV.- Coefficient of correlation table between different variables.

		Progeny	Percent damage	Percent weight loss	Grain size	Develop. period
1	Progeny	-	0.950**-	0.896**-	0.053-	-0.802**-
2	Percent damage	0.950**-	-	0.932**-	0.249+-	-0.891**-
3	Percent weight loss	0.896**-	0.932**-	-	0.223-	0.852**-
4	Grain size	0.053-	0.249+-	0.223-	-	0.183-
5	Develop. period	-0.802**-	-0.891**-	0.852**-	0.183-	-
6	Moisture	0.685**	0.796**	0.857**	-0.450**	-0.767**
7	Ash	-0.083	-0.239+	-0.276+	0.715**	0.337*
8	Protein	-0.713**	-0.834**	-0.853**	0.351*	0.730**
9	Fat	0.654**	0.565**	0.617**	0.139	-0.493**
10	Crude fiber	-0.637**	-0.747**	-0.528**	0.257	0.786**
11	Total carbohydrates	0.521**	0.729**	0.612**	-0.530**	-0.690**

*, ** significant at 5% and 1% probability levels, respectively.

DISCUSSION

The present studies were undertaken on twelve different wheat cultivars/mutants against S. *cerealella.* All the cultivars/mutants were different in grain weight and chemical composition; hence the response of the insect to this food source varied significantly. The lowest percent adult emergence was recorded in IBW-97103 and the highest was observed in IBW -96405. The developmental period was prolonged in IBW -97103, while it was shorter in WS-94194. Also the progeny number was more on WS-94194, while it was less on IBW-97 103. Ahmed *et al*. (1989) reported that the number of emergence is a better indicator of seed resistance than the number of eggs present on the seeds. Similarly, Johnson *et al*. (1990) tested that physical factors of the seeds was not associated with resistance. In the present finding resistance was evaluated on the basis of adult emergence which is in accordance to Ahmed *et al*. (1989), whereas the results of Jhonson *et al*. (1990) are in partial agreement with them with respect to grain weight

Resistance of stored grains to storage insects depends upon multiple factors. Some of the important ones are variety, insect species and grain size (Khattak and Shafique, 1981). Within a variety there could be variations such as texture, smooth or rough surface and chemical constituents of the grains (Khattak *et al*., 1987).

The highest percent weight loss was observed in WS-9419-l, while the lowest percent weight loss was observed in IBW-97103. The protein percentage may be a positive factor here for resistance. Therefore our results are in agreement with those of Mansha (1985), who revealed that for every increase of one percent in carbohydrate content, the percent damage and percent loss in weight increased by 7.12 and 0.34, respectively and concluded that carbohydrates proved as positive factor in increasing the percent damage and percent weight loss. He also found that with an increase of one percent crude protein, the percent damage and percent weight loss decreased by 9.11 and 2.08, respectively. Another key factor appears to be moisture content, because those grains with highest moisture contents also resulted in the greatest number of progeny. This phenomena was clearly reflected in the present results and therefore is in concurrence with them.

Moth emergence was higher in WS-94194, probably because of its larger grain weight, while the progeny number was low on IBW-97103 due to its lower weight. Here our results are in concurrence with that of Khattak *et al*. (1996), who showed that the weight of large grains of maize and wheat was reduced more by the attack of *S. cerealella* than that of small grains and more eggs were laid by females developing from larvae that developed in large grains than by those from larvae in small grains. The comparative resistance of IBW-97103 to *S. cerealella* in the present studies has a great future prospect of safe storage.

The present studies regarding variation in susceptibility response due to varietal difference both in physical and chemical constituents are in line with most of the researchers in the past (Storey *et al.*, 1983; Mehdi *et al.*, 1988; Mohapatra and Hare, 1989; Tirmzy *et al.*, 1989). The results of the present investigation revealed that none of the wheat cultivars was completely immune to *S. cerealella*. Their response to the attack of this pest however, varied significantly.

CONCLUSIONS

To sum up these results for resistance, cultivars can be arranged on the basis of percent weight loss in the following order:

IBW-97103 < IBW-97083 < Bakhtawar-92 < F-Sarhad < IBW-97406 < IBW-97I14 < IBW-97259 < IBW-97110 < IBW-96405 < IBW-97366 < IBW-97112 < WS-94194.

In light of the above findings, it is recommended that prolonged storage of the most susceptible genotypes should be avoided, if possible. If susceptible genotypes have to be stored, then necessary plant protection measures for their safe storage against *S. cerealella* must be undertaken so that losses could be reduced to the minimum. It is also suggested that breeders should consider developing genotypes which, in addition to high potential yield, have higher resistance to stored product insects. Moreover, from food nutrition point of view, it is more advisable to develop high protein varieties to cope with protein deficiency in the human diet. This will simultaneously provide resistance to storage insects like *S. cerealella* which will reduce the cost and environmental pollution.

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