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Resistance in Stored Rice Varieties Against Angoumois Grain Moth, *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae)

Saadia Rizwana[1], Muhammad Hamed[2], Asia Naheed[1]* and Shahid Afghan[1]
[1]*Shakarganj Sugar Research Institute, Jhang.*
[2]*Nuclear Institute for Agriculture and Biology, Faisalabad.*

Abstract.- Studies were undertaken on infestation of eight genotypes of rice against Angoumois grain moth, *Sitotroga cerealella* (Olivier.) under storage condition. The results were based on means of moth emergence, percent weight loss, percent damage and developmental period after the completion of first generation under controlled laboratory conditions. It was found that none of the varieties was completely immune to insect infestation. Rice variety Basmati-370 was found most resistant and Basmati-Pak and G-7 were most susceptible. The level of insect resistance was in the order: IRRI-6 ≥ G-6 ≥ Basmati-2000 ≥ PK-Basmati-385 ≥ Super Kernel Basmati. The correlation between number of moths emerged was positive and highly significant with percent weight loss (r=0.780) and percent damage (r=0.882). Insect susceptibility studies during post-harvest storage should be given due consideration in future rice breeding programmes.

Key words: Angoumois grain moth, infestation, rice varieties.

INTRODUCTION

Rice (*Oryza sativa* L.) is an important cereal and plays an important role in the economic stability of the country. Pakistan is one of the largest rice producing countries, having annual production of more than 5 million tons. Rice occupies 2.9 million hectare that is 10.9% of the total cultivated area with production of 6.9 million tons of milled rice (Anonymous, 2009). Storing grain in storehouses to keep them free from being damaged by insect pests is a problem which is confronted by every householder, whether a cultivator or not. It is estimated that 5-10% of world's grain production is lost due to ravages of insects (Adam, 1998). The losses may reach 50% in tropical countries where summer is hot and humid and storage facilities are improper and inadequate (Ahmad and Ahmad, 2002). Khan (1991) reported loss of about 15 percent rice in storage. Varieties vary in susceptibility and attraction to stored grain insects depending upon their physico-chemcial structures.

The Angoumois grain moth, *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae) is one of the serious insect pests of stored grains in Pakistan (Ahmad, 1982). It is cosmopolitan in distribution. Its young larvae bore into grains and feed on the inside contents rendering grains unfit for human consumption. These cereals are vulnerable to this insect attack and can have either one or all deficiencies that include weight loss, reduction in nutritional value, contamination or tanning, rendering the cereal food unfit for human consumption. Shafique and Ahmad (2003) determined losses in rice varieties from 4.09 to 12.61 %. Hassan *et al.* (1994) surveyed and reported that weight loss due to insect pests in Multan and Bahawalpur godowns ranged between 0.45-0.72%. Due to the variable and enormous losses in cereals it is desired that high insect resistant varieties must be evolved to suppress the population of this insect in stores.

So far many scientists in different countries have sorted out countless varieties of cereals against this insect to incorporate useful information in breeding programme. Such efforts on rice were conducted in India (Sundararaj and Sundararajan, 1990; Prakash and Rao, 1993) and Pakistan (Gillani and Irshad, 1990; Shafique and Ahmed, 2003). Present studies were undertaken to determine the susceptibility/resistance response of rice varieties against this storage insect pest.

* Corresponding author: asia.naheed@shakarganj.com.pk
ento.chrysopa@gmail.com
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MATERIALS AND METHODS

Studies were conducted to determine the resistance or susceptibility response of eight rice varieties against *Sitotroga cerealella* (Olivier). Rice varieties included Super Kernel Basmati, Basmati-Pak, Basmati-2000, PK-Basmati-385, Basmati-370, G-6, G-7 and IRRI-6 that were obtained from Rice Mutation Breeding Group of Nuclear Institute for Agriculture and Biology, Faisalabad. The grains of all test varieties were conditioned in the laboratory for 20 days at the same temperature and relative humidity (28±2ºC and 65±5%RH). Before experimentation, the moisture contents, percent fat, protein and ash contents of all varieties grains were determined according to the standard method of Association of Official Analytical Chemists (A. O. A. C.) (1984). After grinding, grain samples were put separately in petri dishes for oven dry to remove moisture contents at 80°C for 2 hours. For protein (%) analysis, 0.2 g samples were taken in digestion flask (2 replicates/sample) along with 1.0 g digestion mixture and 4.5 ml conc. H_2SO_4. All flasks were put in digestion chamber. Then 5 ml distilled water, 4% boric acid @ 40 g/100 ml water, 0.099 bromocresol green, 0.065 g methyl red powder and 100 ml ethanol were added in each flask and heated on hot plate starting from a temperature 70°C to 370°C until appearance of green colour. Titration was done against conc. H_2SO_4. The percent protein was estimated as under.

$$\% \text{ Protein} = \frac{.014 \times \text{Normality of standard acid used} \times \text{Volume of acid used}}{\text{Weight of sample}} \times 100$$

For fat analysis, 15 g grinded samples of grains were placed in thimble and put in extraction flask. Hexane was poured in extraction chamber. Whole apparatus was heated from 45-50°C till the level of solvent equals to siphon tube. The solvened left the extraction chamber, dissolving fat in it. This process was repeated for 8 hours. Solvent was evaporated in rota vapour at 55-66°C at 91 rpm to get fat. The percent fat was calculated as under.

$$\% \text{ Fat} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

For ash, fat free samples were charred on the flame, then placed in furnace at a temperature at 550-600°C for 4-5 hours. The percent ash was calculated by the formula as under.

$$\% \text{ Ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

The grain size (number of grains/10 g) was determined by counting the number of grains per 10 g of each test variety.

The eggs of *S. cerealella* were obtained from the Entomology Section of Nuclear Institute for Agriculture and Biology, Faisalabad, where the culture of *S. cerealella* had already been maintained on a standard wheat variety at 28±2ºC and 65±5% R.H. with 12 hours light/dark cycle for many generations. From this stock culture adults were obtained and their eggs collected. Eggs were counted with the help of magnifying glass and 24 papers carrying 100 eggs each were placed in each of 10 g sample of rice contained in a jar, covered on the top with a cloth with the help of rubber band. The experiment was designed in eight treatments and four replications with a control allotted to each treatment. All the samples seeded with eggs, were kept under laboratory condition at 28±2°C and 65±5% R.H. The moths were counted after the completion of first generation.

Developmental period was recorded in each treatment on the basis of first adult emergence from the date of initial seeding. Total moths emerged were counted. All post infestation samples were sieved through 60-mesh screen. The dust passed through was discarded while the remaining samples of sound and infested grains were separated and weighed. Percent damage and weight loss were calculated by using the following formulae.

$$\% \text{ damage} = \frac{\text{Wt. of control sample} - \text{Wt. of sound grain in the sample}}{\text{Weight of control sample}} \times 100$$

$$\% \text{ loss} = \frac{\text{Wt. of control sample} - \text{Wt. of (sound + damaged) grain in the test sample}}{\text{Weight of control sample}} \times 100$$

The data were subjected to statistical analysis using DMR and ANOVA tests (Steel and Torrie, 1984).

RESULTS

All genotypes in Table I varied significantly in their grain size. The maximum size was recorded in Basmati Pak that is at par with PK- Basmati-385 whereas the minimum in Super Kernel Basmati. The variation in size of grains was due to the relative genetic attribute of the variety.

Table I.- Grain size in different varieties of rice.

Sr. No.	Varieties	Grain size (No. of grains / 10g)
1	Super Kernel Basmati	598.3 f
2	Basmati-Pak	742.7 a
3	Basmati-2000	673.0 c
4	PK-Basmati-385	736.3 a
5	Basmati-370	709.0 b
6	IRRI-6	630.0 de
7	G-7	617.3 ef
8	G-6	644.0 d

Means sharing similar letters are not significantly different by LSD Test at p≤ .05.
LSD value = 22.79.

Number of moths (Progeny), percent weight loss, damage and developmental period of the insect were significant in varieties (Table II). The maximum number of moths emerged in IRRI-6 (80.7) that was at par with G-7 (78.7) but differed significantly from other varieties. The minimum progeny was found in variety Basmati-370.

Basmati-Pak loosed the maximum weight (25.4) and that was at par with variety G-7 (25.0%). The minimum weight loss was found in Basmati-370 (6.23%) followed by Super Kernel Basmati (7.8%). The maximum insect damage was recorded in Basmati-Pak (33.3%) followed by G-7 (32.7%) and IRRI-6 (30.1), whereas the minimum in Basmati-370 (7.8%) followed by Super Kernel Basmati (13.3-13.5%). The developmental period was extended in Basmati-370 (29.0). It ranged non-significantly from 20.0 to 20.7 days in all other rice varieties.

The correlation (Table III) between number of moths emerged was positive and highly significant with percent weight loss (r=0.780) and percent damage (r=0.882). Insect progeny was positively and non-significantly correlated with moisture contents (r=0.195) of the varieties. Relationship between percent weight loss and percent damage was positive and highly significant (r=0.964). Physical parameters of grains as protein, moisture and ash contents were positively correlated, whereas fat contents were negatively correlated with the insect progeny, grain weight loss and damage.

Varieties Basmati-Pak and G-7 were highly susceptible to Angoumois moth during storage followed by G-6 and Basmati-2000. The results have revealed that high protein, ash and moisture contents had increased susceptibility of grains, whereas high fat contents decreased the insect losses to grains.

DISCUSSION

Present studies showed that no variety was completely immune to the infestation of this pest. Similar conclusions were reported by Pandey *et al.* (1980), Khattak and Shafique (1981), Quyyum (1982), Khattak and Shafique (1986), Ratnasudhakar (1989), Tirmizy *et al.* (1989), and Khattak *et al.* (1996) in experiments while testing different cereals against this storage pest. Similarly, the present results concluded that Basmati-Pak & G-7 were highly susceptible and significantly different from all other varieties. Variety 370 of rice was found to be the least susceptible.

Percent weight loss, damage, adult progeny and insect developmental period was used as the parameters to screen out resistant and susceptible cereals against this insect pest by previous research workers Ayerty (1982), Wahla *et al.* (1984), Khattak and Shafique (1986), Rubbi and Begum (1986); Shazali (1987), Ragumoorthy and Gunathilagaraj (1988); Dhaliwal *et al.* (1989); Mohapatra and Khare (1989), Tirmzy *et al.* (1989), Gillani and Irshad (1990) and Riaz *et al.* (1992), Almeida and

Table II.- Comparison of mean values of insect progeny, percent weight loss, percent damage and developmental period in different genotypes of rice

No.	Varieties	Adult progeny	Weight loss (%)	Damage (%)	Developmental period (days)
1	Super Kernel Basmati	45.0 d	7.8 e	13.5 e	20.3 c
2	Basmati-Pak	57.3 c	25.4 a	33.3 a	20.3 c
3	Basmati-2000	55.7 c	23.0 b	27.4 c	20.0 c
4	PK-Basmati-385	56.3 c	18.2 d	22.0 d	20.3 c
5	Basmati-370	14.0 f	6.2 f	07.8 g	29.0 a
6	IRRI-6	80.7 a	20.3 c	30.1 b	20.7 c
7	G-7	78.7 a	25.0 a	32.7 a	20.0 c
8	G-6	71.3 b	20.1 c	28.9 bc	20.0 c
	LSD value	4.22	1.40	1.95	2.31

Means sharing similar letters are not significantly different by LSD Test at p≤ .05.

Table-III.- Correlation matrix between different parameters.

Parameters	1	2	3	4	5	6	7	8	9
Moisture contents (%)	1.000								
Moth emerged	0.195	1.000							
Grain size	0.522	0.279	1.000						
Developmental period	-0.445	-0.765**	-0.540	1.000					
Percent wt. Loss	0.416	0.780**	0.679*	-0.791**	1.000				
Percent damage	0.382	0.882**	0.520	-0.760*	0.964**	1.000			
Protein (%)	0.006	0.273	-0.227	-0.216	0.069	0.150	1.000		
Fat (%)	-0.337	-0.337	-0.506	0.275	-0.247	-0.233	-0.21	1.000	
Ash (%)	0.436	0.220	0.874**	-0.478	0.513	0.377	-0.414	-0.430	1.000

*=Significant at 5% and ** = Significant at 1% level of probability.

Murta (1995). On the basis of percent weight losses in present studies therefore, Basmati-Pak and G-7 were highest susceptible cultivars showing 25.4 and 25.0 %, while Basmati-2000 with 23.00% weight loss. IRRI- 6 and G-6 were at par with 20.2 and 20.1 % weight losses, respectively. The variety PK-Basmati-385 loosed weight as 18.2 %, Super Kernel Basmati as 7.8 and Basmati-370 as 6.2.

Slight variation in the susceptibility of varieties was found due to their chemical nature. These results are in conformity with the previous research work of Khattak and Shafique (1981). Protein, fat, carbohydrate contents are also responsible for the susceptibility in addition to the main factors as weight loss, percent damage. It was recorded that there was positive correlation between the weight loss and protein contents of the grain. The results of the present studies are not in conformity with previous work of Ragumoorthy and Gunathilagaraj (1988) who reported that resistant varieties have high protein contents. This variation may be due to the inherent nature of their varieties.

The moisture content of the grain was positively and significantly correlated with the percent damage, weight loss and number of moths emerged. These results are comparable with those of Prakash *et al.* (1979), Hameed *et al.* (1984) who reported that the moisture contents had significant effect on the development of stored grain insects but our finding are not in line with the Rodrigues and Pla (1983), Almeida and Murta (1995), who reported that moisture contents of grains were significantly decreased by infestation. The results regarding positive correlation between the numbers of moths emerged, weight loss and percent damage are according to the findings of Gillani and Irshad (1990).

An inverse correlation between the moth emergence, percent weight loss and the percent fat content of the grains was observed. Our results

support the work done by the previous worker Hameed *et al.* (1984) whereas there is negative correlation between the weight loss and the carbohydrate contents of the grains. The overall comparative resistance of test varieties was found in the following order:

Basmati- 370 7.8 > Super Kernel Basmati 13.5 > PK-Basmati-385 22.00 > Basmati-2000 27.4 > G-6 28.9 > IRRI-6 30.1 > G-7 32.7 > Basmati-Pak 33.33.

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