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Assessment of relative resistance in advanced rice genotypes in response to variation in abiotic factors and development of *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae)

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Abstract

The study was planned for the assessment of susceptibility or resistance level in six advanced rice genotypes viz: Super Basmati, Basmati-515, Basmati-2006, Basmati-385, KSK-133 and KSK-282 against *Tribolium castaneum* (Herbst) at three temperatures 28, 32 and 35°C. Qualitative loss assessment includes weight loss, percentage damaged grains and frass weight was calculated after three months of storage. Experiment was also conducted to find out the multiplication of red flour beetle. At all three temperatures significant results were calculated for quantitative loss assessment. The results calculated for percentage damaged grains and frass weight showed that Basmati-2006 and course genotype KSK-133 was most susceptible against red flour beetle attack. On the other hand KSK-282 was highly resistant following by Super Basmati, Basmati-515 and Basmati-385. High weight loss was calculated in Basmati-385 at 28°C at bar with KSK-133 at 32°C. But minimum weight loss was observed in KSK-282 at 35°C. For progeny development, maximum number of insect emergence was calculated in Basmati-2006 and KSK-133 as positive correlation with damaged grains. Least population emergence was found in KSK-282. Overall maximum quantitative losses were observed at 32°C but less at infestation occurred at 28 and 35°C. So the results can be helpful for prolonged storage and these results can be incorporated in modern breeding programs for production of insect resistant varieties.

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Introduction

Agriculture is major and most important part in the economy of Pakistan. It contributes about 22 % in GDP, providing employment for Pakistani labor from 45 and 60% in rural and urban area of Pakistan. It is playing very important role in food production and food security and improving industrialization (Anonymous, 2011). In cropping system of Pakistan, rice crop stand second among major crops production contributing 1.0 percent in GDP and 4.9% value added in agriculture (Anonymous, 2011, Shafique and Chaudry, 2007).

Food products taken from plants and animals are stored at large scale for future use and trade purposes. Food storage is also very important for food security. Large and better storage conditions may prevent future hunger of the human being when there is no productive season for food. But natural forces try to maintain equilibrium against each human activity even in food storage. During food storage, the purity and quality is affected by a number of biotic and abiotic factors. In most of the countries of the world safety of stored products is in political priorities (Anonymous, 2011).

In storage condition a number of insect pests infest the stored rice. Among these stored grain insects red flour beetle, *Tribolium castaneum,* rice weevil, *Sitophilus oryzae* L., Angoumois grain moth, lesser grain borer, *Rhyzopertha dominica* (F) and Khapra beetle, *Trogoderma granarium* (Mark *et al.*, 2010, Shafique and Chaudry, 2007, Ebeling, 2002; Steffan, 1963; Anonymous, 2007). *Tribolium castaneum* is a cosmopolitan insect that can infest stored products both primary as well as secondary insect pest. Emerging form eggs larvae and adult beetle feed ferociously on rice grains. Previous experimental study showed that different genotypes show susceptible or resistant response against attack of red flour beetle (Weston and Rattlingourd, 2000; Shafique and Ahmad, 2003).

It is believed that some non-volatile substances are responsible for the insect attraction towards stored products. Some biochemical reactions in grains and microorganisms like presence of fungi colony may be responsible in stored products consumption. With the passage of time oxidation of lipids cause secretion of some volatile attractants or repellants may attract or repel the insect pests (Trematerra *et al.*, 1998). Inverse relationship is found to be associated between the susceptibility index and the % mortality and developmental time while a positive relation is found in seed damage, weight loss and new F1 progeny (Abebe, *et al.*, 2009). So, the present study was to determine the developmental rate of red flour beetle along with the varietal screening against beetle infestation during storage conditions.

Materials and methods

Collection and rearing of test insects

Adult insects of red flour beetle, *Tribolium castaneum* (Herbst) collected from nearby godowns in Faisalabad location. The collected insects of red flour beetle were reared for six months in the laboratory under controlled conditions at 28±2°C and 65±5 R.H. Homogenous insects was prepared diet of commercial rice varieties. After six months of rearing homogenous population was used to conduct experiments.

Collection and screening of Rice genotypes

To check the varietal resistance six rice genotypes were taken from Rice Research Institute, Kala Shah Kaku. The varieties studied were Super basmati, Basmati-515, Basmati-2006, Basmati-385, KSK-133 and KSK-282. Diseased and damaged grains were removed from each genotype. After cleaning 100g weighted grain sample of each genotype was taken in the plastic jars of 150g capacity tightly covered with rubber band and muslin cloth. In each sample thirty adult beetles of red flour beetle, *Tribolium castaneum* (Herbst) were released in the center of the jar for free choice of oviposition. Each genotype was replicated thrice. This experiment was repeated at three temperatures viz 28, 32 and 35°C. The temperature of each incubator was maintained with 65±5% R.H. Data was collected after 90 days of insect release. Number and weight of damaged and undamaged

grains were counted and weight loss was calculated by following equation (Gwinner *et al.*, 1996).

$$\text{Weight loss \%} = \frac{(W\mu \times Nd) - (Wd \times N\mu) \times 100}{W\mu \times (Nd + N\mu)}$$

The grains were segregated and counted for percent damaged and undamaged grains by using the following equations.

$$\text{Damaged grains \%} = \frac{\text{No. of damaged grains} \times 100}{\text{Total sample grains}}$$

$$\text{Undamaged grains \%} = \frac{\text{No. of undamaged grains} \times 100}{\text{Total sample grains}}$$

Frass was sieved out from infested samples and weighted with an electrical balance. Adult emergence including dead was calculated after 90 days to determine the progeny development.

Results

Results analyzed showed that all rice genotypes suffered losses. But each genotype showed variable degree of susceptibility. Data regarding to insect emergence in rice genotypes was analyzed after 90 days of storage sowed voracious feeding as shown in Table 1.

Table 1. Comparison of mean values of the data regarding No. of adults emergence and weight loss (%) of various rice genotypes infested by red flour beetle, *Tribolium castaneum* (Herbst) at different temperatures.

Treatments	No. of adults emergence			% Weight loss		
	28°C	32°C	35°C	28°C	32°C	35°C
KSK-282	69.00j	97.33hij	83.67ij	15.20bc	13.61bc	1.33c
Basmati-385	132.33fg	115.00ghi	164.33def	36.42a	10.07c	9.04c
Basmati-515	122.67gh	164.00def	155.67ef	14.60bc	15.08bc	6.79c
Basmati-2006	166.67de	254.00a	207.33bc	16.39bc	15.28bc	10.30c
KSK-133	145.67efg	223.00ab	196.00bcd	7.21c	30.80ab	2.45c
Super Basmati	96.00hij	177.00cde	93.67hij	2.03c	11.62c	17.77bc

Adult Emergence

Overall 32°C temperature proved to be most suitable for progeny development following by 35°C and 28°C. Maximum population of beetle was calculated in Basmati-2006 (254) and KSK-133 (223) at 32°C proving as most susceptible varieties against red flour beetle. But Basmati-515 and Basmati-385 showed average adult multiplication at all mentioned temperatures. KSK-282 proved as more resistant against red flour beetle because of less beetle population production (69.00), (97.33), (83.67) at 28°C, 32°C and 35°C respectively (Table 1).

Weight loss

Weight loss was calculated by using counting the number and weight damaged and undamaged grain percentage from above given equation. Among these three temperatures 28 and 32°C at bar each other but least weight loss was observed at 35°C. Maximum weight loss was weighted insusceptible genotypes Basmati-385 (36.42%) along with KSK-133 (30.80%) at 28°C and 32°C respectively. KSK-282 was most resistant due to less infestation with minimum weight loss (1.337%) but at bar with other varieties Super Basmati, Basmati-515 and Basmati-2006 at all above mentioned temperatures (Table 1).

Frass weight

Debris in the form of broken food material, their remaining and insect feces due to insect attack was weighted to guess the relative resistance in rice genotypes. In case of temperatures, minute quantity of frass weight was calculated at 28°C but rest of the temperatures showed almost similar level of response against beetle infestation. Interaction between mean values of temperatures and treatments showed

significant relationship, elaborating Basmati-2006 (6.64g) (6.41g) and KSK-133 (4.65g) (4.47g) the most infested genotypes both at 35 and 32°C respectively. On the other hand KSK-282 proved highly resistant behavior against red flour beetle producing least frass weight (0.87g), (1.04g), (1.13g) at all mentioned temperature variations. Basmati-515, Super Basmati and Basmati-385 showed average infestation at all temperatures at bar each other (Table 2).

Table 2. Comparison of mean values of the data regarding % damaged grains and Frass weight (g) of various rice genotypes infested by red flour beetle, *Tribolium castaneum* (Herbst) at different temperatures.

Treatments	% damaged grains			Frass weight		
	28°C	32°C	35°C	28°C	32°C	35°C
KSK-282	79.76abc	82.20ab	84.40a	0.86f	1.13def	1.04ef
Basmati-385	65.46g	73.900cdef	77.67bcd	2.06cdef	1.82cdef	2.59cde
Basmati-515	69.38fg	68.03fg	76.40bcde	2.04cdef	2.74cd	2.73cde
Basmati-2006	47.67h	46.83h	73.07def	3.45bc	6.40a	6.63a
KSK-133	50.53h	64.43g	70.37efg	2.54cdef	4.65b	4.47b
Super Basmati	70.47efg	69.13fg	76.73bcde	1.57def	2.49cdef	1.48def

Damaged grains percentage

After 90 days of storage, percentage infested grains were counted using the above given percentage equation. Maximum number of damaged grains were calculated at 28°C following by 32 and 35°C. Among treatments Basmait-2006 was most susceptible to beetle attack as compared to others. Course variety KSK-282 was resistant against red flour beetle. Interaction between mean values of treatments and temperatures showed that Basmait-2006 (53.18), (52.33) was 32 and 28°C along with KSK-133 (49.47). Minimum level (15.60), (17.80), (20.23) of infestation was calculated in resistant genotype KSK-282 at 35, 32 and 28°C (Table 2).

Discussion

Our experiments showed varying degree of resistance against the possible insect attack during the storage conditions. Our results are in accordance with Ali *et al.*, 2009 who evaluated the resistance level in different wheat genotypes infested by red flour beetle. They evaluated fifteen wheat genotypes under controlled abiotic conditions. They evaluated Barani-70 as most resistant variety and Wafaq-2001 was most susceptible against beetle infestation. Arthur *et al.*, 2007 checked out the effect of insect infestation cultivated at different locations. They investigated significant relationship among long-grain cultivars within two of the three locations against insect multiplication and infestation. For progeny production of *S. oryzae,* genotype and RH were significant, but not locality. Pittendrigh *et al.*, 1997 investigated the response of relative humidity on the development of rice weevil reared on corn seeds to check supernumerary molts. They found less number (4) of larval molts at 70% R.H as compared to 5 supernumerary molts at low humidity 40% R.H. Chanbang *et al.*, 2008 found the susceptibility of rice genotypes due to the compactness of the kernel. They concluded that toughness of the kernel is directly correlated with beetle infestation. Michael and Riggio (2002) experimented to check the presence of susceptibility/resistance some rice lines to assess variation in susceptibility comparative with two commercial varieties. At the end of their experiment they concluded that some morphological or biochemical process of resistance to the rice water weevil in these lines. Lawrence (1990) determined significant weight loss and progeny development of rice weevil and lesser grain borer during threshing some cereal genotypes. Our experiments also proved a definite effect of temperature on the damage of grains due to rapid insect development as in the case of Shafique and Chaudry (2003) who have already significantly checked out the similar kind of results for insect progeny production. Khattak *et al.*, (2000)

reported considerable relation between adult emergences with other qualitative losses. These results clearly indicated that rice varieties showed significant response to adult emergence of *Sitophilus oryzae* as similar results described by other workers (Shafique and Chaudry; 2003, Shafique and Chaudry; 2007). Horber (1988) correlated the index of susceptibility with the assumption that F1 progeny development rate and the shorter life cycle of insect indicates susceptibility of a line or cultivar towards the insects infesting during the storage conditions.

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