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Categorization of Some Advanced Local Wheat Lines against *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae)

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Abstract

During present investigation, 12 different advanced local wheat *Triticum aestivum* germplasms including 10 lines and 2 varieties were screened against red flour beetle *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) to check their resistance. The healthy seeds of each line/ variety were in dry preserved form placed in small glass containers. The pest damage symptom developed on seeds was rated by counting percent infestation, percent weight losses, frass weight, number of *T. castaneum* emerged and percent germination of particular wheat line. It was evident from the results that all the wheat germplasms were susceptible to *T. Castaneum,* but NIA-MB-02, NIA-MB-03 and NIA-MN-01 were highly susceptible than the entire germplasms due to holding maximum damage of red flour beetle. The relative performance of NIA-MB-01, NIA-MN-08 and Khirman was pointed out as tolerant to the pest infestation. These results are being employed for developing improved wheat varieties and to control the effect of various factors that perturb the grain productivity to create pest resistance in susceptible varieties. From this study, the results imply that stored grain executives should be aware of the potential differences in susceptibility and tolerance attributable to wheat varieties to prevent the development of the pests.

Keywords

Wheat, *Tribolium*, Varietals Susceptibility, Storage Losses, Grain

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1. Introduction

Cereal and pulse grains are amongst the major sources of dietary protein for humans (Deeba et al., 2006; Sarwar, 2010; Sarwar, 2012; 2013 a; Sarwar and Tofique, 2006; Sarwar et al., 2003; 2010; 2012). Among cereal grains, wheat in particular, is among the most important crops globally. Cereal grain losses during storage can reach 50% of total harvest in some countries, and worldwide losses in quality of grain are mainly caused by insects (Fornal et al., 2007), because they have become cosmopolitan since humans began harvesting and storing (Padin et al., 2002). Many variables affect grain storability (Maier et al., 1997), but the primary post-harvest pests of concern are insects and fungi, both of which develop as a function of temperature, moisture content and storage time. Stored grains are an ideal food source for stored product insect pests, providing the essential elements required for continued growth and development. The levels of carbohydrates, proteins, lipids and vitamins required varies with the species concerned (Mason et al., 1997).

Rust-red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) is a polyphagous and cosmopolitan pest in flour mills and wherever cereal products or other dried foods are processed or stored. It is often the most common species in the pest complex attacking stored wheat (Collins and Bartlett, 2011). Its larvae breed well in processed cereal products, but in whole wheat kernels the damage is restricted to the germ (White and Lambkin, 1988).

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It infests damaged or deteriorated grains and responds best to oils characteristic of damaged or fungus-infested grain (Trematerra et al., 2000). Larvae are active, but generally hide within the food, away from light. When agitated or crowded they may secrete quinines, which can cause infested feed to turn pink and develop a pungent odour (Mason, 2003). Karunakaran et al., (2004) reported that infestation caused by *T. castaneum* in unprotected wheat stored for 9 months reduced germination virtually completely and increased visually damaged kernels from 9% to 39%. Badly infested flour is characterized by a sharp odour and mouldy taste. The quinone secretions of *T. castaneum* are very bitter and affect the baking and taste qualities of the infested products. In infested flour, the larvae, pupae and adults are visible due to their larger size but the eggs are difficult to distinguish from flour particles by naked eye. Flour particles may adhere to eggs making their identification difficult (Leelaja et al., 2007).

The insect pests cause economically significant problems to wheat and have a devastating impact on infested grain in the case of specific circumstances. Under favorable conditions, considerable grain losses can occur when susceptible varieties are stored for a longer duration (Sarwar, 2008; Sarwar and Sattar, 2007; Sarwar et al., 2013). The majority of the wheat is milled to produce wheat flour, which is made into different products for consumption. The quality of wheat flour depends on the wheat that is milled and one of the common reasons for grain quality loss is insect infestation. The insects found in the bulk grain get crushed during milling. Many insects also become residents in flour mills. The result is the occurrence of insect fragments in the milled wheat flour (Flinn et al., 2004). In Pakistan context, Sabri et al., (1984) reported that total post harvest loss of wheat was about 7.37% out of which 3.24% was due to stored grain insect pests. The results on % infestation due to *T. castaneum* indicated that statically least % damage (9.06%) was noted in tolerant wheat variety and the prevalent damage (25.10%) recorded in case of susceptible variety (Ali et al., 2009). Modern methods of food grain treatment using insecticides and fumigants to check post harvest losses during storage are highly expensive (White and Leesch, 1995). These treatments, due to their residual effects are toxic and continuous applications of such chemicals lead to environmental pollution and health hazards, besides developing resistance in organism (Champ, 1981; Siddiqui and Sarwar, 2002; Sarwar, 2013 b). There is, therefore, an urgent need to develop environment friendly alternatives with the potentials to replace the highly toxic chemicals. Presently worldwide attention is focused on screening and development of tolerant and high yielding cereals. So, observing the need of the time, the present research program was planned to determine the response of *T. castaneum* to different wheat advance lines.

2. Materials and Methods

Studies were conducted to determine the resistance or susceptibility response of twelve wheat lines/ varieties against *T. castaneum.* Wheat lines, NIA-MB-01, NIA-MB-02, NIA-MB-03, NIA-MN-01, NIA-MN-08, NIA-MN-06, NIA-MN-12, NIA-MNS-06, NIA-MNS-07, NIA-MNS-13; and varieties Khirman and Chakwal, were tested against *T. castaneum* in the laboratory. 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).

Mixed population of *T. castaneum* was collected from different storages of Food Department located at various places in Hyderabad for rearing in the laboratory. The insect, thus collected was kept in wide mouth glass jars covered with muslin cloth. The insect was kept in the laboratory for three months for rearing. The adults of *T. castaneum* were placed in breeding containers in the medium of uninfected wheat grains kept in an incubator at 30± 2ºC and 65± 5% relative humidity. Afterwards, one week old adults of *T. castaneum* were separated in a beaker from grain sample by placing in glass funnel (5 cm in diameter) lined with sieve and an electric bulb lit at the top. In each container, 5 couples of *T. castaneum* adults of uniform age and size were released in each 20 gm samples of wheat grains of each variety. These containers were covered with net to aerate the insect under the identical experimental conditions.

A complete test comprised three replicates of each treatment. Observations were determined since the introduction of insect with the grain of wheat for each variety until adults emergence of the F1 generation. The grain size (number of grains/ 20 gm) was determined by counting the number of grains per sample of each test variety. The adults were counted after the completion of first generation in each treatment. All post infestation samples were sieved through 60-mesh screen. The dust (frass weight) passed through sieve was weighed, while the remaining samples of sound and infested grains were separated and counted. Percent damage and weight loss were calculated by using the following formulae:-

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

$$\text{Percent loss} = \frac{\text{Weight of control sample} - \text{Weight of (sound + damaged)grain}}{\text{Weight of control sample}} \times 100$$

For germination rate of seed (average number of seeds that germinated over the time period), counted out 100 seeds of each wheat line and sown 10 rows of 10 seeds on soil at normal seeding depth of 2-3 cm inside the tray, and recorded number of germinated seeds after 10 days. For calculating germination rate, the following formula was used:-

$$\text{Germination \%} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds in try}} \times 100$$

The data were subjected to statistical analysis by means of DMR and ANOVA tests using Statistix 8.1 analysis version.

3. Results and Discussion

The results showed that there was variability for tolerance in different wheat lines and none of them found to be completely resistant. Significant differences existed among the varieties/ lines for number of bored grain and grain weight loss caused by *T. castaneum*. All wheat lines (Table 1), varied significantly in their percent infestation. The maximum infestation was recorded in NIA-MB-02 followed by NIA-MB-03 and NIA-MN-01, whereas the minimum in NIA-MB-01, NIA-MN-08 and Khirman. The variations in infestation levels of grains were due to the relative genetic attribute of the variety.

Wheat line NIA-MB-02 loosed the maximum percent weight (12.33%) and differed significantly from NIA-MB-03 (11.50%) and NIA-MN-01 (10.33%). The minimum weight loss was found in NIA-MB-01 (2.0%) followed by NIA-MN-08 (2.33%) and Khirman (3.33%). The maximum frass weight due to insect damage was recorded in NIA-MB-02 (0.44 gm) which was at par with NIA-MB-03 (0.41 gm) followed by NIA-MN-01 (0.36 gm), whereas the minimum in NIA-MB-01 (0.05 gm) that was at par with NIA-MN-08 (0.08 gm) followed by Khirman (0.09 gm).

The maximum number of adults were emerged in NIA-MB-02 (36.0) sample but differed significantly from NIA-MB-03 (33.66) that was at par with NIA-MN-01 (32.33) as compared to other varieties. The minimum progeny was found in lines NIA-MB-01 (15.0), NIA-MN-08 (16.33) and Khirman (18.0).

Germination rate (%) over the specific time period ranged significantly from 90.66 to 96.66% in all tolerant wheat lines, on the other hand 82.00 to 89.33% in case of susceptible selections. Rate of germination was an indicator of vigor which increases the chance that seed of specific line will establish in the field. Such resistant varieties could be therefore selected for using in breeding programs for developing varieties resistant to *T. castaneum*.

Table 1. Screening of local wheat lines against *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae).

S. #	Name of genotypes	Percent infestation	Percent weight losses	Frass weight (gm)	Adults emerged	Percent Germination
1	NIA-MB-01	2.99 i	2.0 h	0.05 g	15.0 h	96.66 a
2	NIA-MB-02	14.74 a	12.33 a	0.44 a	36.0 a	82.00 i
3	NIA-MB-03	13.25 b	11.50 b	0.41 a	33.66 b	84.33 h
4	NIA-MN-01	12.33 c	10.33 c	0.36 b	32.33 b	84.66 h
5	NIA-MN-08	3.43 i	2.33 h	0.08 fg	16.33 h	95.33 ab
6	NIA-MN-06	10.10 d	9.66 c	0.30 c	30.33 c	86.33 g
7	NIA-MN-12	6.18 f	5.83 f	0.15 e	23.66 e	93.00 cd
8	NIA-MNS-06	6.67 f	7.16 e	0.19 d	28.00 d	90.66 ef
9	NIA-MNS-07	5.28 g	5.16 f	0.11 f	21.66 f	93.33 c
10	NIA-MNS-13	7.37 e	8.50 d	0.28 c	28.33 d	89.33 f
11	Khirman	4.27 h	3.33 g	0.09 f	18.00 g	94.33 bc
12	Chakwal	6.32 f	6.66 e	0.18 d	25.00 e	91.66 de
S. E.		0.257	0.399	0.015	0.720	0.680
LSD value		0.532	0.806	0.032	1.486	1.404

The values carrying different alphabets are statistically different (P= 0.05).

The lines/ varieties of wheat showed different level of infestation to *T. castaneum*. Wheat lines NIA-MB-02, NIA-MB-03 and NIA-MN-01 proved more susceptible to the pest and gave maximum damaged grains and loss in weight, while variety/ lines NIA-MB-01, NIA-MN-08 and Khirman were relatively more resistant and gave minimum loss in weight on the basis of damaged grains. Although complete immunity was not possible, yet some of the genetic traits could be incorporated for evolving varieties which possess resistant characters. The previous studies have revealed that various wheat varieties responded differentially to the insect species for feeding preference, development and grain weight loss. Therefore, present results receive support from Aheer and Ahmad (1993); Saima and Muhammad (2000); Syed et al., (2001); Sarwar et al., (2004); Sarwar (2009); and Ali et al., (2011) who reported that there was variability in different wheat cultivars which turned out to be resistant or susceptible against red flour beetle.

For a better approach of pest control, this study revealed that all the stored wheat grain of different varieties exhibited the phenomenon of preference/ non-preference to *T. castaneum*. This phenomenon is due in the structure and composition of wheat such as, starches, carbohydrates, and enzymes (Evers et al., 1999); and proteins (Gupta et al., 2000). Some physical and biochemical properties of the cultivars have been assessed by researchers to determine their respective level of resistance to the stored grain insects. The resistance of these cultivars to grain insect's infestation might be attributed to the low content of protein and high content of carbohydrate compared to susceptible cultivars. Kernel hardness, gluten/ amylose content, larval and adult preference and emergence showed difference between resistant and susceptible cultivars (Sayed et al., 2006; Mebarkia et al., 2009). The *Tribolium* sp., can use starch, mannitol, raffinose, sucrose, maltose and cellobiose, as well as various monosaccharides (Chapman, 1998). Mebarkia et al., (2010) suggested that the susceptibility of wheat varieties to grain pest infestation may be attributed to the high content of protein and low content of carbohydrate compared to resistance varieties. Thus, the presence of biochemical constituents within twelve varieties of wheat will allow or prevent the development of this pest, and in the presence of repellents factors and biochemical inhibitors some genotypes showed high tolerance. Entomologists concerned with the stored grain research should be aware of potential differences in susceptibility or tolerance attributable to wheat varieties for proper storage. The tolerant genotypes should be employed for developing improved varieties and to control the effect of various factors that perturb the wheat productivity to create pest resistance in susceptible varieties. As susceptible genotypes are highly preferable by red flour beetle, so these can be used as a quick and mass laboratory culturing host grain for pest, which may be needed in other scientific experiments.

4. Conclusion

The aim of this study was to note the potential effects of red flour beetle *T. castaneum* on twelve wheat lines or varieties after storage under laboratory conditions. Results showed significant differences between the various parameters to evaluate susceptibility of wheat grain to *T. castaneum* and these behaved differently to pest of stored grain. It has been revealed that the most susceptible and preferred varieties for development of this pet species were NIA-MB-02, NIA-MB-03 and NIA-MN-01 and the losses were highest. The least susceptible were found to be the NIA-MB-01, NIA-MN-08 and Khirman acting at the both factors as repellents and biochemical inhibitors in the storage. Thus, grains affected the behavior of pest and they were attractive in different ways by releasing volatile substances. Also, the grain components of the different varieties recommend that the susceptibility of these varieties to *T. castaneum* infestation may be attributed to the high content of protein and low content of carbohydrate compared to resistance varieties. Therefore, these aspects tested in the context of the present study should be taken into account in wheat improvement breeding program. For a better approach of the pest control, the resistant varieties could be therefore selected for using in further breeding for developing resistance during storage.

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