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Susceptibility of certain wheat varieties to the infestation by *Rhyzopertha dominica* (F.) and *Tribolium confusum* (du Val)

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Abstract

Eight Egyptian flour wheat varieties were assessed in order to determine their appropriate level of susceptibility to *Rhyzopertha dominica* (F.) and *Tribolium confusum* (du Val). Free choice test for attraction insect adults was used in the first experiment at time interval ranged from 0.125 to 5 days post infestation. At days, results showed that the lowest attracted numbers of *R. dominica* adults were 5.00 and the highest ones were 22.67 for SAKL8 and SIDS1 varieties, respectively. The varieties can be arranged descendently according to the attracted numbers of *R. dominica* as follow: SAKL8, SAKL1, BACANORA, DEBEIRA, , GIZA168, GIZA164, SIDS6 and SIDS1. The descending order results were obtained for *T. confusum* could be the similar. Statistical analysis demoed significant differences between the numbers of the eight varieties. In the second experiment, the numbers of F1 and the duration of offspring of each stage were determined. Based on the Dobie Index (D.I.) for *R. dominica*, SAKL8, DEBEIRA, BACANORA and SAKL1 were found to be resistant varieties. While the SIDS1 and SIDS6 varieties have a moderate resistant. In the case of *T. confusum* all varieties showed a degree of resistance, except SAKL8 and SIDS1showed a moderate resistant. The BACANORA cultivar showed the lowest D.I. value in the two tested insect species. The obtained results can give a better understanding to the stored-grain managers regarding to the prospective differences in wheat susceptibility to *R. dominica* and *T. confusum* infestation.

Key words: storage grains, wheat varieties, Dobie Index, lesser grain borer, red flour beetle.

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Introduction

Wheat is the first important and strategic cereal crop for the most countries all over the world. The Egyptian national production of wheat is not sufficient for our consumption. The primary purpose of grain storage is to increase the net value of crops by holding grain until the prices will be more affordable (Anderson et al., 1995). Storage methods in developing countries are not good, since the loss in storage grain can be reached to 30 -50% in Africa (Hill, 1990). The insect pests caused quantitative and qualitative damage to grains (Fornal et al., 2007). Lesser grain borer, *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae = Bostrychidae) and the red flour beetle, *Tribolium confusum* (du Val) (Coleoptera: Tenebrionidae) are serious pests of stored wheat. The red and the confused flour beetles attack stored grain products such as flour, cereals, meal, crackers, beans, spices, pasta, cake mix, dried pet food, dried flowers, chocolate, nuts, seeds, and even dried museum specimens (Weston & Rattlingourd, 2000). Management of the insect population's infested stored commodities is a great challenge today, particularly the use of pesticides become more restricted. The use of the environmentally safe alternatives is the focus of research in many laboratories around the world (Silhacek & Murphy, 2006). Residential insecticides are applied to protect grain from damage caused by insects. However, reuse of insecticides alternatives is advisable due to the regulatory restrictions of the use of insecticides and the development of resistance to insecticides (Arthur, 1996). Therefore, we are seeking new approaches based upon the insect's behavior. Sarin and Sharma (1983) revealed that, all the stored grain pests exhibit the phenomenon of preference or non- preference for the grains of different varieties. In spite of resistant or tolerant grain variety has been largely ignored since widely using of insecticides on stored grain, it is one useful alternative control technology for management of stored product insects. The objective of the present study is to screen the susceptibility of eight Egyptian wheat varieties using two parameters; the first, counting the insect numbers that attracted to each variety and the second is using of the Dobie index parameter.

Materials and methods

Culture of the insects: The initial stock population of *R. dominica* and *T. confusum* is picked up from the storage grains in Assiut Governorate, Egypt. These populations were maintained in plastic jars (2 × 2 L), covered with muslin cloth. The whole wheat grains were used as a diet for *R. dominica*, while the milled wheat grains were used for *T. confusum*. For getting a homogeneous culture, a bulk of male and female adults were introduced to the wheat grain media for 25 days, and then removed by sieving. The wheat grain media were kept for six generations. The wheat, which used for experimental studies was stored at (-4°C) for 10 days to eliminate any pest infections. The insect cultures and the experiments were maintained under laboratory conditions of 27±2°C and 70±5 % R.H.

Wheat varieties: The wheat varieties were gotten from the Agronomy Department, Faculty of Agriculture, Assiut University, Egypt. These varieties are SAKL8, DEBEIRA, BACANORA, SAKL1, GIZA168, GIZA164, SIDS6 and SIDS1.

Free choice food preference: The experiment was arranged in a complete randomized design with three replicates per variety. Five grams of whole or milled grains were put in a Petri dish (7 cm). All Petri dishes (3 replicates × 8 variety = 24) were placed in a wooden box (65 ×65 ×8 cm). A batch of 100 couple adults aged 1-2 week was put in a Petri dish (11 cm) which was placed in the center of the box. All Petri dishes were covered by muslin to prevent insects escaping and kept in dark under laboratory conditions. After interval recording periods, the geographic locations of Petri dishes were changed to avoid the effect of geographic directions.. The numbers of adults placed on the varieties were recorded at interval time (0.125, 1, 2, 3, 4, 5 days) after the experiment initiation (Nadeem et al., 2011).

Influence of wheat varieties on the developing stages the tested insects: The susceptibility index was calculated using the method of Dobie and Kilminster (1977) with a slight modification which given by (loge F)/D x 100) where F is the number of F1 insects developing from eggs laid by 3 pairs of *R. dominica* adult during seven days and D is the median development period, estimated as the time (days) from the middle of the oviposition period to the emergence of 50% of the F1 generation. The susceptibility index ranging from 0 to 11, was used to categorized the milled rice varieties, where: 0 - 3 = resistant, 4 - 7 = moderately resistant, 8 - 10 = susceptible and ≥ 11 = highly susceptible (Dobie, 1974). Data were summarized and analyzed using the analysis of variance (ANOVA) by SPSS (version 16 for windows, SPSS Inc., 2007), and means were separated by Least Significant Difference (LSD) at 5% level of probability.

Table 1: Mean number of *R. dominica* adults attracted to eight wheat varieties through different time in the free choice preference under laboratory conditions.

Time (day)	Varieties							
	SIDS1	SIDS6	DEBEIRA	BACANORA	SAKL1	SAKL8	GIZA164	GIZA168
0.125	8.33 d	6.00 e	11,00 c	17.33 a	17.00 a	12.67 b	11.00 c	10.00 c
1	13.33 bc	10.33 d	9.00 de	9.00 de	13.00 bc	9.00 de	14.00 b	16.33 a
2	9.67 d	11.33 c	11,00 c	12.67 b	13.67 b	10.67 c	12.33 b	14.67 a
3	19.00 a	17.67 b	9.67 e	9.00 e	9.00 e	9.00 e	14.33 c	11.33 d
4	20.67 a	19.00 a	9.67 d	7.33 e	7.33 e	7.33 e	15.67 b	12.67 c
5	22.67 a	20.67 b	8.33 e	6.00 f	6.33 f	5.00 f	17.33 c	13.67 d

Means, in the same row, followed by the same letter are not significantly different from each other at 5 % probability level, LSD test.

Results

Significant differences were obtained in the rate of preference by adult stage of *R. dominica* and *T. confusum* (Table 1 & Table 2). At 5 days, SIDS1 wheat variety was significant preferred the adult stage of *R. dominica* with 22.67 numbers. SAKL8 was significantly the least preferred variety with minimum of adults (5) of *R. dominica*. The tested varieties can be arranged in a descending order, based on the attracted numbers of *R. dominica*, as the following: SAKL8, DEBEIRA, BACANORA, SAKL1, GIZA168, GIZA164, SIDS6 and SIDS1. The descending order of the same varieties found to be similar in the arrangement for *T. confusum* (Table 2).

Table 2: Mean number of *T. confusum* adults attracted to eight wheat varieties through different time in the free choice preferences under laboratory conditions.

Time (day)	Varieties							
	SIDS1	SIDS6	DEBEIRA	BACANORA	SAKL1	SAKL8	GIZA164	GIZA168
0.125	8.67 d	13.00 b	13.33 b	17.00 a	17.33 a	13.33 b	13.33 b	12.00 bc
1	10.33 b	10.00 b	9.00 b	11.66 b	15.33 a	14.00 a	14.33 a	15.00 a
2	14.66 ac	15.00 a	11.33 c	12.00 bc	11.33 c	11.00 c	13.66 a	11.00 c
3	19.00 a	17.67 a	9.67 d	9.00 d	9.00 d	9.00 d	14.33 b	11.33 c
4	12.38 c	18.67 a	9.33 d	8.00 de	7.00 e	8.33 de	14.67 b	12.67 c
5	12.42 c	21.00 a	9.33 d	6.00 e	5.00 e	4.33 e	16.00 b	14.33 c

Means, in the same row, followed by the same letter are not significantly different from each other at 5 % probability level, LSD test.

Table 3: Mean number± SD of F1 progeny stages produced by *R. dominica* species reared on eight varieties of wheat.

Varieties	*R. dominica*	
	Larvae	Adults
SIDS1	11.00±1.00 a	7.33±0.58 a
SIDS6	10.00±0.58 a	6.33±0.58 a
DEBEIRA	9.33±1.53 b	6.00±1.00 b
BACANOR	8.33±1.53 b	4.00±1.00 d
SAKL1	7.67±1.53 c	4.67±2.08 d
SAKL8	7.33±1.53 c	4.00±1.00 d
GIZA164	8.67±1.53 b	5.33±1.53 abd
GIZA168	9.33±1.53 b	5.67±2.08 ab

Means, in the same column, followed by the same letter are not significantly different from each other at 5 % probability level, LSD test.

Significant differences were obtained in the number of larvae and adults stages in F1 of *R. dominica* and *T. confusum* (Table 3 & Table 4). The number of F1 progenies and the duration of offspring for each stage were determined. The highest numbers of larvae and adult of F1 progeny produced by *R. dominica* were recorded for SIDS1 variety with 11 larvae and 7.33 adults, while the lowest numbers were found at SAKL8 with 7.33 larvae and 4 adults, respectively (Table 3). Significant differences were obtained in the development duration of stages of F1 of *R. dominica* and *T. confusum* (Table 5 & Table 6). The results shows that there was significant different in the development duration of larvae and adults among wheat varieties (Table 5). The mean developmental time of egg,

larva and adult of *R. dominica* on the wheat varsities are ranging from 10 to 12, 12.67 to 20 and 2.67 to 4.67 days, respectively.

Table 4: Mean number ±SD of F1 progeny stages produced by *T. confusum* species reared on eight varieties of wheat.

Varieties	*T. confusum*		
	Larvae	Pupae	Adults
SIDS1	12.00±2.65 a	10.33±1.53 a	9.33±1.52 a
SIDS6	11.00±1.00 a	9.00±1.00 ab	9.33±0.57 a
DEBEIRA	9.67±0.58 bc	8.00±1.00 b	8.00±1.00 a
BACANOR	7.67±1.52c	6.00±2.00 c	3.67±2.08 c
SAKL1	8.33.0±1.65 c	6..0±1.52 c	5.33.0±1.15 b
SAKL8	7.67±2.08 c	6.00±1.73 c	3.67±1.53 c
GIZA164	10.0±1.00 b	8.0±1.00 b	6.67±0.58 b
GIZA168	10.0±1.00 b	8.33±1.53 b	6.33±0.58 b

Means, in the same column, followed by the same letter are not significantly different from each other at 5 % probability level, LSD test.

Table 5: Mean duration (days± SD) of immature development of *R. dominica* reared on eight varieties of wheat.

Varieties	*R. dominica*		
	Egg	Larvae	Adults
SIDS1	10.00±1.00 a	12.67±2.52 f	4.67±0.58 a
SIDS6	12.00±1.00 a	15.67±2.08 ec	4.33±0.58 a
DEBEIRA	11.33±1.52 a	17.00±1.00 c	4.67±0.58 a
BACANOR	11.67±0.58 a	20.00±1.00 a	3.00±0.00 ab
SAKL1	11.33±0.58 a	18.00±1.00 ab	3.67±0.58 bc
SAKL8	11.67±0.58 a	20.00±1.00 a	2.67±0.58 d
GIZA164	11.33±0.58 a	16.67±1.53 bc	3.67±0.00 bc
GIZA168	11.67±1.53 a	16.33±1.53 db	4.00±0.0 a

Means, in the same column, followed by the same letter are not significantly different from each other at 5 % probability level, LSD test.

Table 5 showed that the SIDS1 variety has the shortest developmental time (27.34 days), while SAKL8 has the longest mean developmental time (34.34 days). Based on the mean developmental time variable and number of F1 progeny emerged were created the susceptibility index (the Dobie Index (D.I.). D.I. in Figures 1 for *R. dominica*, SAKL8, DEBEIRA, BACANORA and SAKL1 were considered as resistant varieties. While the SIDS1 and SIDS6 varieties have a moderate resistance. In case of *T. confusum*, all tested varieties showed resistant, except SAKL8 and SIDS1 (Figure2), which exhibited a moderate resistant. BACANORA variety was shown the lowest D.I. value in for both tested insects.

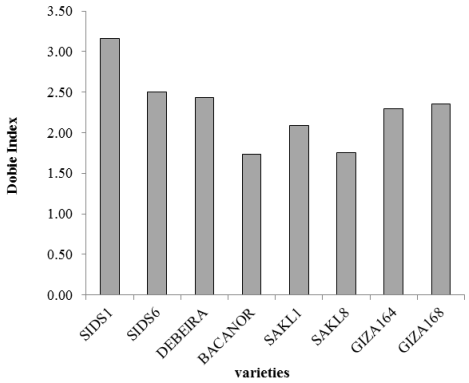

Figure 1. Dobie Index of adults of *R. dominica* on the tested wheat varieties

Discussion

Generally, the tested varieties are showed wide difference as food preferred or in the influence on the progeny produced with the tested insects. SAKL8 variety showed the most tolerant variety, while the opposite results with the SIDS1 variety against the two tested species in the two experiments. Although new wheat varieties have been bred for resistance to insect and disease pests while in field settings, very limited consideration has been given to postharvest insect issues. The obtained results from the two experiments showed that none of these wheat varieties were completely resistant to attack by the two tested insects, their susceptibility to

infestation varied considerably. Toews et al (2000) reported that varieties of wheat vary significantly in their susceptibility to infestation by lesser grain borers. They found that Newana, Madison and Wawawai varieties were produced the least progeny, the opposite was found for Coker 916 and Monroe varities. As evidenced by the wide gradient of susceptibility among varieties varieties can have a significant influence on the apparent resistance or lack thereof to lesser grain borer (Bhatia & Gupta, 1969).

Table 6: Mean duration (days± SD) of immature development of *T. confusum* reared on eight varieties of wheat.

Varieties	*T. confusum*			
	Egg	Larvae	Pupae	Adults
SIDS1	9.00±1.70 c	10.00±1.00 bc	8.00±1.00 b	3.67±0.58 a
SIDS6	9.00±1.00 c	10.33±0.58 b	8.33±0.58 b	3.33±0.58 a
DEBEIRA	10.67±0.58 b	11.00±2.65 b	10.67±2.52 a	3.00±0.00 a
BACANOR	17.00±3.60 a	13.00±2.65 b	4.00±0.92 c	2.33±0.58 a
SAKL1	10.67±0.58 b	17.33±3.53 a	10.00±1.00 a	2.67±0.57 a
SAKL8	12.33±0.58 b	18.67±1.53 a	12.00±2.65 a	2.0±0.00 a
GIZA164	10.33±0.58 a	12.0±1.00 b	8.00±1.00 b	3.33±0.58 a
GIZA168	9.67±1.15 bc	12.33±1.53 b	8.00±1.00 b	3.33±0.58 a

Means, in the same column, followed by the same letter are not significantly different from each other at 5 % probability level, LSD test.

Our outcome from assessing the susceptibility of the eight Egyptian wheat varieties is that all stored grains exhibit the phenomenon of preference/non preference for the grains of different varieties. This phenomenon is due to the structure and composition of a wheat variety such as starches, carbohydrates, enzymes (Evers et al., 1999); proteins (Gupta et al., 2000). In addition hardiness of grains was found to be probable factor of resistance of some cereal varieties to the stored product insects (Williams & Mills, 1980; Shazali, 1987). It was also found that nutritional and chemical content play more important role encouraging the oviposition and development rate of insects in different varieties of cereal besides the physical nature of grains. Cogburn (1974) attributed resistance in Dawn rice variety to antibiosis, due to composition of the bran coat of that variety which caused high mortality in the infesting insects. Khokhar and Gupta (1974) added that high protein content and high grain moisture were linked to the susceptibility to stored product insects. Batta et al (2007) suggested that resistance of some varieties to *R. dominica* (F.) can be attributed to the low protein and high carbohydrate compared to susceptible varieties. Also, Matthew et al., (1990) reported that the susceptibility is attributed to the genetic factors between different varieties of wheat. Recently, Giacinto et al (2008) showed that the antennae of adults of *S. granaries*, detecting a wide variety of compounds such as aliphatic alcalohls, aldehydes, ketones and aromas mixed with the smell of various cereal grains. This character can be playing a very important role in detecting and choosing suitable variety for the insect. Astuti et al (2013) reported that only ash content of Milled rice

varieties positively correlated with eggs numbers, F1 progeny emerged, developmental time of lesser grain borer, *R. dominca*, while the protein, carbohydrate and fat content are not significantly correlated. From the above mentioned statements, we can conclude that the physical and chemical variations among wheat varieties that allow or prevent the pests infestation, may act as repellents and/ or biochemical inhibitors. These results suggested that stored grain managers should be familiar with prospective differences in wheat susceptibility to *R. dominica* and *T. confusum*. Tolerance varieties to insects are one of the most important methods to decrease the insect damage. This investigation can recommend that wheat variety GIZA168 is less susceptible to infestation than GIZA164, SIDS6, and SIDS1. While SAKL8, DEBEIRA, BACANORA and SAKL1 intimated as good candidates as varieties for storage, since they have tolerant genes against *R. dominica* and *T. confusum.*

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