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Relative susceptibility of different graminaceous grains to Grain weevil, *Sitophilus granarius* L. in either choice or non-choice infestation test

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Abstract

The evaluate relative sensibility of fifteen cultivars of graminaceous crops Sorghum (Giza-15, Dorado); Barley (Giza-132, Giza-123); Rice (Giza-181, Sakha-101); Maize (SC-10, SC-131); Wheat (Giza-171, Gimeza-11, Sakha-95, Miser-1, Sids-12, Shandweel-1 and Bani sweaf-5) against *Sitophilus granarius* L. two test (free choice and Non-choice) were conducted in the Research lab at 28±1 °C and 65±5% R.H. The result demonstrated that highly significant differences between various graminiaceous grains in their susceptibility against *Sitophilus granarius* L. infestation. In free choice, the lines were categorized into three categories i.e., Giza-15, Dorado, Giza-171, and Gemiza-11 were found to be greatest susceptible; Giza-123, Giza-181, Sakha-101; SC-131and Miser-1 were found to be less susceptible and shandweel-1 was no injury. Weight loss were categorized into three categories i.e., Giza-15 (71.31±3.01) followed by Dorado (61.55±6.47) were highly weight loss, Giza-181, Sakha-101, SC-131, Misr-1, Bani sweaf-5 found to be less weight loss, Shandweel-1 was no infestation. The result indicated that the adult who emerged in Giza-123, Giza-181, SC-10, SC-131, Bani sweaf-5 were found to be less, Sakha-101, Sids-12, Shandweel-1 were no adult emerged. In the non-choice test, the two varieties, Giza-15, Gimeza-11 Showed the highest percentage of infestation (44.0±3.27) and (48.0±3.27%), followed by Dorado (35.0±2.0%). The varieties Giza-123, Giza-181, SC131, Misr-1, Bani sweaf-5 were the least; Sakha-101, Sids-12, Shandweel-1 observed no infestation. The highest percentage weight losses were in Giza-15 (28.71±3.08) followed by Dorado (22.46±4.53), Giza-123, SC-10, SC131, Miser-1 and Bani sweaf-5 were the least loss. Sakha-101, Sids-12 and Shandweel-1 were no weight loss. No adult emerged observed in Shandweel-1. The least adult emerged recorded in Giza-181, Sakha-101, SC-131, Misr-1 and Bani sweaf-5. These details are important for host plant resistant breeding program for the plant breeder.

Keywords*:* *S.granarius*, graminaceous Grains, choice, non-choice test, infestation.

INTRODUCTION

The Grain Weevil is an important pest of stored grains, causing substantial economic losses worldwide. In Egypt, where agriculture is a crucial sector, protecting grain varieties from weevil infestation is of most importance. Understanding the susceptibility of different grain varieties to Weevil infestation is essential for devising efficient pest control measures and ensuring food security. Seeds form the foundation of the main part of dietary supplying, and specifically, three distinct species (rice, wheat, and maize) account for more than 60% of the aggregate caloric consumption at a global level (FAO 2023). Wheat, Rice, Maize, and Barly are among the most abundant grain crops grown across the world (Wang *et al.* 2018; Ye and Fan, 2021). These agricultural products represent an essential element of our nutritional intake due to their significant content of proteins, carbohydrates, lipids, vitamins, and minerals (Oso and Ashafa, 2021). Due to their substantial economic significance, cereals are prevalent crops cultivated globally and serve as the primary sustenance in regions characterized by a temperate climate (Reynolds and Braun 2022, De Sousa *et al.*2021). It is widely obtainable and ingested by each human beings and domesticated animals According to Ranum *et al*. (2014). The cultivated land area dedicated to Wheat comprises 30.6% of the total global cereal cultivation area (with Maize at 26.7% and Rice at 22.6%), and the global wheat production exceeded 800 million tons in the year 2022 (FAO 2023). Furthermore, the study reveals that wheat production in Egypt is estimated at approximately 16.92 million tons during the period from 2005 to 2020, underscoring its significance as the foremost cereal crop, as per Shehata, G. *et al* (2023)The cereals of these crops are susceptible to invasion by insect pests during storage, attributed to the presence of nutrient elements. The marketability of Cereals is adversely affected once insect pests consume the Cereals, rendering them unsuitable Consumable by humans and resulting in substantial financial losses (Wang *et al*. 2021). Pest species that result in both significant qualitative and quantitative losses during the storage of grains postharvest primarily fall within two insect orders: Coleoptera (approximately 600 kinds), Lepidoptera (70 kinds), and mites (approximately 355 kinds) (Rajendran, 2002; Rajendran and Sriranjini, 2008). In the study by Banga *et al.* (2020), referred that insect pests affecting stored grains are classified into two distinct categories: primary and secondary pests. Primary pests are defined as those that cause harm to intact or healthy grains, whereas secondary pests inflict damage upon grains that are already compromised or damaged. Additionally, primary pests are further subcategorized into internal and external feeders based on the location of their assault (Deshwal *et al*., 2020). The impact of *S.granarius* infestation encompasses both direct grain mass loss from pest direct loss or damage through subsequent contamination with molts, feces, or deceased weevils. Furthermore, the insect's infestation elevates the humidity levels of the Stocked materials, fostering the expedited growth of molds, including highly poisonous types, leading to additional devaluation of the cereals (Boniecki *et al.* 2020, Metodyka *et al.* 2017, Germinara *et al.* 2012). The purpose of this study to evaluation the Relative Sensitivity of fifteen graminaceous crops to infestation with *Sitophilus granarius* under choice and non-choice test.

MATERIALS AND METHODS

Culture of the insect for experimental purposes:

A population of granary weevil was reared and increased for three generations on a mixture of certain types of graminaceous crops in the Plant Protection Department. College of Agric. Sohag University.

Source of graminaceous crops:

Fifteen crops of the family Gramineae were screened to find out the most preferable varieties to Granary Weevil, *Sitophilus granarius* in either choice or non-choice infestation test. The varieties were Sorghum, Giza-15; Dorado; Barly, Giza-132; Barly, Giza-123; Rice, Giza-181; Rice, Sakha-101; Maize, SC-10; Maize, SC-131; Wheat, Giza-171; Wheat, Gimeza-11; Wheat, Sakha-95; Wheat, Misr-1; Wheat, Sids-12; Wheat, Shandweel-1; and Wheat, Bani sweaf-5; These varieties were purchase from Field Crops Research Institute, Agriculture Research Center, Giza, Egypt. All lines used were previously sanitized by keeping them inside a deep freezer for two weeks;

subsequently, the tested lines were rinsed with tap water, allowed to air-dry within insectary conditions, and then subjected to two-week incubation at 28±1 °C and 65±5% relative humidity to achieve moisture content equilibrium.

Option invasion test:

To investigate the preference of diverse graminaceous species of *S.granarius*. Twenty grams of individual lines were adjusted using a precise diagnostic balance with an accuracy of 0.0001 g. and every sample was reserved in a plastic holder. (Height of 10 centimeters and span of 5.0 centimeters). These holder (4 sample * 15 lines = 60 Holders) were set in a glass box (150*70 * 30 cm.). Lots of approximately 500 A pair of Granary Weevils was set free in the box. All samples were reserved under controlled insectary circumstances during for a one generation (temperature 28±1 °C and 65±5% R.H). Samples were inspected at the final stage and reweighed determine the proportion of invasion and the Weight decrease.

Force invasion test

Adult *S.granarius* were obtained from a lot of raising up operation within insectary thermal conditions 28±1°C and 65±5% R.H. In every container 4 sample of lines = 60 container. The adult populations of *S.granarius* were set on 20g grain and in every sample were stored in plastic container (height of 10 centimeters and diameter of 5 centimeters) and permitted to lay eggs for 10 days before being removed. The plastic container were wrapped in muslin and fastened with a rubber band and preserved at 28±1°C and 65±5% RH until the new adults began to appear, the experiment was continue in the insectary until the emergence of adult granary *S.granarius* ceased. This study was also undertaken for one generation percentage infested grain and the decrease in weight was calculated.

Determination of grain weight loss percent of damage:

At the end of the experiments, after the Adults, *S.granarius* were eliminated, and the seeds in every holder were reweigh to identify the weight loss and percentage infestation following (Adams, 1976).

Weight loss = weight of healthy grains before invasion - weight of damaged grains after invasion. Total number of grains per sample was counted and those showing Pest damage were also separated and counted so that the percentage of infested grains could be calculated.

Damaged grains (%) =Number of damaged grains/total number of grains*100

The statistical interpretation:

The data obtained underwent analysis using an ANOVA test, and significant means were differentiated through Duncan's range test utilizing the SPSS 14.0 computer program.

RESULTS AND DISCUSSION

Free Choice invasion test

Data presented within the table (1) shows the percentage of damage seeds and percent decrease in the weight of each graminaceous crop resulting from *S.granarius* after one generation. In general all graminaceous crops had some degree of invasion by the *S.granarius* in the basis for the percentage of damaged grains, The statistical interpretation showed the highly meaningful between graminaceous crops. The graminaceous crops namely Sorghum, Giza-15; Sorghum, Dorado; Wheat, Giza-171 and to Wheat, Gimeza-11 were the greatest damage graminaceous, whereas, the graminaceous crops Barly, Giza-123; Rice, Giza-181; Rice, Sakha-101; Maize, SC-131 and Wheat, Misr-1 were the least damage and one graminaceous (Wheat, Shandweel-1) was zero damage. Moreover, the remaining graminaceous were intermediate. On the other side the statistical analysis showed highly significant between graminaceous crops concerning weight loss, The largest percentage decrease in weight was observed in Sorghum, Giza-15 (71.31±3.01) followed by Sorghum, Dorado (61.55±6.47). Whereas the graminaceous crops namely, Rice, Giza-181; Rice, Sakha-101; Maize, SC-131; Wheat, Misr-1 and, Wheat, Bani Sweaf-5 were the least weight loss and one zero graminaceous crop, Wheat, Shandweel-1. Moreover, the injury was zero loss weight. Moreover remaining graminaceous were observed intermediate.

Table (1). Response of different graminaceous crops to *S.granarius* infestation (free choice test) after one generate

Lines	Mean invasion (%)±SE	Mean weight loss (%)±SE
Sorghum (Giza-15)	74.00±5.16 a	71.31±3.01 a
Sorghum (Dorado)	64.25±3.30 b	61.55±6.47 b
Barly (Giza-132)	23.00±3.83 c	22.39±2.33 e
Barly (Giza-123)	6.00±2.31 fg	10.94±2.00 f
Rice (Giza-181)	9.00±2.00 def	0.46±0.14 h
Rice (Sakha-101)	4.00±0.00 gh	0.89±0.24 h
Maize (SC-10)	13.00±2.00 d	3.55±1.59gh
Maize (SC-131)	9.00±2.00 def	1.58±0.53 h
Wheat (Giza-171)	63.00±6.83 b	37.84±0.92 c
Wheat (Gimeza-11)	61.00±6.83 b	32.38±2.18 d
Wheat (Sakha- 95)	23.00±3.83 c	25.98±5.68 e
Wheat (Misr-1)	10.00±2.31 de	1.01±0.43 h
Wheat (Sids-12)	14.00±2.31 d	6.14±1.55 g
Wheat shandweel-1	0.00±0.00 h	0.00±0.00 h
Wheat bani sweaf-5	10.00±2.31 de	0.36±0.32 h

Means at each column followed by the same letter are not significant at 5% probability.

Non-choice test

Data shown in Table (2) represented the percentage of invasion and grains weight loss of fifteen graminaceous caused by *S.granarius* after one generation. The two graminaceous crops, Sorghum, Giza-15; and Wheat, Gimeza-11 showed the highest percentages of infestation (44.0±3.27 and 48.0±3.27%) Sorghum, Dorado followed graminaceous crops in percentage of infestations (35.0±2.0). The graminaceous groups namely Barly, Giza-123; Rice, Giza-181; Maize, SC-131; Wheat, Misr-1; and Wheat, Bani Sweaf-5 were the least infestation and Rice, Sakha-101; Wheat, Sids-12 and Wheat, Shandweel-1 observed zero infestation, whereas remaining graminaceous crops were in between. Conversely, the greatest percentage weight loss was observed in Sorghum, Giza-15 (28.71±3.08) followed by Sorghum, Dorado (22.46 ± 4.53), whereas, the graminaceous Barly, Giza-123; Maize, SC-10; Maize SC-132; Wheat, Misr-1 and Wheat, Bani Sweaf-5 were the least weight loss. Meanwhile, the graminaceous crops Rice, Sakha-101; Sids-12 and Shandweel-1 were observed zero weight loss. Moreover, remaining graminaceous were intermediate. From previous results we could concluded that, Statistical analysis showed that in free choice test the graminaceous crops Sorghum, Giza-15; Sorghum, Dorado and Wheat, Giza-171 were the greatest infestation with *S.granarius* and also the highest percentage, weight loss. Meanwhile, Wheat, Shandweel-1 observed zero infestation and weight loss. In non-choice test the graminaceous crops, Wheat, Giza-11; Sorghum, Giza-15 and Sorghum, Dorado were observed the highest infestation by *S.granarius* and also the highest percentage weight loss. Whereas the graminaceous crops Rice, Sakha-101; Wheat Sids-12 and Shandweel-1 were observed zero Percentage harm and weight decrease. The variations in the susceptibility of graminaceous crops have been linked to physical characteristics like grain hardness, pericarp surface texture, and nutritional components such as amyloses, lipid, and protein content (Dobie, 1977). Tepping *et al*. (1988) or non-nutritional factors, particularly Phenolic compounds (Serratos *et al*. 1987), have also been identified as influential. Grain hardiness has been highlighted as the primary resistance factor (Bamaiyi *et al*. 2007).

Table (2). Response of certain graminaceous crops to *S.granarius invasion* (No-selection test) after one generation

Varieties	Mean invasion (%) ± SE	Mean weight loss (%) ± SE
Sorghum (Giza-15)	44.00± 3.27b	28.71± 3.08a
Sorghum (Dorado)	35.00±2.00 c	22.46±4.53 b
Barly (Giza-132)	16.00± 3.27d	13.69± 2.72d
Barly (Giza-123)	6.00± 2.31f	1.81± 0.53g
Rice (Giza-181)	7.00± 2.00f	5.31±0.61 f
Rice (Sakha-101)	0.00±0.00 g	0.00±0.00 g
Maize (SC-10)	11.00±3.83 e	1.69± 0.17g
Maize (SC-131)	10.00± 2.31ef	0.53± 0.16g
Wheat (Giza-171)	15.00± 3.83d	8.46± 1.62e
Wheat (Gimeza-11)	48.00± 3.27a	16.89± 1.38c
Wheat (Sakha-95)	16.00± 3.27d	16.28± 3.68c
Wheat (Misr-1)	6.00± 2.31f	1.63± 0.68g
Wheat (Sids-12)	0.00±0.00 g	0.00±0.00 g
Wheat (Shandweel-1)	0.00± 0.00g	0.00±0.00 g
Wheat (Bani Sweaf-5)	6.00±2.31 f	0.29±0.11 g

Means at each column followed by the same letter are not significant at 5% probability.

Effect of different graminaceous crops on *S.granarius* adults emergence:

In free selection test:

Data presented in Table (3) shows the number of adult emerged in different emerged graminaceous varied significantly. The adult emerged in Sorghum, Giza-15 and Sorghum, Dorado were significantly higher than rest of the graminaceous crop. Adult emerged from Wheat, Giza-171 and Wheat, Gimeza-11 were though significantly less than Sorghum, Giza-15 and Sorghum, Dorado, but it was significantly higher than rest the graminaceous crops. The adults that emerged from Barly, Giza-132; Wheat, Sakha-95 and Barly, Giza-123 were intermediate. No adults emerged observed in the graminaceous Wheat, Shandweel-1. Meanwhile the least adults emerged were recorded in Rice, Giza-181; Rice, Sakha-101; Maize, SC-131; Wheat, Misr-1, and Bani Sweaf-5.

In non-choice test:

Data Table (3) shows the mean number of *S.granarius* adult emerged from different graminaceous crops. Statistical analysis showed highly significant variation between graminaceous crops. In Sorghum, Giza-15 and Sorghum, Dorado adults emerged were higher than rest of graminaceous Crops (125.50±4.20) and (16.0±1.83) respectively. The adult emerged in Barly, Giza-123; Rice, Giza-181; Maize SC-10; Maize, SC-131; and Bani Sweaf-5 were the least while Rice, Sakha-101; Wheat, Sids-12; and Wheat, Shandweel-1 showed no adult emerged. The adult emerges in rest graminaceous crops were intermediate. From the previous results we can concluded that the number of emerged adults increasing Caused in an increasing seeds Injury and seeds weight decrease. It can be inferred that resistant liness, therefore, can be utilized as an environmentally friendly way to reduce damage by stored insects under traditional storage conditions. The resistant lines identified in the present study can also be used as a source of resistance in breeding programs to diversity the basis of resistance to this pest. And this data could be valuable for farmers when deciding on long-term storage of a specific cultivar, thereby avoiding those cultivars most severely impacted by the weevil.

Table (3). Means at each column followed by the same letter are not significant at 5% probability.

Graminaceous crops	Mean ± SE	
	No. of adult emergence	
	Free choice test	Non-choice test
Sorghum (Giza-15)	372.50±17.08 a	125.50± 4.20a
Sorghum (Dorado)	347.50±10.79 b	116.00±1.83 b
Barly (Giza-132)	59.50±8.43 e	57.50± 6.45c
Barly (Giza-123)	23.25±3.30 g	9.25± 2.75e
Rice (Giza-181)	4.50±1.29 h	3.75±2.06 f
Rice (Sakha-101)	1.75±0.50 h	0.00±0.00 f
Maize (SC-10)	2.75±0.96 h	3.25±0.50 f
Maize (SC-131)	3.00±0.82 h	3.25±1.50 f
Wheat (Giza-171)	140.75± 6.40c	25.25± 3.59d
Wheat (Gimeza-11)	98.50±7.05 d	27.50± 6.45d
Wheat (Sakha-95)	35.50±3.70 f	23.50± 3.70d
Wheat (Misr-1)	4.50±1.29 h	3.75± 0.50f
Wheat (Sids-12)	16.50±1.29 g	0.00±0.00 f
Wheat (Shandweel-1)	0.00± 0.00h	0.00± 0.00f
Wheat (Bani Sweaf-5)	2.75±0.96 h	3.00± 1.41f

Similar to the present findings with those of Williams Mills (1980) and Shazali (1987) Additionally, it was determined that the nutritional and chemical compositions exert a more significant influence on promoting oviposition and the developmental rate of insects across various cereal varieties, in addition to the physical attributes of the grains. Gupta *et al.* (2000) documented that the hardness of the grains was identified as a potential contributing factor to the resistance of certain cereal varieties against stored product insects. Youssef and Salama (2004) found that line Giza-2 was the least cultivar Invaded by insects considering the total number of emerged adults of stored insects. The four cultivars were significant and accordingly arranged as Giza-2, Single Cross-10, Sweet Grain Sorghum and the more susceptible one was three was Cross-321. El-Syrafi *et al.* (2005) the research investigated the food preference of *S.oryza* and *I.gramarium* towards various Wheat and Maize varieties through non-choice and choice tests. The study revealed that both *S.oryzea* and *T.gromarium* exhibited a preference for certain Wheat and Maize varieties. Specifically, the findings indicated that Sakha-8 and Sakha-93 were susceptible Wheat varieties, with Wheat varieties generally being more preferred by both insects in non-choice or free-choice scenarios. Furthermore, the Wheat variety Sakha-8, followed by Sakha-93, and the Maize variety Tri-H322 were identified as the most preferred options for both insects, while Gize-168 and Okrani were the least preferred in this regard. A study conducted by Giacinto *et al.* (2008) demonstrated that the antennae of adult *S.granarius* are capable of detecting a diverse range of compounds, including aliphatic alcohols, aldehydes, ketones, and aromas associated with various cereal grains. This sensory capability plays a crucial role in the insect's ability to detect and select suitable host plants. Additionally, research by Mahmoud *et al.* (2011) revealed that none of the tested wheat varieties exhibited complete resistance to *S.granarius* infestation in choice or non-choice tests, indicating varying degrees of susceptibility among the tested varieties. In a study conducted by Issa *et al.* (2011), the resistance levels of maize lines and varieties to *S.zeamais* were evaluated. The research findings indicated statistically significant differences ($P > 0.05$) in the mean number of emerged weevils from the various maize lines and varieties. Furthermore, the study revealed that different lines and varieties displayed diverse levels of susceptibility and

weight loss in response to weevil infestation. Awadalla *et al.* (2014) conducted an insectary study to assess the performance of wheat and rice varieties in the context of infestation by stored grain insects. Their non-choice test revealed that Sakha-93 and Shandweel were the most preferred wheat varieties, while Seds-12 was the least preferred. In the case of rice, Sakha-105 emerged as the most preferred variety, with Giza-181, Giza-117, and Egyptian Jasmen being the least preferred. The free-choice test yielded similar results, with Shakha-93 and Shandweel being the most preferred wheat varieties, and Seds-12 being the least preferred. Similarly, Sakha-105 was the most preferred rice variety, while Giza-181, Giza-177, and Egyptian Jasmen were the least preferred. Bhandari *et al.* (2015) screened sorghum lines against the rice weevil based on sensibility index, and detected that the most susceptible lines exhibited the highest sensibility index, while the least susceptible lines displayed the lowest sensibility index. Yadav *et al.* (2018) assessed the relative sensitivity of 10 wheat genotypes to the rice weevil based on Biological metrics such as Progression period and adult emergence Evolvement indicator and infer that none of the wheat genotypes were Defiant to the Examination insect. Methta and Kumar (2021) investigated seven wheat cultivars against infestation by the rice weevil, *S.oryzae*. Among the cultivars, HPW-249, HPW-349, and HPW-236 Showed decreased susceptibility, HPW-155, HS-490, and VL-892 Were classified as moderately vulnerable, and HPW-236 was highly sensibility to invasion.

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