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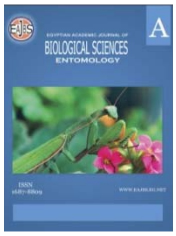

Determining the Fitness Components of (*Sitophilus oryzae* L.) on Imported Wheat in Egypt

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ABSTRACT

The rice weevil, *Sitophilus oryzae* (L.) is an extremely destructive beetle species that attacks different types of stored products worldwide. Four imported wheat from Russia, Ukraine, Australia, Poland and one from Egypt were collected and surveyed for the different insect types "feral weevils" in all samples during the first two months by one time/week. *Sitophilus oryzae*, as it was found from the survey data to be the only dominant species. Natural mixing for the different wheat populations with the Egyptian wheat were done. Different fitness component such as adult's longevity (day), life cycle (day), number of resulting weevils, adult's length (mm) and weight of adults (mg) were calculated for parents and their hybrids. Losses percentage also was detected. The results indicated that all the wheat samples were infected by rice weevils except the Australia wheat. Natural mixing with the Egyptian wheat caused an increase in all biological parameters and heterosis in the next generation.

INTRODUCTION

It is well established fact that lot of efforts should be put to produce "every single grain" but this is of no use if the produced seeds are not saved, which recalls the proverb "a grain saved is a grain equally produced". This adage depends mainly on how best we protect the quality of grains during storage. Loss of grains stored as seed, the future food of our country is to the tune of 7-8% accounting to major share of economic loss worth. Scientists are equally putting their efforts and attempting to find ways and means to reduce losses in storage due to store insect pests **(**Osman *et al*., 2012). After the harvest, grains are necessarily to be stored for consumption. Farmers retain about 70% of their agricultural produce for seed purpose, consumption and for sale **(**Reddy and Pushpamma, 1980**).** Most of the farmers are small and medium farmers who have no proper facilities for drying and storage. Consequently, many times grains are subjected to attack by insects, rodents and mites resulting in both quantitative and qualitative loss. Estimates of post-harvest losses of cereal grains ranged between 5 to 35 per cent in the world. *Sitophilus* species are among the most widespread and destructive primary pests of stored cereals in the world. One of these species, the rice weevil, *S. oryzae* (Linnaeus), is particularly destructive, attacking numerous crops including wheat, rice, maize and split peas (Longstaff 1981 and Grenier *et al.* 1994). However, the lack of information on the mating behavior of *S. oryzae* makes it difficult in understanding the general reproductive biology and thus the development of pest management programmes. It is the most destructive insect pest of the stored raw cereal grains in the world. *S. oryzae* causes substantial losses to store grain amounting to18.30% (Adams, 1976). This species has a relatively short developmental period and high populations can easily be built up (Aitken, 1975). Rice weevils range in size from 1/8 inch to 3/16 inch (3.1 to 4.8 mm) and are dark reddish-brown in colour. The shape of thoracic pits of a rice weevil are round/irregular. Rice weevils often have four light coloured patches on its elytra (wing covers), but these are not always present or visible. The adult rice weevil is 2-3 mm in length depending on the size of grain it feeds on, i.e. larger weevils develop from larger grains (Campbell, 2002). The rice weevil, *Sitophilus oryzae* (L.) is an extremely destructive beetle species that attacks different types of stored products worldwide, i.e., wheat, maize, barley, sorghum, rye, oats, rice, millet, cotton seed, dallisgrass seed, vetch seed, beans, nuts, flour, pasta and cassava (Hill, 2002 and Mason and McDonough, 2012). The major effect of an infestation by *S. oryzae* is the damage to grains caused by the feeding activities of adults and grubs (Longstaff 1981). Males and females feed by chewing holes in grain. Females chew a deep hole with enlarged sides in which they place an egg. The resulting grub hollows out the grain before emerging as an adult to continue the cycle. Egypt remains the world's largest wheat importer. Wheat imports for the 2015/16 marketing year are estimated at 11 million tonnes, about the same as the previous year and the average for the last five years. The imported requirements of cereal in the 2015/2016 are forecast about 19.3 million tonnes, about the same as the previous year and 9 percent higher than the fiveyear average, these imported wheats have many different types of insects and the job of Egyptian Agricultural Quarantine is detecting and identify all the types of these insect and the limit for each, that it is unfit for human consumption, but in some cases, there are some infection due to the egg of insect on the grains, that tack sometimes to emerged the generation. In the present research, we collect some imported wheat samples from Russia, Poland, Australia, Ukraine with the Egyptian wheat to tested the infection by the rice weevil, (*S. oryzae* L.). Therefore, the present research was undertaken to fill in some of lacunae with the following objectives a) to storage some major imported wheat from different centuries i.e., Russia, Poland, Australia, Ukraine beside the Egyptian wheat for six months, to survey the types of insects on the previous samples, to study the effect of crossing or natural mixing among the different wheat population, and calculate the fitness components and heterosis for weevil's parents and their hybrids.

MATERIALS AND METHODS

The present study was carried out from 2015 till 2017 in Department of Stored product pests, Plant protection Research Institute, Agriculture research center, Alexandria, Egypt.Four imported wheat and one from Egypt were surveyed i.e. Russia, Ukraine, Australia, Poland and Egypt. From each country, samples of 20.000 g (20 kg), were drawn at random and divided into four replicates.

Survey and insect identification

12 kg (four replicates, 3 kg each) from each wheat samples were collected and sieved separate in glass jars, each capacity 5 kg to determine and survey the different

insect types "feral weevils" in all samples during the first two months by one time/week. *Sitophilus oryzae*, as it was found from the survey data to be the only dominant species.

Biology of the rice weevil
Stock culture of *Sitophilus oryzae*

Three lots (3 kg) of wheat samples were taken randomly. Wheat lots were used to obtaining the so-called "feral weevils" and their offspring. These weevils were bred separately in glass jars using an incubator conditioned at 28 ±1°C and 70 ± 5% R.H. The weevils could be considered as four different geographical populations.

Wheat grain and experimentation

Wheat grain from the above-mentioned countries were placed in a deep freezer (-10^0C) for three weeks to kill any previous infesting insects (kossou *et al.,* 1992). Equilibrated grains of each country were then transferred to semi-opaque conical cups (10 cm. deep x 3-5 cm. diameter). Twenty grains were put in each cup. Five male/female pairs of Sitophilus oryzae, seven days old were introduced into each cup. Every week the tested grains were replaced by other 20 uninfected ones. Ten infested grains were left and examined for the emergence of adults, whereas the other ten grains were stained to locate the egg plugs. This experiment was replicated four times under laboratory conditions of 28 ±1°C and 70 ± 5% R.H. The following biological parameters were observed and recorded: adult longevity (days), life cycle(days), number of laid eggs, number of resulting weevils, Adults length (mm) and weight of adults (mg/individual).

Parents and Crossing

Three hybrids weevils were obtained from the imported strains with the Egyptian one as follows: E (Egypt) x R (Russia), E (Egypt) x U (Ukraine) and E (Egypt) x P (Poland). No insects were obtained from the Australia wheat. All the laboratory cultures resulting from the abovementioned crosses were kept under controlling incubator at 28±1 °C and 70±5%R.H. Heterosis of an individual cross was determined for each character as the increase in mean of F_1 hybrid over its better parent, according to the following formula adopted by Bhat *et al.* (1971).

$$\text{Heterosis Mid-parents} = \frac{\mu F_1 - \mu\,(P_1+P_2)}{\mu\,(P_1+P_2)} \times 100$$

Where, μF_1: First generation hybrids, $\mu P1$: Mean value of the first parents and $\mu P2$: Mean value of the second parents

Assessment of losses in wheat grains due to the infestation by *S. oryzae* (L.):

Laboratory experiment to quantify losses was performed by using 1500 g rice collected from each country and have been divided into in three replicates. This experiment was conducted mainly to appraise quantitative loss in wheat grains that stored under laboratory conditions of 24-31°C and 75-95 R.H. for six consecutive months (post-harvest loss). Glass jars (500 ml) were used and each jar was filled with 500 g of uninfected grains of each wheat sample. Jars were covered with pieces of muslin cloth and seceded with rubber bands. Artificial infestation was done by using numbers of weevils (50 unsexed weevils/jar). Each treatment was repeated three replicates. Three jars containing only grains were used to monitor weight changes throughout the period of this experiment.

Grain loss is of great importance in case of durable commodities, particularly wheat grains which have been stored for six months. Three replicates of each populations (treatment), 500g were stored for six consecutive months under the laboratory conditions of 26: 30^{0}C and 70: 90% R.H for the parents and their hybrids. The artificial method of infestation was adopted for each sample representing a population and the treatments were infested by 50 unsexed weevils confined with a 500g wheat grain/jar and controls were set up (with no weevils). For the parents, the experiment has been initiated in May 2016 and lasted until October of the same year, while the hybrids initiated in July 2016 and terminated in December of the same year. The losses of the four parents during the storage period are illustrated in Table 5, the weight losses (grams) were found to be increased from May to October.

RESULTS AND DISCUSSION

Survey of weevils on different wheat population

Four different wheat populations were collected from the imported wheat containers beside the Egyptian wheat used in the current study. The wheat samples were collected randomly from ten different wheat containers. The whole wheat grains were stored at the same conditions for six months to survey the different type of insects especially the *Sitophilus* weevils, May to October were the period to survey, we found that all the wheat samples have one type of weevils namely, *Sitophilus oryzae* (L.).

Data in Table 1 showed that at the first month (May) no weevils were appearing (non), while the increase of storage time data indicated high numbers of weevils in the grains (October). Within the current wheat populations, Ukraine wheat showed very high infected percentage by *Sitophilus oryzae* (L.) forward by Russia wheat and Egyptian wheat at the same level. Poland wheat population showed the second grade for weevil's infections. The results showed that no weevils were survey in Australia population (Table 1). The survey divided into five different categories as shown in Table 1, i.e. (-/non) for zero weevils, (+/normal) for weevils from 1:10, (++/high) from 10:50, (+++/very high) for 50:100 and (++++/huge) for more than 100 weevils after six months of storage. When transferring the data from qualitative to quantitative Ukraine and Russia wheat showed the highest average by 2.18 and 2.0 in respect, comparing with the lowest one was zero in Australia wheat. The data showed that just one type of weevil was found in the sored wheat in Egypt, thus was *Sitophilus oryzae* (L.) and this insect cause huge damge for all cereal crops such as wheat, rice, maize, sorghum etc.

Table (1): Survey for *Sitophilus oryzae* (L.) on different wheat population during six months of storage

Population	Storage months						Mean
	May	June	July	August	September	October	
Egypt	-	-	+	++	+++	+++	1.5
Russia	-	+	++	+++	+++	+++	2.0
Ukraine	-	+	++	+++	+++	++++	2.17
Poland	-	-	-	+	++	++	0.83
Australia	-	-	-	-	-	-	0.0
Description	Non	Normal	High	V. high	V. high	Huge	2.6

-=0 weevils, +=<10 weevils /kg, ++=10:50 weevils /kg, +++=50:100 weevils /kg, ++++=>100 weevils /kg.

Biological characteristics of *S. oryzae* (L.)

This study divided into two experiments, the first one was on parent's biology and the second on their hybrids as shown in Table 2 and 3. Six biological parameters were used such as adult's longevity (day), life cycle (day), number of laid eggs, number of resulting weevils, adult's length (mm) and weight of adults (mg).

Parents biology of *S. oryzae* (L.):

For the first character, adults' longevity (day), data in Table 2 showed that the weevils which found in Egyptian wheat had the highest value was 214.12 day. Analysis of variance in Table 2 showed that no significant variations between the Russia and Ukraine wheat populations in relation to this character with LSD=5.71 and the average values were 203.16 and 200.6 day, respectively. Poland wheat population showed the lowest adult longevity was 188.11 days with high significant values with other wheat populations. The data for number of laid eggs in Table 2 showed that Russia and Ukraine weevils populations showed the highest number of laid eggs were 263.60 and 245.11 egg comparing with the two-other weevil's population from Egypt and Poland were 231.12 and 213.43 egg, respectively. High significant variations were observed for this character between the all weevil's populations. For the next biological parameter, life cycle (day) ranged from 27.20 to 32.56 days with high significant variations between Egyptian, Poland and other two wheat population Russia and Ukraine was 2.01 (Table 2). The highest value was recorded to the weevils on Egyptian wheat by 32.56 days, forward by Poland wheat (31.94 days) and finally was the lowest one 27.20 days for Ukraine wheat population. Concerning to number of resulting weevils, data in Table 2 showed that high significant variations between all infected wheat populations by *S. oryzae*. The highest values were recorded to Russia and Ukraine by 247.11 and 231 weevils comparing with 201.13 and 197 for the infected Egyptian and Poland wheat populations with LSD=9.95. Although, the infected Egyptian wheat population showed high adult longevity comparing with Russia and Ukraine but it achieved the less number of resulting weevils (201.13) comparing with others were 247.11 and 231 weevils. Another biological parameter was calculated such adult length (mm) was shown in Table 2. The data showed high significant values between the tested population for adult length. Russian weevils were the largest one (0.07 mm) comparing with Poland weevils (2.21 mm). The Egyptian weevils was 2.88 mm and finally Ukraine weevils was 2.96 mm. Finally, for the parent's biology adults were weighted and results in Table 1 showed that Egyptian weevils was the heaviest (0.032 mg) and no significant variation was observed between Ukraine and Russian weevils.

Table (2): Biological characteristics of *S. oryzae* (L.) parents on different wheat populations

Country / Characters	(R)	(U)	(P)	(A)	(E)	L.S.D. 0.05
Adults longevity (day)	203.16	200.6	188.11	0.0	214.12	5.71
Number of laid eggs (egg)	263.60	245.11	213.43	0.0	231.12	4.23
Life cycle (day)	30.60	27.20	31.94	0.0	32.56	2.01
№ of resulting weevils	247.11	231.0	197.16	0.0	201.13	9.95
Adults length (mm)	03.07	02.96	02.21	0.0	02.88	0.03
Weight of adults (mg)	0.028	0.0271	0.022	0.0	0.032	0.01

*R: Russia, U: Ukraine, P: Poland, A: Australia and E: Egypt

Biology of *S. oryzae* (L.) weevil's hybrids

Three different weevil's hybrids were obtained from natural mixing between the imported and Egyptian wheat i.e. (E x R): Egypt x Russia, (E x U): Egypt x Ukraine, (E x P): Egypt x Poland (Table 3), to calculated the fitness component of *S. oryzae*. Data in Table 3 showed that the first hybrid (E x R) had the highest values in adult's longevity (day) comparing with (E x P) by 256.11, 245.1 and 202.1 days, in respect. When comparing with their parent's data showed there are increase in adult longevity from ~ 45 to 53 days, while when mixing with Poland wheat the value was 202.1 and this value is less that adult longevity in parent Egyptian wheat which was 214.12 days. That mean mixing or hybridization between the Russian, Ukraine with the Egyptian *S. oryzae* population increase the chance for increase adult longevity. High heterosis was observed for the number of laid eggs (egg) in all weevil's hybrids and data in Table 3 showed that there is relationship between parents and their hybrids in his character epically for the high infected population such as Russian and Ukraine. The highest average was 323.11 eggs for E X R and followed 295.10 eggs for E x U with high significant variation (LSD=5.21), while the last hybrid was E x P by average 233.13 eggs (Table 3). Data showed an increase in number of laid eggs in all the weevils hybrids comparing with their parents. The same trend for our data was observed in life cycle (day), E x R recorded in Table 3 the highest value was 33.30 days forward by E x P by 32.90 and finally E x U was 30.10 days. These hybrids achieved high values comparing with their parents for this character. Huge variation was observed for number of resulting weevils in the hybrids comparing with their parents as recorded in Table 3. There were almost 25% increase in resulting weevils when comparing with the overall of parent's population. The overall between Russia and Egypt parent population was 224 and in their hybrid, was 298 weevils. The same results were observed between the Ukraine and Egyptian population and the parents average was 216 comparing with their hybrids was 278 weevils with increase 62 weevils or ~ 20%. On the other hand, nearly good results were observed for the Poland and Egyptian hybrids that recorded 203 weevils comparing with general mean was 198 weevils as presented in Table 3.

For adult's length (mm) the results showed that the first hybrids E x R and E x U had the highest values were 3.44 and 3.16 mm comparing with their parents were 3.07, 2.96 and 2.88 (Table 3). The data showed that due to mixing between the wheat cultivars or population which infected by *S. oryzae* (L.) cause high dame for wheat and the length of these weevils increased and its will eat more and more to complete their life cycles. In fact, with increase of life cycle and longevity, the weight of weevils will increase and this fact was observed in Table 3 for all the hybrids. The hybrids values were 0.033, 0.030 and 0.0301 comparing with control. Study of fitness components are very helpful to know the behaver of weevils and to compare the effect of maxing wheat together on one container. Reviewing the literature, many researchers stated that the female adult of the rice weevil *S. oryzae* (L.) excavates a hole in a host grain; into which it deposits an egg, secreting a mucilaginous plug on top of the egg as the ovipositor is withdrawn. This tiny plug provides the only external evidence that a grain is infested. There are four larval instars, all of which remain within the host grain. Immediately upon hatching, the first instar feeds by burrowing through the tissues of the grain. At the end of the last instar, the larva uses a mixture of frass and larval secretion to seal off the end of the burrow, forming a pupal cell. When the adult has been developed, it remains inside the grain for 1 to 2 days depending upon the host and the environmental conditions before emerging (Singh *et al*. 1976). The current study was in agreement with Bheemanna (1986) who studied the biology of *S. oryzae* on sorghum and he found that pupal period ranged from 8 to 11 days and adult longevity ranging from 14 to 165 and 7 to 11 days with and without food, respectively. Finally, the total life cycle ranged from 38 to 53 days. Also**,** agreement with Baker (1988) studied the biology of four *S. oryzae* population on corn. The progeny production was lowest (70-134) at 28^0C and 55-60% R.H., on average, compared with an average of 155 to 192 adults in this study.

This difference was basically due to differences in weevil's population, laboratory conditions, and the adopted methodology.

The results of the current research were in a line with Wright and Urrelo (1989) who studied the biological parameters of the rice weevils on maize and observed 5 to 6 days of incubation period of rice weevil. The results showed that the adult longevity ranged from 14 to 165 and 7 to 11 days with and without food, respectively. The results reported that adult longevity in male and female was 114 to 115 and 119 to 120 days, respectively; the author reported also that, the larval period ranged from 16 to 20 days on maize grain. Our results confirmed with those of Lucas and Riudavets (2000**)** who studied the biological parameters of rice weevils in white and brown rice grain. These results indicated that, the size is 0.665 mm in length. Egg and larval development take place inside the grain and the life cycle of the weevils lasted 34.8 days at 27C and 69% R.H. The results were in the same trend with those of Yevoor (2003) who showed the pupal period was 8 to 9 days on maize at temperature of 14 to 34^0C and 55 to 88% R.H. The author observed that female lived for 115.76 days; male lived for 97.42 days with food. Female lived for 9.50 days; male lived for 7.32 days without food. The incubation period were 5 days on maize. Finally, our results agree approximately with Asmanizar *et al.* (2012) who summarized the life cycle of the rice weevil *S. oryzae*. The author detected that, females can lay 300 to 400 eggs in their lifetime. They have been 3 to 4 instars, which require an average of 18 days for development. The pupal stage required an average of 6 days and upon transformation, the adult insect will remain within the kernel for 3 to 4 days until it tans (hardens) and matures. The life cycle (egg to egg) may be as short as 32 days in the summer. The adult may live for 3 to 6 months.

Table (3): Biological characteristics of *S. oryzae* (L.) hybrids on different wheat populations.

Characters / Country	(E x R)	(E x	(E x P)	L.S.D. 0.05
Adults longevity (day)	256.11	245.1	202.1	10.01
Number of laid eggs (egg)	323.11	295.10	233.13	5.21
Life cycle (day)	33.30	30.1	32.90	1.79
№ of resulting weevils	298.3	278.3	203.14	8.91
Adults length (mm)	03.44	03.16	02.55	0.04
Weight of adults (mg)	0.033	0.03	0.0301	0.01

*(E x R): Egypt x Russia, (E x U): Egypt x Ukraine, (E x P): Egypt x Poland.

Genetical Studies (Heterosis percentage) on *S. oryzae* (L.)

Hybrid vigor or heterosis was calculated for the three weevil's hybrids to study the effect of maxing or natural storage. The same biological characters were used also. Data in Table 4 showed that for the first character e.g. adults longevity (day) there were high percentage of heterosis for the Egyptian materials with both Russian and Ukraine weevils. For example, E x R, the heterosis percentage was 22.75 % and the second one was E x U by 18.20%, that mean the fertility of these insects/weevils was very high and that cause in increase the longevity of these adults. While, when seen to the other third hybrid E x P, the results indicated that very low percentage of heterosis reached to 1.48%. for the next character number of laid eggs (egg) data in Table 4 showed high percent of heterosis for the first hybrid E x R was 29.18% and 27.11% for the next hybrid E x U and finally was 3.14%. Heterosis percentage for life cycle ranged from 2.01 to 5.71% as recorded in Table 4. The highest values recorded to the Soviet Union countries, Russia and Ukraine with the Egyptian weevils. They recorded 5.75 and 3.73% and the lowest one with Poland was 2.01%. The high damage for any cereals crops is the number of resulting weevils which found. When crossing the Russian and Ukraine wheat with the Egyptian wheat, they gave very high heterosis that was in average more than 30% (Table 4). The hybrids E x R and E x U showed very high percentage of heterosis were 33.09 and 28.80%, this percentage is very high and cause high losses in wheat grains. While, with the Poland population weevils the percentage was very low 5%. Concerning to adult length and weight, the data in Table 4 showed the same trend of results for both weevils from Russia and Ukraine with high percentage of Heterosis reached to 15.63% and 8.21% for adult length and 10 and 7.52% foe weevils weight. While with the Poland weevils this percentage was very low 1.19 and 1.48%. for the previous data we can concluded that it's not right to store the Egyptian wheat with Russian and Ukraine wheat, because the results showed very frightening thing for losses in national treasure, wheat.

Table (4): Heterosis for biological characteristics in *S. oryzae* (L.) attached different wheat populations.

Heterosis Characters	Heterosis (H)		
	E (♂) x R (♀)	E (♂) x U (♀)	E (♂) x P (♀)
Adults longevity	22.75	18.20	1.48
Number of laid eggs (egg)	29.18	27.11	3.14
Life cycle	05.71	03.73	2.01
No. of resulting weevils	33.09	28.80	5.00
Adults length (mm)	15.63	08.21	1.19
Weight of adults (mg)	10.0	07.52	1.48

*(E x R): Egypt x Russia, (E x U): Egypt x Ukraine, (E x P): Egypt x Poland.

Assessment of losses by *S. oryzae* (L.)

Parents and their hybrids losses by *S. oryzae* (L.)

Assessment of losses caused by pests attacking on crops has long been recognized. Reasons for making such assessments are: (1) to establish the economic status of specific pests; (2) to find the infestation that justifies control; (3) to calculate a justifiable expenditure of control; (4) to study the effects of environmental factors on the loss of yield caused by insect pests attack; (5) to give information to manufacturers and distributors of insecticides to enable them to decide when and what action should be taken; (6) to give a basis for directing future research and agricultural planning; and to determine the so-called economic injury level (EIL), which is considered as an attempt to answer the questions "what insect population is causing economic damage"? and "at what insect pest population should control be applied"?

Weight losses (g) of wheat artificially infested by *S. oryzae* were recorded in Table 5. Data indicated that with the increase of stored period, the losses increased i.e. for the first population Russia the losses ranged from 5.11±0.09 to 30.98±1.54 g by general mean 17.83 ±1.06 g. The highest losses were recorded to the Ukraine population which ranged from 3.69±0.31 to 35.59±1.43 g with general mean was 20.00±0.77 g (Table 5). The third one was the Egyptian population which showed losses ranged from 2.49±0.44 to 28.90±0.61 g. The last one was Poland population with range 1.80±0.41 to 21.78±0.66 g with average was 11.14 ±0.36 g.

High significant variations were observed between the current populations epically the Egyptian, Poland and other populations. The total losses percentage ranged from 12.44 % (Poland) to 24.04 % (Ukraine). The Russia population showed 21.39%

and finally the Egyptian population showed 1٨.9٦% (Table 5). Total losses per gram were 120.02 ± 2.56, 106.99 ±2.41, 94.83 ±1.39 and 66.81 ±1.08 g for Ukraine, Russia, Egypt and Poland populations, respectively (Table 5). Data in Table 6 clearly indicated the difference in losses for the three wheat population hybrids. For the offspring E x U, data showed very high losses was 196.43 g (29.28%) forwarded by E x R was 183.61 g (26.72%) and finally E x P (135.93 g) by 17.18 %.

The heterosis percentage was recorded for the three hybrids. Based on the previous data the high percentage of heterosis was observed to E x U (36.18%) and the lowest was 13.90 for E x P as shown in Table 6.

The current results in alien with Banerjee and Nazimuddin (1985) in one study, the maximum grain loss in wheat attributable to a single weevil was measured at 19%, and it was nearly 57% in rice. Five host crops (polished rice, rough rice, wheat, maize, and barley) were tested to determine the host Preference of *S. oryzae* under free- and no-choice conditions. Grain weight decrease, number of F1 progeny, and percent grain damage differed significantly among the various selected host grains. Grain weight loss was found to be the greatest in polished rice (14.11%) in the free-choice scenario, and it was the least in rough rice (2.95%). The greatest percentage of weight loss was observed in wheat in the nonchoice test. The results also agree with Biliwa *et al.* (1990) stated that dry weight loss in untreated stored maize was 54.3% without referring to the storage period. Dey and Sarup (1990) referred to qualitative losses pertaining to total protein, tryptophan (an amino acids), oil content, sugar content in 23-24 varieties of maize due to *S. oryzae* after storage for 60 days. Loss in amino acids supported of this investigation. It is estimated that 20% of the total maize harvest is lost annually due to insect pest attack (Upadhyay *et al*., 2001). *S. oryzae* L. is considered as one of the most destructive primary pests of stored cereals as barley, maize, rice, and wheat (Atwal and Dhaliwal, 2002). Annual grain loss in storage due to these insects approached 15%. A similar result was also reported by Ansari (2003). Regarding individual insect consumption, it has been reported that *S. oryzae* and *Rizopertha domonica* can consume 0.49 mg and 1.5 mg (respectively) of grain daily and produce 11-12 mg and 54 mg (again, respectively) of waste products throughout their lives. Percent grain damage was assessed at 15, 30, 45, and 60 days following experiment inception. The greatest grain damage was observed in polished rice (18.75% for free-choice and 14.00% for no-choice) and was followed by wheat (16.25% for free-choice and 12.50% for no-choice). These values are not unexpected, considering that an exceedingly high level of damage (67.78%) in wheat, while the level was 40.97% in maize. In this study, F1 progeny population (adults) was greatest in polished rice (138.8 in free-choice and 122.5 in no-choice). These values were followed by wheat, maize, barley, and rough rice. While polished rice did indeed appear to be the most preferred host in this study, Lucas (2000) reported a higher rate of increase in the number of *S. oryzae* progeny in brown rice. Results of this study were not in accordance with those of Kamel and Zewar (1973) who assessed losses in corn and elaborated that an increase of 1% mean infestation by *S. oryzae* resulted in a weight loss of maize kernels by 0.33%. Moreover, the recent results of losses were larger than those estimated by Karam *et al.* (1975) who assessed losses in stored grains of five high-yielding hybrid varieties of maize due to the developing larvae of *S. oryzae*. The results showed mean loss in rice grains ranged from 12.44 to 19.11% in parents and from 27.13 to 32.74 in their hybrids. These results agree with those of Singh and Benazed (1974) who estimated an overall yield loss of up to 30% and Rodriguez (1975) stated that loss attributed to insect damage during storage (4-5 months) reached up to 30%. Moreover, Rajan *et al.* (1975) in their studies on *S. oryzae* infesting maize noticed that threonine content in proteins of infested maize was significantly less than in the protein of uninfected materials.

Table (5) Weight losses (g) of wheat artificially infested by *S. oryzae* and stored for six consecutive months under the laboratory conditions of 26: 30°C and 70: 90% R.H.

Country / Months	Russia	Ukraine	Poland	Egypt
May	5.11±0.09	3.69±0.31	1.80±0.41	2.49±0.44
June	8.98±0.81	10.79±0.12	3.02±0.9٨	8.61±0.44
July	13.65±0.85	15.98±0.81	10.79±0.69	11.40±0.45
August	22.77±1.72	25.68±0.29	12.84±1.36	16.93±0.78
September	25.50±1.56	28.29±0.93	16.58±0.56	26.50±0.76
October	30.98±1.54	35.59±1.43	21.78±0.66	28.90±0.61
Total weight losses	106.99 ^{a} ±2.41	20.02 ^{a} ± 2.56	66.81^{c} ±1.08	94.83^{b}±1.39
General mean	17.83 ^{a} ±1.06	20.00 ^{a}±0.77	11.14 ^{c} ±0.36	15.80 ^{b} ±0.59
% losses	21.39 ^{a}	24.04 ^{a}	12.44 ^{c}	18.96 ^{b}
L.S.D. 0.05:	2.97**			

** L.S.D. 0.05 value for the genaral means

Table (6): Mid-parents heterosis in relation to losses of wheat by F_1 hybrids of *S. oryzae* under laboratory conditions at the end of six consecutive months

Hybrids	F_1 Losses (g)	F_1 Losses (%)	P_1 Losses (%)	P_2 Losses (%)	Heterosis Values
E x R	183.61	26.72	18.96	21.39	32.47
E x U	196.43	29.28	18.96	24.04	36.18
E x P	135.93	17.18	18.96	12.44	13.90

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ARABIC SUMMARY

تحديد مكونات المواءمة لسوسة الارز(سيتوفيلس اوريزا)على القمح المستورد في مصر

مروة ابراهيم مقلد

قسم حشرات الحبوب المخزونة– معهد بحوث وقاية النبات–مركز البحوث الزراعية – الاسكندرية – مصر

تعتبر حشرات الحبوب المخزونة وبالاخص سوسة الارز *Sitophilus oryzae* (L.) من اهم الحشرات التى تصيب محاصيل الحبوب على مستوى العالم. خلال هذة الدراسة تم تجميع أربع انواع قمح مستورد من كلا من روسيا و أوكرانيا وبولندا واستراليا من خلال حاويات عشوائية من ميناء الاسكندرية بجانب القمح المصرى وتم تخزين الخمس انواع من القمح تحت نفس الظروف لمدة ستة اشهر. حيث اجريت عديد من الدراسات على هذة الحبوب والتى منها الحصر لاهم انواع حشرات الحبوب المخزونة حيث تبين من خلال الحصر ان سوسة الارز *Sitophilus oryzae* (L.) هى الاكثر شيوعا فى جميع العينات وعلية تم اجراء التجربة. وقسمت التجربة الى صفات خاصة بجيل الاباء واخرى متعلقة بالنسل الناتج حيث تم الحصول على الحشرات الخصبة فى الجيل الاول لجميع العينات لضمان نفس عمر الحشرات واجريت تجارب البيولوجى ومكونات المواءمة فى كلا من جيل الاباء والابناء حيث قدر عمر الحشرات البالغة (باليوم) وعدد البيض الموضوع (البيضة) ودورة الحياة (اليوم) وعدد الحشرات الناتجة وطول الحشرات (ميللميتر) ووزن الحشرات البالغة (الجرام)، هذا بالاضافة الى اجراء تهجين او خلط مشابة للطبيعة بين الاقماح المختلفة لبيان اثر الخلط على قوة النسل الناتج وتقدير مكونات المواءمة والصفات البيولوجية علية. ثم قدر الفاقد بين الاقماح موضع الدراسة عقب فترة التخزين المشار اليها. اوضحت النتائج ان هناك تباين معنوى واضح بين كلا من العينات موضوع حيث كانت روسيا و أوكرانيا الاشد اصابة بحشرات سوسة الارز عن غيرها مثل البولندى والمصرى واظهرت النتائج ان الاقماح الاسترالية هى الاكثر نظافة ولا تحتوى على اى حشرات حتى عقب فترة التخزين السابقة. كما اوضحت النتائج ان مع تهجين حشرات سوسة الارز لكلا من روسيا و أوكرانيا وبولندا مع حشرات الارز المصرية ان قوة الهجين ذادت بمقدرا يفوق ٢٥% مقارنتة بالاباء. وخلاصة هذة الدراسة ان الاقماح المستوردة من كلا من روسيا و أوكرانيا تعتبر الاكثر اصابة تالها البولندى خلال فترة الدراسة مما قد يتسبب فى ذيادة الفاقد فى مخزون القمح هذا بالاضافة انها تخزن جميعا فى صوامع واحدة دون تميز بينها مما قد يذيد من فرصة قوة الهجين بينها وبين بعضها البعض او بين الانواع المصرية وبذلك يحدث ذيادة فى الفاقد العام للحبوب فى مصر وبنصح بتخزين هذة الحبوب منفصلة وذيادة الاستيراد من استراليا والبدء فى استهلاك الحبوب المستوردة الاكثر عرضة للاصابة عن غيرها عقب الاستيراد مباشرة.