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Performance of Some Rice Genotypes Sown on Different Dates in Yield, Quality Traits and Infestation by Lesser Grain Borer

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ABSTRACT

A 2-year field experiment was conducted at the Experimental Farm of Rice Research and Training Center, Sakha, Kafr El-Sheikh Egypt during 2014 and 2015 seasons, to study the effect of sowing date (15^{th} of April, 1^{st} of May and 15^{th} of May) on grain yield of twenty rice genotypes, and infestation by *Rhizopertha dominica* (F.). Sowing date had significant effects on all studied characters in both years. The highest values of number of panicles per hill, number of filled grains per panicle, grain yield, hulling, milling and broken rice grain were recorded in the early sowing date. The number of days from seeding to maturity and number of unfilled spikelets per panicle were recorded in the decline trend, as sowing was delayed. Egyptian Hybrid Rice 1 produced the highest values of grain yield followed by Giza179, and Giza178. Sakha106 produced maximum values of hulling and milling percentages. Regarding to the susceptibility of rice varieties to insect infestation by lesser grain borer, *R. dominica* in storage, data showed that the were Giza 178, Sakha 102, Sakha 104, Sakha 105, Giza 182, Giza179, GZ 9057-6-1-3-3, GZ 9577-4-1-1, GZ 9523-2-1-1-1 and GZ 9514-3-1-3-1 ha lower infestation. The moderate infested varieties were Sakha 103, Sakha 106, GZ 9328-1-2-1-3, GZ 9362-34-2-1-3, GZ 9461-4-2-3-1 and Egyptian Hybrid1. The highest infested ones were Giza 177, Sakha 101, GZ 9057-6-1-3-4 and Egyptian Yasmin. Also, data showed that the number of $F_{1,}$ progeny and susceptibility index (SI) recorded the lowest values when rice was sown on 15^{st} of April, but they recorded the highest values when sown on 15^{th} of May. The duration of life cycle decreased with late sowing dates. Also, results revealed highly positive significant correlation between insect infestation and hulling% and milling%.

Keywords : Rice, sowing date, genotypes, grain quality, *Rhizopertha dominica*.

INTRODUCTION

Rice is one of the most important cereal crops in Egypt for both producers and consumers. Rice yield is controlled by several agronomic factors, from which is planting date. Adjustment the planting date becomes very important under climate change issue. El-Ramady *et al.* 2013 indicated that most effects of climate change on sustainable agriculture in Egypt could be changed through mitigation and adaptation. Metwally *at al.* 2015 reported that early sowing on 10^{th} of April of some Egyptian rice genotypes produced better yield and yield attributes compared with late sowing dates. El-Malky and El-Zun 2014 found that performance of Egyptian rice genotypes varied significantly under different sowing dates. They also reported that early sowing on 1^{st} of May gave more grain yield across rice genotypes compared with late sowing.

Rhyzopertha dominica (F.), an important pest of stored grains, causes economic damage to rough rice through physical damage to the kernel, resulting in reductions in grain quality (Chanbang *et al*., 2008). Chemicals are widely used to control insects in stored grain even though they affect the environment and the consumers (Vadivambal *et al*., 2010). Plant breeders have been selecting pest-resistant varieties to improve crop productivity for many years. Host plant resistance is a cornerstone of many successful integrated pest management (IPM) programs. Plants have many natural characteristics for keeping pests at bay: repellent or toxic chemicals, thorns, hairs and hard to penetrate tissues (Waskom, 1995). Insect-resistant plants are bred to resist or repel pests by physical or biochemical means. An insect-resistant plant can physically deter insects from extracting plant juices, for example, by its leaf hairs. A plant possessing biochemical insect-resistant properties is nutritionally incomplete for the insects that become unable to complete their life cycles (Relf, 1996).

The objectives of the present investigation were to study the genetic behavior of twenty rice genotypes under three sowing dates and the effect of different sowing dates on grain quality characters, as well as to evaluate the effect of different sowing dates on the susceptibility of certain rice genotypes against the infestation by the lesser grain borer, *R. dominica*.

MATERIALS AND METHODS

A 2-year field experiment was carried out at the Experimental Farm of the Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt, during 2014 and 2015 seasons, to study the performance of some Egyptian rice genotypes under different sowing dates. The preceding crop was barley in both seasons.

Twenty rice genotypes; twelve commercial cultivars as well as eight promising lines were evaluated (Table 1). The genotypes were laid out in a randomized complete block design with four replications in each sowing date in both seasons. A combined analysis was used among the three sowing dates in each season to interpret the data.

The seeds of each rice genotype were soaked in water for 24 hours, then drained and incubated for additional 48 hours to hasten germination. Pre-germinated seeds were uniformly broadcasted in the nurseries on 15^{th} of April, 1^{st} of May and 10^{th} of May in both seasons. The permanent field was well prepared. Seedlings were carefully pulled form nursery after 25 days from sowing and transferred to the permanent field. Seedlings were handling transplanted in hills at the rate of 3-4 seedlings/hill and at the spacing of 20x20 cm between hills and rows. The plot size measured 12 m^2 (3 × 4 m). The recommended cultural practices were applied.

Monthly temperature and relative humidity are shown in Table (2) according to records of Sakha Meteorological Station.

Table 1: Rice genotypes, parentage, origin and type.

Genotype	Parentage	Origin	Type
Giza 177	Giza171/Yomji No.1//Pi No.4	Egypt	Japonica
Giza 178	Giza 175/Milyang 49	Egypt	Indica /Japonica
Sakha 101	Giza176/Milyang79	Egypt	Japonica
Sakha 102	GZ4096/Giza177	Egypt	Japonica
Sakha 103	Giza177/Suweon349	Egypt	Japonica
Sakha 104	GZ4096-8-1/GZ4100-9-1	Egypt	Japonica
Sakha 105	GZ5581/GZ4316	Egypt	Japonica
Sakha 106	Giza177/Hexi30	Egypt	Japonica
Giza 182	Giza181/IR39422//Giza181	Egypt	Indica
Giza179	GZ1368/GZ6296	Egypt	Indica /Japonica
GZ 9057-6-1-3-3	GZ1368/GZ6296	Egypt	Japonica
GZ 9057-6-1-3-4	GZ1368/GZ6296	Egypt	Japonica
GZ 9577-4-1-1	GZ6910/Yun Lang14	Egypt	Japonica
GZ 9523-2-1-1-1	GZ6522/Zhang Jia129	Egypt	Japonica
GZ 9328-1-2-1-3	Giza177/TKY1812	Egypt	Japonica
GZ 9362-34-2-1-3	Sakha101/AC2342	Egypt	Japonica
GZ 9461-4-2-3-1	Daey2Beyo/Gz6296-12-1-4-1-1	Egypt	Japonica
GZ 9514-3-1-3-1	AC2348/GZ6522-15-1-1-3	Egypt	Japonica
Egyptian Yasmin	IR262/KDML105	Egypt	Indica
Egyptian Hybrid1	IR69625A/Giza178R	Egypt	Japonica

Table 2. Monthly temperature and relative humidity at Rice Research & Training Center, Sakha, Kafr El-Sheikh in 2014 and 2015 rice growing seasons.

Month	Temperature (^oc) 2014		Temperature (^oc) 2015		Relative humidity (%)	
	Max.	Min.	Max.	Min.	2014	2015
April	28.08	8.38	27.27	11.11	58.78	63.13
May	29.29	10.10	28.99	12.73	57.07	59.34
June	33.33	15.15	33.94	19.19	66.86	63.13
July	32.32	15.86	33.33	20.40	68.48	65.95
August	33.93	16.46	34.72	19.19	70.30	66.91
September	33.34	15.15	32.83	19.19	63.13	62.12
October	28.28	11.11	30.60	16.36	60.60	62.37
November	26.26	8.08	26.26	10.61	68.18	64.49

The studied agronomic characters were growth duration, number of panicles per hill, number of filled grains per panicle, number of unfilled grains per panicle and grain yield. Hulling, milling and broken rice grain percentages were determined.

Insect infestation : Grains were sterilized by freezing at -8^{o}C for one week to get rid of any prior insect infestation. The grain moisture content was adjusted according to the method of AOAC, (2000).

Target insect (lesser grain borer, *Rhizopertha dominica* (F.) (Fam. Bostrichidae) adults, used in this study, were obtained from Stored Product Pests Research Department, Plant Protection Research Institute, Agricultural Research Center, where a standard culture is maintained without exposure to insecticides for several years.

Newly emerged adults (1-5 days old) were used in the experiments. Three replicates of 20 g-grain samples of each cultivar were placed in small plastic jars (6 cm diameter and 10 cm height). Twenty unsexed newly emerging *R. dominica* adults were released in each jar and allowed to lay their eggs. The jars were kept in the laboratory at constant conditions (30 + 2^{o}C, 70 + 5% R.H.). After 20 days, the parents were removed. After emergence (29- 40 days), number of adult progeny (P) and duration of life cycle (D) were recorded. Susceptibility Index (SI) was calculated according to Howe (1971) as follows:

Susceptibility Index (SI) = (Log P / D) x 100

Where*:*

Log(P) = Logarithmic number of adult progeny,

D = duration of life cycle.

Statistical analysis : The analysis of variance by means of "MSTATC" computer software package was carried out as combined analysis for the three sowing dates in each season according to Gomez and Gomez (1984). Treatment means were compared by Duncan's Multiple Range Test (Duncan, 1955). The correlation coefficient was statistically estimated as reported by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1. Agronomic studies:

Data in Table (3) indicated that rice genotypes varied significantly in their number of days to mature due to different sowing dates in both seasons. Sakha103 performed as the earliest genotype, while Egyptian Yasmin performed as the latest one. Sowing rice on 15th of April recorded the longest duration whereas sowing on 1st or 15th of May required less days to mature. These differences might be related to the genetic diversity among evaluated genotypes under different sowing dates. Maiti and Sen (2003) indicated that the growth duration exhibited an increase trend of early planted crop and decrease trend of late planted crop. Similar trend was found by Sedeek *et. al,* 2009.

Table 3. Duration (days) of different rice genotypes under variable sowing dates.

Genotype	2014				2015			
	April 15th	May 1st	May 15th	Mean	April 15th	May 1st	May 15th	Mean
Giza 177	125.3	122.6	119.6	122.5	124.9	122.2	119.2	122.1
Giza 178	135.3	132.6	129.6	132.5	134.9	132.3	129.3	132.2
Sakha 101	141.3	138.6	135.6	138.5	140.9	138.3	135.3	138.2
Sakha 102	126.3	123.6	120.6	123.5	125.9	123.2	120.2	123.1
Sakha 103	120.2	117.6	114.6	117.5	119.9	117.2	114.2	117.1
Sakha 104	136.3	133.6	130.6	133.5	135.9	133.3	130.3	133.2
Sakha 105	124.2	121.6	118.6	121.5	123.9	121.2	118.2	121.1
Sakha 106	126.3	123.6	120.6	123.5	125.9	123.2	120.2	123.1
Giza 182	127.3	124.6	121.6	124.5	126.9	124.2	121.2	124.1
Giza 179	123.2	120.6	118.2	120.7	122.9	120.2	118.2	120.5
GZ 9057-6-1-3-3	123.6	121.6	118.6	121.2	123.1	121.2	118.2	120.8
GZ 9057-6-1-3-4	124.2	124.6	121.6	123.5	123.9	124.2	121.2	123.1
GZ 9577-4-1-1	127.3	123.6	120.6	123.8	126.9	123.2	120.2	123.5
GZ 9523-2-1-1-1	126.3	121.6	118.6	122.1	125.9	121.2	118.2	121.8
GZ 9328-1-2-1-3	124.2	120.6	117.6	120.8	123.9	120.2	117.2	120.5
GZ 9362-34-2-1-3	123.2	121.2	119.6	121.4	122.9	121.6	119.2	121.2
GZ 9461-4-2-3-1	125.3	121.6	118.6	121.8	124.9	121.2	118.2	121.5
GZ 9514-3-1-3-1	124.2	122.2	119.2	121.9	123.9	121.6	117.6	121.0
Egyptian Yasmin	153.3	156.3	159.3	156.3	153.0	155.3	159.0	155.8
Egyptian Hybrid1	136.3	133.6	130.6	133.5	135.9	133.3	130.3	133.2
LSD0.05		4.8		3.5		2.8		2.6
Sowing mean	128.7	126.3	123.7		128.3	125.9	123.3	
LSD0.05		3.4				3.2		

The ability of tested rice genotypes to produce effective tillers was affected significantly by sowing dates (Table 4). Egyptian Hybrid Rice 1 recorded the greatest number of panicles per hill, followed by Giza179, Giza178 and Sakha101. On the other hand, the least number of panicles per hill was recorded with Egyptian Yasmin. It was noted that planting rice on early sowing dates (15th of April or 1st of May) recorded the highest values of number of panicles per hill. Thus, delaying planting significantly reduced panicles per hill. When Egyptian Hybrid Rice 1 was sown on 1st of May, the highest values of number of panicles per hill were recorded. Dawadi and Chaudhary (2013) indicated that significant higher effective tiller per square meter in early sowing might be due to favorable environmental conditions which enabled the plant to improve its growth and development as compared to late sowing dates. Similar trend was found by El-Malky and El-Zun (2014).

Table 4. Number of panicles per hill of different rice genotypes under variable sowing dates.

Genotype	2014				2015			
	April 15th	May 1st	May 15th	Mean	April 15th	May 1st	May 15th	Mean
Giza 177	18.37	20.37	16.03	18.26	19.71	19.79	18.04	19.18
Giza 178	20.04	22.38	18.70	20.37	21.64	20.38	19.37	20.46
Sakha 101	20.70	19.71	18.36	19.59	20.70	19.21	17.70	19.20
Sakha 102	17.70	18.04	18.04	17.93	17.57	19.41	16.83	17.94
Sakha 103	19.04	20.04	19.37	19.48	19.44	20.62	18.70	19.59
Sakha 104	19.71	18.04	17.70	18.48	20.37	19.37	17.57	19.10
Sakha 105	16.70	18.04	15.03	16.59	19.71	20.22	14.23	18.05
Sakha 106	19.37	19.04	13.36	17.26	19.10	18.62	16.30	18.01
Giza 182	18.04	16.70	18.70	17.81	18.44	18.62	16.38	17.81
Giza 179	22.70	21.37	19.04	21.04	20.97	21.95	19.64	20.85
GZ 9057-6-1-3-3	20.86	20.36	16.70	19.31	20.05	19.86	18.56	19.49
GZ 9057-6-1-3-4	19.04	20.37	14.36	17.92	19.44	20.46	17.04	18.98
GZ 9577-4-1-1	19.04	18.70	16.71	18.15	19.65	19.29	16.38	18.44
GZ 9523-2-1-1-1	18.70	20.71	19.04	19.48	16.57	18.37	18.64	17.86
GZ 9328-1-2-1-3	19.71	18.37	16.37	18.15	19.17	17.54	16.10	17.60
GZ 9362-34-2-1-3	17.70	19.04	16.70	17.81	17.57	20.04	16.97	18.19
GZ 9461-4-2-3-1	17.03	18.04	16.03	17.03	20.04	20.04	15.63	18.57
GZ 9514-3-1-3-1	17.03	17.03	18.70	17.59	17.43	17.43	15.57	16.81
Egyptian Yasmin	17.03	17.37	13.69	16.03	17.37	17.37	15.97	16.90
Egyptian Hybrid1	23.05	26.05	20.37	23.16	22.38	26.05	19.71	22.71
LSD0.05		3.03		1.21		2.95		1.86
Sowing mean	19.08	19.49	17.15		19.37	19.73	17.27	
LSD0.05		1.70				2.09		

Number of filled grains per panicle of tested rice genotypes was significantly affected by sowing date and interaction (Table 5). The highest values of number of filled grains per panicle were observed by Egyptian Hybrid Rice 1 followed by Giza179, Giza178 and Sakha101. The greatest number of filled grains per panicle was noticed with early sowing (April 15th). With delay in sowing, the number of filled grains per panicle decreased significantly. Dawadi and Chaudhary (2013) and El-Malky and El-Zun (2014) found that number of filled grains per panicle increased in the early sowing and declined gradually in the successive later sowing dates.

Number of unfilled spikelets per panicle was significantly affected by rice genotype, sowing date and the interaction (Table 6). Sakha 102 and GZ 9577-4-1-1 recorded the lowest values of number of unfilled spikelets per panicle while Egyptian Yasmin recorded the highest ones. Over the genotypes, number of unfilled spikelets per panicle increased with delaying sowing.

Table 5. Number of filled grains per panicle of different rice genotypes under variable sowing dates.

Genotype	2014				2015			
	April 15th	May 1st	May 15th	Mean	April 15th	May 1st	May 15th	Mean
Giza 177	146.0	118.6	120.6	128.4	145.8	123.5	121.2	130.2
Giza 178	173.3	162.0	143.3	159.5	183.4	166.0	145.3	164.9
Sakha 101	152.6	144.2	128.6	141.8	158.0	131.5	120.9	136.8
Sakha 102	144.6	135.6	117.2	132.5	135.5	96.1	123.6	118.4
Sakha 103	137.9	129.2	126.9	131.3	137.8	124.6	115.3	125.9
Sakha 104	157.0	147.3	116.9	140.4	142.8	146.9	129.6	139.8
Sakha 105	129.3	99.5	101.5	110.1	130.1	90.1	104.9	108.4
Sakha 106	131.7	132.0	116.6	126.8	146.2	113.0	111.2	123.5
Giza 182	134.3	133.6	123.9	130.6	130.3	113.6	106.9	116.9
Giza 179	182.6	173.6	129.2	161.8	181.7	175.7	134.9	164.1
GZ 9057-6-1-3-3	155.3	153.0	135.6	148.0	158.8	156.5	130.4	148.6
GZ 9057-6-1-3-4	152.6	126.6	118.6	132.6	151.6	131.1	124.9	135.9
GZ 9577-4-1-1	114.6	90.5	79.5	94.9	123.9	107.1	94.9	108.6
GZ 9523-2-1-1-1	146.7	138.4	106.9	130.7	134.8	146.0	124.9	135.2
GZ 9328-1-2-1-3	157.0	130.6	99.2	128.9	147.6	123.5	102.2	124.4
GZ 9362-34-2-1-3	123.2	100.2	71.8	98.4	119.2	99.0	85.2	101.1
GZ 9461-4-2-3-1	122.3	112.2	63.8	99.4	123.9	113.4	78.8	105.4
GZ 9514-3-1-3-1	122.6	111.9	89.2	107.9	121.2	103.8	99.9	108.3
Egyptian Yasmin	139.9	125.0	117.6	127.5	157.1	133.3	120.0	136.8
Egyptian Hybrid1	197.1	188.4	165.0	183.5	200.5	183.9	161.0	181.8
LSD0.05		23.79		5.97		19.55		4.72
Sowing mean	146.0	132.6	113.6		146.5	128.9	116.8	
LSD0.05		13.87				11.41		

Table 6. Number of unfilled spikelets per panicle of different rice genotypes under variable sowing dates.

Genotype	2014				2015			
	April 15th	May 1st	May 15th	G mean	April 15th	May 1st	May 15th	Mean
Giza 177	9.02	4.68	16.70	10.13	7.01	4.14	8.95	6.70
Giza 178	3.34	12.02	7.01	7.46	3.34	8.60	8.62	6.85
Sakha 101	5.01	11.69	16.03	10.91	6.35	12.36	26.85	15.19
Sakha 102	3.00	4.68	7.35	5.01	7.01	8.95	13.09	9.69
Sakha 103	11.36	7.01	4.68	7.68	7.01	12.22	3.34	7.53
Sakha 104	4.68	5.01	8.68	6.12	10.35	7.82	6.95	8.37
Sakha 105	5.01	9.69	11.02	8.57	5.01	5.54	7.41	5.99
Sakha 106	12.36	12.36	10.69	11.80	5.34	7.28	12.16	8.26
Giza 182	12.02	11.02	29.39	17.48	6.35	10.22	18.70	11.76
Giza 179	3.69	11.36	10.69	8.58	4.34	15.10	22.98	14.14
GZ 9057-6-1-3-3	8.02	21.04	21.36	16.81	6.67	9.82	9.97	8.82
GZ 9057-6-1-3-4	8.02	6.68	12.69	9.13	11.36	8.95	18.17	12.83
GZ 9577-4-1-1	4.01	3.34	8.02	5.12	5.01	3.87	10.42	6.43
GZ 9523-2-1-1-1	5.68	14.03	19.37	13.03	6.68	9.22	14.70	10.20
GZ 9328-1-2-1-3	7.01	8.68	15.03	10.24	7.35	13.36	12.22	10.98
GZ 9362-34-2-1-3	7.35	5.68	6.01	6.35	8.02	5.54	8.02	7.19
GZ 9461-4-2-3-1	10.02	21.04	15.03	15.36	6.35	19.04	15.43	13.60
GZ 9514-3-1-3-1	11.01	6.68	22.71	13.47	8.35	8.95	21.38	12.89
Egyptian Yasmin	11.35	17.70	31.73	20.26	6.35	38.01	32.00	25.45
Egyptian Hybrid1	13.36	13.36	8.35	11.69	16.03	13.49	9.29	12.94
LSD0.05		7.97		2.96		7.43		1.38
Sowing mean	7.77	10.39	14.13		7.21	11.12	14.03	
LSD0.05		4.55				4.36		

It can be observed from Table (7) that grain yield of different rice genotypes was affected significantly by sowing dates as well as the interaction. Egyptian Hybrid Rice 1 produced the highest values of grain yield followed by Giza179, and Giza178. With delay in sowing, the grain yield decreased gradually. The highest values of grain yield were produced by genotypes sown on 15th of April which was statistically at par with that sown on 1st of May. Regarding to the interaction, Egyptian Hybrid Rice 1 produced the highest yield when sown on 15th of April. Giza179 produced the highest grain yield under late sowing. Similar trends were reported by Dawadi and Chaudhary (2013) and El-Malky and El-Zun (2014) who indicated that high yield in early sowing was attributed to increased cumulative mean value of temperature and sunshine hour due to early sowing, more number of productive tillers, more number of grains per panicle and higher seed weight.

Table 7. Grain yield t ha^{-1} of different rice genotypes under variable sowing dates.

Genotype	2014				2015			
	April 15th	May 1st	May 15th	Mean	April 15th	May 1st	May 15th	Mean
Giza 177	8.10	7.99	6.32	7.47	7.96	7.88	5.72	7.19
Giza 178	10.88	9.89	7.41	9.39	10.74	9.77	6.52	9.01
Sakha 101	10.73	9.58	7.26	9.19	10.40	9.47	6.66	8.84
Sakha 102	8.56	8.02	6.76	7.78	8.24	7.90	6.83	7.66
Sakha 103	8.66	7.81	6.21	7.56	8.14	7.70	5.28	7.04
Sakha 104	8.56	8.40	6.22	7.73	8.42	8.29	5.29	7.33
Sakha 105	8.89	8.24	6.81	7.98	8.75	8.13	6.88	7.92
Sakha 106	8.08	8.26	6.09	7.48	7.94	8.14	5.75	7.28
Giza 182	9.27	8.24	7.58	8.36	9.13	8.12	6.65	7.97
Giza 179	9.91	9.48	9.05	9.48	9.77	9.37	9.06	9.40
GZ 9057-6-1-3-3	9.22	8.01	7.36	8.20	9.08	7.90	7.43	8.14
GZ 9057-6-1-3-4	8.62	7.41	6.75	7.59	8.48	7.30	6.83	7.54
GZ 9577-4-1-1	8.50	7.29	6.11	7.30	8.36	7.17	6.52	7.35
GZ 9523-2-1-1-1	8.74	7.53	5.87	7.38	8.60	7.42	5.94	7.32
GZ 9328-1-2-1-3	8.20	6.99	6.34	7.18	8.06	6.88	6.41	7.12
GZ 9362-34-2-1-3	8.38	8.95	6.28	7.87	8.24	8.83	6.36	7.81
GZ 9461-4-2-3-1	8.27	7.06	6.40	7.24	8.13	6.95	6.48	7.19
GZ 9514-3-1-3-1	8.28	7.30	6.42	7.33	8.14	7.18	6.46	7.26
Egyptian Yasmin	8.14	7.51	6.94	7.53	8.00	7.40	5.01	6.80
Egyptian Hybrid1	11.57	10.74	8.97	10.43	11.43	10.25	8.80	10.16
LSD0.05		1.74		1.20		1.76		1.40
Sowing mean	8.98	8.23	6.86		8.80	8.10	6.54	
LSD0.05		1.43				1.41		

Hulling percentage was affected significantly by rice genotype, sowing date and the interaction as presented in Table (8). Sakha 106 produced the highest hulling percentage in contrast to Giza 182 which produced the lowest values. Means of sowing dates over the genotypes showed that rice sown on 15th of April produced the highest values of hulling percentage, while that sown later produced less values.

Table 8. Hulling percentage of different rice genotypes under variable sowing dates.

Genotype	2014				2015			
	April 15th	May 1st	May 15th	Mean	April 15th	May 1st	May 15th	Mean
Giza 177	83.03	81.56	78.96	81.18	83.85	80.72	79.52	81.36
Giza 178	81.09	79.26	77.89	79.41	80.91	78.42	77.46	78.93
Sakha 101	81.46	79.56	80.06	80.36	81.94	78.72	80.62	80.43
Sakha 102	81.96	80.66	79.46	80.69	82.45	79.82	80.02	80.76
Sakha 103	83.96	79.96	78.46	80.79	83.44	79.12	79.02	80.53
Sakha 104	80.86	80.36	79.26	80.16	80.34	79.52	79.82	79.89
Sakha 105	81.36	79.26	76.16	78.93	81.85	78.42	76.72	79.00
Sakha 106	83.26	81.86	80.56	81.89	83.42	82.34	81.12	82.29
Giza 182	78.20	76.56	73.56	76.11	78.68	75.72	74.12	76.17
Giza 179	82.73	81.06	76.93	80.24	80.88	80.89	76.82	79.53
GZ 9057-6-1-3-3	82.83	78.56	79.74	80.38	83.3	77.74	80.28	80.44
GZ 9057-6-1-3-4	80.38	79.05	77.67	79.03	80.86	78.22	78.22	79.10
GZ 9577-4-1-1	81.06	81.66	78.96	80.56	82.54	80.82	79.52	80.96
GZ 9523-2-1-1-1	82.36	80.36	79.46	80.73	82.85	79.52	80.02	80.80
GZ 9328-1-2-1-3	82.16	81.36	78.10	80.54	82.65	80.52	77.99	80.39
GZ 9362-34-2-1-3	82.96	80.36	78.86	80.73	83.45	79.52	79.42	80.80
GZ 9461-4-2-3-1	81.36	80.36	78.66	80.13	80.84	81.52	79.22	80.53
GZ 9514-3-1-3-1	83.16	81.36	79.66	81.39	83.72	81.84	78.82	81.46
Egyptian Yasmin	81.93	80.2	76.85	79.66	82.15	80.02	77.35	79.84
Egyptian Hybrid1	81.96	78.36	78.06	79.46	81.12	78.85	78.62	79.53
LSD0.05		1.06		1.03		1.29		0.90
Sowing mean	81.90	80.09	78.37		82.06	79.61	78.74	
LSD0.05		1.03				0.92		

It can be observed from Table (9) that milling percentage of different genotypes was affected significantly by sowing dates and the interaction. Sakha106 produced maximum values of milling percentage which surpassed significantly all other genotypes. Maximum percentages of milling were produced by genotypes sown on 15th of April, whereas the minimum percentages were recorded in that sown on 15th of May, irrespective of genotypes.

Table 9. Milling percentage of different rice genotypes under variable sowing dates.

Genotype	2014				2015			
	April 15th	**May 1st**	**May 15th**	**Mean**	**April 15th**	**May 1st**	**May 15th**	**Mean**
Giza 177	71.17	70.45	68.34	69.99	71.63	70.08	69.01	70.24
Giza 178	68.94	68.24	66.20	67.79	69.10	67.85	66.88	67.94
Sakha 101	70.44	67.14	66.44	68.01	72.93	68.09	70.11	70.38
Sakha 102	70.44	70.24	67.94	69.54	70.94	69.18	68.61	69.58
Sakha 103	72.04	69.24	67.23	69.50	72.53	68.19	67.91	69.54
Sakha 104	70.94	69.24	67.14	69.11	71.43	68.19	67.81	69.14
Sakha 105	69.44	68.34	65.24	67.67	69.94	67.29	65.91	67.71
Sakha 106	72.54	70.44	69.44	70.81	71.88	70.93	70.11	70.97
Giza 182	66.64	66.24	62.94	65.27	67.13	65.85	63.61	65.53
Giza 179	70.44	69.27	68.94	69.55	70.93	68.89	68.61	69.48
GZ 9057-6-1-3-3	70.64	67.26	68.74	68.88	71.12	66.24	69.39	68.92
GZ 9057-6-1-3-4	67.79	67.76	64.68	66.74	68.28	66.72	64.36	66.45
GZ 9577-4-1-1	70.04	69.74	68.54	69.44	70.53	69.68	69.21	69.81
GZ 9523-2-1-1-1	70.04	70.74	67.64	69.47	70.54	69.68	68.31	69.51
GZ 9328-1-2-1-3	70.44	69.74	67.64	69.27	70.94	68.69	67.64	69.09
GZ 9362-34-2-1-3	70.24	70.74	66.94	69.31	70.74	69.68	67.61	69.34
GZ 9461-4-2-3-1	70.94	70.45	67.64	69.68	70.43	70.38	68.31	69.71
GZ 9514-3-1-3-1	71.64	70.44	68.74	70.27	72.31	70.93	67.69	70.31
Egyptian Yasmin	69.84	69.87	67.94	69.22	70.51	69.48	68.10	69.36
Egyptian Hybrid1	71.44	69.94	67.33	69.57	69.39	70.43	68.01	69.28
LSD0.05		0.61		0.52		0.62		0.49
Sowing mean	70.30	69.28	67.28		70.66	68.82	67.86	
LSD0.05		0.27				0.58		

The data presented in Table (10) revealed the significant effect of rice genotypes , sowing dates and the interaction on broken grain percentage. Maximum broken grain percentage was recorded in rice genotype GZ 9057-6-1-3-3 followed by Egyptian Yasmin. The least broken grain percentage was noted in GZ 9461-4-2-3-1, followed by GZ 9328-1-2-1-3. Concerning sowing dates, maximum broken grain percentage was found in rice sown on 15th of May and minimum broken grain percentage occurred in rice sown on 15th of April.

Table 10. Broken rice grain percentage of different rice genotypes under variable sowing dates.

Genotype	2014				2015			
	April 15th	**May 1st**	**May 15th**	**Mean**	**April 15th**	**May 1st**	**May 15th**	**Mean**
Giza 177	5.76	7.92	9.42	7.70	6.37	8.39	10.14	8.30
Giza 178	7.59	10.67	11.12	9.79	8.50	11.39	12.21	10.70
Sakha 101	6.79	8.07	9.52	8.12	6.25	8.66	10.24	8.39
Sakha 102	5.88	6.66	8.02	6.85	6.36	7.27	8.74	7.45
Sakha 103	5.31	7.06	9.92	7.43	5.79	7.67	10.64	8.03
Sakha 104	4.81	8.37	10.82	8.00	5.29	8.96	11.54	8.60
Sakha 105	6.96	9.22	12.83	9.67	7.57	9.94	13.28	10.26
Sakha 106	6.66	8.62	11.32	8.87	7.27	9.34	11.79	9.46
Giza 182	7.11	8.67	14.13	9.97	7.84	9.26	14.58	10.56
Giza 179	9.02	9.62	10.27	9.64	9.74	10.12	10.86	10.24
GZ 9057-6-1-3-3	13.44	14.82	19.32	15.86	14.30	15.86	19.98	16.71
GZ 9057-6-1-3-4	10.85	11.70	16.85	13.13	12.12	12.56	17.52	14.07
GZ 9577-4-1-1	2.86	8.32	9.32	6.83	3.47	8.79	10.04	7.43
GZ 9523-2-1-1-1	5.36	10.02	10.32	8.57	5.97	10.74	10.65	9.12
GZ 9328-1-2-1-3	2.46	4.41	8.92	5.26	3.07	4.89	9.64	5.87
GZ 9362-34-2-1-3	3.66	7.11	10.82	7.20	4.27	7.59	11.54	7.80
GZ 9461-4-2-3-1	1.85	3.01	6.91	3.92	2.47	3.50	7.64	4.54
GZ 9514-3-1-3-1	3.51	5.91	7.06	5.49	4.00	6.64	7.67	6.10
Egyptian Yasmin	9.07	15.21	20.84	15.04	9.66	16.36	21.24	15.76
Egyptian Hybrid1	6.98	10.97	14.61	10.85	4.79	11.56	15.34	10.57
LSD0.05		1.30		1.10		1.38		1.12
Sowing mean	6.30	8.82	11.62		6.76	9.47	12.26	
LSD0.05		1.17				1.22		

2. Insect studies:

To evaluate susceptibility of rice varieties to insect infestation in storage, *R. dominica* adults were released on tested varieties. The insect infested all rice varieties with variable levels. Data in Tables (11,12 and 13) showed that the lowest infested varieties were Giza 178, Sakha 102, Sakha 104, Sakha 105, Giza 182, Giza179, GZ 9057-6-1-3-3, GZ 9577-4-1-1, GZ 9523-2-1-1-1 and GZ 9514-3-1-3-1. They produced low number of F_1 progeny (ranged from 2.3 to 5.0 insects per jar), longest insect life cycle (34- 40 days), with low values of susceptibility index (SI) (1.12 - 2.00). The moderate infested varieties were Sakha 103, Sakha 106, GZ 9328-1-2-1-3, GZ 9362-34-2-1-3, GZ 9461-4-2-3-1 and Egyptian Hybrid1, as the F_1 progeny ranged from 5.3 to 9.4 insects per jar, the life cycle ranged from 32.3 to 34 days, and SI values were from 2.18 to 2.98. Data revealed that the highest infested varieties were Giza 177, Sakha 101, GZ 9057-6-1-3-4 and Egyptian Yasmin. They produced the highest number of F_1 progeny (10.3-14.2 insects per jar), the life cycle ranged from 29 to 32.3 days and SI values were from 3.33 to 3.80.

Table 11. Mean number of F_1 progeny of *Rhyzopertha dominica* under variable sowing dates of rice genotypes.

Genotype	sowing date			Mean
	April 15th	May 1st	May 15th	
Giza 177	10.0	11.6	13.7	11.4
Giza 178	2.7	3.7	4.7	3.6
Sakha 101	8.0	10.7	12.7	10.3
Sakha 102	1.3	4.0	6.7	4.1
Sakha 103	5.6	6.3	16.7	9.4
Sakha 104	2.7	6.0	6.3	4.9
Sakha 105	3.3	3.7	4.7	3.9
Sakha 106	6.7	7.0	14.7	9.3
Giza 182	2.0	3.0	3.3	2.7
Giza179	2.0	2.3	3.0	2.3
GZ 9057-6-1-3-3	3.3	2.3	6.7	3.8
GZ 9057-6-1-3-4	10.7	16.0	17.0	14.2
GZ 9577-4-1-1	3.0	4.7	7.7	5.0
GZ 9523-2-1-1-1	2.3	3.0	3.7	2.7
GZ 9328-1-2-1-3	4.3	5.3	6.7	5.5
GZ 9362-34-2-1-3	5.0	5.7	7.3	6.1
GZ 9461-4-2-3-1	4.7	5.0	7.0	5.3
GZ 9514-3-1-3-1	2.0	4.0	5.0	3.7
Egyptian Yasmin	12.7	14.7	17.0	14.0
Egyptian Hybrid1	8.0	9.0	10.7	9.2
LSD0.05		5.6		3.2
Sowing mean	5.0	6.4	8.8	
LSD0.05		2.8		

These findings are in agreement with those of El-Malky and El-Zun (2012) who found that Giza 178 and GZ 9577-4-1-1 were the lowest infested rice varieties, Egyptian Hybrid1 was moderately infested, and Egyptian Yasmin was the highest infested by *R. dominica*. Also, results obtained are in agreement with those of El-Aidy *et al.*(2000) who recorded that the rice varieties, Sakha 104, GZ 1368-5-4, GZ 5121-5-2-1, Giza 182 and Giza 181 were the least susceptible to *Sitophilus oryzae* (L.) infestation, whereas the varieties, GZ 5844-60-3-2, GZ 5310-20-3-3, Giza 177, Giza 172 and Reiho were the most susceptible.

Table 12. Duration of life cycle of *Rhyzopertha dominica* under variable sowing dates of rice genotypes.

Genotype	Sowing date			Mean
	April 15th	May 1st	May 15th	
Giza 177	34.0	34.0	29.0	32.3
Giza 178	40.0	34.0	34.0	36.0
Sakha 101	29.0	29.0	29.0	29.0
Sakha 102	40.0	40.0	34.0	38.0
Sakha 103	34.0	34.0	29.0	32.3
Sakha 104	40.0	34.0	34.0	36.0
Sakha 105	34.0	40.0	34.0	36.0
Sakha 106	34.0	34.0	29.0	32.3
Giza 182	40.0	40.0	34.0	36.0
Giza179	34.0	34.0	34.0	34.0
GZ 9057-6-1-3-3	34.0	34.0	34.0	34.0
GZ 9057-6-1-3-4	34.0	29.0	29.0	30.7
GZ 9577-4-1-1	34.0	34.0	34.0	34.0
GZ 9523-2-1-1-1	40.0	40.0	40.0	40.0
GZ 9328-1-2-1-3	34.0	34.0	29.0	32.3
GZ 9362-34-2-1-3	34.0	34.0	34.0	34.0
GZ 9461-4-2-3-1	34.0	34.0	34.0	34.0
GZ 9514-3-1-3-1	34.0	34.0	34.0	34.0
Egyptian Yasmin	34.0	34.0	29.0	32.3
Egyptian Hybrid1	34.0	34.0	34.0	34.0
LSD0.05		6.4		4.6
Sowing mean	35.7	34.7	32.6	
LSD0.05		3.1		

The differences between the present study and those of El-Malky and El-Zun(2012) and El-Aidy *et al.*, (2000) regarding to susceptibility of some rice varieties such as, Sakha 101, Sakha 102, Sakha 103 and Giza179 to insect infestation, may be ascribed to some factors such as the sowing dates, the location, difference of insect type and genetic isolations across the years from 2000 to 2015. Islam (2007) suggested that the susceptibility of rice varieties to the infestation of *S. oryzae* depends not only on a single factor, but also it depends on the combination of many factors like grain hardness, nutritive value, and natural resistance. In addition, the factors comprising grain size and moisture content in the rice grains might be the reasons of severe infestation by the rice weevil population.

Table 13. Susceptibility of some rice cultivars to *Rhyzopertha dominica* infestation under variable sowing dates of rice genotypes.

Genotype	Sowing date			Mean
	April 15th	May 1st	May 15th	
Giza 177	2.94	3.13	3.92	3.33
Giza 178	1.08	1.67	1.98	1.58
Sakha 101	3.11	3.55	3.81	3.50
Sakha 102	0.28	1.51	2.43	1.41
Sakha 103	2.20	2.35	4.22	2.92
Sakha 104	1.08	2.29	2.35	1.91
Sakha 105	1.53	1.67	1.48	1.56
Sakha 106	2.43	2.49	4.03	2.98
Giza 182	0.75	1.19	1.53	1.20
Giza179	0.89	1.06	1.40	1.12
GZ 9057-6-1-3-3	1.53	1.06	2.43	1.63
GZ 9057-6-1-3-4	3.03	4.15	4.24	3.80
GZ 9577-4-1-1	1.40	1.98	2.61	2.00
GZ 9523-2-1-1-1	0.90	1.19	1.42	1.19
GZ 9328-1-2-1-3	1.86	2.13	2.85	2.29
GZ 9362-34-2-1-3	2.06	2.22	2.54	2.27
GZ 9461-4-2-3-1	1.98	2.06	2.49	2.18
GZ 9514-3-1-3-1	0.89	1.77	2.06	1.57
Egyptian Yasmin	3.25	3.43	4.24	3.64
Egyptian Hybrid1	2.66	2.81	3.03	2.83
LSD0.05		2.01		1.81
Sowing mean	1.79	2.19	2.87	
LSD0.05		1.52		

(Susceptibility index)[a] = (Log Mean number of F_1 progeny / Duration of life cycle) x 100

Also, data showed that the number of F_1 progeny and (SI) were lowest in rice sown on 15st of Apil, while the highest values were in rice sown on 15th of May, and the duration of life cycle decreased with late sowing dates. These findings are in agreement with those of Magunmder *et al.* (2013) who reported that the early planted rice had lower pests and natural enemy population as compared to late transplanted rice. There were interaction between varieties and transplanting date, while early transplanted BINA dhan4 rice variety hosted the lowest population of insect pests, but TNl variety when, was cultivated at late season, showed the high insect population. Weston *et al*. (1993) found that late planted dent corn was found free from *Sitotroga cerealella* (Oliv) infestation. Emergence of insect adult after incubation revealed that the infestation was latent in corn grains. The authors suggest that earlier dent corn planting increases the risk of infestation by *S. cerealella*. Weston (1994) suggested that the late planting and early harvest are useful for averting preharvest infestation of maize by *S. cerealella*. Results of both authors are in disagreement with the results of the current investigation. This may be due to defference in the host crop and the insect type.

3. Correlation coefficient :

The relationships among grain yield and stored insect infestation were represented as correlation coefficient values (Table 14). Highly significant positive correlations were observed between grain yield and each of number of panicles per hill and filled grain percentage. Meanwhile, significant positive correlations were observed between grain yield and each of hulling % and milling %. On the other hand, unfilled spikelets per panicle and broken grain % correlated negatively and significantly with grain yield. Since the grain yield is the target, any increase in one or more of yield components will directly reflect grain yield increase. Similar trends were found by Sedeek et al 2009. The correlation coefficient values between insect infestation by *R. dominica* and each of grain yield, panicles per hill and broken% showed no significant correlation, while there were highly positive significant correlation between insect infestation and each of hulling % and milling %. These finding are in agreement with those of Antunes *et al.*. (2016) who found differences of paddy and polished rice to attack by *Sitophilus zeamais* (Motsch.). Paddy rice was more resistant to insect attack, followed by polished rice and then brown rice. Paddy kernels selected with undamaged hull, were completely resistant to attack. Also, Arthur *et.* (2012) showed that the number of progeny of *R. dominica* was positively correlated with feeding damage on the milled rice yield.

Table 14. Correlation coefficient values among studied characters with grain yield and insect infestation by *Rhizopertha dominica* .

Character		Infestation parameter		
	Grain yield	No. of progeny (F_1)	Life cycle	Susceptibility
Duration	0.221	0.491**	-0.233	0.448**
panicles per hill	0.698**	0.159	-0.155	0.191
Filled grains per panicle	0.678**	0.255*	-0.243	0.229
Unfilled spikelets per panicle	-0.265*	0.096	0.011	0.010
Grain yield	1	0.129	-0.238	0.170
Hulling %	0.258*	0.342**	-0.393**	0.409**
Milling %	0.326*	0.317*	-0.396**	0.390**
Broken %	-0.299*	0.027	0.134	-0.072
No. of progeny (F_1)	0.129	1	-0.690**	0.964**
Life cycle	-0.238	-0.690**	1	-0.780**
Susceptibility	0.170	0.964**	-0.780**	1

***Correlation is significant at the 0.05 level (2- tailed).**
**** Correlation is significant at the 0.01 level (2- tailed).**

CONCLUSION

It could be concluded that the highest grain yield was observed with Egyptian Hybrid Rice 1 followed by Giza179, and Giza178 sown on 15th of May. Under late sowing, Giza179 produced the highest grain yield. The lowest infested varieties by *R. dominica* were Giza 178, Sakha 102, Sakha 104, Sakha 105, Giza 182, Giza179, GZ 9057-6-1-3-3, GZ 9577-4-1-1, GZ 9523-2-1-1-1 and GZ 9514-3-1-3-1.

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أداء بعض تراكيب الأرز الوراثية المنزرعة في مواعيد مختلفة في المحصول وجودة الحبوب والإصابة بحشرة ثاقبة الحبوب الصغرى

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أقيمت تجربة حقلية في المزرعة البحثية لمركز البحوث والتدريب في الأرز بسخا ,كفر الشيخ ,مصر خلال موسمي الأرز 2014 و 2015 لدراسة سلوك عشرين تركيبا وراثيا من الأرز منزرعه في ثلاث مواعيد زراعة (منتصف ابريل – أول مايو – منتصف مايو). استهدفت الدراسة تقييم محصول وصفات الجودة وكذلك تقييم حساسية الإصابة بحشرة ثاقبة الحبوب الصغرى .أظهرت النتائج أن صنف الأرز هجين مصري 1 كان متفوقا في معظم الصفات المحصولية المدروسة تبعه الصنف جيزة 178 والصنف جيزة .179 بينما أعطى الصنف سخا 106 أعلى نسب تبييض وتقشير .أدى التبكير في الزراعة إلى زيادة الصفات المدروسة عدا صفتي عمر النبات وعدد السنيبلات الفارغة حيث أدى التبكير في الزراعة إلى نتائج عكسية .بينما سجل الصنف جيزة 179 أعلى محصول تحت ميعاد الزراعة المتأخر .كما أظهرت النتائج أن أصناف جيزة١٧٨, سخا١٠٢, سخا١٠٤, سخا١٠٥, جيزة١٨٢, جيزة١٧٩, GZ 9057-6-1-3-3, GZ 9577-4-1-1, GZ 9523-2-1-1-1, GZ 9514-3-1-3-1 كانت أقل الأصناف إصابة بالحشرة. وكانت الأصناف سخا١٠٣, سخا١٠٦, GZ 9328-1-2-1-3, GZ 9362-34-2-1-3, GZ 9461-4-2-3-1 و هجين مصري ١ متوسطة الإصابة كما كانت أصناف جيزه ١٧٧ وسخا١٠١ و GZ 9057-6-1-3-4 و الياسمين المصري أعلى الأصناف إصابة .أوضحت النتائج أيضا أن مستوى الإصابة بالحشرة يرتفع مع التأخير في مواعيد الزراعة حيث سجلت أقل إصابة في ميعاد الزراعة المبكر (15 أبريل) بينما سجلت أعلى إصابة في ميعاد الزراعة المتأخر (١٥ مايو). كما أظهرت النتائج أيضاً وجود ارتباط إيجابي عالي المعنوية بين الإصابة الحشرية ونسب التبييض والتقشير في أصناف الأرز المختبرة.