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Germplasm Enhancement for Water Stress Tolerance and Storage Insect Resistance in Bread Wheat (*Triticum aestivum* L.)

R.M. Esmail, M.E.S. Ottai and E.A.H. Mostafa

Department of Genetic and Cytology, National Research Centre, Dokki, Cairo, Egypt

Abstract: This study was carried out during three successive seasons 2004/05, 2005/06 and 2006/07, to evaluate fifty F_3 derived lines (from the F_2 diallel cross), with three check varieties under two different irrigation regimes. Twenty different lines were selected from the fifty F_3 lines under each level of irrigation and evaluated under the same conditions in the F_4 and F_5 generations. Also, the effect of irrigation regime on insect infestation of stored grains for six F_5 selected lines under each level was studied. F_3 results revealed that highly significant differences were obtained between the two irrigation regimes for all traits studied. Highly significant differences among genotypes were obtained in normal (L_1) and water stress conditions (L_2) as well as in their combined data for all traits studied except grain yield / plant in combined data only. F_5 results revealed that highly significant differences among F_5 selected lines were found for all traits studied at the two irrigation regimes. Estimated values of selection index indicated that the ranking of lines are not identical in the two irrigation regimes. The best superior lines were identified under each level; twelve F_3 lines were selected under normal irrigation condition (L_1), eight F_3 lines under water stress condition (L_2). Drought susceptibility index were also estimated and detected the more superior genotypes under water stress environments. Results of correlation studies under stress conditions indicated that, grain yield /plant under water stress was significantly positive associated with no. of spikes / plant in both the F_3 and F_5 generations with high magnitude in the F_5. The selection for drought tolerance has improved the magnitude of correlation between important yield components and yield under water stress conditions. High estimates of heritability were noted for all traits in the F_5 comparing to F_3 estimates except 100 grain weight in the F_3 at normal level (L_1). Concerning insect resistance results showed significant variation between wheat lines for their infested grain in all storage periods. Interaction between lines and irrigation levels was found to be highly significant in all storage periods. The arrangement of the studied lines based on their insect resistance was different from one irrigation regime to another.

Key words: *Triticum aestivum L.* · Germplasm enhancement · Water stress · Selection index · Drought susceptibility index · Heritability

INTRODUCTION

There are several important inputs that go into producing a successful crop of wheat. In order to attain maximum economic grain yield all inputs must be managed in an optimal fashion. Water is the first limiting factor and most critical input in desert agriculture. There are distinct options for managing water resources; irrigation was the traditional approach for dealing with water defects but now that water resources are limited, other solutions by plant breeder are sought, for example, development of new cultivars better adapted to drought–prone environments or increases the water use efficiency in crops.

The performance of various wheat lines in different areas depends on their adaptation to the environmental conditions within the area. Ceccarelli [1] found that, genotypes with high harvest index and high grain yield in high input conditions seem unable to maintain a high harvest index when exposed to moisture and nutritional stress. Therefore, germplasm screening for tolerance to drought must occur under controlled environment, where drought will be reliably induced to distinguish between tolerant and susceptible genotypes.

Theoretically, without an expanding genetic base, there will be genetic stagnation at some point in time because maximum improvement has been achieved in

Corresponding Author: Dr. R.M. Esmail, Department of Genetic and Cytology, National Research Centre, Dokki, Cairo, Egypt
E-mail: ramadan_esmail@yhoo.com

particular fixed genetic constructs. The lake of genetic diversity is implicated in the slowing of progress in developing new cultivars with improved yield potential, as well as stress resistance. Germplasm enhancement represent one face of the plant breeding cycle are often responsible for effective utilization and providing basic germplasm used to create new cultivars.

Line selection where the lines are derived from individual plants in the F_2 or F_3 population is commonly used in self-pollinated crops to handle segregating generations arising from crosses.

Drought stress is one of the most widespread environmental stresses, which affect growing and productivity; it induces many physiological, biochemical and molecular responses on plants, so that plants are able to develop tolerance mechanisms which will provide to be adapted to limited environmental conditions [2].

Drought period are especially damaging during two phases of the life of a wheat plant - early growth and anthesis when flowers become fertilization-competent [3].

Cereal grains are exposing to infestation with storage insects especially with the serious major storage insects. Thus quantity and quality reduces of stored grains, addition to loss of some important genetic resources are resulted. Resistance or susceptibility of genotypes to storage insect infestation is affecting by irrigation levels. Therefore, cereal investigation according to their resistance/susceptibility to storage insect infestation is a great aim under different irrigation levels [4, 5].

The objectives of the present study were to (1) study the differential response of wheat genotypes to water deficits, (2) develop germplasm adapted to semiarid regions where water shortage is becoming the limiting factor as well as identify the superior genotypes under optimum conditions, (3) study the grain resistance/susceptibility of wheat lines to infestation with *Rhizopertha dominica*. Fabricius as a major storage insects. (4) The associations among yield components and grain yield in order to define a true breeding objective with this new germplasm.

MATERIALS AND METHODS

The plant materials used were fifty F_3 genotypes of bread wheat (*Triticum aestivum* L), twenty F4 and twenty F_5 genotypes and the three check commercial cultivars, i.e. Sakha 69, Gimmeza 9 and Giza 168. These plant materials were selected from the F2 diallel crosses [6]. The progenies are selected based on high tillering ability of the individual plants selected from the F2 populations (the range of no. of spikes /plant was 15-25). The present investigation was carried out in two field experiments at the Experimental Research Station of the National Research Center at Shalakan El-Kalyoubia Governorate, Egypt, during the three successive seasons 2004/05, 2005/06 and 2006/07.

F_3, the progenies of fifty selected F2 plants and the three check commercial cultivars were planted in 19th December 2004 under two irrigation regimes in the two experiments. In this growing season individual plant selection was exercised in F_3 families that performed well at each irrigation level.

F4, the progenies of twenty selected lines from F_3 under each irrigation level based on visual selection in the field of individual lines rather than on individual plants are further evaluated under two irrigation regimes in the two experiments in 2005/06 growing season without scoring the data.

F_5, in 2006/2007 growing season the twenty lines selected under each level from the F4 were planted in 21st November 2006 under the same irrigation date schedules followed in the former season (Table 1).

Ordinary cultural practices for wheat production were applied. Data were recorded on ten competitive plants from each plot in each replications in the F_3 and F_5 for the five characters, days to heading, plant height (cm), number of spikes per plant, 100- grain weight (g) and grain yield per plant(g). Each experiment was laid out in a randomized complete block deign with three replicates. Each entry was represented by a single row 2.5 m long with plants at 15 cm spacing within rows 30 cm apart.

Table 1: Dates of irrigations for both normal and water stress conditions applied to the tested bread wheat lines in the F_3 and (F_4 & F_5) generations during the three successive seasons 2004/05, 2005/06 and 2006/07

Irrigation date for normal level (L1)		Irrigation date for water stress level (L2)	
F_3	F4 and F_5	F_3	F4 and F_5
Sowing irrig. December,19	Sowing irrig November,21	Sowing irrig. December,19	Sowing irrig November,21
First irrig.January,17	First irrig. December,15	First irrig. January,17	----
Second irrig. February, 22	Second irrig. January,5	-----	Second irrig. January,5
Third irrig.April,14	Third irrig. . February, 11	Third irrig.April,14	----

The analysis of variance for each trait was computed according to Steel and Torrie [7]. Classical selection indices was also computed according to Smith [8] using methodology which is fully described by Singh and Chaudhary [9]. Phenotypic (r_{ph}) and genotypic (r_g) correlation coefficients were estimated for different traits of both of F_3 and F_5 populations evaluated under normal and water stress conditions according to Miller *et al.* [10].

The drought susceptibility index (s) according to Fisher and Maurer [11] was calculated for grain yield per plant to characterize the relative stress tolerance of all genotypes as follows: $S = (1-Y_d / Y_a) / (1- X_d / X_a)$

Where: Yd is the yield of an individual genotype under dry conditions (L_2) and Y_a is the yield of the same genotype in the normal irrigation conditions (L_1) and X_d and X_a are the average yield of all the fifty three genotypes in the F_3 and twenty three ones the F_5 under dry and normal irrigations conditions, respectively.

After harvesting, about 500 gm of harvested grains of the six lines (1 and 2 derived from Giz. 157 x Gim. 3 , 3 and 4 from Sak. 69 x Gim. 3 and 5 and 6 from Sids 8 x Selected line) selected under the two levels from the F_5 to test the infestation with *Rhizopertha dominica* Fabricius as a major storage insects, were placed in a glass jar 1Kg capacity (with three replicates) and sterilized from any insects by heating in an oven at 70°C for 5 hr as reported by Richards [12] recommended. Ten pairs of newly emerged adults of *Rhizopertha dominica*. Fabricius were taken from the third reared generation on wheat grains and added to each jar for two weeks, then removed out. Jars were covered with muslin, secured with rapper bands and kept under laboratory conditions through out the storage time extending from May up to November, 2007. Holey grains were considered as a visual infestation which presented an indicator for grain resistance/ susceptibility to insect infestation. Five replicates (100 gm /replicate) of each jar were examined to separate the grains in to holey and healthy grains. The examination was carried out at the end of three storage periods. 1.5, 3 and 6 months the number of holey grains was calculated as a visual infestation percent for each line under each irrigated level.

RESULTS AND DISCUSSION

F_3 evaluation: Analysis of variance of normal (L_1) and water stress conditions (L_2) of the fifty F $_3$ wheat genotypes and the three check cultivars for the five traits studied are presented in Table 2. Highly significant differences were obtained between the two irrigation regimes for all traits studied. Highly significant differences among genotypes were obtained in normal (L_1) and water stress conditions (L_2) as well as in their combined data for all traits studied except grain yield / plant in combined data only. Also, combined analysis of variance showed that the mean squares due to the interaction of genotypes with levels were highly significant for all traits studied in all cases. This indicates that it is essential to evaluate such traits under different environmental conditions in order to identify the best genetic materials for a particular environment and ascertain that the wheat genotypes responded differently with the two environmental conditions. Effects of irrigation treatment on the studied traits for the tested genotypes are presented in Table 3. Skipping irrigation at booting stage (L_2) gave the shortest plants, lower no. of spikes/plant and heavy grain weight. This may be due to the great requirements for water during booting and flowering stages and the decrease in the activity of meristemic tissue responsible for elongation, El-Monayeri *et al*. [13] and Campbell *et al*. [14] concluded that more optimal moisture conditions are more conductive to translocation of assimilates from straw to grain in wheat. Comparison between the commercial cultivars and the other genotypes (Table 3) showed that the genotype no. 43 was significantly earlier genotype than the check cultivars under the two levels. With respect to no. of spikes /plant lines no .23 and 26 at (L_1), 1, 14 and 17at (L_2) significantly exceeded the average yield of check cultivars. Genotypes no. 18, 19, 26, 43 and 47 under full irrigation (L_1), no.25 under water stress conditions (L_2) had significantly yielded grain more than the commercial cultivars. Generally, the increase in grain yield of wheat under optimal irrigation level may be due to the higher values of yield attributes [15-17]. Patterson *et al*. [18] concluded that under drought conditions plants face not only the problem of water deficit

Table 2: Mean squares from analysis of variance of F_3 lines evaluated under normal (L_1) and water stress conditions (L_2) and combined analysis for all traits studied in 2004/05 season

	D.F		Days to heading			Plant height (cm)			No. of spikes/plant			100-grain weight (g)			Grain yield/plant (g)		
S.O.V	Single	Comb.	L_1	L_2	Comb.	L_1	L_2	Comb.	L_1	L_2	Comb.	L_1	L_2	Comb.	L_1	L_2	Comb.
Levels(L)	--	1	--	--	113.2**	--	--	516.6**	--	--	10.86**	--	--	6.33**	--	--	19.86
Rep.with.L	2	4	6.64	8.03	7.33	1.85	14.03	8.12	1.58	4.04	2.81	0.02	0.3	0.172	3.65	14.6	9.13
Geno. (G)	52	52	56.7**	39.9**	7.83**	245.2**	231.2**	42.36**	2.9**	3.21**	0.36	1.97**	1.09**	0.512**	22.7**	19.7**	2.66
G.x L.	--	52	--	--	88.8**	--	--	343.1**	--	--	5.75**	--	--	2.55**	--	--	39.69**
Error	104	208	1.83	1.59	1.71	13.91	37.9	28.88	1.09	1.14	1.12	0.13	0.27	0.197	7.6	6.82	7.22

*and**significant at 0.05 and 0.01 levels of probability, respectively

Table 3: Mean performance of the fifty F_3 selected lines and the three check cultivars evaluated under normal (L_1) and water stress (L_2) conditions for all traits studied in 2004/05 season

	Days to heading		Plant height (cm)		No. of spikes/plant		100-grain weight (g)		Grain yield /plant (g)	
Genotype	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2
1-G.157xSak.69	89.33	87.33	130.33	119.3	6.33	8	4.64	4.46	14.72	14.05
2-==	87	87	127	111.33	4.67	4.6	4.85	5.06	13.21	11.81
3-==	88.33	88	123	122.3	6	4.33	4.33	4.81	12.17	11
4-==	89.67	86	106.66	106	6.33	4.66	4.31	5.93	12.62	11.82
5-==	91.66	88	111.33	107	5.33	5.33	3.89	5.14	10.95	11.49
6-G.157x Gim.3	86.66	85.67	119.66	120.66	6.66	4	5.05	6.38	16.78	13.23
7-==	91.66	89	118.53	114.33	6.31	5	4.64	5.46	13.92	9.12
8-==	92.32	88	112.34	108	6.33	5	4.51	5.35	13.96	12.13
9-==	94	86.31	114.67	111	6.66	6	4.03	5.37	12.94	14.32
10-==	93.3	88	117.52	113	5.66	5.33	5.56	6.24	16	15.81
11-==	86.21	84.33	101.66	98	4.66	2.33	5.96	5.58	11.38	7.32
12-G.157x Sele	97.66	97.33	123	121	7	4	4.04	5.03	14.14	11.44
13-==	90	88	119.66	111.33	7	5.66	5.51	5.31	15.42	10.29
14-==	89	86.67	115.33	100.66	6	7.33	5.26	5.27	13.39	14.13
15-==	89.67	86.67	112.3	97.16	5.33	5.33	4.07	4.67	14.34	10.88
16-G.157x Sid.5	94	91.36	115	111.31	7	4	5.01	5.03	6.52	11.46
17-==	92.37	86	116.67	115.66	6	7	4.19	5.42	12.04	12.42
18-==	88	83	105	102	4.33	6.66	5.38	4.87	17.51	10.79
19-==	87	83	118.33	107	5.66	5.67	5.6	6.5	19.61	13.53
20-G.157x Sid.7	93.33	93.33	127	117.3	6.33	5	3.62	3.77	11.83	8.52
21-==	93.66	91	136.7	118.62	7.67	5.33	3.88	4.74	11.43	9.57
22-==	93.33	85.33	127	122	5.33	5	4.16	4.19	8.86	7.03
23-==	91	86.67	113	103.3	8	4.33	3.38	5.15	13.51	13.55
24-==	82.33	84.67	132.3	109.67	7.33	5	3.59	4.92	13.23	13.31
25-G.157x Sid.8	92.66	88	115.3	113	6.33	6.66	3.72	5.49	13.07	19.55
26-==	85.31	83.66	126.3	114	8.33	3.66	4.56	5	18.24	8.55
27-==	92.6	85.23	103.6	98	5	4	3.82	5.47	9.42	12.67
28-==	87.61	84.67	98.8	94.33	5.66	4	4.77	5.43	14.69	9.82
29-Gim3xSele.L	86	82.33	117	111.7	7.33	5.23	3.36	5.05	12.29	14.17
30-==	90.66	86.31	104.6	103.3	5.66	4	2.92	4.76	8.31	11.79
31-==	90	88.11	124.3	90.67	6	5.66	5.57	6.22	16.94	9.94
32-==	89	86.67	114	106	6	4.65	4.04	5.33	14.71	10.24
33-Gim3x Sids5	93.66	87.66	122	103	7.33	4	4.11	5.13	11.99	7.99
34-==	90.33	85.33	116	108.6	6	4.64	4.61	5.56	13.56	8.21
35-==	95	87	130.6	101.51	5.33	4	5.78	6.01	14.26	8.53
36-==	90	86	110.67	95.67	4.33	4.66	4.91	5.57	10.34	7.95
37-Gim.3xSids8	89	87	113	103.3	5	3.67	3.42	5.64	9.18	7.14
38-==	90.32	87.33	118.6	113.6	7.66	5.33	3.94	5.32	11	9.73
39-==	85	86.6	115	102.3	4.33	4	4.04	5.76	9.06	12.76
40-Sak.69 xSid8	89	85.5	115	118.6	6.31	6	3.33	4.66	10.93	11.47
41-Sak69x Sel.L	93.66	83	111.3	89.3	7.31	4.66	3.27	4.5	13.69	12.06
42==	93	86	104.3	115.6	7	5	3.1	5.31	11.61	11.45
43-Sak.69x Sid5	76.31	74.3	110.3	101	7.33	4.32	4.73	5.33	18.42	12.75
44-==	95.12	86.33	118	118.3	6	6.31	5.54	5.23	15.01	12.29
45-Sak69xGm.3	86.31	84	105.6	103	6.33	5.33	4.1	4.93	14.68	13.36
46-Sid8x Sele.L	94	87.16	103.7	93.7	6	6	4.66	5.85	11.54	15.09
47-==	86.33	86	116	98.67	6	3.66	4.87	4.37	17.75	9.13
48-==	86	86	106.6	104.3	5.67	6	5.27	4.95	11.76	12.81
49-Sid5x Sele.L	96	90.33	120.6	110	5.33	5.66	5.39	4.94	16.01	12.22
50-==	88.14	86	115.7	99.3	5.66	4.33	3.66	6.01	10.48	10.65
Sakha.69	92	87	110.6	106.7	7	5.33	4.31	6.78	14.84	11.25
Gimmeza9	101	94	104	98.7	5	5.32	4.66	4.88	13.88	16.71
Giza 168	90	88.33	93	90	7.66	5.3	4.26	4.62	16.14	15.68
X	90.29	86.71	115.06	107.08	6.17	5.04	4.42	5.26	13.29	11.6
LSD 0.05	2.19	2.04	6.04	9.95	1.69	1.73	0.59	0.83	4.46	4.23
LSD 0.01	2.9	2.7	7.99	13.19	2.25	2.29	0.78	1.09	5.92	5.59

Table 4: Estimates of selection index (S.I) under normal and water stress conditions and drought susceptibility index (D.S.I) of F_3 selected lines

F_3 Lines	S.I (L_1)	S.I (L_2)	D.S.I	F_3 Lines	S.I (L_1)	S.I (L_2)	D.S.I
1	193.08	131.97	0.35	28	169.93	113.63	2.60
2	181.79	122.5	0.83	29	172.94	124.36	-1.20
3	176.94	129.71	0.75	30	155.37	118.94	-3.29
4	162.52	117.41	0.49	31	180.29	107.74	3.25
5	162.38	121.17	-0.39	32	169.91	116.57	2.39
6	178.98	125.42	1.63	33	171.62	108.8	2.62
7	171.57	123.08	2.71	34	170.2	122.14	3.10
8	165.21	121.10	1.03	35	180.01	115.73	3.16
9	164.79	125.48	-0.84	36	164.59	113.81	1.82
10	171.11	124.19	0.09	37	164.57	116.45	1.75
11	163.68	113.92	2.81	38	171.68	124.37	0.91
12	168.81	119.96	1.50	39	170.75	117.08	-3.21
13	176.72	123.11	2.62	40	167.5	129.6	-0.39
14	172.24	120.03	2.04	41	161.48	110.52	0.94
15	166.35	114.32	1.89	42	155.18	128.59	0.11
16	158.47	118.73	2.41	43	171.55	123.79	2.42
17	167.6	129.15	-0.25	44	169.15	129.73	1.42
18	164.64	122.74	3.02	45	164.9	121.96	0.71
19	178.67	124.59	2.44	46	156.15	113.75	-2.42
20	174.48	121.81	2.20	47	175.6	111.46	3.82
21	183.63	124.73	1.28	48	167.67	124.59	-0.70
22	173.77	130.78	1.62	49	170.45	114.31	1.86
23	166.10	118.38	-0.02	50	160.52	115.84	-0.13
24	186.45	124.60	-0.05	Sakha.69	164.57	126.36	1.90
25	165.73	124.76	-3.89	Gim.9	149.60	111.08	-1.60
26	190.11	125.72	4.17	Giza 168	153.07	111.92	0.22
27	154.61	115.39	-2.71	======	====	====	===

but also poor availability of nutrients, including nitrogen, i.e. nutritional drought, due to slow nutrient mineralization and remobilization in dry and compact soils. Pierre *et al*. [19] found that, also water stress reduced grain yield, test weight and kernel weight and diameter.

Selection index is a statistical tool, which enables the plant breeder to identify and select the outstanding genotypes. So, data were also subjected to discriminate the desirable genotypes from undesirable ones on the basis of selection on several characters simultaneously using phenotype performance. Values of selection index under normal and water stress conditions and drought susceptibility index (D.S.I) of F_3 genotypes are presented in Table 4. Under normal irrigation condition (L_1) twelve F_3 lines (1, 2, 3, 6, 13 …….. and 47) were selected which gave the highest selection indices values. On the other hand under water stress condition (L_2) eight F_3 lines (1, 3, 17, 22, 26, 40, 42 and 44) exhibited high value of selection index.

As regard to drought susceptibility index (D.S.I), twenty F_3 lines (1, 2, 3, 4, 5, 9, 10, 17, 23, 24, 25, 27, 29, 30, 39, 40, 42, 46, 48 and 50) and the two check cultivars, Gimmeza 9 and Giza 168 had the lowest values of (D.S.I) proving to be more drought resistant. The mean performance of grain yield /plant of these genotypes exceeded the average yield of all genotypes (11.60) under water stress condition (L_2) and had also, the highest selection indices values. Consequently, these twenty aforementioned lines are considered the most resistant to water stress conditions and should be exploited in wheat breeding to develop new bread wheat cultivars or to broaden the genetic base for this goal.

F_5 evaluation: Analysis of variance of normal and water stress conditions for all traits studied are presented in Table 5. Highly significant differences among F_5 selected lines were found for all traits studied at the two irrigation regimes (L_1) and (L_2) indicating that the F_5 lines had a great diversity which contributed to the differences in their performance under two environmental conditions. Consequently, we are able to select the outstanding lines at each irrigation level.

Mean performance and selection indices value of the F_5 genotypes and the three check cultivars evaluated under the two irrigation levels (L_1) and (L_2) are presented in Tables 6 and 7, respectively. The data in Table 6 revealed that the earliest plants (days to heading =82.0) were detected in the line no.9, proving to be used in wheat breeding programs for developing short season cultivars. While, the tallest plants (149.67 cm) were obtained in the line no.20. Six lines no. 4, 6, 7, 10, 12 and 20 had high number of spikes /plant. Five lines (4, 8, 9, 12 and 18) significantly yielded more than the commercial check cultivars Gimmeza9 and Giza 168. Results from selection index characterize six outstanding lines (3, 4, 10, 11, 12 and 20) under normal condition (L_1). These lines had the highest mean performance of grain yield and its component (Table 6). Results in (Table 7) of the F_5 data under stress condition (L_2) showed that six lines (1, 2, 3, 9, 10 and 17) had lower days to heading comparative to the earlier check cultivar Giza 168. Menshawy [20] found significant variation among genotypes in the earliness components and concluded that, early genotypes had long grain filling period and low grain filling rate and reverse for late genotypes. Six lines (1, 2, 8, 12, 16 and 18) had the highest no. of spikes /plant, three of them had the highest grain yield /plant. Ceccarelli [1] stated that the most efficient way to improve adaptation and yield in low-input conditions is by direct selection in low input conditions. Results from selection index exhibited eight

Table 5: Mean squares from analysis of variance of F_5 lines evaluated under normal (L_1) and water stress conditions (L_2) for all traits studied in 2006/07 season

		Days to heading		Plant height (cm)		Number of spikes /plant		100-grain weight (g)		Grain yield /plant (g)	
S.O.V	D.F	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2
Reps.	2	9.85	2.44	26.7	5.09	1.08	0.754	0.429	0.065	2.79	36.27
F_5 lines	22	66.74**	40.94**	624.6**	290.5**	7.29**	17.92**	0.990**	0.684**	96.65**	142.5**
Error	44	0.704	0.828	8.02	1.10	0.533	4.10	0.111	0.125	11.8	16.45

*and**significant at 0.05 and 0.01 levels of probability, respectively

Table 6: Mean performance and selection indices values of the twenty F_5 selected lines and the three check cultivars evaluated under normal (L_1) conditions for all traits studied in 2006/2007 season

Genotype No.	Days to heading	Plant height (cm)	No. of spikes /plant	100-grain weight (g)	Grain yield /plant(g)	selection index
1-Giza157xGim3	90.67	123.66	6.02	6.5	18.34	218.9
2 -==	89.33	113	5.55	5.94	10.38	202.74
3-==	97	138	6.92	6	27.06	235.52
4-==	98	140	8.59	5.65	31.46	241.73
5-==	90	127	7.41	5.14	20.5	226.56
6-==	94.66	127	8.9	4.13	23.76	226.44
7-Giza157xSids8	83	104	8.4	4.59	15.08	206.16
8-==	87	106.33	6.84	5.23	27.25	209.26
9-==	82	104	6.99	5.52	27.2	212.51
10-Sakha69XGim3	94	129.66	8.53	5.66	25.66	230.32
11-==	95.33	134	7.7	5.75	27.16	233.76
12- Sakha69Xsids5	96	140.67	8.65	5.36	31.56	244.74
13-Sids5x Sele.L	90.67	118	5.99	6.23	23.48	215.6
14-==	86.66	110.66	4.67	6.07	17.09	205.72
15-==	87	126	3.41	6.12	20.83	223.63
16-==	93.66	111.33	6.88	5	18.56	203.41
17-Sids8xSeleL	92	127.65	7.48	5.11	26.95	229.69
18-==	93.67	114	7.65	4.66	28.78	213.79
19-==	89	102.31	3.43	6.12	12.47	189.83
20-SeleLxGim3	91	149.67	8.43	6.3	25.13	255.63
Sakha.69	94	111.67	7.93	5.41	22.53	207.1
Gimmeza9	102	104.31	6.46	4.74	19.28	186.91
Giza 168	90.67	98	7.79	5.1	23.12	194.08
X	92.62	120.04	6.98	5.54	22.76	==
LSD 0.05	1.38	4.68	1.2	0.55	5.65	==
LSD 0.01	1.84	6.26	1.6	0.73	7.54	==

Table 7: Mean performance and selection indices values of the twenty F_5 selected lines and the three check cultivars evaluated under water stress conditions (L_2) for all traits studied in 2006/2007 season

Genotype No.	Days to heading	Plant height (cm)	No. of spikes /plant	100-grain weight (g)	Grain yield /plant(g)	selection index
1-Giza157xGim3	83	115.33	12	5.06	30.66	240.74
2 -==	85	110	12.67	6.16	51	24184
3-==	85	111	10.3	5.59	35.33	234.79
4-==	87	123	9	5.05	32	240.55
5-==	85.3	117.33	11	5.95	36.66	242.14
6-==	86	111.26	11.32	4.73	33	231.64
7-=	87.61	126.67	8.67	5.64	24.33	241.7
8-Giza157xSids8	82.66	112.33	12	5.08	31.33	238.93
9-==	85	89.66	7.62	5.09	35.33	210.93
10-==	85	92	7	4.69	22.83	208.41
11-==	88	111	11.33	6.25	38	233.48
12-Giza157xSids7	87.83	108.32	12	5.28	33.36	229.1
13-Sakha69xGim3	91.63	112.33	10	5.59	34.66	238.58
14-==	86	111.3	6.67	5.39	32	231.7
15-Sakha69xSele.L	88.33	123.17	11.31	5.13	30.66	240.04
16- Sids8xSeleL	86	101.67	15.62	4.64	44.86	229.42
17-==	85	123.61	7	5.52	36.75	243.97
18-Sakha69x Sids8	87	107	13	5.09	37.33	229.42
19-==	84.33	117	5	6.16	35.33	238.54
20-==	78.33	111	10.67	5.49	37	245.16
Sakha.69	91.63	114	9	5.19	21.58	222.1
Gimmeza9	97.31	102	7	5.26	25.51	202.01
Giza 168	89.63	97.33	8.66	4.63	23.2	207.84
X	86.61	110.78	10.08	5.33	33.16	==
LSD 0.05	1.49	1.72	3.33	0.58	6.65	==
LSD 0.01	1.99	2.31	3.45	0.78	8.91	==

outstanding lines (1, 2, 4, 5, 7, 15, 17 and 20) under low irrigation level (L_2).These outstanding lines should be exploited in the future breeding programs to develop new bread wheat cultivars that possessed high yield potential or *broad a genetic germplasm base* under normal conditions as well as under water stress conditions.

Correlations and heritability: Phenotypic (r_{ph}) and genotypic (r_g) correlation coefficients estimated of both of F_3 and F_5 among all possible pairs of traits studied under normal condition (L_1) are presented in Table 8 as well as under water stress condition (L_2) in Table 9. In the F_3 generation positive and significant phenotypic and genotypic correlation coefficients were found between grain yield /plant with each of no. of spikes /plant (r_{ph}=0.274*and r_g=0.35*) and 100 grain weight (r_{ph}=0.462** and r_g = 0.75**). While, in the F_5 significantly positive phenotypic and genotypic correlation coefficients were found between grain yield /plant with each of no. of spikes /plant (r_{ph}=0.527** and r_g=0.635**) and plant

Table 8: Phenotypic (rph) and genotypic (rg) correlations coefficients between different pairs of traits studied under normal condition (L_1) of the F_3 (upper) and F_5 (lower) wheat lines evaluated

Characters	Grain yield/ plant(g)	No. of spikes /plant	100-grain weight(g)	Plant height (cm)	Days to heading
Grain yield/plant (g)	=(rph)	0.274*	0.462**	0.095	-0.126
	= (rg)	0.35*	0.75**	0.127	-0.232
No. of spikes /plant	0.527**	==	-0.159	0.153	-0.004
	0.635**		-0.373**	0.288*	0.00
100-grain weight (g)	0.122	-0.189	==	0.075	-0.094
	0.041	-0.206		0.078	-0.120
Plant height (cm)	0.468*	0.341	0.461*	===	0.041
	0.562**	0.392	0.529**		0.050
Days to heading	0.321	0.336	-0.057	0.402	==
	0.385	0.362	-0.097	0.404	

*and**significant at 0.05 and 0.01 levels of probability, respectively

Table 9: Phenotypic (rph) and genotypic (rg)correlations coefficients between different pairs of traits studied under water stress condition (L_2) of the F_3 (upper) and F_5 (lower) wheat lines evaluated

Characters	Grain yield/ plant (g)	No. of spikes /plant	100-grain weight (g)	Plant height (cm)	Days to heading
Grain yield/plant (g)	(rph)	0.391*	0.136	0.030	0.022
	(rg)	0.664**	0.120	-0.076	0.018
No. of spikes /plant	0.493*	===	-0.015	0.114	0.001
	0.554**		-0.112	0.252	0.022
100-grain weight (g)	0.322	-0.042	====	-0.057	-0.113
	0.535**	-0.230		-0.201	-0.190
Plant height (cm)	0.032	0.001	0.378	===	0.097
	0.078	0.029	0.485*		0.113
Days to heading	-0.287	-0.166	-0.064	-0.017	====
	-0.509*	-0.249	-0.093	-0.019	

*and**significant at 0.05 and 0.01 levels of probability, respectively

height (r_{ph}=0.468* and r_g=0.562**). Positive and significant phenotypic and genotypic correlation coefficients were found between plant height and 100 grain weight in the F_5. Negative phenotypic and genotypic correlation coefficients was found between no. of spikes / plant and 100 grain weight in both the F_3 and F_5 generations indicating that simultaneous improvement of these two traits may be difficult.

Positive and significant genotypic correlation was found between no. of spikes / plant and plant height in the F_3 only (Table 8). Results of correlation studies under stress conditions (Table 9) indicated that, grain yield /plant under water stress was significantly positive associated with no. of spikes / plant in both the F_3 and F_5 generations with high magnitude in the F_5. Also, grain yield /plant and 100 grain weight were positively and highly significantly correlated in the F_5 (rg = 0.535**). Significant negative genotypic correlation was found between grain yield /plant and days to heading in the F_5 data only (r_g=-0.509*) suggesting longer cycle genotypes had lower yield so, temperatures were very high at the end of cropping season ; hence long cycle lines did not have time for adequate grain filling. Positive and significant genotypic correlation coefficients was found between plant height and 100 grain weight in the F_5 (r_g = 0.485*). Under the two levels insignificant negative correlation was found between 100 grain weight and days to heading in both the F_3 and F_5. Comparison between the two levels in the F_5, positive correlation was found between days to heading with each of grain yield /plant, no. of spikes / plant and plant height at normal level, on the other hand, negative correlation was found between the same traits under water stress conditions. Moreover, positive and significant phenotypic and genotypic correlation between grain yield /plant and plant height was found at normal conditions and insignificant at water stress conditions. These results indicated that the association between different characters was varied in significance and magnitudes from one environment to another and from one generation to another, also, the selection for drought tolerance has improved the magnitude of correlation between important yield components and yield under water stress conditions. Haggag *et al*. [21], Eissa and Awaad [22], Esmail [23] and Zaidi *et al*. [24] confirmed our results. The results of Eissa and Awaad [22] on F_3, F4 and F_5 generations of ten wheat crosses, indicated presence of positive association between grain yield and each of number of spikes/plant, spike length, number of grains / spike and 1000-grain weight. Singh *et al*. [25] found significant and positive correlation between grain yield and number of spikes/ m^2. Menshawy [20] and Haro and Allan [26] found and concluded that, kernel weight and heading date were negatively and highly significantly correlated suggesting possibility to select earlier genotypes with heavier kernel weight. However, positive correlation between days to heading with each of grain yield and plant biomass was found by Zaharieva *et al*. [27]. Haggag *et al*. [21] stated that plant height showed negative correlation with spikes/ m^2 but considerably positive with kernel weight.

Heritability and expected genetic advance under selection (Δg%) for all traits studied in the F_3 and F_5 generations at the two irrigation regimes (L_1) and (L_2) are presented in Table 10. Generally, estimates of heritability for all traits studied were higher under normal level (L_1)

Table 10: Heritability and genetic advance under selection for all traits studied under normal and water stress conditions of the F_3 and F_5 selected lines

Characters	Generations	Heritability (L_1)	Heritability (L_2)	Genetic advance (Δg%) (L_1)	Genetic advance (Δg%) (L_2)
Days to heading	F_3	90.90	88.9	11.6	9.55
	F_5	96.9	94.2	1.84	10.19
Plant height (cm)	F_3	84.7	63.0	22.63	16.76
	F_5	96.2	98.9	40.57	28.73
No.of spikes /plant	F_3	35.4	37.7	1.11	1.23
	F_5	80.9	52.9	1.60	3.97
100-grain weight (g)	F_3	82.2	51.4	1.97	1.09
	F_5	72.5	59.8	1.25	0.86
Grain yield /plant (g)	F_3	39.7	38.7	3.43	3.12
	F_5	70.6	40.8	12.02	8.83

Table 11: Analysis of variances for visual infested grains percent at the three storage periods (1.5, 3 and 6 months) for six wheat lines grown under two different irrigation levels

Source of Variance	D.F.	1st Storage period	2nd Storage period	3rd Storage period
Replicate	2	0.09	0.03	0.25
Irrigated levels (a)	1	18.78**	106.78**	462.25**
Lines (b)	5	5.27*	28.87**	145.25**
Interaction a x b	5	20.78**	102.04**	432.18**
Residual	22	1.56	3.61	26.22

*and**significant at 0.05 and 0.01 levels of probability, respectively

than water stress level (L_2) in the F_3 and F_5 generations except no. of spikes / plant in the F_3 and plant height in the F_5. Also, high estimates of heritability were noted for all traits in the F_5 comparing to F_3 estimates except 100 grain weight in the F_3 at normal level (L_1), indicating that the studied traits had high genetic variance with low environmental variance. The expected genetic advance under selection (Δg %) expressed as a percentage of the mean varied from (1.11) for no. of spikes / plant to (40.57) for plant height at normal level (L_1). Grain yield /plant, as a quantitative trait, had low to moderate heritability with low to moderate genetic advance, revealed the major effect of environmental conditions of the phenotypic variation of this economic trait. High heritability coupled with moderate to high genetic advance for plant height at the two irrigation regimes (L_1) and (L_2) in the two generations and plant yield in the F_5 only, confirming the effectiveness of selection procedures followed of these populations in the early generations to improve these traits and obtain a new outstanding lines adapted to the normal conditions as well as water stress conditions. Menshawy [20], Belay *et al*. [28] and Moghaddam *et al*. [29] found similar results in wheat using different plant materials.

Insect resistance: Results presented in Fig. 1 showed that, the percentage of visual infested grains (holey grains) with *Rhizopertha dominica* Fabricius was increased as the storage period progressed from the first up to second to third storage period (1.5, 3 and 6 months, respectively) for all lines under both irrigation levels (L_1 and L_2).This result is in a good agreement with the results of Jood *et al*. [4] and Pingale *et al.* [5].

On the other hand, analysis of variance in Table 11 showed significant variation between wheat lines for their infested grain in all storage periods. The arrangement of the studied lines concerning to their resistance for insect infestation was 4, 1, 5, 2, 6 and 3 under L_1 and 4, 1, 2, 6, 5 and 3 under L2 (Figs. 1-3). Line 4 was the highest resistant line and had 0.7, 2.03 and 4.0% holey grains under L_1 and 2.7, 6.7 and 14.0% under L_2 at the first, second and third storage periods respectively. Opposite to lines 3, the highest susceptible line had 8.3, 19.0 and 39.0% holey grains under L_1 and 5.7, 13.3 and 27.7% under L_2. Fixed variations for lines resistance or susceptibility to insect infestation were noted throughout all storage periods confirming the different genetic backgrounds of the tested lines (Figs. 1, 2 and 3).These differences between lines took place because insects did not prefer the grains of resistant lines for fed and oviposition. Whereat, lower larval survival, shorter adult life and adverse effect on fecundity were resulted [30, 31]. Interaction between lines and irrigation levels was found to be highly significant in all storage periods. The interest notice is that L_2 produced lower variations among lines in their susceptibility to infestation, where coefficient of variation (CV%) achieved 28.07, 25.78 and 25.57 opposite to 85.20, 82.28 and 88.89 were achieved under L_1 for the three successive storage periods. This result was in similar with the result of Krishnawat and Sharma [32] who observed wide genetic variability between 98 wheat genotypes in their characters recorded under both irrigated and moisture stress environments

Results in Figures 1-3 showed that the infested grains percent was affected significantly by irrigated levels. Under L_2 the grain infestation was increased compared with under L_1 for all lines (except for line 3 decreased) among all storage periods. In fact, insects prefer the grains contained high protein content, the most important substance for feeding [33, 34]. On the other

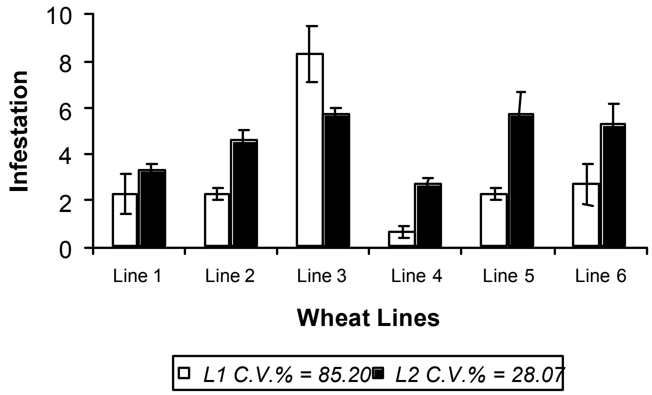

Fig. 1: Percentage of infested grains at the first storage period (1.5 month) with *Rhizopertha dominica* for six wheat lines grown under two different irrigation levels

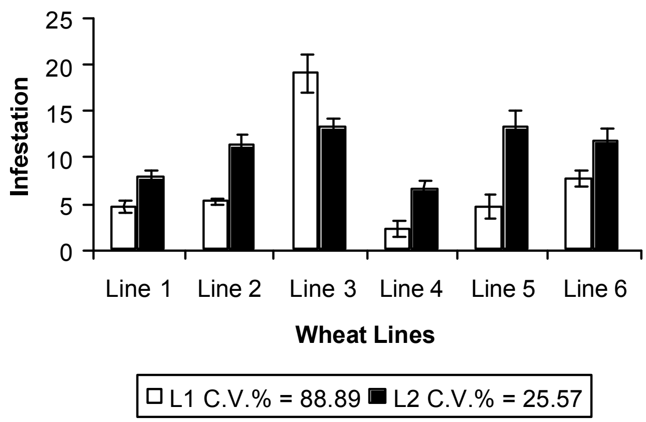

Fig. 2: Percentage of infested grains at the second storage period (3 month) with *Rhizopertha dominica* for six wheat lines grown under two different irrigation levels

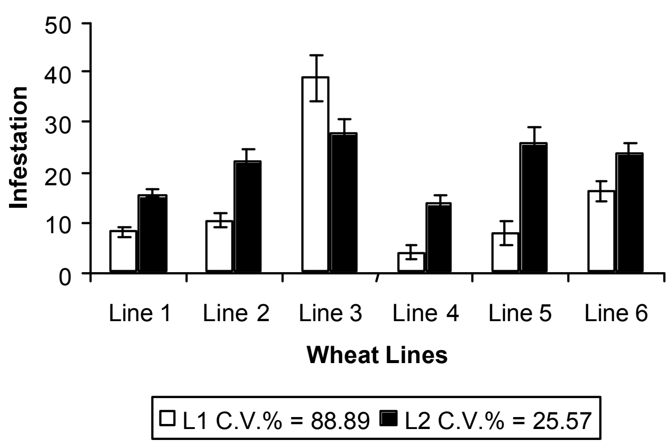

Fig. 3: Percentage of infested grains at the third storage period (6 month) with *Rhizopertha dominica* for six wheat lines grown under two different irrigation levels

hand, Koszanski *et al*. [35] and Kattimani *et al*. [36] recommended that protein content of wheat grains was decreased by frequent irrigation, but fiber, lipid and ash content were increased. Therefore, the infested grains percent was decreased under normal irrigated conditions and increased under water stress condition. While, Guler and Akbay [37] found that grain protein increased with increasing irrigation. Meanwhile, Caglayan *et al*. [38] decided that Bezostoya 1 was the best wheat variety for protein content and quality but was susceptible to insect damage under irrigated conditions.

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