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Generation Mean Analysis for Three Bread Wheat Crosses under Normal and Water Stress Treatments

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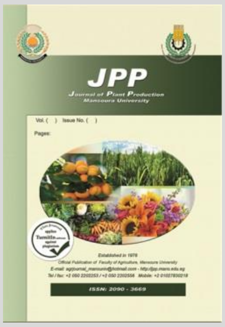

ABSTRACT

The objective of this study was to identify tolerant and susceptible genotypes of bread wheat under different irrigation treatments and determine the type of gene action and some genetic parameters in three bread wheat crosses; (Line 1 × Line 2), (Line1 × Giza 171) and (Misr 2 × Line 3) under normal irrigation and water stress treatments. Genetic materials included six populations (P_1, P_2, F_1, F_2, BC_1 and BC_2) for each cross. Positive and high significant values for heterotic effects relative to the mid- parent of grain yield were found for the second (Line1 × Giza 171) and third cross (Misr 2 × Line 3) under both irrigation treatments, while positive values heterosis for better parent detected for the third cross under both irrigation treatments. Non-allelic interaction was found for all studied characters in all the crosses under both irrigation treatments. Dominance effects were greater than the additive gene effect. Dominance × dominance gene interaction was higher in magnitude than additive × additive and additive × dominance for most characters under both irrigation treatments, indicating that these characters greatly affected by dominance and non-allelic interactions. Heritability in the broad sense was high for all the studied characters in three crosses under both irrigation treatments, while narrow sense heritability estimates were moderate to high for all the studied characters under both irrigation treatments. In general, the highest values of grain yield/plant were in the third cross (Misr2 × Line 3) under both irrigation treatments, based on tolerance index (Line 1) and (Line 2) are the most tolerant for water stress and the first cross (Line1 × Line2) was the most one for water stress tolerant, so this cross is recommended under water stress conditions.

Keywords: Bread wheat, water stress, six populations, Heritability

INTRODUCTION

Climate change is going to have a severe impact on dryland ecosystems and the effects of climate change will be through changes in temperature, rainfall, length of the growing season, and timing of extreme and critical events relative to crop development. (Anderson and Morton, 2008)

Drought tolerance is defined as the ability of a plant to live, grows, and reproduc with limited water supply or under the periodical conditions of water deficit (Turner, 1979). Crop plants should not only have the ability to survive under drought but also the capacity to produce a harvestable yield.

Drought tolerance is a quantitative trait, with complex phenotype and genetic control (McWilliam, 1989). Understanding the genetic basis of drought tolerance in crop plants is necessary for developing superior genotypes through traditional breeding.

Breeding for drought tolerance is further complicated by the fact that several types of abiotic stress can challenge crop plants simultaneously. Higher plants have evolved multiple, interconnected strategies that enable them to survive unpredictable environmental changes. However, these strategies are not always well developed in the cereal cultivars grown by farmers (Fleury *et al*, 2010).

Wheat often suffering drought stress at different growth stages especially during germination, tillering, and early grain filling with the corresponding reduction in biomass production, and grain yield under drought conditions. The selection of drought tolerance genotypes is considered among the crucial in dryland areas as it cannot be controlled or easily apply the inducement drought stress in the field. In addition, there is no precise method for evaluating various genotypes under uncontrollable field conditions (Shaheen and Hood-Nowotny, 2005).

Generation mean analysis provides information on the relative importance of average effects of the genes (additive effects), dominance deviations and effects due to non-allelic genetic interactions in determining the genotypic values of the individuals and consequently, mean genotypic values of families and generations. Generation mean analysis is a simple but useful technique for estimating gene effects for a polygenic trait, its greatest merit lying in the ability to estimate epistatic gene effects such as additive × additive, dominance × dominance and additive × dominance effects (Gamble (1962). The aim of the current research is to identify the tolerant and susceptible genotypes of bread wheat under water stress conditions using six- generation model *i.e.* P_1, P_2, F_1, F_2, BC_1, and BC_2 in three bread wheat crosses and it is hoped that results obtained herein would be of value for Egyptian wheat breeder.

MATERIALS AND METHODS

Three field experiments were conducted during the 2016/17, 2017/18 and 2018/19 growing seasons at the experimental farm of Sakha Agricultural Research Station, Kafr El-Sheikh, Egypt to evaluate three bread wheat crosses (*Triticum aestivum* L.), chosen on the basis of their differences in yields and the performance of several characters under irrigated and drought stress conditions. The names, pedigree, and selection history of the studied parents are presented in Table 1.

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Table 1. Name, pedigree and selection history of the studied parental bread wheat genotypes.

Parent	Name	Pedigree and selection history
1	Line 1	WBLL*2/BRAMBLIMG//HUBRA-21 S.17017-056S-019S-1S-0S
2	Line 2	SAKHA93/3/VEE/PJN//2*KAUZ/5/MAI"S"/PJ//ENU"S"/3/KITO/POTO.19//MO/JUP/4/K134(60)/VEE S.16412-01S-035-4S-0S
3	Giza171	Sakha 93/ Gemmeiza 9 Gz 2003-101-1Gz- 4Gz-1Gz-2Gz-0Gz
4	Misr 2	Skauz / Bav92 CMSS96M03611S-1M-010SY-010M-010SY-8M-0Y-0S
5	Line 3	SITTA/CHIL//IRENA/6/GIZA168/5/MAI"S"/PJ//ENU"S"/3/ KITO/POTO.19//MO/JUP/4/K134(60)/VEE S.16616-018S-015S-2S-0S

In 2016/17 season, three crosses were made by hand, *i.e*., Line 1 × Line 2 (cross 1), Line1 × Giza 171 (Cross 2), Misr 2 × Line 3 (Cross 3). In 2017/18 season, seeds of F_1's were sown to produce F_1 plants and some of these plants were selfed to produce F_2 seeds. Each of F_1 plants were crossed back to their respective parents to produce first back cross (BC_1) and second back cross (BC_2). Also, the F_1 plants were selfed to produce F_2 seeds. In 2018/2019 season, the six populations (P1, P2, F1, F2, BC1 and BC2) were evaluated in two separate irrigation regime experiments. The first experiment (normal treatment, N) was irrigated four times after sowing irrigation *i.e*. five irrigations were given through the whole season. The second experiment (water stress treatment, S) was given one surface-irrigation 30 days after sowing irrigation *i.e*. two irrigations were given through the whole season using a randomized complete block design with three replication in each experiment. Each field plot consisted of 12 rows (one row for each of P_1, P_2 and F_1, two rows for each of $BC_1$and BC_2 and five rows for F_2) besides two border rows were planted to avoid the border effects. The rows were 2.8 m long spaced 30 cm apart and seeds were spaced 20 cm between plants. So, each of the P_1, P_2, F_1, BC_1, BC_2 and F_2 generations have the same field plot size to satisfy the equality of the field plot in each replicate for all the treatments.

To satisfy the analysis of variance of the characters recorded, 200, 60, and 30, 30 and 30 individual F_2, BC_1, BC_2, P_1, P_2 and F_1, plants respectively, were chosen at random from the six populations and all studied characters were recorded. All other cultural practices for wheat cultivation, except irrigation, were applied as recommended. Each experiment was surrounded by a wide border (20m) to minimize the underground water permeability.

Data were recorded on the selected plants of the six populations in each cross for; days to heading (day), days to maturity (day), plant height (cm), number of spikes/plant, number of grains/spikes, 100-grain weight (g), and grain yield/plant (g).

Table 2. Monthly mean of air temperatures (AT, ˚C), relative humidity (RH, %) and rainfall (mm/month) in winter season of 2018/2019 at Sakha location.

Months	Air temperature˚C		Relative	Rainfall
	Max.	Min.	humidity (%)	(mm)
Nov.	25.9	9.8	64.6	0.3
Dec.	22.2	8.9	62.6	71.4
Jan.	20.8	5.4	60.5	53.9
Feb.	21.2	6.7	63.7	28.7
March	22.9	6.5	57.9	18.5
April	26.0	9.9	58.9	11.9
May.	30.3	13.8	58.5	0.0

The meteorological data were recorded for the winter growing season from Sakha meteorological station

Evidences of water stress tolerance:

1) Tolerance index, TOL: Estimation the variation in yield between water stress (Ys) and normal (Y_P) treatment was calculated according to the formula proposed by Rosielle and Hambling (1981).

$$\textbf{TOL} = (Yp - Ys)$$

2) Yield reduction ratio, Yr: The percentage of yield reduction ratio was calculated as according to the following formula suggested by Golestani and Assad (1998)

$$\textbf{Yr} = 1-(Ys/Yp)$$

Genetic analysis:

In each cross, the mean and the variance were studied for P_1, P_2, F_1, BC_1, BC_2 and F_2 generations. The population's means and variances were used to estimate the types of gene action.

- Heterosis was estimated as a percent of the deviation of F_1 hybrids over its mid-parent (M.P) or its better parent (B.P) values by Mather and Jinks (1982) where,

$$\text{Heterosis over mid-parent \% (M.P)} = \frac{\overline{F1} - \overline{MP}}{\overline{MP}} * 100$$

$$\text{Heterosis over the better-parent \% (B.P)} = \frac{\overline{F1} - \overline{BP}}{\overline{BP}} * 100$$

- **Inbreeding depression** was estimated as the average percentage decrease of the F_2 from the F_1 by Mather and Jinks (1971).

$$\text{I. D\%} = \frac{\overline{F_1} - \overline{F_2}}{\overline{F_1}} \times 100$$

- Potence ratio (P) was also calculated according to Peter and Frey (1966).

$$(\overline{F_1} - MP) / \frac{1}{2} (\overline{P_1} - \overline{P_2})$$

- **The population means and the variances** were used to compute the scaling tests A, B and C. Scaling tests were used to check the adequacy of the additive - dominance model for different characters in each cross (Hayman and Mather 1955). The significance of any one of these scales was taken to indicate the presence of epistasis *i.e*. non-allelic interaction. In the presence of non-allelic interaction, various gene effects were estimated using six parameter and to estimate the type of gene effects according to Mather (1949) and Hayman and Mather (1955).
- **The six parameters model proposed by Gamble (1962)** was used to estimate different gene effects.

$$m = \overline{F}_2$$

$$a = \overline{BC}_1 - \overline{BC}_2$$

$$d = -\frac{1}{2}\overline{P_1} - \frac{1}{2}\overline{P}_2 + \overline{F}_1 - 4\overline{F_2} + 2\overline{BC}_1 + 2\overline{BC}_2$$

$$aa = -4\overline{F}_2 + 2\overline{BC}_1 + 2\overline{BC}_2$$

$$ad = -\frac{1}{2}\overline{P}_1 + \frac{1}{2}\overline{P}_2 + \overline{BC}_1 - \overline{BC}_2$$

$$dd = \bar{P}_1 + \bar{P}_2 + 2\bar{F}_1 + 4\bar{F}_2 - 4\overline{BC}_1 - 4\overline{BC}_2$$

Where, the parameters *m, a, d, aa, ad, and dd* refer to mean effects, additive, dominance, additive × additive, additive × dominance and dominance × dominance gene effects, respectively.

- **Heritability in broad (H^2) and narrow (h^2) sense** was calculated according to Mather (1949)

$$H^2 = \frac{\text{Genetic variance}}{\text{Phenotypic Variance}} \times 100$$

Where: Genetic variance = $VF_2 - VE$ **, Phenotypic variance =VF_2**

$$h^2 = \frac{\text{Additive variance}}{\text{Phenotypic Variance}} \times 100$$

Where: Additive variance = $2VF_2 - VBC_1 - VBC_2$

- **The predicted genetic advance under selection (Δg)** was computed according to Johnson *et al.* (1955)

$$\Delta g = K \times \sqrt{VF_2} \times \frac{h^2 n}{100}$$

Where, K= a selection differential with a value of 2.06 under 5 % selection intensity.

The expected gain represented as a percentage of F_2 mean (Δg %) was estimated according to Miller *et al.* (1958).

$$(\Delta g\ \%) = (\Delta g / X) \times 100$$

Where X = mean of F_2 population

RESULTS AND DISCUSSION

Mean performance:

Mean and variance of the six populations (P_1, P_2, F_1, BC_1, BC_2 and F_2) of the three wheat crosses for the studied characters are shown in Table 3 and 4.

The data showed that the F_1 mean values were higher than the mid-values of the two parental means for all the studied characters in all the three crosses, reflecting the prevalence of dominance and heterotic effects controlling these characters except No.spike/plant in the first cross (Line 1 × Line 2) under both treatments and third cross (Misr 2 × Line 3) at normal treatment, No. grains / spike in the first cross (Line 1 × Line 2) at both treatments and the second cross (Line1 × Giza 171) at normal treatment, 100-grain weight in third cross (Misr 2 × Line 3) at stress treatments which were lower than the mid-parent indicating partial dominance for these crosses.

Table 3. Means ($\bar{X}$) and variances (S^2) of the six populations (P_1, P_2, F_1, BC_1, BC_2 and F_2) for days to heading, Days to maturity and plant height in three bread wheat crosses under normal (N) and water stress (S) treatments.

Characters	Crosses	Treat	Statistical parameter	P_1	P_2	M.P	F_1	F_2	BC_1	BC_2
Days to heading (day)	1 (Line 1 × Line 2)	N	$\bar{X}$	78.93	80.36	79.64	83.19	82.90	81.12	84.88
			S^2	0.04	0.02		0.034	0.07	0.17	0.16
		S	$\bar{X}$	75.77	79.70	77.73	83.19	80.72	80.68	82.84
			S^2	0.03	0.04		0.03	0.06	0.18	0.15
	2 (Line1 × Giza 171)	N	$\bar{X}$	81.20	93.57	87.39	87.67	86.22	85.48	88.43
			S^2	0.02	0.02		0.041	0.06	0.15	0.19
		S	$\bar{X}$	78.31	91.50	84.90	86.73	85.97	84.52	88.00
			S^2	0.03	0.02		0.02	0.07	0.16	0.15
	3 (Misr 2 × Line 3)	N	$\bar{X}$	91.83	87.00	89.41	90.88	91.38	94.00	91.38
			S^2	0.02	0.01		0.043	0.10	0.28	0.51
		S	$\bar{X}$	90.56	86.36	88.46	90.50	89.90	91.71	88.41
			S^2	0.02	0.04		0.04	0.08	0.14	0.25
Days to maturity (day)	1 (Line 1 × Line 2)	N	$\bar{X}$	126.80	128.00	127.40	128.03	126.46	126.31	126.62
			S^2	0.02	0.02		0.04	0.08	0.21	0.18
		S	$\bar{X}$	122.23	123.00	122.61	124.85	124.73	123.49	124.97
			S^2	0.01	0.03		0.01	0.04	0.09	0.15
	2 (Line1 × Giza 171)	N	$\bar{X}$	126.70	135.77	131.23	133.47	128.93	126.81	134.46
			S^2	0.02	0.01		0.07	0.08	0.23	0.22
		S	$\bar{X}$	123.40	131.25	127.32	128.22	127.82	122.28	128.75
			S^2	0.04	0.02		0.02	0.04	0.10	0.10
	3 (Misr 2 × Line 3)	N	$\bar{X}$	135.00	134.70	134.85	137.63	132.90	136.30	134.22
			S^2	0.01	0.01		0.03	0.08	0.24	0.22
		S	$\bar{X}$	128.67	129.54	129.11	131.40	130.07	131.59	129.89
			S^2	0.01	0.04		0.02	0.03	0.09	0.09
Plant height (cm)	1 (Line 1 × Line 2)	N	$\bar{X}$	87.33	77.35	82.34	84.44	83.31	86.09	78.81
			S^2	0.036	0.033		0.037	0.277	0.781	0.849
		S	$\bar{X}$	85.91	75.00	80.46	83.44	79.21	83.95	77.03
			S^2	0.009	0.020		0.075	0.373	0.807	1.028
	2 (Line1 × Giza 171)	N	$\bar{X}$	78.07	90.00	84.03	74.53	83.00	76.38	87.40
			S^2	0.01	0.02		0.09	0.59	0.84	2.09
		S	$\bar{X}$	75.20	86.09	80.64	70.53	79.31	72.26	80.80
			S^2	0.01	0.02		0.05	0.30	0.85	0.75
	3 (Misr 2 × Line 3)	N	$\bar{X}$	89.69	80.25	84.97	92.63	94.16	88.41	83.13
			S^2	0.01	0.02		0.08	0.49	1.08	1.38
		S	$\bar{X}$	81.63	75.00	78.32	87.06	87.77	84.71	80.49
			S^2	0.03	0.02		0.07	0.29	0.68	0.76

The F_1 means surpassed the better parent for days to heading in the first cross (Line 1 × Line 2) at both treatments, days to maturity in the first cross (Line 1 × Line 2) under stress treatment and the third cross (Misr 2 × Line 3) under both treatments for days to maturity and plant height, the second cross for No.spike /plant under both treatments and the third cross (Misr 2 × Line 3) under stress treatment, 100-grain weight in the first cross (Line 1 × Line 2) under stress treatment and the second cross (Line1 × Giza 171) under normal treatment. Grain yield/plant in the third cross (Misr 2 ×

Line 3) under both treatments indicating over dominance controlling these traits. The F_2 population mean performance values were between the two parents and less than F_1 for all the studied characters except days to heading in the third cross under normal treatment, the second cross for plant height under stress treatment, the second cross for no.grains/spike under both treatments indicating that these characters are quantitatively inherited.

Meanwhile, the mean values of the F_2 generation were higher than the highest parents for days to heading in the first cross under both treatments, days to maturity in the first cross under stress treatment, plant height in the third cross under both treatments, no.spike/plant in the first and third cross under stress treatment, no.grains/spike in the first cross under both treatments, the first and second cross for 100-grain weight under both treatments and the first cross for grain yield /plant under both treatments indicating that superior parental lines can be selected depending on transgressive segregation for these characters.

However, mean value of BC_1 and BC_2 progenies of the three crosses varied under normal and stress treatments and each tended toward the mean of its recurrent parent.

Table 4. Means ($\bar{X}$) and variances (S^2) of the six populations (P_1, P_2, F_1, BC_1, BC_2 and F_2) for no.spike/plant, no.of grains /spike, 100 grain weight and grain yield / plant in three bread wheat crosses under normal(N) and water stress (S) treatmemts

Characters	Crosses	Treat	Statistical parameter	P_1	P_2	M.P	F_1	F_2	BC_1	BC_2
No.spike /plant	1 (Line 1 × Line 2)	N	$\bar{X}$	12.00	14.17	13.08	11.07	13.09	11.63	12.00
			S^2	0.02	0.01		0.049	0.05	0.15	0.12
		S	$\bar{X}$	8.25	9.05	8.65	7.00	10.05	8.95	8.68
			S^2	0.02	0.02		0.04	0.04	0.10	0.09
	2 (Line1 × Giza 171)	N	$\bar{X}$	11.30	13.03	12.17	14.03	11.02	10.07	8.61
			S^2	0.02	0.01		0.054	0.05	0.13	0.13
		S	$\bar{X}$	8.15	8.04	8.10	9.00	8.09	6.72	6.67
			S^2	0.01	0.01		0.03	0.04	0.10	0.10
	3 (Misr 2 × Line 3)	N	$\bar{X}$	13.73	14.23	13.98	12.00	12.09	12.25	12.00
			S^2	0.02	0.02		0.055	0.08	0.16	0.25
		S	$\bar{X}$	8.44	9.44	8.94	9.60	10.17	9.44	9.07
			S^2	0.01	0.01		0.04	0.04	0.10	0.11
No.grains /spike	1 (Line 1 × Line 2)	N	$\bar{X}$	45.47	45.35	45.41	42.92	48.21	46.06	41.47
			S^2	0.03	0.02		0.08	0.52	1.69	1.21
		S	$\bar{X}$	42.60	42.67	42.63	41.32	42.91	42.96	38.58
			S^2	0.01	0.03		0.08	0.49	1.13	1.24
	2 (Line1 × Giza 171)	N	$\bar{X}$	53.05	55.66	54.35	51.73	52.60	47.07	54.33
			S^2	0.02	0.04		0.12	0.46	1.04	1.28
		S	$\bar{X}$	44.37	49.95	47.16	48.83	49.14	43.00	50.08
			S^2	0.04	0.02		0.09	0.41	1.26	0.97
	3 (Misr 2 × Line 3)	N	$\bar{X}$	54.50	46.03	50.27	51.10	50.14	49.73	50.33
			S^2	0.03	0.02		0.11	0.33	0.90	0.97
		S	$\bar{X}$	48.72	41.57	45.15	47.31	43.83	48.79	39.59
			S^2	0.02	0.01		0.09	0.44	0.97	1.14
100-grain weight (g)	1 (Line 1 × Line 2)	N	$\bar{X}$	4.21	4.47	4.34	4.33	4.71	4.03	3.79
			S^2	0.002	0.002		0.003	0.004	0.008	0.013
		S	$\bar{X}$	3.39	3.49	3.44	3.78	3.90	3.36	3.47
			S^2	0.002	0.002		0.003	0.004	0.008	0.011
	2 (Line1 × Giza 171)	N	$\bar{X}$	4.16	4.43	4.29	4.49	4.63	4.03	4.14
			S^2	0.00	0.00		0.00	0.00	0.01	0.01
		S	$\bar{X}$	3.09	3.70	3.40	3.62	3.97	3.71	3.83
			S^2	0.00	0.00		0.01	0.00	0.01	0.01
	3 (Misr 2 × Line 3)	N	$\bar{X}$	3.36	3.75	3.56	3.70	3.74	3.44	3.72
			S^2	0.00	0.00		0.00	0.00	0.01	0.01
		S	$\bar{X}$	3.08	3.68	3.38	3.27	3.12	3.35	3.38
			S^2	0.00	0.00		0.00	0.00	0.01	0.01
Grain Yield (g)	1 (Line 1 × Line 2)	N	$\bar{X}$	32.32	31.78	32.05	30.68	33.90	32.99	32.99
			S^2	0.026	0.028		0.077	0.357	0.940	0.805
		S	$\bar{X}$	28.99	28.87	28.93	28.67	29.95	28.20	26.00
			S^2	0.019	0.029		0.114	0.333	0.909	0.723
	2 (Line1 × Giza 171)	N	$\bar{X}$	29.55	42.08	35.81	40.77	38.26	28.67	37.24
			S^2	0.03	0.02		0.21	0.44	0.70	1.55
		S	$\bar{X}$	25.37	36.06	30.71	35.89	31.97	26.98	31.14
			S^2	0.03	0.03		0.09	0.60	1.16	1.97
	3 (Misr 2 × Line 3)	N	$\bar{X}$	38.38	43.55	40.96	45.29	39.96	40.96	40.96
			S^2	0.02	0.02		0.06	0.49	0.94	1.70
		S	$\bar{X}$	33.33	33.64	33.48	38.05	37.61	36.63	35.18
			S^2	0.02	0.02		0.06	0.42	1.07	1.00

Generally, the six population mean values were higher increased in the normal treatment than the stress treatment for all the studied characters, revealing the importance of water for plant behaviour. Similar results reported by said (2014), Jamileh *et al.* (2015), El-Nahas (2016) and Elmassry (2018) also, Salman *et al* (2017) and Aboud *et al.* (2020) revealed that drought stress significantly decreased the performance of all the studied characters of all wheat genotypes compared with the normal treatment.

Tolerance Index

The larger value of tolerance index (TOL) and yield reduction ratio (YR) represents relatively more sensitive to water stress, thus a smaller value of both TOL and YR was favored. Selection based on TOL and YR favors genotypes with low yield potential under non-stress treatment and high yield under stress treatment. The results in Table 5 indicated that P_2 (Line1) in the first cross (Line 1 × Line 2) had the lowest both TOL and YR for parents as 2.91 and 0.092 respectively, while the highest parent of both TOL and YR was P_2 (Line 3) in the third cross (Misr 2 × Line 3) as 9.91 and 0.228 respectively However, for F_1 the lowest one showed in the first cross (Line 1×Line 2) as 2.01and 0.07 respectively. On the other hand, the highest F_1 showed at third cross (Misr 2 × Line 3) as 7.24 and 0.16 for TOL and YR, respectively.

Table 5. Tolerance index (TOL) and yield reduction ratio (YR) of grain yield for the studied generations at the three crosses under normal (N) and water stress (S) treatments.

Generation	Stress Indicators	Cross 1 (Line 1 × Line 2)	Cross2 (Line1 × Giza 171)	Cross3 (Misr 2 × Line 3)
P_1	TOL	3.32	4.18	5.05
	YR	0.103	0.141	0.132
P_2	TOL	2.91	6.02	9.91
	YR	0.092	0.143	0.228
F1	TOL	2.01	4.87	7.24
	YR	0.07	0.12	0.16
F_2	TOL	3.95	6.29	2.35
	YR	0.12	0.16	0.06
BC_1	TOL	4.79	1.70	4.33
	YR	0.15	0.06	0.11
BC_2	TOL	6.99	6.10	5.78
	YR	0.21	0.16	0.14

The results indicated that the best F_2 were third cross (Misr 2 × Line 3) and first cross (Line 1×Line 2) which had low values for both TOL and YR. However, F_2 at the second cross (Line1 × Giza 171) had the highest values as 6.29 and 0.16 for TOL and YR, respectively.

The results obtained that the BC_1 which had the lowest values for TOL and YR showed at the second cross (Line1 × Giza 171). However, the highest BC1 was showed at the first cross (Line 1×Line 2) and third cross (Misr 2 × Line 3). For BC_2 the results showed that third cross (Misr 2 × Line 3) was the lowest one at both TOL and YR. On the other hand, the first cross (Line 1×Line 2) and second cross (Line1 × Giza 171) had high values for both TOL and YR.

Generally, the results indicated that the two parents involved in the first cross (Line 1×Line2) were low sensitivity to water stress, so that most of the generations at the first cross had low values at both TOL and YR, so it was favored for water stress treatment. These results are in line with those found by Elhawary (2010), Zebarjadi, A. *et al* (2012) and Aboud *et al* (2020)

Heterosis, Inbreeding depression and Potence ratio:

Heterosis percentage relative to mid and better parents, inbreeding depression and potence ratio in the three crosses under normal and water stress treatments are presented in Table 6 and 7.

The desirable heterosis for days to heading and days to maturity was negative, while the desirable heterosis for yield and yield components characters was positive.

The results showed that heterosis over mid-parents was highly significant positive in most crosses for all the studied characters under both treatment except the third cross (Misr 2 × Line 3) for days to maturity at stress treatment, the second cross (Line1 × Giza 171) for plant height at both treatments, first cross for no. spike/plant and no. grains /spike at both treatments, third cross for no. spike/plant at normal treatment, second cross for no. grains /spike at normal treatment, first cross and third cross for 100-grain weight at normal and stress treatments, respectively and the first cross for grain yield under both treatments, which revealed significant and highly significant negative values.

Table 6. Estimates of heterosis, inbreeding depression percentages and potence ratio (%) for days to heading, days to maturity and plant height in three bread wheat crosses under under normal (N) and water stress (S) treatments.

Characters	Crosses	Treat	Heterosis% MP	Heterosis% BP	Inbreeding Depression %	Potence Ratio%
Days to heading (day)	1	N	4.45**	5.4**	0.35	-4.96
	(Line 1× Line 2)	S	5.35**	8.08**	1.43**	-2.11
	2	N	0.32	7.96**	1.65**	-0.05
	(Line1 × Giza 171)	S	2.16**	10.76**	0.88**	-0.28
	3	N	1.64**	4.46**	-0.55	0.61
	(Misr 2 × Line 3)	S	1.58**	4.79**	0.67*	0.67
Days to maturity (day)	1	N	0.5	0.97**	1.23**	-1.06
	(Line 1×Line 2)	S	1.82**	2.14**	0.1	-5.78
	2	N	1.7**	5.34**	3.4**	-0.49
	(Line1 × Giza 171)	S	0.67**	3.91**	0.32	-0.22
	3	N	2.06**	2.18**	3.44**	18.56
	(Misr 2 × Line 3)	S	-0.66**	2.12**	1.01**	2.01
Plant Height (cm)	1	N	2.56**	-3.31**	1.34*	0.42
	(Line 1×Line 2)	S	3.71**	-2.88**	5.06**	0.55
	2	N	-11.31**	-17.19**	-11.36**	1.59
	(Line1 × Giza 171)	S	-12.55**	-18.08**	-12.45**	1.86
	3	N	9.02**	3.28**	-1.65*	1.62
	(Misr 2 × Line 3)	S	5.73**	6.65**	-0.81	1.42

***, ** Significant at 0.05 and 0.01 levels, respectively. MP: Mid Parent BP: Better Parent**

For heterotic effects relative to the better parent, highly significant positive values were found in the three crosses for days to heading and days to maturity under both treatments, the third cross under both treatments for plant height, second cross under both treatments and third cross under stress treatment for no. spike/plant, first cross under stress treatment and the second cross under normal treatment for 100-grain weight, as for grain yield, positive heterotic values detected for the third cross under both treatments, while the negative values were revealed for plant height in first and second cross under both treatments, no.spike/plant in the first cross under both treatments and third cross under normal treatments, no.grains/spike in three crosses under both treatments, 100-grains weight in the first and second cross under both treatments and normal treatment, respectively and grain yield in the first and second cross under both treatments and normal treatment, respectively. Jatoi *et al,* (2014) note that the magnitude of both mid and better parent heterosis were about twice greater in stress than in non-stress conditions, Elmassry (2018) found that significant positive heterosis relative to better parent was obtained for grain yield and yield component.

Table 7. Estimates of heterosis, inbreeding depression percentages and potence ratio (%) for no.spike/ plant, no.of grains /spike, 100- grain weight and grain yield / plant in three bread wheat crosses under normal (N) and water stress (S) treatments.

Characters	Crosses	Treat	Heterosis%		Inbreeding	Potence
			MP	BP	Depression %	Ratio %
No.spike / plant	1	N	-15.41**	-21.88**	-18.25**	1.86
	(Line 1×Line 2)	S	-19.08**	-22.65**	-43.62**	4.12
	2	N	15.34**	7.67**	21.47**	-2.15
	(Line1 × Giza 171)	S	11.13**	10.38**	10.09**	16.41
	3	N	-14.18**	-15.69**	-0.78*	7.93
	(Misr 2× Line 3)	S	7.34**	1.65**	-5.99**	-1.31
No.grains/ spike	1	N	-5.49**	-5.61**	-12.33**	-42.71
	(Line 1× Line 2)	S	-3.09**	-3.16**	-3.85**	39.50
	2	N	-4.82**	-7.05**	-1.68*	2.01
	(Line1 × Giza 171)	S	3.54**	-2.25**	-0.64	-0.60
	3	N	1.66**	-6.24**	1.87**	0.20
	(Misr 2 × Line 3)	S	4.79**	-2.9**	7.35**	0.61
100-grain weight (g)	1	N	-0.38**	-3.29**	-8.8**	0.13
	(Line 1×Line 2)	S	9.87**	8.36**	-3.15**	-7.07
	2	N	4.49**	1.39**	-3.29**	-1.47
	(Line1 × Giza 171)	S	6.57**	-2.1**	-9.82**	-0.74
	3	N	4.17**	-1.17**	-0.89**	-0.77
	(Misr 2 × Line 3)	S	-3.3**	-11.23**	4.41**	0.37
Grain yield (g)	1	N	-4.26**	-5.06**	-10.49**	-5.11
	(Line 1× Line 2)	S	-0.9*	-1.11**	-4.46**	-4.23
	2	N	13.83**	-3.12**	6.15**	-0.79
	(Line1 × Giza 171)	S	16.87**	-0.45	10.93**	-0.97
	3	N	10.56**	4.01**	11.77**	-1.68
	(Misr 2 × Line 3)	S	13.63**	13.11**	1.16	-29.49

***, ** Significant at 0.05 and 0.01 levels, respectively.** **MP: Mid Parent BP: Better Parent**

Inbreeding depression measured as a reduction in performance of F_2 generation relative to F_1, results showed significant or highly significant positive inbreeding depression values in most crosses for days to heading and days to maturity, plant height in the first cross under both treatments, number of spike/plant in the second cross under both treatments, no.grains/spike in the third cross under both treatments, 100-grains weight in the third cross under stress treatment and grain yield in the second cross under both treatments and third cross under norml treatment, however significant or highly significant negative inbreeding depression values detected for plant height in the second cross under both treatments and third cross under normal treatment, no.spike/plant in the first and third cross under both treatments, no.grains/plant in the first cross under both tretments and second cross under normal treatments, 100-grain weight in the first, second cross under both treatments and third cross under normal treatment and grain yield in the first cross under both treatments.

Potence ratio values were more than unity in most of the studied characters in three crosses under both treatments, referring to the presence of over dominance towards lower or higher parent, Meanwhile, potence ratio values for days to heading in the second and third cross under both treatments, days to maturity in the second cross under both treatments, plant height in the first cross under both treatments, no.grains/spike in the second cross under stress treatment and third cross under both treatments, 100-grains weight in the first cross under normal treatment, second cross under stress treatment and third cross under both treatments, and grain yield in the second cross under both treatments were less than unity, indicating partial dominance for these characters. These results are in line with those obtained by Khaled, Mohamed A.I (2013), Said (2014) and Elmassry and M. El-Nahas (2018).

Estimation of type of gene action:

The type of gene action and scalling tests for all the studied characters are shown in Table 8.

The results revealed the presence of non-allelic interactions for all studied characters in all crosses except for 100-grain weight in the third cross under normal irrigation treatment. It is deserved to mention that at least one of the A, B and C tests were significant for the previous characters, indicating the adequacy of the six-parameter model to explain the type of gene action controlling the character in these crosses However, for the excepted cases, the simple additive-dominance model would be adequate .

The estimated mean effect parameter (m) which reflects the contribution due to the overall mean plus the locus effects and interactions of the fixed loci was found to be highly significant for all the studied characters in the three crosses under normal and stress treatments indicating that these characters are quantitatively inherited.

The additive (a) gene effects Table 4 were positive and significant or highly significant for days to heading and days to maturity in the second cross under both treatments, plant height in the first and third cross under both treatments, no.grains /spike in the first cross under both treatments and third cross under stress treatment and grain yield/plant in the first cross under normal treatment, indicating the contribution of additive gene effect in the inheritance of these characters and the potential for obtaining an additional improvement of these characters by selection using the pedigree method. Moreover, significant and highly significant negative additive effects were detected for days to heading, days to maturity and plant height in the second cross under both treatments, days to heading in the first cross under both treatments, days to maturity in the first cross under stress treatment, no.grains/ plant in the second cross under normal treatment and grain yield in the second cross under both treatments and third cross under normal treatments. Meanwhile, none of the crosses exhibited positive or negative significant additive effects for no.spikes/plant and 100-grain weight.

Dominance gene effects (d) were found to be positive and highly significant for days to heading in the first cross under both treatments and the third cross under normal treatment, days to maturity in the second cross under normal treatment and third cross under both treatments, 100-grain weight and grain yield in the third cross under stress treatment and normal treatment, respectively.

These results showed the great importance of the dominance of gene effects in the inheritance of these characters. On the other hand, highly significant negative effects were obtained for days to maturity in the second cross under stress treatment, plant height in the second and third cross under stress and both treatments, respectively, no.spikes /plant in the first cross under both treatments and second cross under stress treatment, no.grains/plant in the first and second cross under normal treatment and third cross under stress treatment,100-grain weight and grain yield in the first cross under both treatments and second cross under normal treatment, indicating that the alleles responsible for less value of these characters were over dominant over the alleles controlling high value. Ali Erkul *et al* (2010), Elmassry, and El-Nahas (2018) found that both additive and dominance gene action were significant in the inheritance of yield component and the dominance effects were negative and higher than additive effects.

Table 8. Estimates of scaling tests and gene effects for all the studied characters in three bread wheat crosses of bread wheat under normal (N) and water stress (S) treatments.

Characters	Crosses	Treat	Scaling test			Genetic Components						Type of epistasis
			A	B	C	(m)	(a)	(d)	(aa)	(ad)	(dd)	
Days to heading (day)	1	N	0.12	6.21**	5.94**	82.9**	-3.76**	3.94*	0.39	-3.04**	-6.72*	duplicate
	(Line1×Line 2)	S	3.7**	4.09**	3.64*	80.72**	-2.16**	8.3**	4.14*	-0.19	-11.92**	duplicate
	2	N	2.09*	-4.37**	-5.23**	86.22**	-2.95**	3.23	2.95	3.23**	-0.67	duplicate
	(Line1×Giza 171)	S	3.99**	-2.23*	0.59	85.97**	-3.48**	3	1.17	3.11**	-2.93	duplicate
	3	N	5.29**	4.88**	4.94**	91.38**	2.62**	6.7*	5.23	0.21	-15.39**	duplicate
	(Misr 2 × Line3)	S	2.36**	-0.04	1.66	89.9**	3.29**	2.7	0.66	1.2	-2.98	duplicate
Days to maturity (day)	1	N	-2.21*	-2.79**	-5.04**	126.46**	-0.31	0.68	0.04	0.29	4.96	complementary
	(Line1×Line 2)	S	-0.09	2.09*	3.98**	124.73**	-1.47**	0.25	-1.99	-1.09	-0.01	duplicate
	2	N	-6.55**	-0.31	-13.66**	128.93**	-7.65**	9.03**	6.8**	-3.12**	0.06	complementary
	(Line1×Giza 171)	S	-7.07**	-1.98**	0.17	127.82**	-6.47**	-8.33**	-9.22**	-2.54**	18.27**	duplicate
	3	N	-0.03	-3.89**	-13.38**	132.9**	2.08**	12.24**	9.46**	1.93*	-5.53	duplicate
	(Misr 2× Line3)	S	3.11**	-1.15	-0.73	130.07**	1.7**	4.98**	2.69	2.13**	-4.65*	duplicate
Plant height (cm)	1	N	0.4	-4.16*	-0.32	83.31**	7.28**	-1.34	-3.44	2.28	7.2	duplicate
	(Line 1×Line 2)	S	-1.45	-4.37	-10.93**	79.21**	6.91**	8.08	5.1	1.46	0.72	complementary
	2	N	-15.3**	-5.21	-16.07**	83**	-11.01**	1.53	-4.44	-5.05**	24.95**	complementary
	(Line1×Giza 171)	S	-1.21	4.99*	14.88**	79.31**	-8.54**	-21.22**	-11.1**	-3.1*	7.33	duplicate
	3	N	-5.5*	-6.62*	21.44**	94.16**	5.27**	-25.9**	-33.56**	0.56	45.68**	duplicate
	(Misr 2× Line 3)	S	0.73	-1.08	20.32**	87.77**	4.22**	-11.93**	-20.67**	0.9	21.02**	duplicate
No.spike/ plant	1	N	0.2	-1.23	4.05**	13.09**	-0.37	-7.1**	-5.08**	0.72	6.11*	duplicate
	(Line 1×Line 2)	S	2.65**	1.32	8.91**	10.05**	0.27	-6.59**	-4.94**	0.67	0.98	duplicate
	2	N	-5.2**	-6.31**	-8.32**	11.02**	-0.31	-1.33	-3.2	0.56	14.71**	duplicate
	(Line1×Giza 171)	S	-3.7**	-3.7**	-1.83	8.09**	0.05	-4.67**	-5.57**	0	12.97**	duplicate
	3	N	-1.23	-2.23	-3.59*	12.09**	0.25	-1.86	0.13	0.5	3.34	duplicate
	(Misr 2 × Line3)	S	0.84	-0.91	3.61**	10.17**	0.38	-3.02	-3.67*	0.88	3.74	duplicate
No.grains/ Spike	1	N	3.73	-5.33*	16.19**	48.21**	4.59*	-20.28**	-17.79**	4.53*	19.4*	duplicate
	(Line 1× Line 2)	S	1.41	-11.11**	-2.15	42.91**	4.89**	-8.6	-7.54	6.26**	17.24*	duplicate
	2	N	-10.65**	1.28	-1.76	52.6**	-7.27**	-10.23*	-7.61	-5.96**	16.98*	duplicate
	(Line1× Giza 171)	S	-6.62**	1.39	-4.09	49.14**	-2.45	-3.81	-1.13	-4*	6.36	duplicate
	3	N	-6.13**	3.53	-2.16	50.14**	-0.6	0.39	-0.44	-4.83**	3.05	Complementary
	(Misr 2 × Line3)	S	2.2	-9.69**	15.66**	50.14**	9.52**	-20.99**	-23.16**	5.95**	30.65**	duplicate
100-grain weight (g)	1	N	-0.48*	-1.23**	1.49**	4.71**	0.24	-3.22**	-3.2**	0.37*	4.91**	duplicate
	(Line 1×Line 2)	S	-0.45*	-0.32	1.16**	3.9**	-0.11	-1.58**	-1.92**	-0.06	2.69**	duplicate
	2	N	-0.6*	-0.63**	0.98*	4.63**	-0.11	-2.02**	-2.21**	0.02	3.44**	duplicate
	(Line1×Giza 171)	S	0.7**	0.36	1.87**	3.97**	-0.13	-0.59	-0.81	0.17	-0.25	Complementary
	3	N	-0.18	-0.02	0.43	3.74**	-0.27	-0.48	-	-	-	-
	(Misr 2 × Line3)	S	0.36	-0.18	-0.8*	3.12**	-0.03	0.87*	0.98*	0.27	-1.15	duplicate
Grain yield (g)	1	N	2.97	-4.19*	10.14**	33.9**	3.85**	-12.73**	-11.36*	3.58*	12.58	duplicate
	(Line 1×Line 2)	S	-1.28	-5.54**	4.59	29.95**	2.19	-11.67**	-11.41**	2.13	18.23**	duplicate
	2	N	-12.97**	-8.37**	-0.12	38.26**	-8.56**	-16.26**	-21.21**	-2.3	42.55**	duplicate
	(Line1×Giza 171)	S	-7.31**	-9.68**	-5.33	31.97**	-4.16*	-6.48	-11.66*	1.18	28.65**	duplicate
	3	N	-1.76	2.53	-12.67**	39.96**	-4.73**	17.76**	13.44*	-2.14	-14.2	duplicate
	(Misr 2 × Line3)	S	1.89	-1.32	7.36*	37.61**	1.45	-2.24	-6.8	1.6	6.23	duplicate

a: additive, d: dominance, aa: additive × additive, ad: additive × dominance, dd: dominance × dominance
***, ** Significant at 0.05 and 0.01 levels, respectively**

Additive × additive gene effects (aa) were positive and significant or highly significant for days to heading in the first cross under stress treatment, days to maturity in the second and third cross under normal treatment, 100grain weight in the third cross under stress treatment and grain yield/plant in the third cross under normal treatment, suggested that these characters have increasing genes effects and selection for its improvement could be effective. However highly significant negative additive × additive was detected in the second cross for days to maturity and plant height under stress treatment, third cross and first cross for plant height and no.spike/plant, respectively under both treatments, second and third cross for no.spike/plant under stress treatment, first and third cross for no.grains/spike under normal and stress treatment, respectively, first cross under both treatments and second cross under normal treatment for 100-grain weight, first and second cross for grain yield/plant under both treatments. These results showed the dispersion of alleles in parents. Therefore, the selection is of no use in early segregating generations because there is no additive genetic effect to be fixed in these characters.

Additive × dominance (ad) epistasis type was significant or highly significant positive for days to heading in the second cross under both treatments, days to maturity in the third cross under both treatments, no.grains/plant in the first cross under both treatments and third cross under stress treatment, 100-grain weight and grain yield/plant in the first cross under normal treatment. Indicating that it would be better to delay selection to later generations with increased homozygosity, where additive and additive × additive variances are prevailing. Meanwhile, highly significant negative additive × dominance type of gene action was found for days to heading in the first cross under normal treatment, days to maturity and plant height in the second cross under both treatment, no.grains/spike in the second cross under both treatments and third cross under normal treatment and none of the crosses exhibited positive or negative significant additive effects for no.spike/plant in all crosses indicating that the dominance genes are in the low - performance parent.

Dominance × dominance epistasis type was significant or highly significant positive for days to maturity in the second cross under stress treatment, plant height in the second cross under normal treatment and third cross under both treatments, no.spikes/plant in the first cross under normal treatment and second cross under both treatments. No.grains/spike in the first cross under both treatments, second cross under normal treatment and third cross under stress treatment, 100-grain weight in the first cross under both treatments and second cross under normal treatment and grain yield/plant in the first cross under stress treatment and second cross under both treatments. These results confirm the important role of dominance ×dominance gene action in the genetic system controlling these characters and selection should be effective in late generations. Otherwise highly significant negative dominance × dominance was found only for days to heading in the first cross under both treatments and third cross under normal treatment, days to maturity in the third cross under stress treatment, indicating their reducing effect in the expression of these characters and there is no breeding importance in proceeding generations. These results are in line with those obtained by said (2014), Salman *et al* (2017) and Abd El-Rady (2018) which confirm the important role of dominance × dominance gene interaction in the genetic system.

The type of epistasis was determined as duplicate when dominance (d) and dominance × dominance (dd) have different signs in crosses that exhibited significant epistasis, while similar signs of (d) and (dd) reflect complementary epistasis. These results illustrated that duplicate epistasis was prevailing for most characters in three crosses under both treatments, while complementary epistasis was prevailing for days to heading in the first and second cross under normal treatment, plant height in the first cross under stress treatment and second cross under normal treatment, no.grains/spike in the third cross under normal treatment and 100-grain weight in the second cross under stress treatment. This indicates that duplicate epistasis was greater and important when compared with complementary epistasis for most studied characters, as non-additive effects were higher than additive effects in most of the studied characters, intensive selection through later generation was needed to improve these characters.

Heritability and percentage of genetic advance:

The knowledge of heritability guides the plant breeder to predict the behavior of the succeeding generation, making a describable selection and accessing the magnitude of genetic advance improvement that is possible through selection. High heritability can easily be fined with a simple selection procedure resulting in quick progress. Heritability estimates in broad and narrow-sense and genetic advance are presented in Table 9.

Heritability estimates in the broad sense were high for all studied characters in three crosses under both treatments, ranged from 88.93% for 100-grains weight in second cross under stress treatment to 98.93% for plant height in the second cross under normal treatment indicating that most of the phenotypic variability was due to genetic effects.

Heritability estimates in a narrow sense were moderate to high for all studied characters in all crosses and ranged from 52.4% for days to heading in the first cross under stress treatment to 78.96% in days to heading in the first cross under normal treatment, indicating that these characters were greatly affected by additive and non-additive effects and there is an appreciable amount of heritable variation. This agrees with the results explained by Ali E. *et al* (2010) who showed that heritability estimate was medium for no.grains/ spike and high for no.spikes/plant.

The expected genetic advance (Δg) ranged from 1.36 for 100-grain weight in the first cross under normal treatment to 21.01 for plant height in the second cross under normal treatment. The expected genetic advance as a percent of F_2 mean was low to high in most of the three crosses under both treatments, indicating the possibility of practicing selection in early generations to enhance selecting high yielding genotypes. Meanwhile, the remaining characters, which showed the low values of expected genetic advance, suggesting the role of environmental factors and dominance gene action in the inheritance system of these characters.

Table 9. Estimates of Heritability and percentage of genetic advance for all the studied characters in three bread wheat crosses under normal (N) and water stress (S) treatments.

Traits	Crosses	Treat	Heritability percentage		Expected genetic advance	
			h2(b)	h2(n)	Δg	Δg %
Days to heading (day)	1	N	93.82	78.96	7.36	8.88
	(Line1×Line 2)	S	92.04	52.40	4.46	5.52
	2	N	93.84	67.79	6.15	7.14
	(Line1×Giza 171)	S	95.03	64.10	5.89	6.85
	3	N	96.19	60.56	6.91	7.57
	(Misr 2 × Line3)	S	94.67	78.05	7.79	8.67
Days to maturity (day)	1	N	94.94	72.78	7.18	5.68
	(Line1×Line 2)	S	95.18	62.61	4.67	3.74
	2	N	92.91	54.31	5.39	4.18
	(Line1×Giza 171)	S	90.54	62.42	4.27	3.34
	3	N	96.64	59.29	6.07	4.57
	(Misr 2 × Line3)	S	91.03	69.97	4.57	3.51
Plant Height (cm)	1	N	98.30	53.04	9.96	11.96
	(Line1×Line 2)	S	98.54	77.13	16.82	21.23
	2	N	98.93	76.51	21.01	25.31
	(Line1×Giza 171)	S	98.70	66.50	12.97	16.35
	3	N	98.87	75.61	18.97	20.15
	(Misr 2 × Line3)	S	97.90	77.71	15.03	17.13
No.spike/ plant	1	N	92.76	75.90	6.33	48.40
	(Line1×Line 2)	S	90.43	68.13	4.60	45.77
	2	N	91.13	76.14	6.17	55.99
	(Line1×Giza 171)	S	93.00	72.20	5.10	63.03
	3	N	94.33	74.43	7.59	62.79
	(Misr 2 × Line3)	S	92.38	75.33	5.52	54.29
No.grains/ spike	1	N	98.87	61.59	15.89	32.97
	(Line1×Line 2)	S	98.81	78.70	19.64	45.76
	2	N	97.95	73.59	17.80	33.83
	(Line1×Giza 171)	S	98.27	64.67	14.82	30.15
	3	N	97.48	59.72	12.28	24.50
	(Misr 2 × Line3)	S	98.50	78.81	18.55	42.32
100-grain weight (g)	1	N	91.14	62.36	1.36	28.89
	(Line1×Line 2)	S	91.69	66.57	1.41	36.27
	2	N	90.87	76.51	1.82	39.31
	(Line1×Giza 171)	S	88.93	67.29	1.55	39.12
	3	N	93.40	77.74	1.64	43.80
	(Misr 2 × Line3)	S	91.26	77.69	1.57	50.33
Grain Yield (g)	1	N	98.18	77.96	16.63	49.05
	(Line1×Line 2)	S	97.46	77.31	15.91	53.11
	2	N	96.76	71.06	16.77	43.85
	(Line1×Giza 171)	S	98.72	70.11	19.42	60.75
	3	N	98.86	65.07	16.23	40.62
	(Misr 2 × Line3)	S	98.81	77.17	17.89	47.58

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تحليل متوسطات الاجيال لثلاثة هجن من قمح الخبز تحت معاملات الري العادية والاجهاد

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أجريت هذه الدراسة بمزرعة محطة البحوث الزراعية بسخا- كفرالشيخ بهدف تقدير المقاييس الوراثية وطبيعة التأثير الجينى وإيجاد تراكيب وراثية جديدة يمكن الانتخاب من خلالها فى الأجيال الانعزالية التالية للحصول على سلالات (تراكيب) جديدة من القمح متحملة للاجهاد المائي ومتفوقة فى صفاتها المحصولية على الأصناف التجارية المنزرعة لثلاثه هجن وهى (سلالة 1 × سلالة2) ، (سلالة1× جيزة 171) و (مصر2 × سلالة 3) ، باستخدام تحليل السته عشائر (الأب الأول والثانى والجيلين الأول والثانى والهجينين الرجعيين الأول والثانى)، ويمكن تلخيص أهم النتائج المتحصل عليها كالاتي :أظهرت قوة الهجين لصفه محصول الحبوب للنبات بالنسبه لمتوسط الأبوين قيم موجبه وعاليه المعنويه للهجين الاول والثاني تحت معاملات الري العادية والاجهاد في حين أظهرت قوة الهجين بالنسبه لافضل الاباء قيما موجبة وعاليه المعنويه في الهجين الثالث تحت كلا المعاملتين. اشارت النتائج الي وجود تاثير للتفاعلات غير الاليلية لمعظم الصفات وكان تأثير الفعل الجينى السيادي أكبرمن تاثير الفعل الجينى المضيف لمعظم الصفات المدروسة كما دلت النتائج على أن التأثير (السيادى × السيادى) اكبر من التأثيرات (المضيف × المضيف) ، (المضيف × السيادى) لمعظم الصفات المدروسة مما يدل علي التأثيرالاكبر للفعل السيادي والتفاعلات غيرالاليلية. أظهرت درجه التوريث علي النطاق الواسع قيما عاليه في كل الهجن المدروسه في كل الصفات تحت معاملات الري العادي والاجهاد وكانت قيم معامل التوريث بمعناه الضيق متوسطة إلى مرتفعة للصفات المدروسة فى كل الهجن تحت معاملات الري العادي والاجهاد . عموما تشير النتائج أن الهجين الثالث (مصر2 × سلالة 3) أعطي أعلي قيم في محصول الحبوب/نبات تحت كلا معاملتي الري وبناء علي قيم كل من دليل التحمل و نسبة فقد المحصول، السلالة ١ و سلالة 2 هي أكثر الآباء تحملا للإجهاد المائي و كذلك كان الهجين الأول (السلالة ١ × سلالة 2) الأكثر تحملا للإجهاد المائي في معظم العشائر تحت الدراسة لذلك يفضل زراعة هذا الهجين تحت ظروف الإجهاد المائي.