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Estimation of Heterosis, Combining Ability and Utilization of Tolerance Indices to Select *Triticum aestivum L.* Genotypes under Drought Stress

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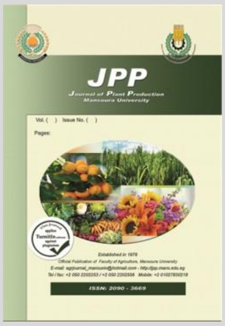

ABSTRACT

One abiotic environmental stressor that decrease wheat yield globally is drought. In the current study, 9x9 diallel schema excluding reciprocals were formed in 2021/2022 growing season. In 2022/2023 season, Parents and 36 crosses assessed (organized in RCBD design) under two main water regimes: well-watered (five irrigations) and water-deficient (one surface irrigations). The findings showed that, for all traits under study, there were significant ($p \leq 0.01$) variations in genotypes and their partitioning under regular irrigation treatment and drought. For every trait under study in both environments, the mean squares (MS) of both types of combining ability (GCA and SCA) were significant. The magnitudes of the GCA/SCA ratios showed that additive and additive by additive gene action types might account for the majority of the total genetic variability linked to these characters. The parental.3 was a good general combiner for number of spikes plant-1 and grain yield plant-1, while, parental variety P7 was the best general combiner for plant height, number of kernels spike-1 and 1000 kernel weight. The highest desirable SCA effects were obtained with P1×P7 for plant height, P1×P5 for number of spike plant-1, P3×P8 for number of kernels spike-1, P6×P7 for 1000- kernel weight, P6×P9 for grain yield under drought stress. The cross P2 x P4 showed the greatest significant and positive heterosis, reached 48.97**,84.25** and 68.63**,33.83 for mid-parent and better-parent in each of drought and normal environment, respectively. The mean squares due to genotypes of (SI) were highly significant SI for most studied traits except spike length.

Keywords: Heterosis, GCA , SCA and drought tolerance.

INTRODUCTION

Wheat is one of the world's most important staple crops, contributing significantly to food security and agricultural productivity. Its influence extends beyond human consumption, influencing economies and agricultural practices. Wheat is a rich source of carbs and protein. It contains critical elements including vitamins (especially B vitamins) and minerals (such iron and magnesium). It is a basic diet for billions of people.

Millions of farmers around the world depend on wheat growing for their livelihoods. It is a crucial crop that affects market dynamics and trade policies in many economies. According to FAO (2023), there are over 220 million hectares (544 million acres) of wheat grown worldwide. Wheat is produced in around 780 million metric tons per year worldwide. A little over 1.3 million hectares (3.2 million acres) of land in Egypt are planted to wheat. Egypt produces about 8 million metric tons of wheat annually. Egypt's local wheat need is largely met by imports.

Drought is the most harmful abiotic environmental stress. It affected negatively to wheat growth, productivity and decrease photosynthesis rate and other vital processes Kang *et al* 2019 and Mondal *et al.* (2021).

Reduced rainfall occurrences and climate change, particularly global warming, are linked to this consequence. Food security and sustainability deteriorated as a result on a worldwide scale Mondal et al. (2021) and Mu *et al.* (2022). The main sustainable breeding strategy for addressing drought difficulties is to produce resilient wheat cultivars that are resistant to water deficit stress, even if other abiotic factors like heat stress are still present Farooq *et al.* 2014 and Obata *et al.* (2022). Furthermore, the stages of wheat growth, such as tillering, flowering, and grain filling period, as well as characteristics like plant height and leaf area index, were all greatly impacted by water scarcity. Deficiency of water diminishes most stages and related traits. Insufficient water at crucial stages, such as flowering and grain filling, prevents photosynthesis and hastens plant senescence Klem *et al.* (2017).

In wheat, heterosis, also known as hybrid vigor, is the phenomena when hybrid progeny show better qualities than their parents. Among its benefits is higher yield. Higher yields and improved growth are common traits of hybrids over non-hybrid cultivars Ghulam *et al.* (2024). Using heterosis to one's advantage aids in the development of resilient and productive wheat varieties, which enhances agricultural stability and efficiency.

In wheat, "combining ability" refers to the ability of various wheat varieties or breeding lines to cross and create attractive and high-yielding offspring. It is essential to raising yield and finding parent lines that combine well aids in the development of wheat cultivars with high yields. By forecasting the outcome of possible crosses, it expedites the breeding process and conserves time and money Rana *et al.* (2024). Ultimately, creating improved wheat varieties that satisfy the demands of agriculture and the environment depends on combining abilities.

Sustainability indices and drought tolerance are essential for preserving environmental health and

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agricultural productivity. This speaks to the resilience of a crop to times when there is a shortage of water. It is crucial for maintaining food security in dry and semi-arid areas, where a common problem is a lack of water. Crops that can withstand drought contribute to yield stabilization and lower crop failure rates. The Sustainability Index evaluates how successfully farming methods strike a balance between environmental protection and productivity. It takes into account things like ecosystem effect, soil health, and efficient resource utilization. Practices that promote long-term agricultural viability and reduce environmental harm are indicated by a high sustainability index.

The aim of current study to, 1) evaluate mean performance, heterosis and combining ability in F1 crosses among 9 parental genotypes for yield and its components under verses irrigation treatments and 2) select the drought-tolerant parent and crosses

MATERIALS AND METHODS

During the two consecutive seasons of 2021/2022 and 2022/2023, this study was conducted at the Experiment, Research Station farm of the Moshtohor Faculty of Agriculture, Benha University, Kalubia Governorate, Egypt. Nine wheat genotypes, namely Yakora (P1), Giza171 (P2), Misr3 (P3), Sids 14 (P4), Gemmiza12 (P5), Sakha95 (P6), L 125 (P7), L 137 (P8) and L 150 (P9). These parents were selected for the current study to reflect a broad range of variety for several agronomic traits and drought resistance assessments. Table (1) lists these varieties' names, pedigrees, and places of origin.

Table 1. The parent genotypes code number, name, pedigree and places of origin.

Code No	Genotype name	Pedigree	Source
P1	YakoraRojo	Ciano67/Sonora 6411Klien Rendidor /3/1L815626Y-2M-1Y-0M-302M	CIMMYT
P2	Giza171	0TUS/3/SARATHB//VEE (CMSS97Y00227 S-5Y-o1oM-o1oY- o1oM-2Y – 1M-0Y- 0GM)	Egypt
P3	Misr3	0asis/SKauz//4* Bcn/3/2*past0r	Egypt
P4	Sids 14	B0w"s"/Vee"s"//B0w's'/Tsi/3/BANI SUEFI SD293-1SD-2SD-4SD-oSD	Egypt
P5	Gemmiza12	oTUS/3/SARA/THB//VEE (CMSS97Yoo227 S-5Y-o1oM-o1oY- o1oM-2Y – 1M-oY- 0GM)	Egypt
P6	Sakha95	SKAUZ*2_SRMA-CMBW91M02694P-oToPY-7M-o1oY -o1oM-o1oY-5	Egypt
P7	L 125	MILAN \ S7125 \\ OAPYMex	CIMMYT
P8	L 137	MILAN \ S7137 \\ OAPYMex	CIMMYT
P9	L 150	MILAN \ S7150 \\ OAPYMex	CIMMYT

The aforementioned parents were hybridized in 9x9 diallel schema without reciprocals crosses giving adequate seeds of total thirty-six crosses in 2021/2022 growing season.

On November 21, 2022, two nearby experiments included the nine parents and their 36 F1 crosses were planted. In the first experiment (drought stress), it was irrigated only one following planting irrigation, while, the second experiment, there were five irrigations as usual. Each experiment had three replications in a randomized complete block design. Each plot was made up of a single row that was five meters long, with 30 cm separating rows and 20 cm separating each plant, allowing for a total of 25 plants per plot. In this case, the dry planting technique was applied. They also followed the other cultural customs of cultivating wheat. The temperature, relative humidity, and amount of rainfall during the evaluation season are showed in Table (2).

From each plot of parents and the F1s, ten guarded plants were chosen at random to record observations on various traits. The traits under investigation were Plant height (PH) (cm), spike length (SL) (cm), number of spikes spike-1, number of kernels spike-1, 1000-kernel weight (g), and grain yield plant-1 (g).

The data of the each experiment was analyzed as recommended statistical analysis according to Snedecor and Cochran (1967). Assuming that genotypes had fixed effects, the significance of different sources of variation was tested using F test.

Each trait's heterosis was calculated as mean squares for parents vs. crosses. Furthermore, Genotype mean square was split into parents, crosses, and parents vs. crosses in this process. Testing the significance of heterosis as an average across all examined crossings was made possible by this process.

According to Paschal and Wilcox (1975), heterosis was also calculated for individual crosse as the percentage deviation of F1 mean performances from either the better parent mean (BP) or the mid-parent value (MP) for F1 date of each trial. Griffing's diallel cross analysis (1956), known as method 2 model I, was used to obtain estimates of the two types of combining ability (general GCA and specific SCA).

Table 2. Temperature, relative humidity (R.H.), and total precipitation totals for Kalubia (Moshtohor) for the 2022–2023 season, on a monthly average.

Months	Temperature C		RH	Rain fall
	Min.	Max.	%	mm/month
November 2022	12.1	25.4	45.7	--
December 2022	10.4	19.9	52.3	0.6
January 2023	8.7	18.2	56.4	1.9
February 2023	8.1	18.5	50.8	0.9
March 2023	9.8	24.1	40.7	0.3
April 2023	15.6	28.2	41.5	0.4
May 2023	20.2	35.4	37.4	--

Stress Tolerance/Sensitive Indices

The water-stressed/seasons (Ys) and well-irrigated/seasons (Yp) grain yield means of the examined crosses were used to compute the stress tolerance/sensitive indices (STI). Table 3 contains the name, abbreviation, formulae, stress tolerance/sensitive indices, and selected value. Furthermore, grain yield refers to the estimated indices shown in Table 3 as well as the well-watered (Yp) and water-stressed (Ys) conditions.

Correlation

Simple correlation coefficients among aforementioned tolerant indices calculated on the basis using SPSS program.

Table 3. Abbreviation , Drought tolerance indices , reference and calculation equations.

No	Abbreviation	Drought indices	Reference	Calculation equation
1	SSI	Stress susceptibility index	Fischer and Maurer, (1978)	$(1-\frac{Ys}{Yp})+(1-\frac{\overline{Ys}}{\overline{Yp}})$
2	TOL	Tolerance	Rosielle and Hamblin, (1981)	Yp – Ys
3	MP	Mean productivity		(Yp + Ys) / 2
4	GMP	Geometric mean Productivity	Fernandez, (1992)	$\sqrt{(Ys \times Yp)}$
5	STI	Stress tolerance index		$\frac{Ys\ x\ Yp}{\overline{Yp}^2}$
6	YI	Yield index	Gavuzzi et al., (1997)	$\frac{Ys}{\overline{Ys}}$
7	YSI	Yield stability index	Bouslama and Schapaugh, (1984)	$\frac{Ys}{Yp}$
8	HAM	Harmonic mean		$\frac{2\ x\ Ys\ x\ Yp}{Ys+Yp}$
9	SDI	Sensitivity drought index	Farshadfar and Javadinia, (2011)	$\frac{Yp-\ Ys}{Yp}$
10	RDI	Relative drought index	Fischer and Maurer, (1978)	$\frac{Ys\ x\ \overline{Yp}}{Yp\ x\ \overline{Ys}}$

Where, Ys,Yp, Ys^- and Yp^- refer to yield in stress, yield on normal conditions, average yield of all genotypes in stress and mean of all genotypes in normal conditions, respectively.

RESULTS AND DISCUSSION

ANOVA and mean performance:

Analysis of variance for all studied traits, i.e., plant height, number of spikes plant^{-1}, spike length, 1000-kernel weight, number of kernels spike^{-1}, and grain yield plant^{-1} under drought and normal irrigation are presented in Table 4. Results indicated that genotypes mean squares and its portioning (parent, crosses and parent vs crosses) were significant for all studied traits under drought and normal irrigation treatment. According to analysis of variance (ANOVA), significant mean squares for genotypes in wheat breeding and genetics reflect significant genetic variations among all studied plant materials, implying that genetic variables contribute meaningfully to traits like yield or its components. Additionally, it draws attention to the possibility of breeding better genotypes since notable variations suggest the existence of beneficial genetic diversity. Demonstrating that, the great variations among all genotypes were found in this concern.The significant genotype is in harmony with works by (Gomaa (2018) , Afiah *et al.* (2019), El-Hosary *et al.* (2019) and El-Safy *et al.* 2020))

Table 4. Ordinary and combining ability mean squares for all studied traits under drought stress (D) and normal irrigation (N).

Source of variance	d.f.	Plant height (cm)	spike length (cm)	Number of spike plant^{-1}	Number of kernel spike^{-1}	1000-kernal weight (gm)	Grain yield plant^{-1} (gm)
				drought stress environment			
Replication	2	0.05	0.14	8.87	10.4	3.99	11.99
Genotypes	44	167.07**	5.08**	53.42**	524.01**	68.48**	829.65**
Parent (P)	8	203.37**	4.65**	24.06**	608.60**	54.15**	763.51**
Cross (C)	35	150.11**	5.26**	60.75**	517.61**	72.42**	853.48**
P vs C	1	470.40**	2.27*	31.78**	71.29**	45.01**	524.79**
Error	88	1.37	0.93	2.72	6.43	2.08	26.12
GCA	8	201.61**	0.83**	14.95**	374.09**	38.79**	303
SCA	36	23.26**	1.89**	18.44**	130.35**	19.28**	270.67**
Error	88	0.46	0.31	0.91	2.14	0.69	8.71
GCA/SCA		8.67	0.44	0.81	2.87	2.01	1.12
				normal environment			
Replication	2	3.94	1.69	0.94	1.68	0.37	33.42
Genotypes	44	139.75**	6.92**	137.05**	475.65**	102.82**	2437.94**
Parent (P)	8	59.00**	8.40**	19.17**	543.71**	68.16**	1376.18**
Cross (C)	35	160.50**	6.51**	163.56**	470.19**	108.77**	2743.49**
P vs C	1	59.34**	9.34**	152.54**	122.20**	171.59**	237.96*
Error	88	2.33	0.98	2.14	7.64	2.47	35.1
GCA	8	118.84**	3.37**	47.82**	328.05**	488.79**	1444.69**
SCA	36	30.53**	2.07**	45.21**	120.88**	88.94**	672.19**
Error	88	0.78	0.33	0.71	2.55	0.82	11.7
GCA/SCA		3.89	1.63	1.06	2.71	5.5	2.15

The significant at the 0.05 and 0.01 probability levels are denoted by the symbols * and **, respectively.

For yield and its components under normal irrigation and drought, mean squares attributed to parents vs crosses as a measure of overall heterosis were significant (Table 4). Such results indicate that heterosis effects were affected by genetic diversity among parents and agree with those obtained by El Shal (2011), Kalhoro *et al.* (2015) ,Fareed, *et al.* (2024).

Mean performance of the tested wheat parents and its crosses among them under drought condition and normal irrigation for plant height, spike length, number of spikes plant^{-1} and number of kernels spike^{-1}, 1000-kernal weight (gm) and grain yield plant-1 (gm) are presented in Table 5.

The parent Yakora Rojo (P_1) gave the lowest significant mean value for plant height under drought environment. Meanwhile, L 150 (P9), the crosses P1xP3, P1xP4, P1xP5, P1xP6, P1xP8, P1xP9 give the lowest values for plant height under both environments (Table 5). Wheat genotypes that are short, sometimes known as dwarf or semi-dwarf genotypes, have a number of important advantages. A higher harvest index is typically found in shorter plants, indicating that a greater percentage of the biomass in the plant is used to produce grains as opposed to straw. Grain yields are frequently increased as a result. Additionally, they are less likely to lodge—fall over—due to the weight of the grain or bad weather. This stability lowers crop loss and increases harvesting efficiency. Improved resource use efficiency: Dwarf cultivars perform better in a variety of environmental circumstances because they often use water, nutrients, and sunshine more effectively. Enhanced Harvest Efficiency: Because shorter plants tend to tangle less and are generally easier to cut and process, harvesting is easier and more efficient with shorter plants (El-Hosary et al. (2019) and El-Safy et al. (2020)).

Table 5. Mean performance of the tested wheat parents and its crosses among them under drought condition and normal irrigation for all studied traits as well as the heterosis relative to mid and better parent for grain yield plant^{-1}.

Genotypes	Traits							
	Plant height (cm)		spike length (cm)		Number of spike plant-1		Number of kernel spike-1	
	D	N	D	N	D	N	D	N
YakoraRojo (P1)	97.33	130.00	17.00	18.67	21.00	25.00	29.91	33.87
Giza171 (P2)	120.33	125.00	18.00	20.67	26.33	29.00	58.25	60.95
Misr3 (P3)	118.00	127.67	17.33	20.00	23.33	27.33	45.43	71.32
Sids 14 (P4)	121.00	131.00	19.33	23.33	21.00	25.67	52.51	54.90
Gemmiza12 (P5)	122.67	125.00	20.33	22.67	24.67	30.00	71.85	82.13
Sakha95 (P6)	122.00	128.67	19.67	20.67	29.00	33.00	46.10	67.49
L 125 (P7)	113.67	126.00	17.67	18.33	26.33	26.67	62.75	66.95
L 137 (P8)	109.67	120.00	19.33	19.67	21.67	29.67	50.60	64.37
L 150 (P9)	110.67	117.67	20.00	21.33	22.00	26.67	76.04	54.59
P1xP2	114.67	126.00	17.33	19.33	19.67	26.00	57.86	79.43
P1xP3	104.00	112.00	18.00	19.67	21.67	27.33	49.57	63.87
P1xP4	107.33	109.00	20.00	21.00	24.33	36.00	55.76	62.69
P1xP5	107.67	108.67	19.00	19.67	33.00	42.67	49.95	57.61
P1xP6	106.67	110.00	19.33	22.00	27.67	32.00	42.86	53.04
P1xP7	121.67	123.33	19.33	21.33	23.67	31.33	50.59	54.26
P1xP8	113.33	114.67	18.67	19.00	29.33	46.00	46.36	46.92
P1xP9	106.67	113.33	18.33	19.67	23.00	32.00	49.50	51.60
P2xP3	124.00	129.67	17.67	19.33	20.33	34.67	56.20	67.75
P2xP4	126.33	130.00	19.67	21.67	31.00	34.67	67.60	80.80
P2xP5	118.00	123.00	21.33	23.00	23.33	38.00	74.78	76.23
P2xP6	130.00	130.67	18.67	21.67	17.33	24.33	49.28	63.07
P2xP7	128.33	135.00	19.67	20.67	18.67	18.67	67.98	82.09
P2xP8	124.00	127.67	18.67	20.67	17.67	20.00	38.83	49.34
P2xP9	119.33	122.00	18.33	20.67	28.33	30.67	48.21	75.07
P3xP4	124.33	125.00	20.33	23.33	26.33	33.67	47.94	85.14
P3xP5	123.33	124.33	18.67	21.00	23.00	40.00	48.05	54.83
P3xP6	127.67	130.00	19.00	20.33	27.33	40.67	19.20	71.13
P3xP7	130.00	132.33	20.67	20.33	19.33	41.67	68.50	78.42
P3xP8	118.00	124.00	17.67	19.00	20.33	33.67	72.71	75.58
P3xP9	117.67	118.00	18.00	19.00	25.33	42.67	65.65	82.44
P4xP5	120.33	122.33	18.33	19.00	22.33	29.33	53.55	63.05
P4xP6	113.33	122.00	18.00	20.33	22.67	27.00	50.93	60.39
P4xP7	131.00	133.33	18.33	18.67	25.00	32.67	66.61	73.80
P4xP8	125.00	127.00	16.67	18.67	29.67	32.00	35.52	51.32
P4xP9	122.67	123.00	16.67	17.67	23.00	27.33	59.21	65.50
P5xP6	120.00	123.00	20.33	21.67	23.67	25.67	22.51	29.40
P5xP7	127.00	130.67	16.67	18.67	17.67	23.33	69.43	70.26
P5xP8	120.67	124.33	15.33	17.00	24.33	25.33	37.08	46.49
P5xP9	119.33	125.00	17.33	18.67	16.33	21.67	57.93	70.62
P6xP7	121.33	137.33	16.67	18.00	17.67	26.33	53.54	54.48
P6xP8	122.00	124.00	19.67	21.33	19.67	21.67	51.17	59.46
P6xP9	115.00	130.67	17.67	18.67	24.33	39.67	63.06	63.80
P7xP8	122.33	132.33	18.33	19.00	13.67	21.00	50.95	53.35
P7xP9	121.33	121.67	18.33	19.67	20.33	27.67	71.41	75.22
P8xP9	115.00	119.00	16.33	18.33	16.67	20.33	38.12	62.81
Mean of parents	115.04	125.67	18.74	20.59	23.93	28.11	54.83	61.84
Mean of crosses	119.70	124.01	18.42	19.94	22.71	30.77	53.01	64.20
Mean of Genotypes	118.77	124.34	18.48	20.07	22.96	30.24	53.37	63.73
LSD 5%	1.90	2.48	1.56	1.61	2.68	2.37	4.12	7.58
LSD 1%	2.52	3.28	2.07	2.13	3.55	3.14	5.45	10.04

Table 5. Cont.

Genotypes	1000-kernel weight (gm)		Grain yield plant-1 (gm)		Heterosis for grain yield plant-1 relative to			
					Mid Parent		Better parent	
	D	N	D	N	D	N	D	N
YakoraRojo (P1)	50.70	54.97	31.82	46.53				
Giza171 (P2)	45.27	49.47	71.42	83.34				
Misr3 (P3)	42.20	54.20	52.25	89.94				
Sids 14 (P4)	49.47	58.13	56.90	78.13				
Gemmiza12 (P5)	49.90	50.27	88.46	123.48				
Sakha95 (P6)	45.23	54.33	72.43	100.56				
L 125 (P7)	41.83	49.67	69.49	87.11				
L 137 (P8)	41.67	46.80	57.85	70.21				
L 150 (P9)	38.77	42.53	56.24	71.11				
P1xP2	36.97	49.80	57.58	74.66	11.54**	14.98**	-19.38**	-10.42**
P1xP3	43.43	44.67	47.20	75.21	12.29**	10.22**	-9.66**	-16.38**
P1xP4	35.23	36.20	53.74	72.57	21.16**	16.43**	-5.54*	-7.12**
P1xP5	40.97	44.93	77.99	95.34	29.69**	12.16**	-11.83**	-22.79**
P1xP6	36.30	36.50	43.13	61.58	-17.27**	-16.27**	-40.46**	-38.77**
P1xP7	52.27	56.90	67.57	89.93	33.39**	34.58**	-2.76	3.23*
P1xP8	44.43	46.23	70.95	98.31	58.25**	68.43**	22.64**	40.02**
P1xP9	32.20	37.70	42.83	53.13	-2.72	-9.67**	-23.84**	-25.28**
P2xP3	43.67	51.00	58.02	102.74	-6.17**	18.58**	-18.76**	14.23**
P2xP4	45.67	53.13	95.58	148.75	48.97**	84.25**	33.83**	78.49**
P2xP5	47.30	51.37	82.01	148.92	2.59	44.01**	-7.29**	20.6**
P2xP6	51.63	55.13	44.60	84.57	-37.99**	-8.03**	-38.43**	-15.9**
P2xP7	45.53	57.60	58.15	87.93	-17.46**	3.17*	-18.58**	0.94
P2xP8	37.57	50.23	32.68	39.06	-49.43**	-49.13**	-54.24**	-53.14**
P2xP9	44.60	46.10	67.88	94.33	6.35**	22.15**	-4.95**	13.19**
P3xP4	45.60	54.57	68.88	130.74	26.22**	55.57**	21.06**	45.35**
P3xP5	45.20	53.73	59.30	99.33	-15.71**	-6.92**	-32.96**	-19.56**
P3xP6	51.73	57.73	40.15	113.16	-35.59**	18.8**	-44.57**	12.53**
P3xP7	45.63	46.63	69.81	132.31	14.69**	49.45**	0.46	47.1**
P3xP8	41.87	46.60	61.70	117.22	12.08**	46.38**	6.65**	30.33**
P3xP9	39.30	40.73	67.61	137.86	24.64**	71.2**	20.21**	53.27**
P4xP5	42.47	44.67	59.07	70.14	-18.72**	-30.42**	-33.22**	-43.2**
P4xP6	40.83	40.90	46.94	66.69	-27.42**	-25.36**	-35.2**	-33.68**
P4xP7	52.20	55.07	91.25	125.26	44.39**	51.6**	31.31**	43.79**
P4xP8	45.47	51.10	47.55	83.92	-17.13**	13.14**	-17.81**	7.41**
P4xP9	39.37	44.00	59.09	71.15	4.46*	-4.65**	3.85	-8.94**
P5xP6	44.83	54.40	23.75	40.65	-70.47**	-63.71**	-73.15**	-67.08**
P5xP7	49.57	50.17	60.41	81.96	-23.51**	-22.17**	-31.71**	-33.63**
P5xP8	46.33	47.57	41.92	56.01	-42.69**	-42.17**	-52.61**	-54.64**
P5xP9	39.47	43.83	41.40	61.12	-42.77**	-37.19**	-53.2**	-50.51**
P6xP7	46.10	52.57	49.52	66.55	-30.22**	-29.08**	-31.63**	-33.82**
P6xP8	43.97	47.13	47.15	56.53	-27.62**	-33.8**	-34.91**	-43.79**
P6xP9	41.47	55.13	84.57	104.64	31.44**	21.9**	16.75**	4.05**
P7xP8	49.57	51.93	35.86	55.40	-43.67**	-29.57**	-48.39**	-36.4**
P7xP9	39.33	43.40	62.64	81.78	-0.36	3.37*	-9.86**	-6.13**
P8xP9	40.10	40.63	31.49	41.76	-44.79**	-40.9**	-45.56**	-41.27**
Mean of parents	45.00	51.15	61.87	83.38				
Mean of crosses	43.56	48.33	56.94	86.70				
Mean of Genotypes	43.85	48.90	57.93	86.04				
LSD 5%	2.34	2.55	8.29	9.61				
LSD 1%	3.10	3.38	10.99	12.74				

The significant at the 0.05 and 0.01 probability levels are denoted by the symbols * and **, respectively.

The most desirable genotypes for spike length were detected by Gemmiza12 (P5), P2xP5 and P3xP4 under drought stress and normal irrigation. The highest values for spike length were detected by Sakha95 (P6), P1xP5 and P2xP4 under drought stress environment and Sakha95 (P6), P1xP5, P1xP5 and P1xP8 under normal irrigation. The parental variety Gemmeiza 12 (P$_5$) gave the highest values for number of kernels spike^{-1} reached 71.85 and 82.13 under drought and normal irrigation, respectively. However the crosses P2xP5 and P3xP8 under drought stress and P1xP2, P2xP4, P2xP7, P3xP4, P3xP7 and P3xP9 at normal irrigation exhibited the highest mean values for this trait.

As for 1000-kernel weight, the heaviest 1000-kernel weight was detected by YakoraRojo (P1), P1xP7, P2xP6, P3xP6 and P4xP7 under drought stress. Meanwhile, Sids 14 (P4), P1xP7, P2xP6, P2xP7, P3xP6, P4xP7 and P6xP9 gave the highest mean values for 1000-kernel weight under normal irrigation.

Regarding, grain yield plant-1 (gm) (Table 4), Gemmiza12 (P5) gave the highest values recording 88.46 gm and 123.48 gm under drought stress and normal irrigation, respectively. Meanwhile, the most desirable high yield plant-1 were detected by P2xP4 and P4xP7 under drought stress and the crosses P2xP4, P2xP5, P3xP4, P3xP7, P3xP9 and P4xP7 at normal irrigation.

Regarding heterosis for grain yield plant^{-1} (Table 5), fifteen and twenty crosses exhibited significant and positive mid-parent heterosis under drought stress and normal irrigation, respectively. Also, seven and fourteen crosses showed considerable and positive heterosis in relative to the better parent. However, the cross P2 x P4 under drought conditions and normal environment showed the most desired heterotic benefits relative to both mid- and better-parent. In comparison to the mid-parent and better-parent, this cross (P2 x P4) showed the greatest significant and positive heterosis, reached 48.97**, 84.25** and 68.63**, 33.83 in each of the two environments, respectively. El-Shal (2011) observed significant and beneficial heterosis effects for grain yield/plant when compared to the mid parent and better parent.

Combining ability:

Table 4 presents the analysis of variance for the combining ability of all studied traits under normal irrigation and drought treatment. For every characteristic under study in contexts, the both type of combining ability general (GCA) and specific (SCA) mean squares were very significant. These findings suggested that the inheritance of these qualities depends on both kinds of combining ability. Additionally, for every characteristic under study, GCA to SCA ratios were more than unity, with the exception of spike length and number of spike plants per plant. This indicates that additive and additive x additive kinds of gene action play a greater role in determining these traits than non-additive gene action. It was previously established that additive effects for yield and its components were mostly responsible for the genetic variance according El Shal (2011), El Hosary *et al* (2012), Gomaa *et al* (2014), Kalhoro *et al.* (2015), Fouad *et al.* (2022), Fareed *et al.* (2024).

General combining ability effects (ĝi):

Estimations of G.C.A effects (ĝi) for each parental genotype for individual trait under drought treatment and normal irrigation are showed in Table 6.

Results showed that the parental genotype P_1(Yakora) had desirable ĝi effect for number of spikes per plant in drought condition and normal irrigation, On the other hand, it had an unfavorable effect in some circumstances.

The parent number 2 (Giza171) had significant positive ĝi effect for plant height, number of kernels per spike and grain yield per plant in both environments; spike length and 1000- kernel weight in normal irrigation, seemed to be the best general combiner for grain yield plant^{-1} under drought condition indicating that (Giza171) could be considered as a good combiner for this traits. On the other hand, it had an unfavorable effect in some circumstances.

The parent P_3 (Misr3) had significant $\hat{g}_i$ effect for plant height in all environments and number of spikes per plant , no of kernels per plant and grain yield per plant in normal irrigation. The parental P_3 seemed to be the best general combiner for grain yield since it gave the highest significant and positive ĝi effects in normal irrigation.

The parental variety P_4 (Sids14) expressed significant and positive ĝi effects for plant height, 1000 kernel weight and grain yield per plant in both environments, spike length in normal irrigation treatment, and no of spikes per plant under stress condition.

The parent P_5(Gemmiza12) showed significant positive effects $\hat{g}_i$ for 1000-kernel weight and grain yield per plant under both conditions and exhibited significant positive $\hat{g}_i$ effects for plant height under drought condition.

The parental variety P_6 (Sakha95) expressed significant and positive ĝi effects for plant height,1000 kernel weight in all environments, spike length in normal irrigation, and no of spikes per plant under drought condition.

The parental variety P_7 (line 125) seemed to be the best general combiner for plant height and 1000 kernel weight since it gave the highest significant and positive ĝi effects for this trait under all environments. Moreover, the parent (P_7) expressed the highest significant and positive ĝi effects for no of kernels per spike under drought stress.

The parental variety P_8 (Line 137) expressed significant and positive ĝi effects for 1000 kernel weight under normal irrigation treatment.

The parental variety P_9 (Line 150) ranked the second best general combiner for no of kernels per spike under drought stress condition.

In summary, the parental variety P7 (line 125) was the best general combiner for plant height, no of kernels per spike, and 1000 kernel weight, while the parental variety 3 (Misr3) appeared to be the best general combiner for the number of spikes per plant and grain yield plant^{-1}.

Specific combining ability effects (ŝij):

Table 7 presents specific combining effects for all studied traits in both studied environments. For plant height, nineteen and fourteen crosses exhibited positive and significant ŝij effects in drought and normal environment, respectively. Moreover, the cross P_1 x P_7 gave the high useful ŝij effects for plant height in drought stress, and the cross P_6 x P_7 in normal irrigation treatment. However, the cross P_4 x P_6 gave negative and significant ŝij effects for plant height in drought condition being -8.79**. For spike length, five crosses in normal irrigation treatment expressed significant and positive ŝij effects. Moreover, the cross P_3 x P_4 gave the most desirable ŝij effects for this trait in normal irrigation (2.57**). For number of spikes per plant, eleven and fourteen crosses expressed significant and positive ŝij effects in drought stress and normal irrigation. However, the best ŝij effects were detected for the cross P_1 x P_5 (8.39**) in drought treatment, and P_1 x P_8 in normal irrigation being 15.95**. Regarding number of kernels per spike, sixteen and twelve crosses combinations expressed significant and positive ŝij effects in drought stress, and normal irrigation, respectively. The cross P_3 x P_8 gave the most desirable ŝij effects for number of kernels per spike in drought treatment being 26.32**. While, the cross P_1 x P_2 gave the most desirable ŝij effects for this trait in normal irrigation (19.5**). Eight and sixteen crosses combinations exhibited significant and positive ŝij effects for 1000- kernel weight in stress and non-stress environment, respectively. However, the cross combination P_6 x P_7 gave significant and positive ŝij effects for 1000 kernel weight in drought stress and normal irrigation being 7.5** and 22.84**, respectively. Eleven and fourteen crosses expressed significant and positive ŝij effects for grain yield/ plant in stress and non-stress condition, respectively. However, the cross P_6 x P_9 gave the best ŝij effects in stress condition recorded 32.27**. Also, the cross P_2 x P_5 (51.31**) gave the most desirable ŝij effects for grain yield per plant in normal irrigation treatment. One may draw the conclusion that the aforementioned cross combinations could be useful in breeding initiatives aimed at creating pure line varieties with high grain yields per plant in drought-prone environments.

Table 6. Estimates of general combining ability effects for all studied traits under drought stress (D)and normal irrigation (N) .

Parent	Plant height		Spike length		No. of Spike per plant		No. of Kernel per spike		1000 kernel weight		Grain yield per plant	
	D	N	D	N	D	N	D	N	D	N	D	N
G1 (YakoraRojo)	-10.09**	-6.04**	0.130	-0.150	1.34**	1.91**	-6.50**	-9.10**	-1.39**	-16.79**	-5.68**	-13.32**
G2 (Giza171)	3.42**	2.78**	0.430	0.70**	-0.050	-1.58**	3.95**	5.31**	0.450	0.83**	5.66**	7.93**
G3 (Misr3)	1.57**	0.66**	-0.420	0.120	0.070	4.24**	-1.37**	7.68**	0.210	0.470	0.010	20.74**
G4 (Sids 14)	2.24**	0.93**	0.370	0.58**	1.53**	0.150	0.760	1.380	0.66**	3.41**	5.35**	5.92**
G5 (Gemmiza12)	1.27**	-1.10**	0.460	0.300	0.310	0.330	2.11**	-0.410	1.59**	2.99**	4.16**	3.64**
G6 (Sakha95)	1.12**	1.96**	-0.050	0.42**	0.80**	0.090	-8.09**	-4.32**	0.80**	4.53**	-4.76**	-5.90**
G7 (L 125)	3.88**	4.96**	-0.540	-0.70**	-1.90**	-2.40**	8.25**	3.50**	2.31**	5.02**	5.19**	3.18**
G8 (L 137)	-0.73**	-0.95**	-0.240	-0.76**	-1.35**	-2.09**	-5.62**	-5.75**	-0.53*	1.52**	-9.28**	-15.61**
G9 (L 150)	-2.67**	-3.22**	-0.140	-0.52**	-0.75**	-0.64**	6.49**	1.72*	-4.10**	-1.98**	-0.640	-6.58**
L.S.D gi 0.05	0.380	0.490	0.680	0.320	0.530	0.470	0.820	1.510	0.470	0.510	1.650	2.000
L.S.D gi 0.0	0.500	0.650	0.900	0.420	0.700	0.620	1.080	1.990	0.610	0.670	2.170	2.630
L.S.D gi-gj 0.05	0.570	0.740	1.020	0.480	0.800	0.710	1.230	2.270	0.700	0.760	2.470	3.000
L.S.D gi-gj 0.01	0.750	0.970	1.350	0.630	1.050	0.930	1.620	2.980	0.920	1.000	3.250	3.950

The significant at the 0.05 and 0.01 probability levels are denoted by the symbols * and **, respectively.

Table 7. Estimates of specific combining ability effects for all studied traits under normal irrigation (N) and drought stress (D).

Crosses	Plant height		Spike length		No. of Spike per plant		No. of Kernel per spike		1000 kernel weight		Grain yield per plant	
	D	N	D	N	D	N	D	N	D	N	D	N
P1xP2	2.57**	4.92**	-1.48	-1.28*	-4.58**	-4.56**	7.03**	19.50**	-5.94**	-25.87**	-0.11	-5.99
P1xP3	-6.25**	-6.96**	0.03	-0.37	-2.70**	-9.05**	4.07**	1.56	0.76	-25.43**	-4.84	-18.23**
P1xP4	-3.58**	-10.24**	1.24	0.51	-1.49	3.71**	8.12**	6.68**	-7.89**	3.75**	-3.63	-6.06
P1xP5	-2.28**	-8.54**	0.15	-0.55	8.39**	10.19**	0.96	3.39	-3.08**	12.91**	21.81**	18.99**
P1xP6	-3.13**	-10.27**	1	1.66**	2.57**	-0.23	4.07**	2.74	-6.96**	2.93**	-4.14	-5.24
P1xP7	9.12**	0.07	1.48	2.12**	1.27	1.59*	-4.54*	-3.87	7.50**	22.84**	10.35**	14.04**
P1xP8	5.39**	-2.69**	0.52	-0.16	6.39**	15.95**	5.10**	-1.95	2.51**	15.68**	18.20**	41.21**
P1xP9	0.66	-1.75*	0.09	0.27	-0.55	0.5	-3.87**	-4.75	-6.16**	10.64**	-8.55**	-13.00**
P2xP3	0.24	1.88*	-0.61	-1.55**	-2.64**	1.77*	0.24	-8.97**	-0.85	3.87**	-5.36*	-11.96**
P2xP4	1.90**	1.95*	0.61	0.33	6.57**	5.86**	9.51**	10.38**	0.7	3.05**	26.86**	48.86**
P2xP5	-5.46**	-3.02**	2.18	1.93**	0.12	9.01**	15.34**	7.61**	1.41	1.71*	14.49**	51.31**
P2xP6	6.69**	1.58	0.03	0.48	-6.37**	-4.41**	0.04	-1.65	6.53**	3.94**	-14.00**	-3.51
P2xP7	2.27**	2.92**	1.52	0.6	-2.34**	-7.59**	2.4	9.56**	-1.08	5.91**	-10.41**	-9.22**
P2xP8	2.54**	1.49	0.21	0.66	-3.88**	-6.56**	-12.88**	-13.94**	-6.20**	2.05*	-21.40**	-39.30**
P2xP9	-0.19	-1.90*	-0.21	0.42	6.18**	2.65**	-15.61**	4.31	4.40**	1.41	5.16	6.94*
P3xP4	1.75**	-0.93	2.12	2.57**	1.78*	-0.96	-4.83**	12.35**	0.88	4.85**	5.82*	18.04**
P3xP5	1.72**	0.43	0.36	0.51	-0.34	5.19**	-6.07**	-16.16**	-0.45	4.44**	-2.57	-11.09**
P3xP6	6.21**	3.04**	1.21	-0.28	3.51**	6.10**	-24.72**	4.04	6.87**	6.90**	-12.80**	12.29**
P3xP7	5.78**	2.37**	-3.30**	0.84	-1.79*	9.59**	8.24**	3.51	-0.74	-4.69**	6.90*	22.36**
P3xP8	-1.61**	-0.05	0.06	-0.43	-1.34	1.28	26.32**	9.92**	-1.66*	-1.22	13.26**	26.06**
P3xP9	-0.01	-3.78**	0.3	-0.67	3.05**	8.83**	7.16**	9.31**	-0.66	-3.59**	10.53**	37.67**
P4xP5	-1.95**	-1.84*	-0.76	-1.95**	-2.46**	-1.38	-2.70*	-1.64	-3.63**	-7.57**	-8.14**	-25.46**
P4xP6	-8.79**	-5.24**	-0.58	-0.73	-2.61**	-3.47**	4.88**	-0.4	-4.48**	-12.88**	-11.35**	-19.37**
P4xP7	6.12**	3.10**	0.24	-1.28*	2.42**	4.68**	4.22**	5.19*	5.38**	0.79	23.00**	30.12**
P4xP8	4.72**	2.67**	-1.73	-1.22*	6.54**	3.71**	-13.00**	-8.04**	1.49	0.33	-6.23*	7.57*
P4xP9	4.33**	0.95	-1.82	-2.46**	-0.73	-2.41**	-1.43	-1.34	-1.04	-3.27**	-3.32	-14.23**
P5xP6	-1.16	-2.21**	1.67	0.87	-0.4	-4.99**	-24.88**	-29.60**	-1.41	1.05	-33.35**	-43.13**
P5xP7	3.08**	2.46**	-1.52	-1.01	-3.70**	-4.84**	5.69**	3.44	1.82*	-3.68**	-6.65*	-10.90**
P5xP8	1.36*	2.04*	-3.15**	-2.61**	2.42**	-3.14**	-12.79**	-11.08**	1.43	-2.77**	-10.66**	-18.06**
P5xP9	1.96**	4.98**	-1.24	-1.19*	-6.19**	-8.26**	-4.05**	5.58*	-1.87*	-3.01**	-19.82**	-21.98**
P6xP7	-2.43**	6.07**	-1	-1.79**	-4.19**	-1.59*	0	-8.43**	-0.86	-2.82**	-8.62**	-16.77**
P6xP8	2.84**	-1.36	1.7	1.60**	-2.73**	-6.56**	11.50**	5.81*	-0.15	-4.75**	3.48	-8.00*
P6xP9	-2.22**	7.58**	-0.39	-1.31*	1.33	9.98**	11.28**	2.67	0.92	6.75**	32.27**	31.08**
P7xP8	0.42	3.98**	0.85	0.39	-6.04**	-4.75**	-5.06**	-8.12**	3.94**	-0.44	-17.76**	-18.20**
P7xP9	1.36*	-4.42**	0.76	0.81	0.02	0.47	3.29*	6.27*	-2.72**	-5.48**	0.38	-0.86
P8xP9	-0.37	-1.18	-1.55	-0.46	-4.19**	-7.17**	-16.13*	3.11	0.89	-4.74**	-16.29**	-22.08**
LSD5%(sij)	1.22	1.59	2.2	1.03	1.72	1.52	2.64	4.86	1.5	1.63	5.3	6.44
LSD1%(sij)	1.6	2.09	2.89	1.36	2.26	2	3.47	6.39	1.97	2.15	6.97	8.47
LSD5%(sij-sik)	1.8	2.34	3.24	1.52	2.53	2.24	3.89	7.16	2.21	2.41	7.82	9.49
LSD1%(sij-sik)	2.36	3.08	4.26	2	3.33	2.95	5.11	9.42	2.91	3.17	10.28	12.48
LSD5%(sij-skl)	1.7	2.22	3.07	1.44	2.4	2.13	3.69	6.8	2.1	2.28	7.42	9.01
LSD1%(sij-skl)	2.24	2.92	4.04	1.9	3.16	2.8	4.85	8.93	2.76	3	9.75	11.84

The significant at the 0.05 and 0.01 probability levels are denoted by the symbols * and **, respectively.

Susceptibility index:

Analysis of Variance and mean performance

Table 8 presents the analysis of variance for the yield and yield component susceptibility index (SI). For all traits, genotype, parents, and parent vs crosses were shown to have highly significant mean squares. These findings show how diverse all of the wheat genotypes in these studies are.

Table 8. Observed mean squares from ordinary analysis of variance for susceptibility index (SI) of yield and its components.

S.O.V.	d.f	Plant height	spike length	Number of spike / plant	Number of kernel / spike	1000- kernel weight (gm)	Grain yield per plant in gm
Replication	2	0.002	0.001	0.021*	0.001	0.001	0.004
Genotypes	44	0.006**	0.008	0.046**	0.079**	0.015**	0.040**
Parent	8	0.014**	0.012	0.015**	0.143**	0.012**	0.021**
Cross	35	0.003**	0.007	0.049**	0.063**	0.016**	0.043**
Par.vs.cr.	1	0.053**	0.011	0.200**	0.108**	0.012*	0.098**
Error	88	0.0002	0.014	0.005	0.008	0.002	0.007
GCA	8	0.002**	0.003	0.016**	0.044**	0.004**	0.033**
SCA	36	0.002**	0.003	0.015**	0.022**	0.005**	0.009**
Error	88	0.0002	0.005	0.002	0.003	0.001	0.002
GCA/SCA		1.229	1.31	1.012	1.996	0.691	3.584

*** and ** refer to the significant at 0.05 and 0.01 levels of probability, respectively.**

Table 9 displays the average performance of the nine parents as well as their crosses of SI wheat. Based on plant height and 1000 kernel weight, Gemmiza12 (P5) produced the desired susceptibility index (SI), according to the results. When it came to grain production per plant, parent Giza171 (P2) appeared to be the best parent. P7, or Parent Line 125, provided the desired SI for the quantity of spikes per plant. The ideal parent in terms of spike length was Parent Line 137 (P8). Regarding the quantity of kernels per spike, Parent L 150 (P9) appeared to be the optimal parent.

Table 9 displays the average susceptibility index performance for 36 cross combinations. The crosses P2 x P6, P3 x P9, and P4 x P9 exhibited the best susceptibility index of stress irrigation in terms of plant height. On the other hand, the P6 x P9 and P6 x P7 hybrids exhibited minimal stress irrigation SI. Given that they had the highest SI for spike length, the crossovers P1 x P8 and P4 x P7 appeared to be the best cross combinations. The cross combinations P2 x P7 exhibited the highest tolerance for stress watering in terms of the number of spikes per plant. Three crosses, P1 x P8, P5 x P7, and P6 x P9, exhibited the best susceptibility index of stress irrigation in terms of the quantity of kernels per spike. Given that they had the highest SI for this attribute, the cross P4 x P6 appeared to be the best cross combinations for 1000- kernel weight. The cross P4 x P5 for grain yield per plant was found to have the most ideal susceptibility index, according to the results.

Combining ability analysis:

Table 8 presents the analysis of variance for the combining ability for SI in yield and yield components. With the exception of spike length, all examined variables showed highly significant variations related to general and specialized combining abilities for SI. These findings suggested that the inheritance of susceptibility index for yield and yield components depends on both additive and non-additive gene action. With the exception of 1000-kernel weight, all attributes had ratios between GCA and SCA greater than unity, indicating that additive and additive x additive kinds of gene action play a greater role in determining these qualities than non-additive gene action. Similar results were reported by El- Borhamy (2000), El- Gamal (2001) and Wafaa, Hassan (2007).

Table 9. Mean performance for susceptibility index (SI) of all studied traits.

Crosses	Plant height	spike length	No. of spikes/ plant	No. of Kernels/ spike	1000 kernel weight	Grain yield plant-1
1x1	0.75	0.91	0.84	0.89	0.92	0.69
2x2	0.96	0.87	0.91	0.97	0.92	0.86
3x3	0.92	0.87	0.86	0.64	0.78	0.58
4x4	0.92	0.83	0.82	0.96	0.85	0.73
5x5	0.98	0.90	0.83	0.88	0.99	0.72
6x6	0.95	0.79	0.88	0.69	0.83	0.72
7x7	0.90	0.96	0.99	0.94	0.84	0.80
8x8	0.91	0.98	0.73	0.79	0.89	0.82
9x9	0.94	0.94	0.83	1.40	0.91	0.80
1x2	0.91	0.90	0.76	0.73	0.74	0.77
1x3	0.93	0.92	0.79	0.78	0.97	0.63
1x4	0.98	0.95	0.68	0.89	0.98	0.74
1x5	0.99	0.97	0.78	0.87	0.91	0.82
1x6	0.97	0.88	0.87	0.81	0.99	0.70
1x7	0.99	0.91	0.76	0.93	0.92	0.75
1x8	0.99	0.99	0.64	0.99	0.96	0.62
1x9	0.94	0.94	0.72	0.96	0.85	0.81
2x3	0.96	0.91	0.59	0.83	0.86	0.57
2x4	0.97	0.91	0.89	0.84	0.86	0.64
2x5	0.96	0.93	0.61	0.98	0.92	0.55
2x6	1.00	0.86	0.71	0.78	0.94	0.53
2x7	0.95	0.95	1.00	0.83	0.79	0.66
2x8	0.97	0.90	0.89	0.79	0.75	0.84
2x9	0.98	0.89	0.92	0.64	0.97	0.72
3x4	0.99	0.87	0.78	0.56	0.84	0.53
3x5	0.99	0.89	0.58	0.93	0.84	0.62
3x6	0.98	0.93	0.67	0.27	0.90	0.35
3x7	0.98	0.70	0.46	0.88	0.98	0.53
3x8	0.95	0.93	0.60	0.97	0.90	0.53
3x9	1.00	0.95	0.59	0.80	0.97	0.49
4x5	0.98	0.97	0.76	0.85	0.95	0.85
4x6	0.93	0.89	0.84	0.85	1.00	0.71
4x7	0.98	0.99	0.77	0.90	0.95	0.73
4x8	0.98	0.90	0.93	0.69	0.89	0.57
4x9	1.00	0.95	0.84	0.91	0.90	0.84
5x6	0.98	0.94	0.93	0.80	0.82	0.60
5x7	0.97	0.89	0.76	0.99	0.99	0.74
5x8	0.97	0.91	0.96	0.80	0.97	0.75
5x9	0.95	0.93	0.75	0.83	0.90	0.69
6x7	0.88	0.93	0.67	0.99	0.88	0.75
6x8	0.98	0.92	0.91	0.87	0.93	0.84
6x9	0.88	0.95	0.62	0.99	0.75	0.81
7x8	0.92	0.97	0.65	0.96	0.96	0.65
7x9	1.00	0.93	0.74	0.95	0.91	0.77
8x9	0.97	0.89	0.82	0.61	0.99	0.76
Mean of parents	0.92	0.89	0.85	0.90	0.88	0.75
Mean of crosses	0.97	0.92	0.76	0.83	0.91	0.68
Mean of Genotypes	0.96	0.91	0.78	0.85	0.90	0.69
LSD 5%	0.03	0.19	0.12	0.14	0.07	0.13
LSD 1%	0.04	0.26	0.15	0.19	0.10	0.17

General combining ability effects (ĝi):

Table 10 presents estimates of G.C.A effects (ĝi) for each parental genotype for SI in yield and yield components. For the other variables under study, the parental variety P2 showed considerable undesired (ĝi) effects in addition to desirable (ĝi) effects in terms of the number of spikes per plant. Plant height was significantly and positively influenced (ĝi) by the parent P3. When it came to plant height and the quantity of spikes per plant, the parent P4 showed notable and favorable (ĝi) benefits. It seems to be the most effective general combiner for these two qualities as a result. Given that it showed significant and positive (ĝi) impacts for plant height and 1000 kernel weight, the parental variety P5 was the best general combiner for these two parameters. P7, exhibited favorable significant (ĝi) effects in terms of the quantity of kernels per spike. Given that it showed the strongest significant and positive (ĝi) effects for both of these variables, the parent P9 appeared to be the greatest general combiner for the number of kernels per spike and grain production per plant.

Table 10. Estimates of general combining ability effects for susceptibility index (SI) of yield and its component .

parent	Plant height	spike length	No. of spikes/plant	No. of Kernels/spike	1000 kernel weight	Grain yield
g1	-0.033**	0.014	-0.009	0.024	0.015*	0.026*
g2	0.005*	-0.012	0.040**	-0.012	-0.033**	0.007
g3	0.007*	-0.026	-0.089**	-0.108**	-0.018*	-0.137**
g4	0.011**	-0.006	0.034**	-0.007	0.004	0.013
g5	0.019**	0.008	0.002	0.028*	0.026**	0.011
g6	-0.006*	-0.024	0.020	-0.069**	-0.012	-0.018
g7	-0.007*	0.006	0.002	0.075**	0.003	0.023
g8	0.001	0.023	0.009	-0.021	0.011	0.025
g9	0.003	0.016	-0.009	0.090**	0.004	0.050**
L.S.D gi 0.05	0.005	0.039	0.023	0.028	0.015	0.026
L.S.D gi 0.0	0.007	0.051	0.030	0.037	0.019	0.034
L.S.D gi-gj 0.05	0.008	0.058	0.034	0.043	0.022	0.039
L.S.D gi-gj 0.01	0.010	0.076	0.045	0.056	0.029	0.051

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

Specific combining ability effects (ŝij):

Table 11 presents specific combining effects for date SI in yield and yield components. The susceptibility index showed significant and favorable impacts for plant height, number of spikes per plant, number of kernels per spike, 1000 kernel weight, and grain yield per plant for fourteen, eight, ten, and five crossings, respectively.

The cross combination P1 x P7 for plant height, the cross P2 x P7 for number of spikes per plant, the cross P3 x P8 for number of kernels per spike, the cross P4 x P6 for 1000 kernel weight, and the cross P6 x P8 for grain yield per plant, however, showed the most desired ŝij effects (Table 11). Since SI values provide a measure of tolerance based on minimization of yield loss during stress rather than non-stress yield, it is possible to conclude that stress tolerant genotypes, as defined by SI values, do not necessarily have a high yield potential.

Assessment of drought tolerance in the tested wheat genotypes, using some drought tolerance indices:

To differentiate between drought resistant and / or tolerance, various selection indices have been employed to find drought-resistant genotypes in wheat, taking into account the potential for grain yield under both favorable and drought-stressed circumstances. Yildirim and Bahar (2010). Table 12 lists the following metrics: stress tolerance index (STI), yield index (YI), yield stability index (YSI), harmonic mean (HM), stress susceptibility index (SSI), sensitive drought index (SDI), and relative drought index (RDI).

In order to choose suitable cultivars under stressful and stress-free conditions, the STI was found to be a more useful index (Moghaddam and HadiZadeh, 2002). The genotypes cultivar Yakora, P2×P8, P5×P6, P7×P8, and P8×P9 showed the smallest STI and were the most susceptible genotypes, whereas P5 (Gemmiza 12), P6 (Sakha 95), P1×P5, P2×P4, P2×P5, P3×P4, P3×P7, P3×P9, P4×P7, and P6×P9 had the largest STI, YP, and YS, suggesting they might be the most promising tolerant. These results are consistent with the work of El-Hosary et al. (2019c), Eid and Sabry (2019), Abdelghany et al. (2016), and Farshadfar et al. (2018). In order to choose suitable cultivars under stressful and stress-free conditions, the STI was found to be a more useful index (Moghaddam and HadiZadeh, 2002). The genotypes cultivar Yakora, P2×P8, P5×P6, P7×P8, and P8×P9 showed the smallest STI and were the most susceptible genotypes, whereas P5 (Gemmiza 12), P6 (Sakha 95), P1×P5, P2×P4, P2×P5, P3×P4, P3×P7, P3×P9, P4×P7, and P6×P9 had the largest STI, YP, and YS, suggesting they might be the most promising tolerant. These results are consistent with the work of El-Hosary et al. (2019), Eid and Sabry (2019), Abdelghany et al. (2016), and Farshadfar et al. (2018).

Under stressful circumstances, genotypes with the greatest GMP and HM values were favored. The genotypes cultivar Yakora, P2×P8, P5×P6, and P8×P9 expressed the most sensitive genotypes, while genotypes P5 (Gemmiza 12), P6 (Sakha 95), P1×P5, P2×P4, P2×P5, P3×P4, P3×P7, P3×P8, P3×P9, P4×P7, and P6×P9 displayed the highest values for these indices, indicating that these genotypes are tolerant.

Genotypes P_5 (Gemmiza 12), $P_2 \times P_4$, $P_2 \times P_5$, $P_3 \times P_7$, $P_3 \times P_9$ and $P_4 \times P_7$ were drought tolerant genotypes based on STI, MP, GMP, and HM indices. The most vulnerable genotypes were P2×P8 and P5×P6, according to the same four indices for cultivar Yakora. Consequently, under both normal and drought-stressed conditions, STI, MP, GMP, and HM are thought to be more effective indices for identifying genotypes with high yields. Comparable outcomes were documented by Eid and Sabry (2019), Ali and El-Sadek (2016), and Mursalova *et al.* (2015).

The highest TOL values were related to genotypes P2×P4, P2×P5, P3×P4, P3×P6, P3×P7, P3×P8 and P3×P9 which recorded values of 53.18, 66.91, 61.86, 73.01, 62.5, 55.52 and 70.25, respectively. Therefore, high amount of TOL is a sign of genotypes susceptibility to stress (Parchin et al., 2013) and (Eid and Sabry 2019). While, P1×P9, P2×P8, P4×P5, P6×P8 and P8×P9which recorded low values 10.3, 6.37, 11.07, 9.38 and 10.27 were considered a tolerant genotypes. Similar results were found by Mahdi, Z. (2012) and Raman et al., (2012).

When compared to genotypes with stress susceptibility index values >1, those with SSI values < 1 could be regarded as drought resistant. The SSI varied from 0.43 for P2 to 1.96 for P3—P6, as seen in Table 16. The lowest values for P4×P5, P2×P8, P6×P8, P4×P9, P1×P5, P6×P9, and P1×P9 were 0.48, 0.5, 0.5, 0.55, 0.58, and 0.59, respectively. Therefore, compared to the other crosses, these ones were thought to be more drought-tolerant. The trend to SDI was the same for these current crosses. These findings are consistent with those of Kumar et al. (2012). Conversely, cross P3×P6, which has a high SSI value of 1.96, is only appropriate for typical irrigation circumstances and may be vulnerable to drought. These findings align with the same SDI trend. Abdi *et al.* (2013), Raman *et al.*, (2012), Eid and Sabry (2019) and Afiah *et al.* (2019) discovered similar outcomes.

Genotypes with highest YI values recoded for P_2, P_5, P_6, P_1×P_5, P_2×P_4, P_2×P_5, P_3×P_4, P_3×P_7, P_3×P_9, P_4×P_7 and P_6×P_9 (1.24, 1.53, 1.26, 1.35, 1.66, 1.42, 1.9, 1.21, 1.17, 1.58 and 1.47, respectively), indicating tolerant genotypes. Regarding to the highest YSI values were recorded for P_2, P_7, P_8, P_1×P_5, P_1×P_9, P_2×P_8, P_4×P_5, P_4×P_9, P_6×P_8 and P_6×P_9 (0.86, 0.80, 0.82, 0.82, 0.81, 0.84, 0.84, 0.83, 0.83 and 0.81, respectively). These current genotypes had the same tend to RDI. These finding are cooperated with Karimizadeh and Mohammadi (2011).

Table 11. Estimates of specific combining ability effects for susceptibility index (SI) of all studied traits.

Crosses	Plant height	spike length	No. of spikes/plant	No. of Kernel/spike	1000 kernel weight	Grain yield
P1xP2	-0.019*	-0.017	-0.050	-0.132**	-0.141**	0.046
P1xP3	-0.001	0.018	0.114**	0.013	0.075**	0.047
P1xP4	0.051**	0.032	-0.124**	0.025	0.056*	0.009
P1xP5	0.051**	0.037	0.006	-0.028	-0.030	0.090*
P1xP6	0.052**	-0.025	0.078*	0.005	0.090**	0.000
P1xP7	0.070**	-0.027	-0.009	-0.012	-0.001	0.009
P1xP8	0.064**	0.040	-0.139**	0.138**	0.034	-0.125**
P1xP9	0.015	-0.005	-0.039	-0.002	-0.066**	0.041
P1xP10	0.000	0.000	0.000	0.000	0.000	0.000
P2xP3	-0.012	0.039	-0.139**	0.101*	0.008	0.005
P2xP4	0.000	0.013	0.045	0.007	-0.013	-0.070
P2xP5	-0.021*	0.020	-0.204**	0.119*	0.026	-0.161**
P2xP6	0.040**	-0.016	-0.121**	0.015	0.080**	-0.153**
P2xP7	-0.004	0.044	0.184**	-0.082	-0.081**	-0.062
P2xP8	0.009	-0.020	0.060	-0.027	-0.132**	0.115**
P2xP9	0.014	-0.028	0.117**	-0.284**	0.095**	-0.028
P2xP10	0.000	0.000	0.000	0.000	0.000	0.000
P3xP4	0.021*	-0.011	0.061	-0.169**	-0.051*	-0.039
P3xP5	0.011	-0.004	-0.114**	0.157**	-0.067**	0.056
P3xP6	0.025**	0.070	-0.034	-0.399**	0.026	-0.184**
P3xP7	0.027**	-0.192**	-0.226**	0.065	0.093**	-0.050
P3xP8	-0.012	0.021	-0.094*	0.250**	0.007	-0.051
P3xP9	0.032**	0.046	-0.084*	-0.032	0.079**	-0.115**
P3xP10	0.000	0.000	0.000	0.000	0.000	0.000
P4xP5	-0.001	0.050	-0.051	-0.021	0.020	0.132**
P4xP6	-0.032**	0.002	0.014	0.074	0.106**	0.021
P4xP7	0.023**	0.072	-0.047	-0.013	0.039	0.002
P4xP8	0.017	-0.034	0.111**	-0.127**	-0.026	-0.162**
P4xP9	0.028**	0.021	0.041	-0.023	-0.014	0.083
P4xP10	0.000	0.000	0.000	0.000	0.000	0.000
P5xP6	0.007	0.041	0.129**	-0.007	-0.091**	-0.089*
P5xP7	0.004	-0.034	-0.019	0.037	0.057*	0.015
P5xP8	-0.005	-0.039	0.174**	-0.057	0.035	0.019
P5xP9	-0.023**	-0.006	-0.015	-0.140**	-0.030	-0.066
P5xP10	0.000	0.000	0.000	0.000	0.000	0.000
P6xP7	-0.060**	0.031	-0.128**	0.132**	-0.015	0.054
P6xP8	0.033**	0.012	0.107**	0.109*	0.033	0.137**
P6xP9	-0.073**	0.045	-0.170**	0.119*	-0.141**	0.087*
P6xP10	0.000	0.000	0.000	0.000	0.000	0.000
P7xP8	-0.026**	0.025	-0.137**	0.056	0.040	-0.091*
P7xP9	0.045**	-0.001	-0.034	-0.063	-0.002	0.001
P7xP10	0.000	0.000	0.000	0.000	0.000	0.000
P8xP9	0.006	-0.057	0.045	-0.311**	0.074**	-0.010
P8xP10	0.000	0.000	0.000	0.000	0.000	0.000
P9xP10	0.000	0.000	0.000	0.000	0.000	0.000
LSD5%(sij)	0.017	0.124	0.074	0.091	0.047	0.084
LSD1%(sij)	0.022	0.163	0.097	0.120	0.061	0.110
LSD5%(sij-sik)	0.025	0.183	0.109	0.135	0.069	0.124
LSD1%(sij-sik)	0.033	0.241	0.143	0.177	0.091	0.163
LSD5%(sij-skl)	0.024	0.174	0.103	0.128	0.065	0.117
LSD1%(sij-skl)	0.031	0.229	0.136	0.168	0.086	0.154

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

Table 12. Mean values of drought tolerance indices and grain yield under normal and drought stress conditions for 27 tested wheat genotypes over the two generations.

Genotypes	Yp	Ys	STI	MP	GMP	HARM	TOL	SSI	YI	YSI	SDI	RDI
1x1	46.53	31.82	0.20	39.18	38.48	37.79	14.71	0.96	0.55	0.68	0.32	1.02
2x2	83.34	71.42	0.80	77.38	77.15	76.92	11.92	0.43	1.24	0.86	0.14	1.28
3x3	89.94	52.25	0.63	71.10	68.55	66.10	37.70	1.27	0.91	0.58	0.42	0.87
4x4	78.13	56.90	0.60	67.52	66.67	65.85	21.24	0.83	0.99	0.73	0.27	1.09
5x5	123.48	88.46	1.48	105.97	104.51	103.08	35.02	0.86	1.53	0.72	0.28	1.07
6x6	100.56	72.43	0.98	86.50	85.35	84.21	28.13	0.85	1.26	0.72	0.28	1.07
7x7	87.11	69.49	0.82	78.30	77.80	77.31	17.62	0.61	1.20	0.80	0.20	1.19
8x8	70.21	57.85	0.55	64.03	63.73	63.43	12.36	0.53	1.00	0.82	0.18	1.23
9x9	71.11	56.24	0.54	63.68	63.24	62.81	14.87	0.64	0.97	0.79	0.21	1.18
1x2	74.66	57.58	0.58	66.12	65.56	65.01	17.08	0.69	1.00	0.77	0.23	1.15
1x3	75.21	47.20	0.48	61.21	59.58	58.00	28.01	1.13	0.82	0.63	0.37	0.94
1x4	72.57	53.74	0.53	63.16	62.45	61.75	18.83	0.79	0.93	0.74	0.26	1.10
1x5	95.34	77.99	1.00	86.67	86.23	85.80	17.35	0.55	1.35	0.82	0.18	1.22
1x6	61.58	43.13	0.36	52.35	51.53	50.73	18.45	0.91	0.75	0.70	0.30	1.04
1x7	89.93	67.57	0.82	78.75	77.95	77.16	22.36	0.76	1.17	0.75	0.25	1.12
1x8	98.31	60.95	0.81	79.63	77.41	75.25	37.36	1.15	1.06	0.62	0.38	0.92
1x9	53.13	42.83	0.31	47.98	47.71	47.43	10.30	0.59	0.74	0.81	0.19	1.20
2x3	102.74	58.02	0.81	80.38	77.21	74.16	44.73	1.32	1.01	0.56	0.44	0.84
2x4	148.75	95.58	1.92	122.17	119.24	116.38	53.18	1.09	1.66	0.64	0.36	0.96
2x5	148.92	82.01	1.65	115.47	110.51	105.77	66.91	1.36	1.42	0.55	0.45	0.82
2x6	84.57	44.60	0.51	64.58	61.41	58.40	39.97	1.44	0.77	0.53	0.47	0.79
2x7	87.93	58.15	0.69	73.04	71.51	70.00	29.79	1.03	1.01	0.66	0.34	0.99
2x8	39.06	32.68	0.17	35.87	35.73	35.59	6.37	0.50	0.57	0.84	0.16	1.25
2x9	94.33	67.88	0.87	81.11	80.02	78.95	26.45	0.85	1.18	0.72	0.28	1.07
3x4	130.74	68.88	1.22	99.81	94.90	90.22	61.86	1.44	1.19	0.53	0.47	0.79
3x5	99.33	59.30	0.80	79.32	76.75	74.27	40.02	1.22	1.03	0.60	0.40	0.89
3x6	113.16	40.15	0.61	76.66	67.41	59.27	73.01	1.96	0.70	0.35	0.65	0.53
3x7	132.31	69.81	1.25	101.06	96.11	91.40	62.50	1.43	1.21	0.53	0.47	0.79
3x8	117.22	61.70	0.98	89.46	85.04	80.84	55.52	1.44	1.07	0.53	0.47	0.78
3x9	137.86	67.61	1.26	102.73	96.54	90.72	70.25	1.55	1.17	0.49	0.51	0.73
4x5	70.14	59.07	0.56	64.61	64.37	64.13	11.07	0.48	1.02	0.84	0.16	1.26
4x6	66.69	46.94	0.42	56.81	55.95	55.10	19.75	0.90	0.81	0.70	0.30	1.05
4x7	125.26	91.25	1.54	108.25	106.91	105.58	34.01	0.82	1.58	0.73	0.27	1.09
4x8	83.92	47.55	0.54	65.73	63.17	60.70	36.37	1.32	0.82	0.57	0.43	0.84
4x9	71.15	59.09	0.57	65.12	64.84	64.56	12.06	0.51	1.02	0.83	0.17	1.24
5x6	40.65	23.75	0.13	32.20	31.07	29.99	16.90	1.26	0.41	0.58	0.42	0.87
5x7	81.96	60.41	0.67	71.18	70.36	69.55	21.55	0.80	1.05	0.74	0.26	1.10
5x8	56.01	41.92	0.32	48.97	48.46	47.95	14.09	0.76	0.73	0.75	0.25	1.12
5x9	61.12	41.40	0.34	51.26	50.30	49.36	19.71	0.98	0.72	0.68	0.32	1.01
6x7	66.55	49.52	0.45	58.04	57.41	56.79	17.03	0.78	0.86	0.74	0.26	1.11
6x8	56.53	47.15	0.36	51.84	51.62	51.41	9.38	0.50	0.82	0.83	0.17	1.24
6x9	104.64	84.57	1.20	94.60	94.07	93.54	20.07	0.58	1.47	0.81	0.19	1.20
7x8	55.40	35.86	0.27	45.63	44.57	43.54	19.54	1.07	0.62	0.65	0.35	0.97
7x9	81.78	62.64	0.69	72.21	71.57	70.94	19.14	0.71	1.09	0.77	0.23	1.14
8x9	41.76	31.49	0.18	36.63	36.27	35.91	10.27	0.75	0.55	0.75	0.25	1.12
Mean	86.04	57.71	0.72	71.87	70.16	68.53	28.33	0.94	1.00	0.69	0.31	1.03

Correlation analysis

To determine the best drought tolerant characteristics, the correlation coefficient between YP, YS, and other quantitative drought tolerance indices was calculated (table 13). YP and YS showed a positive and significant connection (r = 0.810**), indicating that high yielding genotypes can be chosen based on them in both stress and non-stress scenarios (Table 13).

Table 13. Grain yield correlation with drought indices for genotypes of wheat under normal and drought stress conditions.

	Yp m	Ys m	STI	MP	GMP	HM	TOL	SSI	YI	YSI	SDI	RDI
Yp m	1											
Ys m	0.810**	1										
STI	0.943**	0.928**	1									
MP	0.974**	0.921**	0.982**	1								
GMP	0.954**	0.948**	0.985**	0.997**	1							
HARM	0.927**	0.969**	0.981**	0.987**	0.997**	1						
TOL	0.842**	0.365*	0.643**	0.699**	0.641**	0.580**	1					
SSI	0.503**	-0.078	0.241	0.303*	0.233	0.162	0.870**	1				
YI	0.810**	1.000**	0.928**	0.921**	0.948**	0.969**	0.365*	-0.078	1			
YSI	-0.499**	0.082	-0.238	-0.300*	-0.229	-0.158	-0.868**	-1.000**	0.082	1		
SDI	0.499**	-0.082	0.238	0.300*	0.229	0.158	0.868**	1.000**	-.082	-1.000**	1	
RDI	-0.504**	0.077	-0.242	-0.304*	-0.234	-0.163	-0.870**	-1.000**	0.076	1.000**	-1.000**	1

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

On barley, Nazari and Pakniyat (2010) found similar outcomes. Stated differently, a useful criterion for selecting the best cultivars and indices for a given situation is to look for correlations between grain yield and drought tolerance indices. Grain yield under stress conditions (YS) was significantly and positively correlated with STI, MP, GMP, HM, TOL and YI reached, r=0.928**, r=0.921**, 0.948**, 0.969**, 0.365* and 1.00**, respectively. Yield under normal water conditions (YP) was significantly and positively correlated with STI, MP, GMP, HM, Tol, SSI, YI and SDI reached r =0.943**, 0.974**, 0.954**, 0.927**, 0.842**, 0.503**, 0.810**, 0.499**, respectively and significantly negative correlated with YSI (r= -0.499**) and RDI (r= -0.504**). Golabadi et al., 2006 stated that the best suitable index for drought tolerant genotypes is an index that is highly correlated with grain yield under both stress and optimum conditions. The STI, MP, GMP, HM, TOL, and YI indices were found to have a substantial and positive correlation with grain yield under two different situations (Table 13).

As such, these indices may be suitable for screening genotypes of wheat. These results are consistent with the bread wheat research conducted by Muhammadi et al. (2011). The substantial relationships that have been seen between yield under stress and under normal circumstances and quantitative drought resistance indices like MP, GMP, STI, and HM are in line with findings by Mardeh et al. (2006) for bread wheat. Both Eid and Sabry (2019) and Farshadfar et al. (2018) noted that there was a strong correlation between the STI, MP, GMP, HM, and YI indices and grain yield in both generations and under two different conditions.

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تقدير قوة الهجين، والقدرة علي التآلف واستخدام مؤشرات تحمل الجفاف لإختيار التراكيب الوراثية من قمح الخبز تحت ظروف الجفاف

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الملخص

أجريت الدراسة على تسعة تراكيب وراثية من القمح. تم التهجين بينهما بنظام الهجن التبادلية في إتجاه واحد 9×9 بإجمالي ستة وثلاثين هجيناً في الموسم الأول 2022/2021. وفي الموسم الثاني 2023/2022، تم زراعة الآباء التسعة بالإضافة إلي 36 هجين الناتجين منهم في تجربتين متجاورتين. أشارت النتائج إلي أن تباين التراكيب الوراثية معنوياً لجميع الصفات تحت الدراسة تحت ظروف الجفاف والري الطبيعي. وكان التباين الراجع للقدرة العامة والخاصة علي التآلف عالي المعنوية لجميع الصفات تحت الدراسة في كلا البيئتين. كانت النسبة بين القدرة العامة/ الخاصة أعلي من الوحدة للصفات تحت الدراسة فيما عدا طول السنبلة وعدد السنابل علي النبات. أظهر الصنف (P3) قدرة عامة علي التآلف موجبة ومعنوية لعدد السنابل علي النبات ومحصول الحبوب للنبات بينما أظهر (P7) قدرة عامة علي التآلف لإرتفاع النبات، عدد حبوب السنبلة ووزن الـ 1000 حبة. وكانت التأثيرات عالية للقدرة الخاصة علي التآلف حيث أظهر الهجين P1×P7 بالنسبة لصفة طول النبات، والهجين P1×P5 بالنسبة لصفة لعدد السنابل، والهجين P6×P7 بالنسبة لوزن الـ 1000 حبة، والهجين P6×P9 بالنسبة لصفة محصول الحبوب تحت ظروف الجفاف. كان التباين الراجع للتراكيب الوراثية عالي المعنوية لدليل الحساسية للجفاف للمحصول ومكوناته لمعظم الصفات تحت الدراسة ماعدا طول السنبلة. وأظهرت التراكيب الوراثية وهي(P5) :، (P6)، P1×P5, P2×P4, P2×P5, P3×P4, P3×P7, P3×P9, P4×P7 , P6×P9 قيم مرتفعة لمقياس تحمل الاجهاد، والمحصول تحت الري العادي والاجهاد، ومقياس متوسط الانتاجية، ومقياس متوسط الانتاج الحسابي، ومقياس متوسط التوافقية. وكان ارتباط محصول الحبوب تحت ظروف الجفاف موجب ومعنوي مع مقياس تحمل الجفاف ومقياس متوسط الانتاجية ومقياس متوسط الانتاج الحسابي ومقياس متوسط التوافقية ومقياس المحصول الناتج و مقياس التحمل