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Assessment of Variability, Heritability and Genetic Advance Toward some Bread Wheat Genotypes for Drought Tolerance Indices

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ABSTRACT

Twenty genotypes as well as five commercial cultivars (*Triticum aestivum* L.) were evaluated under normal and water stress conditions to identify drought tolerant bread wheat genotypes based on yield traits and drought tolerance indices. Analysis of variance for mean square of genotypes showed high significance of all studied genotypes for the traits. The mean performance showed that the highest yield value was recorded by Giza 168 followed by Giza 171 under normal and water stress irrigation. The values of all studied traits for phenotypic coefficient of variation (PCV) were higher than genotypic coefficient of variation (GCV). The maximum PCV and GCV were recorded for number of spikes m^{-2}, the estimates of broad-sense heritability showed that there was gradation for all the studied traits with values ranged from 25% to 92% and 30% to 91% under both treatments. Drought tolerance indices showed that Giza 171, Giza 168, Sids 12 and Sakha 94 were the best genotypes for drought tolerance with high mean productivity values under most drought indices. Data analysis of correlation coefficients between drought tolerance indices showed that it could be a good phenomenon for selection of genotypes having high stress tolerance by using the best selection indices.

Keywords: Broad-sense heritability- drought indices -*Triticum aestivum* L. - PCV-GCV

INTRODUCTION

Wheat is the most important crop for food security not only in Egypt but all over the world. In 2019-2020, wheat grown area in Egypt was estimated as 1.4 million hectares, with total wheat production approximately was 8.9 million tons (FAO, 2020). Drought is a common feature that leads to large annual fluctuations in rainfed wheat production, especially in dryland areas such as Egypt. Development of a new high yielding and drought tolerant variety is one of the most efficient strategies to improve wheat production. Ali *et al.*, (2013) have shown that wheat yield in developing countries declines to 50-90% of its irrigation potential due to water shortage. In order to develop drought tolerant genotypes, it is important to understand the mechanism and response of plants under water scarce conditions. Mir *et al.*, (2012) indicated that to create tolerant genotypes, it is important to understand the mechanism and response of plants under water deficient conditions. The photosynthetic activity of flag leaves is particularly important during grain filling when the older leaves begin to wilt (Loss and Siddique 1994 and Turner 1997).

The correlation coefficient evaluates the relationship between two traits and does not indicate the relative importance of each factor (Garcia del Moral *et al.*, 2005). Correlation coefficients reveal relationships between independent variables. However, they are not sufficient to describe this relationship when the causal relationship between variables is needed (Korkut and Bilir 1993).

The relationship between germplasm materials can be classified using cluster analysis to show diversity among genotypes useful for plant breeding program. Cluster is useful to identify variables that can be classified into major and subgroups based on similarities and dissimilarities (El-Deeb and Mohamed, 1999 and Jaynes *et al.*, 2003). Rosielle and Hamblin (1981) indicated that stress tolerance (TOL) is defined as the differences in yield between the stress and irrigation environments. In addition, (Ramirez and Kelly, 1998) have shown that geometric mean productivity (GMP) is often used by breeders for relative performance, considering that drought stress in field environments can vary in severity over years.

Golabadi *et al.*, (2006) showed significant and positive correlations of Yp and (MP and STI) and Ys and (MP and STI) revealed that selection could be conducted for high MP and STI under normal and water stress. Yagdi and Sozen (2009) refer that the positive and significant correlation coefficient between agronomic and yield parameters will pave the way for effective selections in wheat breeding program and the correlation coefficient is the most widely used to explain the relationship between the characters..

Analysis of physiological determinants of yield response to heat will provide some information to identify the traits as a screening tool and thus could help in designing future breeding programs related to heat tolerance (Hossain *et al.*, 2021). The objectives of this study were to identify drought resistant bread wheat genotypes, evaluate the efficiency of different genotype classification methods and investigate the relationships between genotypes and different methods for drought tolerance indices.

MATERIALS AND METHODS

Twenty genotypes as well as five commercial cultivars (Tables 1 and 2) of bread wheat (*Triticum aestivum*

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L.) were provided by the National Gene Bank, and Wheat Research Department, Agriculture Research Center, Egypt. Two wheat experiments were carried out at Sids Research Station to study water stress effect on some wheat genotypes

Genotypes were evaluated in a Randomized Complete Block Design with three replications under stress irrigation (only once after 20 days from sowing date) and normal irrigation (five times) during the two successful seasons 2018/2019 and 2019/2020. Each plot consisted of six rows; each row was 3 m long and spaced 30cm apart. Plants within the rows were 20cm distant. All other recommended production technology practices were applied for wheat production in the region. All yield components and physiological data were recorded on each plot as follows: -

1. Days to heading (day).
2. Days to maturity (day).
3. Plant height (cm).
4. Spike length (cm).
5. Number of spikes m^{-2}
6. Canopy temperature.
7. Peduncle length (cm).
8. Total chlorophyll
9. 1000- Kernel weight (g).
10. Number of kernels /spike.
11. Flag leaf area (cm^2).
12. Grain weight / plot (kg).

The canopy temperature (CT) of each genotype was measured using an infrared and K-type thermometer to determine the canopy temperature at heading time. Total chlorophyll content of flag leaves at the grain filling stage was determined using SPAD 502 plus from 5 flag leaves at anthesis and 21 days after anthesis.

Table 1. Name, bar code, source of location of bread wheat genotypes

Name	Bar code	Source of location	Name	Bar code	Source of location
G1	112277	Monufia	G11	112705	North Sinai
G2	112280	Giza	G12	112706	North Sinai
G3	112281	Giza	G13	112718	Giza
G4	112345	Qalyubia	G14	112719	Giza
G5	112346	Beheira	G15	117306	Qena
G6	11266	Giza	G16	117310	Sohag
G7	112687	Sharqia	G17	117311	Sohag
G8	112689	Assiut	G18	117312	Sohag
G9	112700	Monufia	G19	117313	Sohag
G10	112701	Monufia	G20	117314	Sohag

Table 2. Name and pedigree of commercial cultivars

Name	Pedigree and selection history
Giza 171	Sakha 93/Gemmeiza 9 S.6-1GZ-4GZ-1GZ-2GZ-0S
Giza 168	MIL/BUC//Seri CM93046-8M-0Y-0M-2Y-0B-0GZ
Sids 13	Kauz "s" // Tsi / Snb"s" ICW94-0375-4AP-2AP-030AP-0APS-3AP-0APS-050AP-0AP-0SD
Sids 12	BUC//7C/ALD/5/MAYA74/ON//1160.147/3/BB/GLL/4/CHAT"S"/6/MAYA/VUL//CMH74A.630/4*SX SD7096-4SD-1SD-1SD-0SD
Sakha 94	Opata/Rayon//Kauz CMBW90Y3180-0TOPM-3Y-010M-010M-010Y-10M-015Y-0Y

Statistically analysis:

Viability test analysis and correlation coefficient analysis were calculated using past programs (PAleontological Statistics version 3.08).

The variance components and coefficients of variation were estimated using the formula proposed by (Burton, 1952). A combined analysis was performed for the two growing seasons. Means were compared using least significant difference (LSD) at 1% and 5% probability level (Snedecor and Cochran, 1980). The genetic parameters of phenotypic, genotypic coefficient of variation, and genetic advanced were estimated by Burton (1952), the heritability of broad sense was calculated according to (Roy 2000) as follows;

$$\delta^2_g = MS_g - MS_e/r, \quad - \quad \delta^2_{ph} = \delta^2_g + \delta^2_e/r, \quad - \quad H^2 = \delta^2_g / \delta^2_{ph}$$

Genotypic and phenotypic coefficient of variation was calculated by the formula suggested by **Burton (1952)** as, Genotypic coefficient of variation

(GCV)=δ_g X 100 / Ȣ Where, σ_g = Genotypic standard deviation, Ȣ = Population means similarly, the phenotypic coefficient of variation was calculated from the following formula, Phenotypic coefficient of variation

$$(PCV) = \delta_{ph} \times 100 / Ȣ$$

Where,

δ_{ph} = Phenotypic standard deviation Ȣ = Population means

Drought resistance indices were calculated using the following relationships:

1. Stress tolerance index, STI= (Yp*Ys)/ Ȳp2 (Fernandez, 1992).
2. SDI =(Ys-Yp)/ Yp (Ali Dib *et al.* 1990)
3. Mean productivity=MP=(Y_p+Y_s)/2 (Rosielle and Hamblin, 1981). Where mean productivity (MP) is the average yield of genotypes under stress and non-stress conditions.
4. Tolerance= TOL=(Y_p-Y_s) (Rosielle and Hamblin, 1981).
5. Harmonic Mean, HM= 2(YpxYs/Yp+Ys) (Fernandez, 1992)

In the above formulas, Ys and Yp, represent yield under stress, yield under non-stress for each genotype, Ȳs and Ȳp represented yield mean in stress and non-stress conditions for all genotypes, respectively.

RESULTS AND DISCUSSIONS

The analysis of variance for the mean square of genotypes under normal irrigation and water stress is shown in Tables 3, 4 and 5. It shows high significance of most of the genotypes in the studied traits except days to maturity under water stress, number of kernels per spike, number of spikes per m^2, total chlorophyll and peduncle length under both normal irrigation and water stress, in addition to canopy temperature under water stress. This suggests that there is differentiation between all genotypes under the different conditions, which would be important for use in plant breeding programs.

Table 3. Mean square estimates of ordinary analysis for days to heading, days to maturity, plant height and spike length under normal and water stress irrigation over the two seasons.

S.O.V.	DF	Days to heading (day)		Days to maturity (day)		Plant height (cm)		Spike length (cm)	
		N	D	N	D	N	D	N	D
Year	1	4548.51**	2265.93**	5069.23**	2488.81**	1.50	28.17	5.25*	1.97
Error (a)	4	2.77	4.24	6.81	52.63	47.58	193.08	0.34	0.49
Genotype	24	97.53**	33.46*	100.79**	22.84	836.15*	1010.53**	5.20**	7.01**
Genotype X year	24	30.59**	19.61	35.85	21.79	130.32	173.31	5.31**	6.94**
Error (b)	96	4.47	6.66	10.95	12.70	62.50	50.17	1.64	1.86
Total	149	54.05	28.05	63.09	32.08	195.95	223.20	2.78	3.46

***Significant at P ≤ 0.05 level of significance **Significant at P ≤ 0.01 level of significance**

Table 4. Mean square estimates of ordinary analysis for number of kernels per spike, number of spikes m^2, 1000-kernel weight and total chlorophyll under normal and water stress irrigation over the two seasons.

S.O.V.	DF	Number of kernels /spike		Number of spikes m^2		1000- Kernel weight (g)		Total chlorophyll	
		N	D	N	D	N	D	N	D
Year	1	181.83*	1.76	1788.83	7266.24*	14.79	223.89**	5789.58**	1193.42**
Error (a)	4	21.71	9.28	370.02	744.73	15.27	0.48	55.27	16.76
Genotype	24	237.67	194.87	5660.80	7697.74	149.01**	91.48*	282.73	201.45
Genotype X year	24	121.95	44.04	891.33	1344.62	44.21*	29.70	203.92	67.43
Error (b)	96	31.43	135.81	7780.69	578.33	8.13	13.16	82.81	66.68
Total	149	79.39	126.00	6080.44	1877.87	36.46	29.50	170.60	94.28

***Significant at P ≤ 0.05 level of significance **Significant at P ≤ 0.01 level of significance**

Table 5. Mean square estimates of ordinary analysis for canopy temperature, peduncle length, flag leaf area and grain weight per plot under normal and water stress irrigation over the two seasons.

S.O.V.	DF	Canopy temperature		Peduncle Length (cm)		Flag leaf area		Grain weight / plot	
		N	D	N	D	N	D	N	D
Year	1	0.49	197.46*	62.73*	632.43**	10065.76**	2.62	0.09	10.58*
Error (a)	4	2.41	9.86	6.41	11.89	1.30	3.16	0.07	0.69
Genotype	24	8.91*	7.45	69.70	65.81	216.62**	163.64**	1.98**	0.81**
Genotype X year	24	1.89	4.99	33.53	31.84	182.04**	223.57**	0.001	0.33**
Error (b)	96	2.84	4.07	32.40	20.99	8.12	4.79	0.03	0.16
Total	149	3.57	5.95	37.92	33.50	137.00	65.47	0.34	0.36

***Significant at P ≤ 0.05 level of significance **Significant at P ≤ 0.01 level of significance**

Agronomic, physiological traits and yield components:

Mean performance of Twenty-five genotypes of bread wheat (*Triticum aestivum* L.) collected from different areas in Egypt based on 12 qualitative and quantitative characters are given in Tables 6, 7 and 8.

As for days to heading the number of days from sowing to date of 50% appearance of owns through the flag leaf sheaths ranged from 90 days for genotype (G20) to 102.67 days for genotype (G12) under normal irrigation and from 90.17 days for genotype (G3) to 98.17 days for genotype (G9) under water stress treatment, respectively. As for days to maturity, the number of days to physiological maturity for normal irrigation ranged from 135.33 days for genotype (G1) to 147.17 days for Sids 12 under normal irrigation.

Genotype (G20) had the earliest values for days to heading and days to maturity under normal irrigation, while genotype (G12) had the highest mean values for both traits. It's clear that water stress decreased number of days to heading and maturity with different responses among genotypes under study. For plant height, the lowest mean value was recorded for Sids 13 followed by (G8, G2 and G3) under normal irrigation and water stress. The highest mean value was obtained for genotype (G6 and G13) under both treatments. Two genotypes (G5 and G9) recorded the lowest values for spike length while four genotypes (Giza 168, G8, G17 and G18) recorded the highest value under normal irrigation and water stress.

Table 6. The genotypes mean performance under normal and water stress irrigation and for days to heading, days to maturity, plant height and spike length.

	Days to heading (day)		Days to maturity (day)		Plant height (cm)		Spike length (cm)	
	Normal	Drought	Normal	Drought	Normal	Drought	Normal	Drought
G1	93.17	94.50	135.33	139.50	123.33	120.83	9.23	9.33
G2	100.83	90.50	142.83	136.67	110.83	100.00	9.17	9.70
G3	91.83	90.17	137.00	136.17	110.83	104.17	8.35	8.56
G4	95.33	94.50	144.17	140.50	130.83	128.33	7.77	7.85
G5	101.83	90.50	144.33	136.83	130.00	128.33	7.27	7.03
G6	94.33	96.83	137.50	142.83	145.83	145.83	8.08	7.62
G7	101.17	91.33	144.50	139.17	111.67	106.67	8.41	7.58
G8	100.00	91.67	146.33	140.83	107.50	103.33	9.67	10.07
G9	95.83	98.17	138.00	143.67	140.83	135.00	7.73	7.53
G10	92.83	97.00	136.67	140.17	136.67	131.67	8.37	8.17
G11	99.67	94.50	144.00	141.50	125.83	125.83	9.44	9.42
G12	102.67	98.00	146.17	143.33	140.83	134.17	9.16	9.75
G13	102.17	95.83	145.67	140.67	140.83	140.83	8.13	7.53
G14	101.00	94.83	146.67	141.50	129.17	126.67	8.37	9.28
G15	91.00	97.17	138.67	139.83	135.00	137.50	8.60	7.57
G16	99.33	93.17	144.50	140.33	120.83	117.50	9.34	9.01
G17	101.33	96.67	143.17	139.50	124.17	119.17	9.93	10.60
G18	92.00	95.33	137.50	140.00	113.33	110.00	9.90	9.80
G19	99.17	94.83	145.50	141.33	119.17	117.50	9.52	9.47
G20	90.00	95.67	136.17	140.17	138.33	140.00	9.68	9.23
Giza 171	99.17	94.50	146.50	142.00	115.00	115.00	10.25	9.50
Giza 168	100.50	94.33	146.50	142.33	118.33	112.50	11.45	11.16
Sids 13	101.00	94.33	146.17	142.50	105.00	105.00	7.65	9.45
Sids 12	100.83	91.50	147.17	139.83	119.17	120.83	9.33	9.28
Sakha 94	99.33	93.33	146.33	142.33	120.83	117.50	9.62	9.33
Mean	97.85	94.37	142.69	140.54	124.57	121.77	9.04	8.97
L.S.D 0.05%	3.43	4.18	5.36	5.78	12.81	11.48	2.07	2.21
L.S.D 0.01%	4.54	5.54	7.10	7.65	16.96	15.20	2.75	2.93
Minimum	90.00	90.17	135.33	136.17	105.00	100.00	7.27	7.03
Maximum	102.67	98.17	147.17	143.67	145.83	145.83	11.45	11.16

Four genotypes (Giza 168, G8, G17 and G18) showed the highest values for spike length under both normal and water stress irrigation, on contrary the lowest values of spike length recorded to three genotypes (G5, G4 and G9) which showed the lowest ear length. As far as 1000 kernel weight is concerned, the highest mean values were obtained for genotypes G8, Giza 168 and Sakha 94. However, the lowest mean values were obtained for G1, G6 and G20 under both normal and water stress irrigation.

Table 7. The genotypes mean performance under normal and water stress irrigation and for number of kernels per spike, number of spike/m^2, 1000-kernel weight and total chlorophyll.

	Number of kernels /spike		Number of spikes /m^2		1000- Kernel weight (g)		Total chlorophyll	
	Normal	Drought	Normal	Drought	Normal	Drought	Normal	Drought
G1	33.30	32.73	371.67	352.83	34.28	30.60	44.25	44.88
G2	51.82	39.90	429.00	369.17	44.40	41.20	60.28	48.78
G3	38.87	35.22	372.17	358.83	41.44	38.18	47.40	42.27
G4	44.07	43.20	366.17	357.50	43.28	42.49	52.47	51.32
G5	40.33	39.00	366.33	317.17	46.15	42.22	53.80	49.08
G6	41.97	38.55	369.17	350.17	36.24	34.68	44.75	44.63
G7	47.97	47.43	403.67	376.33	47.00	41.04	65.45	59.65
G8	49.56	47.78	416.33	401.83	50.89	49.57	62.98	59.53
G9	53.16	34.50	407.00	339.50	44.49	43.86	67.52	46.82
G10	41.82	40.82	359.17	317.67	45.46	43.29	57.50	39.93
G11	40.18	36.47	384.17	365.17	46.23	44.23	56.10	49.48
G12	53.15	45.42	389.17	345.00	43.50	40.93	65.87	46.15
G13	43.21	43.67	421.83	321.83	47.78	42.07	57.98	55.07
G14	45.30	43.13	404.17	388.83	47.56	46.08	59.55	54.18
G15	33.10	36.47	374.17	354.67	43.51	42.09	60.08	52.73
G16	54.15	45.83	382.83	378.33	46.41	44.71	55.85	46.28
G17	49.30	48.77	392.83	367.83	40.08	39.09	59.07	52.13
G18	42.83	37.63	307.83	282.83	49.66	39.50	46.45	43.45
G19	53.22	50.76	401.17	394.67	48.96	47.09	63.33	60.77
G20	36.03	35.38	327.00	276.67	37.82	37.91	46.52	42.85
Giza 171	45.15	41.65	428.33	403.83	49.06	38.44	61.95	55.78
Giza 168	51.15	52.72	432.50	366.50	48.77	48.07	61.88	52.60
Sids 13	50.33	50.87	413.67	388.83	45.23	42.08	59.83	53.27
Sids 12	49.58	40.12	401.17	288.50	43.54	39.39	63.22	52.85
Sakha 94	49.80	47.22	410.83	381.50	48.57	48.75	60.43	56.58
Mean	45.57	42.21	389.29	353.84	44.09	42.62	57.38	50.44
L.S.D 0.05%	9.09	18.89	142.96	38.98	4.62	5.88	14.75	13.23
L.S.D 0.01%	12.03	25.01	189.27	51.60	6.12	7.78	19.53	17.52
Minimum	33.10	32.73	307.83	276.67	30.28	34.60	44.25	39.93
Maximum	54.15	52.72	432.50	403.83	50.89	49.57	67.52	60.77

Table 8. The genotypes mean performance under normal and water stress irrigation and for canopy temperature, peduncle length, flag leaf area and grain weight per plot.

	Canopy temperature		Peduncle length (g)		Flag leaf area (cm^2)		Grain weight / plot (kg)	
	Normal	Drought	Normal	Drought	Normal	Drought	Normal	Drought
G1	24.32	25.25	45.67	47.33	44.72	37.60	1.77	0.73
G2	23.68	24.78	47.00	43.83	47.96	38.87	2.11	1.58
G3	22.82	23.97	44.17	40.33	56.43	40.65	1.77	1.13
G4	20.72	24.45	47.33	46.33	43.59	44.97	1.70	1.82
G5	23.73	24.75	49.67	50.50	40.51	30.73	2.46	1.58
G6	22.65	24.22	55.50	52.50	46.38	43.85	1.51	1.52
G7	22.32	24.25	50.83	50.17	50.90	39.13	2.83	1.88
G8	21.25	19.87	50.50	50.50	58.36	45.45	2.49	1.86
G9	22.17	24.20	53.17	49.00	36.30	37.58	1.77	1.85
G10	21.07	23.33	49.67	46.33	43.58	35.80	1.12	1.77
G11	24.15	24.22	50.33	51.17	52.33	30.66	1.82	1.63
G12	23.68	23.58	57.50	56.50	40.78	39.87	2.73	1.46
G13	23.60	21.87	46.17	45.67	52.42	40.97	2.54	1.51
G14	21.12	22.55	48.67	47.33	42.80	41.66	2.23	1.65
G15	22.40	23.12	47.50	47.00	52.30	45.58	1.84	1.53
G16	20.70	22.75	44.83	45.00	48.07	38.08	1.76	2.01
G17	21.08	22.83	50.83	47.33	38.33	39.93	2.03	1.65
G18	23.70	22.55	53.00	47.17	42.07	42.97	1.61	1.26
G19	20.75	22.70	53.83	51.67	50.89	38.98	2.40	2.00
G20	24.20	23.22	53.67	51.83	44.18	41.58	1.03	1.06
Giza 171	22.42	23.43	53.17	48.83	50.73	32.56	2.86	2.36
Giza 168	21.55	22.70	47.50	47.83	58.33	49.57	3.18	2.35
Sids 13	22.52	23.67	52.33	51.33	49.13	33.48	2.49	1.80
Sids 12	23.67	22.95	48.33	49.83	49.08	27.93	3.03	1.72
Sakha 94	22.05	23.08	50.67	51.33	53.63	35.32	2.58	1.94
Mean	22.49	23.37	50.07	48.67	47.75	38.95	2.15	1.67
L.S.D 0.05%	2.73	3.27	9.22	7.43	4.62	3.55	0.29	0.65
L.S.D 0.01%	3.61	4.33	12.21	9.83	6.11	4.69	0.39	0.87
Minimum	20.70	19.87	44.17	40.33	36.30	27.93	1.03	0.73
Maximum	24.32	25.25	57.50	56.50	58.36	49.57	3.18	2.36

Regarding canopy temperature, five genotypes (G8, G14, G16, G17, and G19) had the lowest canopy temperature, while four genotypes (G1, G5, G11, and G20) had the highest temperature under normal irrigation. Many researchers also used canopy temperature as tool of screening against drought wheat Lopes and Reynolds (2010). Under conditions of drought-stress, wheat genotypes of relatively lower midday canopy temperatures had a relatively better plant water-status. Canopy temperature in a drought-stressed nursery is therefore being used as one component of a selection index for drought resistance in our wheat breeding program Blum *et al*., (1989)

For grain weight/plot, two genotypes (Giza 168 and Giza 171) scored the highest mean values while four genotypes (G1, G3, G18 and G20) scored the lowest mean values under both normal and water stress irrigation.

The mean performance of 25 genotypes showed that the highest yield value was recorded for Giza 168 followed by Giza 171 under normal irrigation and water stress respectively. The results are similar to those obtained by Abdi *et al*., (2013) and Arab *et al.,* (2021).

Genetic advance parameters:

The estimates of genotypic variance, phenotypic variance, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (in a broad sense), and genetic advance percentage of means are presented in Tables 9 and 10.

For all the traits studied, the magnitude of phenotypic and genotypic variance was found to vary from one trait to another. The values of phenotypic coefficient of variation (PCV) were higher than those of genotypic coefficient of variation (GCV). The highest PCV and GCV values were recorded for number of spikes per m^2 with values (95.12% and 73.61%; 140.34% and 111.12%) under normal and water stress irrigation, respectively. Followed by total chlorophyll, plant height and number of kernels/spikes which indicating the low effect of environment on the expression of these traits and the extent of PCV and GCV varied from one trait to another these results agree with Naeem *et al*., 2015.The results of broad-sense heritability (H^2) estimates show that there was gradation for all the traits studied with values ranging from 25% to 92% and 30% to 91% for normal irrigation and water stress treatment respectively. For normal irrigation, the highest value was 92% for grain weight/plot followed by flag leaf area, days to heading, 1000 kernel weight and plant height with values of 89%, 88%, 86% and 84%, respectively. H^2 values for days to maturity were moderately high with a value of 77%, followed by number of spikes/m^2 and number of kernels/spike with values of 77%, 77% and 69%, respectively. The lowest values were recorded for the rest of characters; canopy temperature with a value of 0.53%, followed by total chlorophyll, spike length and peduncle length with values of 40%, 40% and 25%, respectively. In water stress treatment, the highest value of 91% was observed for flag leaf area followed by plant height with a value of 87%, No. of spikes /m^2, No. kernels/spike and1000-kernel weight with values of 79%, 73% and 73%, respectively. There were moderately high H^2 values for grain weight/plot with a value of 65%, followed by days to heading, and spike length with values of 60% and 55%, respectively. In contrast, the lowest values were recorded for peduncle length with a value of 39% followed by total chlorophyll, days to maturity and canopy temperature with values of 36%, 35% and 30%, respectively. According to the data, the results of H^2 were high for most of the traits studied, suggesting that environmental influence was less than genetic influence in the inheritance of the traits studied and that high estimates of heritability could be successful in wheat improvement. These results agree with Yassin and Ghareeb (2019), Shehab-Eldeen *et al*.,(2020) and Mohamed *et al.,* (2021)

Table 9. Estimation of genetic parameters for different quantitative traits in wheat genotypes under normal (N) and water stress (D) irrigation.

	Days to heading		Days to maturity		Plant height		Spike length		Number of kernels /spike		Number of spikes /m^2	
	N	D	N	D	N	D	N	D	N	D	N	D
$\square^2$g	15.55	4.57	15.28	2.34	131.11	160.45	0.58	0.91	34.33	28.96	859.73	1179.54
$\square^2$ph	17.66	7.59	19.84	6.73	155.86	184.35	1.44	1.67	50.17	39.51	1110.94	1489.79
PCV	6.01	2.68	4.63	1.60	41.71	50.47	5.32	6.22	36.70	31.21	95.12	140.34
GCV	5.30	1.61	3.57	0.56	35.08	43.92	2.13	3.40	25.11	22.87	73.61	111.12
H^2	0.88	0.60	0.77	0.35	0.84	0.87	0.40	0.55	0.68	0.73	0.77	0.79
GA%	7.80	3.62	4.96	1.33	17.39	20.02	10.98	16.27	21.94	22.52	13.67	17.82

$\square^2$g= Genotypic variance, $\square^2$ph= Phenotypic variance, PCV= phenotypic coefficient of variation, GCV= Genotypic coefficient of variation, H^2=heritability in broad sense, and GA% = Genetic advance % of mean

Table 10. Estimation of genetic parameters for different quantitative traits in wheat genotypes under normal (N) and water stress (D) irrigation.

	1000- Kernel weight		Total chlorophyll		Canopy temperature		Peduncle length		Flag leaf area		Grain weight / plot	
	N	D	N	D	N	D	N	D	N	D	N	D
$\square^2$e	18.71	17.57	31.24	21.15	1.15	0.70	5.80	7.16	34.69	26.36	0.32	0.12
$\square^2$g	21.87	23.92	78.88	58.42	2.15	2.33	23.26	18.57	38.92	29.09	0.35	0.18
PCV	16.30	19.01	45.82	38.60	3.19	3.32	15.48	12.72	27.17	24.90	5.42	3.70
GCV	13.94	13.96	18.15	13.98	1.71	0.99	3.86	4.91	24.22	22.56	4.97	2.41
H^2	0.86	0.73	0.40	0.36	0.53	0.30	0.25	0.39	0.89	0.91	0.92	0.65
GA%	18.45	17.66	12.65	11.32	6.32	4.03	4.95	7.05	24.03	25.89	44.69	35.49

$\square^2$g= Genotypic variance, $\square^2$ph= Phenotypic variance, PCV= phenotypic coefficient of variation, GCV= Genotypic coefficient of variation, H^2=heritability in broad sense, and GA% = Genetic advance % of mean.

Drought tolerance indices:

The stress tolerance index (STI) ranged from 1.63 to 0.24 as presented in (Table 11) the higher value of Giza 168 and the lowest value of genotype 20 generally indicate a high stress tolerance of up to 1. Moreover, genotypes 7, 24 and Sakha 94 showed the highest STI rate with values of 1.15, 1.13 and 1.09, respectively. At the same time, these genotypes showed high yield under normal irrigation and water stress. This indicates that they are promisingly tolerant and could contribute to the improvement of a new commercial wheat variety. In contrast, both genotypes 20 and 1 showed the lowest STI rate with values of 0.24 and 0.28, respectively. Mevlut and Sait (2011) indicated that the genotypes with high STI value usually showed a large difference in yield under stress and non-stress conditions. According to susceptibility drought index (SDI), both genotypes 1 and 12 showed high relative tolerance. In contrast, two of the 25 genotypes (10 and 20) out of 25 revealed a negative and low relative tolerance, respectively. The mean productivity (MP) ranged from 0.98 to 2.45 with genotype Giza 168 having the highest value of 2.45 followed by Giza 171, Sids 12 and Sakha 94 with values of 2.34, 2.11 and 2.08 respectively. However, genotype 1 had the lowest value (0.98) followed by genotypes 20, 18 and 3 with values

(1.04, 1.37 and 1.39 respectively). The genotypes with high values of mean productivity are considered more desirable. Regarding the tolerance trait (TOL), the values ranged from -0.54 to 0.78 for the two genotypes 10 and 24, respectively. Rosielle and Hamblin (1981) used the tolerance traits to determine the differences in yield of the genotypes under normal and abiotic stress. Considering the stress tolerance index (HM), which ranged from 2.71 to 1.03, where showed the higher value recorded for Giza 168 and the lowest value recorded to genotype 1, Mohamed *et al.*, (2016) showed that HM are powerful indices for drought and heat tolerance. Akçura *et al.,* (2011) showed that tolerant wheat genotypes under different stress conditions are useful indicator for wheat breeding program when stress is severe, while STI and HM were suggested when stress is not so severe.

According to the data, Giza 171, Giza 168, Sids 12 and Sakha 94 showed the best genotypes for drought resistance with high mean productivity values under most drought indices, which will be beneficial for improving new commercial varieties in wheat plant breeding program.

Table 11. Influences under normal and water stress conditions on grain yields and drought indices for 25 wheat genotypes.

	STI	SDI	MP	TOL	HM	YP	YS
G1	0.28	2.30	0.98	0.51	1.03	1.77	0.73
G2	0.72	0.99	1.73	0.32	1.80	2.11	1.58
G3	0.43	1.41	1.39	0.52	1.38	1.77	1.13
G4	0.53	0.62	1.73	-0.19	1.55	1.70	1.43
G5	0.84	1.40	1.83	0.50	1.92	2.46	1.58
G6	0.46	0.25	1.44	-0.17	1.46	1.51	1.41
G7	1.15	1.31	2.01	0.25	2.26	2.83	1.88
G8	1.01	0.98	1.95	0.17	2.13	2.49	1.86
G9	0.57	0.61	1.67	-0.36	1.62	1.77	1.49
G10	0.30	-0.40	1.50	-0.54	1.17	1.12	1.23
G11	0.64	0.39	1.63	-0.01	1.72	1.82	1.63
G12	0.86	1.82	1.79	0.67	1.90	2.73	1.46
G13	0.83	1.58	1.78	0.55	1.89	2.54	1.51
G14	0.80	1.01	1.76	0.22	1.90	2.23	1.65
G15	0.61	0.65	1.55	0.03	1.67	1.84	1.53
G16	0.64	0.19	1.85	-0.33	1.72	1.76	1.68
G17	0.73	0.74	1.70	0.11	1.82	2.03	1.65
G18	0.44	0.85	1.37	0.23	1.41	1.61	1.26
G19	1.04	0.66	2.01	0.02	2.18	2.40	2.00
G20	0.24	-0.09	1.04	-0.03	1.05	1.03	1.06
Giza 171	1.47	0.69	2.34	-0.04	2.59	2.86	2.36
Giza 168	1.63	1.02	2.45	0.20	2.71	3.18	2.35
Sids 13	0.97	1.08	1.98	0.36	2.09	2.49	1.80
Sids 12	1.13	1.69	2.11	0.78	2.19	3.03	1.72
Sakha 94	1.09	0.97	2.08	0.28	2.22	2.58	1.94

Correlation coefficients:

Among all the four calculated selection indices, thirteen positive significant correlations of twenty-one correlation coefficients were observed between the drought tolerance indices Table .12. Yp positive significant correlations were observed with all the drought tolerance indices (STI, SDI, MP, TOL, HM and Ys) with values (r= **0.93, **0.59, **0.84, **0.58, **0.91 and **0.75). Three positive significant correlations were observed for Ys with (STI, MP and HM) with values (r=**0.93, **0.95 and**0.95). Two significant correlation coefficients were found for HM with STI and MP with values (r=**0.99, and **0.96) similar results agree with Link *et al*., (1999). One significant correlation coefficient was found for TOL with SDI with values (**0.89). For MP, a significant correlation coefficient for STI was found to be (**0.94). These results are consistent with the findings of Naghavi *et al.,* (2013), also, these findings are in consistence with the findings of Golabadi *et al*., (2006), Hooshmandi (2018) and Arab *et al*., (2021) in wheat. Data analysis of correlation coefficients between drought tolerance indices could be a good phenomenon for selection of genotypes having high stress tolerance by using the best selection indices.

Table 12. Correlation coefficients between drought indices traits in wheat genotypes.

	STI	SDI	MP	TOL	HM	YP
SDI	0.27					
MP	0.94**	0.10				
TOL	0.28	0.89**	0.11			
HM	0.99**	0.23	0.96**	0.25		
YP	0.93**	0.59**	0.84**	0.58**	0.91**	
YS	0.93**	-0.07	0.95**	-0.03	0.95**	0.75**

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تقدير التباين الوراثي و وكفاءة التوريث والتقدم الوراثي لبعض التراكيب الوراثية من القمح الخبز لمؤشرات تحمل الجفاف

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تم تقييم عشرون تركيب وراثي من قمح الخبز مجمعة من مناطق مختلفة من مصر بالإضافة إلى خمسة أصناف تجارية من قمح الخبز تحت ظروف الري الموصى بها وظروف الإجهاد المائي في محطة البحوث الزراعية بسدس خلال موسمي 2018/2019 و 2019/2020 لتحديد الطرز الوراثية من قمح الخبز التي تتحمل الجفاف بناءً على نتائج المحصول ومؤشرات تحمل الجفاف و أجريت التجارب في تصميم القطاعات الكاملة العشوائية في ثلاث مكررات . كانت الفروق عالية المعنوية لجميع التراكيب الوراثية في كل الصفات تحت الدراسة. أظهرت النتائج المتحصل عليها أن الصنفين التجاريين جيزة 168 و جيزة171 يمكن استخدامها في برنامج التربية لتحمل ظروف الاجهاد المائي وذلك لتفوقهما في المحصول تحت ظروف الري العادي والاجهاد المائي. كان التباين الوراثي يمثل الجزء الأكبر من التباين المظهري مقارنة بالتباين البيئي في كل الصفات المدرسة. كما سجلت صفة عدد السنابل في المتر المربع قيمة عالية من التباين المظهري والوراثي. أوضحت النتائج أن قيم درجه التوريث على نطاق واسع تراوحت بين 25% الي 92% و 30% الي 91% تحت ظروف الري العادي والاجهاد المائي. أظهرت مؤشرات تحمل الجفاف أن أصناف جيزة 171 وجيزة 168 وسدس 12 وسخا 94 كانت أفضل التراكيب الوراثية لتحمل الجفاف بمتوسط قيم إنتاجية عالية تحت معظم مؤشرات الجفاف. أظهرت تحليل معاملات الارتباط بين مؤشرات تحمل الجفاف أنه يمكن أن يكون طريقة جيدة لاختيار التراكيب الوراثية التي تتحمل الاجهاد المائي.