SVU-International Journal of Agricultural Sciences
Volume 4 Issue (1) pp.: 236-253, 2022
Print ISSN 2636-3801 | Online ISSN 2636-381X
Doi: 10.21608/svuijas.2022.114090.1168

RESEARCH ARTICLE

Performance and stability of some bread wheat genotypes for grain yield and some attributes in response to drought stress

Hassan, M.S. *, M.A. Ali and Somaya A. Hussien

Department of Agronomy, Faculty of Agriculture, South Valley University, 83523 Qena, Egypt.

Abstract

Because of limited of water resources in Egypt, rationalize of irrigation water became necessary. Therefore, development wheat genotypes with drought tolerance is very important, especially with the essential need to expand in growing wheat to narrowing the gap between production and consumption. In this study, twenty-one genotypes of bread wheat were evaluated with testing stability of their performance during two growing seasons; 2018/19 and 2019/20 under drought condition at the Experimental Farm of Faculty of Agric., South Valley Univ., Qena. Drought was applied by two levels after heading 50% of plants; genotypes were irrigated each 14 and 21 days, respectively. Each experiment was designed in a spilt plot arranged in a randomized complete block design (RCBD) with three replications. Results revealed that mean squares due to years, irrigation cycles and genotypes were highly significant for all studied traits, except for days to maturity which did not differ significantly from year to another. Results revealed also that drought caused decreases in estimates of all studied growth and yield traits. The cultivars, Misr 2, Gemmiza 12, Gemmiza 11 and Gemmiza 9 which had highest values of STI with lowest values of TOL, SSI and S were the best drought tolerant cultivars. High estimates of heritability in broad sense were recorded for all studied traits. According to stability parameters, out of fifteen stable genotypes for grain yield (Ard/fed.), the two genotypes line 3 and Shandweell 1 considered to be superior which could be recommended.

Keywords: Drought stress; grain yield; stability analysis; Wheat.

1. Introduction

Wheat is considered as a stable food for human, where the majority of the people depends upon in their diet in Egypt, also in many countries over the world. Whereas, it one of the main sources of calories and protein. According to Chaves *et al.* (2013), it considered the source of calories and protein for 85 % and 82% approximately of global population, respectively. Although the importance of wheat for Egyptian population, the local production that reached to 9 million tons produced from 1370235 ha. (FAO, 2020) is not sufficient. For cover the needs of people that reached to 18 million tons, Egypt imports about 9-10 million tones (Anonymous, 2020). Therefore, expand in growing of wheat is one of the important tools that contributes in narrowing the gap between production and consumption. With progressive global climatic changes and increasing shortage of water resources and worsening eco-environment, rationalize of irrigation water became necessary. Where, growing crops probably practice under water deficiency condition. Bartels and Sunkar (2005) indicated that drought probably has the most essential impact on plants growth and yield compared to the other biotic stresses. Drought negative impacts on all growth stages of wheat but it is more critical at flowering and grain filling

---

***Corresponding author: Mohamed S. Hassan**
Email: elsharany@agr.svu.edu.eg
Received: January 1, 2022; Accepted: March 18, 2022;
Published online: March 26, 2022.
©Published by South Valley University.
This is an open access article licensed under 🅭🅯🄏🄎

stage (Shalaby *et al.*, 2020). Undesirable effects were registered under drought conditions on: chlorophyll content (Nikolaeva *et al.*, 2010), activity of photosynthesis (Mafakher *et al.*, 2010), grain number (Ji *et al.*, 2010), grain filling (Begcy and Walia, 2015), and at the end on grain yield (Cattivelli *et al.*, 2008). Some morphological and physiological traits such as flag leaf area and proline content can be used as markers to select drought tolerance genotypes (Iqbal, 2019). Therefore, because of the essential need to expand in growing wheat under water deficiency, development of drought tolerance genotypes is very important. This work aimed evaluating twenty-one genotypes of bread wheat with testing stability of their performance under normal and drought stress conditions.

2. Materials and Methods

2.1. Experimental site, genotypes and growing practices

This work was conducted during two growing seasons; 2018/19 and 2019/20 at the Experimental Farm of Faculty of Agriculture., South Valley University, Qena, Egypt (600 km. south of Cairo, 26°11'N and 32°44'E). Soil of the experimental site is newly reclaimed land irrigated by underground water. Some properties of both experiments land are shown in Table 1. Minimum, maximum and daily temperatures as well as relative humidity at Qena are given in Table 2.

Table1. Some properties of experimental site in both seasons.

Soil property	Sand (%)	Silt (%)	Clay (%)	Soil texture	pH (1: 2.5)	Organic matter (%)	EC (ds m^{-1})	CaCO3 (%)	Soluble ions (m mol L^{-1})					
									SO $^{--}_{4}$	Cl^{-}	H CO^{-3}	Mg^{++}	Ca^{++}	K^{+}
2018/19	89.20	7.12	3.51	sandy	8.63	0.32	5.30	7.70	55.46	33.22	20.74	1.66	2.73	0.37
2019/20	90.12	6.88	3.12	sandy	8.18	0.25	4.92	7.35	55.42	35.12	20.24	1.53	2.25	0.32

Table 2. Minimum, maximum and mean daily temperature and relative humidity at Qena from sowing to harvesting time in both seasons.

Season	2018-2019						2019-2020					
	Temperature (C^{o})			Relative humidity (%)			Temperature (C^{o})			Relative humidity (%)		
Month	Min.	Max	Daily mean	Min.	Max.	Daily mean	Min.	Max.	Daily mean	Min.	Max.	Daily mean
Nov.	11.5	28.0	19.8	31.0	69.9	50.5	14.4	30.5	22.5	28.7	64.7	46.7
Dec.	8.6	22.2	15.4	39.7	80.4	60.1	9.6	23.8	16.7	35.7	72.9	54.3
Jan.	7.2	21.0	14.1	34.9	73.1	54.0	7.6	20.6	14.1	37.8	77.3	57.5
Feb.	10.3	24.1	17.2	29.5	67.9	48.7	9.7	23.6	16.6	31.6	71.0	51.3
March	11.7	27.2	19.4	22.5	57.0	39.8	13.6	28.9	21.2	23.6	58.9	41.2
April	17.5	32.6	25.0	19.5	46.2	32.9	18.8	32.7	25.7	20.8	48.9	34.9

Source: Meteorology Authority, Qena station, at South Valley Universit

Table 3. Pedigree and origin of the evaluated genotypes.

No.	Name	Pedigree	Origin
1	Giza 164	KVZ/Buha "s"//Kal/Bb CM33027-F-15M-500y-0M	Egypt
2	Shandaweel 1	SITE//MO/4/NAC/TH.AC//3*PVN/3/MIRLO/BUF.CMSS03B00567S-72Y-010M-010Y-010M-0HTY-0SH	Egypt
3	Sakha 93	Sakha 92/TR8 10328 S8871-1s-2s 13-Os	Egypt
4	Sids 1	HD2172/PAVON"s"//1158.57/MAYA74"S"	Egypt
5	Gemmiza 7	CMH74 A. 630/5x//Seri 82/3/Agent CGM 4611-2GM-3GM-1GM-0GM	Egypt
6	Sids 12	BUC//7C/ALD/5/MAYA74/ON//1160,1473//BB/G/GII14/CHAT"s"/6/MAYA/VUL//CMH74A.630/4/*SX, SD7096- 4SD-1SD-0SD	Egypt
7	Sids 14	SW8488*2/KUKUNACGSS01Y00081T-099M-099Y-099M-099B-9Y-0B-0SD	Egypt
8	Sids 2	HD 2206/Hork"s"/3/Napo63/Inia66//Wern "s" SD635-4SD-1SD-1SD-0SD	Egypt
9	Giza 168	MIL/BUC//SeriCM93046-8M-0Y-0M-2Y-0B	Egypt
10	Line3	GALVEZ S87 BW-20771	Mexico (CYMMIT)
11	Line4	IG 433247 ICBW 206011	Pakistan (ICARDA)
12	Sakha 95	PASTOR//SITE/MO/3/CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/4/WBLLI.CMA01Y00158S-040POY-040M-030ZTM-040SY-26M-0Y-0SY-0S.	Egypt
13	Giza 171	SAKHA 93 / GEMMEIZA 9 S.6-1GZ-4GZ-1GZ-2GZ-0S.	Egypt
14	Line 7	IG 44205 ICBW 207017	Jordan (ICARDA)
15	Line 8	IG 107098 ICBW 207886	Iran (ICARDA)
16	Masr 1	OASIS/SKAUZ//4*BCN/3/2*PASTORCMSS00Y01881T-050M-030Y-030M-030WGY-33M-0Y-0S	Egypt
17	Masr 2	SKAUZ/BAV92CMSS96M03611S-1M-010SY-010M-010SY-8M-0Y-0S	Egypt
18	Masr 3	ROHF07*2/KIRITICGSS05B00123T-099T-0PY-099M-099NJ-6WGY-0B-0BGY-0GZ	Egypt
19	Gemmiza 9	Ald"S"/Huac"S"//CMH74A.630/5Xcgm4583-5GM-1GM-0GM	Egypt
20	Gemmiza 11	BOW"S"/KVZ//7C/SER182/3/GIZA168/SAKHA61.GM7892-2-2GM-1GM-2GM-1GM-0GM.	Egypt
21	Gemmiza 12	OTUS/3/SARA/THB//VEE CCMSS97Y00227S-5Y-010M-010Y010M-2Y-1M-0Y-0GM	Egypt

Twenty-one genotypes of bread wheat (*Triticum aestivum* L.) were evaluated under water stressed. Pedigree and origin of these genotypes are presented in Table 3. Water stress treatments were applied by two levels before stage of heading 50% of plants; the genotypes were irrigated each 14 and 21 days under the 1st and 2nd levels, respectively. Under normal irrigation condition, the genotypes were irrigated regularly (each 4-7 days).

These genotypes were grown in a spilt plot arranged in a randomized complete block design (RCBD) with three replications. The main plot included the three irrigation cycles, while the sub-plot comprised the 21 genotypes. The experimental unit included 3 rows, 3m long with 20 cm row spacing and 10 cm interplant spacing. All agronomic practices were applied for the two growing seasons as recommended.

2.2. Measurements

2.2.1. Plant traits

Data were recorded on days to maturity (DM; day), plant height (PH; cm), flag leaf area (FLA; cm2), 100-grain weight (g) and grain yield (GY;

Ard./fed.). In addition, proline content (PC; µg/g fresh weight) was estimated according to the method proposed by Bates *et al.* (1973).

2.2.2. Drought tolerance indices

The following drought resistance indices were calculated on the basis of grain yield:

- The sensitivity (S), (Falconer, 1990).
- Stress Susceptibility Index (SSI), (Fischer & Maurer, 1978).
- Stress Tolerance Index (STI), (Fernandez, 1992).
- Tolerance Index (TOL), (Hossain *et al.*, 1990).

2.3. Statistical analysis

2.3.1. Analysis of variance

Analysis of variance of split-plot design was carried out according to Gomez and Gomez (1984). Combined analysis over the two growing seasons was done after testing the homogeneity. Differences among means were testing by the revised least significant difference (LSD') at 5 and 1% levels of probability according to El-Rawi and Khalafalla (1980). Genotypic (σ2g) and phenotypic (σ2ph) variances and broad sense heritability (h2b) were calculated according to Singh and Chaudhary (1985).

2.3.2. Stability analysis

Stability analysis for the traits; days to maturity (DM), plant height (PH), flag leaf area (FLA), proline content (PC) and grain yield (Ard./fed.) were done according to the method of Eberhart & Russell (1966).

3. Results and Discussion

3.1. Analysis of variance

Combined analysis of variance for the studied traits across two years has been presented in Table 4. Mean squares due to the main effect of year on plant height, flag leaf area, proline content and grain yield were significant ($p>0.01$), indicating that these traits were more affecting to change of season which may be due to presence large differences in climatic factors between seasons (Table 2). Also, the analysis of variance pointed out that, differences in all studied traits due to irrigation applications were significant ($p>0.01$). The point of interest that the first pattern interaction of years × irrigation treatments was insignificant. Hence it can be said the main effect of irrigation did not differ from season to another. Furthermore, the genotypes exhibited significant ($p>0.01$) effects on all studied traits, indicating that considerable genetic variance were involved among them for these traits. The interactions of genotypes with each of year and irrigation treatments were significant ($p>0.01$) except for days to maturity which was insignificant under the interaction I × G and each of 100-grain weight and grain yield which were insignificant under both interactions. This may be due to the sensitivity of these studied genotypes to the environmental changes. Therefore, assessment of these genotypes could be applying at wide range of environments to identify the suitable genotype (s) for each environment and detecting the stable one (s). A considerable variation among wheat genotypes were obtained by Al-Naggar *et al.* (2020), Muhder *et al.* (2020), Shalaby *et al.* (2020), and Semahegn *et al.* (2021).

3.2. Mean performance of the studied traits

3.2.1. Days to Maturity

Mean performance of the twenty-one wheat genotypes which applied by two levels of drought for days to Maturity over all seasons are presented in Table 5. It is evident from the previous table; that earliness in maturity (3 and 5.8% from normal irrigation treatment, respectively) was associated with drought application.

This is logic, as plants under water deficiency condition complete their growth duration in relatively lesser time escaping from the drought stress. Moreover, over all environments, line 3 and line 8 were the earliest genotypes by 120.1 and 120.4 days, respectively, reflecting these genotypes may be had accumulated desirable alleles of earliness. In contrast, line 7 was the latest (126.3 days). Similar results were reported Mehraban *et al.* (2019) and Moayedi *et al.* (2010).

Table 4. Combined analysis of variance, genotypic (σ^2 g) and phenotypic (σ^2) variances and broad sense heritability (h^2_b) of the wheat genotypes under the irrigation cycles for the studied traits in both growing seasons.

S.O.V.	D.F	Mean squares					
		DM	PH	FLA	Proline content	100-grain weight	Grain yield (Ard./fed.)
Years (Y)	1	29.72	779.25**	981.13**	119.08**	3.52	28.50**
Error (a)	4	19.74	13.27	96.06	7.75	0.85	2.03
Irrigation cycles (I)	2	1701.86**	3532.39**	1279.17**	2192.79**	74.72**	215.72**
Y × I	2	7.42	8.72	16.07	5.84	0.02	0.14
Error (b)	8	6.42	9.53	9.59	2.35	0.54	0.96
Genotypes (G)	20	55.11**	296.38**	692.24**	149.46**	3.04**	12.39**
Y × G	20	9.57**	20.26**	17.74**	6.44**	0.34	0.51
I × G	40	2.34	18.79**	5.17**	11.45**	0.28	0.46
Y × I × G	40	2.67	4.22	1.50	1.67	0.18	0.26
Error (c)	240	3.82	8.57	5.18	2.00	0.28	0.53
σ^2_{g}		2.53	15.34	37.47	7.95	0.15	0.66
σ^2_{ph}		3.04	16.29	37.93	8.24	0.19	0.72
h^2_b		0.83	0.94	0.99	0.96	0.79	0.92

** is significant at 0.01 level.

3.2.2. *Plant height*

Results listed in Table 5 clear that plant height of the studied genotypes was reduced by drought applications compared to under normal irrigation. This decrease reached to 7.4 and 13.99% over all genotypes from normal irrigation, respectively. Where the average of plant height ranged under normal irrigation from 70.65 cm for line 3 to 87,12 cm for Giza164 while, it ranged from 64.23 and 58.08 cm to 81.73 and 77.40 cm for Sakha 93 and Giza 164 under the two drought stress treatments, respectively. As well as, over all environments, Giza 164 recorded the highest length of plants (82.08 cm) while the shortest genotype was Sakha 93 (65.08cm). Decreasing in plant height of wheat genotypes by water stress was also reported by Mirbahar *et al.* (2009).

3.2.3. *Flag leaf area*

With regard to flag leaf area, average ranged under normal irrigation from 36.55 cm for line 4 to 56.9 cm2 for Gemmiza12 (Table 6). However, it ranged from 33.09 and 31.50 cm2 to 54.95 and 51.49 cm2. for Shandaweel 1 and Gemmiza 12 under the two irrigation applications, respectively. It is also noticed that drought applications caused reduction in flag leaf area over all genotypes by 7.25 and 14.3 % from normal irrigation, respectively. As well as, over all environments, the lowest estimate of flag leaf area was recorded by Line 4 (34.28 cm2) while, Gemmiza 12 exhibited the highest value (51.49 cm2). Decreasing in flag leaf area of wheat genotypes by water stress was reported by Kazmi *et al.* (2003).

3.2.4. *Proline content*

Estimates of proline content for the twenty-one wheat genotypes, which affected by water irrigation treatments across seasons are included in Table 6. It is clear from the previous table that proline content was sequence increased with increasing drought level and the lowest value was produced under normal irrigation (13.04 µm/g fresh weight) while the maximum estimate was found under the highest drought level (11.94). In addition, over all genotypes drought caused increases in proline content by 34.74% and 89.32% from normal irrigation, respectively. The increase in proline content under drought stress is due to the decrease in proline oxidation (conversion to glutamate) to negligible rates under water-stressed condition, thus the accumulation of proline increases (Stewart, 1977). In this connection Johari-Pireivatlou (2010) and Mwadzingeni *et al.* (2016) also

Table 5. Mean performance of days to heading, maturity and plant height for the 21 wheat genotypes under different irrigation times over two seasons.

Genotypes		Days to maturity				Plant height (cm)			
No.	Names	T1	T2	T3	Average	T1	T2	T3	Average
1	Giza 164	128.0	124.0	121.3	124.4	87.12	81.73	77.40	82.08
2	Shandweell 1	127.0	122.8	119.5	123.1	75.50	71.67	65.96	71.04
3	Sakha 93	125.5	123.0	118.8	122.4	72.93	64.23	58.08	65.08
4	Sids 1	125.7	122.2	118.7	122.2	78.10	70.33	64.20	70.88
5	Gemmiza 7	126.2	122.2	118.3	122.2	74.52	68.33	64.37	69.07
6	Sids 12	126.5	122.8	117.7	122.3	70.82	65.70	61.37	65.96
7	Sids 14	125.3	121.0	116.7	121.0	73.48	70.95	67.16	70.53
8	Sids 2	127.2	123.2	120.5	123.6	73.23	66.72	62.90	67.61
9	Giza 168	129.7	123.7	119.7	124.3	72.33	66.87	62.07	67.09
10	Line 3	124.3	120.0	116.0	120.1	70.65	67.00	63.28	66.98
11	Line 4	128.8	125.5	122.8	125.7	83.63	78.77	74.41	78.94
12	Sakha 95	126.3	122.3	119.3	122.7	73.10	70.35	64.55	69.33
13	Giza 171	127.3	123.8	120.3	123.8	75.83	72.26	67.75	71.95
14	Line 7	130.2	126.3	122.3	126.3	83.13	71.22	62.40	72.25
15	Line 8	123.3	120.8	117.2	120.4	74.33	71.19	66.33	70.62
16	Misr 1	125.5	121.7	116.8	121.3	74.30	64.69	60.60	66.53
17	Misr 2	126.5	123.7	120.3	123.5	76.05	70.15	65.59	70.60
18	Misr 3	124.3	121.5	118.0	121.3	75.53	71.33	63.66	70.18
19	Gemmiza 9	129.7	124.8	121.7	125.4	74.05	65.73	60.49	66.76
20	Gemmiza 11	128.7	124.5	121.7	124.9	76.89	71.78	68.53	72.40
21	Gemmiza 12	127.5	124.2	121.5	124.4	73.92	70.86	66.10	70.29
Mean		123.1	123.1	119.5	123.1	70.29	70.09	65.10	70.29
RLSD at 0.05					1.17				1.73
RLSD at 0.01					1.53				2.26

Table 6. Mean performance of flag leaf area and proline content for the 21wheat genotype under different irrigation cycles over two seasons

Genotypes		Flag leaf area (cm.)				Proline content (%)			
No.	Names	T1	T2	T3	Average	T1	T2	T3	Average
1	Giza 164	45.93	39.74	34.08	39.92	5.44	7.39	14.58	9.14
2	Shandweell 1	38.31	33.09	31.50	34.30	13.04	15.76	20.96	16.59
3	Sakha 93	47.19	45.37	42.77	45.11	6.58	8.31	12.24	9.04
4	Sids 1	46.73	44.21	39.64	43.52	12.44	14.92	19.70	15.69
5	Gemmiza 7	40.01	36.69	33.17	36.62	11.49	13.87	19.03	14.80
6	Sids 12	44.47	42.30	40.44	42.40	9.86	13.04	17.42	13.44
7	Sids 14	39.54	37.84	35.66	37.68	7.73	12.18	16.40	12.10
8	Sids 2	53.22	49.08	45.47	49.26	9.29	12.00	15.87	12.39
9	Giza 168	52.99	49.69	46.42	49.70	6.42	9.58	11.94	9.31
10	Line 3	40.59	37.36	34.20	37.38	5.47	7.83	15.36	9.55
11	Line 4	36.55	34.41	31.87	34.28	10.93	15.15	24.74	16.94
12	Sakha 95	38.60	36.45	33.87	36.31	9.40	14.21	19.77	14.46
13	Giza 171	47.75	44.06	40.08	43.96	8.27	12.00	15.29	11.85
14	Line 7	41.05	37.39	34.21	37.55	12.86	17.54	22.90	17.76
15	Line 8	40.59	35.98	32.79	36.45	10.69	12.43	17.85	13.66
16	Misr 1	41.84	38.31	35.11	38.42	12.80	17.73	23.16	17.90
17	Misr 2	46.84	43.25	39.63	43.24	8.02	13.99	21.62	14.54
18	Misr 3	39.13	36.24	33.25	36.21	7.46	9.29	12.03	9.59
19	Gemmiza 9	40.19	36.88	34.09	37.05	8.63	10.70	12.65	10.66
20	Gemmiza 11	56.81	54.37	51.69	54.29	8.42	12.40	17.72	12.84
21	Gemmiza 12	56.91	54.59	51.49	54.33	9.53	11.91	17.30	12.92
Mean		44.53	41.30	38.16	41.33	9.27	12.49	17.55	13.10
RLSD at 0.05					1.32				0.83
RLSD at 0.01					1.71				1.09

Table 7. Mean performance of, 100 grain weight, Grain yield (Ard./fed.) and Drought resistance indices for the 21 wheat genotype under different irrigation times over two seasons:

Genotypes		100 grain weight (g)				Grain yield (Ard./fed.)				Drought resistance indices			
No.	Names	T1	T2	T3	Average	T1	T2	T3	Average	S	SSI	STI	TOL
1	Giza 164	5.07	3.94	3.77	4.26	9.09	7.83	6.04	7.65	1.17	1.08	0.21	3.05
2	Shandweell 1	5.36	4.92	3.39	4.56	8.58	7.17	5.89	7.21	1.03	1.01	0.20	2.64
3	Sakha 93	5.40	4.64	3.52	4.52	8.39	6.72	5.87	6.99	0.97	0.97	0.20	2.52
4	Sids 1	4.96	4.60	3.64	4.40	8.50	6.56	5.26	6.77	1.24	1.23	0.19	3.24
5	Gemmiza 7	5.60	4.51	3.75	4.62	8.47	7.00	5.67	7.04	1.07	1.07	0.19	2.80
6	Sids 12	5.37	4.44	3.65	4.48	8.58	6.47	5.66	6.90	1.12	1.10	0.20	2.92
7	Sids 14	5.46	4.31	3.79	4.52	8.71	7.13	5.78	7.21	1.12	1.09	0.20	2.93
8	Sids 2	5.36	4.57	3.73	4.55	7.76	7.03	5.83	6.87	0.74	0.80	0.19	1.93
9	Giza 168	5.21	4.49	3.46	4.39	8.61	6.95	5.94	7.17	1.02	1.00	0.20	2.67
10	Line 3	5.19	4.51	4.23	4.64	9.04	7.15	6.44	7.54	0.99	0.93	0.21	2.60
11	Line 4	4.79	4.15	3.15	4.03	6.25	5.05	3.78	5.03	0.95	1.27	0.14	2.47
12	Sakha 95	5.25	4.41	3.68	4.45	8.17	6.57	5.47	6.74	1.03	1.07	0.14	2.70
13	Giza 171	5.00	5.01	3.55	4.52	8.86	7.02	6.10	7.33	1.06	1.00	0.21	2.76
14	Line 7	5.11	4.62	3.29	4.34	6.89	5.67	4.26	5.61	1.01	1.23	0.15	2.63
15	Line 8	5.25	4.31	3.92	4.49	8.79	7.77	5.82	7.46	1.14	1.09	0.20	2.97
16	Misr 1	5.00	4.24	3.59	4.28	8.82	6.69	5.90	7.14	1.12	1.07	0.20	2.92
17	Misr 2	5.40	4.49	3.81	4.56	8.50	7.24	6.86	7.53	0.63	0.62	0.21	1.64
18	Misr 3	4.93	4.19	3.71	4.28	8.18	7.34	5.60	7.04	0.99	1.02	0.14	2.58
19	Gemmiza 9	5.82	5.02	4.19	5.01	9.03	7.66	6.61	7.76	0.93	0.86	0.22	2.42
20	Gemmiza 11	6.36	5.64	5.17	5.72	9.98	8.82	7.65	8.82	0.89	0.75	0.24	2.33
21	Gemmiza 12	6.27	5.78	4.86	5.64	9.71	8.90	7.62	8.74	0.80	0.69	0.24	2.09
Mean		4.58	4.61	3.80	4.58	8.52	7.08	5.91	7.17				
RLSD at 0.05					0.33				0.42				
RLSD at 0.01					0.43				0.55				

noticed increasing in proline content under drought stress.

3.2.5. 100 grain weight

Table 7 shows the effect of drought on mean performance of the wheat twenty-one genotypes for 100-grain weight over all seasons. Mean value ranged under normal irrigation from 4.79 gm. for line 4 to 6.36 gm for the Gemmiza 11 with on average 5.34 gm. Also, it ranged under drought levels from 3.94 gm for Giza164 to 5.78 gm for Gemmiza12 with an average 4.61 gm and from 3.15 gm for line 4 to 5.17 gm for Gemmiza 11 with average 3.80 gm., respectively. Generally, decreasing in 100-grain weight was observed as a result to drought stress applications. Reduction overall genotypes reached to 13.67 and 28.84% from normal irrigation, respectively. It is possible to understand this decrease in 100-grain weight which mainly due to the shortage of moisture which led grains to complete their formation in relatively shorter time without full filling. Thus, the studied genotypes which showing high 100-grains weight under normal irrigation became not able to produce grains with similar weight under drought stress. In addition, among the studied genotypes, the cultivars Gemmiza 11 and Gemmiza 12 exhibited the best 100-grain weight over all environments (5.72 and 5.64 gm). This superiority could be attributed to the genetic structure of them. In this connection, maximum 1000-grain weight (42.55) was obtained under irrigated condition while, the lowest weight (39.15) was under drought stress (Mahmud *et al.,* 2016). Furthermore, reduction in 1000-grain weight of wheat were also reported by Mahmood *et al.* (2020).

3.2.6. Grain yield (Ard. /fed.)

The average grain yield ranged under normal irrigation from 6.25 for line 4 to 9.98 for Gemmiza 11 while, it varied under two drought levels from 5.05 and 5.03 for line 4 to 8.90 for Gemmiza 12 and 7.65 for Gemmiza 11, respectively (Table 7). Therefore, it is concluded that the maximum grain yield was produced under normal irrigation (9.98Ard.), while the lowest value was obtained under the second level of drought stress (5.03Ard.). In addition, drought stresses caused decreases in grain yield over all genotypes by 16.90% and 30.63% from normal irrigation, respectively. Decreasing in grain yield by drought stress is logic as a result to decreasing performance of all studied traits which considered important yield components under this stress. That may be due to reduction in producing metabolites required for increasing all agronomical traits as a result to water shortage compared to under normal irrigation. As well as the importance of water in encourage metabolite processes, hence effective on agronomical traits. Generally, the cultivars Gemmiza 11 and Gemmiza 12 exhibited the best performance of grain yield over all environments (8.82 and 8.74 gm, respectively). This superiority could be attributed to the genetic structure of them. Therefore, it might be used these two cultivars future programs to improvability of wheat under drought stress.

In this connection, reduction in wheat grain yield by drought stress was also observed by Shamsi and Kobraee (2011), Mahmud *et al.* (2016) and Al-Naggar *et al.* (2020).

3.2.7. Drought tolerance indices

The indices of drought tolerance (Sensitivity, Stress Susceptibility Index, Tolerance Index and Stress Tolerance Index) which calculated on the basis of grain yield (Ard. / fed.) are presented in Table 7. Based on the estimates of DSI, the genotypes Misr 2, Gemmiza12, Gemmiza 11, Sids 2, Gemmiza 9, line 3, and sakha 93 which had lower values than unity considered the least susceptibility. Furthermore, according to records of TOL the cultivars Misr 2, sids 2, Gemmiza12, Gemmiza11 and Gemmiza 9 which exhibited the lowest records seem to be the highest drought tolerance. Therefore, these genotypes which exhibited well performance at drought conditions will give higher yield when grown under normal conditions. In addition, according to STI estimates, it could be considered the cultivars Gemmiza 12, Gemmiza 11, Gemmiza 9 and Misr 2 the most drought tolerance cultivars. Concerning the sensitivity test, the cultivars Misr 2, Gemmiza 12, Gemmiza 11 and Gemmiza 9 were less sensitive to drought conditions.

Finally, from the obtained results it is clear that the cultivars, Misr 2, Gemmiza 12, Gemmiza 11 and Gemmiza 9 which had highest values of STI with lowest values of TOL, SSI and S were the best drought tolerant cultivars. Similar results were obtained by Farshadfar *et al.* (2012), Farshadfar *et al.* (2013) and Nouraein *et al.* (2013).

3.3. Variance components

Estimates of genotypic (σ2g) and phenotypic (σ2ph) variances and heritability (h2) for the studied traits for the twenty-one wheat genotypes, which affected by irrigation applications across seasons are included in Table 4. Values of phenotypic (σ2ph) were slightly higher than σ2g ones, reflecting that the phenotypic expression of these traits were little affected by environmental factors. With respect to the heritability, high estimates were obtained, indicating that a large portion of the phenotypic variance is due to genetic causes. Based on these obtained results, selection could be easy and effective for improvement these studied traits. Similar results were also obtained by Ahmad *et al.* (2017), Mwadzingeni *et al.* (2018), Shamuyarira *et al.* (2019) and Salarpour *et al.* (2020).

3.4. Phenotypic Stability analysis

3.4.1. Joint regression analysis

Results of the joint regression analysis of variances (Table 8) showed that the differences among genotypes were significant (p>0.01) for all studied traits. This reflects that presence of genetic variations among the used genotypes for the studied traits. In addition, significant or highly significant differences were noticed for partition of the genotype × environment interaction; Env. + (G × Env.) (linear) and genotype × environment interaction for all the studied traits. Further partitioning for the interaction between genotype and environment into linear (G × Env.) and nonlinear (pooled deviation) exhibited that G× Env. was significant or highly significant for all studied traits. Therefore, it could be said that the studied genotypes did not similarly respond within the environments, so stability analysis according to the method of Eberhart& Russell (1966) was done.

In addition, pooled deviation was highly significant for all studied traits, indicating that the genotypes differed considerably with respect to their stability for these traits and the deviation of all genotypes from linearity was significant and more obvious. Similar results were obtained by Siddhi *et al.* (2018).

Table 8. Joint regression analysis of variance of 21 genotypes for the studied traits over environments.

S. O. V	d.f	Mean square				
		Days to maturity	Plant height (cm)	Flag leaf area (cm.)	Proline (%)	Grain yield (Ard./fed.)
Genotypes (G)	20	18.37**	99.63**	230.72**	49.83**	4.13**
Env. + (G × Env.)	105	11.19**	22.19**	12.96**	16.41**	1.55**
Env. (Linear)	1	987.21**	1368.43**	1123.44**	1505.06**	144.07**
G × Env. (Linear)	20	3.39**	16.93**	3.81*	6.30**	0.39**
Pooled deviation	84	1.42**	7.41**	1.92**	1.09**	0.13**
Pooled error	240	0.85	3.48	1.15	0.44	0.09

*, ** Significant at 0.05 and 0.01 probability levels, respectively.

3.4.2. Stability parameters

Estimates of the stability criteria i. e.; regression coefficients (bi) and deviation from (s2di), in addition the mean performance (of the individual genotype for the studied traits are listed in Tables 9 - 10 and illustrated in Fig. 1-5. Awad (1997) defined that a stable genotype is one has high mean performance (regression coefficient near to unity (bi =1)) and deviation from regression not significantly differ from zero (s2di =0). Based on estimates of bi and s2d, fourteen genotypes (Shandweel1, Sakha 93, Sids1, Gemmiza7, Sids12, Sids14, sids2, line3, line4, Sakha 95, Giza 171, line 7, line 8 and misr1) were stable for days to maturity. Out of them, the two genotypes Sids1 and Sakha 95 considered being desirable (earlier) because of their mean performance was lower than the grand mean overall environments. In addition, the genotypes Giza164, Gemmiza7, Sids12, Sids14, Sids2, line4, Giza171 and Gemmiza12 for plant height, the genotypes Shandwell 1, Sakha 93, Sids 1, Gemmiza 7, Sids 12, Sids 14, Sids 2, Giza 168, Line3, Sakha 95, Giza 171, Line 7, Line 8, Misr 1, Misr 3, Gemmiza 12 and Gemmiza 11 for flag leaf area, the genotypes Giza 164, Shandwell 1, Sids 1, Gemmiza 9, Sids12, Sids14, Sids 2, line 3, Giza 171, line 7, line 8, Misr1, Gemmiza 11 and Gemmiza 12 for proline content were stable.

Also for grain yield (Ard./fed.), Giza 164, Shandwell 1, Sakha 93, Sids1, Gemmiza 7, Sids 14, Line 3, line 4, Sakha 95, Giza 171, line 7, line 8, Misr 3, Gemmiza 9 and Gemmiza 11 could be considered as stable genotypes. Out of them, the two genotypes; line 3 and Shandweell 1 considered to be superior because they had heaviest grain yield comparing with grand mean overall the studied environments.

Due to greater estimate of regression coefficient (bi<1) and estimates of deviation from regression (s2di) that were insignificantly different from zero, genotypes Gemmiza7, Sids12, Sids14, line3 and Misr1 for days to maturity, Sids1, Sids2 and Giza171 for Flag leaf area, genotypes line7 and Misr1 for proline content, genotypes Giza164, Sids14, Giza171 and line 8 for Grain yield (Ard./fed.), seem to be suitable for favorable environments. However, for less favorable conditions (drought stress and other inputs), genotypes Sakha 93 and line 8 for days to maturity, Giza164, line4 and Giza 171 for plant height, Sakha 93, Sids 12, Giza 168, Gemmiza 11 and Gemmiza 12 for flag leaf area, Shandwell 1, Sids1, Sids 12 and line 8 for proline content and Gemmiza 9 and Gemmiza 11 for grain yield (Ard./fed.) could be adapted, because its regression coefficients were insignificantly deviated from zero and less than unity (bi>1). In contrary, it could be considered the remained genotypes were unstable, whereas they showed significance of both or one of the stability parameters (bi and s2di). The obtained results are in agreement with those reported for one or more studied traits by Chamurliyski and Tsenov (2013), Bayoumi *et al.* (2015), Hamam *et al.* (2015), Jhinjer *et al.* (2017) and Siddhi *et al.* (2018).

4. Conclusion

In general, it can be concluded that drought applications caused decreases in performance of studied growth and yield traits. Based on estimates of drought tolerance indices, the cultivars i.e., Misr 2, Gemmiza 12, Gemmiza 11 and Gemmiza 9 were the best drought tolerant cultivars. Out of fifteen stable genotypes for grain yield, the two genotypes; line 3 and Shandweell 1 considered to be superior overall environments. While under normal irrigation condition any genotypes i.e., Giza164, Sids14, Giza171 and line 8 can be used. In contrast, under water deficit condition, Gemmiza 9 and Gemmiza 11 can be recommend.

Table 9. Stability parameters for days to maturity, plant height and flag leaf area of 21 genotypes over environments.

No.	Genotypes	Days to maturity			Plant height (cm)			Flag leaf area		
		$(\overline{X})$	b_i	S^2d	$(\overline{X})$	b_i	S^2d	$(\overline{X})$	b_i	S^2d
1	Giza 164	124.45	0.55^{*}	-0.55	82.08	0.87	-1.24	39.92	1.31	12.61^{**}
2	Shandweell 1	123.13	1.09	0.35	71.04	0.93	4.93^{**}	34.30	1.10	-0.01
3	Sakha 93	122.45	0.93	1.07	65.08	1.56	6.87^{**}	45.11	0.80	-0.86
4	Sids 1	122.17	0.99	0.13	70.88	1.02	4.45^{**}	43.52	1.16	-0.65
5	Gemmiza 7	122.22	1.15	-0.82	69.07	1.15	1.46	36.62	1.24	-0.12
6	Sids 12	122.33	1.30	-0.28	65.96	0.86	0.00	42.41	0.77	-0.61
7	Sids 14	121.00	1.33	0.69	70.53	0.41	-0.43	37.68	0.84	0.37
8	Sids 2	123.61	1.03	0.40	67.62	1.01	-2.26	49.26	1.37	0.18
9	Giza 168	124.34	1.41^{*}	4.30^{**}	67.09	1.04	14.23^{**}	49.70	0.87	0.48
10	Line 3	120.11	1.25	-0.49	66.98	0.26^{*}	3.05^{*}	37.40	0.99	-0.48
11	Line 4	125.72	0.88	-0.15	78.94	0.82	-0.30	34.28	1.07	1.90^{*}
12	Sakha 95	122.67	1.03	-0.45	69.33	0.06^{**}	2.13	36.31	0.52	1.07
13	Giza 171	123.83	1.01	-0.42	71.95	0.75	-1.62	43.96	1.13	-0.58
14	Line 7	126.28	1.15	-0.79	72.25	2.37^{**}	27.35^{**}	37.55	1.00	-0.68
15	Line 8	120.45	0.86	0.36	70.62	0.96	0.92^{**}	36.45	1.20	-0.66
16	Misr 1	121.33	1.26	-0.45	66.53	1.60	4.41^{*}	38.42	0.97	-0.48
17	Misr 2	123.50	0.63^{*}	-0.54	70.60	0.96	-2.47^{*}	43.24	1.51^{**}	2.44^{*}
18	Misr 3	121.28	0.43^{**}	3.96^{**}	70.18	1.12	15.18^{**}	36.21	1.19	0.98
19	Gemmiza 9	125.39	1.23	1.80^{*}	66.38	1.71^{*}	0.77	37.05	0.54^{*}	0.36
20	Gemmiza 11	124.95	0.75	1.74^{*}	72.40	0.60	3.91^{**}	54.29	0.67	1.27
21	Gemmiza 12	124.39	0.73	2.12^{**}	70.29	0.95	1.28	54.33	0.75	-0.31
Mean		123.12			70.28			41.33		
R. L. S. D. 0.05		3.26			3.03			1.45		
R. L. S. D. 0.01		4.38			4.07			1.93		

*, ** Significantly from unity for (b_i) and from zero for (S^2d) at 0.05 and 0.01 probability levels, respectively.

Table 10. Stability parameters for proline and grain yield of 21 genotypes over environments.

No.	Genotypes	Proline			Grain yield Ard/fed.		
		$(\bar{X})$	b_i	S^2d	$(\bar{X})$	b_i	S^2d
1	Giza 164	9.14	1.12	0.81	7.65	1.20	0.00
2	Shandweell 1	16.59	0.95	1.09	7.21	1.03	0.11
3	Sakha 93	9.04	0.71^{*}	-0.01	6.99	1.00	-0.06
4	Sids 1	15.69	0.92	0.58	6.77	1.23	-0.01
5	Gemmiza 7	14.79	0.91	-0.04	7.05	1.18	0.03
6	Sids 12	13.48	0.91	-0.38	6.90	1.14	0.14^{*}
7	Sids 14	12.10	1.01	0.33	7.21	1.20	-0.06
8	Sids 2	12.39	0.81	-0.32	6.87	0.84	0.15^{*}
9	Giza 168	9.31	0.68^{**}	0.39	7.17	0.93	0.31^{**}
10	Line 3	9.55	1.23	0.44	7.54	1.02	0.01
11	Line 4	16.94	1.67^{**}	0.86	5.03	1.01	-0.03
12	Sakha 95	14.46	1.16	6.73^{**}	6.74	1.10	-0.07
13	Giza 171	11.85	0.80	0.51	7.33	1.13	0.11
14	Line 7	17.76	1.19	0.13	5.61	1.06	-0.04
15	Line 8	13.66	0.88	0.08	7.46	1.13	0.07
16	Misr 1	17.90	1.24	0.12	7.14	1.14	0.15^{*}
17	Misr 2	14.55	1.60^{**}	0.29	7.53	0.69^{*}	-0.03
18	Misr 3	9.60	0.56^{**}	-0.31	7.04	0.99	0.04
19	Gemmiza 9	10.66	0.50^{**}	0.05	7.77	0.93	-0.01
20	Gemmiza 11	12.84	1.15	0.43	8.82	0.93	-0.05
21	Gemmiza 12	12.92	1.01	1.92	8.74	0.13^{**}	0.14^{*}
	Mean	13.10			7.17		
	R. L. S. D. 0.05	1.09			0.39		
	R. L. S. D. 0.01	1.45			0.52		

*, ** Significantly from unity for (b_i) and from zero for (S^2d) at 0.05 and 0.01 probability levels, respectively.

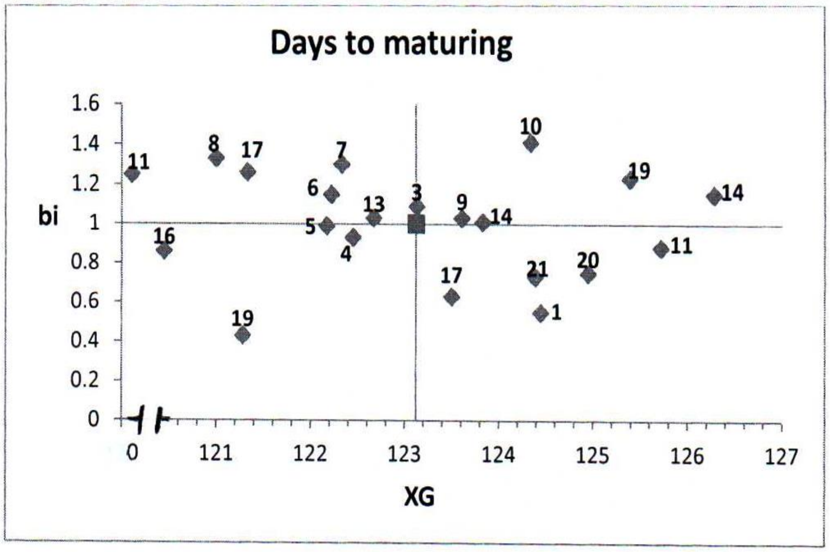

Fig 1. Graphical illustration of the stability parameter (b_i) and the mean performance of each individual genotype for days to maturing.

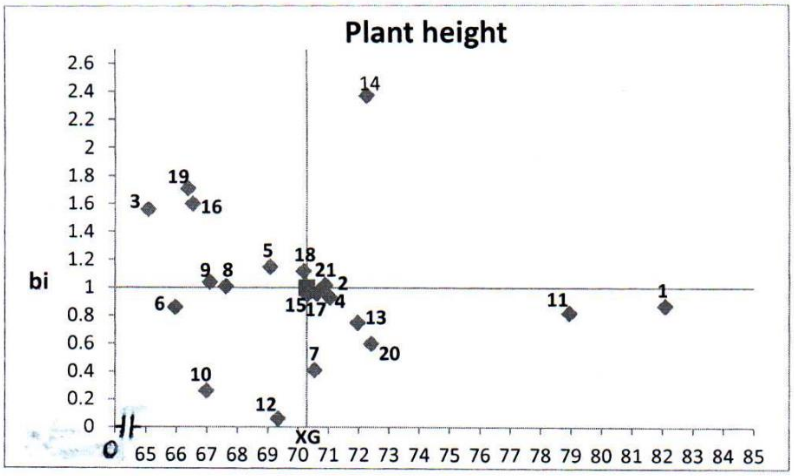

Fig 2. Graphical illustration of the stability parameter (bi) and the mean performance of each individual genotype for plant height.

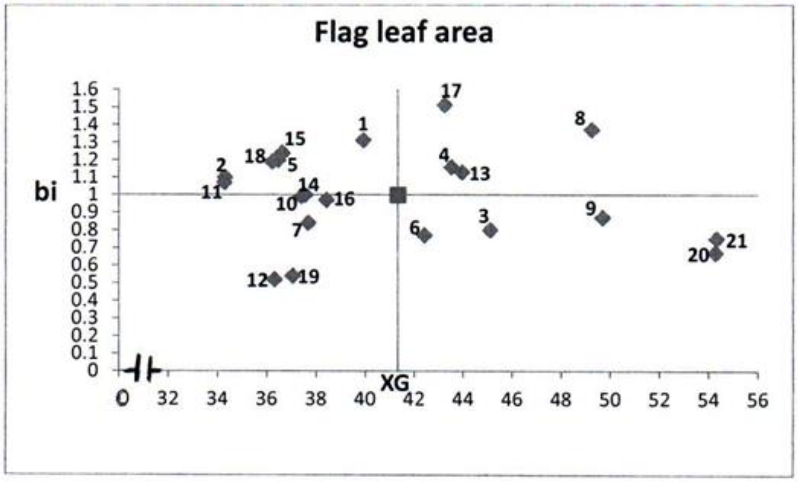

Fig 3. Graphical illustration of the stability parameter (bi) and the mean performance of each individual genotype for flag leaf area.

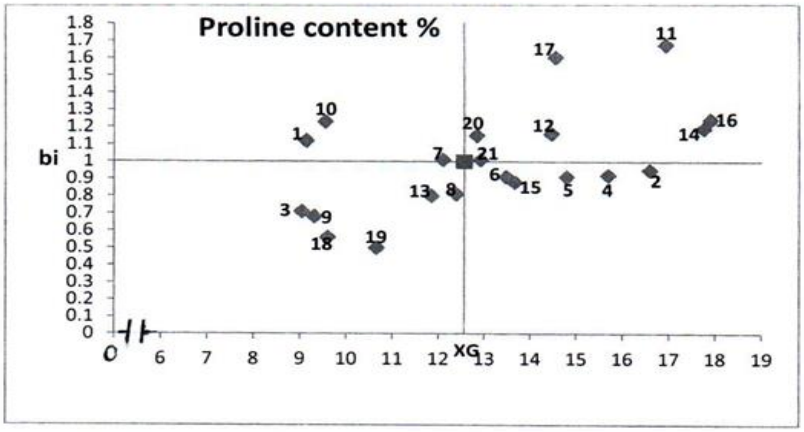

Fig 4. Graphical illustration of the stability parameter (bi) and the mean performance of each individual genotype for proline content %.

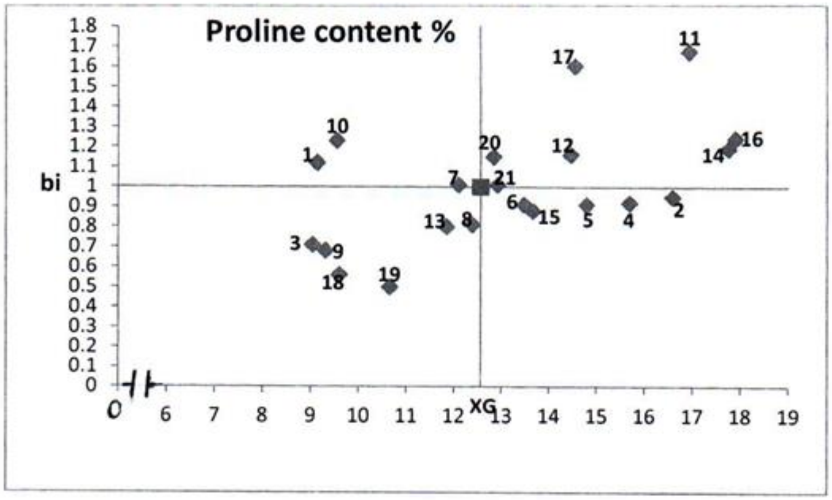

Fig 5. Graphical illustration of the stability parameter (bi) and the mean performance of each individual genotype for grain yield.

Authors' Contributions

All authors are contributed in this research.

Funding

There is no fund in this research.

Institutional Review Board Statement

All Institutional Review Board Statement are confirmed and approved.

Data Availability Statement

Data presented in this study are available on fair request from the respective author.

Ethics Approval and Consent to Participate

This work carried out at Agronomy department and followed all the department instructions.

Consent for Publication

Not applicable.

Conflicts of Interest

The authors declare no conflict of interest.

5. References

Ahmad, N., Khan, A.S., Kashi, M., Rehman, A. (2017). 'Genetic studies of biomass partitioning in wheat under water stress conditions', *The Journal of Animal & Plant Sciences*, 27(1), pp. 144-152.

Al-Naggar, A.M.M., Abd El-shafi, M.A., El-Shal, M.H., Anany, A.H. (2020). 'Selection criteria and selection environment for drought tolerance of Egyptian Wheat (*Triticum aestivum* L.) landraces', *ARRB,* 35(2), pp. 25-40.

Anonymous (2020). *'Egyptian Ministry of Agriculture'*, https://moa.gov.eg/ar/ministry-activities/news/.

Awad, H.A. (1997). 'Phenotypic stability for afrain yield and its contributing characters in durum wheat, *Triticum turgidum* L. var.

Bartels, D., Sunkars, R (2005). 'Drought and salt tolerance in plants', *Critical Reviews in Plant Science*, 24(1), pp. 23-58.

Bates, L.S, Waldern, R.P., Teare, I.D. (1973). 'Rapid determination of free proline for water-stress studies', *Plant Soil* ,39, pp. 205-207.

Bayoumi, T.Y., Amal M. Abd EL-Mageed, Enas S. Ibrahim, Soad A. Mahmoud, El-Demardash, I.S., Abdel-Raheem, A. (2015). 'The Impact of Drought Stress on some Morpho-Physiological Traits and RAPD Markers in Wheat Genotypes', *Journal of Plant Production Sciences,* 4, pp. 27-37.

Begcy, K., Walia, H. (2015). 'Drought stress delays endosperm development and miss regulates genes associated with cytoskeleton organization and grain quality proteins in developing wheat seeds', *Plant Science,* 240, pp. 109-119.

Cattivelli, L., Rizza, F., Badeck, F., Mazzucotelli, E., Mastrangelo, A., Francia E., Marè, C., Tondelli, A., Stanca, A.M. (2008). 'Drought tolerance improvement in crop plants: an integrated view from breeding to genomics', *Field crops research*, 105 (1-2), pp. 1-14.

Chamurliyski, P., Tsenov, N. (2013). 'Yield stability of contemporary Bulgarian winter wheat cultivars (*Triticum aestivum* L.) in Dobrudzha', *Agriculture Science and Technology*, 5 (1), pp. 16 – 21.

Chaves, M.S., Martinelli, J.A., Wesp-Guterres C., Graichen, S., Brammer S.P., Scagliusi, S.M., Consoli, L. (2013). 'The importance for food security of maintaining rust resistance in wheat', *Food security*, 5(2), pp. 157-176.

Durum', *Ann. Agric. Sci.*, (35), pp. 181-194.

Eberhart, S.A., Russel, W.A. Russel. (1966). 'Stability parameters for comparing varieties', *Crop. Sci.*, 6(1), pp. 36-40.

El-Rawi, K., Khalafalla, A.M. (1980). *'Design and analysis of agricultural experiments',* El-Mousel Univ., Iraq, pp.19.

Falconer, D.S. (1990). *'Selection in different environments: effects on environmental sensitivity (reaction norm) and on mean performance',* Genet. Res., Camb, 56, pp. 57-70.

FAOSTAT (2020). *'Food and Agriculture Organization of the United Nations,faostat',* https://www.fao.org/faostat/en/#data/QCL

Farshadfar, E., Poursiahbidi M.M., Safavi, S.M. (2013). 'Assessment of drought tolerance in land races of bread wheat based on resistance/ tolerance indices', *Int J. Adv Biol Biom Res.*, 1(2), pp. 143-158.

Farshadfar, E., Poursiahbidi, M.M., Abooghadareh, A.R.P. (2012). 'Repeatability of drought tolerance indices in bread wheat genotypes', *Intl J. Agri Crop Sci.*, 4 (13), pp. 891-903.

Fernandez, G.C.J. (1992). *'Effective selection criteria for assessing stress tolerance. In: Proceedings of the International Symposium on Adaptation of Vegetables and Other Food Crops in Temperature and Water Stress',* Kuo C.G. (Ed.). Publication, Tainan, Taiwan.

Fischer, R.A., Maurer, R. (1978). 'Drought resistance in spring wheat cultivars: I- Grain yield response', *Aust. J. Agric. Res.*, 29 (5), pp. 897-912.

Gomez, K.A., Gomez, A.A. (1984) *'Statistical procedures for Agricultural Research',* John willey & Sons Inc. New York, USA.

Hamam, K.A., Khaled, A.G.A., Zakaria, M.M. (2015). 'Genetic stability and diversity in yield components of some wheat genotypes through seasons and heat stress under different locations', *J. Plant Production, Mansoura Univ.*, 6 (3), pp. 349 -370.

Hossain, A.B.S., Sears, A.G., Cox, T.S., Paulsen, G.M. (1990). 'Desiccation tolerance and its relationship to assimilate partitioning in winter wheat', *Crop Sci.*, 30, pp. 622-627.

Iqbal, J. (2019). 'Morphological, physiological and molecular markers for the adaptation of wheat in drought condition', *Asian Journal of Biotechnology and Genetic Engineering*, pp. 1-13.

Jhinjer, R. K.; Mavi, G. S., Malhotra, A., Sood, N., Singh B., Kaur, B., Kumar, V., Bhagat, I., Sohu, V. S. (2017). 'Stability analysis for grain yield and micronutrients in bread wheat genotypes', *Advances in Research*, 11(1), pp. 1-8.

Ji, X., Shiran, B., Wan, J., Lewis, D.C., Jenkins, C.L.D, Condon, A.G., Richards, R.A., Dolferus, R. (2010). 'Importance of pre-anthesis anther sink strength for maintenance of grain number during reproductive stage water stress in wheat', *Plant, Cell & Environment*, 33(6), pp. 926-942.

Johari-Pireivatlou, M. (2010). 'Effect of soil water stress on yield and proline content of four wheat lines', *African Journal of Biotechnology*, 9 (1), pp. 036-040.

Kazmi, R.H., Khan M.Q., Abbasi, M.K. (2003). 'Yield and yield components of wheat subjected to water stress under rainfed conditions', *Acta Agronomica Hungarica*, 51(3), pp. 315–323.

Mafakher, A., Siosemardeh, A., Bahramnejad, B., Struik, P., Sohrabi, Y. (2010). 'Effect of drought stress on yield, proline and chlorophyll contents in three chickpea cultivars', *Australian journal of crop science,* 4(8), pp. 580.

Mahmood, T., Abdullah, M., Ahmar, S., Yasir, M., Iqbal, M.Sh., Yasir, M., Ur Rehman, Sh., Ahmed, S., Rana R.M. Abdul Ghafoor., Shah, M.K.N., Du, X., Mora-Poblete, F. (2020). 'Incredible role of osmotic adjustment in grain yield sustainability under water scarcity conditions in wheat (*Triticum aestivum* L.)', *Plants.*, 9, 1208; doi:10.3390.

Mahmud, Md.S., Ullah, Md.J., Baque, Md. A., Naher, L., Mohsin, S.M. (2016). 'Performance of Wheat as Affected by Different Irrigation Levels and Sowing Dates', *A Scientific Journal of Krishi Foundation, The Agriculturists,* 14(2), pp. 77-85.

Mehraban, A., Tobe, A., Gholipouri, A., Amiri, E., Ghafari, A., Rostaii M. (2019). 'The Effects of drought stress on yield, yield components, and yield Stability at different growth stages in bread wheat cultivar (*Triticum aestivum* L.)', *Pol. J. Environ. Stud.,* 28 (2), pp. 739-746.

Mirbahar, A.A., Markhand, G.S., Mahar A.R., Abro, S.A., Kanhar, N.A. (2009). 'Effect of water stress on yield and yield components of wheat (*Triticum aestivum* L.) varieties', *Pa k. J. Bot.,* 41(3), pp. 1303-1310.

Moayedi, A.A., Boyce, A.N., Barakbah, S.S. (2010). 'The Performance of durum and bread wheat genotypes associated with yield and yield component under different water deficit conditions', *Aust. J. Basic & Appl. Sci.,* 4(1), pp. 106-113.

Muhder, N., Gessese, M.K., Sorsa, Z. (2020). 'Assessment of Genetic variability among agronomic traits and grain protein content of elite bread wheat (*Triticum aestivum* L.) genotypes in the central highlands of Ethiopia', *Asian J. Agric. Res.,* 14 (1), pp. 1-12.

Mwadzingeni, L., Shimelis, H., Tsilo T.J. (2018). 'Combining ability and gene action controlling yield and yield components in bread wheat (*Triticum aestivum* L.) under drought-stressed and non-stressed conditions', *Plant Breeding,* 137(4), pp .502–513.

Mwadzingeni, L., Shimelis, H., Tesafy, S., Tsilo, T.J. (2016). 'Screening of bread wheat genotypes for drought tolerance using phenotypic and proline analyses', *Front Plant Sci.*, 7, pp. 1-12.

Nikolaeva, M., Maevskaya, S., Shugaev, A., Bukhov N. (2010). 'Effect of drought on chlorophyll content and antioxidant enzyme activities in leaves of three wheat cultivars varying in productivity', *Russian Journal of Plant Physiology,* 57(1), pp. 87-95.

Nouraein, M., Mohammadi, S.A., Aharizad, S., Moghaddam, M., Sadeghzadeh, B. (2013). 'Evaluation of drought tolerance indices in wheat recombinant inbred line population', *Annals of Biological Research,* 4 (3), pp. 113-122.

Salarpour, M., Pakniyat, H., Abdolshahi, R., Heidari, B., Razi, H., Afzali, R. (2020). 'Mapping QTL for agronomic and root traits in the Kukri/RAC875 wheat (*Triticum aestivum* L.) population under drought stress conditions', *Euphytica.*, 216, 105.

Semahegn, Y., Shimelis, H., Laing, M., Mathew, I. (2021). 'Genetic variability and association of yield and yield components among bread wheat genotypes under drought-stressed conditions', *AJCS.*, 15(06), pp. 863-870.

Shalaby, E.M.M., Galall, E.H., Amro, A., El Ramly, A. (2020). 'Growth and yield responses of ten wheat (*Triticum aestivum* L) genotypes to drought', *SVU-International Journal of Agricultural Science,* 2 (2), pp. 1-17.

Shamsi, K., Kobraee, S. (2011). 'Bread wheat production under drought stress conditions', *Annals of Biological Research,* 2 (3), pp. 352-358.

Shamuyarira, K.W., Shimelis, H., Tapera, T., Tsilo, T.J. (2019). 'Genetic advancement of newly developed wheat populations under drought-stressed and non-stressed conditions', *J. Crop Sci. Biotech.*, 22 (2), pp. 169 - 176.

Siddhi, Sh., Patel, J.B., Patel, N. (2018). 'Stability analysis in bread wheat (*Triticum aestivum* L.)', *Journal of Pharmacognosy and Phytochemistry,* 7(4), pp. 290-297.

Singh, R.K., Chaudhary, B.D. (1985). *'Biometrical Methods in Quantitative Analysis',* Kalayanic Publishers. New Delhi.

Stewart, C.R. (1977). 'Inhibition of Proline Oxidation by Water Stress', *Plant Physiol,* 59, pp. 930.