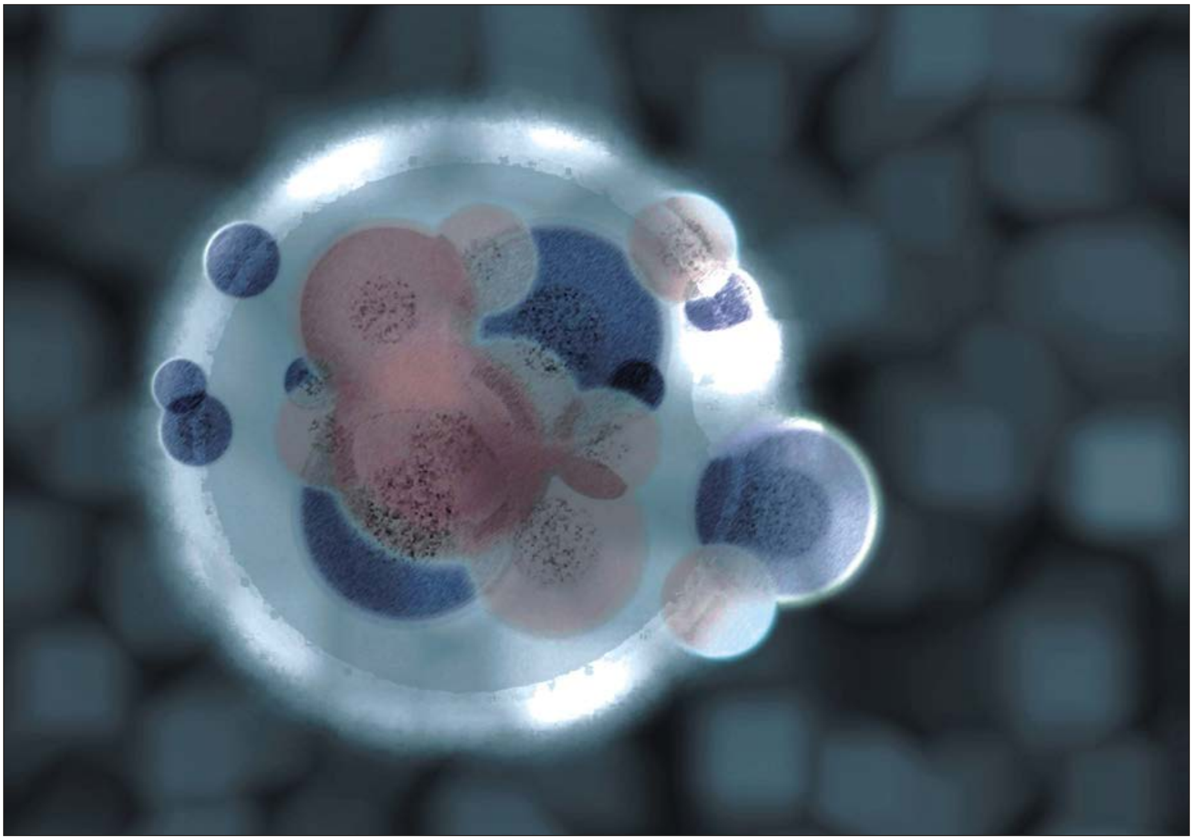

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Evaluation of Yield and Grain Quality of Some Bread Wheat Genotypes under Normal Irrigation and Drought Stress Conditions in Calcareous Soils

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Abstract: This study was designed to assess the impact of normal and water stress conditions on yield and quality of grain and seed of eight wheat genotypes and selection criteria for identifying drought tolerant in wheat bread genotypes. So, field and laboratorial experiments were conducted during 2008/10 seasons. The results indicated that water stress significantly decreased almost the studied traits. The lowest decrease of both seedling length and biological yield was produced from Sakha 93 and line 2, respectively. The genotypes 6, 7 and Sakha 93 gave the highest increase in phenols content. While, the others lines reflected the highest increase in proline content. Lines 3, 7, 6 and 2 showed highest increase in oil content. The value of Phenotypic Coefficient of Variability (PCV) was higher than Genotypic Coefficient of Variability (GCV) for growth, yield and its components characters under both conditions. Under water stress, high heritability (b.s.) produced for plant height, number of kernels/spike, 1000-kernel weight and grain yield. Also, 1000-kernel weight, number of spikes m^{-2} and proline accumulation had highly and significant positive correlation with grain yield. While under normal conditions, grain yield had highly significant negative and positive correlation with days to maturity and plant height, respectively. In general, the high proline and phenols accumulation and number of spikes m^{-2}, 1000-kernel weight and grain yield were recognized as beneficial drought tolerance indicators and may be used as selection criteria in wheat breeding program. Also, planting the genotypes 1, 2, 5 and Sakha 93 may be considered the best parents for drought recovering ability and can be crossed to produce new crosses with desirable characters related to drought tolerance.

Key words: *Triticum aestivum* L., water stress, genotypes, yield, quality, genetic variability

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a major cereal crop in many parts of the world and it is commonly known as king of cereals. It belongs to Poaceae family and globally after maize, wheat is the second most produced food among the cereal crops, rice ranks third. In Egypt, the total production of 8522995 tons with an average yield of 6.45 tons ha^{-1} (FAO, 2009). During grain filling in wheat plants are subjected to some unfavorable conditions such as low winter rainfall, shortage of water irrigation and the need to withholding irrigation for saving water and early land evacuation for cultivating the following crop.

Water deficiency is generally considered as one of the limiting factors for crop productivity, which affects physiological as well as biochemical processes in plants (Osborne *et al.,* 2002). Recent research has shown that root responses to drought include a number of metabolic changes, which can be interpreted as signals passing from root to shoot (Bahrun *et al.,* 2002). To meet up the increasing demand for food grains, efforts are being made to develop modern varieties of wheat with high yield potential. Whenever, a crop variety is evolved, field trials are needed to find out the yield performance and quality in different agro-ecological zones. The protein content of wheat is also reported to be influenced by cultivar (Johnson and Mattern, 1975) and environment (Baenziger *et al.*, 1985). The present study was varieties to moisture stress in terms of number of tillers. Dubey and Sharma (1996) found significant increase in grain yield of wheat by the application of irrigation. Rana and Sharma (1997) used 25 diverse wheat genotypes, which were chosen, based on their yield performance and drought tolerance to study correlations among different characters under moisture stressed and non-stressed environment. They observed strong positive correlation between biological yield, grains/spike, 1000-grain weight and days to maturity and negative correlation with harvest index. Hassan *et al.* (1998) reported significant variation in grain yield of wheat genotypes grown under different management practices. Rana *et al.* (1999) studied 25 genotypes grown in drought and irrigated

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environments for 8 morph-physiological characters. Grain yield followed by grain weight per spike, 1000-grain weight, grains per spike and harvest index showed high sensitivity to moisture stress. Also, they found that heritability and genetic advance estimates for grains per spike and grain weight per spike in both environments and 1000-grain weight and harvest index in the moisture stressed environments showed that these traits were important for phenotypic selection. Naik (2000) conducted correlation studies on 200 wheat genotypes under irrigated and rainfed conditions and found correlation coefficient between yield and yield attributing traits indicated positive and significant correlation of grain yield with spikes m^{-2}, grains per spikelets and harvest index. Drought during the first 6-14 days after anthesis in cereals, reduce the storage capacity of grain by decreasing the number of endosperm cell and the number of amyloplates initiated. Water stress inhibits enzyme activity thereby causing premature desiccation (Saini and Westagate, 2000). Khan *et al.* (2002) found that significant differences in most of the seedling traits among wheat genotypes at different moisture levels (control tap water 100, 70, 50 and 30% tap water of control). The wheat varieties significantly differed with respect to plant height, 1000-grain weight, grain yield and protein content in grains (Kamal *et al*., 2003). Akram *et al.* (2004) stated that Barani-83 performed better and proved to be the most drought tolerant, because of its better osmotic adjustment, while Inqilab-91 was the most sensitive one to water stress as it suffered from maximum loss (37.38%) in grain yield due to decline in 1000-grain weight. Saffer-ul-Hassan *et al*. (2004) used twenty four wheat genotypes and reported the genotypes were highly significant for days to maturity, plant height, number of grains/spike and 1000-grain weight except for yield/plot where significant difference was observed among the genotypes. Also, they found maximum heritability was observed for days to maturity (87.60%), while the minimum value (24.27%) was observed for yield/plot. On the other hand, value of genetic advanced ranged from a minimum 0.06 for grain weight/spike to a maximum 9.79 for yield/plot. They also found the calculated correlation coefficients indicated that day to maturity and plant height were significantly positive correlated with grain yield/plot, while a non significant correlation was observed between grain yield/plot and 1000-grain weight. Bhutta (2006) pointed out that high genetic variation was found in grain yield. Highly significant differences among wheat genotypes in plant height, 1000-kernel weight (g), biological yield m^{-2} (g), grain yield m^{-2} (g) and harvest index (%), however, water stress significantly decreased them (Bayoumi *et al*., 2008). Nouri-Ganbalani *et al.* (2009) reported that under normal irrigation no significant correlation was observed between the grain yield and other morphological characters but under drought stress conditions, there were positive highly significant correlations between grain yield and 1000-grain weight.

Therefore, the aims of the present study were: 1) to assess the impact of water stress on different varieties of wheat, 2) to assess the various biochemical and morphological changes associated with the plants under water stress and 3) to assess the selection criteria for identifying drought tolerant in wheat bread genotypes, so that suitable genotypes can be recommended for cultivation under water stress conditions.

MATERIALS AND METHODS

Two years field experiment was conducted at Al-Nubaria Research Experimental farm, Al Behaira Governorate, Egypt during 2008/09 and 2009/10 seasons to evaluate the effect of the normal irrigation and water stress conditions on growth, yield and its components as well as grain quality of some wheat genotypes. Also, two laboratorial experiments were conducted at Seed Technology Research Unit in Mansoura, Dakahlia Governorate, Field Crop Research Institute, Agricultural Research Center to determine germination percentage and seedling growth of seed produced from field experiments.

Wheat genotypes: The selection of the genotypes was based on their high yielding and resistance rusts. The tested material was seven wheat genotypes imported from International Centre for Improved Wheat and Maize CIMMYT beside the local named (Sakha 93). These genotypes selected from National Wheat Research Program at Nubaria Station, Wheat Research Department, Agricultural Research Center, Ministry of Agriculture and Land Reclamation. Table 1 presents the pedigree of the studied genotypes.

Field experiments: The genotypes were evaluated under two experiments. Experiment one was grown under normal irrigation and experiment two was grown under drought

Table 1: Pedigree of wheat genotypes used for drought tolerance assessment

Entry No.	Pedigree
1	LIRA//BUC/PVN/3/HE1/3*CNO79//2*SERI/4/PRL11 CMSS93Y02800T-8Y-010Y-010M-010Y-6M-0Y
2	PGO/SERI//BAV92 CMSS96M03193S-10M-010SY-010M-010SY-4M-0Y
3	HIDHAB-0DAZ
4	DULUS/METSO CMSS99M02456S-040M-030Y-030M-6Y-1M-3M-0Y
5	HPO/TAN//VEE//3/2*PGO/4/MILAN/5/SSERI 1 CMSS97M03642T-040Y-030M-020Y-040M-7Y-2M-0Y
6	KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES CMSS97M03912T-040Y-030M-020Y-040M-4Y-2M-0Y
7	KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES CMSS97M03912T-040Y-020Y-030M-020Y-040M-4Y-3M-0Y
Sakha 93	Sakha 92 / TR810328 S 8871-1S-2S-1S-0S

Table 2: Physical and chemical characteristics of the soil at the experimental sites during 2008/09 and 2009/10

	Particle size analysis (%)							
Soil depth (cm)	Coarse sand	Fine sand	Silt	Clay	Texture class	$CaCO_3$ (%)	pH	E.C. ($ds\ m^{-1}$)
0-30	11.4	35.7	26.4	26.5	Sandy clayey loam	29.8	8.5	1.05
30-60	8.0	38.9	27.3	27.8	Sandy clayey loam	30.1	8.3	0.90

stress (one time after planting irrigation and the second was at tillering stage). Grains were sown on 18th November 2008/09 and 23rd November 2009/10 seasons. Each experiment was designed in a randomized complete block design with three replications. Each plot consisted of six rows 2.5 m long and 20 cm apart. The area harvested was 2 m^2. All the cultural practices were performed as recommended. The soil of the experimental site was calcareous and its physical and chemical properties were determined according to Page (1982) and presented in Table 2.

Studied characters

Growth, yield and its components characters: After maturity, ten plants were randomly selected from each plot to estimate plant height (cm) and number of Days to Maturity (DM).

At harvesting time, two square meters was randomly chosen from each plot to determine the number of kernels/spikes, number of spikes m^{-2} and 1000-kernel weight. Grain yield was determined by harvesting whole plants in each plot (tons ha^{-1}). Biological yield/plot (BY) was estimated as the total ground dry mater of each plot and converted to tons ha^{-1}. Harvest index (HI) was estimated according to the formula, GY/BY×100.

Grain quality: Samples of grains from each treatment of field experiments were oven dried and ground finely for chemical analysis. Total phenols (mg catechole 100 g^{-1} dry weight) were determined using the Folin-Ciocateau reagent (Singleton and Rossi, 1965). Proline accumulation (μ moles g^{-1} dry weight) was determined according to the method of Bates *et al.* (1973). Oil percentage (%) in grains was determined after extraction with Soxhelt`s apparatus using hexan as an organic solvent according to AOAC (1990). Seed nitrogen percentage was estimated by using micro Kjeldahl apparatus and multiplied by the converting factor (5.75) to get seed protein percentage (Jackson, 1967). Total carbohydrates were estimated using the phenol sulphoric acid method (Dubois *et al*., 1956).

Laboratory experiments: Seeds of each treatment resulted from field experiment were sown and subjected to standard germination test as the rules of International Seed Testing Association (ISTA, 1985). At the end of standard germination test after 8 days from sowing, germination percentage was defined as the total number of normal seedlings. Seedling length (cm) was measured for determined from 10 normal seedlings taken at random from each replicate, then dried in a forced air oven at 105°C for 24 h to obtain seedlings dry weight (g). A completely randomized design with four replicates was used in these experiments.

Genetic parameters: Heritability in broad sense (h^2) was determined as:

$$\delta^2 g / \delta^2 p$$

$$\text{Phenotypic Coeficient of Variability (PCV)} = \frac{\text{Phenotypic Variance } (\delta p)}{x} \times 100$$

$$\text{Genotypic Coefficient of Variability (GCV)} = \frac{\text{Genotypic Variance } (\delta g)}{x} \times 100$$

where, x = grand mean of all entries. The PCV and GCV coefficients of variation were calculated according to Toker (1998). Genetic advance was calculated according to Allard (1960). Expected genetic advance (EGA) as percentage of the grand mean (EGA %).

Statistical analysis: All data were analyzed using SAS-STAT statistical computer software package (SAS Institute, 2001) for each season and then combined analysis for the two seasons was performed for each experiment (Gomez and Gomez, 1984). Differences among treatment means were compared using the least significant differences test (LSD) at the level of 5% of probability. The expected mean squares were calculated according to Snedecor and Cochran (1982). The estimates of variance components were obtained as suggested by Toker (1998) from the combined analysis. The estimate of correlation coefficients was done according to Steel and Torrie (1960).

RESULTS

Growth, yield and yield components: Response of eight wheat genotypes to water stress at tillering stage was evaluated and the results are presented in Tables 3, 4, 5, 6 and 7. The differences among genotypes in all the studied characters were significant in both normal and water stress conditions, except for maturity days under water stress only as well as dry weight of 10-seedlings

Table 3: Growth, yield and yield components of wheat genotypes under normal and irrigation stress conditions (combined data)

	Days to maturity			Plant height (cm)			Number of spikes m^{-2}			Number of kernels/spike		
Genotypes	N	S	Improvement (%)	N	S	Improvement (%)	N	S	Improvement (%)	N	S	Improvement (%)
1	143.5	134.6	-6.20	93.3	88.3	-5.36	356	333	-6.46	45.08	33.13	-26.51
2	144.2	134.2	-6.93	103.8	90.8	-12.52	398	366	-8.04	44.05	32.88	-25.36
3	143.8	135.2	-5.98	100.0	90.8	-9.20	356	350	-1.69	40.66	35.61	-12.42
4	144.3	135.2	-6.31	100.0	89.2	-10.80	376	293	-22.07	36.43	31.79	-12.74
5	143.5	135.7	-5.44	94.2	90.0	-4.46	350	281	-19.71	43.60	37.01	-15.11
6	144.7	134.3	-7.19	99.2	92.5	-6.75	441	350	-20.63	44.11	38.28	-13.22
7	144.7	134.3	-7.19	100.0	90.0	-10.00	454	343	-24.45	40.26	33.48	-16.84
Sakha 93	142.3	134.5	-5.48	91.7	82.5	-10.03	373	330	-11.53	37.86	33.13	-12.49
LSD at 5%	1.8	NS		5.8	4.3		71	57		3.14	2.52	

	1000-kernel weight (g)			Grain yield (ton ha^{-1})			Biological yield (ton ha^{-1})			Harvest index		
Genotypes	N	S	Improvement (%)	N	S	Improvement (%)	N	S	Improvement (%)	N	S	Improvement (%)
1	35.4	32.4	-8.47	5.10	4.65	-8.82	15.20	13.40	-11.84	32.83	33.60	+2.35
2	34.3	32.6	-4.96	5.00	4.52	-9.60	16.00	14.58	-8.88	30.52	30.25	-0.88
3	35.1	32.0	-8.83	5.37	4.46	-16.95	16.34	13.66	-16.40	31.06	33.84	+8.95
4	33.2	27.7	-16.57	4.56	3.79	-16.89	16.20	12.99	-19.81	28.45	29.53	+3.80
5	32.2	34.7	+7.76	5.14	4.55	-11.48	14.92	13.33	-10.66	34.90	34.35	-1.58
6	35.2	33.7	-4.26	5.29	4.48	-15.31	15.92	14.26	-10.43	33.54	32.09	-4.32
7	33.1	34.0	+2.72	5.10	4.18	-18.04	17.20	13.54	-21.28	29.14	31.97	+9.71
Sakha 93	35.9	32.4	-9.75	4.97	4.65	-6.44	14.86	13.40	-9.83	33.55	33.60	+0.15
LSD at 5%	3.5	4.1		0.46	0.43		1.68	1.95		3.13	3.51	

N: Normal irrigation, S: Water stress, NS:Non significant

Table 4: Grain quality, germination % and seedling characters of wheat genotypes under normal and stress irrigation conditions (combined data)

	Phenols content mg catechole/100 g dry weight			Proline content (μ moles/g dry weight)			Oil (%)			Protein (%)		
Genotypes	N	S	Improvement (%)	N	S	Improvement (%)	N	S	Improvement (%)	N	S	Improvement (%)
1	301	373	+23.92	2.21	9.26	+319.01	1.25	1.11	-11.20	11.2	10.30	-8.04
2	310	389	+25.48	2.94	10.39	+253.00	1.40	1.67	+19.29	12.4	11.00	-11.29
3	287	371	+29.27	2.30	8.50	+269.60	1.08	1.71	+58.33	12.3	10.60	-13.82
4	273	363	+32.97	3.06	7.76	+153.60	1.37	1.29	-5.84	11.6	10.80	-6.90
5	278	345	+24.10	3.15	10.27	+226.00	1.45	1.40	-3.45	12.9	12.20	-5.43
6	259	515	+98.84	4.26	6.91	+62.20	1.26	1.59	+26.19	12.5	11.80	-5.60
7	297	524	+76.43	3.07	5.91	+92.50	1.09	1.56	+43.12	13.4	12.80	-4.48
Sakha 93	308	499	+62.01	3.38	7.27	+115.10	1.23	1.20	-2.44	12.4	12.50	+0.81
LSD at 5%	49	47		1.02	1.24		0.45	0.53		0.8	0.74	

	Carbohydrates (%)			Germination (%)			Seedling length (cm)			Dry weight of 10-seedling (g)		
Genotypes	N	S	Improvement (%)	N	S	Improvement (%)	N	S	Improvement (%)	N	S	Improvement (%)
1	75.9	75.5	-0.53	96	89	-7.29	12.8	11.4	-10.94	0.103	0.084	-18.45
2	74.8	73.7	-1.47	99	91	-8.08	13.5	11.8	-12.59	0.113	0.094	-16.81
3	74.1	75.3	+1.62	95	94	-1.05	14.4	12.7	-11.81	0.121	0.095	-21.49
4	75.3	76.7	+1.86	99	95	-4.04	15.4	12.4	-19.48	0.133	0.121	-9.02
5	74.2	74.5	-0.40	97	95	-2.06	13.9	12.1	-12.95	0.117	0.116	-0.85
6	73.1	77.5	+6.02	98	95	-3.06	14.0	12.2	-12.86	0.129	0.123	-4.65
7	74.8	74.7	-0.13	99	98	-1.01	13.4	13.7	+2.39	0.135	0.126	-6.67
Sakha 93	74.5	74.1	-0.54	92	92	0.00	14.8	13.8	-6.76	0.130	0.131	+0.77
LSD at 5%	NS	NS		5	5		1.8	1.9		NS	NS	

N: Normal irrigation, S: Water stress, NS:Non significant

and total carbohydrates percentage under normal and water stress conditions. Data in Table 3 showed that most studied characters of wheat genotypes decreased under water stress compared to well-irrigated genotypes. The maximum reduction in days to maturity was recorded from the lines 6, 7 and 2 (-7.19, -7.19 and -6.93%) followed by the genotypes 4, 1 and 3 (-6.31, -6.20 and -5.98%), respectively. Whereas, the minimum decrease was in case of line 5 and Sakha 93 (-5.44 and -5.48%), respectively. The line 2 showed the maximum decrease in plant height (-12.52%) followed by the genotypes 4, Sakha 93 and 7 (-10.80,-10.03 and -10.00%), while the lowest decrease of plant height was resulted from the genotype 5 (-4.46%) under water drought. Number of spikes m^{-2} of line 7 was affected more and the line 3 of that was less affected by drought stress than other genotypes. The maximum reduction in number of kernels/spike under water stress was produced from the line 1 followed by the line 2. An increase in 1000-kernel weight under water stress was recorded from the line 5 (+7.76%) followed by

Table 5: Genetic parameters for some characters under normal and stress irrigation

Characters	Irrigation treatment	Grand mean	PCV	GCV	h^2 (%) (b.s)	EGA	EGA (%)
MD	N	143.85	1.92	0.93	22.78	1.32	0.92
	S	134.75	1.60	0.42	7.14	0.31	0.23
PH	N	97.77	12.01	9.70	65.14	15.76	16.12
	S	89.27	9.11	7.76	72.60	12.16	13.63
NS m^{-2}	N	388.60	29.54	22.62	58.67	138.73	35.70
	S	331.04	25.36	19.57	59.53	102.69	31.10
NK/SP	N	41.33	23.13	18.86	66.45	13.08	31.64
	S	34.40	17.00	16.10	89.20	10.74	31.22
1000 KW	N	34.42	13.70	7.23	27.86	2.71	7.86
	S	32.30	18.33	15.26	69.30	8.45	26.18
GY	N	5.06	17.50	10.77	38.00	0.69	13.65
	S	4.37	16.74	14.29	72.90	1.097	25.11
BY	N	15.88	15.68	12.92	68.00	0.35	21.93
	S	13.58	17.32	7.14	17.00	0.82	6.06
HI	N	31.75	19.36	16.95	79.61	9.70	30.55
	S	32.79	20.48	14.83	52.38	7.24	22.12

MD: Days to maturity, PH = plant height (cm), NS/m^2 : Number of spikes m^{-2}, NK/SP: Number of kernels/spike, 1000 KW:1000-kernel weight (g), GY:Grain yield (ton ha^{-1}), BY: Biological yield (ton ha^{-1}), HI: Harvest index, N: Normal irrigation, S: Water stress

Table 6: Simple correlation of some traits among promising wheat genotypes studied under normal irrigation conditions

Characters	MD	PH	NK/SP	1000 KW	NS m^{-2}	GY	BY	HI	Phenol	Proline	Oil (%)	Protein (%)	Carbohydrates (%)
MD	1.00												
PH	-0.50**	1.00											
NK/SP	-0.04	0.05	1.00										
1000KW	0.29*	-0.28*	0.28	1.00									
NS m^{-2}	-0.06	0.30*	0.23	-0.17	1.00								
GY	-0.51**	0.64**	0.26	0.04	0.10	1.00							
BY	-0.18	0.57**	0.04	-0.03	0.14	0.50**	1.00						
HI	-0.05	-0.05	0.18	0.02	0.18	0.30*	-0.60**	1.00					
Phenol	-0.25	0.05	-0.06	-0.05	-0.02	0.71	-0.02	0.15	1.00				
Proline	-0.01	0.02	-0.04	-0.01	0.30*	0.03	0.04	0.14	-0.23	1.00			
Oil %	-0.13	0.02	0.09	-0.14	0.06	0.05	0.01	0.04	-0.15	0.03	1.00		
Protein %	0.47**	0.02	-0.02	0.07	0.19	-0.32*	-0.23	0.08	-0.01	0.24	0.09	1.00	
Carbohydrates%	-0.29*	0.16	0.05	-0.15	-0.08	0.06	0.35*	-0.29*	0.21	-0.10	-0.16	-0.33*	1.00

MD: Days to maturity; PH: Plant height (cm), NS m^{-2}: Number of spikes m^{-2}, NK/SP: Number of kernels/spike, 1000 KW: 1000-kernel weight (g), GY: Grain yield (ton ha^{-1}), BY: Biological yield (ton ha^{-1}), HI: harvest index, Phenol (mg catechole/100g dry weight), Proline (μ moles/g dry weight) and *, **: Significant at 0.05 and 0.01 probability levels, respectively

Table 7: Simple correlation of some traits among promising wheat genotypes studied under water stress conditions

Characters	MD	PH	NK/SP	1000 KW	NS m^{-2}	GY	BY	HI	Phenol	Proline	Oil (%)	Protein (%)	Carbohydrates (%)
MD	1.00												
PH	0.17	1.00											
NK/SP	0.06	-0.14	1.00										
1000KW	0.11	0.44**	0.04	1.00									
NS m^{-2}	-0.13	0.09	-0.19	0.12	1.00								
GY	0.18	0.28*	-0.19	0.47**	0.29*	1.00							
BY	0.24	0.35*	-0.12	0.51**	0.25	0.58**	1.00						
HI	-0.16	-0.16	-0.11	-0.11	-0.11	0.35*	-0.45**	1.00					
Phenol	-0.07	0.10	0.05	0.22	0.20	0.08	0.04	0.08	1.00				
Proline	0.10	0.11	-0.11	0.25	0.16	0.33*	0.31*	-0.07	-0.56**	1.00			
Oil%	-0.26	0.20	0.10	0.28*	0.27	0.06	0.30*	-0.33*	0.04	0.09	1.00		
Protein%	0.10	0.20	0.26	0.15	-0.07	-0.11	-0.14	0.14	0.53**	-0.37**	-0.14	1.00	
Carbohydrates%	0.11	0.08	-0.22	-0.14	0.07	0.02	0.09	-0.09	0.04	-0.14	-0.13	-0.02	1.00

MD: Days to maturity; PH: Plant height (cm), NS m^{-2}: Number of spikes m^{-2}, NK/SP: Number of kernels/spike, 1000 KW: 1000-kernel weight (g), GY: Grain yield (ton ha^{-1}), BY: Biological yield (ton ha^{-1}), HI: Harvest index, Phenol(mg catechole/100g dry weight), Proline (i moles/g dry weight)and *, ** : Significant at 0.05 and 0.01 probability levels, respectively

the line 7 (+2.72%). Whilst, the maximum decrease resulted from the line 4 (-16.57%) under water stress conditions. The decline in grain yield/ ha was the maximum (-18.04%) in case of the line 7, followed by the lines 3, 4, 6 and 5, respectively. Whereas, the minimum decrease (-6.44%) was in case of Sakha 93. The results in the same Table showed that biological yield was reduced in all the wheat genotypes under water stress conditions. The maximum decrease in BY (-21.28%) was obtained from the line 7, followed by lines 4 (-19.81%) and 3 (-16.40%). Vice versa, the minimum decrease in biological yield was produced from line 2 (-8.88%). Harvest index was increased by water deficit in all wheat genotypes, except for the lines 2, 5 and 6. The maximum increase in harvest index was resulted from the line 7 (+9.71%) followed by the line 3 (8.95%). While, the maximum reduction of this trait (-4.32%) was recorded from the line 6.

Grain quality: Data in Table 4 showed the maximum increase in phenols content (+98.84%) under limited water supply in case of the line 6 followed by the line 7 and Sakha 93, whereas phenols content was the lowest in case of the line 1 under drought. Proline content increased under water stress compared with the normal irrigation. The maximum increase in proline content (+319.01%) produced from the line 1 followed by the lines 3, 2 and 5. While, proline content showed the lowest increase in case of the line 6 under water stress. On the other hand, water stress led to marked increase in grain oil content of some genotypes under study. The highest increase was resulted from the line 3 followed by the lines 7, 6 and 2. Whilst, the maximum decreased kernel oil content was produced from the line 1 followed by the lines 4 and 5. While, the minimum reduction in oil percentage (-2.44%) was in case of Sakha 93 under water stress. Kernel protein content decreased in all wheat genotypes under water stress. There were no significant differences among all wheat genotypes in total carbohydrates percentage under the normal irrigation and water stress conditions. On the other hand, water stress led to slight increases in grain carbohydrates content in the lines 3, 4, 5 and 6. Whereas, the highest increase (+6.02%) was in case of the line 6.

Germinability (seed quality): With regard the data in Table 4, the germination percentage and seedling length were significantly affected by irrigation treatments. But, there was no marked difference between wheat genotypes in both normal irrigation and water stress in dry weight of 10-seedlings. Water stress reduced all studied seed quality characters. Whereas, the highest values of these traits were produced from plants grown in normal irrigation. The maximum reduction in germination percentage (-8.08%) was in case of the line 2 followed by the line 1 (-7.29%), while, Sakha 93 was not affected by water stress. The maximum decrease in seedling length was produced from the line 4 (-19.81%) followed by the lines 2, 5, 6 and 3. Whilst, minimum decrease was in case of the Sakha 93 (-6.55%) and the increase in seedling length in water stress was +2.39% in case of the line 7.

Genetic parameters: Phenotypic Coefficient of Variability (PCV) and Genotypic Coefficient of Variability (GCV), estimates of the components of variance, broad-sense heritability (h^2), Expected Genetic Advance (EGA) and expected genetic advance as a percentage of mean (EGA %) are shown in Table 5. The PCV was higher than GCV for eight studied characters under normal and stress irrigation. Under normal and stress conditions, the PCV was high values for number of spikes m^{-2}, number of kernels/spike, harvest index, grain yield and biological yield while the low value was shown for days to maturity. Similar results were recorded under stress conditions. The GCV showed highest values for number of spikes m^{-2}, number of kernels/spike and harvest index under normal, also the same results were obtained under stress except for 1000-kernel weight (15.26) and grain yield (14.29). The heritability estimates ranged from 7.14 to 89.2%. In general, high value of heritability was found for number of kernels/spike, plant height, 1000-kernel weight and grain yield under drought stress, while the lowest value was found for days to maturity. The similar results were recorded under normal irrigation for all traits except for the harvest index and biological yield. The expected genetic advance (EGA%) ranged from 0.92 to 35.7 and 0.23 to 31.7 under normal and water stress conditions, respectively, the highest EGA were observed from number of spikes m^{-2}, number of kernel/spike and harvest index under two irrigation conditions as well as 1000-kernels weight and grain yield under water stress conditions. The value of heritability (b.s.) under stress was higher than under normal conditions for plant height, number of kernels/spike, 1000-kernel weight and grain yield. Number of spikes/m^2 and number of kernels/spike gave the highest value of EGA % (35.70 and 31.10, 31.64 and 31.22%) under normal and water stress conditions, respectively. Also, the highest value of EGA % produced in case of 1000-kernel weight, grain yield and harvest index under stress conditions. Crop improvement depends on genetic variability and extent to which traits are heritable. Grain yield is a complex trait, which is influenced by a number of contributing characters. The estimates of the inter relationship between grain yield and other yield attributes and among themselves would facilitate effective selection schemes to improve the yield and drought tolerance.

Correlation studies: Simple correlation coefficients were observed for all possible combinations of the thirteen different characters under normal and stress irrigation in wheat (Tables 6, 7). In present study, plant height and grain yield were negative correlated and high significant with days to maturity under normal irrigation. There was a non significant negative correlation between days to maturity, number of kernels/spike and proline content under normal conditions. Days to maturity was correlated negative and non significant with number of spikes m^{-2}, harvest index, phenol and oil content under normal and stress conditions. Days to maturity was highly positively significant correlated with protein content under normal, while it was positive non significant under stress. On the other hand, it was negatively significant correlated with carbohydrates % under normal but it was positively correlated under stress. There is no significant negative correlation between days to maturity and biological yield under normal conditions but positive and non significant under stress conditions. Grain yield and biological yield were positively and highly significantly correlated with plant height under normal conditions but positively and significantly under stress, there was a positive significant correlation between plant height and number spikes m^{-2} under normal irrigation but non significant and positive under stress. Plant height was not significantly positive correlated with number of kernels/spike under normal conditions, but was not significantly negatively correlated under drought stress. 1000-kernel weight was significantly negative correlated with plant height under normal conditions but was highly significantly positive correlated under stress irrigation.

The relationship of plant height was not significantly and negatively correlated with harvest index under normal and drought conditions. Plant height was positive no significantly correlated with all quality traits under two conditions. Number of spikes m^{-2}, grain yield, biological yield, harvest index and carbohydrates % were not significantly and positive correlated with number of kernels/spike under normal conditions while were non significant and negative under drought conditions. On contrast, the correlated was negative with phenol, protein, and proline under normal but positive under stress. 1000-kernel weight was not significantly negative correlated with number of spikes m^{-2}, biological yield, phenol, proline and oil content under normal conditions. Vice versa, it was positive and not significantly with number of spikes m^{-2} under stress condition. Grain yield and biological yield were positively and highly significant correlated with 1000-kernel weight under stress condition, but grain yield had positive and non significant correlation with 1000-kernel weight under normal conditions. Also, biological yield was not significantly negative correlated with protein content. Harvest index was positively and not significant correlated with 1000-kernel weight under normal conditions but was negatively and not significant under stress condition. There was no significant and positive correlation between number of spikes m^{-2} and grain yield, biological yield and harvest index under normal conditions. A positive and significant correlation was observed between number of spikes m^{-2} and grain yield under stress irrigation and a positively not significant correlation between number of spikes m^{-2} and biological yield under stress irrigation was observed, but negative and no significant correlation with harvest index under stress conditions. A positive highly significant correlation was found between grain yield and biological yield under normal and stress conditions, while positive significant correlation was found between grain yield and harvest index under normal and stress conditions. There was a negative highly significant correlation between biological yield and harvest index under both conditions.

A positive significant correlation was found between grain yield, biological yield and proline content under stress. Whilst, a negative significant correlation and non significant, respectively with protein content under normal conditions. A positive significant and negative significant correlation was found between biological yield and harvest index, respectively with carbohydrates percentage under normal conditions. The same result was found with oil content under stress conditions. Protein content was highly positively correlated significant with phenol content under stress. Vice versa, it was highly negative significant correlated with proline under stress.

DISCUSSION

The decrease in plant height in all genotypes in response to drought stress may be due to decrease in relative turgidity and dehydration of protoplasm which is associated with a loss of turgor and reduced expansion of cell and cell division (Arnon, 1972). Generally, depends on number of effective tillers and 1000-kernel weight. Similar results were recorded by Rana *et al.* (1999) and Bayoumi ***et al.*** (2008). The effect of water stress during grain filling on grain and straw yields may be due to the reduction in rate and duration of filling processes and causing small grain size consequently reducing number of spikes m^{-2}, number of grains/spike, grain weight/spike and 1000-kernel weight.

The genotypes which had high proline content might increase the ability to synthesize osmotic regulators (proline) for protection from the damage of soil water deficits. Furthermore, proline may play a role as an enzyme-stabilizing agent and has the ability to mediate osmotic adjustment, stabilize sub-cellular structure and scavenge free radicals (Hassanein, 2004). The reduction in germination parameters may be due to eventual depletion of grain moisture which produces smaller endosperm and premature seed with potentially reduced germination percentage and seedling vigor. Similar findings were stated by Saini and Westagate (2000). In the power of germination of wheat seeds under the influence of water stress caused by changes in osmotic potential solution sorbitol concluded that the grain before germination period be exposed to mild stress, speed and power will have a better germination (Qalambaran and Dindar, 1998). General functions such aswater and water week alternating elongation of plant seeds increases resistance to stress what can be intense. The reduction in the shoot length and the root length may be due to an impediment of cell division and elongation leading to kind of tuberization. This tuberization and the lignifications of the root system allow the plant to enter a slow-down state, while waiting for the conditions to become favorable again (Fraser *et al*., 1990). Moisture stress probably perturbed the physiological mechanisms of the sensitive varieties more severely than the tolerant ones.

CONCLUSION

It could be concluded that high proline and phenols accumulation and number of spikes/m^2, 1000-kernel weight and grain yield were recognized as beneficial drought tolerance indicators and may be used as selection criteria in wheat breeding program. Also, that planting the genotypes 1, 2, 5 and Sakha 93 may be considered the best parents for drought recovering ability and can be crossed to produce new crosses with desirable characters related to drought tolerance.

REFERENCES

AOAC, 1990. Official Methods of Analysis. 15th Edn., Association of Official Analytical Chemists, Washington DC. USA., pp: 200-210.

Akram, H.M., M.S. Iqbal, M. Saeed, A. Yar, A. Ali, K.A. Sahi and M.A. Nadeem, 2004. Drought tolerance studies of wheat genotypes. Pak. J. Biol. Sci., 7: 90-92.

Allard, R.W., 1960. Principles of Plant Breeding. 1st Edn., John Wiley and Sons Inc., New York.

Arnon, I., 1972. Crop Production in Dry Regions. Leonard Hill, London, pp: 203-211.

Baenziger, P.S., R.L. Clements, M.S. McIntosh, W.T. Yamaziki, T.M. Starling, D.J. Sammons and J.W. Johnson, 1985. Effect of cultivar, environment and their interaction and stability analysis on milling and baking quality of soft red winter wheat. Crop Sci., 25: 5-8.

Bahrun, A., C.R. Jensen, F. Asch and V.O. Mogensen, 2002. Drought induced changes in xylem pH, ionic composition and ABA concentration act as early signals in field grown maize (*Zea mays* L.). J. Exp. Bot., 53: 251-263.

Bates, L.S., R.P. Waldren and I.D. Teare, 1973. Rapid determination of free proline for water-stress studies. Plant Soil, 39: 205-207.

Bayoumi T.Y., M.H. Eid and E.M. Metwali, 2008. Application of physiological and biochemical indices as a screening technique for drought tolerance in wheat genotypes. Afr. J. Biotechnol., 7: 2341-2352.

Bhutta, W.M., 2006. Role of some agronomic traits for grain yield production in wheat (*Triticum aestivum* L.) genotype under drought conditions. Revista UDO Agricola, 6: 11-19.

DuBois, M., K.A. Gilles, J.K. Hamilton, P.A. Rebers and F. Smith, 1956. Colorimetric method for determination of sugars and related substances. Anal. Chem., 28: 350-356.

Dubey, Y.P. and S.K. Sharma, 1996. Effect of irrigation and fertilizers on growth yield and nutrient uptake by wheat. Ind. J. Agron., 41: 48-51.

FAO, 2009. Food and Agricultural Organization. United Nation, Rome, Italy.

Fraser, T.E., W.K. Silk and T.L. Rosr, 1990. Effect of low water potential on cortical cell length in growing region on maize roots. Plant Physiol., 93: 648-651.

Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research. 2nd Edn., John Wiley and Sons Inc., New York, pp: 95-109.

Hassan, M.A., A.M.A. Kamal and M.R. Islam, 1998. A study on the management system of organic and inorganic fertilizers on the yield and yield components in wheat (*Triticum aestivum* L.). Thai J. Agric. Sci., 31: 196-201.

Hassanein, A., 2004. Effect of relatively high concentrations of mannitol and sodium chloride on regeneration and gene expression of stress tolerant (*Alhagi graecrum*) and stress sensitive (*Lycopersicon esculentum* L) plant species. Bulg. J. Plant Physiol., 30: 19-36.

ISTA, 1985. International rules for seed testing. Seed Sci. Technol., 13: 299-355.

Jackson, M.L., 1967. Soil Chemical Analysis. 1st Edn., Prentice Hall of India Pvt. Ltd., New Delhi, India.

Johnson, V.A. and P.J. Mattern, 1975. Improvement of the nutritional quality of wheat through increased protein content and improved amino acid balance. Agron. J., 85: 1023-1028.

Kamal, A.M.A., M.R. Islam, B.L.D. Chowdhury and M.A. Maleque Talukder, 2003. Yield performance and grain quality of wheat varieties grown under rainfed and irrigated conditions. Asian J. Plant Sci., 2: 358-360.

Khan, M.Q., S. Anwar and M.I. Khan, 2002. Genetic variability for seedling traits in wheat (*Triticum aestivum* L.) under moisture stress conditions. Asian J. Plant Sci., 1: 588-590.

Naik, V.R., 2000. Genetic analysis of heat and drought tolerance in tetraploid wheat. Ph.D. Thesis, University of Agricultural Sciences, Dharwad.

Nouri-Ganbalani, A., G. Nouri-Ganbalani and D. Hassanpanah, 2009. Effects of drought stress condition on the yield and yield components of advanced wheat genotypes in Ardabil, Iran. J. Food Agric. Environ., 7: 228-234.

Osborne, S.L., V. Schepers, D.D. Francis and M.R. Schlemmer, 2002. Use of spectral radiance to estimate in season biopmass and grain yield in nitrogen and water stressed crop. Crop Sci., 42: 165-171.

Page, A.L., R.H. Miller and D.R. Keeney, 1982. Methods of Soil Analysis. 2nd Edn., Amercen Society of Agronomy, Madison, WI., USA.

Qalambaran, M.R. and A. Dindar, 1998. Power of wheat seed germination under the influence of water stress induced changes in osmotic potential. Agronomy Congress Abstracts Iran, Karaj, 1377.

Rana, V.K. and S.C. Sharma, 1997. Correlation among some morpho-physiological characters associated with drought tolerance in wheat. Crop Impr., 24: 194-198.

Rana, V., S.C. Sharma and G.S. Sethi, 1999. Comparative estimates of genetic variation in wheat under normal and drought stress conditions. J. Hill Res., 12: 92-94.

SAS, 2001. SAS user's Guide: Statistics. Ver. 8.1, SAS Institute Inc., Cray, NC., pp: 1397-1400.

Saffer-ul-Hassan, M., M. Munir, M.Y. Mujahid, N.S. Kisana, Zahid Akram and A. Wajid Nazeer, 2004. Genetic analysis of some biometric characters in bread wheat (*Triticum aestivum* L.). J. Biological Sci., 4: 480-485.

Saini, H.S. and M.E. Westgate, 2000. Reproductive development in grain crops during drought. Adv. Agron., 68: 59-96.

Singleton, V.L. and J.A. Rossi, 1965. Colorimetric of total phenolics with phosphomolybdic-phosphotungstic acid reagent. Am. J. Enol. Viticult., 16: 144-158.

Snedecor, G.W. and W.G. Cochran, 1982. Statistical Methods. 7th Edn., State University Press, Ames, Iowa, USA.

Steel, R.G.D. and J.H. Torrie, 1960. Principles and Procedures of Statistics. 1st Edn., McGraw Hill, New York, pp: 107-109.

Toker, C., 1998. Estimate of heritability and genotype by environment interaction for 100-seed weight, days to flowering and plant height in Kabuli chickpeas (*Cicer arietinum* L). Turk. J. Field Crops, 3: 16-20.