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Increasing Yield Potential of Promising Bread Wheat Lines under Drought Stress

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Abstract: Fifty four spring wheat (*Triticum aestivum* L.) genotypes of diverse origin evaluated for four water irrigation treatments over two seasons. That evaluated 54 spring wheat promising lines for 4 potential competition traits, including plant height (PH), heading to date (HD), 1000-kernel weight (TKW), and grain yield (GY) for the ability of these genotypes to achieve high yields. Differences were found among the 54 spring wheat genotypes for grain yield. The analysis of variance revealed that PH, HD, TKW, and GY were highly significant affected by genotypes, water irrigation treatments and years. The present results reported that drought stress reduced grain yield. The results show that wheat genotypes responded differently to various water irrigation treatments. The seven lines numbers 2, 9, 14, 18, 26, 35 and 47 gave highest grain yield under normal treatment (I_1), while the seven lines numbers 2, 4, 14, 22, 35, 47 and 50 gave the highest grain yield under stress treatment (I_2), moreover the seven lines numbers 2, 4, 15, 18, 22, 35 and 50 gave the highest grain yield under high stress treatment (I_3), on other hand the seven lines numbers 4, 15, 18, 22, 35, 51 and 53 gave the highest grain yield under high stress treatment (I_4) over two seasons. Our results indicate that direct selection would be most effective tool to increase the grain yield, while indirect selection on other traits may be effective in improving tolerance to stress. Clearly these data show that lines with similar agronomic performance and different genetic constitutions in this study that can be combined in a breeding program to potentially improve tolerance to drought stress.

Key words: Wheat - lines - drought stress.

INTRODUCTION

Wheat is an important staple crop around the world. Its importance has risen even more due to the frequently experienced food shortages and its role in world trade. Increasing wheat production to meet higher demands by growing population is still a challenge in many countries. Higher production is only possible via higher yielding, better quality, and drought tolerance varieties. Successful breeding programs require wide variation. Many investigators reported that skipping irrigation at any of the wheat developmental stages, particularly tillering, booting, heading, flowering, milk-ripe soft dough-ripe stages, led to a significant reduction in grain yield and its components[31,1,3,4,13]. Most of these studies indicated that yield reduction, was more pronounced if irrigation was skipped at tillering or heading stage. Whereas,[11] reported that milk-ripe and booting stages were the most sensitive ones to water stress. Genotypic differences in yield and its components among yield cultivars grown under water stress conditions, they could identify the most tolerant and most sensitive ones to water stress at different developmental stages[3,4,26]. Water is one of the most important ecological factors determining crop growth and development; water deficit plays a very important role in inhibiting the yields of Crops[17]. An efficient use of limited water resources and better growth under limited water supply are desirable traits for crops in drought environments. In recent years, many studies about the effects of supplemental irrigation on yield performance and water use efficiency have shown that proper supplemental irrigation can increase crop yield by significantly improving soil water conditions and their water use efficiency[10]. Water stress tolerance is seen in all plant species, but its extent varies from species to species. Although the general effects of drought on plant growth in crop plants are fairly well known[23, 29]. Landraces may be conveniently used both as a yardstick for progress in plant breeding, and as an interesting genetic resource for plant breeding, as they display a genetic diversity beyond the range available in modern cultivars[6]. Drought stress decreased leaf area duration, cumulative water transpired, net assimilation rate, mean transpiration rate, harvest index, and biomass yield[18]. Water use efficiency is the ratio of seed yield to water utilized, is generally inversely proportional to these verity of the drought stress 25% reduction in seed yield due to drought stress, expressed as the drought intensity index[28], stress reduces (20-100%) overall plant growth or biomass yield, number of seeds, harvest index, seed yield, seed weight, and seed quality in dry bean[34,14]. The most important meteorological factors affecting crop water requirement are air temperature and humidity, solar radiation, and wind speed[5]. In hot dry arid regions such as those found in Upper Egypt, wheat and other crops use large quantities of water for

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optimum growth due to the profusion of energy and the desiccating influence of the atmosphere. Furthermore, vapor removal is affected by wind speed because air movement transfers water vapor above the surface in a manner that is positively correlated with evapotranspiration. The objectives of this study were 1) to compare diverse genotypes and cultivars under drought stress, 2) to detect the effect of drought stress on yield and other traits of asset wheat genotypes.

MATERIALS AND METHODS

Fifty four genotypes were collected from diverse origin (Table 1). The experiments were conducted at the Experimental Farm of Faculty of Agriculture, Sohag University, Egypt on the 15^{th} November 2006/2007 and 2007/2008 of both seasons, in a split-split plot arrangement of treatments with three replicates. The levels of irrigation treatments were assigned to the main plot and genotypes were assigned randomly sub-plot, respectively. Each genotypes was sown in two rows with 3 meters long and 30 cm apart rows (sub plot size = 2.0 x 3.0 x 0.30 = 1.8 m^2). The genotypes were evaluated under water regimes. The first treatment was gave normal irrigation as control treatment (I_1), while in the second treatment was irrigated and withholding the irrigation after the milk stage until harvest as stress treatment (I_2), the third treatment was irrigated and withholding the irrigation after the booting stage until harvest as high stress treatment (I_3) and the fourth treatment was irrigated and withholding the irrigation after tillering stage until harvest as highly stress treatment (I_4). At harvest, data were recorded on plant height (PH), heading to date (HD), 1000-kernel weight (TKW), and grain yield (GY). Genotypes can be divided into four groups based on their yield response to stress conditions[15]: (1) genotypes producing high yield under both water stress and non-stress conditions (group A), (2) genotypes producing high yield under non-stress (group B) (3) genotypes producing high yield under stress conditions (group C) and (4) genotypes with poor performance under both stress and non-stress conditions (group D). Statistical analysis was performed using the analysis of variance (ANOVA) followed by least significant difference (LSD) test. Group average hierarchical cluster analysis using SPSS (version 10) program was used to develop dendrogram subgroups,[33]. All data were analyzed using the SAS (ver. 9.1.3) GLM procedure[30].

RESULTS AND DISCUSSION

The analysis of variance revealed that plant height, days to heading; 1000-kernel weight and grain yield were highly significantly affected by years, water regime treatments, and genotypes (Table 2). However, the water regimes x genotypes interaction were found highly significant for all traits studied. While water regimes x years interaction were showed highly significant for 1000-kernel weight and grain yield traits.

Plant Height: The average plant height of 54 genotypes over all treatments during two years ranged from 38.69 cm for genotype no. 28 to 119.28 cm for genotype no. 23 with an average of 80.07 cm over all genotypes (Table 3). The average of genotypes no. 2, 4, 5, 6, 7, 8, 17, 21, 45 and 46 revealed the lowest reduce in plant height under I_2 treatment as compared with normal irrigation (Table 7). The genotypes no. 2, 4, 5, 6, 15, 18, 22, 35, 39 and 42 showed the lowest reduction in plant height under I_3 treatment. The lowest decrease was found of genotypes no. 2, 4, 5, 6, 8, 15, 18, 22, 35 and 39 in plant height under I_4 treatment (Table 7). Moreover, genotypes no. 2, 4, 5 and 6 gave the least reduction under I_2, I_3 and I_4 as compared to normal irrigation. It is of importance to know that withholding irrigation from milking, booting and tillering stages until harvest decreased plant height by an average of 15.75, 23.06 and 37.69% as compared with normal irrigation.[13]summarized the effect of irrigation treatments on wheat yield attributes it could be concluded that skipping the irrigation at tiller stage produced the shortest plants with shortest spikes and lowest number of spikes/ m^2. These results are in harmony with those obtained by[16, 13].

Days to Heading: The average days to heading of 54 genotypes over all treatments during two years ranged from 45.46 days for genotype no. 4 to 104.33 days for genotype no. 51 with an average of 67.22 days over all genotypes (Table 4). The average of genotypes no. 2, 4, 5, 6, 7, 8, 17, 21, 45 and 46 revealed the lowest decrease in days to heading under I_2 treatment as compared with normal irrigation (Table 8). The genotypes no. 2, 4, 5, 6, 15, 18, 22, 35, 39 and 42 showed the lowest reduction in days to heading under I_3 treatment. The lowest decrease was found of genotypes no. 2, 5, 6, 8, 15, 18, 22, 35, 39 and 42 in days to heading under I_4 treatment. Furthermore, genotypes no. 2, 5 and 6 gave the least reduce under I_2, I_3 and I_4 as compared to normal irrigation. It is of importance to know that withholding irrigation from milking, booting and tillering stages until harvest reduced days to heading by an average of 13.75, 18.84 and 25.98% as compared with normal irrigation.[2, 13] reported that skipping the irrigation at heading stage, produced the lowest number of spikelets and hence grains/spike. A reduction in number of spilelets/spike and in number of fertilized ovules might explain. These results are in harmony with those obtained by[2, 13].

1000-kernel Wight: The average 1000-kernel weight of the 54 genotypes over treatments during two years (Table 5) ranged from 18.87 g. for genotype no. 30 to 57.20 g. for genotype no. 19 with an average of 35.49

Table 1: Brief description of the origin and the name of the fifty four bread wheat genotypes.

Ent. No.	Origin	Name	Cont. of Ent. No.	Origin	Name
1	Afghanistan	TRI 2794	28	Germany	TRI 25286
2	Afghanistan	TRI 2814	29	Germany	Devon
3	Afghanistan	TRI 2843	30	Mongolia	TRI 7790
4	Afghanistan	TRI 2846	31	Mongolia	TRI 7794
5	Afghanistan	TRI 2858	32	Mongolia	TRI 8149
6	China	TRI 2420	33	Mongolia	TRI 8394
7	China	TRI 2444	34	Mongolia	TRI 17629
8	China	TRI 2446	35	Spain	TRI 12856
9	China	TRI 2447	36	Spain	TRI 12866
10	China	TRI 2492	37	Spain	TRI 12874
11	ICARDA	CHAM-4	38	Spain	TRI 12887
12	ICARDA	KATILA-13	39	Spain	TRI 18675
13	ICARDA	QIMMA-12	40	Russia	TRI 12736
14	ICARDA	HAMAM-1	41	Russia	TRI 12737
15	ICARDA	HUD-10	42	Russia	TRI 12738
16	ICARDA	HAMAM-14	43	Turkey	TRI 19821
17	ICARDA	ASHOSHA-1	44	Turkey	TRI 19837
18	Indian	TRI 2474	45	Egypt	Local line 1
19	Indian	TRI 2477	46	Egypt	Local line 2
20	Indian	TRI 2485	47	Egypt	Local line 2
21	Indian	TRI 2514	48	Egypt	Local line 3
22	Indian	TRI 2592	49	Egypt	Local line 4
23	Iran	TRI 5580	50	Egypt	Local line 5
24	Iran	TRI 5625	51	Egypt	Sedes 1
25	Iran	TRI 5631	52	Egypt	Giza 168
26	Iran	TRI 5635	53	Egypt	Local line 8
27	Iran	TRI 5646	54	USA	TRI 17189

Table 2: Mean squares (MS) of the analysis of variance of all studied traits under water regimes treatments over two years.

Source of variance	D.F	M.S.			
Parameters		plant height	heading to date	1000-kernel weight	Grain yield
Years (Y)	1	7205.91**	3578.75**	2701.18**	39.56**
Water regime (W)	3	78083.19**	24205.52**	19006.86**	1031.16**
Y x W	3	68.42	27.73	421.62**	2.28**

Table 2: Continued.

Genotypes (G)	53	1783.63**	1190.66**	535.14**	44.91**
G x Y	53	3.06	2.13	1.17	0.12**
G x W	159	166.68**	74.45**	61.19**	3.29**
G x Y x W	159	1.18	0.58	2.06	0.03**
Error	862	79.34	33.92	1.79	0.011

Table 3: Mean of plant height for 54 bread wheat genotypes under water regimes treatments and over two seasons.

Ent. No.	Mean over two seasons I_1	I_2	I_3	I_4	Over all mean	Cont.Ent. No	Mean over two seasons I_1	I_2	I_3	I_4	Overall mean
	Plant height.(cm)										
1	86.58	75.82	70.73	60.34	73.37	28	78.62	58.73	52.46	38.69	57.13
2	85.15	75.88	76.24	61.80	74.77	29	88.58	70.43	56.23	41.46	64.17
3	105.40	89.50	79.48	67.55	85.48	30	106.43	90.08	84.84	73.89	88.81
4	109.52	103.34	97.29	80.22	97.60	31	106.78	78.58	68.39	47.87	75.40
5	98.19	89.55	86.08	72.62	86.61	32	96.13	75.93	62.33	43.46	69.46
6	103.69	92.63	92.37	75.27	90.99	33	99.57	77.44	63.90	46.05	71.74
7	90.98	88.30	75.32	60.62	78.81	34	88.92	70.63	59.25	41.88	65.17
8	105.40	97.54	84.98	75.51	90.86	35	99.22	85.06	85.87	73.34	85.87
9	115.70	94.56	93.75	80.54	96.14	36	114.33	99.59	86.94	72.88	93.43
10	105.75	92.85	86.07	72.25	89.23	37	117.42	101.19	95.87	80.21	98.67
11	82.06	70.96	67.09	58.38	69.62	38	106.78	90.73	82.29	72.92	88.18
12	88.58	71.44	68.00	58.31	71.58	39	106.43	93.46	88.91	76.76	91.39
13	101.97	85.30	83.39	66.94	84.40	40	98.88	85.16	75.70	63.75	80.87
14	98.19	82.79	79.21	64.35	81.14	41	99.22	87.78	77.68	65.78	82.62
15	87.55	74.02	75.85	65.88	75.82	42	95.45	83.70	80.99	68.25	82.10
16	91.33	79.41	73.06	62.70	76.63	43	101.63	89.82	82.99	70.11	86.14
17	83.09	73.64	66.00	55.75	69.62	44	98.88	87.51	78.09	65.57	82.51
18	90.64	77.61	77.54	65.99	77.95	45	87.55	78.14	70.06	59.56	73.83
19	95.45	80.46	77.56	67.76	80.31	46	91.33	83.93	73.67	62.40	77.83
20	97.51	83.95	75.53	63.37	80.09	47	95.45	81.28	77.15	64.77	79.66
21	97.85	86.80	78.32	64.43	81.85	48	99.01	83.42	76.18	61.69	80.08
22	98.19	85.70	85.78	71.12	85.20	49	117.35	90.76	75.20	50.60	83.48
23	119.48	90.10	76.28	53.49	84.84	50	109.18	86.20	77.50	57.82	82.67
24	100.25	72.02	60.29	42.98	68.89	51	98.88	81.70	78.98	62.57	80.53
25	101.28	82.67	67.87	49.59	75.36	52	105.75	83.47	70.87	48.48	77.14
26	97.16	77.26	74.49	58.80	76.93	53	99.22	75.00	69.86	48.40	73.12
27	94.42	74.48	59.80	43.29	68.00	54	108.15	86.03	73.39	52.08	79.91
						Mean	99.01	83.42	76.18	61.69	80.07

LSD at 0.05 0.01
Irrigation (I): 1.37 1.81
Genotypes (G): 5.05 6.64

Table 4: Mean of days to heading for 54 bread wheat genotypes under water regimes treatments and over two seasons.

Days to heading(days)										
Ent. No.	Mean over two seasons				Overall mean	Cont.Ent. No	Mean over two seasons				Overall mean
	I_1	I_2	I_3	I_4			I_1	I_2	I_3	I_4	
1	85.15	76.39	72.39	67.28	75.30	28	77.35	59.28	55.07	46.66	59.59
2	76.70	69.69	71.83	63.54	70.44	29	88.73	72.34	60.28	50.69	68.01
3	77.68	67.43	61.58	57.43	66.03	30	85.48	74.05	71.56	67.91	74.75
4	55.90	53.86	49.87	45.46	51.27	31	71.83	54.28	51.85	47.77	56.43
5	71.83	66.96	65.82	60.28	66.22	32	77.03	62.27	52.90	48.82	60.25
6	76.05	69.38	70.84	62.92	69.80	33	78.98	62.90	53.75	49.10	61.18
7	72.48	71.57	60.02	54.32	64.59	34	70.20	57.16	50.26	46.45	56.02
8	86.45	81.73	73.14	70.57	77.97	35	73.45	64.53	66.46	61.55	66.50
9	79.95	66.97	67.96	63.61	69.62	36	77.03	68.64	61.69	56.83	66.05
10	76.38	68.60	65.19	59.79	67.49	37	83.85	73.94	71.81	65.66	73.81
11	86.78	76.80	74.29	70.23	77.02	38	79.63	69.25	64.54	62.34	68.94
12	81.25	67.11	65.70	61.72	68.94	39	79.63	71.51	69.71	65.40	71.56
13	76.70	65.69	65.78	57.97	66.54	40	81.58	71.88	65.77	60.79	70.01
14	80.28	69.38	67.88	60.54	69.52	41	71.18	64.39	58.53	54.28	62.10
15	79.95	69.16	72.47	68.20	72.45	42	70.20	62.86	62.46	57.31	63.21
16	77.68	69.14	65.19	61.07	68.27	43	72.15	65.24	61.74	56.94	64.02
17	76.70	69.49	63.91	59.05	67.29	44	76.70	69.42	63.66	58.54	67.08
18	77.03	67.41	69.02	63.86	69.33	45	70.20	64.04	58.95	54.74	61.98
19	87.75	75.72	74.80	71.06	77.33	46	75.73	71.10	64.06	59.28	67.54
20	87.10	76.73	70.92	65.29	75.01	47	73.13	63.67	62.09	56.98	63.97
21	85.80	77.87	72.04	65.03	75.19	48	78.69	67.89	63.88	58.31	67.19
22	84.83	75.84	77.43	69.76	76.96	49	83.85	66.54	57.00	49.58	64.24
23	72.48	56.13	52.04	48.23	57.22	50	82.23	66.66	61.76	53.53	66.04
24	70.85	53.04	49.82	47.61	55.33	51	104.33	88.24	87.33	76.17	89.02
25	71.50	59.83	52.25	47.47	57.76	52	103.35	83.80	73.44	57.83	79.61
26	77.03	62.71	62.04	57.12	64.72	53	79.95	62.03	59.51	49.38	62.72
27	78.65	63.53	52.79	47.75	60.68	54	75.40	61.49	54.14	47.93	59.74
						Mean	78.75	67.92	63.91	58.29	67.22

LSD at 0.05 0.01
Irrigation (I): 0.89 1.18
Genotypes (G): 3.29 4.34

Table 5: Mean of 1000-kernel weight for 54 bread wheat genotypes under water regimes treatments and over two seasons.

	1000-kernel weight(g)										
Ent. No.	Mean over two seasons				Overall mean	Cont.Ent. No	Mean over two seasons				Overall mean
	I_1	I_2	I_3	I_4			I_1	I_2	I_3	I_4	
1	37.83	33.32	28.31	25.09	31.14	28	45.83	33.77	22.25	30.31	33.04
2	53.14	46.15	37.80	28.58	41.42	29	38.90	34.40	31.35	25.48	32.53
3	38.55	35.29	31.43	24.92	32.55	30	23.75	21.44	18.64	18.87	20.68
4	50.86	42.13	31.97	29.40	38.59	31	48.39	39.55	32.80	29.21	37.49
5	45.34	36.34	26.23	28.84	34.19	32	49.71	44.98	41.27	27.30	40.82
6	47.67	40.02	30.87	28.56	36.78	33	38.65	32.66	27.84	25.99	31.29
7	44.82	39.42	32.98	27.13	36.09	34	49.99	47.61	44.80	26.15	42.14
8	48.81	44.64	39.66	26.99	40.02	35	47.53	39.84	32.56	28.55	37.12
9	46.45	38.72	29.93	28.44	35.89	36	41.57	36.74	32.86	26.26	34.36
10	42.81	33.80	23.68	28.32	32.15	37	45.62	40.59	36.14	27.06	37.35
11	28.15	22.27	18.38	21.86	22.66	38	46.59	37.34	26.52	29.17	34.90
12	48.33	35.47	26.40	31.11	35.32	39	34.39	26.58	19.83	25.22	26.50
13	26.28	22.34	21.17	20.38	22.54	40	45.34	37.73	31.44	28.18	35.68
14	45.86	38.51	35.86	28.13	37.09	41	39.69	29.91	21.81	27.78	29.80
15	43.44	34.48	27.90	28.40	33.55	42	44.23	37.79	32.05	27.48	35.39
16	48.12	35.08	26.09	31.16	35.11	43	48.95	40.02	31.39	29.31	37.42
17	56.37	46.61	40.22	30.00	43.30	44	47.49	35.39	23.76	30.63	34.32
18	46.07	37.09	30.07	28.93	35.54	45	43.99	39.35	35.07	26.64	36.27
19	57.20	48.87	44.97	29.14	45.04	46	43.82	38.19	33.70	27.04	35.69
20	47.77	37.45	30.60	29.82	36.41	47	54.63	45.04	34.52	29.98	41.04
21	53.11	42.27	35.22	30.58	40.29	48	45.12	37.80	31.32	27.69	35.48
22	48.46	37.33	28.35	30.31	36.11	49	43.19	37.70	32.63	26.87	35.10
23	44.69	39.44	36.11	27.01	36.81	50	44.30	38.04	32.32	27.41	35.52
24	48.78	44.36	42.53	27.07	40.68	51	42.57	37.61	34.68	26.51	35.34
25	40.04	35.25	32.36	25.88	33.38	52	49.75	41.76	32.71	28.94	38.29
26	50.79	40.38	32.56	30.22	38.49	53	49.05	44.81	39.75	27.04	40.16
27	47.32	37.85	30.51	29.35	36.26	54	47.56	37.53	26.72	29.66	35.37
						Mean	45.14	37.76	31.35	27.71	35.49

LSD at 0.05 0.01
Irrigation (I): 0.21 0.27
Genotypes (G): 0.76 0.99

g. over all genotypes. Table 9 showed the redaction average in 1000-kernel weight under I_2 treatment was low for genotypes no. 3, 8, 24, 29, 30, 32, 34, 37, 45, and 53 as compared with normal irrigation. The genotypes no. 3, 8, 23, 24, 25, 29, 32, 34, 51 and 53 indicated the lowest reduce in 1000-kernel weight under I_3 treatment. Furthermore, genotypes no. 1, 10, 11, 13, 28, 29, 30, 33, 39 and 41 showed the lowest decrease in 1000-kernel weight under I_4 treatment. It is clear that genotype no. 29 gave the lowest decrease under all drought stress treatments as compared to normal irrigation. It is of interest to note that withholding irrigation from milking, booting and tillering stages until harvest reduced 1000-kernel weight by an average of 16.35, 30.55 and 38.61% as compared with normal irrigation.[21] found that exposing wheat plant to drought during heading; dough, jointing with heading and spike-initiation with dough stages significant reduced 1000-kernel weight compared and with control,[22] found a reduction of about 14.1% in 1000-kernel weight under skipping irrigation at milk stage and[16] reported that large variations in the response to water regimes for 1000- kernel weight.[13] reported skipping irrigation at soft dough-ripe stage produced lightest 1000-grain weight and hence the lightest grain weight/spike compared with other skipping irrigation treatments. The reduction in photosynthetic efficiency and the lack of photosynthates translocated to the developing grains due to withholding irrigation. These results are in agreement with those found by[2, 12, 3, 22, 16].

Grain Yield, Ton/ha: The average of grain yield are presented in (Table 6) of the 54 genotypes over treatments during two years ranged from 0.30 ton/ha for genotype no. 45 to 9.22 ton/ha for genotype no. 47 with an average of 3.71 ton/ha over all genotypes. Redaction average in grain yield under I_2 treatment was low for genotypes no. 1, 3, 4, 5, 22, 23, 24, 25, 38 and 44 as compared with normal irrigation (Table 10). The genotypes no. 1, 3, 4, 11, 15, 22, 24, 25, 38 and 44 indicated the lowest reduce in grain yield under I_3 treatment. Moreover, genotypes no. 1, 3, 4, 11, 15, 24, 25, 38, 44 and 53 showed the lowest decrease in grain yield under I_4 treatment. It is clear that genotypes no. 1, 3, 4, 24, 25, 38 and 44 gave the lowest decrease under all drought stress treatments as compared to normal irrigation. It is of interest to note that withholding irrigation from milking, booting and tillering stages until harvest reduced grain yield by an average of 28.05, 41.31 and 74.17% as compared with normal irrigation.[21] reported that omitting irrigation at a growth stage before anthesis had adverse effects on yield and correlated traits either in sandy or clay-loam soils. However,[35] reported a reduction of about 60% in grain yield and[22] obtained a decrease of about 40.86% in grain yield under skipping irrigation at milk stage.[16] found final yield was reduced 67.14% when withholding the irrigation at the tillering, heading and grain filling stages.[13]reported the lowest grain yield/spike was recorded when skipping irrigation at soft dough-ripe stage due to the decrease of 1000-grain weight.[19, 3, 4]they mentioned that irrigation at the late jointing was recommended due to its greater effect on tiller survival. This implies that developmental and physiological processes at lat jointing are critical in determining final grain yield and water stress should be avoided at this growth stage. The present results are in agreement with those obtained by[20, 12, 22, 16].

Cluster Analysis: The objective of cluster analysis was to define the degree of relatedness in yielding ability under I_1, I_2, I_3 and I_4 in wheat genotypes. The cluster analysis, based on Euclidean distances using yield characters among wheat genotypes graphically illustrated as dendrogram (tree diagram). The dendrogram of yield analysis under normal irrigation and drought stress treatments have categorized the fifty four studied wheat genotypes into groups; first contains two subgroups within each group "A" and "B" were detected at 25 Euclidean distances (Figs., 1, 2, 3 and 4). The cluster was further spirited into seven subgroups (Fig., 1) under normal irrigation treatment (I_1) within each group A1, A2, A3, A4, A5, B1 and B2 detected in genotypes no. (12, 37, 4, 16, 42, 50, 51, 6, 15, 22 and 53), (9, 18, 2, 26, 14, 35 and 47), (17, 49, 3, 36, 45, 46, 44 and 27), (7, 25 and 8), (21, 34, 19 and 29), (43, 48, 10, 24, 5, 32, 52, 1, 30, 11, 20, 28, 38, 39, 13, 23 and 40) and (41, 54, 31 and 33), respectively. While under stress treatment (I_2) eight subgroups (Fig., 2) within each group A1, A2, A3, A4, B1, B2, B3 and B4 detected in genotypes no. (47), (2, 4, 6, 9, 35, 37, 14, 22 and 18), (26, 50, 15, 12, 42, 21, 51 and 53), (16, 23, 5, 19 and 24), (17, 44, 36, 45, 46, 49 and 27), (8, 25 and 7), (1, 29, 39, 43, 10, 52, 48, 38, 20, 32, 34, 11, 13, 40 and 33) and (3, 54, 41, 31, 28 and 30), respectively. On the other hand under high stress treatment (I_3) eight subgroups (Fig. 3) within each group A1, A2, A3, B1, B2, B3, B4 and B5 detected in genotypes no. (9, 37, 35, 47 and 50), (18, 21, 14, 26 and 6), (4, 22, 2 and 15), (16, 20, 11, 39, 10, 48, 43, 38, 51, 5, 23, 52 and 1), (19, 42, 12, 24 and 53), (45, 49, 46, 27, 8, 25 and 7), (3, 28, 34, 13, 40, 33, 32 and 29) and (41, 54, 30, 31, 36, 17 and 44), respectively. Moreover, under high stress treatment (I_4) seven subgroups Fig., 4) within each group A1, A2, B1, B2, B3, B4 and B5 detected in genotypes no. (4), (18, 35, 15, 47, 53, 22 and 51), (19,

Table 6: Mean of Grain yield for 53 bread wheat genotypes under water regimes treatments and over two seasons.

Grain yield(ton/ha)											
Ent. No.	Mean over two seasons				Overall mean	Cont.Ent. No	Mean over two seasons				Overall mean
	I_1	I_2	I_3	I_4			I_1	I_2	I_3	I_4	
1	5.02	4.10	3.68	2.49	3.82	28	4.99	3.31	2.57	0.55	2.86
2	8.57	6.52	5.66	1.11	5.46	29	6.17	4.09	3.11	0.66	3.51
3	3.23	2.85	2.66	2.16	2.72	30	5.02	3.14	2.30	0.56	2.76
4	7.90	6.45	5.73	3.94	6.00	31	4.51	2.77	2.00	0.51	2.45
5	5.65	4.77	3.75	0.92	3.77	32	5.66	3.81	2.88	0.59	3.24
6	7.79	5.98	4.42	1.00	4.80	33	4.70	3.54	2.96	1.45	3.16
7	1.65	1.18	0.98	0.38	1.05	34	6.78	3.79	2.49	0.84	3.47
8	2.15	1.50	1.23	0.39	1.31	35	8.88	6.03	5.10	3.14	5.79
9	8.67	6.00	4.93	1.47	5.27	36	3.32	2.44	2.00	0.89	2.16
10	5.82	4.21	3.41	1.44	3.72	37	8.03	5.91	4.85	2.10	5.22
11	4.95	3.91	3.39	2.04	3.57	38	5.42	4.33	3.79	2.38	3.98
12	8.09	5.29	4.12	0.97	4.62	39	5.42	4.03	3.39	1.54	3.59
13	5.39	3.67	2.92	0.69	3.17	40	5.19	3.62	2.94	0.85	3.15
14	9.00	6.26	4.64	2.36	5.56	41	4.30	2.91	2.21	0.49	2.48
15	7.57	5.71	5.39	3.21	5.47	42	7.86	5.29	4.00	0.82	4.49
16	7.90	4.64	3.32	0.99	4.21	43	5.75	4.05	3.25	0.99	3.51
17	3.43	2.38	1.96	0.60	2.10	44	2.91	2.36	2.08	1.36	2.17
18	8.76	6.13	4.56	3.12	5.64	45	2.86	1.92	1.51	0.30	1.65
19	6.39	4.77	3.96	1.87	4.25	46	2.86	2.00	1.57	0.50	1.74
20	4.96	3.81	3.33	1.78	3.47	47	9.22	6.96	5.09	2.87	6.03
21	6.84	5.32	4.57	2.12	4.71	48	5.78	4.18	3.41	1.50	3.72
22	7.48	6.25	5.76	2.94	5.61	49	3.44	2.09	1.52	0.38	1.86
23	5.32	4.59	3.62	1.11	3.66	50	7.74	5.53	5.23	1.56	5.01
24	5.91	4.71	4.11	2.62	4.34	51	7.74	5.02	3.82	2.97	4.89
25	1.68	1.39	1.24	0.86	1.29	52	5.53	4.24	3.60	1.99	3.84
26	8.47	5.54	4.69	2.57	5.32	53	7.24	5.14	4.21	2.88	4.87
27	2.58	1.79	1.45	0.39	1.55	54	4.30	2.85	2.21	0.55	2.48
						Mean	5.79	4.17	3.40	1.50	3.71

LSD at	0.05	0.01
Irrigation (I):	0.016	0.021
Genotypes (G):	0.058	0.077

Table 7: Percent reduction in plant height affected by water stress treatments over two years.

		Plant height					
Genotypes	$\left(\frac{I_1-I_2}{I_1}\right)\%$	$\left(\frac{I_1-I_3}{I_1}\right)\%$	$\left(\frac{I_1-I_4}{I_1}\right)\%$	Cont. Genotypes	$\left(\frac{I_1-I_2}{I_1}\right)\%$	$\left(\frac{I_1-I_3}{I_1}\right)\%$	$\left(\frac{I_1-I_4}{I_1}\right)\%$
1	12.43	18.3	30.3	28	25.3	33.28	50.79
2	10.89	10.46	27.41	29	20.49	36.52	53.19
3	15.08	24.6	35.91	30	15.36	20.29	30.58
4	5.64	11.17	26.75	31	26.4	35.95	55.17
5	8.8	12.34	26.04	32	21.02	35.17	54.79
6	10.66	10.91	27.4	33	22.23	35.83	53.75
7	2.95	17.21	33.38	34	20.57	33.37	52.9
8	7.46	19.38	28.37	35	14.27	13.46	26.08
9	18.27	18.97	30.39	36	12.89	23.95	36.26
10	12.2	18.61	31.67	37	13.82	18.36	31.69
11	13.52	18.24	28.85	38	15.03	22.93	31.7
12	19.35	23.23	34.17	39	12.19	16.46	27.88
13	16.35	18.22	34.36	40	13.88	23.44	35.53
14	15.68	19.33	34.46	41	11.53	21.71	33.7
15	15.45	13.37	24.75	42	12.3	15.14	28.5
16	13.05	20	31.34	43	11.61	18.34	31.01
17	11.37	20.56	32.9	44	11.5	21.02	33.69
18	14.37	14.45	27.2	45	10.75	19.97	31.97
19	15.7	18.74	29.01	46	8.1	19.33	31.67
20	13.9	22.54	35.01	47	14.84	19.17	32.14
21	11.29	19.96	34.16	48	15.75	23.06	37.69
22	12.72	12.65	27.58	49	22.65	35.99	56.91
23	24.59	36.16	55.23	50	21.05	29.02	47.05
24	28.16	39.86	57.12	51	17.37	20.12	36.72
25	18.38	32.99	51.03	52	21.07	32.98	54.16
26	20.49	23.34	39.49	53	24.41	29.6	51.22
27	21.12	36.67	54.15	54	20.45	32.14	51.85

I_1 = normal irrigation

I_2 = withholding irrigation after milk stage until harvest.

I_3 = withholding irrigation after booting stage until harvest

I_4 = withholding irrigation after tillering stage until harvest

Table 8: Percent reduction in days until heading affected by water stress treatments over two years.

			Days to heading				
Genotypes	$\left(\frac{I_1-I_2}{I_1}\right)\%$	$\left(\frac{I_1-I_3}{I_1}\right)\%$	$\left(\frac{I_1-I_4}{I_1}\right)\%$	Cont. Genotypes	$\left(\frac{I_1-I_3}{I_1}\right)\%$	$\left(\frac{I_1-I_2}{I_1}\right)\%$	$\left(\frac{I_1-I_4}{I_1}\right)\%$
1	10.28	14.99	20.99	28	23.36	28.8	39.67
2	9.14	6.34	17.16	29	18.47	32.06	42.87
3	13.19	20.72	26.06	30	13.36	16.28	20.55
4	3.66	10.79	18.68	31	24.42	27.81	33.49
5	6.78	8.36	16.07	32	19.16	31.32	36.62
6	8.77	6.85	17.27	33	20.35	31.93	37.83
7	1.26	17.18	25.06	34	18.58	28.4	33.83
8	5.46	15.4	18.37	35	12.14	9.52	16.2
9	16.24	14.99	20.44	36	10.88	19.91	26.22
10	10.19	14.64	21.71	37	11.82	14.36	21.69
11	11.5	14.39	19.07	38	13.03	18.94	21.71
12	17.4	19.14	24.04	39	10.2	12.45	17.86
13	14.35	14.23	24.42	40	11.88	19.37	25.48
14	13.57	15.44	24.58	41	9.53	17.76	23.74
15	13.49	9.36	14.69	42	10.46	11.02	18.36
16	10.99	16.07	21.38	43	9.57	14.42	21.08
17	9.39	16.67	23.01	44	9.5	17.01	23.67
18	12.49	10.39	17.09	45	8.77	16.02	22.02
19	13.7	14.76	19.02	46	6.11	15.41	21.72
20	11.9	18.57	25.04	47	12.93	15.09	22.08
21	9.24	16.03	24.2	48	13.72	18.82	25.9
22	10.59	8.72	17.77	49	20.65	32.02	40.87
23	22.55	28.2	33.45	50	18.93	24.89	34.9
24	25.13	29.68	32.8	51	15.42	16.29	26.99
25	16.33	26.93	33.6	52	18.92	28.94	44.04
26	18.59	19.45	25.84	53	22.41	25.57	38.24
27	19.23	32.88	39.29	54	18.44	28.2	36.43

I1 = normal irrigation

I2 = withholding irrigation after milk stage until harvest.

I3 = withholding irrigation after booting stage until harvest

I4 = withholding irrigation after tillering stage until harvest

Table 9: Percent reduction in 1000-kernel weight affected by water stress treatments over two years

	1000-kernel weight						
Genotypes	$\left(\frac{I_1-I_2}{I_1}\right)\%$	$\left(\frac{I_1-I_3}{I_1}\right)\%$	$\left(\frac{I_1-I_4}{I_1}\right)\%$	Cont. Genotypes	$\left(\frac{I_1-I_2}{I_1}\right)\%$	$\left(\frac{I_1-I_3}{I_1}\right)\%$	$\left(\frac{I_1-I_4}{I_1}\right)\%$
1	11.91	25.15	33.66	28	26.32	51.44	33.86
2	13.16	28.86	46.23	29	11.55	19.4	34.5
3	8.46	18.46	35.35	30	9.71	21.51	20.52
4	17.16	37.14	42.2	31	18.27	32.22	39.65
5	19.86	42.16	36.4	32	9.52	16.98	45.09
6	16.05	35.24	40.08	33	15.5	27.99	32.75
7	12.05	26.41	39.48	34	4.75	10.38	47.69
8	8.55	18.74	44.71	35	16.18	31.5	39.94
9	16.66	35.56	38.78	36	11.61	20.94	36.83
10	21.05	44.68	33.85	37	11.04	20.78	40.68
11	20.9	34.72	22.35	38	19.86	43.08	37.4
12	26.61	45.38	35.63	39	22.71	42.35	26.67
13	14.97	19.45	22.44	40	16.79	30.66	37.84
14	16.03	21.82	38.68	41	24.66	45.07	30.02
15	20.62	35.78	34.61	42	14.56	27.54	37.88
16	27.1	45.78	35.25	43	18.24	35.86	40.12
17	17.31	28.64	46.77	44	25.47	49.98	35.51
18	19.49	34.73	37.21	45	10.54	20.28	39.44
19	14.56	21.38	49.06	46	12.85	23.1	38.28
20	21.6	35.94	37.59	47	17.56	36.82	45.13
21	20.42	33.68	42.43	48	16.22	30.59	38.63
22	22.97	41.5	37.47	49	12.73	24.46	37.79
23	11.73	19.18	39.56	50	14.14	27.06	38.13
24	9.06	12.8	44.5	51	11.66	18.52	37.73
25	11.95	19.18	35.37	52	16.06	34.24	41.83
26	20.49	35.89	40.5	53	8.66	18.96	44.88
27	20.01	35.52	37.98	54	21.09	43.82	37.64

I1 = normal irrigation

I2 = withholding irrigation after milk stage until harvest.

I3 = withholding irrigation after booting stage until harvest

I4 = withholding irrigation after tillering stage until harvest

Table 10: Percent reduction in grain yield affected by water stress treatments over two years.

			Grain yield				
Genotypes	$\left(\frac{I_1-I_2}{I_1}\right)\%$	$\left(\frac{I_1-I_3}{I_1}\right)\%$	$\left(\frac{I_1-I_4}{I_1}\right)\%$	Cont. Genotypes	$\left(\frac{I_1-I_2}{I_1}\right)\%$	$\left(\frac{I_1-I_3}{I_1}\right)\%$	$\left(\frac{I_1-I_4}{I_1}\right)\%$
1	18.36	26.62	50.39	28	33.57	48.39	88.9
2	23.96	34	87.04	29	33.68	49.54	89.24
3	11.73	17.7	32.96	30	37.46	54.23	88.84
4	18.27	27.45	50.11	31	38.48	55.74	88.68
5	15.49	33.69	83.69	32	32.72	49.12	89.53
6	23.24	43.26	87.21	33	24.75	37.13	69.1
7	28.2	40.35	77.01	34	44.15	63.28	87.62
8	30.28	42.6	82.03	35	32.09	42.58	64.7
9	30.74	43.14	83.02	36	26.53	39.85	73.36
10	27.62	41.44	75.26	37	26.38	39.59	73.8
11	21.12	31.65	58.9	38	20.04	30.13	56.1
12	34.66	49.05	88.04	39	25.63	37.48	71.67
13	31.88	45.79	87.14	40	30.26	43.47	83.7
14	30.48	48.45	73.73	41	32.37	48.63	88.55
15	24.66	28.81	57.66	42	32.74	49.14	89.6
16	41.27	57.91	87.48	43	29.58	43.44	82.85
17	30.59	42.87	82.41	44	19.02	28.59	53.25
18	30.02	47.88	64.31	45	32.63	47	89.38
19	25.28	37.92	70.69	46	29.88	44.88	82.5
20	23.31	32.95	64.1	47	24.49	44.83	68.89
21	22.1	33.12	68.97	48	27.73	40.95	74
22	16.52	23.01	60.67	49	39.21	55.91	88.9
23	13.77	31.97	79.05	50	28.53	32.41	79.87
24	20.25	30.41	55.68	51	35.09	50.65	61.54
25	17.41	26.33	48.83	52	23.26	34.95	64.08
26	34.64	44.63	69.7	53	29.06	41.79	60.24
27	30.71	43.98	84.79	54	33.69	48.55	87.22

I1 = normal irrigation

I2 = withholding irrigation after milk stage until harvest.

I3 = withholding irrigation after booting stage until harvest

I4 = withholding irrigation after tillering stage until harvest

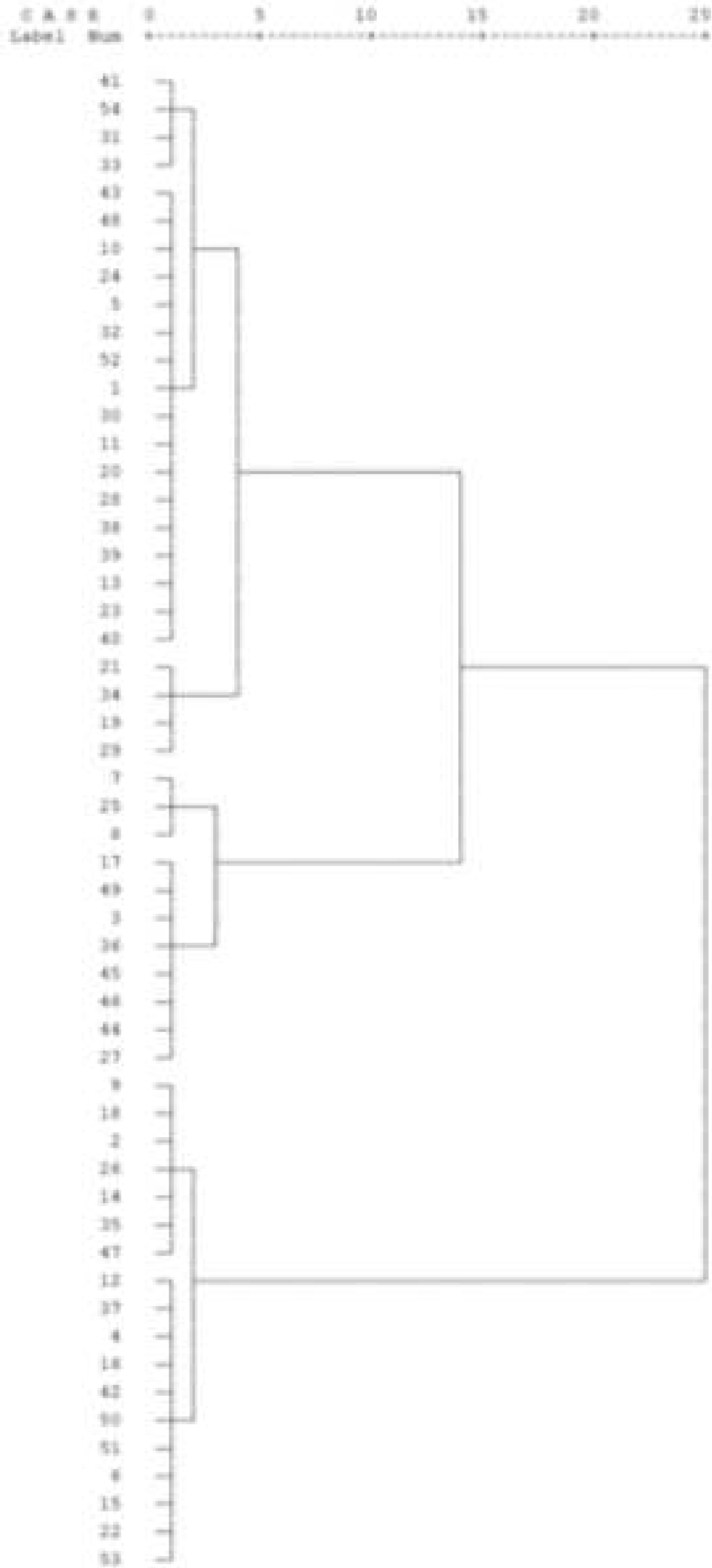

Fig. 1: Dendorogram of fifty four bread wheat genotypes based on the data classified form yield means under control irrigation (I^1) condition.

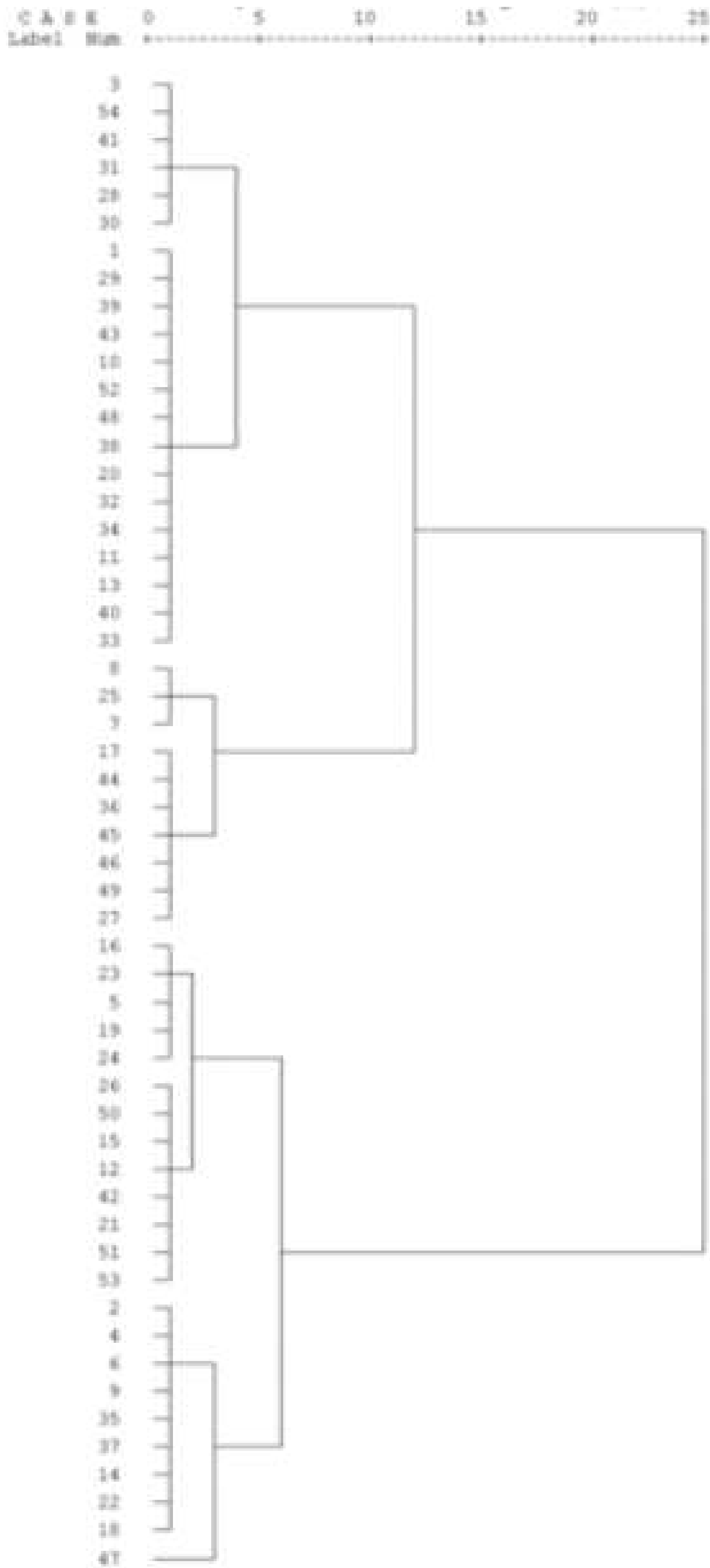

Fig. 2: Dendorogram of fifty four bread wheat genotypes based on the data classified form yield means under drought stree (I^2) condition.

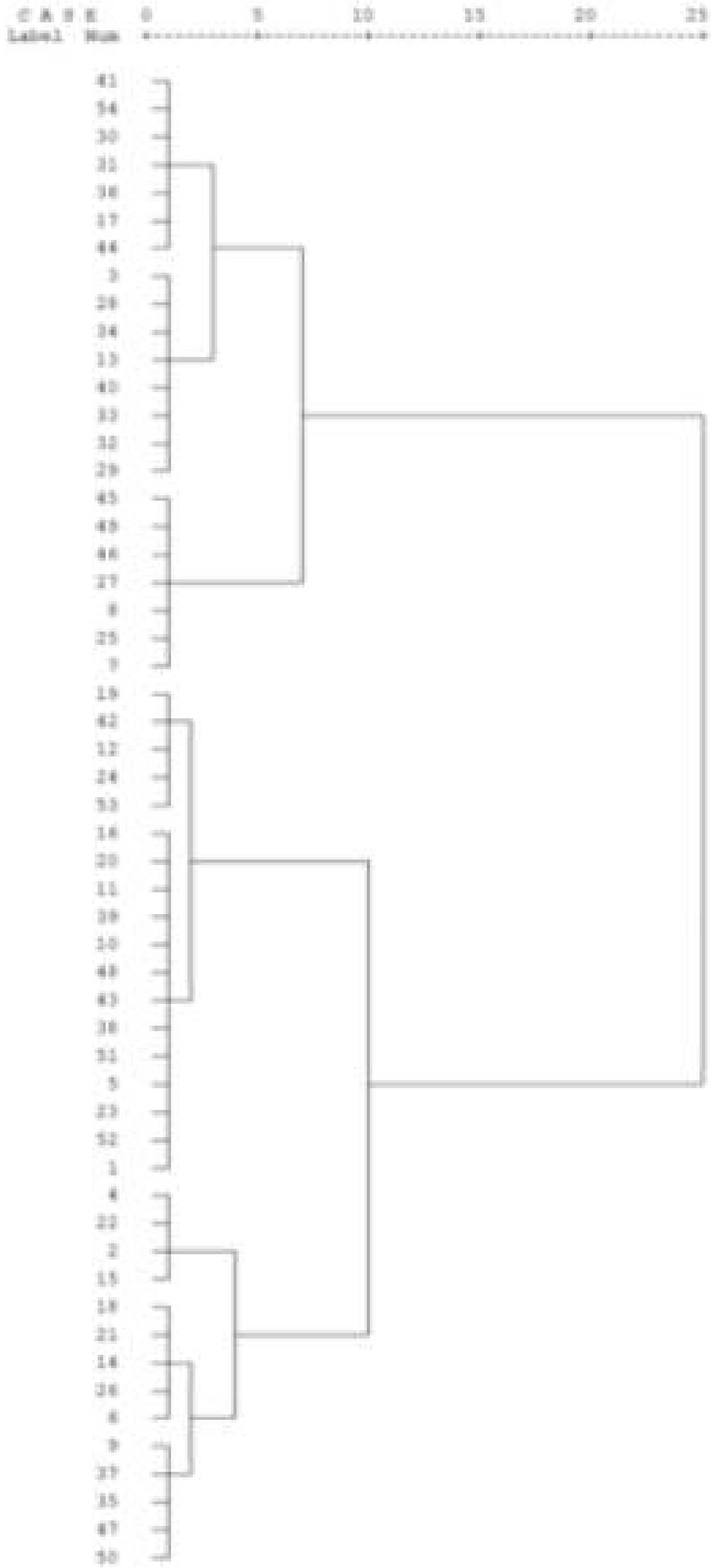

Fig. 3: Dendorogram of fifty four bread wheat genotypes based on the data classified form yield means under drought stree (I^3) condition.

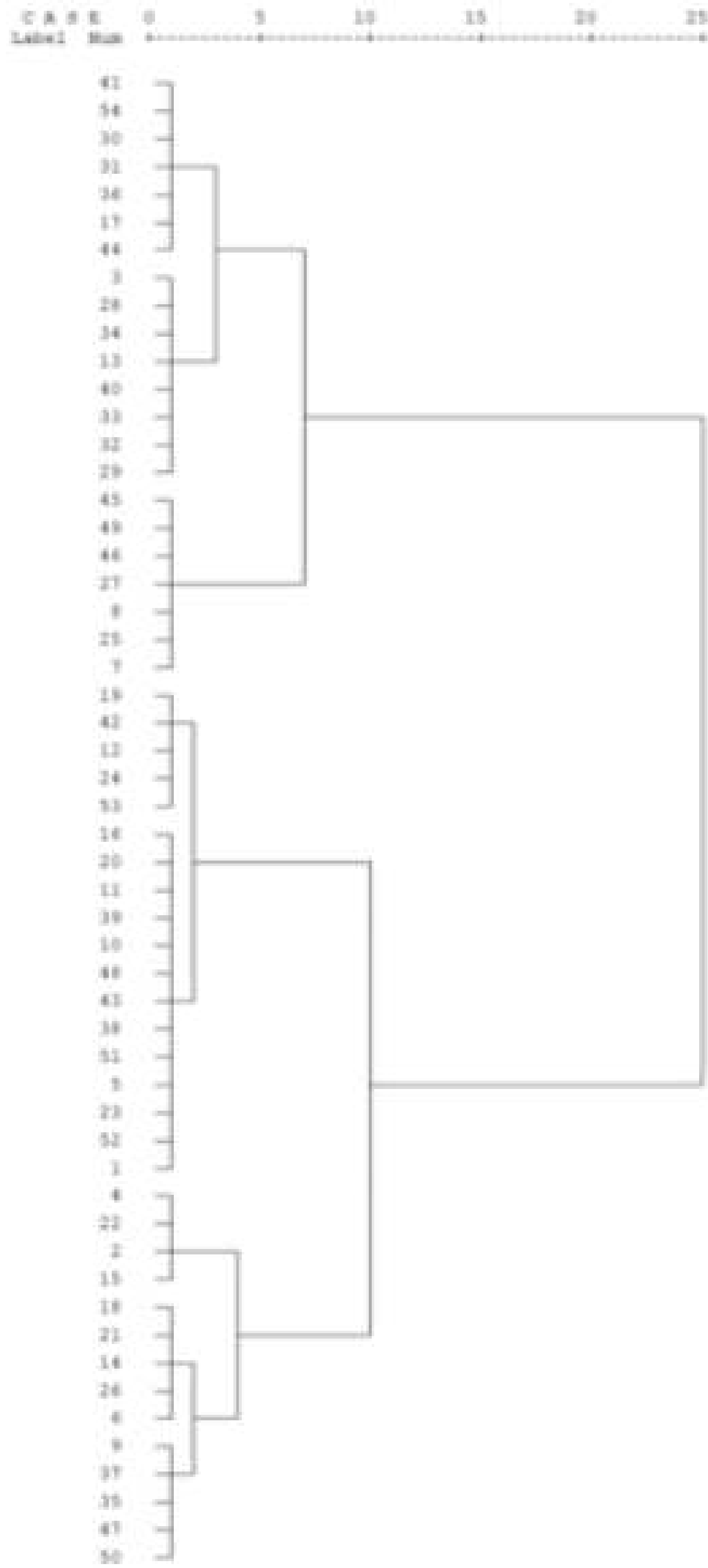

Fig. 4: Dendorogram of fifty four bread wheat genotypes based on the data classified form yield means under drought stree (I^4) condition.

20, 11, 52, 21, 37 and 3), (14, 38, 24, 26 and 1), (10, 33, 9, 39, 50, 48 and 44), (2, 23, 16, 43, 6, 12, 34, 40, 25, 42, 5 and 36) and (28, 54, 30, 17, 32, 41, 46, 31, 13, 29, 8, 49, 7, 27 and 45), respectively (Table 6). The first contains the high yielding subgroup A1 of the fifty four genotypes under different water regimes. The genetic divergence can provide visual idea about variables presented in wheat genotypes in additions to assuring the continued genetic improvement[24]. The present study is in agreement with those obtained[32,25,27,16].

Genotypes Groups under Stress Treatments: There were four group genotypes can be divided into four groups based on their yield response to stress conditions. Data presented in Table (6) show during over the two season (2006/2007 and 2007/2008) the genotypes it is observed the bread wheat genotypes no. 4, 14, 18, 26, 35 and 47 gave the highest grain yield under both normal irrigation and drought stress treatments conditions (I_1, I_2, I_3 and I_4) (group A), with an averages (7.90, 6.45, 5.73 and 3.94), (9.00, 6.26, 4.64 and 2.36), (8.76, 6.13, 4.56 and 3.12), (8.47, 5.54, 4.69 and 2,57), (8.88, 6.03, 5.10 and 3.14) and (9.22, 6.96, 5.09 and 2.87) ton/ha, respectively. On other hand under non-stress (group B) the genotype no. 2, 9, 14, 18, 35 and 47 gave the highest grain yield with an average (8.57, 8.67, 9.00, 8.76, 8.88 and 9.22) ton/ha, respectively. The genotypes no. 4, 15, 18, 22, 35 and 47 gave the highest grain yield under drought stress I_2, I_3 and I_4 (group C) with an averages (6.45, 5.73 and 3.94), (5.71, 5.39 and 3.12), (6.13, 4.56 and 3.12), (6.25, 5.76 and 2.94), (6.03, 5.10 and 3.14) and (6.96, 5.09 and 2.87)ton/ha, respectively. Moreover, the genotypes no. 7, 8, 27, 45 and 46 gave the lowest grain yield under both under normal irrigation and drought stress treatments conditions (I_1, I_2, I_3 and I_4) with an averages (1.65, 1.18, 0.98 and 0.38), (2.15, 1.50, 1.23 and 0.39), (2.58, 1.79, 1.45 and 0.39), (2.86, 1.92, 1.51 and 0.30) and (2.86, 2.00, 1.57 and 0.50) ton/ha, respectively (group D). The genotypes were divided into four groups based on their yield response to stress conditions according to[15]. Thus, indirect selection for a drought-prone environment based on the results of optimum condition will not be efficient. These results are in agreement with those of[7, 8] who found that landraces of barley and wheat with low yield potential were more productive under stress condition. The lack of response to improved environmental conditions may be related to a lack of adaptation to high-moisture conditions[9].

Conclusion: The plant height, days to heading, 1000-kernel weight and grain yield decreased under a drought stress of I_2, I_3 and I_4. The results of this study indicated that wheat genotypes no. 4, 15, 18, 22, 35 and 47 can be selected to grow under drought stress conditions, significantly affecting the grain yield production of the cultivars check compared with other genotypes. Large scale trait evaluations may enhance utilization of plant genetic resources collections by increasing genetic variability for economically significant traits into wheat breeding programs. A wide genetic base, useful for breeding purposes was found in this study for plant height, days to heading, 1000-kernel weight and grain yield. Moreover, selection based on the tolerance indices calculated from the yield under different conditions, we are breeding for the genotypes adapted for a wide range of drought stress.

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