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Original article

Study of genetic diversity and cluster analysis for morphological traits of bread wheat under drought stress conditions

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Extended abstract

Introduction

Bread wheat is one of the grains in the world that provides 20% of the plant-derived protein to the people of the world (Acevedo et al., 2002; Godfray et al., 2010). Drought is an important environmental factor limiting the production of wheat and other crops in the world. Water scarcity has made the production of higher drought-tolerant cultivars an important goal in many breeding programs. One of the goals of wheat cultivation in arid and semi-arid regions is to achieve cultivars that are more tolerant of drought stress at the end of the season in conditions of water restriction and lack of irrigation and have less yield reduction. By achieving such figures, it is possible to increase the efficiency of operations in those conditions and to a large extent prevent the waste of water resources. The aim of this study was to identify agricultural traits associated with changes in wheat grain yield under drought stress and drought-tolerant lines.

Materials and methods

In this study, 111 lines along with 3 cultivars of Shahid Narin, Barzegar, and Sistan in the form of repeated experiments (Agent) in 1396 in the research farm of the Research Center located in Yazd city (at 15 degrees and 53 minutes to 40 degrees And 54 minutes east longitude and 46 degrees and 31 minutes to 15 degrees and 32 minutes north latitude and altitude 1200 meters). In order to check the production capacity of the lines, the control was repeated at intervals of every 20 lines. Each line was planted in 2 lines of 2.5 m with a planting distance of 20 cm. In order to investigate the effect of drought stress at the end of the season on the relevant traits in the post-flowering stage, irrigation was stopped. During the growing season, grain yield, yield, and morphological components were evaluated and compared with control cultivars. A simple correlation was used to obtain the relationship between the traits. To identify the main variables that affect grain yield, multi-variable analysis was used by stepwise regression analysis.

Results and discussion

The experimental results showed that there is a great variety among the studied lines. Regression tests showed that traits such as 1000-grain weight, number of days to ripening, spike length, plant height, and spike weight had a positive and significant effect on grain yield and explained a significant share of yield changes. The classification of lines is based on cluster analysis by the UPGMA method in 9 groups.

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Based on the obtained results, 15 genotypes were selected that had more grain yield and some more suitable agricultural characteristics than other genotypes and cultivars.

Conclusion

Although drought stress affects most plant growth traits, this effect depends on the time the plant is exposed to water stress and the lines being tested. The results of this study show that water stress has a different effect on the growth of wheat lines and shows that the ability of bread wheat lines to tolerate drought stress is different. Also, the genetic material in this experiment could be a valuable resource that, in addition to removing new traits, provides a great variety for breeders to improve and produce drought-tolerant wheat cultivars.

***Keywords*:** Bread wheat, Cluster analysis, Genetic diversity, Quantitative and Qualitative traits

Table 1. The value of grain yield and different traits of bread wheat genotypes

No.	GY	TKW	DHE	DMA	SL	PLH	G.w/ spike	No.G /spike	NO.spikelets / spike	Spike weight	Yield% over checks		
											Narin	Barzegar	sistan
	kg/plot	gr			cm	cm	gr			gr			
Narin	4200	38	74	120	9.5	95	3.67	72.7	17	4.07	100	100	100
Barzegar	5000	30	78	121	9	96	2.07	37.7	17	3.93	100	100	100
Sistan	4500	28	77	121	10	100	1.50	26.0	16	2.93	100	100	100
1	2900	32.5	68	117	9.5	116	2.13	57.3	18	4.23	58	65	63
2	3600	22.5	77	115	10	118	2.23	53.7	19	4.40	72	81	78
3	4100	35.5	84	118	9	105	1.23	34.7	16	3.17	82	93	89
4	3000	32	85	123	9.5	120	1.20	43.0	18	3.20	60	68	65
5	4900	31	75	118	9.5	103	2.17	38.3	14	4.20	98	111	107
6	3300	28.5	78	121	8.5	92	1.30	36.3	14	3.30	66	75	72
7	4100	27	84	122	10	93	1.00	35.3	19	2.93	82	93	89
8	3300	30	68	114	10	98	1.63	40.0	14	3.50	66	75	72
9	5800	30	72	116	10.5	106	1.73	31.0	15	3.67	116	131	126
10	4400	29	63	115	11.5	105	2.33	50.0	17	4.57	88	99	96
11	3600	20	60	110	10	107	1.83	44.0	17	3.87	72	81	78
12	3900	26.5	77	120	10	115	1.33	28.7	17	3.27	78	88	85
13	3400	28.5	83	120	11.5	120	1.63	37.3	18	3.67	68	77	74
14	5000	30	77	120	9.5	118	1.40	31.0	17	3.40	100	113	109
15	3900	25	83	121	12	122	1.53	39.3	17	3.53	78	88	85
16	4900	30.3	78	121	11	116	1.17	32.0	19	3.03	98	111	107
17	4300	30	77	118	9.5	120	1.70	34.3	16	3.83	86	97	93
18	3800	30.5	73	118	10.5	125	1.70	36.7	19	3.60	76	86	83
19	3900	29	86	122	12	112	1.47	46.3	18	3.47	78	88	85
20	4500	21	73	119	11.5	108	1.50	47.0	16	3.63	90	102	98
Narin	5300	30	75	118	11.5	96	2.17	41.3	16	4.27	100	100	100
Barzegar	5000	25	80	118	11	92	2.43	46.7	13	4.47	100	100	100
Sistan	4500	29.5	83	120	9.5	95	2.60	37.3	14	4.53	100	100	100
21	4700	28.5	80	122	12	108	1.37	42.7	14	3.40	94	106	102
22	5800	28	73	119	11	86	2.30	49.3	16	4.50	116	131	126
23	5600	30	74	119	10.5	94	1.90	42.0	17	4.10	112	126	122
24	5400	31.5	77	120	12	93	2.47	49.7	18	4.60	108	122	117
25	6100	27.5	78	119	12	95	2.33	47.0	20	4.47	122	138	133
26	4700	31	77	120	13	101	1.07	30.0	14	3.20	94	106	102
27	4700	32	77	122	12.5	95	1.77	33.7	18	3.90	94	106	102
28	4800	28	76	120	11.5	117	1.80	39.3	18	3.90	96	108	104

Table 1. Continued

No.	GY	TKW	DHE	DMA	SL	PLH	G.w/ spike	No.G /spike	NO.spikelet /spike	Spike weight	Yield% over checks		
											Narin	Barzegar	sistan
	kg/plot	gr			cm	cm	gr			gr			
29	5200	34.5	77	120	14	104	2.13	42.3	19	4.40	104	117	113
30	4900	31.5	77	119	11.5	90	1.10	27.3	18	3.37	98	111	107
31	4900	31.5	78	122	10.5	120	1.23	25.7	18	3.40	98	111	107
32	4200	33.5	81	120	10.5	128	2.13	53.0	16	4.43	84	95	91
33	5900	32	81	121	11	90	2.20	51.7	18	4.70	118	133	128
34	5600	33	77	121	10.5	93	1.87	48.7	18	3.83	112	126	122
35	3300	29.5	78	119	8.5	120	1.10	28.0	15	3.27	66	75	72
36	3800	31	75	120	10.5	116	1.67	34.7	16	3.53	76	86	83
37	1500	31	86	121	11	119	0.67	18.0	18	2.40	30	34	33
38	2900	31.5	86	125	8.5	125	1.60	22.3	17	3.57	58	65	63
39	3800	31	84	122	10.5	95	2.20	44.3	17	4.30	76	86	83
40	4500	35	85	123	10.5	100	1.57	39.3	19	3.83	90	102	98
Narin	4900	30	74	120	10	94	2.30	40.7	14	4.40	100	100	100
Barzegar	5300	32.5	77	121	11	96	2.10	36.7	16	4.03	100	100	100
Sistan	5500	24.5	77	121	11	85	1.40	32.7	16	3.70	100	100	100
41	3000	31.5	73	124	9.5	114	1.20	30.7	14	3.07	60	68	65
42	3900	27.5	72	124	11	125	1.17	30.3	17	3.00	78	88	85
43	1200	27.5	72	118	12	114	1.10	28.0	16	2.90	24	27	26
44	2300	28	68	114	11	115	0.90	19.7	17	2.67	46	52	50
45	4000	30	68	114	10.5	115	1.93	36.7	16	3.87	80	90	87
46	3000	34.5	76	119	12	120	1.70	28.7	17	3.57	60	68	65
47	4000	29	76	119	10.5	110	1.60	27.0	18	3.53	80	90	87
48	3100	30	72	120	11.5	106	1.87	31.3	19	3.73	62	70	67
49	4400	27	71	114	12	106	2.20	40.3	15	4.17	88	99	96
50	3800	27	72	114	12.5	123	2.03	44.0	17	4.03	76	86	83
51	2200	26	74	113	11.5	96	1.37	36.7	16	3.37	44	50	48
52	3500	32	66	110	12	106	1.63	3.3	15	3.53	70	79	76
53	4200	29	85	119	11	128	0.93	22.6	18	2.83	84	95	91
54	2800	28	78	120	9.5	118	2.53	49.6	15	4.93	56	63	61
55	2700	26.5	84	119	11	129	0.87	20.0	17	2.80	54	61	59
56	1200	26.5	84	119	9.5	120	0.97	21.3	19	3.03	24	27	26
57	2600	23.5	74	118	11	105	1.00	34.6	18	2.90	52	59	57
58	2800	30.5	74	119	10	118	2.53	47.3	9	4.77	56	63	61
59	3000	24.5	73	117	10.5	122	1.63	37.3	10	3.57	60	68	65
60	1600	24.5	70	115	10	118	1.67	33.7	9	3.53	32	36	35
Narin	5300	32.5	71	118	10.5	96	1.60	27.7	8	3.57	100	100	100
Barzegar	4100	24.5	76	119	10	102	2.07	35.0	8	4.07	100	100	100
Sistan	5600	27	76	120	10	100	1.97	33.7	8	3.63	100	100	100
61	2100	24.5	73	119	8.5	118	1.47	37.3	8	3.53	42	47	46

Table 1. Continued

No.	GY	TKW	DHE	DMA	SL	PLH	G.w/ spike	No.G /spike	NO.spikelet/ /spike	Spike weight	Yield% over checks		
											Narin	Barzegar	sistan
	Kg/plot	gr			cm	cm	gr			gr			
62	2700	33	77	124	10	118	0.50	11.0	9	2.37	54	61	59
63	2300	28	78	124	12.5	128	0.33	6.7	8	2.27	46	52	50
64	2800	25	72	112	10	126	1.90	31.7	8	3.87	56	63	61
65	2700	23	72	114	10	118	0.67	19.0	9	2.47	54	61	59
66	3800	30	70	114	11	130	2.37	38.7	8	4.30	76	86	83
67	2500	26.5	71	117	12	124	1.70	30.0	9	3.70	50	56	54
68	3000	32	78	119	11	126	1.03	26.0	18	3.00	60	68	65
69	2100	23.5	77	119	8.5	124	1.43	38.7	19	3.40	42	47	46
70	4000	25.5	77	119	10	109	0.97	27.7	18	2.93	80	90	87
71	2200	29.5	75	114	11	112	1.33	27.7	9	3.27	44	50	48
72	2300	32	68	111	13	118	1.70	33.3	16	3.57	46	52	50
73	1900	24	68	108	9.5	120	0.67	37.0	8	2.53	38	43	41
74	3100	26	68	117	8.5	115	2.83	50.3	7	4.97	62	70	67
75	3200	27.5	73	117	9.5	109	1.93	35.0	8	4.03	64	72	70
76	2900	28	77	119	9.5	124	2.03	38.3	9	4.13	58	65	63
77	4100	25.5	74	119	12	105	1.17	26.3	8	2.97	82	93	89
78	900	22	77	118	11.5	125	0.80	20.0	8	2.57	18	20	20
79	4000	31	76	119	8	124	1.70	27.3	9	3.53	80	90	87
80	600	21	78	121	9.5	88	1.20	36.3	7	3.03	12	14	13
Narin	5300	27.5	74	121	10	102	2.80	46.7	8	5.00	100	100	100
Barzegar	5100	24.5	76	121	11.5	100	2.50	43.7	8	4.47	100	100	100
Sistan	3200	25.5	76	121	12	103	3.13	48.3	8	5.17	100	100	100
81	4100	28	77	119	11	114	1.00	21.7	7	2.70	82	93	89
82	3600	26.5	74	114	12	119	1.53	31.3	7	3.33	72	81	78
83	1600	27.5	77	119	8	120	0.97	24.7	9	2.97	32	36	35
84	5100	36.5	72	118	9.5	102	2.00	37.0	8	3.90	102	115	111
85	2800	29.5	62	106	8.5	110	1.33	28.3	6	3.07	56	63	61
86	4200	28	86	126	13	100	0.80	21.3	9	2.63	84	95	91
87	3700	33.5	72	120	10.5	120	1.40	32.3	8	3.20	74	84	80
88	5400	28.5	77	119	11.5	96	2.80	46.7	9	3.43	108	122	117
89	5200	25	72	119	11.5	94	1.57	36.3	8	4.60	104	117	113
90	4400	26	83	120	11	96	1.13	26.3	10	3.27	88	99	96
91	4500	23	83	120	10.5	98	2.27	43.3	9	4.10	90	102	98
92	4200	28	80	122	11	110	1.50	37.3	10	3.43	84	95	91
93	4400	25	80	122	11	106	1.60	35.7	8	3.63	88	99	96
94	3600	23.5	76	117	11	102	1.90	42.3	9	3.97	72	81	78
95	4300	26	84	123	11.5	115	1.17	36.7	10	3.00	86	97	93
96	4700	29	71	114	14	117	2.20	41.0	9	4.47	94	106	102
97	3700	27	73	117	12	115	1.63	26.7	9	3.53	74	84	80

Table 1. Continued

No.	GY	TKW	DHE	DMA	SL	PLH	G.w/ spike	No.G /spike	NO.spikelet / spike	Spike weight	Yield% over checks		
											Narin	Barzegar	sistan
	kg/plot	gr			cm	cm	gr			gr			
98	3700	26.5	77	118	14	116	1.27	28.0	21	3.23	74	84	80
99	3700	28	77	121	10.5	100	1.97	45.3	11	4.13	74	84	80
100	3400	24	72	120	9.5	102	2.03	35.0	9	4.13	68	77	74
Narin	5300	28.5	76	120	9.5	98	2.43	41.0	9	4.40	100	100	100
Barzegar	4100	25.1	76	121	10.5	96	3.50	68.3	8	6.60	100	100	100
Sistan	5100	26.5	74	117	10.5	98	2.10	40.7	9	4.10	100	100	100
101	5200	27.5	72	118	11.5	108	1.80	38.0	9	3.77	104	117	113
102	4300	29	76	120	10.5	106	2.50	48.0	19	4.53	86	97	93
103	5500	29	77	120	10.5	95	1.77	49.0	7	3.83	110	124	120
104	4600	27	85	121	9.5	114	1.20	30.3	9	3.03	92	104	100
105	5200	29.6	77	119	10	98	1.97	43.3	7	4.07	104	117	113
106	4100	22	74	119	8.5	98	1.63	41.0	8	3.57	82	93	89
107	4800	28.5	74	120	8.5	98	1.60	42.7	8	3.53	96	108	104
108	3500	34	81	121	9.5	103	2.07	47.0	9	4.13	70	79	76
109	4400	26	77	119	10.5	108	1.97	37.7	7	3.90	88	99	96
110	4000	28	82	119	10	98	1.83	34.3	8	3.80	80	90	87
111	3200	33	83	120	11	128	1.83	34.7	9	3.93	64	72	70
Narin	4700	22.5	72	119	11.5	100	2.23	40.0	8	4.27	100	100	100
Barzegar	2400	33.4	76	120	10	88	2.30	45.7	7	4.57	100	100	100
Sistan	3800	26.5	77	120	11.5	98	1.87	32.7	9	3.83	100	100	100

Table 2. Descriptive statistics for different traits in bread wheat genotypes and the check Cultivars

	Trait	GY§	TKW	DHE	DMA	SL
		kg/ha	gr			cm
Bread wheat genotypes	**Range**	5500	16.5	26	20	6
	Minimum	600	20	60	106	8
	Maximum	6100	36.5	86	126	14
	Mean	3734.2	28.14	76	118.6	10.65
	Std. Dev.	1154.7	3.36	5.38	3.43	1.28
	CV%	*30.92*	*11.85*	*7.08*	*2.89*	*12.02*
check Cultivars	**Range**	571.4	3.07	3.43	0.71	0.29
	Minimum	4428.5	26.8	73.7	119.4	10.36
	Maximum	5000	29.86	77.14	120.1	10.64
	Mean	4676.2	28.40	75.95	119.8	10.47
	Std. Dev.	293.23	1.55	1.93	0.377	0.148
	CV%	*17.36*	*13.28*	*3.37*	*1.03*	*7.91*

Table 2. Continued

	Trait	PLH§	GW/S	NG/S	NO.Spikelets / Spike	Spike weight
		cm	gr			gr
Bread wheat genotypes	**Range**	44	2.5	54	15	2.7
	Minimum	86	0.33	3.33	6	2.27
	Maximum	130	2.83	57.33	21	4.97
	Mean	110.65	1.59	35.22	13.36	3.59
	Std. Dev.	11.16	0.51	9.91	4.51	0.59
	CV%	*10.09*	*31.19*	*28.13*	*33.8*	*16.63*
check Cultivars	**Range**	1.57	0.38	8.9	0.43	0.6
	Minimum	95.7	2.08	35.9	11	3.99
	Maximum	97.3	2.46	44.8	11.43	4.59
	Mean	96.6	2.32	41.6	11.3	4.28
	Std. Dev.	0.837	0.21	4.99	0.247	0.302
	CV%	*4.6*	*25.24*	*27.17*	*33.89*	*16.92*

§ Grain Yield: GY, Kernel Weight-1000: TKW, Days to Heading: DHE, Days to Maturity: DMA, Spike Length: SL, Plant Height: PLH, Grain weight per spike:GW/S, Number grain per Spike: NG/S

Table 3. Simple correlation coefficients among the traits in bread wheat genotypes

	Trait	GY	1	2	3	4	5	6	7	8
1	**TKW§**	0.281**	**							
2	**DHE**	0.1	0.164	**						
3	**DMA**	0.218*	0.22*	0.723**	**					
4	**SL**	0.227*	0.057	0.008	-0.012	**				
5	**PLH**	-0.479**	-0.003	-0.014	-0.117	-0.055	**			
6	**GW/S**	0.409**	0.132	-0.237**	-0.15	0.002	-0.246*	**		
7	**NG/S**	0.39**	-0.01	-0.076	-0.005	-0.082	-0.342**	0.75**	**	
8	**NO.spikelets/spike**	0.145	0.258**	0.172	0143	0.208*	0.005	-0.006	0.105	**
9	**Spike weight**	0.431**	0.141	-0.191*	-0.092	0.01	-0.267**	0.933**	0.756**	0.059

*,** Significant at 5% and 1% levels of probability, respectively.
§ Grain Yield: GY, Kernel Weight-1000: TKW, Days to Heading: DHE, Days to Maturity: DMA, Spike Length: SL, Plant Height: PLH, Grain weight per spike:GW/S, Number grain per Spike: NG/S

Table 4. Stepwise regression analysis of grain yield and morphological characteristics in bread wheat genotypes

Model§	B coefficient	The standard error	Beta	t Value	Sig.	R^2
Constant	-4935.5	3581.4		-1.378	0.171	
TKW†	52.60	26.35	0.156	1.996	0.048	39.30
DMA	56.25	26.62	0.166	2.113	0.037	37.09
SL	189.2	68.02	0.209	2.782	0.006	33.10
PLH	-32.94	8.11	-0.324	-4.063	0.00	20.11
Spike weight	585.8	153.9	0.306	3.805	0.00	28.63

§ Dependent Variable: yield (kg/ha).
† Kernel Weight -1000: TKW, Days to Maturity: DMA, Spike Length: SL, Plant Height: PLH
Y-intercept (a) = -4936; SE=916.131; R^2=39.33%; Adjusted R^2 =36.52%

Table 5. Results of component analysis on studied traits

	Factors			
Traits	**1**	**2**	**3**	**4**
GY§	0.652	0.405	0.116	-0.318
TKW	0.198	0.473	0.317	0.444
DHE	-0.166	0.814	-0.322	0.065
DMA	-0.039	0.838	-0.360	0.021
SL	0.071	0.203	0.722	-0.430
PLH	-0.497	-0.193	0.178	0.633
GW/S	0.909	-0.198	-0.035	0.191
NG/S	0.847	-0.061	-0.204	0.104
NO.spikelets / spike	0.122	0.434	0.530	0.294
Spike weight	0.919	-0.132	-0.031	0.195
Relative variance	31.47	20.808	12.258	10.609
cumulative variance	31.47	52.279	64.537	75.146

*, **, ns significance at the probability levels of 0.05,0.01 respectively and non significance.
§ Grain Yield: GY, Kernel Weight -1000: TKW, Days to Heading: DHE, Days to Maturity: DMA, Spike Length: SL, Plant Height: PLH, Grain weight per spike:GW/S, Number grain per Spike: NG/S

Table 6. Number of genotypes in each cluster

Cluster	Number Genotype
1	1-2-8-9-10-11-20-45-49-50-66-96-101
2	3-4-6-7-12-14-16-17-18-31-35-36-38-41-42-46-47-48-61-68-69-70-79-83-87-111
3	5-22-23-24-25-33-34-102
4	13-15-19-21-26-27-28-29-30-32-39-40-98
5	37-53-55-56-62-63
6	43-44-51-57-65-78-80
7	52-59-60-64-67-71-72-73-81-85-97
8	54-74-75-76-84-88-89-91-94-99-100-103-105-106-107-108-109-110-112-113-114
9	77-81-86-90-92-93-95-104

Table 7. Frequency of genotypes per cluster in terms of quanitative traits

traits	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6	Cluster7	Cluster8	Cluster9
GY§	4153.85	3538.46	5450.0	4338.46	2433.33	1785.71	2718.18	4004.55	4287.5
TKW	27.3462	29.8769	30.25	30.3077	29	24.4286	27.3636	27.6364	26.6875
DHE	69.6154	77.3846	76.375	80.2308	82.3333	73.5714	70.1818	75.7273	81.125
DMA	114.923	120.269	119.625	120.692	121	116.571	112.818	119.182	121.5
SL	11.1157	9.826	10.875	11.96	10.83	10.93	10.95	10.07	11.25
PLH	112.08	116.5	95	108.31	125.67	108.71	117.27	102.82	107.5
GW/S	1.995	1.383	2.216	1.617	0.711	1.004	1.52	2.07	1.195
NG/S	43.21	31.51	46.83	38.69	16.61	27.67	29.12	41.81	29.45
NS/S	14.615	15.538	17.5	17.46	14.83	13	9.63	8.59	8.875
Spike weight	4.04	3.34	4.36	3.74	2.62	2.84	3.41	4.118	3.08

§Grain Yield: GY, Kernel Weight -1000: TKW, Days to Heading: DHE, Days to Maturity: DMA, Spike Length: SL, Plant Height: PLH, Grain weight per spike:GW/S, Number grain per Spike: NG/S, Number of spikelets per spike: **NS/S**