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Stability Analysis for Grain Yield and its Components of Some Durum Wheat Genotypes (*Triticum durum* L.) Under Different Environments

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ABSTRACT
Evaluation of wheat genotypes under different environments is essential for testing stability of their performance and range of adaptations. Where, development of any crop genotypes with adaptation to changes is one of most important goal of breeding program. This study examined fifteen durum wheat accessions over different eight environments; two planting dates: Nov. 30th (favorable) and Dec. 30th (unfavorable) at two locations: Assiut and Qena during two seasons (2010/2011 and 2011/2012). The experiment was grown in a randomized complete blocks design with three replications in each location. The objective of this investigation was to study the stability parameters of the fifteen durum wheat genotypes under different environments. The combined analysis of variance for environment (E), genotype (G) and (G×E) interaction was highly significant for all studied traits, suggesting differential responses of the genotypes and the need to stability analysis. The stability parameters are useful in characterizing genotypes by showing their relative performance in various environments. Results revealed that highly yielding genotypes can also be stable. The genotype No. 12 had desired performance (grain weight/spike) compared to the grand mean, regression coefficient (bi) did not differ significantly from unity and least deviation from regression (S^2d), indicating the role of linear portion of G×E interaction in the performance of this genotype. The value of regression coefficient (bi) of genotypes No. 12 for No. of grains/spike, No. 8 and 13 for grain weight/spike, No. 1, 2, 5, 8, 9, 14 and 15 for grain yield/plant were less than one (bi<1), indicating that these genotypes were considered specially adopted to unfavorable environments. Meanwhile, the value of regression coefficient of genotypes No. 9 for plant height, No. 13 for No. of grains/spike, No. 3,12 and 14 for grain weight/spike and No. 10 for grain yield/plant had bi values more than unity (bi>1) and could be adapted to optimum environment.

Key words: Durum wheat, stability analysis, genotye×environment interaction, grain yield

INTRODUCTION
Wheat is one of the most important cereal crops in Egypt, where depends upon the majority of the people in their diet. However, total wheat consumption has drastically increased due to over population growth by about 2.25% per year in 2012 (Anonymous, 2012). Egypt imports about 45% of its wheat requirements (Gad, 2010). Therefore, increasing wheat production is an important goal to reduce the gap between production and consumption (Rizkalla *et al*., 2012). This can be achieved

by developing high yielding varieties, application of improved agro-techniques and cultivating wheat in newly reclaimed soils. It is also important to mention that the successful of new varieties must show high performance for yield and its components. But beside that, breeding for yield stability for a wide range of different environmental conditions has always been important. Where, the phenotypic performance of a genotype may not be the same under diverse agro climatic conditions. This variation is due to G×E interaction which reduces the stability of a genotype under different environments (Ashraf *et al*., 2001). Also, Mustatea *et al*. (2009) showed that high-yielding cultivar can differ in yield stability and suggest that yield stability and high grain are mutually exclusive. In addition, Shah *et al*. (2009) found highly significant differences for genotype-location, genotype-year and genotype-location-year interactions for all the studied traits for ten wheat varieties. Thus G×E interaction studies are important as the interaction plays a significant role in the expression of the performance of different genotypes in different environments. So, many studies have been conducted to investigate stability of wheat genotypes under different environments (Amin *et al*., 2005; Aycicek and Yildirim, 2006; Ulker *et al*., 2006; Rasul *et al*., 2006; Akcura *et al*., 2009; Parveen *et al*., 2010; Al-Otayk, 2010; El Ameen, 2012). One of the most frequently used techniques for genotype stability estimation is by Eberhart and Russell (1966). They reported that, a genotype is considered stable if it has a unit regression over the environments (b = 1) and the deviation from regression not significantly different from zero ($S^2d = 0$). Therefore, a genotype with high mean yield over the environment, unit regression coefficient (b = 1) and deviation from regression equal to zero ($S^2d = 0$) will be a better choice as a stable genotype (Awad, 1997). Therefore, the present study was attempted to investigate the adaptation of fifteen durum wheat genotypes under different conditions by identifying and developing genotypes that more adapted and more stable in production under these environments and to study the stability parameters of them.

MATERIALS AND METHODS

Field trials: A field experiment consisting of fifteen durum wheat genotypes was conducted in eight environment; two planting dates i.e., Nov. 30th (favorable) and Dec. 30th (unfavorable) at two locations i.e., Experimental Farm of Assiut University, Assiut (27°11'N and 31°10'E) and Experimental Farm of South valley University, Qena (26°11'N and 32°44'E) during two winter seasons i.e., 2010/2011 and 2011/2012. A list of the fifteen genotypes, pedigree and origin are presented in Table 1.

Experimental design: The experiment was grown in a randomized complete blocks design with three replications in each location. The experimental plot comprise three rows of 3.5 m long with 30 cm wide, sowing was in hills spaced 10 cm. apart and contained 35 plants in each experiment. The recommended practices of wheat production were followed throughout the growing seasons.

Yield and yield measurements: Data were collected from each plot on random sample for each genotype. Number of days from sowing to heading, plant height, number of grains/spike, grain weight/spike, grain yield/plant and 1000-grain weight were recorded.

Layout of the different environments: Eight environments were used as follows: E1 is the first sowing date in the first season at the Experimental Farm of Assiut University, Assiut; E2 is the first sowing date in the first season at the Experimental Farm of South Valley University, Qena; E3 is

Table 1: The pedigree and origin of the fifteen genotypes

Entry No.	Pedigree	Origin
1	Tarro-3	-
2	Beltagy-2 :-ICD97-0396-T-IAP-5AP-0AP-4AP-0AP-4AP-0AP	-
3	MrfI/Stj 2//BcrchI :-ICD 99-0027-C-0AP-14AP-AP-9AP-AP	-
4	AAZ//ALTAR84/ALD/3/AJAIA/4/AJAIA-12/..	Mexico 03-04
5	AJAIA-12/F3LOCAL (SEL.ETHIO. 135.85)//..	Mexico 03-04-DSC371DSN
6	TARRO-I/2×YUAN-I//AJAIA-13/yAZI	Mexico 03-04
7	CBC 509 CHILE/4/SKEST//HUT/TUB/3/SILVER	Mexico 03-04
8	RASCON-21/3/MQUE/ALO//FOJA/4/GUANAY/5/...	Mexico 03-04
9	LLARETA-INIA/GUANAY//RASCON-37/2×TARRO-2	Mexico 03-04
10	POD-11/YAZI-I/3/GREEN-14//YEV-10/AUK	Mexico 03-04
11	GUAYACAN-INIA/3/STOT//ALTAR84/ALD	Mexico 03-04
12	CBC514CHILE/SOMAT-4/3/HUI/YAV79//DON87	Mexico 03-04
13	Bcr/GroI//Mgn/I:-ICD97-0396-T-IAP-AP-5AP-OAP-14AP-AP	-
14	Sohag 3 (Commercial variety)	Egypt
15	Beni Suef 3 (Commercial variety)	Egypt

the second sowing date in the first season at the Experimental Farm of Assiut University, Assiut; E4 is the second sowing date in the first season at the Experimental Farm of South Valley University, Qena; E5 is the first sowing date in the second season at the Experimental Farm of Assiut University, Assiut; E6 is the first sowing date in the second season at the Experimental Farm of South Valley University, Qena; E7 is the second sowing date in the second season at the Experimental Farm of Assiut University, Assiut and E8 is the second sowing date in the second season at the Experimental Farm of South Valley University, Qena.

Statistical analysis and stability parameters

Data analysis: Data collected were subjected to analysis of variance (Steel and Torrie, 1980) and treatment means were compared statistically using the test of Least Significant Differences (LSD).

Stability analysis: Stability parameters were computed according to Eberhart and Russell (1966). If regression coefficient (b) is significantly larger or smaller than one, the genotype is considered more adapted to favorable and unfavorable environments, respectively with respect to the site mean yield. If b is not significantly different from one, the genotype is considered stable for all environments. The hypothesis that any regression coefficient does not differ from unity, it was tested by the t-test using its own standard error for regression. The second stability parameter was mean square of the deviation from regression for each genotype. For the regression analysis of variance, the residual from the combined analysis of variance were used as a pooled error to test the S^2d values. A significant F-value would indicate that the S^2d was significantly different from zero. The appropriate analysis of variance is given with this model, the sum of squares due to environments and genotype×environments (linear) and deviations from the regression model.

RESULTS AND DISCUSSION

Environment-genotype variations and G×E interactions: Combined analyses of variance for the fifteen genotypes evaluated under eight divergent environments are given in Table 2.

The differences among the environments were highly significant for all studied traits. Also, the mean square of genotypes and the interaction between the genotypes and the interaction between

Table 2: Analysis of variance for days to heading, plant height, number of grains/spike, grain weight/spike, grain yield/plant and 1000-grain weigh

		Mean squares					
SOV	df	Days to heading	Plant height	No. of grains/spike	Grain weight/spike	Grain yield/plant	1000-grain weight
Environments (E)	7	2122.94**	11676.96**	9858.05**	37.17**	1985.60**	2930.50**
Error	16	7.23	48.78	30.07	0.121	2.59	11.37
Genotypes (G)	14	85.43**	155.80**	120.11**	0.202**	5.08**	218.73**
E×G	98	25.91**	56.46**	126.54**	0.190**	2.87**	59.32**
Error	224	3.52	9.50	16.92	0.058	1.76	6.43

**Significant at the 0.1% level of probability

Table 3: Mean days to heading of the 15 durum wheat genotypes evaluated in eight environments

	Environments								
Genotypes	E1	E2	E3	E4	E5	E6	E7	E8	Mean
1	106.33	88.33	87.33	77.33	85.00	90.00	78.00	80.67	86.62
2	106.33	90.00	85.67	78.67	82.00	90.33	79.00	81.67	86.71
3	107.00	88.33	90.33	86.33	89.33	92.00	81.00	82.00	89.54
4	105.67	86.00	92.33	87.00	88.67	92.67	85.33	81.33	89.88
5	104.00	90.33	92.67	83.33	91.67	92.00	83.00	82.00	89.88
6	109.67	89.33	95.33	90.33	96.33	97.33	87.67	84.00	93.75
7	105.67	87.67	95.00	90.67	95.00	91.67	84.67	79.67	91.25
8	101.67	85.67	92.00	90.67	90.67	93.33	83.33	79.00	89.54
9	102.00	88.67	93.67	85.67	88.33	93.67	79.67	81.67	89.17
10	96.00	84.67	93.00	88.67	89.33	95.33	79.33	82.67	88.63
11	95.00	84.33	93.67	83.33	90.33	91.00	81.00	81.33	87.50
12	93.33	89.00	96.67	87.00	91.67	95.33	83.67	83.67	90.04
13	105.33	85.33	89.00	85.33	85.67	91.33	78.67	81.00	87.71
14	107.33	86.00	94.67	85.00	94.33	86.00	87.67	83.33	90.54
15	103.33	87.33	94.67	89.33	94.67	91.33	85.00	84.00	91.21
Mean	103.24	87.40	92.40	85.91	90.20	90.227	82.47	81.87	89.46

$LSD_{0.05}$ of enviroumeuts = 0.77, $LSD_{0.05}$ of genotypes = 1.06 and $LSD_{0.05}$ of environments×genotypes = 1.53

the genotypes and environments found to be highly significant for all studied traits. These results indicated that genotypes interacted differently with the environments. The results in this study are generally in harmony for one or more of the studied traits with reported by Rharrabti *et al.* (2003), Amin *et al.* (2005), Aycicek and Yildirim (2006), Ulker *et al.* (2006), Rasul *et al.* (2006), Shah *et al.* (2009) and Akcura *et al.* (2009).

For days to heading as presented in Table 3, the average of the environments ranged from 81.87 days for E8 environment to 103.24 days for E1. As for the genotypes, the earliest genotype was No. 1 it recorded 86.62 days while the latest genotype was No. 6 which recorded 93.75 days. The earliest genotype was No. 1 under E4 while the latest one was the genotype No. 6 under E1. Early heading which shown in Qena (heat environment) with late sowing (probably exposure the plants to high temperatures) over all environments and genotypes could be due to affecting by high temperature compared to others. Concerning plant height (Table 4), the average of the environments ranged from 56.11 cm for E8 to 96.54 for E5. As for the genotypes, the tallest

Table 4: Mean plant height of the fifteen durum wheat genotypes evaluated in eight environments

	Environments								
Genotypes	E1	E2	E3	E4	E5	E6	E7	E8	Mean
1	85.96	66.00	91.67	71.67	94.58	56.37	91.11	48.57	75.74
2	94.45	75.67	92.22	78.00	97.06	57.93	90.99	54.77	80.14
3	96.11	80.67	102.78	65.67	99.00	70.97	93.58	58.23	83.38
4	103.33	77.00	92.22	64.00	95.21	66.00	89.03	59.90	80.84
5	92.78	70.67	90.56	57.67	88.69	61.57	88.17	50.73	75.11
6	92.22	75.67	88.33	72.33	90.92	65.57	83.73	56.33	78.14
7	96.11	74.67	96.11	61.33	92.52	58.53	89.29	56.57	78.14
8	97.78	71.00	94.45	63.33	100.30	62.33	90.87	50.37	78.80
9	97.22	73.00	94.44	64.67	96.74	64.73	87.17	56.57	79.32
10	96.66	71.33	92.78	75.67	94.42	55.33	86.90	53.80	78.36
11	83.41	79.33	93.89	59.67	96.00	61.00	83.07	58.47	76.86
12	93.33	74.33	99.72	82.33	104.00	68.03	91.83	53.60	83.40
13	92.78	80.33	94.44	62.67	96.88	66.20	91.71	58.63	80.46
14	96.67	80.00	89.45	65.33	98.67	60.70	84.81	59.57	79.40
15	98.52	70.33	96.66	77.67	103.12	57.33	94.14	65.60	82.92
Mean	94.49	74.67	93.89	68.13	96.54	62.17	89.09	56.11	79.40

$LSD_{0.05}$ of environments = 1.27, $LSD_{0.05}$ of genotypes = 1.74 and $LSD_{0.05}$ of environments×genotypes = 4.93

genotype was No. 12 it recorded 83.40 cm while the shortest was No. 1 which recorded 75.74 cm. The tallest genotype was No.12 under E5 while the shortest one was the genotype No. 1 under E8. These results are in harmony with previous days to heading trait, where the same environments which had early heading included the shortest genotypes. This might be due to delaying the elongation of plants after heading. Al-Otayk (2010) found a decrease in plant height by delaying sowing date.

For mean No. of grains/spike (Table 5), the mean of the environments ranged from 18.33 grains for E6 to 52.49 grains for E7. As for the genotypes, the genotype No. 6 gave the highest No. of grains by 45.91 grains while the lowest grains gave by No. 11 which recorded 30.06 grains. The best genotype was No. 6 under E5 while the worst genotypes were both 7 and 11 under both E6 and E4 environments, respectively.

Regarding mean grain weight/spike (Table 6), the mean of the environments ranged from 0.62 g for E6 to 2.79 g for E5 environment. As for the genotypes, the genotype No. 12 had the heaviest grain weight/spike (1.94) while the lightest one was No. 5 which recorded 1.64. The heaviest grain weight/spike genotypes were both No. 4 and 11 under E5 environment while the lightest one was the genotype No. 11 under E4 environment.

For mean grain yield/plant (Table 7), the average of the environments ranged from 1.30 g for E4 environment to 15.35 g for E5 environment. As for the genotypes, the genotype No. 12 gave the heaviest grain yield/plant where it recorded 8.81 g. while the lightest grain yield/plant genotype was No. 10 which recorded 7.25 g. The heaviest grain yield/plant genotypes were both No. 4 and 11 under E5 environment while the lightest grain yield/plant one was the genotype No. 11 under E4 environment. These results indicating that Qena (heat environment) with late sowing (probably exposure the plants to high temperatures) had the worst records. Menshawy (2007) reported that reduction of grain yield by delaying sowing date could be attributed to grain-filling process that is harmfully affected by high temperatures and kernels reaching to maturity before complete filling.

Table 5: Mean No. of grains/spike of the fifteen durum wheat genotypes evaluated in eight environments

	Environments								
Genotypes	E1	E2	E3	E4	E5	E6	E7	E8	Mean
1	55.10	35.33	49.93	39.00	48.30	26.00	42.27	18.00	39.24
2	49.03	40.00	50.10	37.33	49.63	21.33	43.77	17.33	38.69
3	53.20	33.00	57.60	16.33	53.17	13.00	53.20	18.33	37.23
4	49.17	30.67	47.13	20.33	53.97	37.00	49.83	19.33	38.43
5	49.33	34.00	42.33	25.33	48.63	27.00	52.73	17.33	37.09
6	55.20	53.33	55.95	23.00	65.80	26.33	64.70	23.00	45.91
7	50.57	36.67	59.43	21.00	50.58	7.67	63.07	23.67	39.08
8	50.17	33.00	46.33	29.33	46.22	10.00	47.60	23.67	35.79
9	39.88	44.00	53.50	32.67	48.10	17.67	55.77	19.00	38.82
10	48.87	22.00	57.67	41.33	54.23	14.33	56.40	19.67	39.12
11	61.10	37.33	49.00	7.67	60.05	15.33	60.00	22.00	30.06
12	51.04	35.00	48.93	30.00	51.20	18.33	51.90	20.00	38.30
13	49.53	35.00	53.63	27.00	49.17	11.67	49.67	24.00	37.46
14	49.07	35.00	48.87	28.33	52.30	10.00	50.37	28.00	37.74
15	53.23	31.33	50.80	46.00	51.73	19.33	46.07	20.00	39.81
Mean	50.97	35.71	51.48	28.31	52.21	18.33	52.49	20.89	38.81

$LSD_{0.05}$ of environments = 1.70, $LSD_{0.05}$ of genotypes =2.33 and $LSD_{0.05}$ of environments×genotypes = 6.58

Table 6: Mean grain weight/spike of the 15 durum wheat genotypes evaluated in eight environments

	Environments								
Genotypes	E1	E2	E3	E4	E5	E6	E7	E8	Mean
1	2.72	1.17	2.34	1.25	2.65	0.79	2.05	0.66	1.70
2	2.56	1.46	2.48	1.24	2.84	0.74	1.94	0.56	1.73
3	2.69	1.33	2.22	0.90	3.09	0.49	2.42	0.71	1.73
4	2.74	1.25	2.48	1.02	3.26	1.16	2.31	0.68	1.86
5	2.58	1.33	1.90	0.60	2.61	1.04	2.44	0.60	1.64
6	3.20	2.01	2.17	0.61	3.02	0.84	2.54	0.73	1.89
7	2.63	1.63	2.39	0.63	2.81	0.25	3.03	0.92	1.79
8	2.64	1.29	2.06	0.87	2.58	0.46	2.38	1.00	1.66
9	2.71	1.67	2.29	0.81	2.39	0.49	2.54	0.74	1.71
10	2.77	0.97	2.45	1.31	2.54	0.33	2.16	0.70	1.65
11	2.78	1.73	2.51	0.18	3.26	0.52	2.58	0.96	1.82
12	2.96	1.53	2.67	1.17	3.01	0.67	2.67	0.85	1.94
13	2.60	1.55	2.50	1.21	2.59	0.43	2.19	0.86	1.74
14	2.40	1.34	2.51	0.67	2.67	0.37	2.50	0.81	1.66
15	2.54	1.44	2.53	1.50	2.54	0.70	2.07	0.71	1.75
Mean	2.70	1.45	2.37	0.93	2.79	0.62	2.39	0.77	1.75

$LSD_{0.05}$ of environments = 0.11, $LSD_{0.05}$ of genotypes = 0.14 and $LSD_{0.05}$ of environments×genotypes = 0.39

Moreover, for mean 1000-grain weight (Table 8), the average of the environments ranged from 33.02 g for E6 environment to 54.37 for E5 environment indicating that wide detected range of environment differences. As for the genotypes, the heaviest 1000-grain weight genotype was No. 3 it recorded 47.73 g while the lightest 1000-grain weight genotype was No. 6 which recorded 37.06 g. The heaviest 1000-grain weight genotype was No. 12 under E1 environment while the lightest 1000-grain weight one was the genotype No.10 under E6 environment.

Table 7: Mean grain yield/plant of the fifteen durum wheat genotypes evaluated in eight environments

	Environments								
Genotypes	E1	E2	E3	E4	E5	E6	E7	E8	Mean
1	14.98	1.33	12.87	1.63	14.60	1.35	11.26	1.79	7.48
2	14.08	2.73	13.63	1.67	15.60	2.46	10.67	1.70	7.82
3	14.80	1.87	12.23	1.50	17.01	1.88	13.33	1.52	8.02
4	15.05	1.67	13.64	1.57	17.95	1.97	12.71	1.59	8.27
5	14.17	1.90	10.77	1.20	14.34	1.91	13.44	1.20	7.37
6	17.60	3.13	11.92	0.83	16.59	2.91	13.95	0.86	8.47
7	15.71	1.80	13.15	0.87	15.48	1.82	16.65	0.89	8.30
8	14.52	1.97	11.32	1.07	14.17	1.99	13.11	1.22	7.42
9	14.93	2.00	12.62	1.27	13.15	2.03	13.97	1.29	7.66
10	11.74	1.67	13.46	1.80	13.95	1.68	11.90	1.80	7.25
11	15.27	2.20	11.77	0.23	17.95	2.21	14.17	0.66	8.06
12	16.26	2.50	14.67	1.63	16.58	2.52	14.71	1.57	8.81
13	14.29	1.87	12.65	1.17	14.23	1.95	12.05	1.36	7.45
14	13.17	1.60	13.83	1.10	14.70	1.61	13.77	1.26	7.63
15	13.96	1.90	13.92	2.00	13.97	1.93	11.37	2.01	7.63
Mean	14.70	2.01	12.83	1.30	15.35	2.01	13.14	1.38	7.84

$LSD_{0.05}$ of environments = 0.55, $LSD_{0.05}$ of genotypes = 0.75 and $LSD_{0.05}$ of environments×genotypes = 2.12

Table 8: Mean 1000-grain weight of the 15 durnm wheat genotypes evaluated in eight environments

	Environments								
Genotypes	E1	E2	E3	E4	E5	E6	E7	E8	Mean
1	49.36	33.57	46.12	32.17	56.26	32.04	47.47	37.92	41.86
2	51.89	35.80	48.21	33.70	57.21	34.88	44.17	36.43	42.79
3	53.57	41.03	46.73	59.03	58.24	36.54	44.92	41.76	47.73
4	55.70	42.80	49.41	49.13	61.15	28.95	45.97	33.99	45.89
5	52.39	38.80	44.29	35.03	54.57	38.11	45.71	34.07	43.00
6	49.11	37.87	35.58	25.63	46.41	31.04	39.20	31.66	37.06
7	55.07	44.37	46.86	30.80	59.70	32.87	47.46	38.11	44.41
8	52.56	42.47	44.59	29.80	55.81	38.20	46.68	43.40	44.19
9	50.95	37.87	43.02	24.80	49.73	27.49	45.21	36.44	39.44
10	45.58	49.80	43.53	31.43	46.76	23.26	38.08	36.61	39.38
11	46.29	41.80	38.91	23.40	50.36	33.51	42.68	40.21	39.65
12	61.65	42.03	54.25	38.73	54.57	36.60	50.38	41.97	47.52
13	55.08	44.57	46.51	35.43	52.91	30.31	44.06	36.48	43.17
14	55.60	38.53	48.04	23.43	57.48	38.62	48.95	28.92	42.45
15	53.81	45.73	44.89	33.37	54.39	32.90	40.93	35.20	42.65
Mean	52.57	41.14	45.40	33.72	54.37	33.02	44.86	36.88	42.74

$LSD_{0.05}$ of environments =1.05, $LSD_{0.05}$ of genotypes =1.44 and $LSD_{0.05}$ of environments×genotypes = 4.06

Joint regression analysis: Analysis of variance for each of the studied traits over all environments and genotypes when stability parameters are estimated for each genotype across the used environments are presented in Table 9. All mean squares of E+(G×E) were highly significant for all studied traits, indicating that the environments and their interaction with genotypes played important role in determining all studied traits. Similar results were obtained by Ulker *et al.* (2006), Shah *et al.* (2009) and Akcura *et al.* (2009).

Table 9: The joint regression analysis variance for days to heading, plant height, number of grains/spike, grain weight/spike, grain yield/plant and 1000-grain weight

		MS					
Source of variance	df	Days to heading	Plant height	No. of grains/spike	Grain weight/spike	Grain yield/plant	1000-grainweight
Genotypes (G)	14	85.43**	155.80**	120.11**	0.202	5.08**	218.73**
Env.+(G×Env.)	105	165.71**	831.16**	775.26**	2.65**	135.05**	251.19**
Env. (linear)	1	14860.60**	81738.68**	69006.35**	260.19**	13899.21**	20513.49**
G×Env. (linear)	14	35.45**	41.22**	179.92**	0.20	5.51**	54.97**
Pooled deviation	90	22.70**	55.07**	109.75**	0.17	2.27**	56.12**
Pooled error	224	3.52	9.50	16.92	0.058	1.76	6.43

Table 10: Genotype average performance of eight envirouments, Stability parameters for days to heading and plant height

	Plant height			Days to heading		
Genotypes	S^2d	bi	Mean	S^2d	bi	Mean
1	75.81**	1.47	75.74	37.93**	2.34**	86.62
2	60.36**	0.94	80.14	63.06**	1.69*	86.71
3	51.45**	1.21	83.38	7.36	2.79**	89.54
4	58.70**	0.82	80.84	8.95*	1.53*	89.88
5	41.43**	1.34	75.11	8.37*	1.34*	89.88
6	17.59	2.71**	78.14	7.91*	2.49**	93.75
7	31.46**	1.85*	78.14	20.30**	1.57**	91.25
8	15.58	4.53**	78.80	18.88**	0.62	89.54
9	16.27	1.23	79.32	8.69*	1.28	89.17
10	62.48**	1.31	78.36	32.27**	0.32	88.63
11	93.19**	0.17	76.86	18.85**	0.84	87.50
12	105.81**	1.08	83.40	35.78**	1.30	90.04
13	41.01**	0.48	80.46	12.01**	2.45**	87.71
14	47.22**	0.48	79.40	50.07**	1.10	90.54
15	107.67**	1.15	82.92	10.03**	0.13	91.21
		79.40			89.46	Mean

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

Mean squares of environments (linear) for all studied traits (Table 9), were highly significant indicating differences between environments and their considerable influence on all studied traits. This result is generally in line with those reported by Parveen *et al.* (2010) and Gowda *et al.* (2010).

It is also important to mention that the linear component of genotype-environment interaction was highly significant for all studied traits, except grain weight/spike, therefore, it could be proceed in the stability analysis Eberhart and Russell (1966). These results indicated that the relative ranks of the genotypes differed from one environment to another. Similar results were found by Al-Otayk (2010).

The highly significant of pooled deviation for all studied traits, except grain weight/spike indicated that the genotypes differed considerably with respect to their stability for all mentioned studied traits. These results are in line with those obtained by Al-Otayk (2010).

Stability parameters: For each genotype, the values of mean performance over environments ($\bar{X}$), the stability regression coefficient (bi) and deviation from regression (S^2d) for all studied traits, are presented in Table 10-12. A stable genotype is one with a high mean performance, unit regression

Table 11: Genotype average performance of eight environments, stability parameters No. of grains/spike and grain weight/spike

	Grain weight/spike			No. of grains/spike		
Genotypes	S^2d	bi	Mean	S^2d	bi	Mean
1	0.13*	1.50	1.70	113.11**	0.57	39.24
2	0.17**	4.20**	1.73	76.97**	0.45	38.69
3	0.05	2.04	1.73	48.54**	3.65**	37.23
4	0.24**	1.01	1.86	196.93**	0.09	38.43
5	0.22**	0.77	1.64	66.05**	0.49	37.09
6	0.31**	2.07	1.89	165.30**	1.89**	45.91
7	0.29**	2.73*	1.79	107.27**	2.97**	39.08
8	0.08	0.02	1.66	46.53**	0.33	35.79
9	0.13*	0.45	1.71	116.47**	0.41	38.82
10	0.25**	0.85	1.65	210.82**	1.44	39.12
11	0.34**	3.10**	1.82	233.01**	2.60**	30.06
12	0.02	1.89	1.94	4.12	0.17	38.30
13	0.10	0.35	1.74	32.66	1.21	37.46
14	0.10	1.66	1.66	62.77**	0.78	37.74
15	0.19**	4.33**	1.75	165.71**	0.13	39.81
Mean			1.75			38.80

*,**Significantly different from nnity for (bi) and from zero for (S^2d) at the 0.05 and 0.01 probability levels, respectively

Table 12: Genotype average performance of eight environments, stability parameters grain yield/plant and 1000-grain weight

	1000-grain weight			Grain yield/plant		
Genotypes	S^2d	bi	Mean	S^2d	bi	Mean
1	37.55**	1.36*	41.86	1.96	0.23	7.48
2	23.80**	1.43*	42.79	3.23	0.28	7.82
3	188.61**	0.37	47.73	1.32	1.97*	8.02
4	128.00**	1.27	45.89	2.40	2.51*	8.27
5	20.87**	0.30	43.00	1.50	0.44	7.37
6	24.93**	0.41	37.06	4.48*	2.12*	8.47
7	7.45	4.34**	44.41	4.02*	2.83**	8.30
8	36.45**	0.50	44.19	0.83	0.79	7.42
9	26.94**	2.05**	39.44	2.50	0.30	7.66
10	114.84**	0.44	39.38	3.13	1.08	7.25
11	67.68**	0.38	39.65	3.56	2.77**	8.06
12	36.38**	1.21	47.52	0.21	14.83**	8.81
13	15.22*	1.35*	43.17	0.32	2.98**	7.45
14	92.66**	2.44**	42.45	2.12	0.99	7.63
15	20.50**	1.17	42.65	2.49	0.74	7.63
Mean			42.74			7.84

*,**Significantly different from nnity for (bi) and from zero for (S^2di) at the 0.05 and 0.01 probability levels, respectively

coefficient (b = 1) and deviation from regression equal to zero (Awad, 1997). The simultaneous consideration of three stability parameters for individual genotype revealed that genotype No. 12 gave the highest grain weight/spike (1.94 g) over the grand mean with regression coefficient 1.89 and did not differ significantly from unity, in addition least deviation from regression (Table 11). Due to greater value of regression coefficient (bi<1), genotypes No. 9 for plant height, (Table 10), No. 13 for No. of grains/spike, No. 3, 12 and 14 for grain weight/spike (Table 11) and No. 10 for grain yield/plant (Table 12), could be well adapted to favorable environment condition. Genotypes No. 12 for No. of grains/spike while genotypes No. 8 and 13 for grain weight/spike (Table 11). Also, genotypes No. 1, 2, 5, 8, 9, 14 and 15 for grain yield/plant, Table 12 were considered specially adapted to unfavorable environment because their regression coefficients were less than one (bi<1). Genotypes No. 3, 4, 6, 7, 11 and 12 gave higher grain yield/plant (8.02, 8.27, 8.47, 8.30, 8.06 and 8.80 g) but it had high values of S^2d showing sensitivity to environmental changes and an unpredictable grain yield (Eberhart and Russell, 1966). Similar results were also reported by Al-Otayk (2010).

CONCLUSION

In general, it can be concluded that, the evaluated genotypes varied in response to the diverse environments. Concerning locations, Qena appears as unfavorable environment compared to Assiut. In addition, the worst records for most studied traits were investigated under Qena with delaying sowing interaction. Finally, genotype No., 12 is considered a stable over all environments for grain weight/spike. Due to values of regression coefficients (bi) genotypes No. 9 for plant height, No. 13 for No. of grains/spike, No. 3, 12 and 14 for grain weight/spike and No. 10 for grain yield/plant could be adapted to favorable environment. Genotypes No. 12 for No. of grains/spike, No. 8 and 13 for grain weight/spike, No. 1, 2, 5, 8, 9, 14 and 15 for grain yield/plant were considered specially adopted to unfavorable environments.

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