Egypt. J. Plant Breed. 20(5):885 – 902 (2016)

STABILITY ANALYSIS OF BREAD WHEAT UNDER DIFFERENT ENVIRONMENTS

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ABSTRACT

A great challenge for wheat breeding programs is increasing yield without sacrificing its stability. This study presents the yields and stability parameters of 43 bread wheat genotypes, tested in 10 diverse environments in Egypt during the two growing seasons 2013/2014 and 2014/2015. These environments distributed along the Egypt map from 215 m above sea level (asl) at Toshka in south Egypt to 22 m asl at El-Nobaria in the north. The separate field trials were arranged in randomized complete block design with 3 replications then combined analysis of variance was performed for the obtained data. The diversity of conditions included in the study was reflected by large variation of a grain yields/plant of the 43 genotypes, which varied from 1.50 g/plant to 77.34 g/plant. It was concluded that the most stable genotypes were G14 and G18 over all the environments while genotype G30 was found to be the best performer under the poorer conditions. Moreover, genotypes considered to be stable for grain yield were not stable for other characters except genotype G14 which was stable for grain yield and spike number per plant.

Key words: ***Wheat, Yield, Stability.***

INTRODUCTION

Wheat is one of the most important cereal crops in the world specially in developing countries (said *et al* 2015). In Egypt, the area for living and cultivation land did not exceed 5% from the total area. There is a big gap between production and consumption of wheat (about 52%) (FAO 2013) as the majority of the people use wheat as common source of carbohydrates in their daily diets. To fill this gap there is a bad need to grow wheat in new environments in addition to the river Nile valley. But these new environments suffer from some abiotic stresses such as drought, heat and salinity. Information about phenotypic stability is useful for the selection of crop varieties as well as for breeding programs and stress tolerance of a plant genotype is a product of many physiological and morphological characters for which effective selection criteria have not yet been developed (Ludlow and Muchow 1990). Therefore, grain yield and its components is the major selection criteria for enhancing the adaptation to environmental stresses in breeding programs (Ozkan *et al* 1998). Grain yield stability is one of the most important goals of breeding programs, especially in the sub-tropical environments. The ideal wheat genotype is the one which high yield under any environmental conditions, but most genotypes do not give the same response in all environments (Carvalho *et al* 1983). When genotype and environment have interaction, the response of a genotype is changed when the yield of this genotype is compared over various types of environments. There are many statistical techniques, which

can identify the variation in individual genotypic responses and one of these techniques is Eberhart and Russell (1966) model which has been widely used in studies of stability and adaptability of genotypes. A genotypes is considered as stable if it gave high mean yield, recorded a regression coefficient (bi) value close to 1.0 and its deviation form mean regression (S^2_{di}) did not differ significantly from zero. The objective of this study was to identify high yielding and stable genotypes that perform well under different locations and water stress conditions.

MATERIALS AND METHODS

Plant Material and experiments

A panel of 43 bread wheat genotypes (Triticum aestivum L.) was included in the current study (17 local cultivars, 6 imported cultivars, 12 promising inbred lines developed in Agronomy Department, Assiut University and 8 landraces) as shown in Table 1. Ten experiments were conducted during 2013/2014 and 2014/2015 growing seasons at ten distinguished environments as follows;

1. Faculty of Agriculture Experimental Farm, Assiut University, Assiut Province, Egypt in clay soil (lat 27° 02' N, long 31° 01' and alt 70 m asl) at two planting dates as favorable conditions, *i.e*. Dec. 1, 2013 (E_1) and Dec. 3, 2014 (E_2). In addition, there are two planting dates as a heat stress conditions *i.e*. Feb.1, 2014 (E_3) and Feb. 9, 2015 (E_4) as plants suffered from terminal high temperature during anthesis and grain-filling stages.
2. Agricultural Production and Research Station, National Research Centre (NRC), El -Nubaria Province, Egypt in sandy soil (Lat 30° 05' N, long 30° 08' and alt. 22 m asl) using to different levels of irrigation water requirements added by sprinkler irrigation following Abdelraouf et al 2013. The first level was considered as drought stress conditions (50% of irrigation requirements) sowing at Nov. 20, 2013 (E5) and Nov. 18, 2014 (E6). The second level was normal irrigation conditions (100% of irrigation requirements) sowing at Nov. 20, 2013 (E7) and Nov. 18, 2014 (E8).
3. Toshka Research Station, The Egyptian Desert Research Center, Aswan, Toshka Province, Egypt in sandy soil (Lat 22° 28' N, long 31° 32' and alt. 215 m asl) using drip irrigation system sowing at Dec. 1, 2014 (E9)
4. Faculty of Agriculture Experimental Farm, Assiut University, New Vally, El-Kharga Province, Egypt in sandy soil (lat 25° 31' N, long 30° 36' and alt. 33 m asl) using surface irrigation Dec. 3, 2014 (E10).

Maximum and minimum temperatures during the growing the two seasons 2013/2014 and 2014/2015 for all locations are presented in Table 2.

Table 1. List of the 43 genotypes and its origin.

Origin	Name	Genotype Code
Egypt Local cultivars	Gemmeiza 07	G01
	Gemmeiza 09	G02
	Gemmeiza 10	G03
	Giza 160	G04
	Giza 164	G05
	Giza 165	G06
	Giza 168	G07
	Misr 01	G08
	Sahel 01	G09
	Sakha 08	G10
	Sakha 69	G11
	Sakha 92	G12
	Sakha 93	G13
	Seds 01	G14
	Seds 04	G15
	Seds 12	G16
	Shandaweel 1	G17
Imported from Sudan	Beknora	G18
	Debera	G19
	Nelen	G20
	Snora	G21
Imported from Canada	Canada 462	G22
	Canada 515	G23
Promising inbred lines developed at Agronomy Department Assiut University, Egypt	H258	G24
	Assiut 103	G25
	Assiut 1006	G26
	Assiut 216	G27
	Assiut 108	G28
	Sel 160	G29
	Assiut 204	G30
	Assiut 724	G31
	MK 7-83	G32
	Asiut 103 *Giza 168 (F8)	G33
	Sakha 93 * 168 (F8)	G34
	Assiut 216 * Gemmeiza 9 (F8)	G35
Landraces	MW 278	G36
	L 1351	G37
	L 1203	G38
	L 1290	G39
	L 887	G40
	L 741	G41
	L 1457	G42
	L 780	G43

Table 2. Monthly average of minimum (Min) and maximum (Max) temperature (°C) at all locations during the growing seasons 2013/2014 and 2014/2015.

Location	El-Noubaria				Assiut				El-Kharga				Toshka			
Season	2013-2014		2014-2015		2013-2014		2014-2015		2013-2014		2014-2015		2013-2014		2014-2015	
Temperature	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
December	10.3	19.8	11.7	21.2	7.6	21.4	8.8	23.3	7.0	24.4	9.0	24.1	14.2	26.9	13.9	27.2
January	9.6	20.2	8.7	19.4	6.4	22.4	5.5	20.5	6.3	23.5	7.0	23.5	11.6	25.3	10.1	23.7
February	10.6	20.3	9.1	18.8	7.5	23.9	7.9	22.8	7.1	25.1	8.2	25.3	13.0	27.6	12.7	27.3
March	12.3	22.7	12.5	21.5	12.2	27.8	12.2	27.2	10.2	28.1	11.2	29.2	17.2	32.0	16.8	31.5
April	14.2	25.6	13.1	23.4	15.8	32.8	14.6	29.1	15.4	34.7	17.5	34.1	21.5	37.3	18.1	33.1
May	17.7	28.4	17.9	27.4	19.8	35.5	19.7	35.5	20.6	38.2	22.6	39.3	24.8	39.9	24.5	39.5
June	21.3	30.2	20.7	28.9	22.6	37.7	21.4	36.6	23.7	39.8	24.4	40.2	26.8	41.7	25.7	40.9

http://eg.freemeteo.com/weather/?language=english&country=egypt

Each experiment consisted of the 43 genotypes was grown in the field with plant to plant distance of 20 cm and row to row distance of 30 cm with 3 replications (Each replication consisted of one nursery row of 3 m in length. All experiments were fertilized according to the recommended treatments in each experiment region. By the end of May after maturity, a sample of 5 guarded plants from each row was harvested then kept in green house till well drying for phenotypic evaluation.

Phenotypic evaluation

Phenotypic data was assessed on 6 agronomic traits including; plant height in cm, spike length in cm, spike number per plant, grain yield per plant in gram, biological yield per plant in gram and harvest index.

Statistical Analysis

Analysis of variance (ANOVA) was carried out using Proc Mixed of SAS package version 9.2 (SAS 2008) and means were compared by revised Least Significant Difference (LS D') at 5% level of probability (Steel and Torrie 1981). Stability parameters, regression coefficient (b_i) and deviation mean squares (S^2_{di}) were performed to Eberhart and Russell (1966) approach. The G x E was partitioned into its components due to linear regression (b_i) at the i^{th} genotype on the environment mean, and deviation (d_{ij}). The most stable genotype would have bi=1 with low deviation mean squares (S^2_{di}), where S^2_{di} describe the contribution of genotype i to GE-interaction.

RESULTS AND DISCUSSION

Mean performance and environmental index:

Genotype means, phenotypic index (Pi) and environmental index (E. index) for grain yield and other studied traits are presented in Tables 3, 4, 5, 6, 7 and 8. Since the environmental index was calculated as the difference between each environment mean and the general mean over all environments.

Table 3. Mean performance for plant height of 43 wheat genotypes evaluated at 10 different environments.

Gt	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	Mean	Pi
G01	77.33	92.67	74.17	47.00	74.33	74.67	95.67	93.33	73.67	77.00	77.98	4.95
G02	82.15	84.00	55.42	56.67	68.33	61.00	77.33	79.33	75.33	75.67	71.52	-1.51
G03	80.17	92.67	53.17	51.67	73.00	78.33	104.00	100.00	63.33	73.33	76.97	3.93
G04	80.33	94.33	50.33	52.00	86.00	82.00	98.33	95.67	69.33	79.67	78.80	5.76
G05	83.43	81.00	58.37	56.67	63.00	68.33	68.33	68.67	75.00	78.33	70.11	-2.92
G06	72.83	88.67	46.00	50.00	78.33	79.33	101.67	103.33	71.00	73.67	76.48	3.45
G07	76.67	88.67	53.50	71.67	75.67	76.00	83.33	83.33	81.33	98.67	78.88	5.85
G08	78.33	80.00	57.00	53.33	71.00	72.00	81.67	81.67	74.33	84.33	73.37	0.33
G09	93.83	92.67	49.83	50.00	62.67	65.33	65.67	65.67	61.67	64.67	67.20	-5.84
G10	93.33	90.33	87.67	65.67	81.00	79.00	95.67	96.33	71.33	82.00	84.23	11.20
G11	92.33	83.67	70.83	63.00	86.00	84.33	89.00	84.67	60.00	75.33	78.92	5.88
G12	91.00	69.00	73.33	46.67	64.33	64.00	92.33	93.00	63.00	68.67	72.53	-0.50
G13	89.83	66.67	73.33	39.67	54.33	57.33	58.33	63.67	62.33	68.33	63.38	-9.65
G14	80.17	80.33	47.67	54.33	74.33	74.00	103.33	101.67	73.33	80.33	76.95	3.91
G15	62.56	75.00	50.11	50.33	75.33	71.67	71.00	72.33	60.67	72.00	66.10	-6.94
G16	55.11	83.67	42.78	43.33	61.33	60.67	79.33	79.67	65.00	74.00	64.49	-8.55
G17	75.50	76.00	58.33	57.67	69.33	69.00	81.67	82.33	67.00	68.33	70.52	-2.52
G18	64.17	63.33	48.89	50.33	68.33	66.67	101.67	100.00	61.00	76.67	70.11	-2.93
G19	75.00	75.00	50.83	52.00	71.67	69.00	66.67	68.00	74.00	72.33	67.45	-5.59
G20	87.83	87.67	57.83	47.00	65.67	63.00	80.67	80.33	60.67	72.33	70.30	-2.74
G21	80.00	80.00	65.44	61.67	58.33	64.33	66.67	68.00	67.67	75.33	68.74	-4.29
G22	76.33	77.67	59.00	47.67	76.00	78.67	101.33	101.00	64.00	77.67	75.93	2.90
G23	89.67	89.33	66.78	64.33	72.33	74.33	109.33	109.67	65.33	82.00	82.31	9.27
G24	101.33	106.67	49.08	51.67	70.33	74.00	85.33	93.33	86.67	79.33	79.77	6.74
G25	79.22	81.00	43.36	44.33	50.33	50.67	84.33	83.67	75.33	70.67	66.29	-6.75
G26	87.89	85.33	44.29	43.00	51.67	53.00	89.00	88.33	71.33	76.33	69.02	-4.02
G27	99.75	105.00	47.82	50.33	69.33	68.67	93.33	91.67	77.67	81.67	78.52	5.49
G28	95.33	95.67	55.83	53.33	65.67	63.33	81.00	81.00	67.33	74.00	73.25	0.21
G29	79.87	81.67	61.05	61.67	70.33	74.00	73.33	75.00	69.00	79.33	72.53	-0.51
G30	85.33	84.67	64.67	58.33	79.67	77.00	76.67	75.67	71.33	91.33	76.47	3.43
G31	71.50	73.00	42.50	41.67	77.00	77.00	77.33	77.67	71.67	86.00	69.53	-3.50
G32	79.83	79.67	64.78	56.67	82.33	82.00	81.67	81.67	74.33	76.00	75.89	2.86
G33	79.10	75.33	42.00	40.00	50.33	57.67	83.67	81.67	67.00	71.67	64.84	-8.19
G34	68.27	69.67	42.47	43.33	62.33	62.67	85.67	87.33	71.00	62.33	65.51	-7.53
G35	90.81	92.67	62.39	63.67	68.33	64.67	61.67	60.00	74.00	84.67	72.29	-0.75
G36	114.80	109.33	68.08	71.67	90.67	87.33	73.33	75.00	80.33	88.00	85.85	12.82
G37	76.17	76.33	58.22	55.33	81.67	80.67	83.33	86.33	64.00	82.67	74.47	1.44
G38	70.50	71.00	52.11	51.00	60.67	59.00	71.67	76.67	64.33	68.33	64.53	-8.51
G39	85.83	86.67	65.00	63.00	88.00	89.67	87.67	89.00	71.67	76.00	80.25	7.21
G40	80.17	80.33	51.28	46.00	55.00	60.00	68.33	68.33	69.33	69.00	64.78	-8.26
G41	92.67	92.33	58.44	61.67	86.33	89.33	80.33	79.00	68.67	81.67	79.04	6.01
G42	83.83	83.67	69.33	66.67	87.00	83.33	81.33	77.67	73.33	85.00	79.12	6.08
G43	76.17	76.33	55.00	48.33	69.67	70.33	63.33	62.33	60.00	71.67	65.32	-7.72
Mean	82.24	83.69	56.94	53.59	70.87	71.10	82.68	82.86	69.50	76.89	73.04	
LSD $_{0.05}$	4.28	3.00	7.45	3.26	5.10	4.55	4.79	4.66	3.18	5.61		
E. Index	9.20	10.65	-16.10	-19.45	-2.17	-1.94	9.65	9.82	-3.53	3.86		

Gt = Genotype, Pi = phenotypic index and E. index =environmental index

Table 4. Mean performance for spike length of 43 wheat genotypes evaluated at 10 different environments.

Gt	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	Mean	Pi
G01	12.83	13.17	10.33	10.83	5.00	5.83	11.67	11.50	10.83	10.00	10.20	1.13
G02	12.55	12.83	10.11	10.33	5.67	6.00	7.67	9.00	11.50	10.33	9.60	0.53
G03	11.58	14.50	9.33	10.17	9.00	9.67	9.33	9.83	9.83	9.67	10.29	1.23
G04	12.00	11.17	8.42	8.33	7.67	7.17	9.00	9.50	10.17	8.67	9.21	0.14
G05	12.19	11.83	8.93	8.67	5.83	5.83	8.33	7.83	8.83	9.17	8.74	-0.32
G06	11.92	12.83	8.72	8.83	8.67	9.17	8.67	9.00	9.83	10.33	9.80	0.73
G07	12.00	15.00	8.67	11.00	6.83	7.83	10.17	10.83	13.00	11.50	10.68	1.62
G08	11.25	11.67	10.17	8.33	8.00	8.67	9.50	8.83	9.67	8.67	9.48	0.41
G09	13.50	13.50	10.31	10.67	5.50	5.83	7.67	8.33	9.50	8.50	9.33	0.26
G10	13.25	11.83	11.33	9.67	7.83	7.17	10.17	10.17	9.50	9.00	9.99	0.93
G11	14.33	10.33	9.83	8.17	8.17	8.50	8.50	8.67	6.33	9.67	9.25	0.18
G12	15.25	9.83	10.17	8.00	5.00	5.67	7.17	7.67	8.67	6.67	8.41	-0.66
G13	14.00	9.33	11.50	7.67	7.00	7.33	7.67	7.83	9.17	9.33	9.08	0.02
G14	11.00	14.00	7.33	9.67	7.17	7.17	9.00	9.00	9.17	9.00	9.25	0.18
G15	10.64	10.50	8.60	10.33	7.83	8.17	10.17	9.67	8.50	10.00	9.44	0.37
G16	10.00	13.00	7.56	9.00	8.33	8.67	8.17	9.17	9.17	8.83	9.19	0.12
G17	11.50	11.50	10.50	9.00	6.83	7.17	9.50	8.67	9.17	9.17	9.30	0.23
G18	9.83	8.73	8.39	8.50	5.00	4.50	10.00	9.67	9.00	8.17	8.18	-0.89
G19	11.42	11.83	9.75	9.67	6.00	5.83	8.93	9.33	8.50	7.33	8.86	-0.21
G20	10.00	10.00	6.92	6.83	6.17	5.83	6.67	7.33	7.50	7.17	7.44	-1.62
G21	9.92	9.83	8.31	8.33	6.83	6.67	8.33	8.50	9.33	8.67	8.47	-0.59
G22	11.50	11.00	8.81	8.00	8.00	7.67	10.00	9.17	9.50	9.50	9.31	0.25
G23	13.00	13.50	9.92	9.67	5.17	5.67	10.33	10.50	9.33	8.67	9.58	0.51
G24	13.74	14.47	10.77	11.33	5.67	6.17	11.50	11.17	9.17	11.67	10.56	1.50
G25	7.66	7.83	7.34	7.50	5.83	5.50	6.67	7.00	9.33	8.67	7.33	-1.73
G26	9.44	9.17	7.21	7.00	5.67	5.33	7.50	6.83	9.83	8.33	7.63	-1.43
G27	10.13	10.67	6.81	7.17	6.00	5.67	9.17	9.17	6.67	8.83	8.03	-1.04
G28	13.25	13.50	8.83	8.83	6.33	7.17	7.50	7.83	8.67	9.50	9.14	0.08
G29	10.76	11.00	9.08	9.17	6.33	6.83	7.67	7.83	8.67	10.00	8.73	-0.33
G30	13.33	13.67	11.75	11.00	8.00	7.33	9.83	9.83	11.17	12.50	10.84	1.78
G31	14.17	14.33	8.83	8.50	9.67	10.00	11.50	11.50	12.00	11.50	11.20	2.13
G32	12.33	12.67	10.50	10.83	9.00	9.00	11.33	11.50	12.33	10.33	10.98	1.92
G33	8.61	8.20	7.35	7.00	6.00	5.83	8.17	9.33	8.50	8.07	7.71	-1.36
G34	9.31	9.50	7.19	7.33	7.33	6.50	10.67	11.00	8.33	8.67	8.58	-0.48
G35	12.58	12.83	9.31	9.50	7.67	6.33	10.00	10.00	9.33	9.83	9.74	0.67
G36	9.63	9.17	8.55	9.00	6.33	5.67	5.67	5.50	9.67	8.00	7.72	-1.35
G37	9.75	8.67	8.33	8.33	7.67	9.17	8.00	8.50	7.50	8.83	8.48	-0.59
G38	14.33	14.67	11.17	12.50	3.25	3.83	7.50	8.50	11.67	11.33	9.88	0.81
G39	8.08	7.50	6.58	6.50	6.67	6.17	6.33	7.17	7.00	6.67	6.87	-2.20
G40	10.83	10.67	8.33	8.50	6.83	7.67	7.33	7.67	9.50	9.17	8.65	-0.42
G41	10.83	10.67	8.61	9.33	7.83	7.83	8.67	9.00	8.83	9.33	9.09	0.03
G42	9.75	8.50	8.08	7.83	5.50	5.50	6.83	7.00	6.67	8.33	7.40	-1.67
G43	11.08	11.17	7.92	6.83	6.23	7.33	7.00	7.67	8.33	8.33	8.19	-0.88
Mean	11.51	11.41	8.99	8.92	6.77	6.90	8.73	8.93	9.28	9.21	9.13	
LSD' $_{0.05}$	0.86	1.10	1.02	1.38	1.36	1.14	1.39	1.50	1.21	1.22		
E. Index	2.38	2.28	-0.15	-0.21	-2.36	-2.23	0.26	-0.20	0.15	0.07		

Gt = Genotype, Pi = phenotypic index and E. index =environmental index.

Table 5. Mean performance for spike number per plant of 43 wheat genotypes evaluated at 10 different environments.

Gt	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	Mean	Pi
G01	26.00	21.67	6.25	6.50	3.33	2.67	5.33	5.67	7.00	3.33	8.78	0.32
G02	16.14	16.50	10.76	11.00	6.00	6.00	4.33	3.67	14.67	5.00	9.41	0.95
G03	15.75	15.00	5.83	8.00	3.33	2.00	8.67	8.00	8.33	3.33	7.82	-0.63
G04	18.75	16.50	11.38	7.50	2.67	3.33	6.33	7.00	11.67	5.33	9.05	0.59
G05	18.88	18.33	12.70	12.33	5.33	4.67	5.00	4.67	12.00	6.33	10.03	1.57
G06	22.25	21.50	8.67	10.33	2.00	2.67	6.33	8.67	7.67	3.33	9.34	0.89
G07	14.50	15.00	4.75	6.00	1.67	2.00	3.00	4.00	8.33	9.00	6.83	-1.63
G08	16.83	12.33	8.11	10.33	2.00	2.00	11.67	9.67	7.33	6.33	8.66	0.21
G09	17.00	16.67	9.39	9.00	3.67	5.00	5.33	3.67	7.67	5.33	8.27	-0.18
G10	26.50	17.33	7.50	12.50	2.33	2.33	7.33	6.33	8.00	6.67	9.68	1.23
G11	21.00	17.33	8.75	12.00	1.00	1.67	7.33	7.33	11.00	5.00	9.24	0.79
G12	18.67	18.00	12.50	11.50	4.00	3.33	5.67	6.33	10.33	7.67	9.80	1.35
G13	20.00	16.00	8.33	7.00	3.00	4.00	4.33	5.33	10.67	4.67	8.33	-0.12
G14	18.25	15.50	9.33	11.50	3.00	2.00	6.00	5.00	9.33	5.67	8.56	0.11
G15	24.42	18.17	10.83	10.67	2.00	1.67	3.00	3.33	9.00	5.00	8.81	0.36
G16	16.50	16.50	5.50	10.00	2.67	3.33	3.33	3.67	6.67	5.00	7.32	-1.14
G17	14.00	15.00	6.50	7.67	3.33	2.33	5.33	5.33	5.00	3.67	6.82	-1.64
G18	20.50	20.33	9.33	13.00	2.50	2.67	7.00	7.00	10.33	5.00	9.77	1.31
G19	13.00	11.50	7.17	7.67	3.33	3.33	4.00	5.00	6.67	5.67	6.73	-1.72
G20	19.00	20.00	7.50	8.33	4.67	4.67	6.33	5.33	10.67	4.33	9.08	0.63
G21	20.17	18.33	6.17	6.00	4.67	3.33	4.33	4.67	10.00	5.67	8.33	-0.12
G22	23.17	20.67	9.33	8.00	2.67	2.00	10.00	10.33	9.33	3.67	9.92	1.46
G23	13.25	14.00	8.33	10.00	1.67	2.67	7.33	8.33	8.00	5.67	7.93	-0.53
G24	9.82	10.33	10.13	10.67	2.67	2.67	5.33	6.00	12.67	3.33	7.36	-1.09
G25	13.69	14.00	8.31	8.50	3.33	3.67	6.00	5.33	11.33	5.00	7.92	-0.54
G26	14.08	13.67	10.30	10.00	4.67	3.33	4.00	5.67	10.33	5.00	8.10	-0.35
G27	10.77	11.33	9.50	10.00	9.67	8.00	5.67	6.67	11.33	5.33	8.83	0.37
G28	24.67	14.67	6.75	11.00	4.67	3.00	3.67	4.33	6.00	5.33	8.41	-0.04
G29	10.76	11.00	11.88	12.00	4.00	3.33	4.67	4.67	8.33	5.00	7.56	-0.89
G30	13.83	10.67	8.33	11.50	4.67	4.33	8.33	6.67	7.00	5.33	8.07	-0.39
G31	18.50	18.00	5.83	5.00	3.00	3.00	3.00	3.00	10.00	3.00	7.23	-1.22
G32	15.00	13.33	4.67	5.67	5.00	4.00	3.00	3.67	5.67	7.00	6.70	-1.75
G33	12.60	12.00	7.88	7.50	2.67	2.67	9.33	9.00	12.00	5.00	8.06	-0.39
G34	11.11	11.33	8.33	8.50	3.67	3.67	9.67	9.67	9.33	5.33	8.06	-0.39
G35	6.37	6.50	7.84	8.00	4.67	4.00	4.67	5.00	6.67	6.00	5.97	-2.48
G36	18.20	17.33	10.13	10.67	5.33	5.00	11.00	11.67	16.00	12.00	11.73	3.28
G37	20.25	17.50	8.00	9.50	4.00	4.33	8.33	7.67	5.67	7.67	9.29	0.84
G38	11.50	12.00	6.50	6.67	3.50	4.33	2.33	3.00	5.67	5.33	6.08	-2.37
G39	23.67	17.33	8.67	13.00	7.33	6.00	4.33	4.67	10.00	11.67	10.67	2.21
G40	13.75	11.50	9.00	8.50	3.67	3.67	4.33	4.00	8.67	4.00	7.11	-1.34
G41	17.25	17.50	9.28	6.67	5.67	7.67	4.33	4.00	7.67	6.33	8.64	0.18
G42	20.17	13.50	7.33	10.50	9.00	11.00	7.67	6.33	12.67	9.67	10.78	2.33
G43	17.33	15.67	5.75	9.00	4.67	4.67	5.33	4.67	9.67	7.00	8.38	-0.08
Mean	17.16	15.38	8.36	9.29	3.88	3.77	5.87	5.91	9.22	5.70	8.45	
LSD' $_{0.05}$	3.41	4.86	2.39	4.47	2.07	2.24	1.59	1.78	6.26	2.17		
E. Index	8.71	6.93	-0.10	0.84	-4.58	-4.68	-2.58	-2.55	0.76	-2.75		

Gt = Genotype, Pi = phenotypic index and E. index = environmental index

Hence, it is directly reflecting the rich or poor environment in term of positive and negative values, respectively.

Data showed that E_1 environment was the most favorable and rich environment for spike length, spike number per plant, biological and grain yields as it gave the highest E. index, on the other hand, E_{10} environment was the most favorable for harvest index. Moreover, E_2 environment was rich and the most favorable for plant height under this study.

For plant height, the average of environments varied from 53.59 cm for E_4 conditions to 83.69 cm for E_2 conditions (Table 3). The tallest genotype was G36 under E_1 with value of 114.80 cm, while genotype G13 was the shortest one under E_4 conditions (39.67 cm). This might be due to delaying the elongation of plant after heading. These results are in agreement with those of Al-Otayk (2010) and Hassan *et al* (2013), who found a decrease in plant height by delaying sowing date.

Concerning spike length, data arranged in Table 4 showed that as a general mean over all genotypes the best environment was E_1 with spike length of 11.51 cm, on contrary the lowest value (6.90 cm) was recorded by E_5 environment. From the genotypic view as a general mean over all environments the highest phenotypic index (2.13) was recorded by genotype G31, while the lowest phenotypic index (-2.20) was assigned to genotype G39. The interaction between genotype and environment was highly significant and genotype G12 had the highest spike length (15.25 cm) under E_1 condition, while genotype G38 gave the lowest spike length (3.25 cm) under E_5 conditions. These results are in harmony with those obtained by Mirbahar *et al* (2009).

Regarding spike number per plant (Table 5), the environment index ranged from -4.68 for E_6 conditions to 8.71 for E_1 conditions. As a general mean over all environments genotype G36 surpassed all the evaluated genotypes (11.73 spikes per plant), while genotype G35 had the lowest number of spikes per plant with phenotypic index of -2.48. For the interaction genotype G10 recorded the highest spike number per plant (26.50) under E_1 conditions, while genotypes G11 had the lowest number (1 spike per plant) under E_5 conditions. These results may be due to that under E_5 conditions plants faced severe drought stress during tillering stage as compared with E_1 environment which led to reduction in spike number per plant at harvest. These results are in agreement with those obtained by Saqib *et al* (2013).

For grain yield per plant data in Table 6 showed that the average of environments ranged from 4.09 g to 37.99 for E_6 and E_1 environments, respectively. Moreover, as a general mean over all environments, genotype G01 gave the highest value of grain yield per plant (19.79 g), while genotype G35 gave the lowest one (7.89 g).

Table 6. Mean performance for grain yield per plant of 43 wheat genotypes evaluated at 10 different environments.

Gt	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	Mean	Pi
G01	69.84	57.98	8.22	9.59	3.29	2.98	16.12	14.90	9.69	5.31	19.79	5.85
G02	30.40	31.08	9.67	9.89	5.61	6.42	9.26	5.90	25.72	7.90	14.19	0.24
G03	40.06	41.23	5.55	5.40	6.74	3.65	15.62	17.32	8.99	3.64	14.82	0.88
G04	47.63	46.57	14.42	9.70	4.49	4.92	14.25	10.72	23.55	7.29	18.36	4.41
G05	47.11	45.74	11.99	11.64	5.37	4.01	8.77	7.44	16.47	6.53	16.51	2.57
G06	57.63	54.47	11.35	8.60	4.28	4.03	10.24	10.35	10.22	5.28	17.64	3.70
G07	38.37	38.93	7.01	7.10	2.09	3.06	7.91	10.66	15.15	15.50	14.58	0.64
G08	28.50	26.23	8.16	9.04	2.94	3.11	18.58	19.16	9.68	12.85	13.83	-0.12
G09	77.34	48.52	8.16	9.18	3.05	3.51	8.51	5.44	10.88	4.76	17.94	3.99
G10	61.15	48.96	10.80	11.77	3.35	2.96	13.96	12.15	12.00	7.80	18.49	4.55
G11	53.17	39.75	10.25	13.74	1.76	1.92	7.49	10.15	15.85	4.90	15.90	1.95
G12	31.32	33.21	4.90	8.07	3.24	3.13	8.94	7.45	9.83	6.33	11.64	-2.30
G13	26.29	21.16	9.50	6.35	3.20	3.25	7.09	7.58	20.36	6.05	11.08	-2.86
G14	40.36	40.13	8.85	11.60	4.35	1.66	16.07	8.34	12.24	9.69	15.33	1.38
G15	30.96	32.81	11.57	12.43	2.72	1.64	5.72	4.46	17.80	7.17	12.73	-1.22
G16	42.45	42.45	11.34	10.80	4.56	7.35	8.68	7.22	6.44	6.76	14.81	0.86
G17	28.39	30.89	7.83	6.88	3.01	2.99	11.04	7.56	9.26	6.14	11.40	-2.54
G18	35.65	34.60	7.84	11.23	3.77	1.96	12.74	12.23	15.33	7.00	14.24	0.29
G19	18.30	18.35	5.64	4.20	3.40	2.69	9.66	9.56	9.41	7.05	8.83	-5.12
G20	77.21	48.21	8.95	8.37	3.52	4.15	11.59	9.97	13.68	6.96	19.26	5.32
G21	46.48	41.58	5.40	6.65	4.73	3.72	8.92	9.86	14.89	7.44	14.97	1.02
G22	67.43	46.54	9.84	7.50	3.49	3.19	20.37	16.74	13.77	4.68	19.35	5.41
G23	23.86	28.79	6.87	7.15	1.50	1.76	13.78	11.06	11.90	10.66	11.73	-2.21
G24	22.93	24.13	8.03	8.45	2.91	2.09	11.58	10.56	12.09	4.68	10.74	-3.20
G25	27.78	28.40	6.80	6.95	2.85	2.33	9.92	8.90	24.49	8.89	12.73	-1.21
G26	29.53	28.67	8.86	8.60	6.11	4.19	8.03	9.45	14.47	8.51	12.64	-1.30
G27	25.98	27.35	7.98	8.39	9.97	7.95	9.32	11.26	14.10	7.29	12.96	-0.99
G28	59.86	44.86	7.11	10.39	4.30	3.66	9.38	12.96	6.89	5.86	16.53	2.58
G29	18.28	18.69	11.72	11.83	3.26	2.74	9.05	9.30	8.87	9.52	10.33	-3.62
G30	31.63	26.57	9.23	12.70	7.93	6.05	14.92	12.70	11.25	10.20	14.32	0.38
G31	40.50	36.60	6.50	4.25	4.56	5.79	11.39	6.07	9.09	8.36	13.31	-0.63
G32	39.43	35.56	5.84	4.27	6.98	5.69	5.97	8.50	4.99	11.56	12.88	-1.07
G33	22.36	21.29	6.67	6.36	3.25	2.37	20.23	11.37	19.38	7.53	12.08	-1.86
G34	19.44	19.83	7.34	7.49	4.42	3.90	21.24	17.98	15.11	6.33	12.31	-1.64
G35	9.89	10.10	4.39	4.48	3.60	2.78	13.90	10.63	9.56	9.62	7.89	-6.05
G36	21.83	20.79	6.41	6.75	3.38	2.26	6.69	6.33	13.19	12.03	9.97	-3.98
G37	38.40	33.50	4.71	7.81	6.73	8.58	21.89	20.18	6.86	11.88	16.05	2.11
G38	25.56	29.35	6.71	6.17	2.03	1.59	4.28	7.25	9.44	7.68	10.01	-3.94
G39	45.53	39.24	6.57	9.52	10.40	8.29	6.58	8.16	9.60	11.89	15.58	1.63
G40	22.25	22.25	9.71	7.66	4.94	5.36	6.05	7.68	9.98	5.00	10.09	-3.85
G41	45.08	47.45	5.81	5.13	6.40	7.86	9.27	7.18	10.32	8.25	15.28	1.33
G42	41.55	41.55	6.49	7.19	6.51	8.92	9.61	6.83	12.67	14.07	15.54	1.60
G43	25.97	26.04	6.55	8.19	6.49	5.50	7.94	8.77	8.12	5.86	10.94	-3.00
Mean	37.99	34.43	8.08	8.36	4.45	4.09	11.22	10.19	12.64	7.97	13.94	
LSD' $_{0.05}$	6.25	10.76	2.17	4.52	3.16	3.27	5.96	5.29	7.25	3.55		
E. Index	24.05	20.48	-5.86	-5.58	-9.49	-9.85	-2.72	-3.75	-1.30	-5.97		

Gt = Genotype, Pi = phenotypic index and E. index = environmental index

The interaction between genotypes and environments was highly significant and genotype G09 under E_1 conditions gave the highest yield per plant (77.43 g), while genotype G23 gave the lowest grain yield per plant (1.50 g) under E_5 conditions.

Regarding biological yield (Table 7), the average of the environments ranged from 13.36 g for E_6 conditions to 102.60 g for E_1 conditions. The highest value of biological yield was obtained from genotype G09 with value of 195.08 g under E_1 conditions, while the lowest value (4.12 g) was obtained from genotype G11 under E_5 conditions.

For harvest index (Table 8), the average of the environments varied from 27.61 to 40.63 under E_4 and E_{10} environments, respectively. This might be due to that in E_4 environment plants faced high temperature during anthesis and grain filling stages which led to great reduction in grain yield and then harvest index was the lowest as compared with all other environments (Menshawy 2007).

Genotype G14 possessed the highest value of harvest index (52.33) under E_7 conditions, while genotype G23 was the lowest one (13.27) under E_8 conditions. According to phenotypic index, the best genotype of harvest index over all environments was genotype G38 with value of 4.31.

Data in Table 9 showed that variance due to environments (E), genotypes (G) and GxE interaction are highly significant for all studied traits under this study. These results indicated the presence of variation in the mean performance of all 43 genotypes across environments and in the environmental mean across all test genotypes.

In this respect, Eberhart and Russell (1966), Ibrahim *et al* (1984), Ragheb *et al* (1993), Soliman (2006), Abd El-Moula (2011) and Ibrahim (2015), stated that the basic cause of the differences among genotypes in their yield stability is the wide occurrence of genotype x environment (GxE) interaction.

Variance due to GxE linear was highly significant for all plant height, spike length, spike number per plant, grain yield and biological yield implying a differential yield performance of genotypes under various environments.

On the other hand, G x E linear was not significant for harvest index, indicated that only the deviation mean square was considered important. These findings are in agreement with Okuyama *et al* (2005).

Variance due to pooled deviation was highly significant for all studied traits. This result indicated that performance of different genotypes fluctuated significantly from their respective linear path of response to environment.

Table 7. Mean performance for biological yield per plant of 43 wheat genotypes evaluated at 10 different environments.

Gt	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	Mean	Pi
G01	181.55	149.37	25.41	29.05	9.90	8.42	59.35	59.77	26.37	12.33	56.15	15.52
G02	91.30	93.35	36.09	36.90	11.35	12.71	34.06	26.18	57.91	19.00	41.88	1.25
G03	108.20	114.20	24.77	33.90	20.21	11.54	56.17	55.81	25.52	9.00	45.93	5.30
G04	118.50	110.50	45.47	27.30	11.84	13.84	46.53	44.81	52.89	17.00	48.87	8.23
G05	114.33	111.00	37.32	36.23	16.59	13.53	24.13	21.44	42.96	18.67	43.62	2.99
G06	140.43	134.22	30.62	30.70	14.53	16.88	41.10	50.77	29.62	13.33	50.22	9.59
G07	112.82	119.43	23.12	27.35	5.78	7.73	21.01	28.16	36.50	39.67	42.16	1.52
G08	78.22	69.93	24.28	29.10	12.72	12.95	83.18	73.88	22.53	29.67	43.65	3.01
G09	195.08	114.80	27.17	29.33	11.33	14.50	31.85	21.21	29.56	12.67	48.75	8.12
G10	161.32	128.00	29.55	42.30	8.52	7.94	34.51	29.93	28.40	20.67	49.11	8.48
G11	131.62	101.73	34.49	41.40	4.12	5.49	20.16	23.65	41.64	13.67	41.80	1.16
G12	77.10	80.40	19.55	30.55	11.95	10.53	34.73	35.16	23.79	17.67	34.14	-6.49
G13	71.95	69.00	27.63	20.60	9.56	11.35	16.66	18.98	54.94	13.67	31.43	-9.20
G14	114.18	112.45	35.84	34.90	12.80	6.65	30.42	18.60	25.81	23.33	41.50	0.87
G15	103.63	103.25	35.98	41.07	6.80	4.59	16.34	15.70	39.67	17.67	38.47	-2.16
G16	108.75	108.75	31.20	38.10	11.67	16.87	21.52	20.64	19.92	16.67	39.41	-1.22
G17	87.35	90.10	27.87	30.60	11.73	9.45	40.06	35.23	21.33	14.00	36.77	-3.86
G18	99.07	95.93	24.52	36.40	9.98	7.79	45.64	44.98	36.21	15.67	41.62	0.99
G19	46.65	46.65	19.62	16.97	11.88	10.60	32.03	36.57	21.13	17.67	25.98	-14.66
G20	180.71	120.92	25.39	25.10	11.45	12.32	35.02	29.80	38.56	15.33	49.46	8.83
G21	115.18	103.87	18.19	21.60	14.74	11.03	23.32	25.45	35.85	17.00	38.62	-2.01
G22	143.40	117.37	30.40	25.83	14.07	11.25	76.18	72.90	32.37	14.33	53.81	13.18
G23	71.20	85.80	28.12	28.90	7.07	9.19	80.19	84.28	27.14	24.00	44.59	3.96
G24	62.10	65.37	35.40	37.27	9.40	8.25	47.09	49.57	49.95	14.33	37.87	-2.76
G25	67.22	68.73	24.65	25.20	8.42	7.92	24.66	22.02	62.71	22.33	33.39	-7.25
G26	77.22	74.97	27.71	26.90	18.00	12.69	21.29	27.89	38.93	19.00	34.46	-6.17
G27	69.03	72.67	26.09	27.47	27.95	22.72	31.11	37.03	37.89	18.67	37.06	-3.57
G28	146.43	111.10	21.40	36.50	13.39	10.07	22.52	29.05	17.13	15.67	42.33	1.69
G29	62.40	63.80	44.25	44.70	11.30	9.46	23.34	23.64	22.99	23.67	32.95	-7.68
G30	79.48	65.33	26.48	49.25	28.22	24.26	50.26	41.31	23.84	26.00	41.44	0.81
G31	124.68	120.65	31.58	22.65	18.04	19.97	38.35	30.71	32.33	20.33	45.93	5.30
G32	126.32	111.03	21.05	21.70	24.17	19.50	18.76	24.68	20.54	32.00	41.98	1.34
G33	54.43	51.83	23.52	22.40	9.26	7.96	65.70	52.63	45.33	21.00	35.40	-5.23
G34	50.86	51.90	26.85	27.40	15.57	14.80	99.06	79.33	36.15	14.00	41.59	0.96
G35	55.52	56.65	25.84	26.37	13.80	11.45	29.43	26.00	21.73	25.00	29.18	-11.45
G36	68.46	65.20	23.59	24.83	11.10	9.28	19.87	19.94	43.02	30.33	31.56	-9.07
G37	101.35	88.60	17.75	32.40	26.00	29.94	65.57	60.38	20.12	24.33	46.64	6.01
G38	63.45	69.30	20.78	25.60	5.04	4.85	11.00	16.50	20.18	20.33	25.70	-14.93
G39	125.85	108.50	23.43	33.90	33.12	26.79	25.02	28.28	25.07	30.00	46.00	5.36
G40	62.10	62.10	29.76	24.50	13.60	14.22	18.57	20.07	23.39	11.67	28.00	-12.63
G41	147.75	153.70	24.93	20.63	24.94	32.46	22.57	19.05	21.92	17.67	48.56	7.93
G42	141.35	141.35	20.57	30.65	18.94	24.60	26.31	20.20	30.47	28.67	48.31	7.68
G43	73.22	70.23	18.40	25.33	17.38	16.00	25.06	24.30	23.37	15.67	30.90	-9.74
Mean	102.60	94.28	27.36	30.23	14.14	13.36	36.97	35.50	32.27	19.61	40.63	
LSD $_{0.05}$	16.31	27.80	7.90	16.67	8.99	8.85	14.12	11.16	23.70	7.96		
E. Index	61.97	53.65	-13.27	-10.40	-26.49	-27.28	-3.66	-5.13	-8.36	-21.02		

Gt = Genotype, Pi = phenotypic index and E. index = environmental index.

Table 8. Mean performance for harvest index of 43 wheat genotypes evaluated at 10 different environments.

Gt	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	Mean	Pi
G01	38.45	38.82	32.21	32.55	32.96	34.41	27.17	24.15	38.87	43.33	34.29	0.59
G02	32.56	33.29	26.42	27.02	49.35	50.21	26.44	21.60	44.82	41.85	35.36	1.65
G03	37.06	36.23	22.39	15.67	33.36	31.42	27.17	31.06	35.13	40.13	30.96	-2.74
G04	40.28	42.57	32.43	35.40	37.37	34.92	29.14	23.54	44.50	44.45	36.46	2.76
G05	42.45	41.21	32.94	31.98	32.07	29.27	36.33	34.33	40.75	34.97	35.63	1.93
G06	41.03	40.58	37.01	28.30	29.36	23.32	24.99	20.20	34.48	39.58	31.89	-1.82
G07	34.10	32.86	30.24	26.12	35.71	39.58	37.63	37.88	41.70	39.04	35.49	1.79
G08	36.47	37.71	33.61	32.00	23.08	23.96	22.33	25.83	43.86	42.96	32.18	-1.52
G09	39.74	41.97	29.98	31.44	26.89	23.93	26.63	24.66	39.71	37.74	32.27	-1.43
G10	37.95	38.42	36.66	27.69	38.75	37.21	40.42	40.17	42.23	37.79	37.73	4.03
G11	40.30	38.03	29.73	33.01	42.72	35.51	37.02	42.81	38.36	35.76	37.33	3.62
G12	40.63	41.39	24.98	26.73	26.44	29.32	25.14	21.58	41.56	35.59	31.34	-2.36
G13	36.34	30.63	34.35	30.64	32.87	28.82	42.62	39.34	38.74	44.03	35.84	2.14
G14	35.35	35.70	24.66	33.08	34.23	24.22	52.33	44.78	48.02	41.55	37.39	3.69
G15	29.88	31.80	32.18	29.82	38.41	35.03	34.72	28.64	44.69	39.93	34.51	0.81
G16	39.02	39.00	36.40	27.85	38.93	42.02	39.49	34.28	33.72	39.63	37.03	3.33
G17	32.47	34.14	28.31	23.06	24.67	31.88	26.28	21.15	43.36	43.85	30.92	-2.79
G18	35.98	36.05	31.99	30.65	37.01	24.04	27.73	27.18	42.76	44.14	33.76	0.05
G19	39.28	39.53	28.42	24.92	28.72	25.40	29.50	25.22	43.57	39.96	32.45	-1.25
G20	42.77	39.89	35.25	33.31	30.53	33.75	32.32	32.51	36.77	44.63	36.17	2.47
G21	40.25	40.09	29.71	30.40	31.80	31.99	38.15	38.38	41.51	43.98	36.63	2.92
G22	46.99	39.60	31.78	29.08	24.15	27.63	26.87	22.26	42.93	32.47	32.38	-1.33
G23	33.50	33.53	24.38	24.26	21.03	18.95	16.75	13.27	43.95	43.60	27.32	-6.38
G24	35.52	37.39	22.31	23.48	29.84	25.48	24.67	21.13	24.34	31.83	27.60	-6.10
G25	40.36	41.26	27.03	27.64	33.97	29.65	38.96	40.06	39.23	39.90	35.81	2.10
G26	39.47	38.32	33.11	32.15	34.06	32.51	37.35	33.52	39.20	44.96	36.46	2.76
G27	36.71	38.64	28.61	30.12	35.42	35.02	30.00	30.60	37.57	39.17	34.19	0.48
G28	40.86	40.38	34.06	27.75	32.02	36.59	42.02	44.58	40.15	37.22	37.56	3.86
G29	28.45	29.09	26.24	26.50	27.10	27.72	37.72	37.97	43.76	41.65	32.62	-1.08
G30	39.89	40.36	34.79	25.79	27.77	24.41	29.61	30.78	47.56	39.10	34.01	0.30
G31	32.44	30.14	20.48	19.65	25.13	27.68	29.12	19.68	28.01	41.16	27.35	-6.35
G32	31.25	32.42	28.26	19.79	29.49	29.33	31.72	34.55	23.47	36.67	29.69	-4.01
G33	43.01	40.96	29.75	28.34	33.35	30.05	31.08	21.14	43.05	39.61	34.03	0.33
G34	37.34	38.10	26.61	27.15	28.07	26.48	21.04	22.66	41.02	45.92	31.44	-2.26
G35	17.88	18.24	17.11	17.46	25.41	24.40	47.32	40.83	46.08	39.11	29.39	-4.32
G36	33.50	31.91	25.87	27.23	30.32	24.36	33.51	31.39	30.64	39.95	30.87	-2.83
G37	37.88	37.75	26.57	23.64	28.02	29.10	32.97	32.64	34.54	48.71	33.18	-0.52
G38	40.15	41.91	32.29	24.79	40.13	33.98	38.82	43.85	46.89	37.33	38.01	4.31
G39	36.18	36.16	28.08	28.74	30.53	29.41	26.30	28.67	39.42	39.34	32.28	-1.42
G40	35.80	35.70	32.67	31.02	35.11	35.55	32.62	38.57	44.67	43.30	36.50	2.80
G41	30.50	30.84	23.29	24.97	25.33	24.50	41.08	37.94	47.56	44.82	33.08	-0.62
G42	29.49	29.79	31.47	23.33	34.75	36.61	35.93	33.61	41.66	49.21	34.58	0.88
G43	35.52	37.33	35.77	32.59	37.77	34.28	31.29	35.11	35.21	37.21	35.21	1.51
Mean	36.63	36.51	29.54	27.61	31.95	30.56	32.57	31.03	40.00	40.63	33.70	
LSD' $_{0.05}$	3.26	4.48	4.75	5.48	8.22	6.43	6.52	6.20	8.16	15.89		
E. Index	2.93	2.80	-4.16	-6.09	-1.75	-3.15	-1.14	-2.68	6.30	6.93		

Gt = Genotype, Pi = phenotypic index and E. index = environmental index

Table 9. Stability analysis for all studied traits of 43 wheat genotypes evaluated at 10 different environments.

SOV	df	Plant height	Spike length	Spike number per plant	Grain yield	Biological yield	Harvest index
Environments (E)	9	15206.16**	308.11**	2707.17**	18781.86**	129058.52**	2611.81**
Genotypes(G)	42	358.63**	10.97**	15.78**	89.20**	555.81**	83.40**
G x E	378	215.00**	4.00**	17.19**	127.49**	937.51**	79.27**
E + (E x G)	387	187.88**	3.72**	26.57**	186.99**	1305.07**	45.92**
E (linear)	1	45618.62**	929.87**	8115.51**	56307.56**	386967.28**	7737.96**
G x E (linear)	42	131.82**	4.06**	22.87**	275.11**	1597.86**	29.32
Pooled deviation	344	62.66**	0.98**	3.51**	13.10**	148.21**	25.59**
G01	8	63.89**	1.60**	5.97**	12.13**	92.80**	17.16**
G02	8	20.07**	0.90**	6.11**	25.67**	110.83**	105.75**
G03	8	66.40**	1.22**	3.45**	17.08**	115.93**	18.46**
G04	8	48.70**	0.37	2.27	11.35**	67.74*	23.87**
G05	8	39.37**	0.10	2.85*	8.28*	90.75**	11.56*
G06	8	95.10**	0.78**	3.24**	9.48*	35.34	40.46**
G07	8	81.26**	1.79**	4.48**	11.42**	136.03**	17.03**
G08	8	12.91**	0.46*	7.80**	21.21**	470.96**	33.44**
G09	8	103.79**	0.85**	1.43	43.98**	366.75**	22.79**
G10	8	56.24**	0.68**	5.00**	6.26	74.85*	11.87*
G11	8	63.86**	2.91**	1.97	13.34**	124.49**	17.49**
G12	8	125.69**	2.85**	1.76	2.38	18.30	22.62**
G13	8	151.98**	2.62**	1.50	16.23**	144.73**	22.66**
G14	8	73.07**	1.23**	0.99	5.80	75.82*	76.26**
G15	8	39.37**	0.51*	2.16	17.91**	142.73**	18.90**
G16	8	67.12**	1.30**	1.85	14.45**	95.32**	17.12**
G17	8	9.34**	0.31	1.60	2.75	26.31	15.73**
G18	8	180.48**	1.85**	1.33	3.84	36.93	16.78**
G19	8	31.97**	0.77**	0.30	2.90	36.49	6.39
G20	8	22.40**	0.24	2.23	35.98**	179.64**	10.92*
G21	8	37.89**	0.10	3.15*	2.60	45.95	6.12
G22	8	90.30**	0.35	6.51**	24.21**	251.66**	44.18**
G23	8	104.44**	0.74**	2.82*	10.35*	567.43**	36.35**
G24	8	65.37**	1.31**	7.71**	5.14	164.48**	24.78**
G25	8	73.96**	0.94**	1.45	24.35**	184.74**	15.85**
G26	8	62.76**	0.72**	2.03	2.29	31.84	2.67
G27	8	32.62**	1.10**	3.38**	3.81	24.29	5.50
G28	8	44.89**	0.77**	6.90**	17.44**	118.19**	23.13**
G29	8	10.16**	0.40	5.81**	7.25	115.91**	30.49**
G30	8	38.62**	0.67**	2.43	2.97	75.48*	18.22**
G31	8	81.43**	1.89**	3.42**	5.60	44.09	16.35**
G32	8	22.45**	0.42*	3.40**	15.19**	167.58**	24.37**
G33	8	33.60**	0.73**	5.38**	26.94**	285.31**	18.60**
G34	8	61.07**	1.99**	3.71**	29.08**	805.93**	18.07**
G35	8	141.57**	0.30	1.49	12.57**	13.45	148.40**
G36	8	191.89**	1.75**	5.85**	7.30	77.76**	10.21*
G37	8	42.33**	0.43*	3.89**	30.24**	201.48**	13.96**
G38	8	6.93*	2.77**	1.53	5.37	51.13	26.31**
G39	8	39.25**	0.13	7.54**	16.75**	149.96**	4.21
G40	8	34.08**	0.40	1.15	2.61	26.00	7.43
G41	8	61.97**	0.08	4.86**	14.03**	331.87**	43.13**
G42	8	24.65**	0.41	6.65**	12.59**	185.67**	31.01**
G43	8	38.98**	0.60**	1.51	1.93	10.12	3.84
Pooled error	860	3.48	0.21	1.25	4.21	30.67	5.13

***, ** indicate significant differences at 0.05 and 0.01 levels of probability, respectively.**

Stability parameters:

Stability analysis according to Eberhart and Russell (1966) was used. Regression coefficient (bi) for each genotype and deviation from regression (S^2_{di}) for all studied traits are shown in Tables 10 and 11. A genotype with high mean yield, regression coefficient (bi) close to 1.0 coupled with small value of deviation S^2_{di} is considered stable. Genotype with bi value more than 1.0, high S^2_{di} and positive phenotypic index (Pi) is adapted to high yielding environments. On the other hand, a genotype which has bi less than 1.0, low S^2_{di} and positive Pi indicated high resistance to environmental fluctuation and thus increases the specificity of adaptability to poor yielding environments (Wachira *et al* 2002 and Akura *et al* 2005).

For plant height, there is no genotype passed all stability parameters, but genotypes G08, G30 and G39 may be considered more stable when compared with the rest of genotypes as they had insignificant regression coefficient from unity, lower values of deviation from regression as compared with other genotypes in this study (Table 10).

Regarding spike length, genotypes G04, G17, G22, G35 and G41 exhibited fair stable as they had positive Pi, bi around 1.0 and low value of S^2_{di} (Table 10). In addition, for spike number per plant as general mean over all environments, the highest four genotypes which passed all stability parameters were G04, G12, G14 and G20 as their regression coefficients were almost equal to 1.0 with low value of deviations from regression (Table 10).

For grain yield per plant (Table 11) the most stable genotypes were genotypes G14 and G18 as they had a high grain yield/plant as compared with the general mean over all environments, regression coefficient close to 1.0 and deviation from regression (S2di) not significant from zero. Genotype G30 was suitable for unfavorable environments as its regression coefficients lower than unity, its phenotypic index was positive, and low value of deviation from regression. On the other hand, genotypes G09, G20, G22 and G28 were suitable for favorable environments due to their regression coefficient greater than 1.0 with high grain yield and high value of deviation from regression.

Regarding biological yield (Table 11), the simultaneous consideration of three stability parameters for individual genotype manifested that genotype G18 gave higher value than the general mean over all environments, insignificant regression coefficient from unity and low value of deviation from regression, therefore this genotypes is considered stable for biological yield. Finally, genotypes G21, G26, G27 and G40 are considered the most stable genotypes for harvest index, whereas had regression coefficient close to1.0 and low deviation from regression with mean values above the grand mean across all environments.

Table 10. Stability parameters for plant height, spike length and spike number per plant of 43 wheat genotypes evaluated under 10 environments.

Gt	Plant height			Spike length			Spike number per plant		
	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}
G01	77.98	1.09	60.41**	10.20	1.58**	1.39**	8.78	1.70**	4.72**
G02	71.52	0.89	16.59**	9.60	1.51*	0.69**	9.41	0.98	4.86**
G03	76.97	1.51*	62.92**	10.29	0.81	1.01**	7.82	0.94	2.20**
G04	78.80	1.44	45.22**	9.21	0.91	0.16	9.05	1.14	1.02
G05	70.11	0.65	35.89**	8.74	1.34	-0.11	10.03	1.17	1.60*
G06	76.48	1.52*	91.62**	9.80	0.79	0.57**	9.34	1.52**	1.99**
G07	78.88	0.75	77.78**	10.68	1.35	1.58**	6.83	0.96	3.23**
G08	73.37	0.92	9.43**	9.48	0.68	0.25*	8.66	0.82	6.55**
G09	67.20	1.06	100.31**	9.33	1.69**	0.64**	8.27	1.05	0.18
G10	84.23	0.70	52.76**	9.99	1.06	0.47**	9.68	1.55**	3.75**
G11	78.92	0.75	60.38**	9.25	0.88	2.69**	9.24	1.36**	0.72
G12	72.53	1.01	122.21**	8.41	1.58**	2.64**	9.80	1.15	0.51
G13	63.38	0.55	148.50**	9.08	1.01	2.41**	8.33	1.21	0.25
G14	76.95	1.42	69.59**	9.25	1.15	1.02**	8.56	1.14	-0.26
G15	66.10	0.70	35.89**	9.44	0.53*	0.29*	8.81	1.62**	0.91
G16	64.49	1.15	63.64**	9.19	0.67	1.09**	7.32	1.12	0.60
G17	70.52	0.74	5.86**	9.30	0.96	0.10	6.82	0.91	0.35
G18	70.11	1.19	177.00**	8.18	0.92	1.63**	9.77	1.40**	0.08
G19	67.45	0.66	28.49**	8.86	1.19	0.56**	6.73	0.71*	-0.95
G20	70.30	1.19	18.92**	7.44	0.88	0.02	9.08	1.24	0.98
G21	68.74	0.42*	34.41**	8.47	0.68	-0.12	8.33	1.27	1.90*
G22	75.93	1.30	86.82**	9.31	0.74	0.14	9.92	1.45**	5.26**
G23	82.31	1.29	100.96**	9.58	1.64**	0.53**	7.93	0.80	1.57*
G24	79.77	1.62*	61.89**	10.56	1.71**	1.09**	7.36	0.59**	6.46**
G25	66.29	1.38	70.48**	7.33	0.47*	0.72**	7.92	0.83	0.20
G26	69.02	1.62*	59.28**	7.63	0.85	0.51**	8.10	0.83	0.78
G27	78.52	1.74**	29.14**	8.03	0.95	0.89**	8.83	0.32**	2.13**
G28	73.25	1.24	41.41**	9.14	1.47*	0.55**	8.41	1.37**	5.65**
G29	72.53	0.60	6.68**	8.73	0.94	0.19	7.56	0.60**	4.56**
G30	76.47	0.73	35.14**	10.84	1.27	0.46**	8.07	0.60**	1.18
G31	69.53	1.14	77.95**	11.20	0.99	1.68**	7.23	1.30*	2.17**
G32	75.89	0.68	18.97**	10.98	0.75	0.21*	6.70	0.81	2.15**
G33	64.84	1.42	30.12**	7.71	0.52*	0.52**	8.06	0.65**	4.13**
G34	65.51	1.19	57.59**	8.58	0.49*	1.78**	8.06	0.48**	2.46**
G35	72.29	0.52	138.09**	9.74	1.21	0.09	5.97	0.16**	0.24
G36	85.85	0.82	188.41**	7.72	0.78	1.54**	11.73	0.85	4.59**
G37	74.47	0.86	38.85**	8.48	0.18**	0.22*	9.29	1.10	2.64**
G38	64.53	0.76	3.45*	9.88	2.38**	2.56**	6.08	0.68*	0.28
G39	80.25	0.79	35.77**	6.87	0.31**	-0.08	10.67	1.20	6.29**
G40	64.78	0.93	30.60**	8.65	0.80	0.19	7.11	0.77	-0.10
G41	79.04	0.90	58.49**	9.09	0.63	-0.14	8.64	0.96	3.61**
G42	79.12	0.49*	21.17**	7.40	0.78	0.20	10.78	0.70*	5.40**
G43	65.32	0.65	35.50**	8.19	0.98	0.39**	8.38	0.98	0.26

Gt = Genotype, *, ** indicate significant differences at 0.05 and 0.01 levels of probability, respectively.

Table 11. Stability parameters for grain yield per plant, grain yield per plant and harvest index of 43 wheat genotypes evaluated under 10 environments.

Gt	Grain yield per plant			Biological yield per plant			Harvest index		
	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}
G01	19.79	1.96**	7.92**	56.15	1.90**	62.11**	34.29	0.96	12.03**
G02	14.19	0.77*	21.46**	41.88	0.89	80.14**	35.36	0.86	100.62**
G03	14.82	1.15	12.87**	45.93	1.16	85.24**	30.96	1.39	13.33**
G04	18.36	1.31**	7.14**	48.87	1.17	37.05*	36.46	1.13	18.74**
G05	16.51	1.32**	4.07*	43.62	1.16	60.06**	35.63	0.70	6.43*
G06	17.64	1.68**	5.27*	50.22	1.49**	4.65	31.89	1.07	35.32**
G07	14.58	1.08	7.21**	42.16	1.23	105.34**	35.49	0.61	11.90**
G08	13.83	0.65**	17.00**	43.65	0.64**	440.27**	32.18	1.34	28.30**
G09	17.94	1.99**	39.77**	48.75	1.79**	336.07**	32.27	1.17	17.66**
G10	18.49	1.63**	2.05	49.11	1.63**	44.17*	37.73	0.48	6.73*
G11	15.90	1.38**	9.13**	41.80	1.29*	93.80**	37.33	0.26*	12.36**
G12	11.64	0.91	-1.83	34.14	0.78	-12.39	31.34	1.40	17.48**
G13	11.08	0.61**	12.02**	31.43	0.68*	114.04**	35.84	0.61	17.53**
G14	15.33	1.12	1.59	41.50	1.20	45.13*	37.39	0.97	71.13**
G15	12.73	0.87	13.70**	38.47	1.10	112.05**	34.51	0.70	13.77**
G16	14.81	1.18	10.23**	39.41	1.14	64.63**	37.03	0.29	11.99**
G17	11.40	0.81	-1.46	36.77	0.91	-4.38	30.92	1.55	10.60**
G18	14.24	0.96	-0.37	41.62	1.01	6.24	33.76	1.21	11.65**
G19	8.83	0.45**	-1.31	25.98	0.39**	5.80	32.45	1.53	1.26
G20	19.26	1.94**	31.77**	49.46	1.72**	148.95**	36.17	0.81	5.78*
G21	14.97	1.29**	-1.61	38.62	1.19	15.26	36.63	1.03	0.99
G22	19.35	1.72**	20.00**	53.81	1.40**	220.97**	32.38	1.20	39.05**
G23	11.73	0.68**	6.14*	44.59	0.72*	536.74**	27.32	2.06**	31.21**
G24	10.74	0.60**	0.93	37.87	0.54**	133.79**	27.60	0.72	19.65**
G25	12.73	0.75*	20.14**	33.39	0.63**	154.05**	35.81	0.96	10.72**
G26	12.64	0.74**	-1.93	34.46	0.71*	1.15	36.46	0.86	-2.47
G27	12.96	0.60**	-0.40	37.06	0.57**	-6.39	34.19	0.74	0.37
G28	16.53	1.58**	13.23**	42.33	1.45**	87.50**	37.56	0.53	18.00**
G29	10.33	0.38**	3.04	32.95	0.53**	85.22**	32.62	1.00	25.36**
G30	14.32	0.67**	-1.24	41.44	0.56**	44.79*	34.01	1.43	13.09**
G31	13.31	1.10	1.39	45.93	1.28*	13.41	27.35	1.22	11.22**
G32	12.88	1.05	10.98**	41.98	1.23	136.89**	29.69	0.41	19.24**
G33	12.08	0.52**	22.73**	35.40	0.42**	254.62**	34.03	1.36	13.47**
G34	12.31	0.40**	24.87**	41.59	0.35**	775.24**	31.44	1.67	12.94**
G35	7.89	0.14**	8.36**	29.18	0.47**	-17.24	29.39	1.13	143.27**
G36	9.97	0.53**	3.09	31.56	0.61**	47.07**	30.87	0.73	5.08*
G37	16.05	0.90	26.03**	46.64	0.86	170.79**	33.18	1.40	8.83**
G38	10.01	0.77*	1.15	25.70	0.68*	20.44	38.01	0.92	21.17**
G39	15.58	1.14	12.54**	46.00	1.14	119.27**	32.28	1.02	-0.92
G40	10.09	0.54**	-1.60	28.00	0.57**	-4.68	36.50	0.82	2.30
G41	15.28	1.33**	9.81**	48.56	1.62**	301.18**	33.08	1.49	38.00**
G42	15.54	1.12	8.38**	48.31	1.50**	154.98**	34.58	1.08	25.88**
G43	10.94	0.66**	-2.28	30.90	0.68*	-20.57	35.21	0.21*	-1.29

Gt = Genotype, *, ** indicate significant differences at 0.05 and 0.01 levels of probability, respectively.

CONCLUSION

From this study it could be concluded that genotypes with various genetic background did not give the same response to environmental changes. Moreover, from results of this study we observed that genotypes which considered to be stable for grain yield were not stable for

other characters except genotype G14 which was stable for grain yield and spike number per plant, this might be due to a close relation between grain yield and spike number per plant.

ACKNOWLEDGEMENT

The authors gratefully acknowledge to Prof. Dr. M. El-Morshidy as he provided us with the promising lines and landraces which used in this study. Also authors gratefully acknowledge associate Prof. Bakry Ahmed from National Research Center in addition to Dr. Saad Nassar from Desert Research Center for their kind help during this study. Also the authors thank the staff of Agronomy department farm at Assiut University for their excellent technical assistance.

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تحليل الثبات لقمح الخبز تحت بيئات مختلفة

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تمثل زيادة المحصول دون الحفاظ على ثباتها التحدى الاعظم لبرامج التربية فى القمح. ومن ثم تعرض هذه الدراسة كمية المحصول و ادلة الثبات لعدد ٤٣ تركيب وراثى من قمح الخبز تم اختبارها تحت ١٠ بيئات مختلفة فى مصر خلال موسمى الزراعة ٢٠١٣/٢٠١٤ و ٢٠١٤/٢٠١٥. تمتد هذه البيئات على الخريطة المصرية من ارتفاع ٢١٥ متر فوق سطح البحر فى توشكى اقاصى الجنوب الى ٢٢ متر فوق سطح البحر فى النوبارية فى الشمال. تم عمل التجارب الفردية باستخدام تصميم القطاعات الكاملة العشوائية فى ثلاث مكررات ثم حللت البيانات المتحصل عليها باستخدام تحليل التباين المشترك. ادى التباين الكبير بين البيئات المستخدمة الى وجود تباين ملحوظ فى كمية المحصول تراوحت من ١,٥٠ الى ٧٧,٣٤ جم/النبات. ويمكن تلخيص النتائج فى ان التركيب الوراثى رقم ١٤ و رقم ١٨ اظهرا درجة عالية من الثبات على مدى البيئات المستخدمة بينما كان التركيب رقم ٣٠ اكثر التراكيب مواءمة للبيئات الفقيرة. علاوة على ذلك وجد ان التراكيب الوراثية التى اثبتت ثباتها فى صفة المحصول لم تكن ثابتة فى باقى الصفات ما عدا التركيب رقم ١٤ حيث كان ثابت فى صفة المحصول بالاضافة الى صفة عدد السنابل/النبات.

المجلة المصرية لتربية النبات ٢٠ (٥) :٨٨٥- ٩٠٢ (٢٠١٦)