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Grain Yield Stability of New Bread Wheat Genotypes (*Triticum aestivum* L.) under Normal and Heat Stress Conditions

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FORTY-TWO bread wheat genotypes (*Triticum aestivum* L.) were evaluated in eight environments in Egypt: two locations and two planting dates during the two 2016-2017 and 2017-2018 growing seasons. The objectives of this study were to estimate grain yield, number of spikes plant^{-1}, 1000-kernel weight and plant height of these 42 bread wheat genotypes under different environments and to determine their stabilities. Combined analysis shows that most mean squares was attributed to environmental effects, indicating that environments were diverse, with large differences among environmental means causing most of variation in grain yield and the other studied traits. Mean squares due to genotypes were highly significant for grain yield and the other traits, indicating that the existence of inherent genetic variability and point to the possibility of selecting a stable wheat genotypes .Mean squares due to Geno x Env were highly significant for all studied traits, indicating that there are substantial differences in genotypic response across environments. Mean squares due to genotypes were significant for all studied traits. Mean squares of E+ (GxE) were highly significant for all studied traits. Linear components of genotype-environment interaction were significant or highly significant for all studied traits. The highest-yielding genotypes overall environment were G21 (360.25g), G15 (349.52g) and G13 (303.96g) and did not differ significantly from check variety Giza-168 (341.76g). Six genotypes namely, G13, G21, Giza-168 Shand-1, misr-1 and Sahel-1 showed better general adaptability across environments.

Keywords: Bread wheat (*T. aestivum* L.), Stability parameters, Yield stability.

Introduction

Cereal, which includes wheat, rice, maize, and barley make up the bigger part of crop production in the world and they continue to be the most important food source for human consumption. Bread wheat is a daily source of carbohydrates of the majority of Egyptian citizen and there is a big difference between production and consumption of Egyptian wheat. Wheat imports are projected to increase slightly in Egypt despite strong local production. Wheat area harvested in Egypt was 1.3 million ha produced 8.80 million metric tones with an average of 6689.5kg/ha (FAO STAT, 2018) while, wheat consumption in 2017-2018 estimate of 19.8 million tones (USDA STAT, 2018). To improve food security we need to expand growing wheat in new environments due to the limited area of the agriculture land, but these new environments suffer from some abiotic stresses, such as heat, water shortage and salinity. Grain yield stability is one of the most important goals of breeding programs, especially in sub-tropical environments.

Successful new bread wheat varieties should optimize high performance for grain yield and be stable over a wide range of environmental

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conditions, but most genotypes do not give the same performance in all environments (Carvalho et al., 1983). Consistency of performance is estimated on genotype x environment interaction. The variety which has small G x E interaction is considered stable. There are many statistical techniques, which could be used to identify the variation in individual genotypes responses and the most famous techniques is Eberhart & Russell (1966) model, which has been used widely in several studies of stability and adaptability of genotypes. A genotype is considered stable if it possesses a high mean yield ($\bar{X}$), regression coefficient (bi) value close to 1.0 and deviation from mean regression (S^2_{di}) does not differ significantly from zero. The objectives of this study were to estimate grain yield and other agronomic traits of 42 bread wheat genotypes under different environmental conditions across two growing seasons and different planting dates to determine the stable genotypes.

Materials and Methods

Plant material and experiments

Forty-two bread wheat genotypes (*Triticum aestivum* L.) were evaluated for two years (2016-2017 and 2017-2018) at two planting dates in two locations *viz.*, Sohag and New valley Agriculture Research Farms. The description of eight environments which used are shown in Table 1.

The experimental design was a randomized complete block design with three replicates. The plot consisted of one row with 3m long with 20.0cm apart and 10cm between plants. Pedigree descriptions of 42 evaluated genotypes are presented in Table 2.

TABLE 1. Description of eight environments which used to evaluate the 42 bread wheat genotypes in this study.

Location name	Longitude and latitude	Growing season	Environment
The Faculty of Agric. Res. Farm, Sohg Univ. (Sohag Governorate)	Latitude: (31° 42’ 30’’ N) longitude: (26° 33’ 36’’ E)	2016-2017	E_1= Nov. 30, (favorable)
			E_2= Dec. 30 (heat stress)
		2017-2018	E_3= Nov. 27, (favorable)
			E_4= Dec. 30 (heat stress)
The Faculty of Agric. Res. Farm, New Valley Univ. (New Valley Governorate)	Latitude: (30° 19’ 12’’ N) Longitude: (25° 15’ 36’’ E)	2016-2017	E_5= Nov. 28, (favorable)
			E_6= Dec. 30 (heat stress)
		2017-2018	E_7= Nov. 27, (favorable)
			E_8= Dec. 29 (heat stress)

TABLE 2. Pedigree description of 42 bread wheat genotypes evaluated in 8 environments during 2016/2017 and 2017/2018 growing season.

Genotype	Pedigree
G1-G18	Derived from a cross between Sids 4 x Tokwie
G19-G38	Derived from a cross between Sids 4 x Kasyon/glennson-81
G39 (Check 1)	Giza 168 (high yielding local variety)
G40 (Check 2)	Shandweel 1 (high yielding local variety)
G41 (Check 3)	Misr 1 (high yielding local variety)
G42 (Check 4)	Sahel 1 (drought tolerant variety)

Sids 4: High yielding local variety
Tokwie: Drought tolerant variety introduced from South Africa
Kasyon/glennson-81: Introduced from ICARDA
Abbreviation: Shandweel 1 = Shand 1

Phenotypic evaluation:

At harvest data were recorded on the following characteristics, (I) Grain yield plot^{-1}, (II) Number of spikes plant^{-1}, (III) 1000-kernel weight (g) and (IV) Plant height in cm (Lauro et al., 2005; Hassan et al., 2013; Ibrahim & Hamada, 2016).

Statistical analysis

Analysis of variance for each environment and combined across all environments was run according to Gomez & Gomez (1984) using Proc Mixed of SAS Package Version 9.2 (SAS/STAT, 2008). Data were subjected to Eberhart and Russell's model for estimating three parameters of stability *viz*, mean **($\bar{X}$)**, regression coefficient (bi) and mean squares deviation (S^2di) for each genotype (Eberhart & Russel, 1966).

Results and Discussion

Analysis of variance, mean performance and environmental index

Combined analysis of variance for all studied traits of the 42 bread wheat genotypes evaluated at 8 environments showed that the majority of mean squares was attributed to environmental effects (Env), indicating that environments were diverse, with large differences among environmental means causing most of variation in grain yield and the other studied traits. Mean squares due to genotypes (Geno) were highly significant for grain yield and the other traits, indicating that the existence of inherent genetic variability and point to the possibility of selecting a stable wheat genotype. Mean squares due to Geno X Env were highly significant for all studied traits, indicating that there are substantial differences in genotypic response across environments (Table 3). Similar results were obtained by Akcura et al. (2006), Lata et al. (2010) and Raj et al. (2019), mean performance and environmental index (E. index) of each environment for all studied traits are presented in Tables 4 and 5. The environmental index was performed as the difference between each environment mean and the general mean overall environments. They considered unfavorable environments as those with negative or zero indices and favorable environments as those with positive indices.

Concerning grain yield, data in Table 4 shows that the favorable environments for the grain yield depending on E. index were E_1, E_3 and E_5, while, E_2, E_4, E_6, E_7 and E_8 were the unfavorable. The average yield of environments varied from 177.48 to 368.07g, for E_8 and E_1, respectively. The highest-yielding genotypes across environments were G21 (360.25g), G15 (349.52g) and G13 (348.29g) and did not differ significantly from check variety Giza 168 (341.76g,). In general, the check variety Giza 168 gave the highest grain yield at Sohag Governorate but the chick variety Shand 1 gave the highest mean values of grain yield at New valley Governorate. Hence, Shand 1 is suitable to be grown under New Valley conditions. The interaction between genotypes and environments was highly significant and G19 (508.32g), G27 (503.45g) and G15 (502.17g) under normal condition at Sohag rejoin (E_1) exhibited the highest values of grain yield, respectively and didn't differ significantly from the check variety Giza 168 considering them as promising varieties.

TABLE 3. Combined analysis of variance for all studied traits for 42 bread wheat genotypes evaluated in 8 different environments, during 2016/2017 and 2017-2018 growing seasons.

S. O. V	df	Grain yield plot^{-1} (g)	number of spikes plant^{-1}	1000-kernel weight (g)	Plant height (cm)
Environment (Env.)	7	641070.31**	256.23**	4932.80**	18866.84**
Rep (Env.)	16	1142.29**	0.364	10.18**	92.79**
Genotypes (Geno.)	41	56042.08**	23.96**	275.23**	1027.19**
Geno. x Env.	287	5685.03**	2.90**	62.43**	172.29**
Pooled error	656	543.86	0.26	4.39	12.22

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

TABLE 4. Mean performance of grain yield plot^{-1} (g) and number of spikes plant^{-1} for 42 bread wheat genotypes evaluated in 8 different environments, during 2016-2017 and 2017-2018 growing seasons.

Geno.	Grain yield plot^{-1} (g)									Number of spikes plant^{-1}								
	Sohag				New valley				Mean	Sohag				New valley				Mean
	2016-2017		2017-2018		2016-2017		2017-2018			2016-2017		2017-2018		2016-2017		2017-2018		
	Normal	Heat stress	Normal	Heat stress	Normal	Heat stress	Normal	Heat stress		Normal	Heat stress	Normal	Heat stress	Normal	Heat stress	Normal	Heat stress	
G1	447.40	293.94	385.95	286.07	307.11	187.96	275.43	166.23	**293.76**	11.10	8.27	10.80	7.97	9.64	7.33	8.33	5.51	**8.62**
G2	247.04	187.77	183.46	175.79	154.82	133.18	145.95	153.30	**172.66**	9.16	11.00	8.53	11.17	10.58	8.33	9.44	7.43	**9.45**
G3	189.85	162.57	253.99	148.35	254.12	162.03	154.28	115.45	**180.08**	11.17	7.28	10.55	6.47	10.32	6.00	8.67	4.97	**8.18**
G4	330.24	184.91	296.98	183.91	312.87	174.04	238.23	147.72	**233.61**	10.07	5.92	9.58	5.24	9.44	6.33	8.00	4.68	**7.41**
G5	360.85	262.47	368.53	264.46	221.27	222.40	185.45	214.64	**262.51**	9.83	5.97	9.47	6.67	7.93	6.33	8.33	6.67	**7.65**
G6	290.21	212.22	256.36	195.16	274.09	131.81	196.00	96.70	**206.57**	9.03	5.99	9.78	5.08	11.27	5.67	9.67	4.77	**7.66**
G7	375.45	242.70	345.81	209.02	295.80	147.69	205.45	91.73	**239.21**	7.68	5.33	7.66	4.79	8.72	5.33	7.22	4.81	**6.44**
G8	320.09	214.65	434.11	200.90	149.74	129.40	145.81	147.00	**217.71**	10.90	7.33	11.15	6.21	9.89	7.33	9.11	6.56	**8.56**
G9	300.93	152.88	402.00	145.25	259.04	140.50	212.57	114.05	**215.90**	10.57	7.58	9.63	7.60	10.14	7.33	9.56	6.99	**8.70**
G10	359.04	253.01	364.43	266.51	192.31	170.44	165.20	147.91	**239.86**	8.67	6.70	8.57	6.36	6.69	6.00	6.67	5.98	**6.95**
G11	345.60	231.00	324.40	201.60	265.28	110.16	188.30	79.05	**218.17**	9.87	7.34	9.56	6.54	9.49	5.67	8.56	3.99	**7.63**
G12	423.55	242.87	449.37	254.66	294.35	192.78	223.77	173.02	**281.80**	9.97	7.72	9.49	7.59	9.08	7.67	8.11	6.83	**8.31**
G13	440.91	304.05	421.17	303.31	343.82	290.61	378.47	303.96	**348.29**	12.37	7.72	12.77	8.39	11.18	8.11	11.78	8.30	**10.08**
G14	325.07	220.84	305.04	236.08	318.57	231.73	339.71	192.01	**271.13**	9.80	8.51	9.25	9.56	11.47	9.33	11.67	8.97	**9.82**
G15	502.17	294.17	427.50	322.36	310.37	298.37	349.77	291.45	**349.52**	9.53	10.50	9.32	9.50	13.37	10.67	12.00	9.70	**10.57**
G16	243.43	192.02	355.52	204.17	203.05	155.56	174.30	162.07	**211.27**	11.67	7.90	11.82	7.39	10.81	8.67	10.56	7.54	**9.54**
G17	323.31	231.25	285.03	170.66	310.71	152.43	220.03	115.18	**226.07**	10.40	6.50	10.00	5.24	8.19	6.22	8.00	6.07	**7.57**
G18	254.59	128.91	386.77	99.40	215.73	224.13	190.63	221.31	**215.19**	9.70	8.63	9.82	9.38	11.33	9.67	10.89	8.78	**9.77**
G19	508.32	256.79	465.01	237.53	309.08	167.71	301.70	162.89	**301.13**	12.62	7.53	12.08	6.25	12.07	6.89	11.17	5.99	**9.32**
G20	393.66	232.01	386.95	198.18	223.43	150.88	208.23	174.42	**245.97**	11.27	7.80	11.18	8.29	10.74	8.67	10.67	7.89	**9.56**
G21	477.74	303.74	424.42	323.68	373.76	307.05	373.01	298.62	**360.25**	10.97	7.68	10.62	6.66	9.61	6.67	9.00	6.07	**8.41**
G22	413.65	299.49	399.16	264.25	335.82	164.07	342.79	114.48	**291.71**	10.00	7.99	9.56	6.57	10.99	5.67	10.44	5.24	**8.31**
G23	366.51	250.19	338.07	200.90	303.93	168.26	255.55	142.26	**253.21**	10.23	7.23	10.78	5.81	9.00	7.22	8.44	6.66	**8.17**

TABLE 4. Cont.

Geno.	Grain yield Plot^{-1} (g.)									Number of spikes plant^{-1}								
	Sohag				New valley				Mean	Sohag				New valley				Mean
	2016-2017		2017-2018		2016-2017		2017-2018			2016-2017		2017-2018		2016-2017		2017-2018		
	Normal	Heat stress	Normal	Heat stress	Normal	Heat stress	Normal	Heat stress		Normal	Heat stress	Normal	Heat stress	Normal	Heat stress	Normal	Heat stress	
G24	376.82	252.11	355.71	210.75	308.13	174.36	315.93	145.72	**267.44**	10.79	9.33	10.70	9.18	11.03	8.00	10.56	7.24	**9.60**
G25	417.16	259.17	380.39	241.96	229.44	135.41	183.54	112.11	**244.90**	12.06	7.28	11.87	6.59	9.30	6.67	8.44	6.07	**8.53**
G26	236.67	163.16	209.94	152.51	329.90	263.40	331.80	248.43	**241.97**	10.37	5.69	9.57	4.98	9.94	6.67	9.00	6.51	**7.84**
G27	503.45	283.53	469.15	334.93	337.32	210.80	321.53	160.77	**327.68**	12.90	8.86	12.43	7.86	10.40	8.33	9.67	7.74	**9.77**
G28	454.25	236.53	450.68	246.22	295.68	172.26	266.00	180.03	**287.71**	10.84	10.80	10.98	10.02	10.01	8.67	9.67	7.84	**9.85**
G29	322.62	137.98	416.38	114.46	305.52	135.82	221.90	146.09	**225.10**	11.33	8.17	11.40	7.16	11.07	8.00	10.89	6.73	**9.34**
G30	478.34	260.12	460.76	302.59	373.78	207.79	373.57	212.28	**333.65**	11.23	8.00	10.85	6.56	11.97	10.33	11.56	6.70	**9.65**
G31	430.76	284.21	390.01	292.33	292.69	219.86	204.63	182.79	**287.16**	10.90	7.34	10.60	6.43	9.16	7.67	8.33	7.97	**8.55**
G32	319.63	208.54	291.31	175.89	299.34	143.19	254.80	136.20	**228.61**	8.76	5.88	8.79	5.14	11.39	8.33	9.33	6.30	**7.99**
G33	294.90	182.27	263.36	141.59	248.58	178.31	238.00	184.94	**216.49**	7.63	5.42	8.15	5.94	9.62	8.67	8.89	6.88	**7.65**
G34	339.41	264.12	321.73	223.22	293.20	151.83	249.20	150.91	**249.20**	10.78	8.50	10.82	8.95	10.12	8.67	8.89	7.60	**9.29**
G35	234.36	141.67	205.00	147.70	277.94	207.12	224.47	195.53	**204.22**	8.83	6.53	8.57	6.40	7.89	7.33	7.44	6.88	**7.48**
G36	404.23	294.56	383.58	269.45	271.99	152.93	265.53	147.60	**273.73**	11.30	7.94	11.42	7.79	9.68	8.67	9.33	8.39	**9.31**
G37	316.59	197.79	301.87	189.52	250.70	183.41	251.30	194.47	**235.71**	12.17	7.75	12.10	8.15	11.11	9.33	10.11	8.76	**9.93**
G38	400.54	308.91	382.49	255.14	289.95	218.45	208.60	133.28	**274.67**	10.97	8.17	10.89	8.71	11.44	9.33	10.56	9.13	**9.90**
Giza 168	484.62	292.47	439.86	273.31	337.36	279.18	338.57	288.70	**341.76**	10.10	8.13	9.88	7.88	9.33	7.86	9.22	7.75	**8.77**
Shand 1	437.33	292.78	414.34	271.69	357.72	294.27	350.47	301.10	**339.96**	11.77	8.40	11.72	8.36	10.56	8.44	9.78	8.29	**9.66**
Misr 1	387.74	239.15	371.55	240.20	317.90	253.62	303.10	255.22	**296.06**	7.41	6.91	7.68	6.12	8.29	7.67	7.89	7.21	**7.40**
Sahel 1	379.81	288.57	367.58	250.22	273.54	254.23	282.33	252.68	**293.62**	8.63	7.53	8.47	7.21	8.29	7.78	8.11	7.90	**7.99**
Mean ($\bar{X}$)	**368.07**	**236.72**	**360.37**	**224.43**	**283.80**	**191.65**	**253.71**	**177.48**	**262.03**	**10.33**	**7.68**	**10.17**	**7.28**	**10.06**	**7.70**	**9.38**	**6.96**	**8.70**
E. index	106.04	-25.31	98.35	-37.60	21.77	-70.38	-8.32	-84.55	-	1.64	-1.02	1.48	-1.42	1.37	-0.99	0.68	-1.74	-
Rev. LSD	**31.54**	**30.19**	**20.38**	**21.41**	**44.18**	**50.94**	**39.47**	**27.55**	**11.58**	**0.69**	**0.75**	**0.35**	**0.37**	**0.84**	**0.94**	**0.91**	**0.90**	**0.25**

TABLE 5. Mean performance of 1000-kernel weight and plant height (cm) for 42 bread wheat genotypes evaluated in 8 different environments during 2016/2017 and 2017-2018 growing seasons.

Geno.	1000-kernel weight (g)									Plant height (cm)								
	Sohag				New valley				Mean	Sohag				New valley				Mean
	2016-2017		2017-2018		2016-2017		2017-2018			2016-2017		2017-2018		2016-2017		2017-2018		
	Normal	Heat stress	Normal	Heat stress	Normal	Heat stress	Normal	Heat stress		Normal	Heat stress	Normal	Heat stress	Normal	Heat stress	Normal	Heat stress	
G1	53.01	40.50	46.60	39.26	38.55	32.47	38.24	30.68	**39.91**	97.16	69.33	97.67	68.33	75.62	60.00	77.67	59.56	**75.67**
G2	45.42	24.25	38.38	26.64	36.41	33.10	37.80	32.61	**34.33**	97.80	88.44	96.67	84.00	90.12	67.00	75.56	56.33	**81.99**
G3	39.57	27.22	31.26	28.51	36.84	33.70	32.42	28.80	**32.29**	86.77	71.11	84.67	72.33	78.21	60.67	72.22	54.00	**72.50**
G4	37.06	30.58	31.53	24.97	35.09	31.27	34.11	30.15	**31.85**	108.5	75.67	106.7	77.33	71.77	58.33	69.67	59.33	**78.41**
G5	49.36	44.11	44.44	35.02	45.31	32.10	40.24	30.43	**40.13**	115.3	80.44	113.0	81.67	103.9	84.67	100.6	77.44	**94.62**
G6	38.61	23.55	30.97	22.30	44.86	30.40	40.70	27.81	**32.40**	103.0	68.33	100.7	66.67	103.4	80.33	97.78	71.56	**86.46**
G7	42.41	24.29	38.30	24.78	41.11	31.43	32.15	21.39	**31.98**	94.70	67.78	93.00	68.33	78.19	64.00	73.67	60.44	**75.01**
G8	38.54	24.42	34.24	29.13	34.51	29.73	28.56	20.75	**29.99**	111.7	78.33	110.0	80.00	93.07	74.00	85.44	67.89	**87.55**
G9	57.53	44.20	45.00	39.65	44.96	29.07	35.33	26.63	**40.30**	99.96	99.44	98.00	98.33	88.80	75.33	84.44	69.33	**89.21**
G10	47.74	33.12	40.87	26.77	39.50	28.37	34.27	24.74	**34.42**	96.48	69.33	93.67	73.33	88.90	63.67	82.44	59.00	**78.35**
G11	40.80	31.54	33.17	30.32	42.98	36.07	39.00	32.45	**35.79**	109.4	93.67	108.0	95.33	98.40	75.00	92.33	66.11	**92.29**
G12	47.62	41.27	42.11	36.09	40.44	34.73	33.08	28.90	**38.03**	105.2	70.00	103.7	65.00	78.19	63.67	76.89	58.22	**77.61**
G13	51.80	27.74	42.64	29.56	41.34	37.73	37.16	34.05	**37.75**	105.7	70.89	104.0	72.67	100.7	78.33	82.11	62.44	**84.60**
G14	37.56	29.27	37.43	28.18	41.70	30.87	35.56	26.41	**33.37**	90.89	90.78	87.00	90.33	95.47	72.33	86.00	63.00	**84.47**
G15	60.62	43.26	55.67	48.68	43.32	34.20	38.76	30.28	**44.35**	110.9	92.33	110.0	93.33	92.47	71.00	82.56	63.44	**89.50**
G16	44.79	31.56	37.71	30.89	41.69	30.43	35.46	25.52	**34.76**	90.17	72.44	89.67	74.00	81.40	70.33	83.11	70.11	**78.90**
G17	37.59	17.04	30.94	20.78	52.31	29.93	39.37	22.23	**31.27**	107.6	62.44	105.7	63.00	94.57	70.00	88.22	63.11	**81.83**
G18	34.23	25.22	29.57	24.64	38.83	29.47	34.30	26.52	**30.35**	89.70	70.89	87.00	72.67	82.96	67.00	80.22	66.44	**77.11**
G19	44.41	35.92	36.42	35.06	34.20	30.37	29.34	27.02	**34.09**	103.0	77.00	101.7	78.33	85.22	60.67	81.89	60.67	**81.05**
G20	48.61	42.36	40.53	38.11	32.33	28.30	33.24	28.57	**36.51**	106.1	89.44	104.3	85.00	103.6	74.00	103.6	76.67	**92.82**
G21	52.62	32.38	42.04	34.30	49.03	36.17	40.23	29.64	**39.55**	117.2	96.67	108.3	94.67	93.91	73.00	91.44	73.89	**93.64**
G22	47.16	32.35	43.00	32.22	44.72	34.97	41.80	31.08	**38.41**	106.1	96.11	104.3	100.0	91.67	77.00	87.78	66.44	**91.17**
G23	41.22	19.78	31.35	21.40	50.24	32.93	40.67	24.90	**32.81**	93.36	90.56	91.67	91.67	85.67	60.00	88.78	70.56	**84.03**

TABLE 5. Cont.

Geno.	1000-kernel weight (g.)									Plant height (cm)								
	Sohag				New valley				Mean	Sohag				New valley				Mean
	2016-2017		2017-2018		2016-2017		2017-2018			2016-2017		2017-2018		2016-2017		2017-2018		
	Normal	Heat stress	Normal	Heat stress	Normal	Heat stress	Normal	Heat stress		Normal	Heat stress	Normal	Heat stress	Normal	Heat stress	Normal	Heat stress	
G24	36.73	24.48	30.86	25.12	41.97	29.33	37.80	26.35	**32.81**	102.1	92.00	103.3	93.33	103.7	83.00	89.78	65.56	**84.03**
G25	45.94	37.99	37.51	35.96	42.65	31.97	40.12	29.50	**31.58**	110.0	94.14	105.0	91.67	93.75	70.67	89.00	64.00	**91.58**
G26	37.61	24.79	30.65	24.56	38.34	36.70	35.72	32.24	**37.71**	108.3	87.00	113.7	85.00	78.51	63.00	79.78	64.00	**89.78**
G27	51.86	30.86	41.36	36.83	54.74	31.67	39.14	24.17	**32.58**	99.15	90.00	98.00	93.33	99.17	78.33	91.33	74.33	**84.91**
G28	43.05	25.77	36.48	26.39	39.40	33.70	39.36	31.03	**38.83**	107.3	95.67	107.7	97.00	79.83	67.67	75.67	70.11	**90.46**
G29	51.18	43.44	46.90	40.02	40.64	32.43	35.87	29.24	**34.40**	96.62	65.00	94.67	60.00	75.25	58.00	79.11	71.67	**87.62**
G30	40.79	20.79	33.00	24.79	43.54	31.13	32.95	23.75	**39.97**	111.5	78.89	109.7	76.67	100.5	67.33	103.8	76.33	**75.04**
G31	48.45	30.82	37.55	32.60	55.78	31.43	36.68	20.31	**31.34**	95.48	90.11	98.33	87.00	76.73	61.67	81.56	71.78	**90.58**
G32	36.62	15.68	32.19	20.44	40.82	30.00	36.11	26.70	**36.70**	109.2	83.33	107.7	75.00	87.67	56.00	84.89	70.00	**82.83**
G33	37.44	20.61	34.37	23.66	45.31	40.23	39.57	35.64	**29.82**	96.33	73.67	96.00	76.67	91.21	72.33	87.33	79.44	**84.22**
G34	40.02	25.64	33.28	26.46	42.63	37.80	30.57	26.09	**34.60**	107.0	96.11	105.0	96.67	97.13	74.67	99.33	80.33	**84.12**
G35	48.12	36.44	40.64	30.64	48.96	37.13	38.02	29.05	**32.81**	96.57	71.11	94.33	75.00	91.67	67.00	93.00	75.56	**94.52**
G36	47.69	31.08	40.21	29.41	54.53	28.17	33.52	15.72	**38.63**	95.85	68.33	93.00	73.33	74.57	58.67	82.78	68.33	**83.03**
G37	37.99	29.69	34.17	27.46	46.27	28.37	31.30	19.39	**35.04**	107.1	68.33	103.3	67.33	90.00	59.33	90.67	74.89	**76.84**
G38	45.98	28.65	42.82	30.41	39.48	29.97	31.58	21.51	**31.83**	108.3	95.00	105.0	101.7	87.54	70.00	97.67	92.33	**82.62**
Giza 168	46.74	34.84	40.60	35.29	38.41	28.97	32.14	25.23	**33.80**	106.1	71.56	104.3	70.67	93.98	76.67	102.7	93.67	**94.68**
Shand 1	36.20	21.58	29.51	21.87	46.58	37.37	35.66	26.31	**35.28**	79.68	64.44	80.67	60.00	62.37	63.00	76.44	77.11	**89.95**
Misr 1	42.06	28.12	36.07	27.50	44.27	32.73	34.72	22.32	**31.89**	83.16	68.89	81.33	65.00	75.77	78.33	86.78	86.22	**70.46**
Sahel 1	40.95	27.58	33.21	29.36	49.48	32.80	35.30	29.19	**33.47**	105.3	66.11	103.7	71.00	74.25	70.00	92.89	84.56	**78.18**
Mean ($\bar{X}$)	**44.14**	**30.11**	**37.51**	**29.91**	**42.95**	**32.37**	**35.90**	**27.03**	**34.99**	**101.7**	**80.03**	**100.1**	**80.06**	**87.85**	**68.95**	**86.40**	**69.91**	**84.38**
E. index	9.14	-4.88	2.52	-5.09	7.96	-2.62	0.91	-7.96	-	17.33	-4.35	15.72	-4.31	3.48	-15.4	2.03	-14.4	-
Rev. LSD	**3.71**	**4.01**	**2.54**	**3.76**	**2.46**	**2.61**	**2.70**	**2.35**	**1.04**	**2.51**	**5.12**	**5.80**	**5.75**	**5.90**	**5.09**	**5.59**	**4.18**	**1.74**

For number of spikes plant^{-1}, data presented in Table 4 showed that the favorable environments for this trait were E_1, E_3, E_5 and E_7, which are favorable planting dates. According to general mean overall environments, there are 3 genotypes (G13, G15 and G37) significantly surpassed the best check variety (Shand 1). The lowest number of spikes plant^{-1} were observed under E_2, E_4 and E_8 (unfavorable planting dates). These results may be attributed to plants incurring heat stress during the tillering stage compared with normal conditions. Similar results obtained by Saqib et al. (2013) and Ibrahim & Hamada (2016).

Concerning 1000-kernel weight, data in Table 5 showed that the favorable environments were E_1, E_5 and E_3, respectively. The average of environments ranged from 27.03 to 44.14g, for E_8 and E_1, respectively. Based on the general mean overall environments, genotype G15 had the highest value of 1000-kernel weight (60.62g) followed by G9 (57.53g) and G1 (53.01g) in addition to significantly surpassed the best chick variety Shand l.

For the check varieties data in Table 5 showed that Giza-168 was the best one under Sohag Governorate, while shand 1 was the best check variety under New valley condition. These results indicated that shand 1 may be withstand under abiotic stress like heat and salinity. The interaction between genotypes and environments was highly significant and G15, G9, G1, G21 and G13 under E_1 gave the highest values of 1000-kernel weight and surpassed the check variety Giza168 and are considered promising varieties for heavy kernel weight. The lowest value of 1000-kernel weight obtained from E_2, E_4, E_6 and the E_8, these results may be due to short grain-filling duration (Dias & Lidon, 2009). Sareen et al. (2012), and Song et al. (2015) showed that there was a significant reduction in the rate of filling in wheat cultivars resulted from increase of temperature.

For plant height, the average of environments ranged from 68.95 cm under E_6 to 101.7cm under E_1 (Table 5). The highest values of plant height were detected from G21 (117.2cm) and G5 (115.3cm) under E_1, while lowest values were detected from G3 (54.0cm) and G2 (56.3cm) under E_8 these may be due to delaying the elongation of the plant after heading. The same results were obtained by Al-Otayk (2010), Hassan et al. (2013) and Ibrahim & Hamada (2016), who showed that a decrease of plant height by delaying planting date.

Stability analysis

The stability analysis conducted for eight environments is shown in Table 6. Mean squares due to genotypes was significant for grain yield and the other studied traits, suggesting the possibility of selecting stable wheat genotypes from the investigated materials. The genotype by environment interaction component was farther partitioned into linear (E Linear) and (GxE linear) and non-linear (pooled deviation) components. The linear components mean squares is highly significant, indicating that the predictable components shared genotype-environment interaction. Preponderance of linear genotype-interaction is of great practical importance, in that there are differences among the linear regression coefficient for each genotype. In this respect, Eberhart & Russell (1966) and Freeman & Perkins (1971) stated that the basic cause of the differences among genotypes in their yield stability is the wide occurrence of an G x E interaction.

Mean squares of E + (G x E) were highly significant for all studied traits hence, the environments and their interaction with genotypes played an important role in determining all the studied traits. The same results were obtained by Ulker et al. (2006), Shah et al. (2009) and Hassan et al. (2013). Mean squares of the environment (E linear) are highly significant for all studied traits, indicating that the presence different among environments and their considerable influence on all studied traits. Parveen et al. (2010), Goda et al. (2010) and Hassan et al. (2013) obtained similar results.

Linear components of genotype-environment (G x E Linear) interaction were significant or highly significant for all studied traits, indicating that the wheat genotypes gave different performance from one environment to another. Al-Otayk (2010) and Hassan et al. (2013). Mean squares due to pooled deviation were highly significant for grain yield plot^{-1}, number of spikes plant^{-1}, 1000-kernel weight, and plant height, indicating that performance of the evaluated wheat genotypes significantly fluctuated from their respective linear path of response to environments.

TABLE 6. Stability analysis of all studied traits for 42 bread wheat genotypes evaluated in 8 different environments, during 2016/2017 and 2017-2018 growing seasons.

S. O. V	df	Grain yield plot^{-1} (g.)	Number of spikes plant^{-1}	1000-kernel weight (g.)	Plant height (cm)
Genotypes (G)	41	56042.08**	23.96**	275.23**	1027.19**
E + (G x E)	294	6937.71**	2.978**	59.47**	205.81**
E (linear)	1	1495820.00**	597.933**	11511.73**	44035.78**
G x E (linear)	41	4836.59**	2.956**	27.72*	92.36**
Pooled deviation	252	1371.29**	0.621**	19.19**	50.40**
Pooled error	656	543.86	0.258	4.388	12.223

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

Stability parameters

Stability analysis was performed according to Eberhart & Russell (1966). Regression coefficient (b_i) and deviation from regression (S^2di) are given in Table 7. Genotypes with high mean performance, a regression coefficient of unity (b_i= 1), and small value of deviation from regression (S^2di= 0) provide better general adaptability across environments. (Eberhart & Russell, 1966; Finlay & Wilkinson, 1963). Genotypes with high mean, b_i more than unity with non- significant deviation from regression (S^2di), indicate that these genotypes are suitable for favorable environments. On the other hand, a genotype which gives b_i less than unity with non-significant S^2di, and low mean, indicate that these genotypes have resistance to environmental fluctuation. Thus, a genotype has the specificity of adaptability to poor environments (Wachira et al., 2002; Akcura et al., 2005; Umadevi et al., 2009).

Stability parameters of grain yield plot^{-1} of 42 bread wheat genotypes evaluated under eight environments are presented in Table 7. Regression coefficient varied from 0.02 (for G26) to 1.77 (for G19). 8 out of 42 genotypes *viz*., G1, G13, G21, G24, Giza 168 Shand 1, misr 1 and Sahel 1 revealed average stability across environments, whereas had grain yield above-grand mean, coefficient of regression (b_i) non-significantly different from unity and deviation from regression (S^2di) non-significantly different from zero.

Out of forty-two wheat genotypes, four genotypes *viz*., G12, G19, G28 and G30 had grain yield more than the general mean, regression coefficient values significantly more than unity (b_i> 1) with non-significant deviation from regression (Table 7). Hence, these genotypes are suitable for favorable environments and there is yield reduction in the unfavorable environments. On the other hand, only one wheat genotype (G2) is suitable for unfavorable or poor environments whereas, had regression coefficient value significantly less than unity (b_i < 1) with non-significant deviation from regression. Four wheat genotypes *viz*., G22, G27, G31 and G36 showed higher grain yield, but had significant values of S^2di and are considered sensitivity genotypes to environmental changes and an unpredictable grain yield (Eberhart & Russell, 1966). Similar results were obtained by Al-Otayk (2010), Hassan et al. (2013) and Mohammadi & Amri (2013).

For number of spikes plant^{-1} (Table 7) genotypes *viz.,* G9, G16, G20, G34, G36, G37, G38, Giza-168 and Shand-1 had above-average number of spikes, regression coefficient (b_i) values non significantly different from unity, and deviation from regression (S^2di) values non significantly different from zero. Thus, these were considered more stable than the other genotypes for spikes plant^{-1}. The genotypes G19 and G29, with b_i> 1 and had average values above general mean were adapted to favorable conditions. The genotypes G35, misr 1, Sahel 1 with bi< 1 and low mean were more adapted to unfavorable environments.

For 1000-kernel weight, data in Table 7 showed that the most stable genotypes were G21, G22 and G35 whereas had coefficient of regression values (b_i) not significantly different from unity and S^2di values non significantly different from zero. Generally, most of genotypes exhibited significant deviation from regression (S^2di) values from zero. Thus, based on coefficient of regression most of genotypes had an average response in all environments. according to Becker & Leon (1988) genotypes with bi values of unity showed an average response to changing environmental conditions.

TABLE 7. Stability parameters of grain yield plot^{-1} (g), number of spikes plant^{-1}, 1000-kernel weight and plant height for 42 bread wheat genotypes evaluated in 8 environments, during 2016-2017 and 2017-2018 growing seasons.

Geno.	Grain yield plot^{-1} (g)			Number of spikes plant^{-1}			1000-kernel weight (g)			Plant height (cm)		
	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}
G1	293.76	1.24	646.86	8.62	1.16	0.74**	39.91	0.79	30.13**	75.67	1.20	5.76
G2	172.66	0.36**	534.79	9.45	0.02**	2.06**	34.33	0.86	18.00**	81.99	1.04	61.34**
G3	180.08	0.52*	1132.25*	8.18	1.60**	0.23	32.29	0.61*	2.80	72.50	0.87	10.18
G4	233.61	0.92	707.39	7.41	1.49*	-0.02	31.85	0.48*	3.95	78.41	1.46*	61.09**
G5	262.51	0.77	1710.93**	7.65	0.93	0.38	40.13	0.88	18.28**	94.62	1.16	40.27**
G6	206.57	0.85	885.12	7.66	1.69**	0.69**	32.40	1.08	23.51**	86.46	1.02	129.48**
G7	239.21	1.30	624.98	6.44	1.04	0.10	31.98	1.26	2.49	75.01	1.02	7.61
G8	217.71	1.24	4053.63**	8.56	1.34	0.10	29.99	0.84	5.02	87.55	1.29	13.38
G9	215.90	1.30	1174.44*	8.70	0.99	0.02	40.30	1.18	50.20**	89.21	0.70	78.69**
G10	239.86	1.01	2435.69**	6.95	0.59*	0.42	34.42	1.15	10.18*	78.35	1.11	13.18
G11	218.17	1.26	730.57	7.63	1.39	0.56*	35.79	0.63*	5.71	92.29	1.14	34.97**
G12	281.80	1.40*	523.28	8.31	0.72	0.07	38.03	0.69*	18.28**	77.61	1.40	25.71*
G13	348.29	0.77	352.30	10.08	1.42*	0.47*	37.76	1.05	17.05**	84.60	1.19	74.68**
G14	271.13	0.61*	1400.46**	9.82	0.44**	0.98**	33.37	0.82	2.13	84.47	0.61	76.09**
G15	349.52	0.95	1209.80**	10.57	0.30**	2.11**	44.35	1.04	73.25**	89.50	1.26	50.10**
G16	211.27	0.75	1383.17**	9.54	1.29	0.05	34.75	1.00	0.35	78.90	0.66	3.24
G17	226.07	0.97	1064.52*	7.57	1.24	0.44	31.27	1.57*	43.44**	81.83	1.43*	84.74**
G18	215.19	0.75	5248.70**	9.77	0.45*	0.46*	30.35	0.70*	5.83	77.11	0.72	3.18
G19	301.13	1.77**	125.67	9.32	2.03**	0.01	34.09	0.54*	18.82**	81.05	1.30	1.32
G20	245.97	1.24	698.18	9.56	1.05	0.05	36.51	0.48*	47.51**	92.82	0.99	30.45*
G21	360.25	0.86	302.75	8.41	1.30	0.12	39.54	1.28	-0.56	93.64	1.17	28.05*
G22	291.71	1.37	1901.02**	8.31	1.44*	0.95**	38.41	1.00	1.37	91.17	0.93	67.07**

TABLE 7. Cont.

Genotype	Grain yield plot^{-1} (g)			Number of spikes plant^{-1}			1000-kernel weight (g)			Plant height (cm)		
	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}
G23	253.21	1.09	233.21	8.17	1.15	0.34	32.81	1.47*	33.07**	84.03	0.76	68.15**
G24	267.44	1.13	728.65	9.60	0.31**	2.01**	31.58	0.91	10.64*	91.58	0.86	60.42**
G25	244.90	1.42*	1549.66**	8.53	1.54**	0.84**	37.70	0.75	6.76	89.78	1.19	37.90**
G26	241.97	0.02**	5072.96**	7.84	1.41*	0.38	32.58	0.59*	18.55**	84.91	1.39	55.45**
G27	327.68	1.57**	901.57*	9.77	1.29	0.60**	38.83	1.59*	9.61*	90.46	0.68	22.16
G28	287.71	1.52**	120.10	9.85	0.48*	0.81**	34.40	0.88	10.01*	87.62	1.04	117.79**
G29	225.10	1.41*	2429.97**	9.34	1.39*	0.02	39.97	0.76	34.34**	75.04	1.06	51.38**
G30	333.65	1.42*	737.00	9.65	1.36	1.27**	31.34	1.22	6.21*	90.58	1.34	45.22**
G31	287.16	1.11	1395.82**	8.55	0.96	0.59**	36.70	1.66*	14.24**	82.83	0.84	56.43**
G32	228.61	0.94	730.08	7.99	1.18	1.64**	29.82	1.10	27.89**	84.22	1.43*	19.43
G33	216.49	0.63	627.48	7.65	0.65	1.44**	34.60	0.79	52.81**	84.12	0.72	20.17
G34	249.20	0.94	483.30	9.29	0.73	0.21	32.81	0.92	12.82**	94.52	0.85	20.75
G35	204.22	0.25**	1763.32**	7.48	0.56*	0.10	38.63	1.11	2.60	83.03	0.86	35.84**
G36	273.73	1.22	991.02*	9.31	0.90	0.37	35.04	1.83**	17.94**	76.84	0.99	17.17
G37	235.71	0.71	87.74	9.93	1.12	0.39	31.83	1.16	11.01**	82.62	1.33	55.48**
G38	274.67	1.14	1558.05**	9.90	0.78	0.18	33.80	1.20	11.75**	94.68	0.73	75.34**
Giza 168	341.76	1.05	572.70	8.77	0.67	-0.04	35.28	0.87	17.22**	89.95	0.82	138.63**
Shand 1	339.96	0.79	412.66	9.66	1.02	0.14	31.88	1.04	36.13**	70.46	0.38**	63.05**
Misr 1	296.06	0.77	340.21	7.40	0.31**	0.21	33.48	1.17	1.15	78.18	0.12**	69.22**
Sahel 1	293.62	0.68	198.65	7.99	0.29**	-0.02	34.73	1.03	12.27**	83.46	0.96	121.16**

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

Regarding plant height, (Table 7) data showed that majority of genotypes showed the coefficient of regression values (bi) non-significantly different from unity. In contrast, most of genotypes exhibited significant deviation from regression (S^2di) values from zero. Thus, based on coefficient of regression most of genotypes had an average response in all environments. According to Eberhart & Russell (1966) concept, 5 genotypes viz., G8, G19, G33, and G34 were considered more stable than the other genotypes.

Conclusion

The highest-yielding genotypes overall environments were G21 (360.25g), G15 (349.52g) and G13 (348.29g). In general, the check variety Giza168 gave the highest grain yield (484.62g) at Sohag Governorate, while the chick variety Shand 1 gave the highest values of grain yield (357.72g) at New valley Governorate. Hence, shand-1 may be suitable for agriculture under New Valley conditions. For grain yield results revealed that genotypes *viz.,* G13, G21, Giza 168 Shand 1, misr 1 and Sahel 1 showed better general adaptability across environments, whereas exhibited high values of grain yield per plot, coefficient of regression not significantly different from unity and less values of deviation from regression.

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ثبات انتاجية بعض التراكيب الوراثية الجديدة لقمح الخبز (*Triticum aestivum* L.) تحت الظروف الطبيعية وظروف الإجهاد الحرارى

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تم تقييم ثبات الانتاجية لعدد 42 تركيب وراثى من قمح الخبز تحت 8 بيئات مختلفة (ميعادى زراعة، موقعين وموسمين زراعيين) خلال موسمى الزراعة 2017-2016 و 2018-2017 ونفذت التجارب الحقلية بمحافظتى سوهاج والوادى الجديد، مصر. وتم دراسة صفات محصول الحبوب/قطعة تجريبية وعدد السنابل للنبات الواحد ووزن 1000 حبة وارتفاع النبات. تم استخدام موديل ايبرهارت وراسل 1966 لتقديرمتوسط الاداء والثبات لهذه الصفات. اظهر التحليل المشترك للتباين فروق معنوية جدا بين البيئات وتمثل معظم متوسطات مربعات الانحرافات، مما يشير إلى أن هناك تنوع بين البيئات وهذا يفسر الاختلافات الكبيرة فى متوسط محصول الحبوب ومتوسط الصفات المدروسة الأخرى بين البيئات. أيضاً كان التفاعل بين التراكيب الوراثية والبيئات معنوى لكل الصفات محل الدراسة. كان التباين بين التراكيب الوراثية معنوياً بالنسبة لصفة محصول الحبوب وباقى الصفات المدروسة، وهذا يدل على أن هناك اختلافات وراثية تسمح بانتخاب تراكيب وراثية ثابتة. كان متوسط مجموع مربعات الانحرافات الراجعة للبيئات والتفاعل بين التراكيب الوراثية والبيئات (الخطى) معنويا أو عالى المعنوية لكل الصفات المدروسة. افضل البيئات بالنسبة لمحصول الحبوب اعتمادا على الدليل البيئى كانت البيئة الأولى والثانية بينما البيئة السادسة والثامنة كانت اقلهم محصولا. علاوة على ذلك اعطت التراكيب الوراثية رقم 21 و15 و 13 على الترتيب اعلى متوسط محصول حبوب من خلال جميع البيئات. وبناءا على تحليل الثبات كان هناك 8 تراكيب وراثية وهى رقم 1، 3 ،21، 24 ، جيزة -168، شندويل-1، مصر-1 و ساحل-1 اظهرت قدرة عالية على التاقلم خلال البيئات المختلفة بالنسبة لصفة محصول الحبوب.