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YIELD STABILITY OF WHEAT UNDER SOME DROUGHT AND SOWING DATES ENVIRONMENTS IN DIFFERENT IRRIGATION SYSTEMS

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ABSTRACT: Several field experiments were conducted to screen 29 bread wheat lines (*Triticum aestivum* L.), 5 durum wheat lines (*Triticum durum* L.) and 4 commercial check varieties for grain yield (ardab/fad.) under twelve diverse environments for drought and heat stress in drip and sprinkler irrigation systems of newly reclaimed sandy soils and surface flood irrigation system of old clay soils. The combined analyses of variance showed highly significant differences among environments, genotypes and environments x genotypes for all irrigation systems. Wheat genotypes had higher grain yield under drip irrigation than sprinkler and surface flood irrigation systems. Drought stress and delay sowing date reduced grain yield for all wheat genotypes compared with optimum water irrigation and favorable sowing date. Grain yield over twelve environments ranged from 15.06 for Line 2 to 20.02 (ardab/fad.) for Line 13. Wheat Lines 9, 18 and 21 exhibited the desirable drought and heat sensitivity indices under all irrigation systems (SI < 1). The mean square of joint regression exhibited highly significant differences among genotypes (G), environments (E), the G x E interaction, (E + G × E) and environment (linear). Also, the linear interaction (G x E linear) was highly significant when tested against pooled deviation. Phenotypic stability parameters indicated that bread wheat genotypes Misr 1, Line 13, Line 14 and Line 3 and durum lines 31 (G33), 33 (G35) and 32 (G34) were highly adapted to favorable environments, whereas G36 (Line 34) was adapted to drought stress and delay sowing date environments. Genotypic stability parameters showed that the most desired and stable wheat genotypes were Line 10 and Misr 1. The AMMI analysis of variance showed that environments explained 77.21% of total variation and it was greater than genotypes (5.30%) and genotype × environment (GEI) (12.54%). IPCA 1 score explained 25.08% and IPCA 2 had 17.81% of the total GEI for AMMI model. Whereas, IPCA 1 score explained 36.02% and IPCA 2 had 17.56% of the total GGEI for SREG model. According to the ASV ranking the bread wheat genotypes, Line 10, Giza 168, Line 15, Line 8 and Sakha 93 and durum line 31 (G33) were more stable. GGE biplot exhibited Line 3 as ideal wheat genotype for grain yield. Positive and significant correlation coefficients between $\overline{X}_g$, b_i, α_i and P_i were found among each other. The stability parameters *i.e.*, S^2_{di}, λ_i, W^2_i, CV (%) and ASV were significantly correlated between each other, indicating that they measured similar aspects of stability.

Key words: Wheat, drought, stability, AMMI model, drip, sprinkler, flood irrigation.

INTRODUCTION

Wheat is one of the most strategic cereal crops in Egypt with a cultivation area of about 1.26 million hectares gave total production of 8.1 million metric tons (USDA, 2016). With increasing human, the policy of the country aims to improve wheat production in sandy soils based on new technologies as using, irrigation systems, biofertilizers and developed new wheat genotypes so as to meet the increasing demand of local consumption. Water scarcity is one of the major problems for crop production in Egypt, thus improvement of water management

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in agriculture, which is the biggest water consumer, is necessary to enhance agricultural productivity in order to meet food demands of the growing population.

The most of area under wheat crop is irrigated by surface flood irrigation, with very poor water use efficiency. Conversely it is more efficient at leaching salts in saline soils. Wheat can be produced successfully with a proper variety of irrigation systems. Drip and sprinkler irrigation systems can apply smaller amounts of water than surface flood systems.

Potential expansion of wheat area is only possible in Egyptian deserts, but the soil in these areas is sandy with low water holding capacity and thus exposes wheat plants to water stress. Such drought stress causes great losses in wheat yield. A proper irrigation system (sprinkler or drip irrigation) is recommended. Drip irrigation supplies water directly to the root zone of plants and water savings of up to 40-80% (Brown, 2006; El-Habbasha *et al.,* 2014-15), whereas sprinkler system is weakness because some water is lost by evaporation even before it hits the surface soil, especially in hot and arid settings, which release water at a lower level, close to the soil surface, lose less water through evaporation and drift (Brown, 2006).

Also, drip irrigation has several advantages over surface and sprinkler methods, such as improves quality and yield of wheat as well as it increases the water and nutrient use efficiency (Eissa *et al*., 2010; Abdelraouf *et al*., 2013; Wang *et al.,* 2013; Rekaby *et al.,* 2016). Furthermore, Noreldin *et al.* (2015) reported that grain yield of wheat was higher under drip irrigation (6.78 ton/ha) compared to sprinkler irrigation (6.20 ton/ha). The application of N significantly enhanced the growth of drip irrigated wheat plants (Rekaby *et al.,* 2016), who recommended to fertilize drip irrigated wheat by 240 kg N per hectare in Assiut region.

Wheat production in Egypt using drip irrigation was study by several researchers (Abd El- Rahman, 2009; Eissa *et al*., 2010; Abdelraouf *et al*., 2013, Noreldin *et al.* 2015; Rekaby *et al.,* 2016). In Morocco, Kharrou *et al.* (2011) found that drip irrigation applied to wheat was more efficient with 20% of water saving and +28% increase of grain yield in comparison with surface irrigation.

The water use efficiency (WUE) is one of the most important indices for determining optimal water management practices. Selection of wheat genotypes with better adaptation to drought stress should increase the productivity of wheat at newly reclaimed sandy soils.

Selection of different wheat genotypes under environmental stress conditions is one of the main tasks of plant breeders for exploiting genetic variations to improve the stress-tolerant cultivars (Khan and Mohammad, 2016)

Many statistical methods have been proposed to find out the stability of new cultivars. The joint regression analysis of either phenotypic values (b_i and S^2_{di}) was first suggested by Yates and Cochran (1938) and was later modified and used by Finlay and Wilkinson (1963) and Eberhart and Russell (1966).The genotypic stability was discussed by Tai (1971), who used two stability parameters (α_i and λ_i). Francis and Kannenberg (1978), proposed coefficient of variability (CV_i). Wricke (1962), used the wricke's ecovalence (W^2_i) and Lin and Binns (1988), suggested the superiority measure (P_i) of each genotype as stability parameter.

The additive main effects and multiplicative interaction (AMMI) model was proposed by Gauch, (1988 and 1992). The AMMI has proven useful for understanding complex genotype x environments interaction. The AMMI stability value (ASV) was proposed by Purchase (1997) and Purchase *et al.* (2000). The AMMI and SREG models were used for obtaining the GE and GGE biplots, respectively. Biplots of the first two principal components were used to illustrate these relationships (Gabriel, 1971; Kempton, 1984).

The objectives of the current study were to screen wheat lines with high yield potential and stability; identify drought tolerant wheat genotypes under water stress conditions and evaluate the level of association among the numerous stability parameters.

MATERIALS AND METHODS

Field experiments were conducted to screen 29 bread wheat lines (*Triticum aestivum* L.), 5 durum wheat lines (*Triticum durum* L.) and 4 commercial check varieties for drought and heat stresses. The pedigrees for wheat genotypes are given in Table 1.

The field trials were carried out in 12 environments under three different irrigation systems, drip, sprinkler and surface irrigation in Agricultural Experimental Station, Fac. Agric., Zagazig Univ., at El-Khattara region for drip and sprinkler irrigation and Ghazalla region for surface irrigation. The experimental layout at each environment was a randomized complete block design with three replications.

Drip irrigation trials were carried out in six environments which are the combination between; two years (2011/2012 and 2012/2013) and three water levels (1050, 1550 and 2050 m^3/fad., as severe, moderate and optimum, respectively). Quantities of water irrigation were adjusted by a water counter for all irrigation treatments. The underground water (around 900 ppm of total salts) was used. About 45 irrigations were applied during each season. Drip lines, the in-line GR dripper laterals were installed 0.35 m apart and the emitters were spaced 0.30 m apart. The plot area 2.1 m^2 included 6 rows, 2 m long and 17.5 cm apart.

Sowing dates were on 23 and 24th of November in the 1st and 2nd seasons, respectively. Nitrogen fertilizer (110 Kg/fad.) in the form of urea (46.5% N) was applied with the irrigation water in seven equal doses, first split was applied at sowing while the other doses were applied after 15 days from sowing and then, in 10 days intervals. Phosphate and potassium fertilizers were applied at the rates of 150 kg/fad. (15.5% P_2O_5) and 50 Kg/fad. (48% K_2O), respectively before sowing for phosphate fertilizer, while potassium fertilizer was added with the irrigation water in two equal portions after 20 and 40 days from sowing. Compost (2.5 ton/fad.) was drilled before sowing, it had an average total N of 0.65%, total P of 376 ppm, total K of 7052 ppm and organic matter 18.35%. The soil mechanical and chemical analyses of the experimental sites are given in Table 2.

Sprinkler irrigation trials were carried out at 2012/2013 season on two sowing dates; 21th November (favorable sowing) and 20th December (late sowing) with 1840 and 1530 m^3/fad., respectively. The plot area 3.15 m^2 included 9 rows, 2 m long and 17.5 cm apart. Nitrogen fertilizer (110 Kg/fad.) in the form of ammonium nitrate (33.5% N) was applied in five equal doses, first split was applied at sowing while the other dosses were applied 15 days after sowing and then, in 15 days intervals. Phosphate and potassium fertilizers were applied at the rates of 150 kg/fad. (15.5% P_2O_5) and 50 Kg/fad. (48% K_2O), respectively before sowing for phosphate fertilizer, potassium fertilizer was added in two equal portions after 20 and 40 days from sowing.

Surface irrigation trials were carried out in four environments which are the combination between; two years (2013/2014 and 2015/2016) and two water regimes (drought and normal irrigations with 870 and 1830 m^3/fad, respectively). Plots were irrigated immediately after sowing and subsequent irrigations were done at tillering, jointing, flowering and grain filling stages under normal irrigation treatment. However, under water stress treatment, irrigation was prevented after tillering stage up to maturity. The plot area was 4 m^2 included 11 rows, 2 m long and 17.5 cm apart. Sowing dates were on 17 and 19th of November in the 1st and 2nd seasons, respectively. Fertilizer was applied at the recommended rate of 75 kg N and 31 kg P_2O_5/fad., with one third dose of nitrogen and full dose of phosphorous worked into the soil during seed bed preparation. Whereas the second dose of 50 kg N/fad., was applied prior to tillering stage using urea (46.5% N). Phosphorous was added as calcium superphosphate (15.5% P_2O_5). All other cultural practices were applied as recommended.

The combined analyses of variance were performed according to Gomez and Gomez (1984). The phenotypic stability analysis was computed as outlined by Eberhart and Russell (1966). The genotypic stability analysis was calculated according to Tai (1971). Coefficient of variability (CV_i) was computed according to Francis and Kannenberg (1978). Wricke's ecovalence (W^2_i) was estimated according to Wricke (1962). The superiority measure (P_i) was computed according to Lin and Binns (1988). The additive main effects and multiplicative interaction method (AMMI) was computed as proposed by Gauch (1988 and 1992). Spearman's rank correlation coefficient was performed according to Steel and Torrie (1980).

Table 1. Pedigree of 29 bread wheat lines, 5 durum wheat lines and 4 commercial check varieties

No.	Entry/Name		Pedigree	Selection history
G1	6003	Bread line 1	BABAX/LR42//BABAX*2/3/BRAMBLING/	CGSS01B00042T-099Y-099M-099Y-099M-16Y-0B
G2	6014	Bread line 2	BABAX/LR42//BABAX*2/3/TUKURU/	CGSS01B00050T-099Y-099M-099Y-099M-64Y-0B
G3	6013	Bread line 3	BABAX/LR42//BABAX*2/3/TUKURU/	CGSS01B00050T-099Y-099M-099Y-099M-45Y-0B
G4	6017	Bread line 4	BABAX/LR42//BABAX*2/3/BRAMBLING/	CGSS01B00046T-099Y-099M-099Y-099M-21Y-0B
G5	6032	Bread line 5	D67,2/P66,270//AE,SQUARROSA (320)/3/	CMSS99M02230S-040M-040SY-21M-1Y-0M-8Y-0B-0SY
G6	6029	Bread line 6	CROC_1/AE,SQUARROSA(224)//OPATA/3/PASTRO	CMSA00Y00086S-0P0Y-040M-040SY-030M-12ZTY-0M-0SY
G7	6034	Bread line 7	FRET2*2/KIRITATI	CGSS01B00061T-099Y-099M-099M-099Y-099M-3Y-0B
G8	6052	Bread line 8	KIRITATI/WBLL1	CGSS02Y00138S-099M-099Y-099M-44Y-0B
G9	6064	Bread line 9	QT6581/4/PASTOR//SITE/MO/3/CHEN/,	CMSA00M00159S-15M-3Y-0M-7Y-0B-0SY
G10	6067	Bread line 10	T,DICOCCON P194614/AE,SQUARROSA (409)//BCN	CMSS00M001113S-050Y-020M-030Y-030M-3Y-0M-0Y
G11	6068	Bread line 11	TC870344/GYI//TEMPORALERA M87/AGR/3/TOBA97	CMSA00Y00661S-0P0Y-040M-040SY-030M-3ZTM-0ZTY-0M-,
G12	6078	Bread line 12	WAXWING*2/4/SNI/TRAP#1/3/KAUZ*2TRAP//KAUZ	CGSS01B00055T-099Y-099M-099M-099Y-099M-64Y-0B
G13	6083	Bread line 13	WAXWING*2/KUKUNA	CGSS01B00057T-099Y-099M-099M-099Y-099M-11Y-0B
G14	6084	Bread line 14	WAXWING*2/KUKUNA	CGSS01B00057T-099Y-099M-099M-099Y-099M-13Y-0B
G15	6094	Bread line 15	WBLLI*2/BRAMBLING	CGSS01B00062T-099Y-099M-099M-099Y-099M-62Y-0B
G16	6093	Bread line 16	WBLLI*2/BRAMBLING	CGSS01B00062T-099Y-099M-099M-099Y-099M-47Y-0B
G17	6098	Bread line 17	WBLLI*2/KIRITATI	CGSS01B00063T-099Y-099M-099M-099Y-099M-15Y-0B
G18	6099	Bread line 18	WBLLI*2/KIRITATI	CGSS01B00063T-099Y-099M-099M-099Y-099M-50Y-0B
G19	6109	Bread line 19	YANAC/3/PRL/SARA//TSI/VEE#5/4/CROC_1/,	CMSA00Y00810T-040M-0P0Y-040M-040SY-030M-7ZTM-0ZTY
G20	6127	Bread line 20	TEMPORALERA M 87*2/KONK	CGSS99B00034F-099Y-099M-099Y-099M-44Y-0B
G21	6126	Bread line 21	TEMPORALERA M 87*2/CHOS	CGSS99B00034F-099Y-099M-099Y-099M-12Y-0B
G22	6125	Bread line 22	KINGBIRD	CMSS99M00216S-040M-030Y-030M-16Y-2M-0Y
G23	12/08	Bread line 23	ICB97-0727-0AP	
G24	13/08	Bread line 24	ICB97-0838-0AP	
G25	14/08	Bread line 25	ICB97-1207-0AP	
G26	Giza 168	Check variety	MIL/BUC//SERI	CM93046-8M-0Y-OM-2Y-OB
G27	Sakha93	Check variety	SAKHA 92/TR 810328	S8871-1S-2S-1S-0S
G28	3	Bread line 26	CWB117-77-77-9-7/ICB-102893//GKOmega	ICBH94-0114-0AP-0AP-9AP-0AP
G29	15	Bread line 27	ICB91-0539-7APP-0AP-3AP-0AP	
G30	13	Bread line 28	ICB97-0905-0AP	
G31	7846	Durum line 29	POHO_1/YEBAS_8//RASCON_37/2*TARRO_2	CDSS99B01121T-0TOPY-0M-0Y-1B-0Y
G32	7861	Durum line 30	BCRIS/BICUM//LLARETA INIA/3/DUKEM_12/,	CDSS99B01189T-0TOPY-0M-0Y-83Y-2M-0Y
G33	7894	Durum line 31	STOT//ALTR 84/ALD/3/GREEN_18/FOCHA_1//,	CDSS00Y01095T-0TOPB-13Y-0BLR-5Y-0B-0Y-1M-0Y
G34	7909	Durum line 32	RASCON_37/TAROO_2//RASCON_37*2/3/STO T// ,	CDSS00B00221T-0TOPY-0B-1Y-0M-0Y-1B-0Y
G35	7925	Durum line 33	CBC 509 CHILE/SOMAT_3,1/3/RASCON_37/,	CDSS00B00444T-0TOPY-0B-31Y-0M-0Y-1M-0Y
G36	6234	Bread line 34	CWB217-77-77-9-7/ICB-102893//	ICBH94-0114-0AP-0AP-9AP-0AP
G37	Sahel 1	Check variety	NS732/PIMA//VEE#5	CR735-4SD-1SD-1SD-OSD
G38	Misr 1	Check variety	OASIS/SKAUZ//4*BCN/3/2*PASTOR	CMSS00Y0188IT-050M-030Y-030M-030WGY-33M-0Y-0S

Table 2. Soil mechanical and chemical analyses of the experimental sites

Region	Properties	Sand (%)	Silt (%)	Clay (%)	Texture class	Organic matter	Available (N) ppm	Available (P) ppm	Available (K) ppm	pH
	Drip soil									
	2011/2012	85.4	3.5	11.1	Loamy sand	0.52	15.2	17.9	48.2	7.86
El-Khattara	2012/2013	85	10	5	Sandy	0.26	12.7	11.6	36.7	8.03
	Sprinkler soil									
	2012/2013	91.5	4.2	4.3	Sandy	0.26	8.5	10.6	33.8	8.13
Ghazalla	2013/2014	10	35	55	Clay	1.09	29.25	18.9	100.3	8.25

A PC Microsoft Excel, SPSS and SAS 9.1 ® Computer programs for Windows (2003) were used for the statistical analysis. Differences among genotype means were tested using a revised LSD test at the 0.05 level according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

Analysis of Variance

The combined analyses of variance for grain yield (ardab/fad.) (Table 3) showed highly significant differences among environments for this trait under all irrigation systems, suggesting that the environments under study were different under each irrigation system. Highly significant effects among years (Y) were obtained for drip and surface irrigation systems. This result reflects the wide differences in environmental conditions prevailing during the growing seasons for each irrigation system. The main effect of water irrigation levels (I) was highly significant for both drip and surface irrigation systems. The studied wheat genotypes (G) had also highly significant differences for all irrigation systems, reflecting the wide genetic diversity between them.

Significant differences for the first order interaction of year x irrigation (Y × I) items were detected in each of the drip and surface irrigation systems, this indicated the different influences of environmental conditions on different water irrigation levels.

The first order interaction of genotypes × environments (G × E) were found in each irrigation systems, indicating that the studied wheat genotypes differed in their response to the environmental conditions, suggested that it is essential to determine the degree of stability for each genotype.

The first order interaction of genotypes × years (G × Y) differed significantly in drip and surface irrigation systems, moreover the genotype-years interaction component (G × Y) accounted for the most part of total G × E interaction in drip and surface irrigation systems. This means reveling that growing seasons had the major effect on the relative genotypic potential of grain yield (ardab/fad.). Otherwise, highly significant interactions between genotypes × irrigations (G × I) were found in drip and surface irrigation systems.

For the second order (G × Y × I) interaction, there were a differential response between genotypes to years and irrigations system for grain yield (ardab/fad.) under drip and surface irrigation systems. These results reflected the importance of environmental factors of each year and water irrigation levels on the performance of genotype regarding this trait under drip and surface irrigation systems.

Mean Performance

The analysis of variance revealed significant differences for grain yield (ardab/fad.) among the

Table 3. The combined analyses of variance over six, four and two environments for drip irrigation, surface irrigation and sprinkler irrigation, respectively and 38 wheat genotypes for grain yield (ardab/fad.)

SOV	Drip irrigation			Surface irrigation			Sprinkler irrigation		
	df	SS	MS	df	SS	M.S	df	SS	MS
Environment (E)	5	8054.559	1610.912**	3	5319.612	1773.204**	1	878.439	878.439**
Reps./ Env.	12	868.440	72.370	8	17.884	2.236	4	1.165	0.291
Years (Y)	1	426.705	426.705**	1	232.637	232.637**			
Y × I	2	128.431	64.216**	1	8.061	8.061*			
irrigation (I)	2	7499.423	3749.712**	1	5078.914	5078.914**			
Genotypes (G)	37	2399.684	64.856**	37	982.840	26.563**	37	232.886	6.294**
G × E	185	1975.968	10.681**	111	1052.815	9.485**	37	109.729	2.966**
G × Y	37	406.874	10.997**	37	483.546	13.069**			
G × I	74	360.972	4.878**	37	288.306	7.792**			
G × Y × I	74	1208.122	16.326**	37	280.962	7.594**			
Pooled Error	444	929.566	2.094	296	619.872	2.094	148	34.293	0.232
Total	683	14228.217		455	7993.023		227	1256.512	

* , ** Significant at 0.05 and 0.01 levels of probability, respectively.

thirty eight wheat genotypes for all environments in three irrigation systems. Generally, drought stress and delay sowing date reduced grain yield for all genotypes compared with optimum water irrigation and favorable sowing date (Table 4).

The mean performance for wheat genotypes under drip irrigation of six environments exhibited that in 1st year, the average of grain yield varied from 9.74 to 18.82 (ardab/fad.) for G5 (Line 5) and G3 (Line 3), respectively for the 1st environment (severe water stress) with an average 14.47 (ardab/fad.). Moreover, in 2nd environment (moderate water stress) it ranged from 14.07 to 28.99 (ardab/fad.) for G6 (Line 6) and G13 (Line13), respectively with an average 20.22 (ardab/fad.). At the same time, it varied from 19.02 to 29.69 (ardab/fad.) for G24 (Line 24) and G13 (Line 13), respectively for the 3rd environment (optimum irrigation) with an average of 23.48 (ardab/fad.).

Furthermore, in 2nd year under drip irrigation, the lowest yield (9.66 ardab/fad.) was produced by G5 (Line 5), while the highest yield (18.31 ardab/fad.) was produced by G36 (Line 34) for the 4th environment (severe water stress) with an average 14.09 (ardab/fad.). Similarly, in the 5th environment (moderate water stress), the wheat line 18 (G 18) had the lowest yield (14.12 ardab/ fad.), while G35 (Line33) had the highest yield (21.80 ardab/fad.) with an average 17.81 (ardab/ fad.). Whereas, grain yield varied from 17.21 to 28.21 (ardab/fad.) for G21 (Line 21) and G31 (Line 29), respectively for the 6th environment (optimum irrigation) with an average of 21.38 (ardab/fad.).

With respect to sprinkler irrigation, the grain yield varied from 8.69 to 14.19 (ardab/fad.) for G1 (Line 1) and G38 (Misr 1), respectively for the 7th environment (favorable sowing date) with an average of 11.55 (ardab/fad.). Additionally, in the 8th environment (late sowing date) it ranged from 6.12 to 9.53 (ardab/fad.) for G18 (Line 18) and G13 (Line13), respectively with an average of 7.63 (ardab/fad.).

Subsequently, grain yield under surface irrigation varied from 11.33 to 18.99 (ardab/ fad.) for G30 (Line 28) and G18 (Line 18), respectively for the 9th environment (drought stress) with an average of 14.58 (ardab/ fad.). Moreover, it ranged from 16.00 to 25.76 (ardab/

Table 4. Mean performance for 38 wheat genotypes under different irrigation systems for grain yield (ardab/fad.)

Water system	Drip irrigation						Sprinkler irrigation		Surface irrigation				Comb.
Year	2011/2012			2012/2013			2012/2013		2013/2014		2015/2016		
Environment	L_1	L_2	L_3	L_1	L_2	L_3	S_1	S_2	Drought	Normal	Drought	Normal	
Genotype	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}	
G1	12.72	20.98	21.74	12.25	16.73	18.07	8.69	6.38	15.14	23.81	13.10	17.64	15.61
G2	14.57	15.91	21.65	12.95	15.21	18.64	9.72	7.41	12.09	21.33	13.17	18.06	15.06
G3	18.82	22.74	27.89	15.33	18.54	22.70	10.25	7.68	14.21	18.93	10.95	26.05	17.84
G4	17.84	22.54	24.23	14.09	16.28	17.80	11.39	7.44	14.81	22.40	14.83	21.41	17.09
G5	9.74	20.32	22.13	9.66	16.46	19.52	8.73	7.25	11.84	20.53	13.84	21.43	15.12
G6	9.80	14.07	21.28	11.09	16.22	24.52	9.56	8.06	13.74	22.69	14.30	20.54	15.49
G7	13.41	20.37	21.02	10.32	14.84	23.19	11.49	8.31	16.45	20.77	12.28	17.85	15.86
G8	14.92	20.39	24.01	13.25	16.05	23.63	11.81	7.62	13.67	17.67	13.88	20.89	16.48
G9	13.78	19.45	20.03	15.46	16.69	21.41	11.08	8.37	14.91	19.33	13.51	19.63	16.14
G10	12.17	17.81	22.19	12.81	17.29	18.36	9.71	7.25	12.13	19.39	13.27	20.83	15.27
G11	15.45	19.04	19.58	14.93	18.08	18.83	9.23	7.60	15.73	21.65	10.61	17.72	15.71
G12	15.90	20.74	26.94	12.70	18.10	23.34	13.05	8.77	14.75	19.76	9.13	17.94	16.76
G13	16.19	28.99	29.69	16.46	20.00	24.04	13.66	9.53	17.87	23.25	16.36	24.25	20.02
G14	14.60	26.74	28.73	14.10	19.07	23.47	13.23	9.21	16.74	25.39	16.28	24.53	19.34
G15	14.03	18.84	24.04	14.03	15.79	19.72	11.85	8.37	15.23	20.72	14.05	17.45	16.18
G16	13.55	20.30	24.82	11.28	18.42	20.64	11.29	6.80	14.77	23.36	10.85	17.30	16.12
G17	15.65	20.76	20.96	9.68	15.55	17.29	11.81	6.61	17.49	20.83	16.77	22.56	16.33
G18	16.29	21.27	25.62	12.98	14.12	18.66	10.45	6.12	18.99	19.40	13.24	18.92	16.34
G19	12.09	19.73	20.63	16.03	17.51	19.83	9.51	7.37	16.13	22.37	9.75	20.83	15.98
G20	11.00	22.66	24.05	11.67	17.40	20.03	12.15	7.35	14.29	19.89	11.22	17.61	15.78
G21	16.75	20.57	23.01	11.83	13.92	17.21	11.40	8.16	13.71	19.41	12.00	17.54	15.46
G22	16.92	20.60	22.94	13.98	17.71	21.47	12.59	8.25	14.48	19.20	10.03	16.70	16.24
G23	13.25	19.03	25.28	16.29	19.90	21.28	12.44	7.36	11.92	17.71	14.63	19.03	16.51
G24	17.58	15.90	19.02	15.48	17.34	20.27	8.84	7.33	15.01	23.12	14.27	20.10	16.19
G25	15.71	17.87	22.96	13.55	18.20	23.31	13.04	6.90	14.48	19.44	9.85	17.17	16.04
G26	13.17	19.11	22.73	16.66	20.93	20.33	13.43	7.82	13.73	20.26	12.95	21.12	16.85
G27	17.91	21.58	24.08	14.01	17.24	24.06	12.96	6.99	14.61	20.37	13.80	20.93	17.38
G28	14.79	21.05	24.57	14.72	17.43	21.58	13.07	7.32	13.65	25.76	14.92	17.78	17.22
G29	17.64	21.16	24.72	13.68	16.95	18.10	12.90	7.28	15.97	22.67	12.20	18.21	16.79
G30	12.30	20.57	21.11	16.73	19.20	20.20	10.80	7.42	11.33	16.00	11.50	14.91	15.17
G31	12.79	18.16	22.57	15.36	19.34	28.21	11.25	8.21	13.49	18.32	16.43	22.29	17.20
G32	17.75	19.69	23.35	16.57	21.79	27.12	13.73	8.53	13.65	21.84	11.33	19.89	17.94
G33	14.50	20.90	27.94	15.71	21.25	26.29	13.31	7.71	16.13	24.24	12.72	21.47	18.51
G34	14.36	20.97	24.14	17.67	18.48	24.20	11.93	8.04	12.35	21.96	9.68	21.11	17.07
G35	12.01	22.48	26.32	12.38	21.80	22.60	13.11	7.52	14.90	21.45	14.80	21.41	17.57
G36	12.29	16.85	18.84	18.31	19.45	21.08	11.30	6.13	13.09	16.77	11.04	16.57	15.14
G37	9.97	16.81	19.83	13.72	17.56	17.93	10.07	6.65	14.32	22.69	12.71	20.23	15.21
G38	17.74	21.49	27.65	17.67	20.03	23.52	14.19	8.74	16.14	22.80	13.34	23.44	18.90
Mean	14.47	20.22	23.48	14.09	17.81	21.38	11.55	7.63	14.58	20.99	12.88	19.82	16.58
LSD' $_{0.05}$	2.44	2.29	3.40	1.88	2.37	2.26	0.69	0.75	1.77	2.45	1.62	3.00	0.62
Env. index	-2.10	3.65	6.91	-2.49	1.24	4.80	-5.02	-8.95	-2.00	4.41	-3.69	3.25	
Reduction (%)	38.36	13.88		34.10	16.69			33.98	30.54		35.01		

Where, L_1=1st water level (severe), L_2 = 2nd water level (moderate), L_3 = 3rd water level (optimum), S_1 = 1st sowing date (favorable) and S_2 = 2nd sowing date (late) fad.) for G30 (Line 28) and G28 (Line 26), respectively for the 10th environment (well-irrigated) with an average of 20.99 (ardab/fad.) in the 1st year. On the other hand, in 2nd year grain yield varied from 9.13 to 16.77 (ardab/fad.) for G12 (Line 12) and G17 (Line 17), respectively for the 11th environment (drought stress) with an average of 12.88 (ardab/fad.) and it ranged from 14.91 to 26.05 (ardab/fad.) for G30 (Line 28) and G3 (Line 3), respectively for the 12th environment (well-irrigated) with an average of 19.82 (ardab/fad.).

In continuous, grain yield over twelve environments ranged from 15.06 to 20.02 for G2 (Line 2) and G13 (Line 13), respectively, with an average of 16.58 (ardab/fad.). Various investigators stated similar results (Hamam and Khaled, 2009; Tammam and Abd El Rady, 2010; Tawfelis *et al,*. 2011; Abd El-Shafi *et al.,* 2014; Abdallah *et al.,* 2015; El-Moselhy *et al.,* 2015 and Al-Maskri *et al.,* 2016), they reported that the mean performance of wheat genotypes differ from environment to another.

It is clear that, under drip irrigation, the drought stress caused a reduction in grain yield in the 1st and 2nd water levels by an average of 38.36% and 13.88% in the 1st year and 34.10% and 16.69% in the 2nd year, respectively compared with the 3rd level (optimum). In this respect, under surface irrigation, the reduction percentages were 30.54% and 35.01% in the 1st and 2nd years, respectively under drought compared with well-irrigated. The results of Kiliç and Yağbasanlar (2010), Amiri *et al.* (2013), Allahverdiyev *et al.* (2015) and Al-Maskri *et al.* (2016) supported the obtained results, where water stress is considered as the main factor limiting wheat plant growth and reduced grain yield.

The reduction percentage due to late sowing was 33.98% compared with favorable date under sprinkler irrigation, indicating delay sowing date reduced wheat grain yield as a results of exposure to high temperature, which reduces grain filling period. These results are in line with those reported by Mostafa *et al.* (2009); Hamam and Khaled (2009), who noted that delayed sowing caused marked reduction in grain yield. Abdallah *et al.* (2015) showed that grain yield/plant of bread wheat genotypes was significantly decreased (34.06%) with delaying sowing dates. Farooq *et al.* (2011) reported that late sowing or heat stress reduces plant photosynthetic capacity through metabolic limitations and oxidative damage to chloroplasts, with concomitant reductions in dry matter accumulation and grain yield.

Drought Sensitivity Index (DSI)

The drought sensitivity index (DSI) values for grain yield (ardab/fad.) were calculated in order to determine the stress tolerant of wheat genotypes based on minimization of yield, losses at water deficit (1st level) compared to normal irrigation (optimum) under drip and surface irrigation systems. The wheat genotypes showing DSI values less than 1.0 (DSI < 1) are more tolerant to drought stress while those with values above 1.0 are sensitive to drought stress. Analysis of variance for drought sensitivity index recorded significant differences for wheat genotypes.

Results presented in Table 5 show that the following wheat genotypes had the most desirable sensitivity index to drought tolerance (DSI < 1), *i.e*., G2 (Line 2), G3 (Line 3), G4 (Line 4), G9 (Line 9), G11 (Line 11), G18 (Line 18), G21 (Line 21), G24 (Line 24), G29 (Line 27) and G36 (Line 34) for 1st and 2nd seasons under drip irrigation; G7 (Line 7), G8 (Line 8), G9 (Line 9), G15 (Line 15), G17 (Line 17), G18 (Line 18), G21 (Line 21), G29 (Line 27), G30 (Line 28), G31 (Line 29) and G36 (Line 34) in both 1st and 2nd seasons under surface irrigation. Conversely, the wheat genotypes, *i.e*., G5 (Line 5), G12 (Line 12), G16 (Line 16), G20 (Line 20), G26 (Giza 168) and G33 (Line 31) had DSI above one at 1st and 2nd seasons under drip and surface irrigation systems, thus these genotypes were more sensitive to drought stress.

Heat Sensitivity Index (HSI)

The heat sensitivity index (HSI) values were calculated for determining the stress tolerant wheat genotypes based on minimization of yield, losses at late sowing date compared to favorable sowing (optimum) under sprinkler irrigation system. Significant differences among wheat genotypes were recorded for HSI under sprinkler irrigation system. Therefore, wheat genotypes G1 (Line 1), G2 (Line 2), G3 (Line 3),

Table 5. Drought sensitivity index (DSI) values for grain yield under drip and surface irrigation systems and heat sensitivity index (HSI) under sprinkler irrigation

Genotype	Drip irrigation		Surface irrigation		Sprinkler irrigation
	2011/2012	2012/2013	2013/2014	2015/2016	2012/2013
G 1	1.08	0.94	1.19	0.73	0.78
G 2	0.85	0.90	1.42	0.77	0.70
G 3	0.85	0.95	0.82	1.66	0.74
G 4	0.69	0.61	1.11	0.88	1.02
G 5	1.46	1.48	1.39	1.01	0.50
G 6	1.41	1.61	1.29	0.87	0.46
G 7	0.94	1.63	0.68	0.89	0.81
G 8	0.99	1.29	0.74	0.96	1.04
G 9	0.81	0.82	0.75	0.89	0.72
G 10	1.18	0.89	1.23	1.04	0.75
G 11	0.55	0.61	0.90	1.15	0.52
G 12	1.07	1.34	0.83	1.40	0.97
G 13	1.19	0.92	0.76	0.93	0.89
G 14	1.28	1.17	1.12	0.96	0.89
G 15	1.08	0.85	0.87	0.56	0.86
G 16	1.18	1.33	1.20	1.07	1.17
G 17	0.66	1.29	0.52	0.73	1.30
G 18	0.95	0.89	0.07	0.86	1.22
G 19	1.08	0.56	0.91	1.52	0.66
G 20	1.41	1.22	0.92	1.04	1.16
G 21	0.71	0.92	0.96	0.90	0.84
G 22	0.68	1.02	0.81	1.14	1.01
G 23	1.24	0.69	1.07	0.66	1.20
G 24	0.20	0.69	1.15	0.83	0.50
G 25	0.82	1.23	0.84	1.22	1.39
G 26	1.10	0.53	1.06	1.10	1.23
G 27	0.67	1.22	0.93	0.97	1.35
G 28	1.04	0.93	1.54	0.46	1.29
G 29	0.75	0.72	0.97	0.94	1.28
G 30	1.09	0.50	0.96	0.65	0.92
G 31	1.13	1.34	0.86	0.75	0.80
G 32	0.63	1.14	1.23	1.23	1.12
G 33	1.25	1.18	1.10	1.16	1.24
G 34	1.06	0.79	1.43	1.55	0.96
G 35	1.42	1.33	1.00	0.88	1.26
G 36	0.91	0.39	0.72	0.95	1.35
G 37	1.30	0.69	1.21	1.06	1.00
G 38	0.93	0.73	0.96	1.23	1.13

G6 (Line 6), G7 (Line 7), G9 (Line 9), G10 (Line 10), G11 (Line 11), G19 (Line 19), G24 (Line 24) and G31 (Line 29) exhibited HSI values less than unity (0.78, 0.7, 0.74, 0.46, 0.81, 0.72, 0.75, 0.52, 0.66, 0.50 and 0.80, respectively), hence these genotypes were considered as more tolerant to late sowing (heat temperature stress) regarding their grain yield (Table 5). Furthermore, the wheat genotypes showing HSI values near or equal 1.0 were moderate to late sowing, in this respect, wheat genotypes G13 (Line 13), G14 (Line 14), G15 (Line 15), G21 (Line 21) and G29 (Line 27), G34 (Line 32), G4 (Line 4), G22 (Line 22) and G37 (Sahel 1), had HSI values near one (0.89, 0.89, 0.86, 0.84, 0.92, 0.96,1.02, 1.01 and 1.0 respectively).

On the other side, G8 (Line 8), G16 (Line 16), G17 (Line 17), G18 (Line 18), G20 (Line 20), G23 (Line 23), G25 (Line 25), G26 (Giza 168), G27 (Sakha 93), G28 (Line 26), G29 (Line 27), G35 (Line 33), and G38 (Misr1) had HSI values more than 1.0, it may be classified as sensitivity to late sowing. Various investigators stated similar results (Abdel-Nour, 2011; Abd-Allah and Amin, 2013; Hamam, 2013; Abdallah *et al.,* 2015). They recorded a wide range of response to late sowing tolerance in wheat.

Joint Regression Analysis of Variance

The mean square of joint regression analysis of variance for grain yield of the thirty eight wheat genotypes under twelve environments (Table 6) exhibited highly significant differences among genotypes (G), environments (E) and the G × E interaction for this trait, indicating the presence of genetic and environmental variability among the studied wheat genotypes. In addition, the variance of environments was of greater magnitude than mean squares of genotypes (G) and Genotype × Environment (G × E). In this respect, Environment + Genotype x Environment (E + G × E) had highly significant effects for this trait. The G × E interaction was further partitioned into linear and non-linear (pooled deviation) components. The mean square due to environment (linear) was highly significant, indicating that differences existed between environments and revealed predictable component shared G × E interaction with un-predictable. Also, the linear interaction (G × E linear) was highly significant when tested against pooled deviation, showing genetic differences among genotypes for their regression on the environmental-index, so it could be proceeded in the stability analysis (Eberhart and Russell, 1966) for grain yield.

The non-linear (pooled deviation) responses as measured from regression was highly significant when tested against pooled error, indicating that a degree of non-linearity among 38 wheat genotypes across twelve environments still existed in the G × E interaction effects. Highly significant differences for G × E interaction for grain yield were reported by many investigators (Hamam and Khaled, 2009; El Ameen, 2012; Motamedi *et al.,* 2013; El-Moselhy *et al*., 2015; Al- Maskri *et al.*, 2016).

Phenotypic Stability

The estimates of phenotypic stability parameters have been computed according to Eberhart and Russell (1966) for evaluating the 38 wheat genotypes for grain yield.

The importance of both linear (b_i) and non-linear (S^2_{di}) sensitivity for the expression of the trait was thus evident. Eberhart and Russell (1966) procedure involves the use of joint linear regression where the yield of each wheat genotype is regressed on the environmental mean yield. According to phenotypic stability model, a stable wheat genotype should have a high mean yield, b = 1.0 and $S^2_{di} = 0$.

The regression coefficient (b_i) for grain yield of thirty-eight wheat genotypes ranged from 0.78 to 1.27 for G36 (Line 34) and G14 (Line 14), respectively, indicating the genetic variability among wheat genotypes in their regression response for this trait (Table 7). The (b_i) values were deviated significantly from unity (bi>1) for G3 (Line 3), G13 (Line 13), G14 (Line 14) and G33 (Line 31) (1.24*, 1.23*, 1.27* and 1.26*, respectively), indicating greater sensitivity to environmental changes and were relatively suitable in favorable environments, adequate water and other inputs. Meanwhile, the (b_i) value was deviated significantly and had less values than unity (b_i<1) for G36 (Line 34), indicating that this wheat genotype was adapted to drought stress and delay of sowing date. On the other side, remaining wheat genotypes had (b_i) values not deviated significantly from unity, indicating that these genotypes were adapted well under wide range of environments for grain yield (ardab/ fad.).

Table 6. Joint regression analysis of variance over twelve environments and 38 wheat genotypes for grain yield (ardab/fad.)

SOV	df	SS	MS
Environments (E)	11	9466.502	860.591**
Reps (Env.)	24	44.990	1.875
G × E	407	1537.281	3.777**
Genotypes (G)	37	649.393	17.551**
E + G × E	418	11003.784	26.325**
Environment (linear)	1	2989.422	2989.422**
G × E (linear)	37	6630.320	179.198**
Pooled deviation	380	1384.042	3.642**
Pooled Error	888	592.543	0.667

** Significant at 0.05 and 0.01 levels of probability, respectively.

Table 7. Genotype means over 12 environments and stability parameters of the 38 wheat genotypes for grain yield (ardab/fad.)

Genotype	Mean ($\overline{X}_g$)	PI	bi	S^2di	Alpha (α)	Lambda (λ)	P_i	W_i	CV (%)
G 1	15.605	-0.97	1.04	2.661**	0.043	4.657*	19.69	33.75	11.69
G 2	15.060	-1.52	0.87	1.224**	-0.125	2.646*	24.41	22.82	9.13
G 3	17.842	1.27	1.24*	5.682**	0.240	8.882*	8.92	77.82	14.12
G 4	17.088	0.51	0.97	3.088**	-0.025	5.254*	12.30	37.71	11.34
G 5	15.121	-1.45	1.10	3.406**	0.097	5.699*	22.37	43.07	13.35
G 6	15.488	-1.09	1.02	7.529**	0.021	11.469*	23.70	82.08	18.48
G 7	15.858	-0.72	0.94	2.815**	-0.058	4.872*	18.49	35.67	11.77
G 8	16.481	-0.09	1.00	1.665**	-0.001	3.263*	14.13	23.32	9.27
G 9	16.138	-0.44	0.82	0.308	-0.181*	1.364	17.12	17.88	6.12
G 10	15.267	-1.31	0.95	0.919	-0.050	2.219	21.89	16.49	8.25
G 11	15.705	-0.87	0.87	2.140**	-0.133	3.928*	20.37	32.50	10.67
G 12	16.760	0.18	1.08	3.413**	0.081	5.709*	13.88	42.44	12.05
G 13	20.024	3.45	1.23*	2.862**	0.234*	4.937*	1.76	48.88	9.38
G 14	19.340	2.76	1.27*	2.284**	0.268*	4.128*	3.34	47.32	8.88
G 15	16.176	-0.40	0.87	0.438	-0.133*	1.546	17.17	15.48	6.50
G 16	16.116	-0.46	1.14	1.459**	0.135	2.974*	16.50	25.82	9.05
G 17	16.330	-0.25	0.87	6.963**	-0.135	10.675*	18.33	80.83	16.92
G 18	16.339	-0.24	1.00	5.025**	-0.005	7.965*	16.27	56.93	14.60
G 19	15.983	-0.59	1.01	2.883**	0.005	4.968*	17.90	35.51	11.79
G 20	15.778	-0.80	1.05	2.048**	0.053	3.800*	17.95	27.86	10.44
G 21	15.459	-1.12	0.84	2.484**	-0.158	4.408*	21.57	37.70	11.48
G 22	16.240	-0.34	0.90	1.846**	-0.101	3.516*	16.70	27.66	9.76
G 23	16.512	-0.06	0.95	3.037**	-0.052	5.183*	15.90	37.72	11.66
G 24	16.190	-0.39	0.83	5.028**	-0.168	7.968*	19.80	63.98	14.74
G 25	16.040	-0.54	0.97	2.251**	-0.035	4.083*	18.06	29.48	10.65
G 26	16.853	0.28	0.91	1.772**	-0.092	3.412*	14.33	26.48	9.27
G 27	17.379	0.80	1.04	1.153**	0.041	2.546*	9.79	18.62	7.76
G 28	17.220	0.64	1.05	2.459**	0.051	4.374*	11.99	31.90	10.27
G 29	16.788	0.21	0.95	2.607**	-0.049	4.581*	14.27	33.34	10.78
G 30	15.173	-1.40	0.83	4.555**	-0.168	7.307*	24.26	59.25	15.06
G 31	17.200	0.62	1.01	7.450**	0.012	11.358*	13.73	81.21	16.56
G 32	17.935	1.36	1.04	4.639**	0.037	7.424*	10.20	53.40	12.84
G 33	18.513	1.94	1.26*	0.916	0.260*	2.213	6.25	32.62	6.80
G 34	17.073	0.50	1.13	2.653**	0.129	4.645*	11.79	37.37	10.67
G 35	17.567	0.99	1.16	2.338**	0.164	4.204*	9.68	36.70	9.87
G 36	15.143	-1.43	0.78*	5.134**	-0.219	8.116*	25.93	69.89	15.91
G 37	15.208	-1.37	0.93	3.326**	-0.072	5.587*	23.98	41.22	13.14
G 38	18.896	2.32	1.09	0.589	0.090	1.758	5.13	14.58	5.93
Mean ($\overline{\overline{X}}$)	16.576								
LSD 0.05	0.622								

$\overline{X}_g$ = grand mean (ardab/fad.), PI = phenotypic index ($\overline{X}_g$ - $\overline{\overline{X}}$), b_i = regression coefficient, S^2_{di}= mean square deviations from linear regression, α_i= linear response to environmental effects, λ_i = the deviation from linear response, P_i = cultivar superiority measure; W^2_i = Wricke's ecovalence and CV_i (%)= coefficient of variability.

* , ** Significant at 0.05 and 0.01 levels of probability, respectively.

The deviations from regression (S^2_{di}) for grain yield varied from 0.308 for G9 (Line 9) to 7.7529 for G6 (Line 6). The stable wheat genotypes with lowest S^2_{di} values and not significantly different from zero (0.308, 0.438, 0.589, 0.916 and 0.919) were G9 (Line 9), G15 (Line 15), G38 (Misr 1), G33 (Line 31) and G10 (Line 10). Conversely, the other wheat genotypes with the highest and significant (S^2_{di}) values were unstable. The desirable and stable wheat genotype according to three phenotypic stability parameters ($\bar{g}$, b_i and S^2_{di}) for grain yield was G38 (Misr 1) with a mean yield $\bar{g}$= 18.896 above the grand mean (16.576 ardab/ fad.), b = 1.09 and the S^2_{di} = 0.589. Wheat lines G9 and G15 were stable with b_i and S^2_{di} but had mean values below the grand mean. On the other side, wheat lines G3, G13, G14 and G33 had the highest mean values (17.842, 20.024, 19.340 and 18.513 ardab/fad) but b_i and S^2_{di} values were significant. Giza 168 (G26) and Sakha 93 (G27) were stable with mean yield values above the grand mean (16.853 and 17.379 ardab/fad, respectively) and b_i did not differ significantly from unity (0.91 and 1.04, respectively) but unstable with S^2_{di} values (1.772** and 1.153**). Also wheat lines G4, G28, G31 and G32 were stable with mean yield values above the grand mean and b_i did not differ significantly from unity but they had significant S^2_{di} values. Hence, these wheat genotypes could be useful in wheat breeding programs for improve grain yield under drought and heat stress.

Fig. 1 show that, wheat genotypes G13 (Line 13), G14 (Line 14), G38 (Misr-1), G33 (Line 31), G3 (Line 3), G35 (Line 33), G12 (Line 12) and G34 (Line 32) had $b_i > 1$ and $\bar{x}_i > \bar{\bar{X}}$. These wheat genotypes had greater sensitivity to environmental changes and had well adaptation to rich environments for grain yield (ardab/fad). The wheat genotypes G32 (Line 30), G27 (Sakha 93), G28 (Line 26) and G31 (Line 29) had b_i =1 and $\bar{x}_i > \bar{\bar{X}}$. These wheat genotypes had good adaptation to all environments. The wheat genotypes G4 (Line 4), G29 (Line 27) and G26 (Giza 168) had $b_i < 1$ and $\bar{x}_i > \bar{\bar{X}}$, they good adapted to poor environments. Furthermore, wheat genotypes G16 (Line 16) and G5 (Line 5) had b_i >1 and $\bar{x}_i < \bar{\bar{X}}$. These genotypes adapted poorly to rich environments. Meanwhile, the wheat lines G18 (Line 18), G19 (Line 19), G20 (Line 20), G1 (Line 1) and G6 (Line 6) had b_i =1 and $\bar{x}_i < \bar{\bar{X}}$, therefore they adapted poorly to all environments. Line 8 exhibited b_i =1 and $\bar{x}_i = \bar{\bar{X}}$, it adapted moderately to all environments. The remaining wheat genotypes in the left-lower quarter had $b_i < 1$ and $\bar{x}_i < \bar{\bar{X}}$ were adapted badly to poor environments.

Genotypic Stability Parameters

The results in Table 7 and Fig. 2 for grain yield show that all wheat genotypes were stable and insignificant for linear response to environmental effects (α_i) except G9 (Line 9), G13 (Line 13), G14 (Line 14), G15 (Line 15) and G33 (Line 31). On the other hand, all wheat genotypes exhibited significant values for the deviation from linear (λ_i) except G9 (Line 9), G10 (Line 10), G15 (Line 15), G33 (Line 31) and G38 (Misr 1).

A simultaneous consideration of the two genotypic stability parameters (αi and λi), the most desired and stable wheat genotypes were G10 (Line 10) and G38 (Misr 1) (α = -0.05 and 0.09, respectively and λ_i = 2.219 and 1.758, respectively).

The Superiority Measure (P_i)

Lin and Binns (1988) defined superiority measure (Pi) as the distance mean square between the wheat genotypes response and the maximum response over environments. Wheat genotypes with the lowest superiority measure (Pi) values are considered the most stable genotype. Accordingly, wheat genotypes G13 (Line 13), G14 (Line 14), G38 (Misr-1), G33 (Line 31), G3 (Line 3), G35 (Line 33), G27 (Sakha 93) and G32 (Line 30) had the highest stability. In contrast, wheat genotypes G2 (Line 2), G5 (Line 5), G6 (Line 6), G30 (Line 28), G36 (Line 34) and G37 (Sahel 1) had the lowest stability. There is a good similarity between the mean grain yield ranking and the superiority measure ranking a cross twelve environments (Table 7).

Wricke's Ecovalence (W^2_i)

Wricke (1962) defined the concept of ecovalence as the contribution of each wheat genotype to the genotype x environment (G × E) interaction sum of squares. When the ecovalence value is higher, the genotypes contribution to the

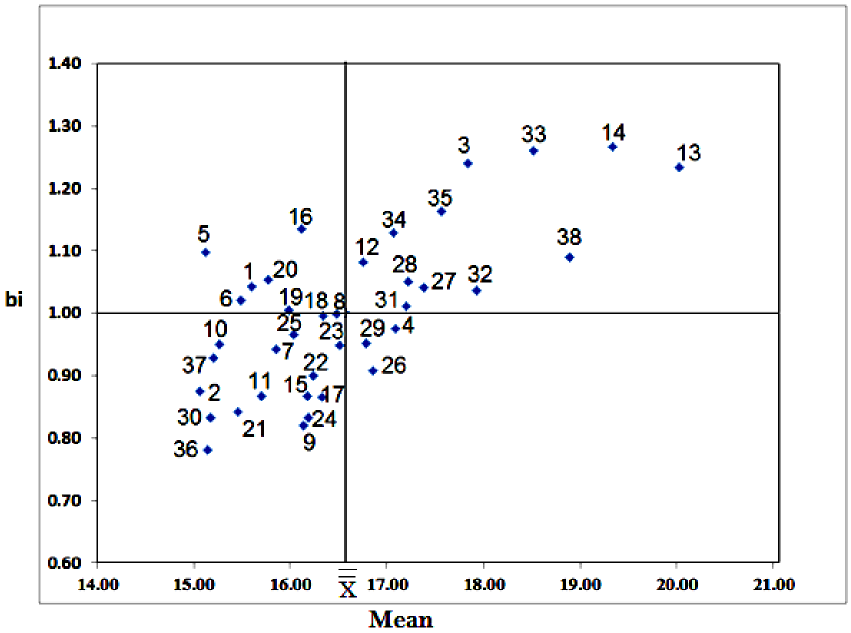

Fig. 1. Classification of 38 wheat genotypes based on the mean of grain yield (ardab/fad.) and regression coefficient b_i.

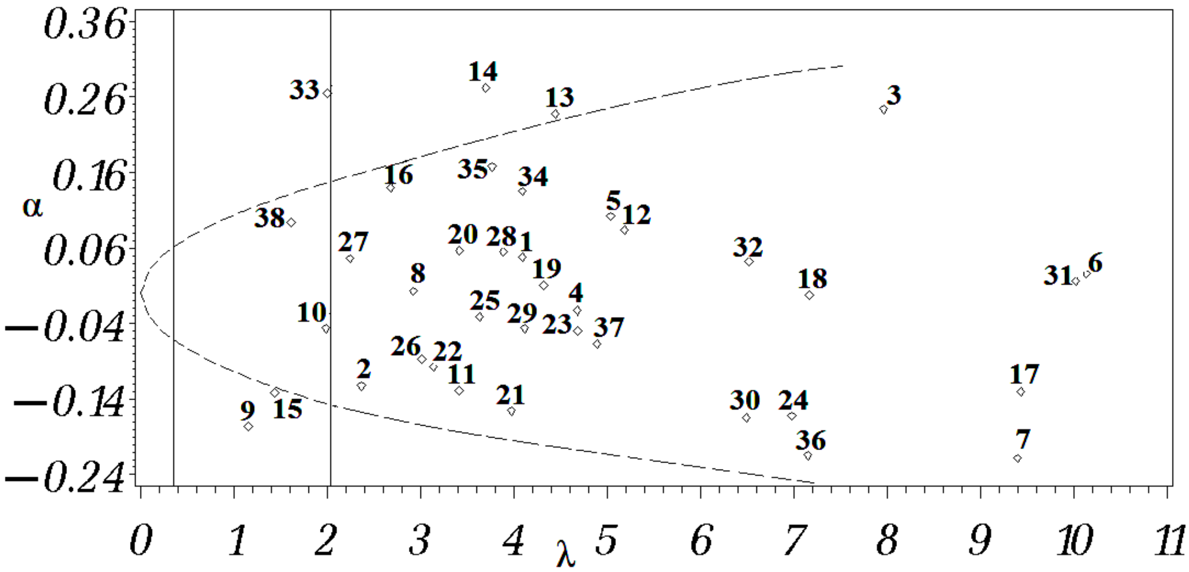

Fig. 2. Genotypic stability parameters (α_i and λ_i) for 38 wheat genotypes of grain yield (ardab / fad.)

total G × E sum of the squares is also greater. Based on Wricke's ecovalence parameter, it was found that the wheat genotypes G38 (Misr 1), G15 (Line 15), G10 (Line 10), G9 (Line 9), G27 (Sakha 93), G2 (Line 2), G8 (Line 8) and G16 (Line 16) were more stable as they exhibited minimum values of this parameter. On the other side, the wheat genotypes G3 (Line 3), G6 (Line 6), G17 (Line 17), G24 (Line 24), G31 (Line 29) and G36 (Line 34) had the lowest stability, they should high ecovalence (Table 7).

Coefficient of Variability (CV_i)

Francis and Kannenberg (1978) used the conventional CV (%) of each genotype as stability measure. The coefficient of variability measure depends on the diversity of the wheat environments in the experiments. Therefore, the wheat genotypes G38 (Misr-1), G9 (Line 9), G15 (Line 15), G33 (Line 31), G27 (Sakha 93), G10 (Line 10), G14 (Line 14) and G16 (Line 16) had stable over all the environments as they acquire minimum values (5.93, 6.12, 6.50, 6.80, 7.76, 8.25, 8.88 and 9.05, respectively) than other wheat genotypes. On the other side, the genotypes G6 (Line 6), G17 (Line 17), G31 (Line 29) and G36 (Line 34) were unstable, wherein they gave maximum CV (%) values (18.48, 16.92, 16.56 and 15.91%) than other wheat genotypes (Table 7).

Additive Main Effects and Multiplicative Interaction (AMMI) and the Sites Regression (SREG) Model

The analysis of variance for AMMI and SREG models for grain yield showed highly significant effects of environments (E), genotypes (G) and the G × E interaction (Table 8). Environments explained 77.21% of total variation and it was greater than genotypes (5.30%) and genotype × environment (GEI) (12.54%). The all IPCA scores of wheat genotypes in the AMMI and SREG analyses were significant except IPCA 11. IPCA 1 score explained 25.08% and IPCA 2 had 17.81% of the total GEI for AMMI model. Also, IPCA 1 score had 36.02% and IPCA 2 had 17.56% of the total GGEI for SREG model.

A genotype with the smaller AMMI stability value (ASV) is considered as more stable (Purchase, 1997; Purchase *et al.,* 2000). According to the ASV ranking (Table 9 and Fig. 3), wheat genotypes G35 (Line 33), G11 (Line 11), G15 (Line 15), G8 (Line 8), G27 (Sakha 93), G7 (Line 7) and G28 (Line 26) were more stable (0.160, 0.401, 0.409, 0.436, 0.447, 0.483 and 0.502, respectively). Conversely, wheat genotypes G17 (Line 17), G36 (Line 34), G31 (Line 29), G32 (Line 30), G18 (Line 18), G6 (Line 6) and G4 (Line 4) were unstable (2.285, 2.160, 1.975, 1.959, 1.732, 1.715 and 1.541, respectively).

GE Biplot Graph for the AMMI

Biplots graph scores of environments and genotypes of the first bilinear term (IPCA1) against scores of environments and genotypes of the second bilinear term (IPCA2) (Gabriel, 1971; Kempton, 1984) are presented in Fig. 3. The graphic display of the GEI biplot for 38 wheat genotypes (assessed G1 to G38) and twelve environments (assessed E1-E12) in the AMMI model for grain yield.

The wheat genotypes and environments that were located far away from the origin were more responsive to environmental changes. Environments E2, E3, E6, E11 and E10 were the most differentiating environments, while environments E1, E7, E8 and E12 were less responsive. Furthermore, the vertex wheat genotypes G3 (Line 3), G12 (Line 12), G36 (Line 34), G31 (Line 29), G6 (Line 6), G17 (Line 17), G18 (Line 18) and G13 (Line 13) were located far away from the origin, which were more responsive to environmental changes and are considered as specifically adapted genotypes, as they have the longest distance from the origin in their direction and genotypes with long vectors were assigned as either the best or the poorest performers in the environment.

Based on the genotype-focused scaling, the wheat genotypes G10 (Line 10), G27 (Giza 168), G15 (Line 15), G35 (Line 33), G8 (Line 8), G28 (Sakha 93), G19 (Line 19), G11 (Line 11) and G38 (Misr1) were the desirable. These wheat genotypes were located near the origin and had less responsive than the corner wheat genotypes.

Table 8. AMMI and SREG analysis of variance over twelve environments for grain yield (ardab/fad.)

Source of variation	df	AMMI			SREG		
		Sum of square	Mean of square	Percent	Sum of square	Mean of square	Percent
Environment (E)	11	28399.507	2581.773**	77.21	28399.507	2581.773**	77.21
Reps / Env.	24	44.990	1.875		44.990	1.875	
Genotype (G)	37	1948.179	52.653**	5.30	1948.179	52.653**	5.30
G × E	407	4611.844	11.331**	12.54	4611.844	11.331**	12.54
IPCA1	47	1156.800	24.613**	25.08	2362.790	50.272**	36.02
IPCA2	45	821.410	18.254**	17.81	1151.880	25.597**	17.56
IPCA3	43	743.560	17.292**	16.12	777.060	18.071**	11.85
IPCA4	41	471.020	11.488**	10.21	525.220	12.810**	8.01
IPCA5	39	434.440	11.139**	9.42	461.600	11.836**	7.04
IPCA6	37	340.700	9.208**	7.39	431.700	11.668**	6.58
IPCA7	35	225.040	6.430**	4.88	258.330	7.381**	3.94
IPCA8	33	145.530	4.410**	3.16	222.950	6.756**	3.40
IPCA9	31	121.590	3.922**	2.64	142.410	4.594**	2.17
IPCA10	29	92.250	3.181**	2.00	121.200	4.179**	1.85
IPCA11	27	59.460	2.202	1.29	70.350	2.606	1.07
Pooled Error	888	1777.630	2.002		1777.630	2.002	
Total	1367	36782.15			36782.15		

* , ** Significant at 0.05 and 0.01 levels of probability, respectively.

AMMI, Additive Main Effects and Multiplicative Interaction; SREG, the Sites Regression Model.

Table 9. Scores of the 38 wheat genotypes and twelve environments considered (E_1-E_{12}) for two first axes of the biplot representation (IPCA 1 and IPCA 2) and AMMI stability value (ASV) for AMMI and SREG models

Genotype	AMMI				SREG	
	IPCA 1	IPCA 2	ASV	Rank	IPCA 1	IPCA 2
G1	-0.848	-0.559	1.319	24	-0.665	-0.93
G2	-0.112	-0.645	0.664	12	-1.081	-0.23
G3	-0.110	1.177	1.187	21	1.277	0.04
G4	-1.094	0.047	1.541	32	0.347	-1.10
G5	-0.567	-0.597	0.997	18	-0.724	-0.60
G6	0.492	-1.569	1.715	33	-0.872	0.39
G7	-0.319	-0.175	0.483	6	-1.361	-0.22
G8	0.173	0.362	0.436	4	0.118	0.22
G9	0.318	-0.503	0.673	13	-0.498	0.24
G10	-0.064	-0.505	0.513	8	-0.790	-0.13
G11	0.026	-0.400	0.401	2	-0.804	-0.09
G12	0.218	1.288	1.324	25	0.421	0.33
G13	-0.809	0.860	1.428	30	2.446	-0.60
G14	-1.000	0.229	1.427	29	1.971	-0.84
G15	-0.273	-0.139	0.409	3	-0.341	-0.31
G16	-0.369	0.259	0.580	11	-0.138	-0.35
G17	-1.510	-0.837	2.285	38	-1.892	-1.59
G18	-1.177	0.501	1.732	34	0.001	-1.16
G19	0.088	-0.529	0.544	10	-0.494	0.01
G20	-0.356	0.559	0.751	14	-0.258	-0.32
G21	-0.879	0.487	1.330	26	-0.624	-0.91
G22	0.262	0.829	0.907	16	-0.173	0.27
G23	0.758	0.278	1.104	19	0.053	0.78
G24	0.145	-1.322	1.338	27	-0.706	-0.03
G25	0.713	0.524	1.132	20	-0.301	0.72
G26	0.652	-0.260	0.954	17	0.057	0.62
G27	0.028	0.445	0.447	5	0.607	0.08
G28	-0.297	-0.278	0.502	7	0.326	-0.30
G29	-0.804	0.419	1.207	22	0.141	-0.81
G30	1.020	0.557	1.541	31	-0.867	0.98
G31	1.331	-0.621	1.975	36	0.315	1.35
G32	1.367	0.361	1.959	35	0.778	1.42
G33	0.523	0.287	0.790	15	1.360	0.64
G34	0.864	0.456	1.300	23	0.458	0.92
G35	-0.064	0.133	0.160	1	0.816	0.03
G36	1.525	-0.227	2.160	37	-1.135	1.41
G37	-0.055	-1.335	1.337	28	-1.097	-0.20
G38	0.202	0.442	0.526	9	1.521	0.30
E1	-0.502	1.064	1.278	4	1.307	-0.48
E2	-1.629	1.739	2.878	11	2.339	-1.40
E3	-0.785	2.047	2.327	8	3.038	-0.43
E4	1.968	-0.121	2.775	10	0.871	1.89
E5	1.667	-0.095	2.349	9	1.208	1.68
E6	2.347	0.253	3.316	12	1.723	2.52
E7	0.411	0.579	0.819	2	1.208	0.47
E8	0.222	-0.470	0.564	1	0.488	0.18
E9	-1.198	-0.545	1.773	5	0.744	-1.24
E10	-1.151	-1.655	2.316	7	0.892	-1.24
E11	-0.854	-1.951	2.292	6	0.641	-0.96
E12	-0.496	-0.846	1.097	3	1.873	-0.43

AMMI, Additive Main Effects and Multiplicative Interaction; SREG, the Sites Regression Model.

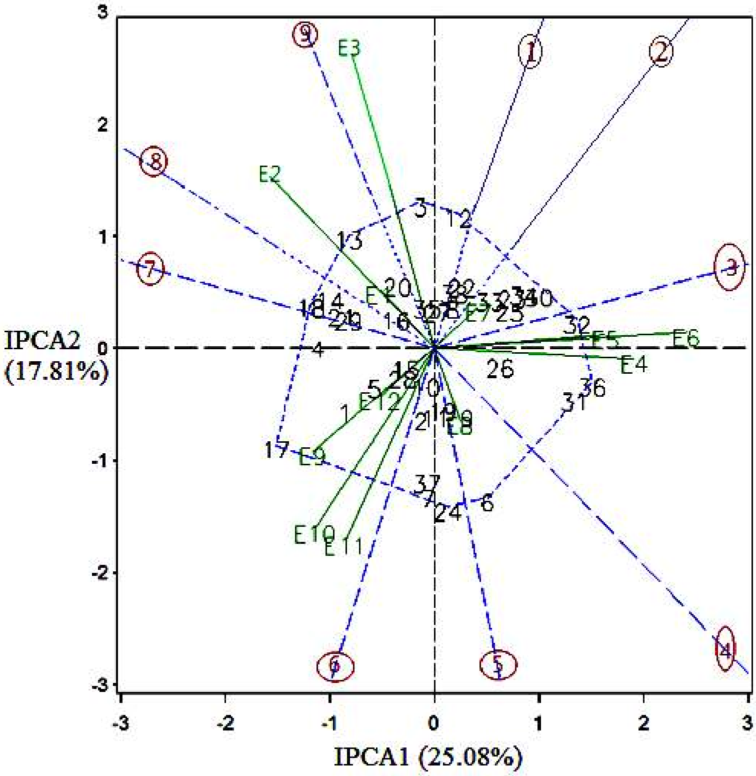

Fig. 3. Graphics display of the GE biplot for 38 wheat genotypes (assessed G1-G38) and twelve environments (assessed E1- E12) in the AMMI model for grain yield (ardab/fad.)

GGE Biplot for the SREG Mode

Fig. 4. show graphic display of the GGE biplot for thirty-eight wheat genotypes for grain yield assessed (G1 – G38) and the twelve environments considered (E_1-E_{12}) in the SREG model.

The results revealed that, G3 (Line 3) was ideal wheat genotype for grain yield, as it had the highest vector length of the high yielding genotypes (IPCA1 = 1.277) with zero GE (IPCA2 = 0.04), as represented by the arrow pointing to it in Fig. 4. A genotype is more desirable if it is located closer to the ideal wheat genotype, thus G35 (Line 33), G38 (Misr-1), G27 (Sakha 93), G33 (Line 31) and G28 (Line 26) were the most desirable wheat genotypes. The environments E_4, E_5, E_6 and E_7 were positively correlated because all angles among them were smaller than 90˚ (an acute angle), as well as among E_3, E_{12}, E_1 and E_2 (Table 10). Conversely, the environment E_9 with E_4, E_5 and E_6 had negatively correlated because the angle among them was higher than 90˚ (an obtuse angle). Moreover E_2 with E_5 and E_6 were not correlated (a right angle). The ideal test environment was E_3, it had large IPC1 scores (3.038) and small IPC2 scores (-0.43). The favorable environments were E_6, E_3 and E2, but the unfavorable ones were E_7, E_1, E_8 and E_{11} for grain yield.

Correlation Between Stability Parameters

The results in Table 11 show that the mean for grain yield ($\bar{X}_g$) had positive and significant correlation with linear response to environmental effects (α_i), regression of coefficient (b_i) and cultivar superiority measure (P_i), indicating that high grain yielding wheat genotypes had larger values for b_i and α_i and lower values for P_i. In contrast, mean grain yield was weakly correlated with the other stability parameters. Wheat genotypes with lower regression coefficients (b_i) tended to have lower yields and were more adaptable to poor environments. Positive and significant correlation coefficients between $\bar{X}_g$, bi, α_i and Pi were found between each other. A rank correlation coefficient between (bi) and (α_i),

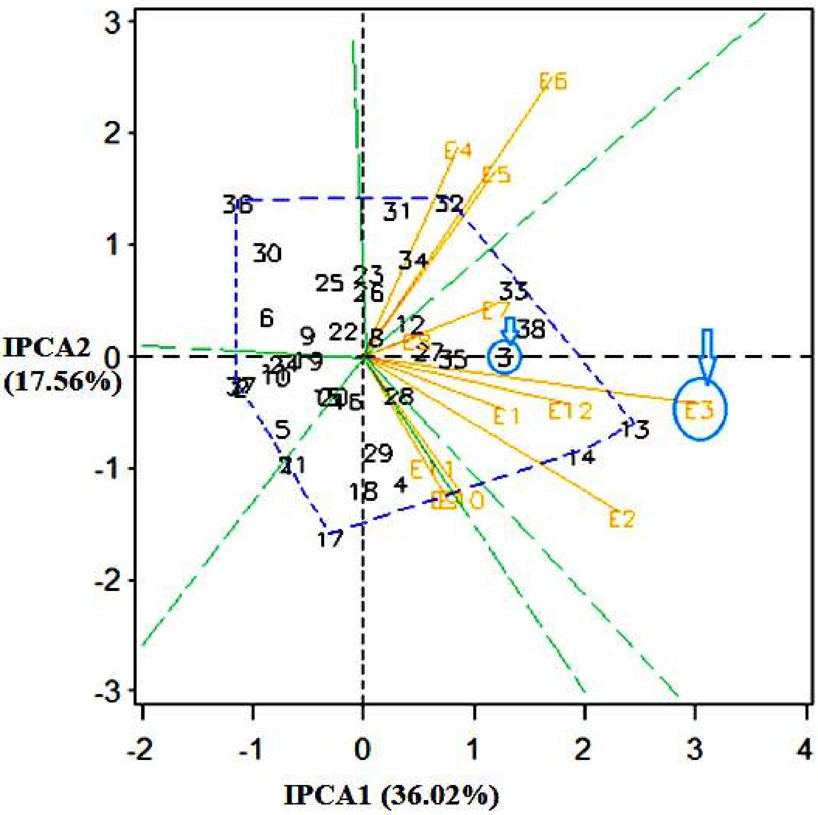

Fig. 4. Graphics display of the GGE biplot for 38 wheat genotypes (assessed G1-G38) and twelve environments (assessed E1- E12) in the SREG model for grain yield (ardab/fad.)

Table 10. Pearson correlation coefficients among twelve environments considered (E_1-E_{12})

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11
E1	1.000										
E2	0.330*	1.000									
E3	0.375*	0.731*	1.000								
E4	0.250	0.054	0.109	1.000							
E5	-0.020	0.206	0.351*	0.605**	1.000						
E6	0.096	0.126	0.386*	0.341*	0.556**	1.000					
E7	0.379*	0.484*	0.630*	0.298	0.504**	0.482**	1.000				
E8	0.221	0.398*	0.452**	0.220	0.260	0.513**	0.447**	1.000			
E9	0.359*	0.459*	0.314*	-0.129	-0.130	-0.027	0.210	0.108	1.000		
E10	0.089	0.246	0.266	-0.089	0.081	0.026	0.091	0.173	0.418**	1.000	
E11	-0.055	0.209	0.171	-0.149	-0.043	0.041	0.072	0.125	0.201	0.233	1.000
E12	0.183	0.408*	0.476**	0.129	0.272	0.334*	0.142	0.346*	0.269	0.282	0.480**

* , ** Significant at 0.05 and 0.01 levels of probability, respectively.

Table 11. Spearman's rank correlation coefficients between measures of stability for the 38 wheat genotypes across twelve environments

Stability measures	$\bar{X}_g$	b_i	S^2_{di}	Alpha (α)	Lambda (λ)	P_i	W^2_i	CV (%)
Mean ($\bar{X}_g$)	1							
b_i	0.580**	1						
S^2_{di}	0.080	0.045	1					
Alpha (α)	0.580**	1.00**	-0.045	1				
Lambda (λ)	0.075	0.046	1.00**	0.046	1			
P_i	0.972**	0.686**	0.183	0.686**	0.179	1		
W^2_i	-0.036	-0.041	0.945**	-0.041	0.945**	0.072	1	
CV (%)	0.295	0.209	0.958**	0.209	0.958**	0.393*	0.865**	1
ASV	-0.010	0.100	0.758**	0.100	0.759**	0.098	0.805**	0.684**

$\bar{X}_g$ = grand mean (ardab/fad.), b_i = regression coefficient, S^2_{di}= mean square deviations from linear regression, α_i= linear response to environmental effects, λ_i = the deviation from linear response, P_i = cultivar superiority measure; W^2_i = Wricke's ecovalence, CV_i%= coefficient of variability and ASV =AMMI stability value
* , ** Significant at 0.05 and 0.01 levels of probability, respectively.

also among (S^2_{di}) and (λ_i) was closely 1. The stability parameters *i.e.*, S^2_{di}, λi, W_i^2 , CV (%) and ASV were significantly correlated between each other, indicating that they measured similar aspects of stability. Hence, it is possible in wheat breeding program to use only one of them as a measure of stability. Similar results were recorded by Akcura *et al.* (2006) reported high rank correlations among $\bar{X}_g$, bi and α_i.

Conclusion

According to the various stability parameters, *i.e.* phenotypic stability, genotypic stability, cultivar superiority, Wricke's ecovalence and AMMI, the most desired and stable genotypes were Misr 1, Line 31, Sakha 93, Line 3, Line 10, Line 13, Line 14 and Line 16. These genotypes could be useful in wheat breeding programs for improving grain yield under various environments.

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REFERENCES

Abdallah, E., M.M.A. Ali, M.A. Taha and A.H. Salem (2015). Combining ability and mode of gene action for earliness, yield and some yield attributes of bread wheat (*Triticum aestivum* L.) genotypes grown under different sowing dates. Zagazig J. Agric. Res., 42 (2): 215-230.

Abd-Allah, S.M.H. and I.A. Amin (2013). Genotypic differences for heat tolerance traits in bread wheat using five parameters genetic model. Alex. J. Agric. Res., 58 (2): 83- 96.

Abdel-Nour, N.A.R. (2011). Genetic studies on grain yield and earliness components in bread wheat of different photothermal response. Egypt, J. Agric. Res., 89 (4): 1435-1461.

Abd El-Rahman, G. (2009). Water use efficiency of wheat under drip irrigation systems at Al-Maghara Area, North Sinai, Egypt. Ame.-Eurasian J. Agric. and Environ. Sci., 5 (5): 664 - 670.

Abd El-Shafi, M.A., E.M.S. Gheith, A.A. Abd El-Mohsen and H.S. Suleiman (2014) Stability analysis and correlations among different stability parameters for grain yield in bread wheat. Sci. Agric., 6 (3): 135-140.

Abdelraouf, R.E., S.F. El Habbasha, M.H. Taha and K.M. Refaie (2013). Effect of irrigation water requirements and fertigation levels on growth, yield and water use efficiency in wheat. Middle- East J. Sci. Res., 16 (4): 441-450.

Akcura, M., Y. Kaya, S. Taner and R. Ayranci (2006). Parametric stability analyses for grain yield of durum wheat. Plant Soil Environ., 52 (6): 254–261.

Allahverdiyev, T.I., J.M. Talai, I.M. Huseynova and J.A. Aliyev (2015). Effect of drought stress on some physiological parameters, yield, yıeld components of durum (*Triticum durum* Desf.) and bread (*Triticum aestivum* L.) wheat genotypes. Ekin J. Crop Breed and Gen., 1 (1): 50-62.

Al-Maskri, A., W. Al-Busaidi, H. Al-Nadabi, A. Al-Fahdi and M. M. Khan (2016). Effects of drought stress on wheat (*Triticum aestivum* L.) cv. Coolly. Int. Conf. on Agric., Food, Biological and Health Sci., (AFBHS-16) August 22-24, Kuala Lumpur (Malaysia): 128-130.

Amiri, R., S. Bahraminejad and S.J. Honarmand (2013). Effect of terminal drought stress on grain yield and some morphological traits in 80 bread wheat genotypes. Int. J. Agric. Crop. Sci., 5 (10): 1145-1153.

Brown, L.R. (2006). Plan B 2.0 Rescuing a Planet Under Stress and a Civilization in Trouble (W.W. Norton; Exp Upd editio). 365p. http://www.earth-policy.org/ mobile/ books/ pb/pbch7_ss3.

Eberhart, S.A. and W.W. Russell (1966). Stability parameters for comparing varieties. Crop Sci., 6: 36 – 40.

Eissa, M.A., M. Nafady, H. Ragheb and K. Attia (2010). Management of phosphorus fertigation for drip irrigated wheat under sandy calcareous soils. World J. Agric. Sci., 6 (5): 510-516.

El-Ameen, T. (2012). Stability analysis of selected wheat genotypes under different environment conditions in upper Egypt. Afr. J. Agric. Res., 7 (34): 4838-4844.

El-Habbasha S.F., E.M. Okasha, R.E. Abdelraouf and A.S.H. Mohammed (2014-15). Effect of pressured irrigation systems, deficit irrigation and fertigation rates on yield, quality and water use efficiency of groundnut. Int. J. Chem. Tech. Res., 7 (1): 475-487.

El-Moselhy, O.M., A.A.G. Ali, H.A. Awaad and A.A. Sweelam (2015). Phenotypic and genotypic stability for grain yield in bread wheat across different environments. Zagazig J. Agric. Res., 42 (5): 913-926.

Farooq, M., H. Bramley, J.A. Palta and K.H.M. Siddique (2011). Heat stress in wheat during reproductive and grain-filling phases. Critical Rev. in Plant Sci., 30:1–17.

Finlay, K.W. and G.N. Wilkinson (1963). The analysis of adaptation in a plant-breeding programme. Aust. J. Agric. Res., 14: 742–754.

Francis, T.R. and L.W. Kannenberg (1978). Yield stability studies in short-season maize. I. A descriptive method for grouping genotypes. Can. J. Plant Sci., 58: 1029-1034.

Gabriel, K.R. (1971). The biplot graphic display of matrices with application to principal component analysis. Biometrika, 58: 453–467.

Gauch, H.G. (1988). Model selection and validation for yield trials with interaction. Biometrics, 44: 705-715.

Gauch, H.G. (1992). Statistical Analysis of Regional Trials: AMMI Analysis of Factorial Designs. Elsevier, Amsterdam, Netherlands. 278.

Gomez, K.A. and A.A Gomez (1984). Statistical Procedures for Agricultural Research. 2nd Ed., John Wiley and Sons, New York.

Hamam, K.A. and A.G.A. Khaled (2009). Stability of wheat genotypes under different environments and their evaluation under sowing dates and nitrogen fertilizer levels. In: Aust. J. Basic and Appl. Sci., 3 (1):206-217.

Hamam, K.A. (2013). Response of bread wheat genotypes to heat stress. Jordan J. Agric. Sci., 9 (4): 486-506.

Kempton, R.A. (1984). The use of biplots in interpreting variety by environmental interactions. J. Agric. Sci., 103 : 123–135.

Khan, F.U. and F. Mohammad (2016). Application of stress selection indices for assessment of nitrogen tolerance in wheat (*Triticum aestivum* L.). The J. Anim. and Plant Sci., 26(1): 201-210.

Kharrou, M.H., S. Er-Raki, A. Chehbouni, B. Duchemin, V. Simonneaux, M. LePage, L. Ouzine and L. Jarlan (2011). Water use efficiency and yield of winter wheat under different irrigation regimes in a semi-arid region. Agric. Sci., 2: 273-282.

Kiliç, H. and T. Yağbasanlar (2010). The effect of drought stress on grain yield, yield components and some quality traits of durum wheat (*Triticum turgidum* ssp. durum) cultivars. Not. Bot. Hort. Agrobot. Cluj., 38 (1): 164-170.

Lin, C.S. and M.R. Binns (1988). A superiority measure of cultivar performance for cultivar x location data. Canadian J. Plant Sci., 68: 193-198.

Mostafa H.A.M., R.A. Hassanein, S.I. Khalil, S.A. El-Khawas, H.M.S. El-Bassiouny and A.A. Abd El-Monem (2009). Effect of arginine or putrescine on growth, yield and yield components of late sowing wheat. J. Appl. Sci. Res., 6:177-183.

Motamedi, M., P. Safari and H. Vaezi (2013) Study of stability and adaptation on yield components of bread wheat (*Triticum aestivum* L.) genotypes. Int. J. Biosci., 3(2): 234-240.

Noreldin, T., S. Ouda, O. Mounzer and M.T. Abdelhamid (2015). CropSyst model for wheat under deficit irrigation using sprinkler and drip irrigation in sandy soil. J. Water and Land Deve., 26: 57–64.

Purchase, J.L. (1997). Parametric analysis to describe genotype x environment interaction and yield stability in winter wheat. Ph. D. Thesis, Department of Agronomy, Faculty of the Free State, Bloemfontein, South Africa.

Purchase, J.L., H. Hatting and C.S. Van Deventer (2000). Genotype x environment interaction of winter wheat (*Triticum aestivum* L.) in South Africa: II. Stability analysis of yield performance. S. Afr. J. Plant Soil, 17: 101-107.

Rekaby, S.A., M.A. Eissa, S.A. Hegab and H.M. Ragheb (2016). Effect of nitrogen fertilization rates on wheat grown under drip irrigation system. Assiut J. Agric. Sci., 47 (3):104-119.

SAS Institute, Inc. (2003). SAS Proprietary Software Release 9.1. SAS Inst., Inc., Cary, NC.

Steel, R.G. and J.H. Torrie (1980). Principles and Procedures of Statistics. McGraw-Hill, New York.

Tai, G.C.C. (1971). Genotypic stability analysis and its application to potato regional trials. Crop Sci., 11:184-190.

Tammam, A.M. and A.G. Abd El Rady (2010). Genetical studies on some morpho-physiological traits in some bread wheat crosses under heat stress conditions. Egypt. J. Agric. Res., 89 (2): 589- 604.

Tawfelis, M.B., K.A. Khieralla, M.A. El Morshidy and Y.M. Feltaous (2011). Genetic diversity for heat tolerance in some bread wheat genotypes under upper Egypt conditions. Egypt. J. Agric. Res., 89 (4): 1463-1480.

USDA (2016). United States Department of Agriculture.https://apps.fas.usda.gov/psdonline/circulars/production.pdf.

Wang, J., S. Gong, D. Xu, Y. Yu and Y. Zhao (2013). Impact of drip and level-basin irrigation on growth and yield of winter wheat in the North China plain. Irrig. Sci., 31: 1025–1037.

Wricke, G. (1962). Über eine Methode zur Erfassung der Ökologischen Streuberite in Feldversuchen. Z. Pfanzenzüchtg, 47: 92-97.

Yates F. and W.G. Cochran (1938). The analysis of groups of experiments. J. Agric. Sci., 28: 556–580.

ثبات محصول القمح تحت بعض بيئات الجفاف ومواعيد الزراعة لنظم ري مختلفة

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أجريت عدة تجارب حقلية فى ١٢ بيئة مختلفة بهدف غربلة ٢٩ سلالة قمح خبز و ٥ سلالات قمح ديورم و٤ أصناف تجارية لتحمل الجفاف والإجهاد الحرارى تحت نظامي الرى بالتنقيط والرش فى ارض رملية والري بالغمر في أرض طينية ثقيلة، أظهر التحليل التجميعي وجود اختلافات عالية المعنوية بين البيئات والتراكيب الوراثية والتفاعل بين التركيب الوراثي × البيئة لجميع نظم الري، أعطت التركيب الوراثية أعلى محصول حبوب تحت نظام الرى بالتنقيط مقارنة بالرى بالرش والرى بالغمر، انخفض محصول حبوب جميع التراكيب الوراثية عند تعرض النباتات للجفاف والتأخير فى ميعاد الزراعة (الإجهاد الحراري)، تراوحت قيم متوسط محصول الحبوب عبر ١٢ بيئة بين ١٥,٠٦ للسلالة ٢ إلى ٢٠,٠٢ أردب/ فدان للسلالة ١٣، أعطت سلالات قمح الخبز ٩ ، ١٨ و ٢١ قيما مرغوبة لدليل تحمل الحساسية للجفاف تحت جميع نظم الرى، أظهر تحليل التباين للانحدار وجود اختلافات عالية المعنوية بين البيئات والتراكيب الوراثية والتفاعل بين التركيب الوراثي × البيئة وكذلك التفاعل بين البيئة + التركيب الوراثي x البيئة، أيضاً أظهر تحليل الثبات أن التفاعل الخطى بين التركيب الوراثى × البيئة كان عالي المعنوية لصفة محصول الحبوب، وأظهرت مقاييس الثبات تميز صنف قمح الخبز مصر ١ والسلالات ١٣ و١٤ وسلالات قمح الديورم ٣١ ، ٣٣ و٣٢ بدرجة عالية من الأقلمة لظروف البيئات الغنية، بينما كانت سلالة قمح الديورم ٣٤ متأقلمة لبيئات الجفاف والتأخير فى ميعاد الزراعة. وأظهر تحليل الثبات الوراثى أن السلالة ١٠ والصنف مصر١ كانا الأكثر ثباتاً، أظهر تحليل التباين للـ AMMI أن نسبة الاختلاف بين البيئات كانت ٧٧,٢١% من الاختلافات الكلية وبين التراكيب الوراثية ٥,٣% وبين التفاعل بين التركيب الوراثي × البيئة ١٢,٥٤%، بينما كانت نسبة الاختلافات لـ IPCA1 ١٧,٨١% و٢٥,٠٨% لـ IPCA2، بينما كانت قيم IPCA1 ٣٦,٠٢% و١٧,٥٦% للـ IPCA2 لتحليل SREG ، اظهر تحليل الثبات وفقاً لقيمة ASV أن التراكيب الوراثية لقمح الخبز (السلالة ١٠، جيزة ١٦٨ ، السلالة ١٥، السلالة ٨ ، سخا ٩٣) وسلالة قمح الديورم ٣١ كانت الأكثر ثباتا، أظهر شكل GGE أن السلالة ٣ كانت التركيب النموذجي حيث تميزت بالمحصول العالى وانخفاض قيمة تباينها فى البيئات المختلفة، أظهر تحليل معامل ارتباط الرتب وجود علاقة ارتباط موجبة ومعنوية بين كل من $\bar{X}_g$ ، bi، α_i و P_i وكذلك بين كل من مقاييس الثبات S^2_{di} ، λi ، W^2_i ، CV% و ASV ، مما يشير إلى إمكانية استخدام مقياس واحد من بينها للتعبير عن ثبات التراكيب الوراثية في البيئات المختلفة.

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