Egypt. J. Plant Breed. 24(4):823– 838(2020)

GGE-BIPLOT ANALYSIS OF YIELD STABILITY IN MULTI-ENVIRONMENTS OF SOME BREAD WHEAT GENOTYPES IN EGYPT

E.A.M. Abd Elhamid

Wheat Research Department, Field Crops Research Institute, A. R. C. Egypt

ABSTRACT

Seven promising bread wheat lines at six different locations, represented different ecological zones obtained from the national wheat research program and were tested with two new commercial cultivars Misr3 and Sakha 95. in a yield trial in two successive seasons (2017/2018 and 2018/2019). The experimental design was a randomized complete block design with four replications. Stability parameters of grain yield were calculated for the new promising lines and the two commercial cultivars. The results showed that the genotypes G2, G4, G5, G6 and G7 did not differ significantly out yield the two checks cultivars, Misr3 and Sakha 95. Line G6 and Misr 3 showed more stability in grain yield compared to the other genotypes. GGE-biplot analysis showed that it is preferable to grow the genotype G 6 in the regions of Sakha, Sids and Shandaweel, and the cultivar Sakha 95 at Nubaria and Etay-El-Barood regions, while genotype G7 was the best when grown in El-Mattana area. The genotype G6 was considered an ideal genotype.

Key words: ***Wheat, Triticum aestivum, Environment, GGE-Biplot, Multi-Environments, Phenotypic, Yield Stability.***

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal food commodities not only in Egypt but also all over the world. Currently, Egypt is one of the largest wheat importers in the world according to (US Wheat Associates Weigand, C. (2011). Wheat is an important staple food for about two billion people all over the world (36% of the world population). The annual consumption of wheat grains in Egypt is about 18.6 mil. t, while the annual local production is about 9 mil. t (2016). Grain yield was increased from 1.7 mt in 1980 to 9 mt. in 2016 and the increase was achieved by increasing wheat area from 1.34 to 3.26 mil. fed and grain yield from 1.3 to 2.76 t fed.-1 in the same period (Food and Agricultural Organization (FAO), (2016). Sahar *et al* (2018) reported that Egypt imports about 45% of its wheat requirements. An important objective of the Egyptian government is reducing the dependence on imported wheat by enhancing average grain yield and production (Abd El-Mohsen and Abd El-Shafi 2014). Reducing the gap between national production and consumption could be possible via expanding wheat area to the new reclaimed land and vertically, via growing high yielding cultivars and applying the recommended cultural practices (Abdel Aleem *et al* 1997, Hamada *et al* 2017 and Abdel-Majeed *et al* 2018). Many investigators reported significant differences among wheat cultivars in their response to the environmental conditions, hence, the stable cultivars with high grain yield could confront wheat production and preserve high level of grain yield (Mosaad *et al* 2000, Shehab EI-Din *et al* 2000, Hamada *et al* 2002 and Gad allah *et al* 2008).

The objectives of this investigation were: 1) to evaluate seven promising wheat lines and two cultivars (9 entries) under six locations for two years which represent a wide range of environments in Egypt, 2) estimate the stability parameters using some stability analysis methods, i.e. Eberhart and Russel (1966) and GGE biplot analysis to identify the ideal wheat genotype according to (Yan 2001.

MATERIALS AND METHODS

The materials of the present study consisted of promising nine bread wheat (*Triticum aestivum* L.) genotypes, including 7 wheat lines which were selected wheat research program in addition to the two new cultivars Misr 3 and Sakha 95. These genotypes were evaluated in two successive winter seasons (2017/2018 and 2018/2019) at six locations; namely Sakha (S), Etay Elbarood (ET), Nubaria(NU), Sids (Sd), Shandaweel(Sh) and EL-Mattana(MT). Names, pedigree and selection history of the tested genotypes are presented in Table (1).

Table 1. Name and pedigree of nine bread wheat genotypes used in the study.

Genotype	Names, pedigree and selection history
G1	WAXWING/MISR1 CGM10-103550-1GM-2GM-4GM- OGM
G2	SHANDWEEL 1 /4/ OASIS / SKAUZ // 4*BCN /3/ 2*PASTOR S. 16954 -019S -010S-4S -0S
G3	WBLL1*2/BRAMBLING // KAMB1*2/KIRITATI S. 17023 -033S -022S-1S -0S
G4	KAMB1*2/BRAMBLING // PFAU/MILAN S. 17101 -030S -025S-9S -0S
G5	ATTILA/3*BCN//BAV92/3/TILHI/5/BAV92/3/PRL/SARA//TSI/VEE#5/4/CROC_1/AE.SQUARROSA (224)//2 *OPATA*2 /6/ HUW234 + LR34 /PRINIA //UP2338 * 2 / VIVITSI CMSS10B01047T-099TOPY-099M-099NJ-099NJ-13WGY-0B-0S
G6	PASTOR//HXL7573/2*BAU/3/SOKOLL/WBLL1/6/2*OASIS/5*BORL95/5/CNDO/R143//ENTE/MEXI75/3/AE.SQ/4/2*OCI CMSA10M00162T-050Y-099ZTM-099NJ-099NJ-18WGY-0B-0S
G7	BAVIS #1*2 /4/PASTOR//HXL7573/2*BAU/3/ SOKOLL /WBLL1 CMSA10M00223T-050Y-099ZTM-099NJ-099NJ-9WGY-0B-0S
Misr3	ATTILA*2/PBW65*2/KACHU CMSS06Y00582T-099TOPM-099Y-099ZTM-099Y-099M-10WGY-0B-0EGY
Sakha95	PASTOR//SITE/MO/3/CHEN/AEGILOPS SQUARROSA (TAUS) //BCN /4/ BLL1 CMSA01Y00158S-040P0Y-040M-030ZTM-040SY-26M-0Y-0SY-0S-0SY-0S.

*** Source: Wheat Research Dep., Field Crops Res. Inst., ARC, Egypt.**

Planting dates in the six sites were within the optimum sowing date was between 10 and 30 November in the two growing seasons. The genotypes were evaluated in a randomized complete block design experiment with four replications according to Steel et al (1997). All cultural practices were applied as recommended for wheat production at each location.

Stability analysis

Stability analysis was carried out using Eberhart and Russell (1966) model. The following formula was used.

$Y_{ij} = \mu_i + B_i I_j + \partial_{ij}$ where:

Y_{ij} is the genotype mean of the ith genotype at the jth environment (i=1, 2... n); μ_i is the mean of the ith genotype over all environments.

$B_i I_j$ is the regression coefficient that measures the response of the ith genotype to varying environments.

∂_{ij} is the deviation from regression of the ith genotype at the jth environment and I_j is the environmental index obtained as the mean of all genotypes at the jth environment minus the grand mean. [$I_j = (\Sigma_i Y_{ij}/v) - (\Sigma_i \Sigma_j Y_{ij}/vn)$, $\Sigma_j I_j = 0$]

Eberhart and Russell (1966) proposed that the ideal variety is one that has three characteristics as follows:

1. Regression coefficient significantly different from zero ($b \neq 0$) and not significantly different from unity ($b = 1$).
2. Minimum value of the deviation from regression, i.e. ($S^2d = 0$).
3. High performance across a reasonable range of environments.

The regression coefficient (b_i) was used to determine the adaptation of the tested genotypes according to Finlay and Wilkinson (1963). Genotypes which here (b_i) less than unity are adapted to favorable environments, while those which their (b_i) more than unity are adapted to stress environments.

A superiority measure (P_i) was proposed by Lin and Binns (1988). It is defined as the distance mean square between the cultivars response and the best cultivar in each location. Let X_{ij} be the yield of the i^{th} cultivar grown in the j^{th} location, and let M_j be the maximum yield value among all cultivars in the j^{th} location. Then, the superiority measure of the i^{th} tested cultivar, (P_i), can be defined as the square of the mean square of the distance between the i^{th} tested cultivar and the maximum one over all locations as follows:

$P_i = \sum (Xij – Mj)2 /(2n)$ where, n is the number of locations.

GGE biplot analysis

The GGE biplot analysis (i.e., the genotype main effect (G) and the genotype × environment interaction (G×E) (Frutos *et al*. 2014 and Hossain *et al* 2018 is a useful tool for plant breeders and geneticists to find out the maximum yield and stable genotypes across multiple locations; as well as to find out the best favorable location for a specific genotype through acquiring graphical form (Gabriel 1971, Yan and Kang 2003 and Koutis *et al* 2012).

RESULTS AND DISCUSSION

Mean performance

The data in Table (2) show the results of the mean grain yield ard. Fad^{1}. of the studied genotypes the genotype G6 recorded the highest grain yield across the two seasons at Sakha and Sids locations. The cultivar Sakha 95 recorded the highest grain yield across the two seasons in Etay EL Barood and Nubaria locations. Genotypes G2, G3, G4, G5, G6 and G7 outyielded the two check cultivars at Shandaweel site in the first season and Sakha 95 in the second seasons. At EL-Mattana location, the genotypes G2, G3, G7 and Misr 3 surpassed the other genotypes and the check cultivar Sakha 95 in the first season, while the genotypes G1, G2, G4, G5, G6 and G7 did not differ significantly from the two check cultivars Misr 3 and Sakha 95 in the second season. The variation in grain yield revealed the distinct and differential effects of different environmental conditions. Similar results were obtained Kumar *et al* 2014 and Charan *et al* 2018.

Results also show the mean grain yield of the nine wheat genotypes evaluated under six different locations in the two growing seasons 2017/2018 and 2018/2019 and the average of the two seasons. Superiority of genotypes across the average differed from one location to another indicating GxE interaction. The check cultivar Sakha 95 and genotype G6 recorded the highest mean grain yield all over mean of the six locations in the first season, However, the genotypes G2, G4, G5, G6 and G7 did not differ significantly from the two check cultivars Misr 3 and Sakha 95 for mean of grain yield. These results are in harmony with those reported by (Kumar *et al* 2014, Gab Alla *et al* 2018, Abd EL-Hamid *et al* 2019 and Zen El- Abdeen 2019**).** Allard and Bardshow (1964) called these types of genotypes as well buffered genotypes that are preferred by plant breeders. Eberhart and Russell (1966) also identified the ideal cultivar as a high yielding one over a wide range of environments.

Stability parameters

The results of stability parameters using the models of Lin and Binns (1988) are presented in Table (3). Under this stability approach, the genotypes showing the lowest values of these parameters are considered stable. Results cleared that the five genotypes namely G2, G3, G4, G5, G7, and the check cultivar Misr 3 were considered to be the most stable genotypes where they had the minimum contribution of the (GxE) interaction. Piepho and Lotito (1992) pointed out that most stability statistics that based on variance components models have good properties under certain statistical assumptions, such as normal distribution of data while they will be used with caution if these assumptions are violated; *e.g.* in the presence of extreme values.

Eberhart and Russel (1966) proposed that an ideal genotype is the one which has the highest yield across a broad range of environments with a regression coefficient (b_i) value of 1.0 and deviation mean squares of zero. Thus, a genotype with unit regression coefficient ($b_i = 1$) and deviation not significantly different from zero ($S^2d = 0$) is considered to be the most stable genotype

The regression coefficient (b_i) for grain yield (ardab/fed.), deviated insignificantly from unity ($b_i > 1$) in the wheat promising genotypes G2, G3, G4, G5, G6, G7 and the check cultivar Misr3 indicating a greater sensitivity to environmental changes and were relatively suitable in favorable environments, (Shabana *et al* 1980). On the other hand the (b_i) values were significantly less than unity G1and the check cultivar Sakha 95 showing more suitability to stress environments. These findings for the genotype agrees with these obtained by (Patel *et al* 2014 , Kurt Polat *et al* 2016 and Zen El- Abdeen 2019).

Table 2. Mean grain yield (ardab/ fed) of nine bread wheat genotypes tested across 12 environments.

Years	2017/2018							2018/2019							Overall Mean
Loc. / Gts	Sakha	Etay.	Nubaria	Sids	Shand.	EL-Mattana	Mean	Sakha	Etay.	Nubaria	Sids	Shand..	EL-Mattana	Mean	
G1	21.84	14.36	15.18	21.90	17.62	24.22	19.19	17.26	20.87	20.25	26.90	24.13	21.36	21.79	20.49
G2	20.50	15.55	13.83	25.70	18.91	26.67	20.19	21.65	21.17	22.70	29.11	31.26	22.07	24.66	22.43
G3	21.68	14.44	12.91	19.82	20.09	25.60	19.09	20.84	21.98	24.93	29.77	28.17	19.86	24.26	21.67
G4	21.33	13.88	15.17	22.44	18.04	23.74	19.10	24.63	22.01	25.20	29.35	28.86	23.06	25.52	22.31
G5	20.48	16.10	14.24	22.27	17.25	24.64	19.16	21.77	23.27	27.73	29.70	28.56	24.98	26.00	22.58
G6	24.81	15.46	19.38	25.77	17.00	24.42	21.14	26.02	20.82	23.44	32.51	32.30	23.17	26.38	23.76
G7	20.55	15.75	13.78	23.36	18.85	26.91	19.87	25.24	22.19	24.51	29.12	30.64	25.29	26.17	23.02
Misr 3	21.14	15.33	17.96	24.30	16.57	27.41	20.45	23.53	23.27	26.11	29.40	31.95	23.92	26.36	23.41
Sakha 95	20.87	20.56	26.28	24.83	16.16	22.64	21.89	21.90	24.26	27.21	29.95	26.34	22.64	25.38	23.64
Mean	21.47	15.71	16.53	23.38	17.83	25.14	20.01	22.54	22.20	24.68	29.53	29.13	22.93	25.17	22.59
Lsd 0.05	2.17	1.86	1.65	2.13	3.01	2.64	1.14	1.77	1.96	2.18	2.51	4.27	4.51	2.49	1.55

Loc. = Locations and Gts = Genotypes

Table 3. Means, phenotypic index (Pi), regression coefficient (b) and deviation from regression (S^2d) for grain yield of nine wheat genotypes over 12 environments.

Genotype	$\bar{x}$	Pi	B	S^2 d
G1	**20.49**	**-2.10**	**0.78***	**1.82**
G2	**22.43**	**-0.16**	**1.12**	**1.51**
G3	**21.67**	**-0.92**	**1.06**	**2.55**
G4	**22.31**	**-0.28**	**1.07**	**0.14**
G5	**22.58**	**-0.01**	**1.08**	**1.27**
G6	**23.76**	**1.17**	**1.12**	**3.20**
G7	**23.02**	**0.43**	**1.12**	**1.32**
Misr 3	**23.41**	**0.82**	**1.12**	**0.18**
Sakha 95	**23.64**	**1.05**	**0.53***	**7.89**
Mean	***22.59***			
L.S.D$_{0.05}$	***1.55***			

Regression analysis

The mean squares of linear regression analysis across locations were significant among the 12 environments and nine genotypes for grain yield (Table 4). Accordingly, variance due to G x E interaction was significant. The variance due to genotypes x environments (G x E) interaction was further partitioned into linear and non-linear (pooled deviation) components. Mean squares values for both these components were significant, however, linear component was greater in magnitude than its counter parts pooled deviation; which revealed that there were genetic differences among genotypes for their regression on the environmental index, and performance of genotypes would be predicted for an individual environment. These results are in accordance with the findings of (Salem *et al* (2000), Yadav *et al* (2009), Patel *et al* (2014), Kurt Polat *et al* (2016) and Zen El- Abdeen (2019)

Table 4. Stability analysis of variance for 9 bread wheat genotypes at twelve environments.

SOV	df	S.S	M.S	f c
Total	107	2359.15		
V	8	103.95	12.99**	4.09
Env+(V×EN)	99	2255.20	22.78**	7.17
Env(linear)	1	1896.44	1896.44**	596.69
V×EN(Linear)	8	72.71	9.09*	2.86
pooled deviation	90	286.05	3.18*	3.27
G1	10	27.88	2.79**	2.87
G2	10	24.77	2.48**	2.55
G3	10	35.24	3.52**	3.63
G4	10	11.08	1.11	1.14
G5	10	22.41	2.24*	2.31
G6	10	41.71	4.17**	4.30
G7	10	22.88	2.29*	2.36
Misr 3	10	11.48	1.15	1.18
Sakha 95	10	88.59	8.86**	9.12
pooled error	324	314.58	0.97	

fc = f calculated

Environment identification by 'Which-Won-Where' pattern

The 'which-won-where' pattern view of the GGE biplot helps to identify which genotype performed the best in each environment and in each mega-environment. Mega-environment is defined as a group of environments that consistently participate the best set of genotypes (Yan and Rajcan 2002), as well as test environments with different winning genotype located at the vertex of the GGE polygon and situated in different sectors. Results of the tested six locations Sakha (S), Etay Elbarood (ET), Nubaria (NU), Sids (Sd), Shandaweel (Sh) and Mattana (MT) in Both seasons (1&2) were identified as (locations by seasons) all environments (S1, S2, ET1, ET2, NU1, NU2, Sd1, Sd2, Sh1, Sh2, MT1 and MT2) were located in sectors. The GGE biplot polygon view sides in Figure (1) facilitate comparison between genotypes. Based on genotype located at the extreme point of the polygon in a sector, the genotypes G6, Sakha 95, G1, G3 and G7 were the most responsive ones across all environments.

Whereas, the genotypes in the right side were the highest positively means converse in the left side with a negative response.

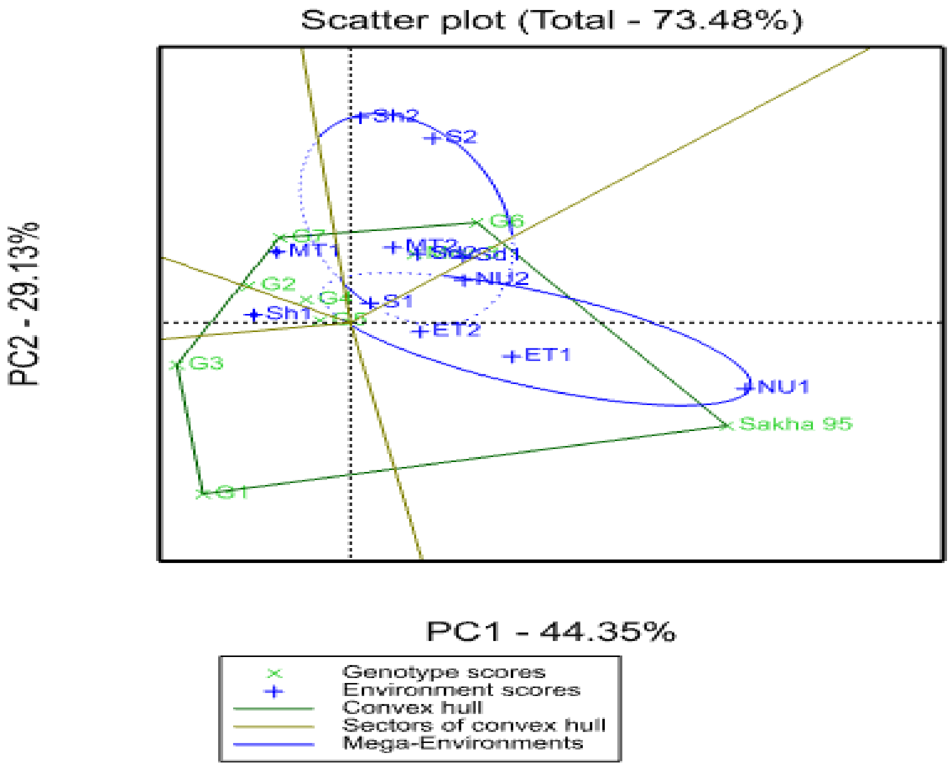

Fig. 1. Polygon of GGE biplot showing that difference of 12 environments of nine bread wheat genotypes. (2017/18 and 2018/19).

The polygon showed that all studied environments were divided into 4 mega-environments. The genotypes G6 and G7 were the most positively responsive in mega-environment 1 represented by locations, (Sh2, S2, MT2, Sd1, Sd2, Nu2, S1, and ET2) therefore, they had the highest grain yield. Meanwhile, the check cultivar Sakha 95 presented the most positively highest yield in mega-environment 2 which include Nu1, and ET1 locations.

However, mega-environment 3 and 4 containing (Sh1) and (MT1), respectively, had a negative response and the poorest yield was shown by genotype G2. The results of the present study are in accordance with previous findings of Muhammad Kadir *et al* (2018) and Akbar Hossain *et al* (2018).

The polygon view of a GGE biplot clearly displayed the which-won-where pattern Yan (2001) since each sector showed the vertex with the indicative genotype and the positions of all other genotypes showing their responsiveness to the environment under study.

A- Evaluation of genotypes and environments based on the ideal ones

Comparing the performance of the genotype and environments with that of an ideal genotype and environment, respectively can be used to evaluate both genotypes and environments (Yan 2015). Whereas, an ideal genotype and environment had high yield performance and stable across environments, as well as the ideal one was located in the first or the nearest concentric circle in the biplot. The closer to the ideal genotype and environment were the stable ones GGE-biplot for comparisons of the genotypes with the ideal genotype illustrated that genotype G6 was situated in the central circle (in the middle circle) which was considered as the ideal genotype with high yield potential and relative stability compared to the rest of evaluated genotypes. Figure (2). The genotypes (Misr3, Sakha 95 and G7) were considered as desirable genotypes because they are the closest to the ideal genotype or around the center of concentric circle. Meanwhile, the farthest genotypes from the ideal were considered as the poorest yielding ones. Alike the ideal environment locating in the first concentric circle in the environment focused biplot was S2 (Sakha, season2) to select widely adapted genotype yield. Environments Sd1 and Sd2 (Sids in both seasons) and MT1, NU1and Sh1. Mattana, Nubaria and Shandaweel in the second season were the nearest to the ideal environment followed by S1 (Sakha, season 1). This implied that, stability diversity may due to the change in the tested location not only, also It may be due to the difference in environmental conditions from one season to anther. These results were in line with these obtained by Akbar Hossain *et al* (2018) and Muhammad Kadir *et al* (2018)

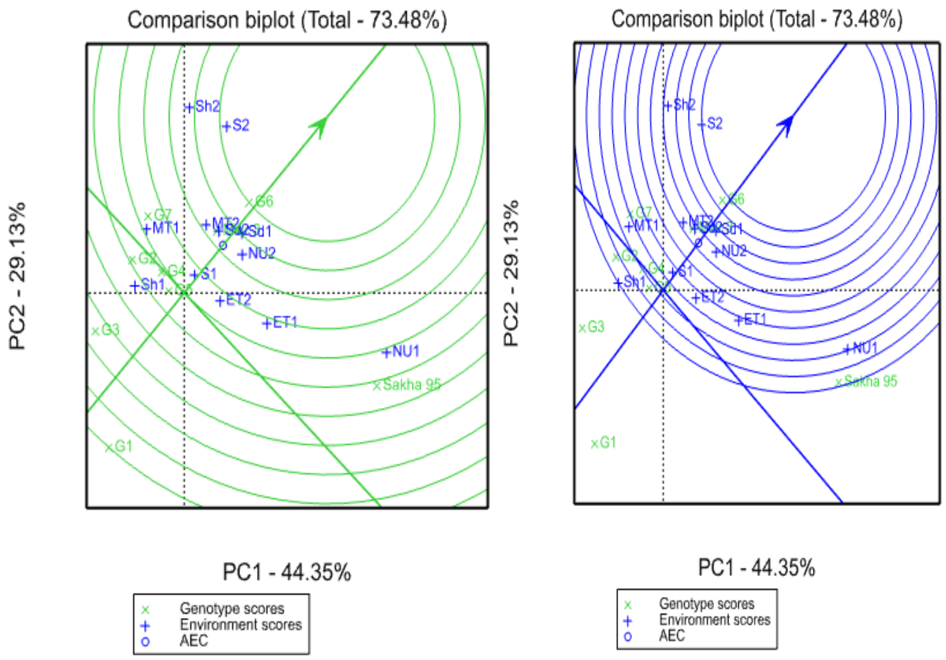

Fig. 2. Grain yield GGE-biplot showing the comparison of both genotypes and environments with the 'ideal' ones.

CONCLUSION

Bread wheat genotypes under study showed differences in stability and performance across environments and the importance of genotype by environment interactions were clearly observed. Therefore, exploiting genotype-environment interactions in crop improvement activities is the main target of plant breeder to identify the superior genotype. It is preferable to grow the genotype G6 in the regions of Sakha, Sids and Shandaweel, and it is preferable to cultivate the cultivar Sakha 95 in Nubaria and Etay-El-Barood regions, while Line 7 was the best when cultivated in El-Mattana area.

ACKNOWLEDGMENT

Sincere thanks to wheat research department FCRI, ARC, Egypt. financial and genetic materials for proving necessary facility to accomplish this search.

REFERENCES

Abd el Aleem, M. M., N. S. Hanna and S. K .Mahmoud (1997). Evaluation of some durum and bread wheat varieties for dual purpose of forage and grain Egypt. J. Appl. Sci., 12(11):127-141.

Abd El-Hamid E.A.M., M.A. Aglan And Eman M.A. Hussein (2019). Modified method for the analysis of genotype by trait (GT) biplot as a selection criterion in wheat under water stress condition. Egypt. J. Agron., 41 (3) pp 293-312.

Abd El-Majeed, S.E., A.A. Hamada, E.A.M. El-Saied, M.B. Toweefles, H.S. El-Borhamy, W.A.M. El-Awady, R.M.A. Kumber, A.A. Swelam, I.A. Amin, S.A.M. Sleem, S.M. Hassan, S.M.A. Abdel-Dayem, S.M. Hammad, M.A. Abdel-Rahman, S.A. El-Sawy, M.A. Hassan, M.A.M.A. El-Maghraby, A.M. Abdel-Al, M.Y. Ghoneam, A.A. Morad, H.M. El-Gharabawy, A.T.H. Moustafa, T.H. Abd El-Salam, A.A. Hagras, M.A. Aglan, E.A. Abd El-Hameed, Kh.I. Gad, W.Z.E. Farahat, Kh.El. Ibraheem, M.M. Zakaria, M.S.M. Mahmoud, A.M. Morsy, I.S.M. Abdel-Lateef, S.N. Nathan, M.N.T. Abdel-Kader, E.Gh. Galal, M.M. Mohiy, S.T. Eissa, G.A. Nour El-Din, M.Y.M Yossef, M.A. Darweesh, A.S. Abdel-Hameed, A.G. Abd El-Rady, M.M. Mohamed, M.M.M. Gab Alah, M.N.A. El-Hawary, M.S. Salous, A.A. Zain El-Abdeen, S.A. Mohamed, M.T. Shehab Eldeen, M.M.M. Yasseen, A.I Abdel-Sadek, A.M Sharshar, E.L.E. El-Masry, E.E. Moawad, Y.A. El-Gohary, Y.S.I. Koubissy, Y.M. Faltaos, G.M.M. Soliman, M.S.A Genady, M.O.E. Mohamed, O.M.A. El-Mosselhy, Z.A.A. El-Rashidy, S.I. El- Saied, A.M. Mostafa, A.A. Gomma, E.H. Ghanem, A.H. Abdel-Latif, N.S. Hanna, S.A. Ali, M.A.M. Eid, M.S.S. Saleh, M.A. Gouda, F.A.M. Hefnawy, A.A. Ageez, N.A.R. Abdel-Fatah, M.A. Moustafa, T.M. Shehab El Din, A.A. El-Hag, M.A.M. Abo Shereef, S.R.S. Sabry, M.M.M. Abde-Aleem, M.S.A Sharshar, A.M. Gad-Allah, G.A. El-Shaaray, E.M. Sadek, A.M. Tammam, M.A. Ismail, N.A. Reiad, A.M.M. Moussa, H.I. Hendawy, R.A. Abdel Salam, A.M.A. Abo-Warda, H.A. Ashoush, S.H. Abo El-Ela.(2018). Misr 3: A new Egyptian bread wheat cultivar. The Seventh Field Crops Conference, 18-19 Dec. Giza, Egypt 192 – 207.

Abd El-Mohsen, A.A. and M.A. Abd El-Shafi (2014). Regression and path analysis in Egyptian bread wheat. J. of Agri-Food and Appl. Sci., 2(5): 139-148.

Akbar Hossain, M.A.H.S. Jahan, Jagadish Timsina, Jaime A. Teixeira da Silva, M. Golam Mahboob and M. Farhad (2018). Biplot yield analysis of heat-tolerant spring wheat genotypes (*Triticum aestivum* L.) in multiple growing environments. Open Agriculture, 3: 404–413.

Allard, R.W. and A. D. Bardshow (1964). Implication of genotype - environmental interaction in application plant breeding. Crop Sci 4: 504-507.

Charan, S., P. Srivastava, A. Sharma, P. Kumar P. Chhuneja, V. S. Sohu and N. S. Bains (2018). Stability analysis for grain yield and some quality traits in bread wheat (*Triticum aestivum* L.) J. of Applied and Natural Science, 10 (1): 766-474.

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

Finlay, K.W. and G.N.Wilkinson , (1963) The analysis of adaptation in a plant brceding programme. Australian, Journal of Agricultural Research, Victoria, 14, 742-754.

Food and Agriculture Organization (FAO). (2016). Statistics Division, United Nations.

Frutos, E., M.P Galindo and V. Leiva (2014). An interactive biplot implementation in R for modeling genotype-by-environment interaction. Stoch. Env. Res. Risk A., 28 (7), 1629–1641.doi: 10.1007/s00477-013-0821-z

Gab Alla, M.M.M., Eman M.A. Hussein and W.M. Fares (2018). Evaluation of some bread wheat genotypes using genotype by trait (gt) bi-plot analysis. The Seventh Field Crops Conference, 18-19 Dec., Giza, 59 – 78.

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

Gad Allah A. M., M. A. EL- Maghraby and H. S. EL- Borhamy (2008). Genotype by environment interaction and its implications in stability of wheat genotypes. 1. ADV. Agric. REC., (Fac. AG. Saba Basha). 13(1):27-40.

Hamada, A.A., H.S. El-Borhamy, S.M. Hammad, M.A. Abdel-Rahman, A.A. Hagras, M.A. Aglan, E.A. Abd El-Hamid, W.Z. Farahat, Kh.El. Ibraheem, M.A. Darweesh, M.M. Mokhtar, M.N. El-Hawary, S.A. Mohamed, M.T. Shehab Eldeen, M.M. Yaseen, A.M Sharshar, M.S. Gendy, S. Abdel-Majeed, E.A. El-Sayed, M. Toweefles, W.M. El-Awady, S.H. Abo El-Ela, R.M. Kumber, A.A. Swelam, I.A. Amin, S.A. Sleem, S.M. Hassan, S.M. Abdel-Dayem, S.A. El-Sawy, M.A. Hassan, M.A. El-Maghraby, A.M. Abdel-Al, M.Y. Moubark, A.A. Morad, H.M. El-Gharabawy, A.T. Mostafa, T.H. Abd El-Salam, K.I. Gad, M.M. Zakaria, M.S. Mahmoud, A.M. Morsy, A.A. Mahmoud, I.S. Abdel-Latif, S.N. Nathan, M.N. Abdel-Kader, E.G. Galal, M.M. Abd El-Salam, S.T. Eesa, G.A. Nour El-Din, M.Y. Mohamed, A.S. Abdel-Majeed, A.G. Abd El-Rady, M.M. Mohamed, M.S. Salus, A.A. Zain El-Abdeen, A.I Abdel-Sadek, E.L.E. El-Masry, E.E. Moawad, Y.S.I. Kobessy, Y.M. Faltaoss, Y.A. El-Gohary, G.M.M. Soliman, A.A. Gomma, E.H. Ghanem, M.G. Mosaad, A.H. Abdel-Latif, N.S. Hanna, S.A. Ali, M.A. Moussa, M.S. Saleh, M.A. Gouda, F.A. Hefnawy, A.A. Ageez, N.A. Radi, M.A. Mostafa, T.M. Shehab El Din, A.A. El-Hag, M.A. Abo Shereef, S.R.S. Sabry, M.M.M. Abde-Aleem, M.S. Sharshar, A.M. Gad-Allah, G.A. El-Shaaray, E.M. Sadek, A.M. Tammam, M.A. Ismail, N.A. Reiad, A.M. Moussa, H.I. Hendawy, R.A. Abdel Salam, A.M.A. Abo-Warda, H.A. Ashoush,

M. Sallam and W. Abd El-Samad (2017). Sakha 95: a new high yielding and rust resistant bread wheat cultivar. Egypt. J. Plant Breed, 21(1):67-84.

Hamada, A. A., M. A. Abo – Warda, H.I. Hendawy and M. M. Abdel - Aleem (2002). Yield stability of some Egyptian newly released bread wheat cultivars. Minufyia J. Agric . Res., 27(6): 1377-1389.

Hossain, A., M. Farhad, M.A. Jahan, M.G. Mahboob, J. Timsina and J.A Teixeira da Silva.,(2018). Biplot yield analysis of heat-tolerant spring wheat genotypes (*Triticum aestivum* L.) in multiple growing environments. Open Agric. 3(1) 404–413. doi.org/10.1515/opag-2018-0045

Koutis, K., A.G Mavromatis., D. Baxevanos and M.,Koutsika-Sotiriou, (2012). Multi-environmental evaluation of wheat landraces by GGE biplot analysis for organic breeding. Agric. Sci., 3(1) 66–74. Doi: 10.4236/as.2012.31009.

Kumar, V., B. S. Tyagi, A. Verma and I. Sharma (2014). Stability analysis for grain yield and its components under different moisture regimes in bread wheat (*Triticum aestivum*) Indian J. of Agric. Sci., 84 (8): 931-936.

Kurt Polat, P. O., E. A. Cifci and K. Yagd (2016) Stability performance of bread wheat (*Triticum aestivum* L.) lines J. Agr. Sci. Tech. 18: 553-560.

Lin, C.S. and M.R. Binns (1988). A method for analyzing cultivar x location x year experiments: a new stability parameter. Theor. Appl. Genet. 76:425–430.

Mosaad, M., M. EI-Monofy, T. Shehab EI-Din, R. Mitkees, M. Mahrous, A. Hamada, A. Ageez, A. Bassiouni, M. El-Shami, M. Abdel Aleem, M. Eid, Abdel Ghani, M. Eskander, A. Hanna, S. Sabry, A. Abdel Latif, M. Sharshar , I. Sadek , M. Mostafa , A. Aba-Warda, Y. Abdel Gawad , A. Mousa , S. Abdel Majeed , A. Tammam , N. Abdel Fattah , M. Moshref, E. EISayed, H. Ashoush, M. Towfeeles , H. Mahjoub, A. Moustafa, F. Hefnawy, H. Hendawy, S. Ali, A. Abdel Karim, A. Khattab, M. Abdel Fattah, A. Menshawy, H. EI-Borhamy, A. Gomaa, F. EI-Sayed , O. Khalil, K. Hegazi , A. Ali, E. Ghanem , S. Mahmoud and M. Khalifa (2000). Gemmiza 9: A new Egyptian high yielding and rust resistant bread wheat cultivar for Delta region. J. Agric. Sci. Mansoura Univ. 25(12):7407-7419.

Muhammad, Kadir, Kaimuddin, B.Muhammad Farid, Yunus Musa, Amin Nur, Roy Efendi and Karlina Syahruddin (2018). GGE-biplot analysis of yield stability in environment trial of tropical wheat (*Triticum aestivum* L.) genotype under dry season in Indonesia Res. on Crops 19 (4) : 680-688

Patel, B. C., Y. M. Rojasara, V. R. Akbari and J. A. Patel (2014) Stability analysis for grain yield in bread wheat (*Triticum aestivum* L.) Journal of Wheat Research 6(2):160-162

Piepho, H. and S. Lotito (1992). Rank correlation among parametric and non-parametric measures of phenotypic stability. Euphotic, 64: 221-225.

Sahar, A. Farag, S.K.A. Ismail and Sawsan A. El-Ssadi (2018). Estimating phenotypic and genotypic path coefficient, an application on wheat (*Triticum aestivum* L.) genotypes. Int. J. Cur. Microbiol. App. Sci. 7(2): 2494-2505.

Salem, A. H., S. A. Nigem, M. M. Eissa and H. F. Oraby (2000). Yield stability parameter for some bread wheat genotypes. Zagazig J. Agric. Res., 27(4):789-803.

Shabana, R., T. Bailey and K. J. Frey (1980). Production traits of oats selected under low medium and high productivity. Crop Sci., 20(6):739-744.

Shehab EI-Din, T., M. EI-Monofy, M. Mosaad, R. Mitkees, M.Mahrous, A. Hamada, A. Ageez, A. Bassiouni, M. EI-Shami, M. Abdel Aleem, M. Eid, Abdel Ghani, M. Eskander, A.Hanna, S. Sabry, A. Abdel Latif, M. Sharshar, I. Sadek, M. Mostafa, A. Abo-Warda, Y. Abdel Gawad, A. Mousa, S. Abdel Majeed, A. Tammam, N. Abdel Fattah, M. Moshref, E. EI-Sayed, H. Ashousb, M.Towfeeles, H. Mahjoub, A. Moustafa, F. Hefnawy, H. Hendawy, S. Ali, A. Abdel Karim, A. Khattab, M. Abdel Fattab, Menshawy, H. EI-Borbamy, A. Gomaa, F. EI-Sayed, O. Khalil, K. Hegazi, A. Ali, E. Khanem, S. Mahmoud and S. Sherif (2000). Gemmiza 7: A new Egyptian long spike wheat cultivar. J. Agric. Sci., Mansoura Univ. 5(11):6709-6720.

Steel, R.G.D., J.H. Torrie, D.A. Dickey (1997). Principles and Procedures of Statistics: A Biometrical Approach. 3rd ed. Mc Graw Hill Book Co. New York.

Weigand, C. (2011). Wheat Import Projections Towards 2050. US Wheat Associates (USWA).

Yadav, S.K, R.S. Raje and S. R. Maloo (2009). Identification of high yielding, salt tolerant and stable genotypes of bread wheat. Indian Journal of Genetics and plant breeding, 69(4): 394-399.

Yan, W. (2001). GGE biplot - a Windows application for graphical analysis of multi-environment trial data and other types of two-way data. Agron. J. 93:1111–1118.

Yan, W. (2015). Mega-environment analysis and test location evaluation based on unbalanced multiyear data. Crop Sci., 55:113–122.

Yan, W. and I. Rajcan. (2002). Biplot evaluation of test sites and trait relations of soybean in Ontario. Crop Sci., 42:11–20.

Yan W. and M. S. Kang, (2003). GGE biplot analysis: A graphical tool for Breeders, Geneticists and Agronomists. CRC Press, Boca,

Zen El- Abdeen A.A. (2019). The performance and stability of some wheat genotypes under different environments. Egypt. J. Plant breed. 23(6):999– 1019.

تحليل المحاور الثنائية للثبات في المحصول لبعض التراكيب الوراثية من قمح الخبز في مصر

السيد على محمد عبد الحميد
قسم بحوث القمح- معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية- محطة بحوث سخا

تم اختبار سبعة تراكيب وراثية مبشرة ناتجة من البرنامج القومي لقسم بحوث القمح مقارنة مع اثنين من الأصناف التجارية الجديدة وهما مصر 3 وسخا 95 وذلك خلال الموسمين 2018/2017 و2018 /2019 بواقع 6 مواقع في كل موسم تمثل معظم المناطق الزراعية في مصر وكان التصميم المستخدم القطاعات الكاملة العشوائية في أربعة مكررات. وقد أظهرت النتائج عدم وجود فرق معنوي في محصول الحبوب بين السلالات 2و 4و 5و6و7 مقارنة بصنفي المقارنة سخا 95 ومصر 3 في حين كانت السلالة رقم6 والصنف التجاري مصر 3 الأكثر ثباتاً في المحصول مقارنة بالتراكيب الوراثية الأخرى واظهر تحليل المحاور الثنائية انه يفضل زراعة السلالة رقم 6 في مناطق سخا وسدس وشندويل ويفضل زراعة الصنف سخا 95 في منطقة النوبارية وايتاي الباورد بينما كانت السلالة رقم 7 الأفضل عند زراعتها بمنطقة المطاعنة وان السلالة رقم 6 تعتبر أفضل التراكيب الوراثي المثالي.

المجلة المصرية لتربية النبات 24(4): 823- 838 (2020)