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PERFORMANCE AND YIELD STABILITY ANALYSIS OF TWO-ROW BARLEY GENOTYPES UNDER DIFFERENT ENVIRONMENTS

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ABSTRACT

The present investigation was carried out to assess the phenotypic stability of grain yield and its contributing characters under eight different environmental conditions for 12 barley genotypes. Grain yield in different locations shows that Sakha and Gimmeza locations produced the highest grain yield (5.84 and 5.56) t/ha respectively. According to stability parameters (b_i, S^2_d, R^2_i) and average yield results revealed that L9, L10 promising lines and Giza 128 cultivar showed average stability with general adaptability. However, L1 and L8 were adapted to high yielding environments. On the other side, L2, L5 and L3 promising lines were adapted to low yielding environments.
Key words*: **Hordeum vulgare L., Stability, Grain yield, Genotype and interaction.***

INTRODUCTION

Barley used as (food, feed and malt) is one of the most important cereal crops grown in many developing countries as a valuable grain crop which rank 4^{th} among the cereal crops (FAOSTAT, 2022). It is generally consumed as food, and fodder (Pour-Aboughadareh *et al* 2021). In Egypt barley, extensive genetic diversity exists that provides ease to screen genotypes under marginal growth conditions. Barley exhibits moderate tolerance to salinity; however, it's morpho-physiological and yield attributes have been least studied on degraded marginal lands. Therefore, cultivation of a salt-tolerant barley genotype has been proposed as an alternative option to retain its yield in hyper arid and saline regions. In contrast, it is also essential to expose them to varying salinity levels for the evaluation of their growth, yield performance and physiological attributes. This kind of study is very important to develop efficient breeding programs and tool kits of salt tolerant crop genotypes and to assess the growth, physiological and yield traits under field conditions (El-hendawy *et al* 2005, Hussain *et al* 2017).

Abiotic stresses are major environmental constraint that halts the plant growth and results in devastating yield losses (Munns and Tester, 2008, Hussain *et al* 2016). Salinity is one of the main abiotic stress factors that also trigger the impact of secondary stresses (drought, oxidative). Additionally, agricultural lands are becoming scarce due to several anthropogenic activities, and it is predicted that if it will continue at the rapid, it will cause threat to food security by 2050 (Panuccio *et al* 2022). The effects of drought on yield of crops depend on their severity and the stage of plant growth during which they occur (Rauf *et al* 2007). Improve yield under drought is a major goal of plant breeding (Cattivelli *et al* 2008). The best strategy for crop productivity, yield improvement, and yield stability under drought conditions is to develop drought -tolerant crop varieties (Cattivelli *et al*. 2008). The objective of this study was select the genotypes stable to included in breeding program and selecting tolerant barley genotypes under different Egyptian conditions .

MATERIALS AND METHODS

Eight field experiments were carried out at four locations (Kafr El-Hamam, Gimmeza, Sakha and New Valley (El-Dakhla)), Egypt in two successive seasons (2019/2020 and 2020/2021) using 12 genotypes to study their yield and stability under studied environments.

1- Plant materials

The experimental materials for the study consisted of 12 barley genotypes. These genotypes were two cultivars Giza 128 and Fortona, 10 promising lines (L1, L2, L3, L4, L5, L6, L7, L8, L9 and L10). Name, pedigree and origin of studied genotypes are given in Table (1).

Table 1. Name, pedigree and origin of two-rowed barley genotypes.

Name	Pedigree	Origin
Giza 128	WI2291"/4/"11012-2"/"70-22425"/3/"Apm"/"IB65'//A116'	CHECK
FORTONA	SCARLET/ MARNI	CHECK
L1	CANELA//ATAH92/GOB	ICARDA
L2	PFC92126/BICHY2000	ICARDA
L3	AJO 61/6/Vmorales	ICARDA
L4	SVANHALS-BAR/MSEL//AZAF/GOB24DH /3/NE167/CLE176	ICARDA
L5	Check 2 - RIHANE-03	EGYPT
L6	Giza 128/Marsi	EGYPT
L7	Giza 128/WI 2291	EGYPT
L8	Giza 128/WI 2291	EGYPT
L9	Lignee1335+Soufara-02/3/RM1508/Por//WI2269/4/Hml-02/ArabiAbiad//ER/Apm	ICARDA
L10	WABAR2242//LIMON/BICHY2000	ICARDA

2. Description of the experiment sites

The description of the experiment sites including soil analysis and location are presented in Tables 2 and 3, respectively.

Table 2. Mechanical and chemical analysis of locations soil*.

Location	Available(ppm)			PH	Ec dc/m	$CaCo_3$ %	Clay %	Silt%	Sand %	Soil texture*
	N	P	K							
Kafr El Hamam	65.0	8.6	335	7.8	1.15	1.43	50.6	38.3	11.4	Loam
Gimmeza	53.2	18.6	490	7.7	2.01	3.86	39.6	41.8	18.6	Clay
Sakha	66.8	8.0	430	8.1	3.0	1.32	54.4	9.20	36.4	Clay Loam
New Vally	54.2	2.6	29.0	8.2	0.12	22.8	11.5	24.6	63.9	Sandy Loam

*** These analyses were done by soil and water Research Institute, ARC, Egypt.**

Table 3. Latitude, longitude and altitude of the experiment sites.

Site	latitude	longitude	Altitude
Kafr El Hamam	30 02 N	31 13 E	22 m
Gimmeza	30 48 N	31 07 E	9 m
Sakha	31 07 N	30 57 E	10 m
New Vally	31 17 N	32 27 E	14 m

3. Statistical analysis

Normality distribution in each environment was checked out by the Wilk Shapiro test (Neter *et al* 1996). An analysis of variance (ANOVA) was done for each environment separately. A combined analysis of variance was done from the mean data of each environment, to create the means for the different statistical analyses methods. Homogeneity test of variances was performed according to procedures reported by Gomez and Gomez (1984). To evaluate the stability of tested genotypes across the eight environments, parametric stability statistics were used to estimate stability in this study. Three stability parameters were performed. The first and second parameter were proposed by Eberhart and Russell (1966), *i.e*. the slope value (b_i) and deviation from regression parameter (S^2_{di}). The third was coefficients of determination (R_i^2) according to Pinthus (1973).

RESULTS AND DISCUSSION

Analysis of variance

Combined analysis of variance for grain yield is presented in Table (4). Results of combined analysis showed that differences among environments were highly significant for grain yield, indicating that the eight environments (E) are different in their conditions. And treatments showed significant effects for genotypes. Also, significant ($p<0.05$) mean squares due to genotypes (G) x environments interaction indicated that genotypes performed differently at different environments.

Table 4. Combined analysis of variance for grain yield of 12, two-row barley genotypes in 8 environments.

SOV	df	Mean squares
		Grain yield
Environments	7	7.33**
Rep/ environments	23	0.005
genotypes	11	2.06**
Env. X genotypes	77	0.05**
Pooled error		0.003

***, ** significant at 0.05 and 0.01 probability level, respectively**.

Mean performance

Data in Table (5) show the mean performance of the tested 12 barley genotypes across locations in 2019/2020 season. Results in Table (5) cleared that genotypes differed significantly and high significantly in all studied traits, except spike length. The vegetative growth stage (days to heading) ranged from 83 for (L6) to 95 (L1). Days to maturity from 136 days for L2 and Fortona to 125 days The Longer plant height ranged from 117 cm for L3 to 86 cm for L1. Spike length ranged from 10.9 cm for Giza 128 to 8.0 cm for L9. The highest grain yield of the first group was accompanied with high values of yield components, *i.e.* spikes/m2, grain weight/spike and biological yield (L9). On the other side, the low values of the yield components (Fortona in spikes/m2, L8 in weight/spike and L5 in biological yield. Similar results were also found by pervious investigators (Abad *et al* 2013, Talukder *et al* 2014 Lodhi *et al* 2015, Mondal *et al* 2016, Abdel-Raouf *et al* 2017 and A. Guendouz and Bendada 2022).

Table 5. Means of morphological characters and yield components for 12 barley genotypes across 8 locations in 2019/2020 season.

Genotypes	H.D. (day)	M.D. (day)	Plht (cm)	SPL (cm)	Ped.L (cm)	No. Spk/m^2	Wt G/spk	BY (t/h)
Giza 128	88	130	115.0	10.9	21.0	510	1.6	14.4
FORTONA	91	136	91.2	9.0	14.5	350	2.1	12.1
L1	95	135	86.0	8.8	14.0	368	1.2	12.0
L2	93	136	89.7	8.9	14.0	520	1.2	14.0
L3	90	130	117.0	10.4	23.5	300	1.6	14.4
L4	85	126	108.7	8.6	20.5	414	1.6	14.1
L5	90	129	102.2	9.2	18.5	520	1.9	9.7
L6	83	125	99.1	9.5	14.5	510	1.7	12.9
L7	84	125	110.8	9.7	25.5	379	1.3	11.6
L8	89	127	100.7	9.5	21.0	421	1.1	11.6
L9	88	134	106.6	8.0	22.5	540	2.2	14.5
L10	89	128	110.6	9.2	31.5	378	2.1	12.3
Mean	88.75	130.08	103.13	9.31	20.08	434.1	1.63	12.80
L.S.D	*	*	*	n.s	*	*	*	**

H.D. = Days from sowing to heading. M.D. = Days from sowing to physiological maturity.
Plht = plant height. SPL = spike length.
No.Spk/m^2 =. Number of spikes/m^2. Wt G/spk= Grain weight/spike.
Ped.L = peduncle length. BY = biological yield.
***, **, ns indicate significant at 0.05 and 0.01 levels of probability and non-significant, respectively.**

Data in Table 6 show the mean performance of the tested 12 barley genotypes across locations in 2020/2021 season. Results in Table (6) cleared that genotypes differed significantly and highly significantly in all studied traits, except days from sowing to heading and grain weight/spike. The vegetative growth stage (days to heading) ranged from 78 for (L3) to 86 (fortona). Days to maturity from 123 days for L6 and to 109 days Giza 128 and L7.

Table 6. Means of morphological characters and yield components for 12 barley genotypes across 8 locations in 2020/2021 season.

Genotypes	H.D. (day)	M.D. (day)	Plht (cm)	SPL (cm)	Ped. L (cm)	No. Spk/m²	Wt G/spk	BY (t/h)
Giza 128	80	109	104.5	9.5	16.0	385	1.3	11.0
FORTONA	86	119	105.5	9.0	13.5	387	1.6	10.8
L1	79	113	93.5	8.7	15.0	395	1.2	14.0
L2	82	115	99.5	9.7	13.5	500	1.1	13.4
L3	78	115	112.5	10.7	12.0	277	1.5	13.0
L4	80	118	108.0	10.2	15.0	390	1.2	13.0
L5	80	113	86.5	8.5	15.5	395	1.2	7.8
L6	89	123	91.0	9.0	12.5	511	1.3	8.7
L7	80	109	104.0	11.2	16.5	359	1.4	14.0
L8	85	118	100.5	9.7	14.5	491	1.1	9.2
L9	79	113	112.0	8.7	15.5	514	1.7	17.7
L10	83	120	121.0	10.0	18.0	502	1.5	12.0
Mean	81.75	115.42	103.21	9.58	14.79	425.50	1.34	12.05
LSD	ns	*	*	*	*	*	ns	**

H.D. = Days from sowing to heading. M.D. = Days from sowing to physiological maturity.
Plht = plant height. SPL = spike length.
No.Spk/m^2 =. Number of spikes/m^2. Wt G/spk= Grain weight/spike.
Ped.L = peduncle length. BY = biological yield.
***, **, ns indicate significant at 0.05 and 0.01 levels of probability and non-significant, respectively.**

The Longer plant height ranged from 121 cm for L10 to 86.5 cm for L5. Spike length ranged from 11.2 cm for L7 to 8.5 cm for L5. The highest grain yield of the first group was accompanied with high values of yield components, *i.e.* spikes/m^2, grain weight/spike and biological yield (L9). On the other side, the low values of the yield components (L3 in spikes/m^2, L2 and L8 in weight/spike and L5 in biological yield. Similar results were also found by pervious investigators (Abad *et al* 2013; Talukder *et al* 2014; Lodhi *et al* 2015, Mondal *et al* 2016, Abdel-Raouf *et al* 2017 and Guendouz and Bendada 2022).

Data in Table 7 show that the mean performance of the grain yield (t/ha) ranged from 1.43 to 7.32 t/ha for "L4" in E 4 and "L9" in E7, respectively.

Table 7. Mean grain yield (to/ha) for 12 barley genotypes and their combined mean across eight environments.

Genotypes	E1	E2	E3	E4	E5	E6	E7	E8	Mean
Giza 128	3.87	5.95	6.07	3.69	6.90	5.95	6.67	4.11	5.40
FORTONA	3.10	5.60	6.07	3.45	5.83	5.42	6.43	3.72	4.95
L1	2.62	5.24	5.83	2.98	5.54	5.54	6.37	3.68	4.72
L2	3.69	5.95	6.31	3.57	5.12	5.77	6.01	3.42	4.98
L3	3.39	5.36	5.60	2.86	5.95	5.06	3.57	3.27	4.38
L4	2.44	4.94	4.94	1.43	5.18	4.74	2.38	3.36	3.68
L5	2.44	4.76	5.00	2.62	4.64	4.40	4.88	2.89	3.95
L6	2.56	5.06	5.42	2.62	5.48	4.23	3.63	3.14	4.02
L7	3.39	5.00	5.06	2.50	6.49	4.40	5.65	2.89	4.42
L8	3.60	5.60	6.07	2.74	6.37	5.24	6.55	3.48	4.96
L9	3.71	6.67	7.14	4.17	6.55	6.55	7.32	4.29	5.80
L10	4.17	6.55	6.67	3.81	6.55	6.31	6.43	3.96	5.55
Mean	3.20	5.69	5.98	3.16	5.90	5.44	5.71	3.59	4.83

E 1= Kafr El Hamam season 2019/2020., E5= Kafr El Hamam season 2020/2021.
E 2= Gimmeza season 2019/2020., E 6= Gimmeza season 2020/2021.
E 3 = Sakha season 2019/2020., E 7 = Sakha season 2020/2021.
E 4 = New Vally season 2019/2020. E 8 = New Vally season 2020/2021.

With regard to yield in different locations across seasons and genotypes, Table (7) shows that mean of Sakha and Gimmeza produced highest grain yield t/ha in average of the two environments (5.84 and 5.56) respectively. The advantage of both locations may be due to its favorable conditions, *i.e.* soil characters and climate factors for growing barley. On the other hand, New vally location was the poorest location with lower values of grain yield (Table 7). This may be due to unfavorable conditions of this location.

Stability and adaptation parameters

The parameters estimated to evaluate the relative stability of 12 two-row barley genotypes across a range of environmental conditions are presented in Table 8.

According to Eberhart and Russell (1966) results in Table (8) and Figures (1) indicated that L9, L10 promising lines and Giza 128 cultivar could be considered stable genotypes because their (b_i) value did not differ significantly from unity and their (S^2_{di}) values did not differ significantly from zero for grain yield. These findings show that all genotypes exhibited by high values (≥ 0.75) of coefficient of determination (R^2_i), except L2 line for grain yield (0.55). This means that the linear regression was good fits to the actual values of grain yield for stable genotypes with high (R^2) value. On the other hand, the adapted genotypes to low yielding environments, *i.e.* which exhibited low (b_i) value < 1 are L6 and L7 promising lines for grain yield t/ha (Table 8 and Figure 1). These findings are in close agreement with those of Abdel-Raouf *et al* 2017and Guendouz and Bendada 2022).

Table 8. Stability parameters for grain yield of 12 barley genotypes over 8 environments.

Genotypes	$\bar{X}$	(b_i)	(S^2_{di})	(R^2_i)
Giza 128	4.86	1.05	0.07	0.93
FORTONA	5.96	1.35*	2.65*	0.66
L1	6.56	1.43*	0.04	0.96
L2	4.84	0.46*	0.93	0.55
L3	4.10	0.19*	1.87*	0.71
L4	3.96	1.10	0.09	0.57
L5	4.70	0.31*	0.54	0.56
L6	5.06	1.35*	2.92*	0.72
L7	4.38	1.31*	1.12	0.53
L8	5.34	1.11	1.71*	0.80
L9	4.74	1.05	0.07	0.96
L10	5.06	1.06	1.08	0.90

***, ** Significantly different from 1.0 for the regression coefficients and from 0.0 for the deviation mean squares at the 0.05 and 0.01 levels of probability, respectively.**

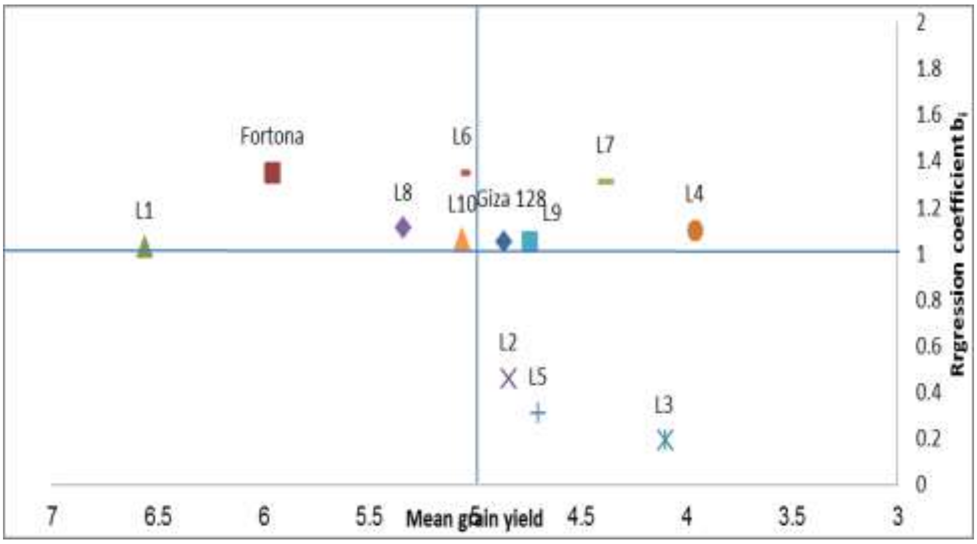

Fig. 1. Relationship between mean grain yield and regression coefficients of 12 barley genotypes tested across 8 different environments.

CONCLUSION

According to stability parameters (b_i, S^2_d, R^2_i) and average yield results revealed that L9, L10 promising lines and Giza 128 showed average stability with general adaptability. However, L1 and L8 were adapted to high yielding environments. On the other side, L2, L5 and L3 promising lines are adapted to low yielding environments.

REFERENCES

Abad, A., M.R. Khajehpour, M. Mahloji and A. Soleymani (2013). Evaluation of phenological, morphological and physiological traits in different lines of barley in Esfahan region. Intl J Farm and Alli Sci. 2 (18): 670-674.

Abdel-Raouf, M. S., A.A. Kandil, A.A. El-Sayed and A.M. Attya (2017). Stability of hull-less barley genotypes grown at different environments in Egypt.Alex. J. Agric. Sci. Vol. 62(1) :45-54.

Guendouz, A. and H. Bendada (2022). Stability analysis for the grain yield of some barley (*Hordum vulgare* L.) Genotypes growing under semi-arid conditions. International Journal of bio-resource and Stress Managemen . 13(2): 172-178.

Cattivelli, L, F. Rizza, F.W. Badeck, E. Mazzucotelli, A.M. Mastrangelo, E. Francia, C. Mare, A. Tondelli and A.M. Stanca (2008). Drought tolerance improvement in crop plants: An integrated view from breeding to genomics. Field Crop Res 105, 1-4. http://dx.doi.org/10.1016/j.fcr.2007.07.004

El-Hendawy, S.E., Hu. Yuncai, M. Gamal, M. Ahmed, E. Salah and Urs Schmidhalter (2005). Evaluating salt tolerance of wheat genotypes usingmultiple parameters.Europ. J. Agronomy 22 (2005) 243–253.

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

FAOSTAT (2022). Available online:http://faostat.fao.org (accessed on 20 January 2022).

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

Hussain, S.T., S. Lei, T. Akram, M. J. Haider, S.H. Hussain, and M. Ali (2018). Kurt Lewin's Process Model for Organizational Change: The Role of Leadership and Employee Involvement: A Critical Review. Journal of Innovation and Knowledge, 3, 123-127

Hussain, S., W. Ahmed, R.M.S. Jafar, A. Rabnawaz and Y. Jianzhou (2017). eWOM source credibility, perceived risk and food product customer's information adoption. *Comput. Hum. Behav.* 66 96–102. 10.1016/j.chb.2016.09.034.

Lodhi, R.D., L.C. Prasad, S.S. Bornare, A.H. Madakemohekar and R. Prasad (2015). Stability analysis of yield and its component traits of barley (Hordeumvulgare L.) genotypes in Multi- Environment trials in the North Eastern plains of India.Sabro Journal of Breeding and Genetics 47 (2): 143-159.

IranStat (2019). Agriculture Statistics of Iran for Crops, 1st ed.; Statistical Center of Iran: Tehran, Iran, 2019.

Mondal, S., R.P. Singh, E.R. Mason, J. Huerta-Espino, E. Autrique and A.K. Joshi (2016). Grain yield, adaptation and progress in breeding for early-maturing and heat-tolerant wheat lines in South Asia. Field Crops Research (192): 78–85.

Munns, R and R.A. James (2003). Screening methods for salinity tolerance: A case study with tetraploid wheat. Plant Soil 253, 201-218. http://dx.doi.org/10.1023/A:1024553303144.

Neter, J., M. Khutner, C. Nachtsheim and W. Wasserman (1996). Applied Linear Statistical Models.4th Ed. Chicago Irwin Series.Time Mirror.Education Group, pp.111-121.

Panuccio, Maria. R., F. Marra, A. Maffia, C. Mallamaci and A. Muscolo (2022). Recycling of agricultural (orange and olive) bio-wastes into ecofriendly fertilizers for improving soil and garlic quality. Resources, Conservation and Recycling Advances (15): 200083

Pinthus, J.M. (1973). Estimate of genotype value: a proposed method. Euphytica, 22:121-123.

Pour-Aboughadareh, A., A. Barati, S.A. Koohkan, M. Jabari, A. Marzoghian, A. Gholipoor, K. Shahbazi-Homonloo, H. Zali, O. Poodineh and M. Kheirgo (2021). Dissection of genotype-by-environment interaction and yield stability analysis in barley using AMMI model andstability statistics. Bulletin of the National Research Centre.46:19 -31.

Rauf, M., M. Munir, M. Ul-Hassan, M. Ahmed and M. Afzai (2007). Performance of wheat genotypes under osmotic stress at germination and early seedling growth stage. African Journal of Biotechnology 8, 971-975.

Talukder, A.S.M.H.M., G. K. McDonald and G.S. Gill (2014). Effect of short-term heat stress prior to flowering and early grain set on the grain yield of wheat. Field Crops Research (160): 54–63.

تقييم الأداء و الثبات لتراكيب وراثية من الشعير ثنائي الصفوف تحت ظروف بيئية مختلفة

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قسم بحوث الشعير– معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية

يختلف أداء الشعير بين التراكيب الوراثية وفي هذا البحث تم إجراء تقييم الثبات المظهري لمحصول الحبوب ومكوناته تحت ثمانية ظروف بيئية مختلفة باستخدام ١٢ تركيب وراثيًا من الشعير. أظهر محصول الحبوب في مواقع مختلفة أن سخا والجميزة أنتجا أعلى محصول للحبوب علي مدار البيئتين لكل منهما (٥,٨٤ و ٥,٥٦) طن/هكتار. وفقا لمعاملات الثبات (b_i ،S^2_{di} ،R^2_i) ونتائج متوسط المحصول وجد أن السلالات الواعدة L9 و L10 و Giza 128 أظهرت ثباتًا متوسطًا مع قابلية عامة للتأقلم. ومع ذلك، تأقلمت التراكيب الوراثية L1 و L8مع البيئات عالية الإنتاجية. على الجانب الآخر ، تأقلمت التراكيب الوراثية L2 و L5 و L3 مع البيئات ذات العائد المنخفض.

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