PERFORMANCE AND STABILITY FOR GRAIN YIELD AND YIELD COMPONENTS OF SIX-ROW BARLEY CULTIVARS UNDER VARIOUS ENVIRONMENTS IN KURDISTAN REGION-IRAQ

Abdulla, A. A.* **K. M. Mustafa**
Researcher **Asst. Prof.**
Dept. Biotech. and Crop Sci., Coll. Agric. Eng. Sci. University Sulaimani, Iraq
kamil.mustafa@univsul.edu.iq

ABSTRACT

This study was aimed to investigate yield and yield components of barley (Hordeum vulgare L.) under six different environmental conditions E_1- E_6 including two sowing date S_1 and S_2 at three location (Qlyasan, Kanipanka, Chamchamal) in KIR using 10 barley cultivars (C), Numar, Rafidain, Al-warka, Al-Amal, IPPA 265, IPPA 99, Arivat (local), Samir, Qalay 1, and Ukraine (Common cultivated). Experiment was applied using to complete randomized blocks design. The stability analysis was done using the linear regression model. The differences between the means were compared through Duncan multiple range test. The results was revealed that the mean sum of squares due to cultivars, environment, and C x E were highly significant for all studied characters. The cultivar Numar which had highest mean grain yield (3.559) th^{-1}, high bi value1.96 and low S^2di 0.058) considered optimal yield stability cultivar. The combination C_1E_3 gave the top grain yielding (6.91 th^{-1}) due to very high GS, high NS and good TGW performances.

Key words: GEI, sowing date, locations, rainfed, phenotypic characters.
***Part of M.Sc. thesis of the 1st author**

أداء واستقرارية الحاصل و مكوناته لاصناف الشعير ذو ستة صفوف تحت بيئات مختلفة في أقليم كردستان – العراق

ئالان احمد عبدالله* **كامل محمود مصطفى**
باحث **أستاذ مساعد**
قسم التقنيات الحياتية وعلوم المحاصيل، كلية علوم الهندسة الزارعية، جامعة السليمانية

المستخلص

تم إجراء هذا البحث لدراسة الثبات المظهرى لحاصل الحبوب ومكوناته تحت ستة ظروف بيئية مختلفة E1 – E6 بما فى ذلك موعدي بذار S1 و S2 (بداية ديسمبر ونهاية ديسمبر) فى ثلاثة مواقع (قليسان ، كانيبنكة، جمجمال) في إقليم كردستان العراق باستعمال 10 أصناف من الشعير العراقي (C) ، نومار ، والرافدين ، والوركاء ، والأمل ، وإباء 265 ، وإباء 99 ، واريفات (محلي) ، وسمير ، وقلعة 1، وأوكراني (مقارنة). تطبقت التجربة وفق تصميم القطاعات العشوائية الكاملة (R.C.B.D). تم إجراء تحليل الآستقرارية باستعمال نموذج الانحدار الخطي. وجد أن متوسط مجموع المربعات لتأثير الأصناف ، والبيئة ، و تداخلهما ذو معنوية عالية لجميع الصفات المدروسة ، والتي تفوقت فيها التأثيرات البيئية على الأصناف و التداخل البيئي– الوراثي. اعطى الصنف نومار أعلى متوسط حاصل (3.559) طن هـ$^{-1}$ ، قيمة bi عالية 1.96 ،وقيمة S^2di منخفضة 0.058 ,عليه هو الصنف الأمثل لاستقرار الغلة. أعطت التوليفة C_1E_3 أعلى إنتاجية للحبوب 6.91 طن هـ$^{-1}$ نتيجة الآرتفاع العالي لعدد الحبوب/سنبلة، وارتفاع عدد السنابل ، وأداء وزن 1000 حبة الجيد. غلبة الظروف البيئية في التباين الكلي لجميع الصفات. وعليه يمكن ان تساعد بيانات المعلومات المقدمة هنا في برنامج اختبار على مدى يتطلب المزيد من المواقع والعمليات الزراعية والسنوات لتوصيف أداء أصناف الشعير الواعدة في المنطقة المطرية في العراق بشكل كامل.

الكلمات المفتاحية: تداخل وراثي بيئي, مواعيد الزراعة, مواقع, مناطق مطرية, الصفات المظهرية.
*** جزء من رسالة الماجستير للباحث الاول**

Received:14/5/2022, Accepted:28/8/2022

INTRODUCTION

Barley (*Hordeum vulgare* L.) is ranked fourth amongst the cereals after maize, rice, and wheat overall (11). Barley is one of the oldest domesticated crops and was world crop used for animal feed, malting, and brewing, for seed, and for direct human consumption (33). Barley is a hardy crop grown throughout the temperate and tropical regions of the world (5, 11), Adaptation to climate change by adjusting sowing dates and using improved genotypes can mitigate the negative effects of climate change on barley production (13). Management is also an important factor that affects phenology; important factors include sowing date, fertilizer application, irrigation, and other management practices. In fact, early or late sowing times can expose crops to frost, heat, or terminal drought events (20). Genotypes, sowing dates, and their interaction significantly impacted most of the studied traits such as grain yield, the early sowing in late October yielded higher than intermediate sowing in mid-November and late sowing in during early December (21). Many previous studies were done on different cereal crops' stability, bread wheat stability (2), and durum wheat stability (17). Kurdistan Region-Iraq is one of the Mediterranean region, that are characterized by high inter-annual variability of temperature and rainfall patterns (7).Characterization of barley genotypes in the KRI will improve the understanding of how climate variability and extreme events impact each genotype. Several statistical models have been developed over the Location to analyze G x E interaction and especially yield stability over environments. The major objective of the multi environmental trials METs is the Evaluation of genotypic performance, to deal with the genotype-environment interactions (32). Stability variance (29). Regression slope (12), deviation from regression (9), and coefficient of determination (23). The reason for the basic differences in the performance of genotypes in wide environments is due to the interaction of the genotype with the environment (22).Grain yield and its associated features are a product of the cultivar's genotype (G), the environment (E) in which it is grown, and the interaction between G and E. An optimum cultivar is one that produces the best yield in a variety of environments (14). Grain number in barley grown in a range of environments is highly correlated with yield (27). The current research was aimed to identify barley stable cultivars with high productivity across different environments in Kurdistan Region-Iraq.

MATERIAL AND METHODS

Ten six - row barley cultivars Numar, Rafidain, Al-warka, Al-Amal, IPPA 265, IPPA 99, Arivat, Samir, Qalay 1, and Ukraine, were cultivated in three different locations with two sowing dates for each location (six environments) at Kurdistan Region-Iraq During the growing season 2020-2021 under rainfall conditions the properties and the location of the experimental environments are given in Table (a).The experiment was conducted using Randomized Complete Block Design (RCBD) with three replications. 30 experimental units / environment, 4 row / cultivar, 3 m long row, 0.2 m between rows planted, copy area = 2.4 m^2, use of 180 seeds / row (seeding rate) = 300 seeds / m^2 = 3 million h^{-1} of seeds. At the field, the number of spikes m^{-2} was calculated at maturity, plants were harvested from each line as a whole to calculate grain yield (t h^{-1}), and the grain number $spike^{-1}$ was calculated from ten spikes taken at random. Analysis of variance for each environment and pooled analysis over environments were computed. Three parametric stability methods included the mean; joint regression coefficient (bi), deviation from regression (S^2di) (9) a cultivar with a unit regression coefficient (bi = 1) and the deviation not significantly differing from zero ($S^2di = 0$) was taken to be a stable genotype with a unit response, and the differences between the means were compared through Duncan multiple range test (8). The stability of yield performance for each cultivar was calculated by regression the mean yield of individual cultivars on the environmental index and calculating the deviations from regress the mean grain yield of individual cultivars on the environmental index and calculating the deviations from regression as suggested by Eberhart and Russell (1966) (9). Regression coefficient (bi) was considered as an indication of the response of the cultivar to

the varying environment while the environment and cultivar × environment interactions were partitioned into three components viz., environment (linear), genotype x environment (linear), and deviation from regression (pooled deviation over the genotypes). The stability analysis was done using the linear regression model suggested by Eberhart and Russell (1966) (9).The data were subjected to statistical analysis in OPSTAT (http://14.139.232.166/opstat/index.asp), statistical software developed by CCS Haryana Agriculture University, Hisar (Haryana), India (28).

Table a. Agro-climatic characteristics of the environments tested in Sulaimani Kurdistan-Iraq

Environment (E)					Latitude Longitude masl	Soil Properties	Rainfall (mm)
Location	Code	Sowing Date					
Qilyasan (guaranteed rain area)	E1	1st sowing date	the onset of Dec	9/12/2020	35°34'N 45°22'E 765	Texture: Clay PH : 7.85 O.M : 1.66	378.8
	E2	2nd sowing date	end of Dec	28/12/2020			
Kanipanka (guaranteed rain area)	E3	1st sowing date	the onset of Dec	10/12/2020	35°22' N 45°43' E 550	Texture: Clay PH : 7.45 O.M : 1.33	307.1
	E4	2nd sowing date	end of Dec	29/12/2020			
Chamchamal (semi guaranteed rain area)	E5	1st sowing date	the onset of Dec	11/12/2020	35°34' N 44°47' E 898	Texture: Silty Clay PH : 7.49 O.M : 1.73	285.2
	E6	2nd sowing date	end of Dec	30/12/2020			

RESULTS AND DISCUSSION

Table1 shows the results of the analysis of variance of the data for the grain yield and their component of barley cultivars that were sowing in six environments, which was highly significant (P<0.01) for all the characters for each environment under study to clarify that high variation was found among barley cultivars for all characters. These results are in agreement with those observed by Al-Magheer et al. (2020) (3). In the same table also, the ANOVA for Stability (Eberhert and Russel Model) for mean square of the cultivars, environment, and their interactions appeared highly significant (P<0.01) for all characters. These results were in consensus with those previously found by (18). Prasad (25) mentioned that significant differences were observed among the Cultivars for all the studied traits over all 3 individual environments. Cultivars × environment interactions were highly significant for all the studied characters. The significance of all interactions of cultivars for all characters indicates the difference in the behavior of some of them according to the different environmental conditions in which they grow, the contribution of cultivars to improved crop yield and its components was closely related to environment.

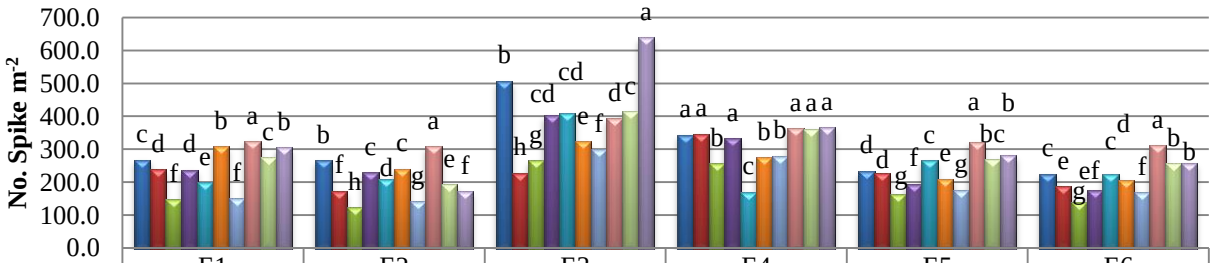
No. Spikes m^{-2} : Figure 1 shows that cultivars performed better than others each environment separately, at the E_1 the C_8 achieved the highest number (325), and the lowest number achieved by C_7, C_3 the differences between them did not significant (150.3, 147.7 spikes respectively). In the E_2 the C_8 had the most (309.3), C_3 had the lowest (124.7spikes). In the E_3 the C_{10} recorded the highest number with (640), and C_2 recorded the lowest number (228 spikes). In the E_4 the C_{10} recorded the highest number which was a part with C_9, C_8, C_2, and C_1, and the C_5 scored less number. The C_8 in the E_5 achieved the highest number (323), and the C_7, C_3 the lowest (176.7, 164.3 spikes). In E_6 the C_8 had the highest number (310.7) and C_3 the lowest number (139 spikes). Could be in order that, the reduction in assimilations transported to the new developing tiller may owe in large part to the demise of the new tiller and the decrease in the number of spikes. Gomaa et al. (15) mentioned differences among wheat genotypes across environments for the studied NS reached the significance level using fifteen cultivars in six environments. The cultivar Samir C_8 was almost superior to the rest of the cultivars, excelled in five out of six environments. As Al Myali et al. (4) mentioned that Samir was superior to the other cultivars in yield characters using three cultivars of barley at different sowing. The C_7, C_3 scored the lowest NS compared to the other cultivars in all environments.

Table 1. Analysis of variance for the studies characters for each Environment and across six environments in Kurdistan Region-Iraq, growing season 2020-2021.

Source of Variation		d.f	Mean Squares			
			No. Spike (NS)	No. grain Spike (NGS)	1000 Grain Weight (TGW)	Grain Yield (GY)
E1	C	9	12,070.519**	101.485**	48.658**	1.053 **
	e	18	24.507	1.512	1.358	0.015
E2	C	9	9,743.115**	80.781**	27.566**	0.803 **
	e	18	63.915	1.418	1.093	0.011
E3	C	9	43,751.926**	31.725**	66.781**	6.550**
	e	18	102.937	3.401	2.880	0.051
E4	C	9	12,069.070**	63.383**	46.225**	2.706**
	e	18	328.270	2.079	1.665	0.044
E5	C	9	7,581.467**	113.129**	31.614**	0.927 **
	e	18	69.900	3.193	1.693	0.026
E6	C	9	7,750.981**	100.293**	42.684**	0.883 **
	e	18	75.737	1.966	1.309	0.015
ANOVA for Stability (Eberhert and Russel Model)						
Cultivar (C)		9	16,753.426**	91.287**	70.851**	2.947**
Environment (E)		5	49,011.820**	187.847**	134.500**	10.440**
C X E		45	2,847.120**	14.462**	3.398**	0.272 **
E+ CX E		50	7,463.590	31.801	16.509	1.289
E (Linear)		1	245,059.098**	939.234**	672.501**	52.200**
E X C (Lin)		9	7,258.732**	24.666**	5.273**	1.001 **
Pooled Deviation		40	1,569.795**	10.720**	2.637**	0.081 **
Pooled Error		108	110.878	2.262	1.666	0.027

***: Significant (P≤0.05) **: high Significant. (P≤0.01)**

The mean of cultivars shows that the C_{10} and C_8 were the highest and C_3 the lowest. The E_3 was the best measure of the environment, the superiority of E_3 could be due to the quality of the soil, the climate, and the sowing date (S_1). E_2 and E_6 were the worst environments due to their late sowing and weather conditions, and the performance of cultivars interaction in all environments show that C_{10} X E_3 achieved the highest number this is due to the fact that this cultivar got the appropriate location and sowing date to express itself, and C_3 X E_2 the lowest as shown in Table (2) due to this cultivar was poor and sowing at a late time and under unfavorable climate conditions. As it turns out with (21) too. The location, sowing date performance showed that reduction ratio by roughly between E_1, E_2 16.08%, E_3, E_4 20.26%, and E_5, E_6 8.61%. Environmental performances showed that environments 1, 3, and 5 (S_1) were favorable, whereas environments 2, 4, and 6 (S_2) were unfavorable with a reduction ratio of roughly % 15.81 could be due to the short growing period resulting in shorting growing stage and fewer tellers for mention and therefore fewer spikes number. The percentage increases from E_3 to E_4, E_1, E_5, E_6, and E_2 appointments was 25.4, 58.3, 65.6, 80.2, and 88.6 respectively. The values of the regression coefficient (bi) varied from 2.230 for the cultivar C_{10} to 0.417 for cultivar C_2.



	E1	E2	E3	E4	E5	E6
C1	267.7	266.3	507.3	344.3	234.0	225.7
C2	238.0	174.3	228.0	346.7	227.3	188.3
C3	147.7	124.7	266.0	257.0	164.3	139.0
C4	237.3	229.0	402.7	333.3	194.7	176.0
C5	200.0	209.3	408.3	170.3	266.0	226.0
C6	308.3	241.3	324.7	275.7	210.3	205.0
C7	150.3	141.0	300.7	280.3	176.7	169.0
C8	325.0	309.3	394.0	362.7	323.0	310.7
C9	276.0	193.0	415.0	362.0	269.7	256.3
C10	306.3	172.7	640.0	367.3	281.3	259.0

Figure 1. Means of the No. spike m^{-2} of 10 cultivars of six-row barley that tests in six Environments in Kurdistan region- Iraq, growing season 2020-2021, Values followed by the same letter are not significantly different using Duncan's multiple range test (Duncan's MRT).

This variation in regression coefficients indicates that genotypes (Cultivars) had different responses to environmental changes. The C_{10} had a high mean with regression values bi > 1 (2.230) which a part with C_1 (1.462) that describe cultivar with higher sensitivity to environmental change and greater specificity of adaptability to high yielding (high input), C_8 had high mean with S^2di near to 0 (-27.987), which show that cultivars was stable. C_2 had low mean with bi < 1 (0.417) provides a measurement of greater resistance to environmental change and thus increases the specificity of adaptability to low NS environments.

Table 2. Means Cultivars, Environments and C X E interaction of No. spike m^{-2} performance, Stability parameters of different models of 10 six-row barley cultivars at six different environments in Kurdistan region-Iraq, growing season 2020-2021.

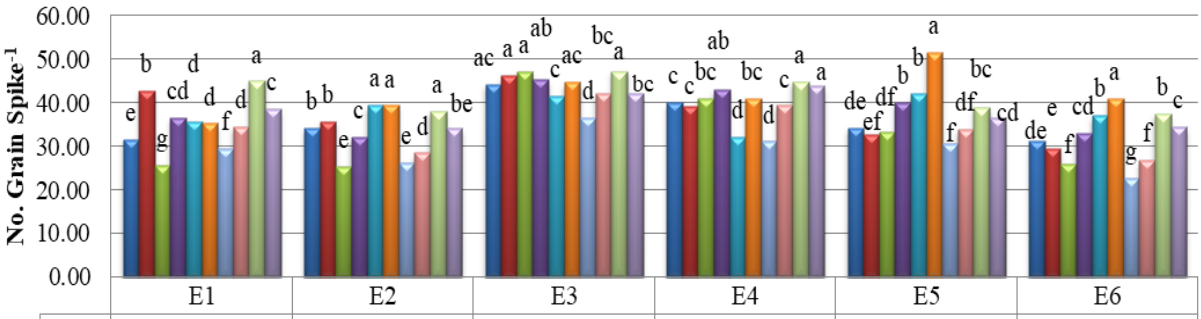
C \ E	E1	E2	E3	E4	E5	E6	Means	(bi)	S^2_{di}
C1	267.7^{f-s}	266.3^{f-s}	507.3^{b}	344.3^{c-i}	234.0^{j-u}	225.7^{k-v}	307.5^{ab}	1.462	1,027.632
C2	238.0^{i-u}	174.3^{p-v}	228.0^{j-v}	346.7^{c-h}	227.3^{j-v}	188.3^{o-v}	233.8^{de}	0.417	3,505.134
C3	147.7^{uv}	124.7^{v}	266.0^{f-s}	257.0^{g-t}	164.3^{s-v}	139.0^{uv}	183.1^{f}	0.835	520.758
C4	237.3^{j-u}	229.0^{j-v}	402.7^{c-e}	333.3^{c-j}	194.7^{n-v}	176.0^{o-v}	262.2^{cd}	1.196	820.435
C5	200.0^{m-v}	209.3^{l-v}	408.3^{cd}	170.3^{q-v}	266.0^{f-s}	226.0^{k-v}	246.7^{d}	0.820	4,925.595
V6	308.3^{d-l}	241.3^{h-u}	324.7^{c-k}	275.7^{f-r}	210.3^{l-v}	205.0^{l-v}	260.9^{cd}	0.534	1,366.611
C7	150.3^{t-v}	141.0^{uv}	300.7^{e-n}	280.3^{f-p}	176.7^{o-v}	169.0^{r-v}	203^{ef}	0.927	700.275
C8	325.0^{c-k}	309.3^{d-l}	394.0^{c-e}	362.7^{c-g}	323.0^{c-k}	310.7^{c-l}	337.5^{a}	0.481	-27.987
C9	276.0^{f-q}	193.0^{o-v}	415.0^{c}	362.0^{c-g}	269.7^{f-s}	256.3^{g-t}	295.3^{bc}	1.098	525.796
C10	306.3^{d-m}	172.7^{q-v}	640.0^{a}	367.3^{c-f}	281.3^{f-o}	259.0^{g-s}	337.8^{a}	2.230	1,964.113
Means	245.6^{c}	206.1^{d}	388.7^{a}	309.96^{b}	234.7^{cd}	215.5^{d}	266.8		

bi: Regression coefficient, S²di: Deviation from regression

No. Grains Spike^{-1}

Figure 2 shows the performance of cultivars for NGS character under each environment. For E_1 the highest number of grains was for C_9, and the lowest was for C_3, and in E_2, the performance of C_5, C_6, and C_9 was higher compared to the other cultivars, and C_7, and C_3 was the lowest. In E_3 the C_2 had high value which a part with the C_3, and their performance was the best and the bad performance was for the C_7. The good performance was for C_9, and C_{10}, and bad was

for C_5, and C_7 in E_4. For the E_5 and E_6 the C_6 and C_7 were recorded the best and bad performance for both respectively. Gomaa et al. (15) mentioned differences among genotypes each environment for NGS reached the significance level. The mean of cultivars show that the C_6, and C_9 were highest and the C_7 the lowest, and mean for the environments E_3 the best and E_2, E_6 the low mean environments. Moustafa et al. (21) mentioned that the sowing date has an effect on the yield components. The performance of cultivars' interaction in all environments shows that C_6 X E_5 achieved the highest and C_7 X E_6 had the lowest number (Table 3). The location sowing date performance showed that reduction ratio by roughly between E_1, E_2 6.46%, E_3, E_4 9.59%, and E_5, E_6 14.71%. Environmental performances showed that environments 1, 3, and 5 (S_1) were favorable, whereas environments 2, 4, and 6 (S_2) were unfavorable with a reduction ratio by roughly % 10.28. The percentage increases from E_3 to E_4, E_5, E_1, E_2, and E_6 appointments was 10.6, 17.1, 23.0, 31.5, and 37.3 respectively.



	E1	E2	E3	E4	E5	E6
C1	31.67	34.33	44.33	40.00	34.33	31.33
C2	42.87	35.80	46.33	39.33	32.67	29.53
C3	25.63	25.47	47.20	41.07	33.20	26.00
C4	36.67	32.13	45.33	43.13	40.20	32.93
C5	35.80	39.47	41.47	32.20	42.07	37.07
C6	35.27	39.40	44.73	41.07	51.53	41.00
C7	29.47	26.20	36.67	31.13	30.63	22.67
C8	34.60	28.47	42.27	39.40	34.00	26.80
C9	45.00	38.07	47.27	44.93	38.93	37.53
C10	38.53	34.07	42.07	43.87	36.47	34.47

Figure 2. Means of the No. grain spike^{-1} of 10 cultivars of six-row barley that test in six Environments in Kurdistan region- Iraq, growing season 2020-2021, Values followed by the same letter are not significantly different using Duncan's multiple range test (Duncan's MRT).

The values of the regression coefficient (bi) varied from 2.034 for the cultivar C_3 to 0.133 for cultivar C_5. This variation in regression coefficients indicates that genotypes (Cultivar) had different responses to environmental changes. C_4 had high mean with bi >1 (1.205) which a part with C_1, C_2 (1.088, and 1.081 respectively) with higher sensitivity to environmental change and greater specificity of adaptability to high yielding (high input). This is similar to the report of (25). C_7 had low mean with bi=1(1.064), S^2di near to 0 (0.876) that show that cultivars was more stable, C_6 had high mean with regression values bi < 1 (0.472) which a part with C_9, C_{10}, C_5 (0.796, 0.786, 0.133 respectively) as shows in Table (3). that describe cultivar provides a measurement of greater resistance to environmental change and thus increases the specificity of adaptability to low yielding environments consistent with the results of (2).

1000 Grains Weight

Figure 3 shows the performance of cultivars for TGW characters for each environment. For E_1 the heaviest of TGW was achieved by C_8 which a part with C_{10}, and the lighter was achieved by C_3. In E_2, the performance of C_8, and C_4, was high compared to the other cultivars. These results are in agreement with those observed by Al Myali et al. (4). The C_3 was the low in E_2. In E_3 the C_4 had the heaviest which a part with the C_3, and their

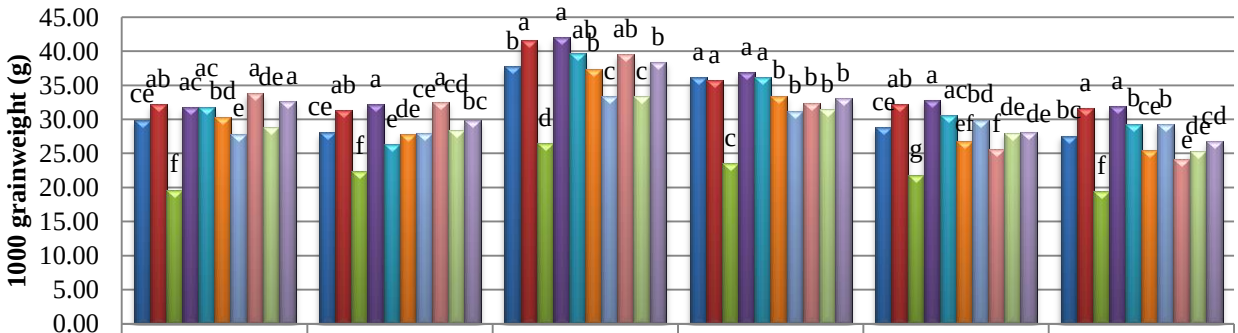
performance was the best and the lighter was for the C_3. The heaviest TGW was for the C_4 which a part with C_1, C_5, and C_2, and lighter was for the C_3 in E_4. For the E_5 the C_4 achieved the heaviest, and the lightest achieved by C_3. In E_6 the C_4, and C_2 were recorded the best, while C_3 recorded the worst performance. Gomaa et al. (15) mentioned differences among cultivars for each environment for TGW character reached the significance level. Regarding to TGW under all environments, the C_3 recorded the worst value compared to all cultivars other. Sediq et al. (26) Stated that TGW is influenced by different Cultivars and sowing date. The C_4 excelled in five out of six environments, and in the sixth, C_4 was one of the big values for this character.

Table 3. Means Cultivars, Environments and C X E interaction of No. Grains Spike^{-1} performance, Stability parameters of different models of 10 six-row barley cultivars at six different environments in Kurdistan region- Iraq, growing season 2020-2021.

C \ E	E1	E2	E3	E4	E5	E6	Means	(bi)	S^2_{di}
C1	31.67^{n-u}	34.33^{k-s}	44.33^{a-f}	40.00^{b-l}	34.33^{k-s}	31.33^{n-u}	35.90^{bc}	1.088	4.335
C2	42.67^{b-i}	35.80^{h-r}	46.33^{a-c}	39.33^{c-m}	32.67^{l-u}	29.53^{q-v}	37.80^{b}	1.081	21.693
C3	25.63^{uv}	25.47^{uv}	47.20^{ab}	41.07^{b-k}	33.20^{l-t}	26.00^{t-v}	33.10^{d}	2.034	8.816
C4	36.67^{g-q}	32.13^{m-u}	45.33^{a-d}	43.13^{b-h}	40.20^{b-l}	32.93^{l-u}	38.40^{b}	1.205	1.632
C5	35.80^{h-r}	39.47^{c-m}	41.47^{b-k}	32.20^{m-u}	42.07^{b-j}	37.07^{f-q}	38.00^{b}	0.133	16.345
C6	35.27^{i-r}	39.40^{c-m}	44.73^{a-e}	41.07^{b-k}	51.53^{a}	41.00^{b-k}	42.20^{a}	0.472	32.059
C7	29.47^{q-v}	26.20^{t-v}	36.67^{g-q}	31.13^{o-u}	30.63^{p-u}	22.67^{v}	29.50^{e}	1.064	0.876
C8	34.60^{j-r}	28.47^{r-v}	42.27^{b-i}	39.40^{c-m}	34.00^{k-s}	26.80^{s-v}	34.30^{cd}	1.342	1.961
C9	45.00^{a-e}	38.07^{d-p}	47.27^{ab}	44.93^{a-e}	38.93^{c-n}	37.53^{e-p}	41.90^{a}	0.796	6.922
C10	38.53^{d-o}	34.07^{k-s}	42.07^{b-j}	43.87^{b-g}	36.47^{g-q}	34.47^{j-r}	38.30^{b}	0.786	5.026
Means	35.60^{c}	33.30^{d}	43.80^{a}	39.60^{b}	37.40^{c}	31.90^{d}	36.93		

bi: Regression coefficient, S^2di: Deviation from regression

The means of cultivars show that the C_4, and C_2 were the heaviest and C_3 was the lightest, and means for the environments E_3 the best and E_6 the lowest mean environments The same results appeared in the effect of the sowing date on yield components with (21).



	E1	E2	E3	E4	E5	E6
C1	29.92	28.05	37.80	36.17	28.80	27.60
C2	32.19	31.33	41.63	35.69	32.19	31.68
C3	19.65	22.32	26.47	23.50	21.86	19.41
C4	31.75	32.15	42.02	36.93	32.85	31.95
C5	31.84	26.40	39.67	36.14	30.55	29.36
C6	30.39	27.84	37.41	33.46	26.82	25.55
C7	27.87	28.03	33.39	31.24	29.94	29.29
C8	33.82	32.55	39.57	32.44	25.57	24.21
C9	28.81	28.43	33.36	31.48	28.04	25.28
C10	32.63	29.90	38.41	33.08	28.10	26.75

Figure3. Means of the 1000 grains weight of 10 cultivars of six-row barley that test in environments in Kurdistan region- Iraq, growing season 2020-2021, Values followed by the same letter are not significantly different using Duncan's multiple range test (Duncan's MRT).

The performance of C X E show that C_4 X E_3 achieved the heaviest value and C_3 X E_6, E_1 were the lowest explain that TGW is influenced by various sowing dates and the selection of various cultivars for sowing as shown in Table (4). In the same Table, the location and sowing date performances shows that reduction ratio by roughly between E_1 and E_2 4.01%, E_3 and E_4 10.7%, and E_5 and E_6 4.8% in delaying the sowing date, the grain filling period is short and negatively affects the TGW. These results are in agreement with those observed by Al-Edelby et al. (2021) (1). This could be referred to as the effect of favorable environmental factors on accelerating photosynthesis at the optimum sowing date and consequently increased synthases that are transferred into grains. This could be due to the intense competition among plants for nutrients, soil moisture, and light. Environmental performances showed that environments 1, 3, and 5 (S_1) were favorable, whereas environments 2, 4, and 6 (S_2) were unfavorable with a reduction ratio by roughly % 6.86. The percentage increases from the E_3 to the E_4, E_1, E_2, E_5, and E_6 appointments was 11.9, 23.7, 28.8, 29.8, and 36.4 respectively. The values of the regression coefficient (bi) varied from 1.312 for the cultivar C_8 to 0.631 for cultivar C_3. This variation in regression coefficients indicates that genotypes (Cultivar) had different responses to environmental changes. C_5 and C_8 had 2nd means with bi > 1(1.215, and 1.312) that shows higher sensitivity to environmental change and greater specificity of adaptability to high yielding (high input) this is similar to the report of (27). C_2 and C_4 had high means with bi=1 (1.056, and 1.080) that shows that both cultivars were stable. C_7, and C_9 had low means with bi < 1 (0.483, and 0.743) as shows in Table (4). that describe cultivar provides a measurement of greater resistance to environmental change and thus increases the specificity of adaptability to low yielding environments this is similar to the report of (30).

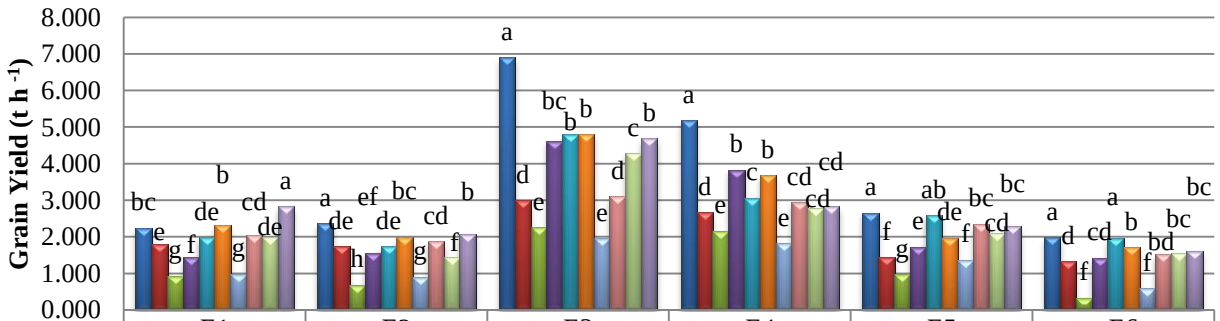
Table 4. Means Cultivars, Environments and C X E interaction of 1000 Grain Weight performance, Stability parameters of different models of 10 six-row barley cultivars at six different environments in Kurdistan region- Iraq, and growing season 2020-2021.

C \ E	E1	E2	E3	E4	E5	E6	Means	(bi)	S^2_{di}
C1	29.92^{j-s}	28.05^{o-t}	37.80^{c-e}	36.17^{d-g}	28.80^{l-t}	27.60^{q-u}	31.39^{bc}	1.168	1.093
C2	32.19^{h-l}	31.33^{i-p}	41.63^{ab}	35.69^{e-h}	32.19^{h-l}	31.68^{i-o}	34.12^{a}	1.056	0.738
C3	19.65^{y}	22.32^{w-y}	26.47^{s-v}	23.50^{v-x}	21.86^{xy}	19.41^{y}	22.20^{e}	0.631	1.345
C4	31.75^{i-n}	32.15^{h-l}	42.02^{a}	36.93^{c-f}	32.85^{g-k}	31.95^{i-m}	34.61^{a}	1.080	1.036
C5	31.84^{i-m}	26.40^{s-v}	39.67^{a-c}	36.14^{d-g}	30.55^{i-q}	29.36^{k-s}	32.33^{b}	1.215	3.535
V6	30.39^{i-r}	27.84^{p-t}	37.41^{c-e}	33.46^{g-j}	26.82^{r-v}	25.55^{t-w}	30.25^{cd}	1.213	0.017
C7	27.87^{p-t}	28.03^{o-t}	33.39^{g-j}	31.24^{i-q}	29.94^{j-s}	29.29^{k-s}	29.96^{d}	0.483	1.007
C8	33.82^{f-i}	32.55^{h-k}	39.57^{a-d}	32.44^{h-l}	25.57^{t-w}	24.21^{u-x}	31.36^{bc}	1.312	10.687
C9	28.81^{l-t}	28.43^{m-t}	33.36^{g-j}	31.48^{i-p}	28.04^{o-t}	25.28^{t-w}	29.23^{d}	0.743	0.175
C10	32.63^{g-k}	29.90^{j-s}	38.41^{b-e}	33.08^{g-j}	28.10^{n-t}	26.75^{r-v}	31.48^{bc}	1.100	1.181
Means	29.89^{c}	28.69^{d}	36.97^{a}	33.01^{b}	28.47^{d}	27.11^{e}	30.69		

bi: Regression coefficient, S^2di: Deviation from regression

Results shows in Figure (4) C_{10} in E1 outperformed the other cultivars, scoring the highest, while the lowest yield, scored by C_7, which was shared by C_3 for this value. Concerning the E_1, the yield components that have a role in determining the GY, then C_{10} recorded the second-largest NS and the highest value of TGW that had a role to obtain the largest yield in this environment, while C_7 and C_3, recorded the lowest yield components values that affected the latter's value of the GY. For E_2, C_1 recorded the high GY which were the yield components of this cultivar NS and GS second largest value in this E, and the lowest value recorded by C_3 with low yield components. For E_3, C_1 had the highest yield as the components NS, TGW scored the second-highest value compared to the other cultivars, and the NGS was high too making the highest yield, while the lowest yield given by C_3 and C_7 that their components recorded low value that affects the yield. C_1 recorded the highest yield compared to the other cultivars in E_4 the height of its components NS, and TGW, and that gave it the highest yield, the lowest yield given by C_3, and C_7 that their components recorded low value. In E_5 the high grain yield was recorded by C_1 while the

components of the yield were high but not higher compared to the other cultivars, and low yield was recorded by C_3 that their NS and TGW were the lowest. C_1 achieved a high yield that shared this value with C_5 in E_6. For C_1 their TGW was of high value, while C_5 their NGS and TGW were of high value, and C_3 achieved a low yield where their NS and TGW were the lowest. For that, the crucial factor is growing site-specific cultivars that are better adapted to the surrounding environment for the largest grain yield.



	E1	E2	E3	E4	E5	E6
C1	2.250	2.361	6.907	5.185	2.658	1.991
C2	1.796	1.750	2.991	2.665	1.444	1.333
C3	0.935	0.685	2.259	2.171	0.981	0.333
C4	1.435	1.565	4.626	3.833	1.731	1.426
C5	1.982	1.741	4.793	3.063	2.583	1.963
C6	2.324	1.981	4.796	3.685	1.974	1.713
C7	0.991	0.908	1.965	1.818	1.370	0.592
C8	2.045	1.882	3.102	2.944	2.352	1.518
C9	1.991	1.435	4.278	2.787	2.093	1.565
C10	2.824	2.083	4.695	2.833	2.296	1.620

Figure 4. Means of the grain yield of 10 cultivars of six-row barley that test in Environments in the Kurdistan region- Iraq, growing season 2020-2021, Values followed by the same letter are not significantly different using Duncan's multiple range test (Duncan's MRT).

For the means of cultivars and environments and GE interaction values of GY Table 5 shows that the C_1 was the highest and C_7 was the lowest, For C_1 the mean values of the yield components, the NS was the second-high value, and the GS and TGW were the third-highest values. The environmental means for GY, E_3 was the best that came due to the mean of environmental yield components NS, NGS, and TGW recorded the highest value, while E_6 had the lowest mean environment due to the mean of environmental yield components being the lowest. The performance of C X E showed that C_3 X E_3 achieved the highest value, where this cultivar interacted with E3 the NS scored the second-highest value and a high NGS value, while C_3 X E_6, that their components NS, TGW were recorded the lowest and low NGS. The location, sowing date performance show that reduction ratio by roughly between, E_1 and E_2 11.74%, E_3 and E_4 23.34%, and E_5 and E_6 27.87%. As explained by (6, 3). The importance of optimizing sowing dates for barley in order to successfully produce high grain yields. An optimal sowing date produces maximum, number of spikes m^{-2} and number of grains $spike^{-1}$, 1000 grain weight, and grain yields compared to early and late sowings. Changes in environmental factors, i.e. temperature and precipitation, have potential impacts on plant growth stages, productivity, and grain quality. Environmental performances showed that environments 1, 3, and 5 (S_1) were favorable, whereas environments 2, 4, and 6 (S_2) were unfavorable with a reduction ratio by roughly % 21.72 acceleration of growth and development as a result of exposure to high temperatures, the lack of rain at the end of the growing season is the influencing. The percentage increases from the E_3 to the E_4, E_5, E_1, E_2, and E_6 appointments was 30.4, 107.4, 117.6, 146.5, and 187.6% respectively.

In Table 5, the values of the regression coefficient (bi) varied from 1.958 for the cultivar C_1 to 0.494 for cultivar C_7. This variation in regression coefficients indicates that genotypes had different responses to environmental changes. Based on the definition described by Pour-Aboughadareh et al. (2019) (26) the genotypes with low values (bi<1) are very suitable for low-yielding environments, but the contrary for the genotypes with high values (bi>1). C_1 had high means mean with bi > 1 (1.958) that shows higher sensitivity to environmental change and greater specificity of adaptability to high yielding (high input). These results are in agreement with those observed by others (10, 16). C_9 had high mean yield with bi=1 (1.008) and S^2di near to zero (0.055) that shows cultivar was stable. C_7, C_2 and C_3 had low mean with bi < 1 (0.494, 0.633 and 0.752) , that describe cultivars provides a measurement of greater resistance to environmental change and thus increases the specificity of adaptability to low yielding environments. These results are in agreement with those observed by Teklu (2015) (30).

Table 5. Means Cultivars, Environments and C X E interaction of Grain Yield (t h $^{-1}$) performance, Stability parameters of different models of 10 six-row barley cultivars at six different environments in Kurdistan region- Iraq, growing season 2020-2021.

C \ E	E1	E2	E3	E4	E5	E6	Means	(bi)	S^2_{di}
C1	**2.250^{i-p}**	**2.361^{i-p}**	**6.907^{a}**	**5.185^{b}**	**2.658^{i-n}**	**1.991^{k-q}**	**3.559^{a}**	**1.958**	**0.058**
C2	**1.796^{l-s}**	**1.750^{m-s}**	**2.991^{g-k}**	**2.665^{i-n}**	**1.444^{p-u}**	**1.333^{p-v}**	**1.997^{d}**	**0.633**	**0.038**
C3	**0.935^{r-v}**	**0.685^{t-v}**	**2.259^{i-p}**	**2.171^{i-p}**	**0.981^{q-v}**	**0.333^{v}**	**1.227^{e}**	**0.752**	**0.052**
C4	**1.435^{p-u}**	**1.565^{o-u}**	**4.626^{b-e}**	**3.833^{c-g}**	**1.731^{n-s}**	**1.426^{p-u}**	**2.436^{bc}**	**1.360**	**0.084**
C5	**1.982^{k-q}**	**1.741^{n-s}**	**4.793^{b-d}**	**3.063^{g-j}**	**2.583^{i-o}**	**1.963^{k-r}**	**2.688^{b}**	**1.071**	**0.121**
V6	**2.324^{i-p}**	**1.981^{k-q}**	**4.796^{bc}**	**3.685^{f-h}**	**1.974^{k-r}**	**1.713^{n-t}**	**2.746^{b}**	**1.189**	**0.023**
C7	**0.991^{q-v}**	**0.908^{s-v}**	**1.965^{k-r}**	**1.818^{l-s}**	**1.370^{p-v}**	**0.592^{uv}**	**1.274^{e}**	**0.494**	**0.038**
C8	**2.045^{j-p}**	**1.882^{l-s}**	**3.102^{g-i}**	**2.944^{g-k}**	**2.352^{i-p}**	**1.518^{p-u}**	**2.307^{cd}**	**0.571**	**0.044**
C9	**1.991^{k-q}**	**1.435^{p-u}**	**4.278^{b-f}**	**2.787^{h-m}**	**2.093^{i-p}**	**1.565^{o-u}**	**2.358^{b-d}**	**1.008**	**0.055**
C10	**2.824^{h-l}**	**2.083^{i-p}**	**4.695^{b-e}**	**2.833^{h-l}**	**2.296^{i-p}**	**1.620^{n-u}**	**2.725^{b}**	**0.965**	**0.206**
Means	**1.857^{cd}**	**1.639^{de}**	**4.041^{a}**	**3.098^{b}**	**1.948^{c}**	**1.405^{e}**	**2.332**		

bi: Regression coefficient, S^2di: Deviation from regression.

Analysis of variance of the Eberhert and Russel Model displayed a significant preponderance the environmental status in the total variation for GY (57.38), NS (46.77), NGS (38.95) and TGW (45.97%), a large percentage of the sums squares for the environment indicated that environments were diverse which cause most of the variation in grain yield and its components, and this means the environment have the greatest role to determine the characters, similar found with (19). The cultivar contribution, which came in the second rank were GY (29.16), NS (28.78), NGS (30.07) and TGW (43.58%), and followed by the genotype by environment interaction values, which were GY (13.46), NS (2.25), NGS (26.98) and TGW (10.45%) and that one came in the last rank indicating substantial variances in growing environments, some of which could be caused by the considerable ranges in rainfall experienced by different environments. For the cultivar variation, the 1000 grain weight (TGW) possessing the most significant effect compared to other characters. Grain yield (GY) the highest affected by environmental variation followed by No. Spike (NS), TGW, and No. grain spike (NGS). For the C X E variation, NGS more effective followed by NS, GY, and TGW (Figure 5). Those variations could be due to number of genes which control the traits.

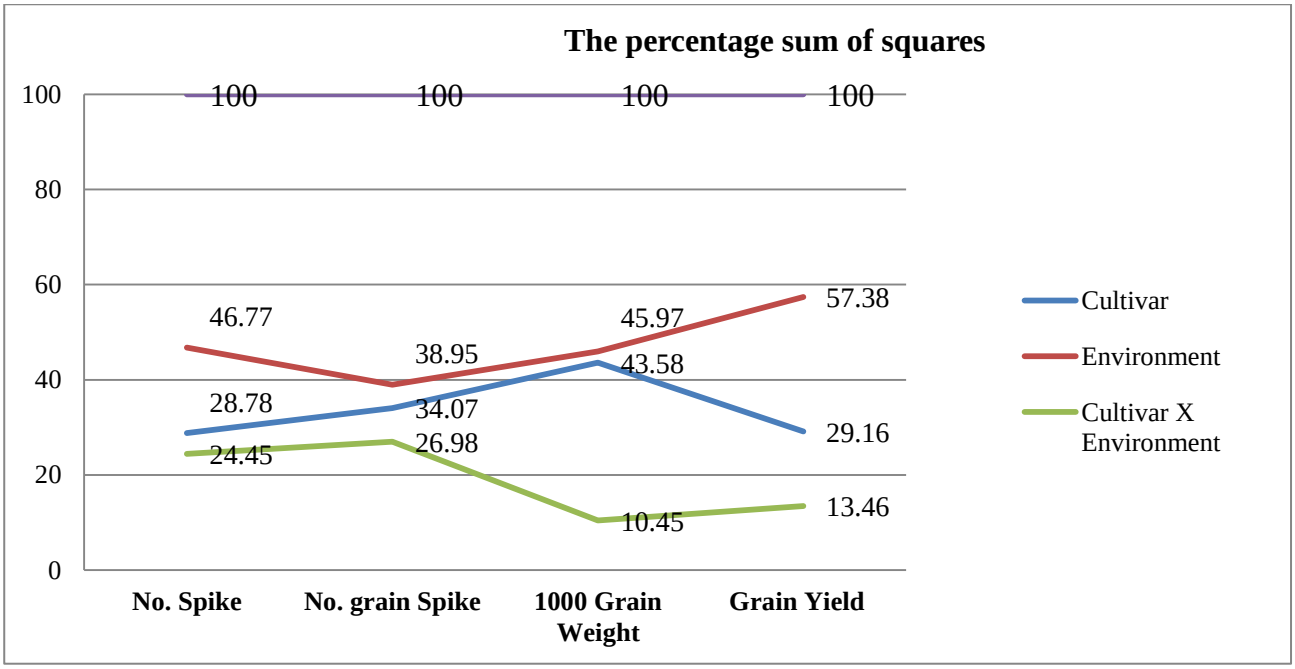


Figure5. The percentage sum of squares and total variation explained by environment (E), cultivars (C), and cultivar X environment interactions for grain yield and there component of the 10 cultivars of six-row barley cultivars tested at six environments in Kurdistan region-Iraq, growing season 2020-2021.

CONCLUSIONS

In conclusion for results, highly significant for cultivars, environments and GE interactions variances were observed in rainfed Kurdistan-region zone for 10 barley cultivars in term of grain yield and its components (NS, NGS, TGW) grown in six different environments and the combination C_1E_3 gave the top grain yielding (6.91 th^{-1}) due to very high GS, high NS and good TGW performances. The cultivar Numar which have the highest mean yield, high bi value and low S2di considered optimal yield stability cultivar, is an active reacting to favorable environmental indicated by an above-mentioned regression parameters. The predomination of the environmental conditions in the total variation of all studied characters, while the cultivars (genotypes) were the second contributor, however cultivar by environment interaction scored the least contribution. Therefore, most of the performance differences of barley cultivars in these experiments were due to sowing dates and locations. The information data offered here assist a testing program over more locutions, cultural practices and years to fully characterize the performance of promising barley cultivars in the rainfed area of Iraq.

REFERENCES

1. Al-Edelby, R., D. A. S. AL-Ouda, and D. R. Baldia. 2021. Evaluating the performance of certified barley (*Hordeum vulgare* L.) varieties under rainfed and supplementary irrigation conditions. Journal of Hama University. 4(3):1-15.

2. Al-Falahi, M., K. M. Dawod, and F. A. Omer, 2021. Yield stability evaluation for bread wheat genotypes under environmental variations. Iraqi Journal of Agricultural Sciences. 52(6):1449-1460. https://doi.org/10.36103/ijas.v52i6.1486

3.Al-Magheer, H. A., L. Aldahak, and S. H. Al-Sali. 2020. Evaluation of growth and productivity of barley (*Hordeum vulgare* L.) genotype under southern Iraq conditions. Int. J. Plant Res. 21:132-136.

4. Al Myali, A. A. H., A. S. Hassoon, and A. A. K. Alaameri. 2020. Effect of variety and planting date on growth and yield of barley (*Hordeum Vulgare* L.). Plant Archives. 20(1):355-358. DOI:10.13140/RG.2.2.28756.42886

5. Aliaa. K. M. and N. A. Mutlag 2022. Effect of salt stress on yield and its components of four cultivars of barler. Iraqi Journal of Agricultural Sciences. 53(3): :645-653. https://doi.org/10.36103/ijas.v53i3.1574

6. Beleggia, R., D. B. Ficco, F. M. Nigro, V. Giovanniello, S. A. Colecchia, I. Pecorella, and P. De Vita. 2021. Effect of sowing date on bioactive compounds and grain morphology of three pigmented cereal species. Agronomy. 11(3):591. DOI: 10.3390/agronomy11030591

7. Cammarano, D., D. Ronga, E. Francia, T. Akar, A. Al-Yassin, A. Benbelkacem, S. Grando, I. Romagosa, A. M. Stanca, and N. Pecchioni. 2021. Genetic and management effects on barley yield and phenology in the mediterranean basin. Frontiers in Plant Science. 12:578. DOI:10.3389/fpls.2021.655406

8. Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics. 11(1):1-42. DOI:10.2307/3001478

9. Eberhart, S. t. and W. Russell. 1966. Stability parameters for comparing varieties 1. Crop Science. 6(1):36-40. DOI:10.2135/cropsci1966.0011183X000600010011x

10. EL-Shawy, E. 2018. Stability analysis of yield and its components for promising barley genotypes under water stress and saline affected fields. Annals of Agricultural Science, Moshtohor. 56(3):641-652. DOI:10.21608/assjm.2018.49694

11. FAOstat. 2020. Barley production. Available online: http://www.fao.org/faostat/en/#data: Food and Agriculture Organization.

12. Finlay, K. and G. Wilkinson. 1963. The analysis of adaptation in a plant-breeding programme. Australian Journal of Agricultural Research. 14(6):742-754. DOI:10.1071/AR9630742

13. Fu, L., Q. Shen, L. Kuang, J. Yu, D. Wu, and G. Zhang 2018. Metabolite profiling and gene expression of Na/K transporter analyses reveal mechanisms of the difference in salt tolerance between barley and rice. Plant Physiology and Biochemistry. 130:248-2. DOI:10.1016/j.plaphy.2018.07.013

14. Gallagher, J., P. Biscoe, and R. Scott. 1975. Barley and its environment. v. stability of grain weight, Journal of Applied Ecology. 12(1):319-336. DOI:10.2307/2401735

15. Gomaa, M., M. EL-Badawy, A. El Hosary, S. R. El-Areed, and A. Amer. 2018. Stability analysis for yield and its components in Wheat. Egyptian Journal of Plant Breeding. 22(7):1535-1550.

16. Guendouz, A. and H. Bendada. 2022. Stability analysis for the grain yield of some barley (*Hordeum vulgare* L.) genotypes growing under semi-arid conditions', International Journal of Bio-Resource and Stress Management. 13(2):172-178. DOI: 10.23910/1.2022.2469

17. Hussain, M., M. A. Sadeeq, and S. Hassan. 2022. Stability analysis and estimation some genetic parameters for grain yield and its components for some durum wheat genotypes Iraqi Journal of Agricultural Sciences. 53(1):84-90. https://doi.org/10.36103/ijas.v53i1.1511

18. Jhinjer, R., G. Mavi, A. Malhotra, N., Sood, B. Singh, B. Kaur, V. Kumar, I. Bhagat, and V. Sohu. 2017. Stability analysis for grain yield and micronutrients in bread wheat genotypes. Advances in Research. 11(1):1-8. DOI: 10.9734/AIR/2017/35461

19. Kendal, E. and Y. Dogan. 2015. Stability of a candidate and cultivars (*Hordeum vulgare* L) by GGE biplot analysis of multi-environment yield trial in spring barley. Poljoprivreda i Sumarstvo. 61(4):307. DOI:10.17707/AgricultForest.61.4.37

20. Mahmood, J. W. and M.F.H. AL-hassan.2023. Effect of hierarchy of the production of tillers in wheat (*Triticum aestivum* L.) cultivar (KM5180) under the influence of planting dates. Res. Crop. 24 (2): 236-240.

21. Moustafa, E. S., E.-S. E. El-Sobky, H. I. Farag, M. A. Yasin, A. Attia, M. O. Rady, M. F. Awad, and E. Mansour. 2021. Sowing date and genotype influence on yield and quality of dual-purpose barley in a salt-affected arid region. Agronomy. 11(4):717.DOI:10.3390/agronomy11040717 ·

22. Neisse, A. C., J. L. Kirch, and K. Hongyu. 2018. AMMI and GGE biplot for genotype× environment interaction: a medoid–based hierarchical cluster analysis approach for high–dimensional data. Biometrical Letters. 55(2):97-121. DOI: 10.2478/bile-2018-0008

23. Pinthus, M. J. 1973. Estimate of genotypic value: A proposed method. Euphytica. 22(1):121-123. DOI: 10.1007/BF00021563

24. Pour-Aboughadareh, A., M. Yousefian, H. Moradkhani, P. Poczai, and K. H. Siddique. 2019. Stabilitysoft: A new online program to calculate parametric and non-parametric stability statistics for crop traits. Applications in Plant Sciences. 7(1):e1211. DOI 10.1002/aps3.1211

25. Prasad, R. 2015. Stability Analysis of Yield and its Component Traits of Barley (*Hordeum vulgare* L.) Genotypes in Multi-

Environment Trials in the North Eastern Plains of Iindia. Sabrao J. Breed. Genet. 47(2):143-159.

26. Sediq, O., A. Rafiq, and Y. Hedayat. 2019. Effect of sowing dates on grain yield of wheat crop (*Triticum aestivum* L.) in Dar-ul-Aman Research Farm in Kabul Afghanistan. Environment and Ecology. 37(1):27-30.

27. Serrago, R. A., I. Alzueta, R. Savin, and G. A. Slafer. 2013. Understanding grain yield responses to source–sink ratios during grain filling in wheat and barley under contrasting environments. Field Crops Research. 150:42-51. DOI:10.1016/j.fcr.2013.05.016

28. Sheoran, O. 2010. Online Statistical Analysis (OPSTAT), Software developed by Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India. http://www.hau.ernet.in/opstat.html.

29. Shukla, G. 1972. Some statistical aspects of partitioning genotype-environmental components of variability. Heredity. 29(2):237-245. DOI: 10.1038/hdy.1972.87

30. Teklu, W. G. 2015. Adaptation of food barley (*Hordeum vulgare* L.): Genotypes. Journal of Agricultural Sciences (Belgrade). 60(2):227-235. DOI: 10.2298/JAS1502227W

31. Ullrich, S. 2011. Significance, adaptation, production, and trade barley, Barley: production, improvement, and uses. World Agriculture Series. Wiley-Blackwell. A. John Wiley and Sons, Inc. Oxford, UK. 3-13. DOI:10.1002/9780470958636.ch1

32. Wricke, G. 1962. Uber Eine Methode Zur Erfassung Der Okologischen Streubreite in Feldverzuchen. Z. Pflanzenzuchtg. 47(1):pp 92-96.