Journal homepage
www.ajas.uoanbar.edu.iq
Anbar Journal of Agricultural Sciences
(University of Anbar – College of Agriculture)

ASSESSMENT OF SOME RECENTLY INTRODUCED BARLEY CULTIVARS IN RESPONSE TO SOIL AND FOLIAR FERTILIZATION

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Article info

Received: 2022-07-02
Accepted: 2022-08-10
Published: 2022-12-31

DOI -Crossref:
10.32649/ajas.2022.176775

Cite as:
Omer, F. A., A. H. Mohammed, D. N. Sulaiman, and O. O. Salih. (2022). Assessment of some recently introduced barley cultivars in response to soil and foliar fertilization. Anbar Journal of Agricultural Sciences, 20(2): 485-496.

Abstract

Barley can be cultivated and gives better yields in a large number of environments under various fertilization practices. This experiment was conducted in two growing seasons 2018/2019 and 2019/2020 under rainfall condition. Four new introduced cultivars of barley (Arta, Tadmor, Clipper and Furat2) along with two commonly grown cultivars (Local-1 and Local-2) were represented in the current study; Soil (DAP) and foliar fertilization treatments were also involved; the treatments were arranged through Split Plot Design in RCBD with four replications where the seasons considered the main plots, barley genotypes sub plots and fertilization sub-sub plots.

The results of the present study demonstrated that each of Arta and Furat2 cultivars performed better in respect to growth and final grain yield under the multi environment conditions of the study. Additionally, the soil application of DAP and foliar fertilization treatment influenced significantly on the yield and growth parameters in various proportions. Application of both DAP and foliar treatments on barley that were grown under the rainfed condition resulted in the highest grain yield, better yield components and most of the growth traits during both growing seasons compared to control treatment. The GGE biplot analysis also showed the alignment of the introduced barley cultivars to the side of DAP and foliar fertilizers for final grain yield and most of yield component parameters demonstrating the importance of both fertilizers and mainly soil (DAP) for enhancing the yield of barley under rainfed environments.

Keywords: Foliar fertilizer, DAP, Soil fertilizer, Barley, Growth, Yield.

تقييم بعض اصناف الشعير المدخلة حديثا بالاستجابة للتسميد الارضي والورقي

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الخلاصة

يزرع الشعير بنجاح ويعطي حاصلا جيدا في البيئات المختلفة وتحت ظروف تسميد متباينة. نفذت هذه الدراسة في موسمين 2019/2018 و2020/2019 تحت الظروف الديمية لمحافظة دهوك وشملت اربعة اصناف من الشعير المدخلة حديثا الى المنطقة (Arta، Tadmor، Clipper، Furat2) بالإضافة الى صنفين محليين يزرعان من قبل فلاحي المنطقة (محلي1 ومحلي2)، وايضا معاملات التسميد الارضي والورقي بالإضافة الى معاملة المقارنة (بدون تسميد). تم ترتيب المعاملات في تصميم القطع المنشقة ضمن القطاعات العشوائية الكاملة وبأربع مكررات حيث اعتبرت المواسم القطاع الرئيسي والاصناف القطاع الثانوي ومعاملات السماد القطاع الثانوي–الثانوي.

اظهرت نتائج هذه الدراسة تفوق كل من الاصناف Arta وFurat2 في كل من صفات النمو والحاصل تحت البيئات المختلفة بينما كانت تأثير السماد الارضي والورقي معنوية بمستويات متباينة بحيث كلتا المعاملتين كانت متفوقة في الحاصل ومعظم صفات النمو بالمقارنة مع المعاملة بدون سماد. اظهرت تحليل GGE وقوع اصناف الشعير المتفوقة في جانب السماد الارضي والورقي في صفة الحاصل ومعظم صفات النمو مبينا اهمية كلا السمادين وخاصة الارضي (DAP) في تحسين انتاجية الشعير تحت الظروف الديمية.

كلمات مفتاحية: السماد الورقي، السماد الارضي، داب، الشعير، النمو، الحاصل.

Introduction

Barley (*Hordum vulgare L.*) is one of the world's most important cereal crops. It has been cultivated as a food and feed source from the beginning of settled agriculture and is widely adapted to a broader range of environments, especially low rainfall environments compared to other cereals due to its relatively low transpiration rate (15). it was the main bread plants of the Hebrews, Greeks and Romans (9). The protein content of most barley varieties may vary from 7.5-15% of the dry weight of the grain, while the starch content varies from 50-60%. Barley is grown nearly in all cultivated areas of the temperate zones, in many subtropical areas, and in high altitude sections of the torrid (hot) zones of both hemispheres. Some of early investigators considered Mesopotamia to be the center of origin of cultivated barley, but Nicolas Vavilov

considered that Abyssinia was the principal center, because many diverse forms grow wild there; this region is particularly rich in hulled, awned types of barley (11). In Iraq, the Kurdistan region (Duhok, Erbil, and Sulaimanya Governorates) with Ninevah region are the highest producers of barley; and it's also grows at middle part of Iraq, namely Wasit, Diala, Babylon and Thi-Qar.

Despite the normally narrow ranges and crispy distribution of annual rainfall, Iraqi Kurdistan region is characterized by wide ecological diversity and climatic variations. Accordingly, a large range of cultivars from different crops has introduces and settled. Barley tends to be grown in areas below 350 mm of rainfall and durum wheat in the 350-450 mm zone (2); over 90% of the region's rainfed barley yields are low, ranging from 0.6 tons.ha^{-1} in Jordan and Iraq to 1.8 tons ha^{-1} in Turkey. Inappropriate crop rotation, low fertilizer input, inappropriate weed control tactics, dates of sowing, and use of low yield local varieties account for such low yields. The demand for barley is attributed to increasing demand for livestock products. Much of the applied research in cereals in general and barley in particular has been designed to enhance production in an integrated crop-livestock system.

(19 and 13) reported the increasing of barley final grain yield in relation to foliar and DAP fertilizer application. Also, (10) recorded significant increases of both growth and yield of barley cultivars in respond to the foliar fertilization. (8) concluded in a study that barley cultivars gave a clear response to foliar application with increases in all morphological (plant height, leaves number, flag leaf area, numbers of tillers, shoot dry weight), physiological (chlorophyll content, total nitrogen and protein) and yield characters (No. spikes.plant^{-1}, 100-grains weight and final grain yield.plant^{-1}) compared with the control treatment.

On the other hand, (14) recommended that with the maximum values of fertilizers for barley cultivars corresponding to about 120 kg N.ha^{-1}, they declared that it's not advisable to exceed this dose because there will be no benefit to the plant and implies a risk of environmental contamination especially under rainfed environments. Also, (6) stated that the fertilizer application is based on the aim of barley cultivation, for malt or for feed; the results showed that as NPK fertilizer increased malting barley grain yield and straw, protein content, and weight of kernels, but had no effect on hectoliter weight. Similarly, (1) concluded that the fertilizer level of 100 kg.ha^{-1} DAP is economically best and recommendable for improving quality and productivity of barley in northern region of Jordan. Therefore, we conducted a 2-year trial in a rainfall site of Duhok region to evaluate the growth and yield of six recently introduced barley genotypes in response to soil and foliar fertilization in regards of various agronomic characteristics.

Materials and Methods

Based on the growth and yield adaptability and assessment, four new introduced genotypes of barley (Arta, Tadmor, Clipper and Furat2) along with two commonly grown cultivars (Local-1 and Local-2) were represented in the current study (Table 1). Soil and foliar fertilization treatments were also involved representing each of DAP; Diammonum phosphate: 18:46:0 in a recommended rate of 120 kg.ha^{-1} sprayed at the

beginning of tillering stage at the early March and Eco-Zinc foliar fertilizer in a rate of 5000 ml.ha^{-1} at heading stage in addition to control treatment. The study was implemented in two growing seasons 2018/2019 and 2019/2020. The treatments were arranged in Split Plot Design in RCBD with four replications where the seasons considered the main plots, barley genotypes sub plots and fertilization sub-sub plots.

The site was prepared for planting using tractor-drawn moldboard and disc harrow. DAP fertilizer was then applied as broadcast by hand to the plots (1.5 m wide×3 m long) each plot had five sowing rows in 30 cm apart. The seeding rate was 100 kg.ha^{-1} for each genotype and adjusted for each plot based on germination percentage and grain weight with planting dates around mid-November for both seasons manually. After crop emergence, weeds were controlled using proper herbicides and then the field emergency was calculated via counting the number of plant in one of the middle lines then converted to percentage as the weight of seeds was known for each line. As is typical of the area, rainfall was variable and unevenly distributed through the growing season (Figure1). In season 2018/19, the annual rainfall was 666.9 mm and 779.24 mm for 2019/20 season, as recorded in a site meteorological station.

Table 1 Information about the barley cultivars involved in the study.

	Variety	Release	Pedigree	Origin	Breeding information
1	Arta	2016	6/Emir/sbt//CM67/3/F8-HB-854-23/121 ICB97-0282-0AP-23AP-15TR-0AP	ICARDA	White Introduction
2	Tadmor	2016	ER/Apm/3/W12291/Tadmor ICB04/0754-0AP-26AP-0AP	ICARDA	Black Introduction
3	Clipper	2016	W12291*2/W12269/7/Hml-02/5/Cq/Cm//Apm/3/12410/4/Giza134-2L/6/ ICB05-0484-BAP-0AP	ICARDA	White Introduction
4	Furat2	-	SB-INC-AUB-15	Iraq	White
5	Local-1	-	Local	Iraq	Black
6	Local-2	-	Local	Iraq	White

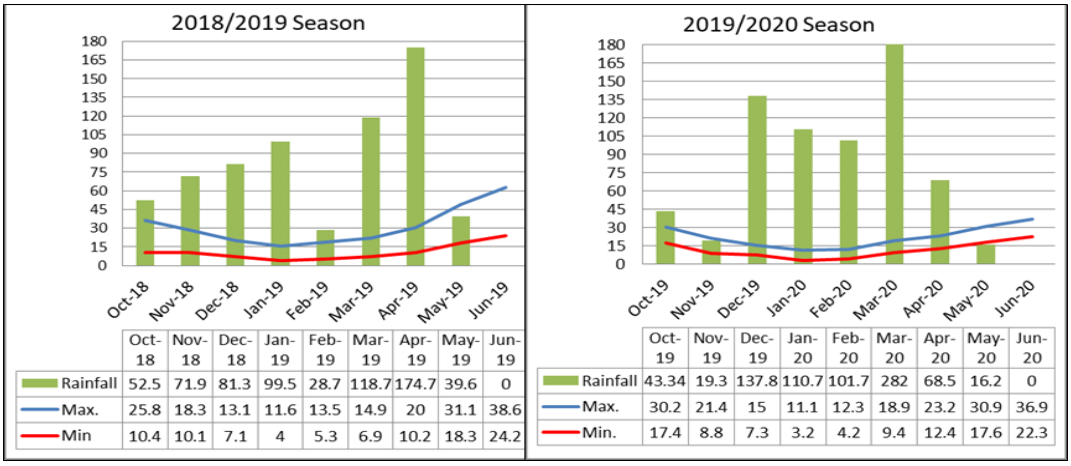

Figure 1 Metrological data for the experiment site at both growing seasons.

All growth traits were measured each at their favorable time for both seasons; flag leaf area was calculated based on (5) formula; (W*L*0.75). At the full maturity stage, one square meter (1m^2) from the middle rows of each experimental unit was harvested manually 5 cm above soil at early June for yield quantity, quality and further required

measurements. Tadmur genotype was harvested 5 days earlier. The harvested crops were kept in polyethylene bags after taking five spikes randomly for spike measurements such as spike length, number of seeds per spike. Subsequently the yield for both seasons were transferred to the laboratories of Agricultural Research Center of Duhok for threshing and cleaning which were carried out by the spike thresher Machine.

The data were statistically analyzed using GenStat programe, version 10. Duncan Multiple Range test (DMRT) at 0.05 level was used for the mean comparisons. Also, analyses of significant interactions for final yield and some yield component parameters were carried out by GGE biplot test.

Results and Discussion

Growth Characteristics: Field emergence (%): Significant differences among barley cultivars were observed for the percentage of field emergence (Table 2). Furat2 and Local-2 showed the lowest field emergence, 52.03% and 48.06%, respectively. The highest value was observed for Local-1 (65.28%). Field emergence was also significant in regards to growing seasons. The 2019/20 was superior (64.63%) compared to 58.95% for the 2018/19 growing season. On the other hand, the effect of fertilizers was not significant. All interactions between the study factors were also significant on the field emergence percentage; barley cultivars had the notable contribution on the signification of the all involved factors interactions. Seed emergence may be affected by seed vigor, sowing depth and other soil and climatic conditions (Fig.1). The maximum field emergence and further growth traits (e.g. early growth, plant height) of wheat and barley are mainly affected by the sowing depth and day/night temperature (7).

Table 2 Mean of field emergence (%) of barley cultivars as affected by various fertilizers in different growing seasons.

Seasons	Fertilizers	Barley Cultivars						Seasons X Fertilizers	Mean of Seasons
		Arta	Tadmor	Clipper	Furat2	Local-1	Local-2		
2018	**Control**	65.3 ab	63.67 ab	64.67 ab	64.3 ab	65.3 ab	32.33 c	59.28 b	**58.95 b**
	DAP	65.6 ab	64.67 ab	64.33 ab	64.0 ab	65.0 ab	30.67 c	59.06 b	
	Foliar	63.6 ab	63.67 ab	63.67 ab	64.3 ab	64.6 ab	31.00 c	58.50 b	
2019	**Control**	62.6 b	62.67 b	64.00 ab	65.3 ab	64.0 ab	64.67 ab	63.89 a	**64.63 a**
	DAP	65.6 ab	66.67 ab	65.67 ab	64.3 ab	64.0 ab	63.33 ab	64.94 a	
	Foliar	63.0 ab	64.67 ab	64.00 ab	63.6 ab	68.67a	66.33 ab	65.06 a	
Seasons X Cultivars	**2018**	64.89 a	64.00 a	64.44 a	64.00 a	65.00 a	31.33 b	Mean of Fertilizers	
	2019	63.78 a	64.67 a	64.56 a	64.44 a	65.56 a	64.78 a		
Cultivars X Fertilizers	**Control**	64.00 a	63.17 a	64.33 a	64.83 a	64.67 a	48.50 b	**61.58 a**	
	DAP	65.67 a	65.67 a	65.00 a	64.17 a	64.50 a	47.00 b	**62.00 a**	
	Foliar	63.33 a	64.17 a	64.17 a	63.67 a	66.67 a	48.67 b	**61.78 a**	
Mean of Barley Cultivars		64.43 a	64.33 a	64.50 a	64.03 a	65.28 a	48.06 b		

* Within each factor and their interactions values followed by similar alphabetical letters are not significantly different at 5% according to DMRT.

Plant Height (cm): Also for plant height, significant genotypic effects were observed (Table 3). Plant height varied between 83.00 for Arta and 79.28 cm for Local-2 cultivar. With respect to growing seasons and fertilization treatments, plant height was not

differed significantly. The interactions between all studied factors were also significant. The interaction of control treatment of fertilizer application in 2019/20 season, Arta cultivar in 2018/19 season, Arta with DAP fertilizer, and the second order interaction of Furat2 in 2019/20 season with control treatment were recorded highest plant height compared to other interactions. Plant height is genetically controlled by the Rht genes (17), but growth conditions such as water availability and temperature can significantly influence plant height. All tested cultivars are of the semi-dwarf type (80-100 cm). Similar results regarding plant height in drought prone environments were reported by (17).

Table 3 Mean of plant height (cm) of barley cultivars as affected by various fertilizers in different growing seasons.

Seasons	Fertilizers	Barley Cultivars						Seasons X Fertilizers	Mean of Seasons
		Arta	Tadmor	Clipper	Furat2	Local-1	Local-2		
2018	**Control**	82.33a-e	82.0a-f	80.0b-g	82.67a-e	82.0a-f	75.00g	80.67bcd	**81.90a**
	DAP	85.00abc	81.6a-g	86.0abc	84.33a-d	81.0a-g	77.67d-g	82.61ab	
	Foliar	86.33ab	81.3a-g	81.6a-g	84.33a-d	81.3a-g	79.67b-g	82.44abc	
2019	**Control**	79.67b-g	80.6a-g	80.0b-g	86.67ab	85.3abc	87.33a	83.28a	**81.04a**
	DAP	85.67abc	84.6abc	77.0efg	80.00b-g	77.6d-g	75.33fg	80.06cd	
	Foliar	79.00c-g	75.3fg	80.0b-g	81.00a-g	82.6a-e	80.67a-g	79.78d	
Seasons X Cultivars	**2018**	84.56a	81.6abc	82.5abc	83.78ab	81.4abc	77.44d	Mean of Fertilizers	
	2019	81.44abc	80.2bcd	79.0cd	82.56abc	81.8abc	81.11abc		
Cultivars X Fertilizers	**Control**	81.00a-e	81.3a-d	80.0b-e	84.67ab	83.6abc	81.17a-d	**81.97a**	
	DAP	85.33a	83.1abc	81.5a-d	82.17a-d	79.3cde	76.50e	**81.33a**	
	Foliar	82.67a-d	78.3de	80.8a-e	82.67a-d	82.0a-d	80.17b-e	**81.11a**	
Mean of Barley Cultivars		83.00a	80.9ab	80.7ab	83.17a	81.6ab	79.28b		

* Within each factor and their interactions values followed by similar alphabetical letters are not significantly different at 5% according to DMRT

Leaf Area (Cm^2): Table 4 displayed a significant genotype and environment effect representing by growing seasons and fertilizers determined for flag leaf area trait. Also, all interactions among the studied factors were significant. It is obvious that flag leaf area shows a similar genotypic pattern across growing seasons and fertilization that generally a higher flag leaf area was recorded in Clipper genotype, whereas the performance in the Tadmor was inferior. Leaf area was better in 2018/19 season as the maximum and minimum temperature and also rainfall at the active grow period (April) was higher compared to 2019/20 season (Fig.1). Foliar fertilizer was superior and recorded 16.58 cm^2 compared to soil DAP or control treatments due to the fast reaching of nutrient through foliar spraying to the leaf and other parts of the plant (10).

Table 4 Mean of leaf area (cm^2) of barley cultivars as affected by various fertilizers in different growing seasons.

Seasons	Fertilizers	Barley Cultivars						Seasons X Fertilizers	Mean of Seasons
		Arta	Tadmor	Clipper	Furat2	Local-1	Local-2		
2018	Control	12.02f-i	9.86i	11.95f-i	11.5ghi	11.42ghi	12.6e-i	11.56d	**14.93a**
	DAP	13.98d-h	13.7d-h	14.88c-g	13.8d-h	14.30d-h	14.4d-h	14.20b	
	Foliar	18.61ab	15.8b-e	20.91a	20.2a	20.59a	17.9abc	19.01a	
2019	Control	12.33e-i	11.7f-i	15.10c-f	14.1d-h	14.77c-g	13.0d-i	13.51bc	**13.49b**
	DAP	12.57e-i	13.9d-f	12.83e-i	13.7d-h	11.27hi	12.5e-i	12.79c	
	Foliar	13.97d-h	13.7d-h	16.37bcd	14.6d-h	12.53e-i	13.6d-h	14.15b	
Seasons X Cultivars	2018	14.87ab	13.1bcd	15.92a	15.2a	15.43a	14.9a	Mean of Fertilizers	
	2019	12.96cd	13.1bcd	14.77abc	14.1a-d	12.86d	13.0bcd		
Cultivars X Fertilizers	Control	12.18fg	10.8g	13.53ef	12.8efg	13.09ef	12.8efg	**12.54c**	
	DAP	13.27ef	13.8def	13.86def	13.8def	12.78efg	13.4ef	**13.50b**	
	Foliar	16.29bc	14.7cde	18.64a	17.4ab	16.56abc	15.7bcd	**16.58a**	
Mean of Barley Cultivars		13.91bc	13.13c	15.34a	14.6ab	14.14abc	14.0bc		

* Within each factor and their interactions values followed by similar alphabetical letters are not significantly different at 5% according to DMRT

Yield and yield components characteristics: Grain yield can be dissected into its main components number of spikes per unit area, number of kernels per spike and kernel weight. Growing environments and fertilization may affect these components differently in different genotypes:

Number of Tillers (spike.m^{-2}): The main effects variety and fertilization were significant for number of tillers per unit area trait, while the effect of growing season was not significant. The interactions between the studied factors were not significant excluding the second order interaction of all treatments.

The number of fertile tillers per unit area was generally highest for Arta, Tadmor, Furat2 and local-2 and lowest for Clipper and Local-2 varieties (Table 5). DAP fertilization unconventionally produced the highest number of fertile tillers (176.9 tillers.m^2) and surpassed significantly both foliar or control treatments. It is also observed from the interaction of all treatments that mostly the DAP fertilizer with all factors enhanced the production of tillers per unit area. The biplot analysis clearly dispay the arranging most of the intorduced barley cultivars to the side of DAP fertilizer for the number of tillers per unit arae (Figure 2). Diammonium phosphate (DAP) is an important component of many metabolic processes (photosynthesis, respiration, storage, energy transfer, cell division, cell expansion, etc.) and others in plants and also its associated with the growth factors such as improving the root system growth, enhancing stem strength, improving flowering and seed production, and increasing the plant resistance to stress. The obtained results are in harmony with those of (1).

Table 5 Mean of number of tillers (spikes.m-2) of barley cultivars as affected by various fertilizers in different growing seasons.

Seasons	Fertilizers	Barley Cultivars						Seasons X Fertilizers	Mean of Seasons
		Arta	Tadmor	Clipper	Furat2	Local-1	Local-2		
2018	**Control**	156.7abc	185.7abc	163.3abc	167.3abc	147.3abc	132.0abc	158.7b	**168.5a**
	DAP	204.7a	202.0ab	190.3abc	200.7abc	152.0abc	188.7abc	189.7a	
	Foliar	162.0abc	167.3abc	128.7bc	146.0abc	153.3abc	184.3abc	156.9b	
2019	**Control**	191.7abc	162.3abc	127.0c	147.3abc	150.7abc	187.3abc	160.4b	**161.8a**
	DAP	157.0abc	166.7abc	163.7abc	143.3abc	168.7abc	181.7abc	164.2b	
	Foliar	158.7abc	127.0c	195.7abc	178.0abc	179.0abc	126.7c	160.8b	
Seasons X Cultivars	**2018**	174.4a	185.0a	160.8a	171.3a	150.9a	168.3a	Mean of Fertilizers	
	2019	169.1a	152.0a	156.7a	161.7a	166.1a	165.2a		
Cultivars X Fertilizers	**Control**	174.2a	174.0a	149.0a	155.3a	145.2a	159.7a	**159.6b**	
	DAP	180.8a	184.3a	168.8a	182.2a	160.3a	185.2a	**176.9a**	
	Foliar	160.3a	147.2a	162.2a	162.0a	166.2a	155.5a	**158.9b**	
Mean Barley Cultivars		171.8a	168.5a	161.4b	163.7a	158.5b	166.8a		

* Within each factor and their interactions values followed by similar alphabetical letters are not significantly different at 5% according to DMRT

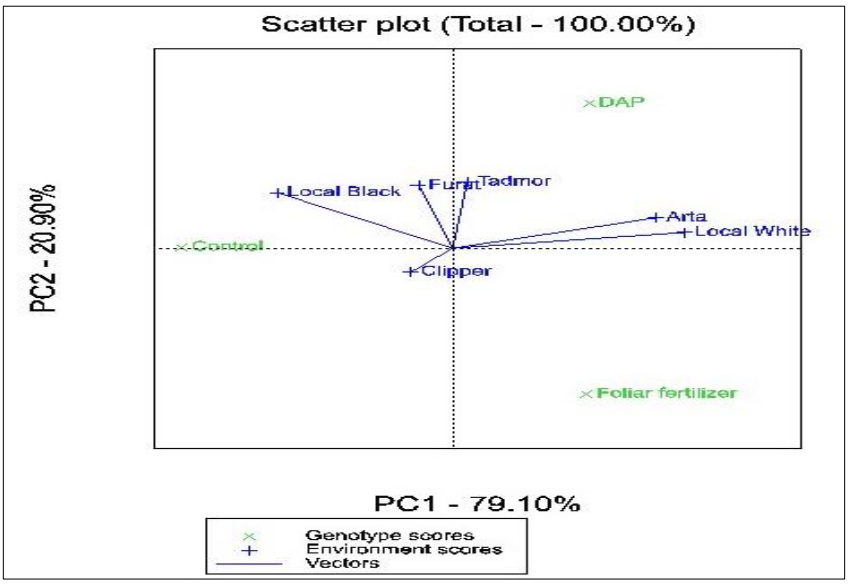

Figure 2 GGE biplot for number of tillers in respond to the fertilization.

Number and grain weight: Tables 6 and 7 include the number of seeds per spike and grain weight (weight of 1000 seeds). Single effects of the studied factors was significant only for the barley genotypes in regards to the grain number, Local-1 recorded higher number of grains per spike (26.5 grains) compared the 24.44 grains recorded by the Clipper genotype. The interactions between the studied factors was significant for the number of grains and makes it obvious that mainly DAP and/or foliar fertilizer is responsible for the significant interaction term and they clearly contributed for the increasing of the weight of 1000 grains compared to control treatment.

As for the weight of grains (Table7), also, the effect of single factors was significant only for barley cultivars and the Furat2 with Local-1 recorded highest values, 48.67g and 46.36g respectively while Arta cultivar was inferior for this trait and recorded lowest value 33.44g. The interaction of the studied factors also was significant on the weight of 1000 grain. Foliar fertilizer was the contributor for enhancing grain weight

in most of the interactions. On the other hand, growing season and namely 2018 season was somewhat superior to 2019 season in interaction effects. The 2018 season influence on the grain weight may due to the higher rainfall amount in the last three months of the barley growth period (March, April, and May) which resulted in higher 1000 weight of the wheat nursery and increasing the grain filling period and accumulating higher nutrients in seeds and consequently better grain weight (Fig. 1). The positive effect of early flowering on grain mass was also demonstrated by Sio-Se (12).

Table 6 Mean of number of seeds per spike (No.) of barley cultivars as affected by various fertilizers in different growing seasons.

Seasons	Fertilizers	Barley Cultivars						Seasons X Fertilizers	Mean of Seasons
		Arta	Tadmor	Clipper	Furat2	Local-1	Local-2		
2018	**Control**	28.67a-d	26.67a-f	27.00a-f	26.67a-f	27.33a-f	28.67a-d	27.50a	**27.31a**
	DAP	28.67a-d	29.67ab	24.00c-g	28.33a-e	27.00a-f	25.33a-g	27.67a	
	Foliar	26.67a-f	26.67a-f	26.67a-f	25.33a-g	28.33a-e	30.00a	27.28a	
2019	**Control**	21.33g	25.33a-g	22.33fg	24.33c-g	25.00a-g	22.33fg	23.44b	**24.35a**
	DAP	24.33c-g	23.33efg	23.00fg	24.33c-g	29.00abc	26.33a-g	25.06b	
	Foliar	27.33a-f	25.00a-g	23.67d-g	24.67b-g	22.33fg	24.33c-g	24.56b	
Seasons X Cultivars	**2018**	28.00a	27.67a	25.89ab	26.78ab	27.56a	28.00a	Mean of Fertilizers	
	2019	24.33bc	24.56bc	23.00c	24.44bc	25.44abc	24.33bc		
Cultivars X Fertilizers	**Control**	25.00ab	26.0ab	24.67ab	25.5ab	26.17ab	25.50ab	**25.47a**	
	DAP	26.50ab	26.50ab	23.50b	26.33ab	28.00a	25.83ab	**26.11a**	
	Foliar	27.00ab	25.83ab	25.17ab	25.00ab	25.33ab	27.17a	**25.92a**	
Mean Barley Cultivars		26.17ab	26.11ab	24.44b	25.61ab	26.50a	26.17ab		

Table 7 Mean of 1000 weight (g) of barley cultivars as affected by various fertilizers in different growing seasons.

Seasons	Fertilizers	Barley Cultivars						Seasons X Fertilizers	Mean of Seasons
		Arta	Tadmor	Clipper	Furat2	Local-1	Local-2		
2018	**Control**	26.50d	36.1bcd	36.00bcd	38.30bcd	57.50ab	35.17bcd	38.42a	**41.3a**
	DAP	36.4bcd	36.3bcd	53.6a-d	42.17bcd	52.83ab	29.0bcd	42.97a	
	Foliar	32,4bcd	50.6a-d	31.5bcd	63.17a	27.00cd	34.00bcd	42.19a	
2019	**Control**	31.0bcd	34.6bcd	36.0bcd	40.0bcd	55.6a-d	36.83bcd	39.03a	**39.8a**
	DAP	37.0bcd	36.0bcd	50.83a-d	41.6bcd	51.8a-d	32.5bcd	41.47a	
	Foliar	33.0bcd	46.5bcd	40.17bcd	52.6a-d	34.3bcd	57.0abc	43.53a	
Seasons X Cultivars	**2018**	32.20b	41.3ab	41.06ab	52.56a-d	46.44ab	33.06b	Mean of Fertilizers	
	2019	33.27b	38.7ab	44.00ab	44.78ab	46.28ab	42.11ab		
Cultivars X Fertilizers	**Control**	28.45e	35.8cde	36.50b-e	39.17b-e	56.58ab	37.50b-e	**38.72a**	
	DAP	36.42b-e	37.6b-e	51.75a-d	41.9b-e	54.3abc	31.25e	**42.22a**	
	Foliar	33.17de	48.5a-e	36.33cde	64.92a	31.17e	45.00a-e	**43.86a**	
Mean of Barley Cultivars		33.44b	40.2ab	41.53ab	48.67a	46.36a	37.41ab		

* Within each factor and their interactions values followed by similar alphabetical letters are not different significantly at 5% according to DMRT.

Final grain yield ($t.ha^{-1}$): Table 8 displays the significant differences among the single effect as well as the interactions of the studied factors on the final grain yield. The yield was higher in 2019 season as the amount annual rainfall was higher in this season; 779.24 mm compared to 666.9 mm in 2018 season. Each of Arta and Furat2 were superior and recorded 2.9 and 2.7 $t.ha^{-1}$ respectively compared to Local-2 cultivar which

was inferior in final grain yield. DAP fertilizer significantly obtained highest grain yield (2.80 $t.ha^{-1}$) followed by foliar application.

The interaction of barley cultivars with 2019 growing season and DAP fertilizer performed better final grain yield; also, DAP fertilizer interaction with 2019 season was superior compared to other interactions. The second order interaction of all involved factors exhibited the superiority of Furat2 and Local-1 cultivars with DAP fertilizer in 2019 season and recorded highest final grain yield; the reason behind the superiority of each of Arat and Furat2 cultivars as well as DAP fertilizer may due to their contribution for producing higher number of tillers per unit area (Table 5).

The winning barley cultivars within this mega environment are Arta followed by Furat2 as they showed stable superiority in mean grain yield along with the growing seasons and fertilizer application. Arta exhibited higher grain yield in both seasons and in both DAP and foliar fertilization; Furat2 cultivar produced good grain yield in 2018 season and with foliar fertilizer in 2019 season. In the different growing season grain yield was influenced by different components. In 2018 significant correlations (r=0.68*) were estimated with number of tillers (Table 5) while in 2019 season correlated with field emergence (r=0.72*). (3) found also significant variation in grain yield for different what varieties in multi-location experiments. (16) reported similar contributions of yield components to grain yield. Grain yield was also significantly associated with the amount of rainfall in the respective locations (Fig. 1) (4) reported that reduction of wheat grain yield under drought is associated with the reduction in photosynthesis rate and other growth performance which affect negatively all grain traits and also the grain yield can be associated with growth habit.

The GGE biplot for the interaction of final grain yield with both enivironments and fertilizers is displayed in Figure 3. The barley cultivars group together along the PC1 axis which explains >90% and >60% of the variation for seasons and fertilizers respectively. The 'winning' cultivars within 2018environment are Arta and Furat which showed superiority in grain yield. The other two varieties in this sector are Clipper and Tadmor in 2019 season. The position of cultivar local-1 in the biplot is far from both seasons, which demonstrates the inferiority of this particular cultivar to both seasons. On the other side Arta with DAP and foliar fertilizer showed obtuse angle compared to control treatment indicating good responding to these type of fertilization for improving the final grain yield.

Table 8 Mean of grain yield (t.ha^{-1}) of barley cultivars as affected by various fertilizers in different growing seasons.

Seasons	Fertilizers	Barley Cultivars (C)						Seasons X Fertilizers	Mean of Seasons
		Arta	Tadmor	Clipper	Furat2	Local-1	Local-2		
2018	Control	1.39hij	1.40hij	1.70ghij	1.47hij	1.27ij	0.47 j	1.289d	**1.75 b**
	DAP	2.94b-g	2.18e-i	2.069f-i	2.66c-h	1.86ghi	1.71ghij	2.241c	
	Foliar	2.35a-i	1.66hij	1.90ghi	1.78ghi	1.23ij	1.31ij	1.709d	
2019	Control	3.79abc	3.89abc	3.88abc	3.24a-f	3.12b-f	3.18a-f	3.881a	**3.56 a**
	DAP	3.61a-d	3.55a-d	3.21a-f	4.58a	4.04a	3.40a-e	3.359ab	
	Foliar	3.43a-d	3.34a-e	3.64a-d	3.43a-e	3.15a-f	3.61a-d	3.438ab	
Seasons X Cultivars	2018	2.232b	1.753bcd	1.892bc	1.975bc	1.458cd	1.167d	Mean of Fertilizers	
	2019	3.616a	3.596a	3.583a	3.584a	3.576a	3.40a		
Cultivars X Fertilizers	Control	2.59abc	2.64abc	2.79ab	2.77ab	2.86ab	1.82abc	**2.48b**	
	DAP	3.28a	2.87ab	2.64abc	2.952ab	2.49abc	2.55abc	**2.80a**	
	Foliar	2.895ab	2.50abc	2.77ab	2.60abc	2.19abc	2.46abc	**2.59b**	
Mean Barley Cultivars		2.92a	2.67ab	2.73ab	2.77a	2.51ab	2.28b		

* Within each factor and their interactions values followed by similar alphabetical letters are not significantly different at 5% according to DMRT.

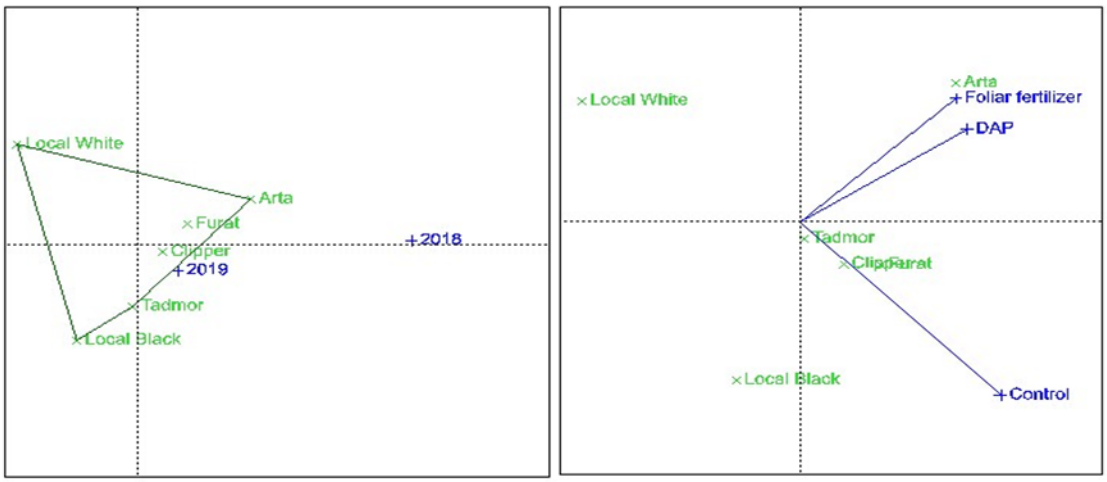

Figure 3 GGE biplot of final grain yield interaction with environments and fertilizers.

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