Response of some six rowed barley varieties (*Hordeum vulgare L.*) to micronutrient Fe for growth and yield under dry farming condition

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Abstract:

This study carried out in Sulaimani region at Bakrajo directorate of agriculture research station during the cultivate season of 2017-2018 to evaluate the response of four barley varieties (Tadmor, Zabad, Legnee and Arivat) to three levels of Fe- EDDHA (0, 20 and 40 kg ha^{-1}), the design of split plot was conducted. The results of the study confirmed that there were significant differences among genotypes for all studied characters. The application of 40 kg/ha Fe- EDDHA produced maximum value for almost all studied characters. The maximum grain yield was 6.333T/ha produced by Lignee variety as 40 kg/ha of Fe- EDDHA was applied. Maximum positive direct effect in grain yield recorded by biomass yield 1.551, and followed by harvest index and weight of grains/ spike 1.347 and 0.866 g respectively. This indicates that the increase of these components causes some increase in grain yield.

Key words: *Barley, Variety, Fe fertilization, Growth, yield and yield components, Correlation and Path analysis.*

إستجابة بعض أصناف الشعير ذو الستة الصفوف (***Hordeum vulgare L***) للمغذي الدقيق- الحديد للنمو والحاصل تحت ظروف الزراعة الجافة

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الخلاصة:

أجريت هذه الدراسة في محطة البحوث الزراعية في بكره جو – محافظة السليمانية, خلال موسم الزراعة 2017-2018 , لتقييم إستجابة أربعة أصناف من الشعير (Tadmor, Zabad , Lignee و Arivat) إلى ثلاثة مستويات من الحديد (0 , 20 و 40 Fe-EDDHA كغم/ هكتار) , وفقا لتصميم القطع المنشقة ورتبت القطع الرئيسية وفقا لتصميم القطاعات العشوائية الكاملة. أظهرت نتائج الدراسة وجود فروق معنوية بين الأصناف لجميع الصفات المدروسة. أعطى إستخدام (40 كغم Fe-EDDHA / هكتار قيمة قصوى لمعظم الصفات المدروسة, وكان أعلى إنتاج الحبوب هو (6.333 كغم/ هكتار) لصنف Lignee بإستخدام (40 كغم Fe-EDDHA/ هكتار وجد بأن الحاصل البايولوجى سجل أعلى قيمة لتأثير المباشر على حاصل الحبوب 1.551 ويليه دليل الحصاد و وزن الحبوب/ سنبلة 1,347 و 0.866 على الترتيب وهذا يدل على أن زيادة هذه المكونات تسبب بعض الزيادة في حاصل الحبوب .

TNTRODUCTION

Barley (*Hordeum vulgare L.*) a member of *Poaceae* is one of the first crops domesticated for human consumption and among the most important cereals cultivated worldwide since it can grow in large number of environmental conditions. The growing worldwide demand for barley is placing pressure on new innovations to improve the cultivars with greater yield (1). Barley is the modest grain which has a broad range of compatibility and transmittance between other crops. Following wheat, rice and maize barley is the fourth essential grain in the globe (2). Since grains especially barley make up 60 to 70% of human calorie intake around the world to reach self-sufficiency in agricultural products surface unit yield must be increased, so micronutrients role in quality improvement

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of agricultural products are of great importance (3, 4). Research on barley bears special significance due to its great elasticity of adaptation under various stresses and lot of potential both for domestic and industrial uses. The major uses of barley grains however are in the production of malt, which is used to make beer, beverage industrial alcohol, whisky, malt syrups, melted milk and vinegar (5). Necessity of iron for plant development was discovered by Knop and Vansachs in 1860s (6). Iron plays decisive role in plant metabolism particularly in chlorophyll synthesis which is vital for plant photosynthesis. In many enzymes such as catalases and peroxidases as well as flavoproteins iron is a key structural component (7, 8). Malakooti and Tehrani (9) suggested that iron deficiency may adversely affect grain growth and eventually community's health. Barley is considered as one of the first cereals domesticated for use by man as food and feed. It is an important rabi cereal crop grown through the temperate and tropical regions of the world. It occupies the fourth position in terms of acreage and third position in terms of crop production. Barley is cultivated on around %11 of the world total area under cereal cultivation. It has very broad ecological adaptation ranging from North America, Argentina, North Africa and most of Asiato Australia (10). (11) reported that iron is critical for chlorophyll formation and photosynthesis, and is important in the enzyme systems and respiration of plants.

The objective of this study is to evaluate the effect of various levels of Fe-EDDHA on yield with yield parameters of barley and choosing the best variety of Barely grown in this area.

Materials and Methods:

This experiment was conducted during the winter season of 2017-2018, to study the effect of Fe- EDDHA fertilizer levels on yield and yield components of some genotypes of Barley in Experimental Farm in directorate of agriculture research in Bakrajo on location Latitude (35^0 33' ; N) and Longitude (450 21; E, 750 MASL). Some physical and chemical properties of the experimental soil determined in table (1). Moreover, the temperature and monthly rainfall precipitation at Bakrajo is shown in Table (2). The experiment was conducted with split- plot design, the main plots arranged according to CRBD and replicated three times. Four varieties of Barely were selected for cultivation, which have been provided by the Sulaimani Agricultural Research Center, names; Tadmor, Zabad, Lignee and Arivat , emplemented in the main plots.Some different levels of iron fertilizer were added to the subplots (0, 20 and 40 kg ha^{-1}) as Fe-EDDHA, The treatments were exerted with sowing. . Each main plot was consisted of three subplots with 3 rows, each subplot consist of 3 lines (0.20 m between lines and 0.10 m between plants). Planting date was on December 19, 2017. Nitrogen fertilizer was applied after sowing time. All other agronomic practices and weed control were accomplished according to normal field practices. Statistical analyses of variance as a general test was done according to analysis of 2 factors, and the means were tested according to least significant difference (L.S.D) using significant level of 0.05 (7). The LSD test was done to find the significant differences between treatments means at 5% probability level. The mature plants were harvested on 25 June 2018 to estimate biological yield, seed yield and yield components.

Studied Characteristics:

The studied characters were:

- Number of days to 50% flowering, Number of days to heading, Plant height (cm), Flag leaf area, Number of tillers/ m2, Number of spikes/ m^2, Spike length, Number of grains /spike, Weight of grain / spike, 1000 grain weight, Biological yield , Grain yield, Chlorophyll content and Harvest index .

$$H.I.= \frac{Grain\ yield\ (Tons/ha)}{Biological\ yield\ (Tons/ha)}$$

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Table 1: Some physical and chemical properties of soil analysis at experimental site:

Soil properties		***value***
Sand (mg kg^{-1})		40.5
Silt (mg kg^{-1})		657.3
Clay (mg kg^{-1})		302.2
Texture class		Silty Clay loam
ECe (ds m^{-1})		1.78
PH		7.94
O.M (%)		2.24
Total N (%)		0.10
Available Phosphate (mg kg^{-1})		4.51
Available Iron (mg kg^{-1})		0.848
Available Zinc (mg kg^{-1})		0.039
CaCo3 (%)		21
Soluble cations and anions Meq L^{-1}	Ca^{+2}	1.1
	Mg^{+2}	0.42
	K^{+}	0.38
	Na^{+}	0.091
	CO_3^{-2}	Nill
	$HCO3^{-}$	3.6
	CI^{-}	0.12

Table 2: Average air temperature and rainfall during the growing seasons of 2017-2018 at Bakrago Location

Months	***Average Air Temperature (°C)***		***Rainfall (mm)***
	Max.	***Min.***	
November	21.3	7.6	44.5
December	11.1	3.0	158.0
January	11.10	1.46	59.2
February	13.02	0.26	96.5
March	17.73	7.45	111.5
April	23.89	10.97	54.5
May	31.63	13.48	27.7
Total			551.9

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Results and Discussion:

Data represent in table (1) illustrate the differences among varieties for growth characters. Highly significant differences present among varieties for all growth characters except chlorophyll content and number of tillers/ plant which were significant (Appendix 1). Tadmor variety recorded minimum number of days to flowering (113.444) days, while Lignee 527 variety spent minimum number of days to heading (105.333). Maximum values due to the characters Plant height, flag leaf area and chlorophyll content were (87.852 cm, 7.833 cm^2 and 55.156) respectively recorded by Arivat variety. The highest number of tillers / plant was (4.730) recorded bay Zabad variety. Significant differences were reported previously among barley genotypes for most growth characters by (12, 5, 13, 14).

Data present in table (2) explain the effect of iron micronutrient on some growth characters. All growth characters responded high significantly to iron except days to heading and number of tillers /plant which were not significant (Appendix 2). The application of (40kg/ha) recorded minimum number of days to flowering (117.5), while the application of this level recorded the highest value for the characters plant height, flag leaf area and chlorophyll content reached (72.723cm, 6.522cm^2 and 98.225) respectively. The similar results were found where wheat plant showed an increase in dry matter, grain yield and straw yield significantly as compared with control (15). Also, the leaf chlorophyll content and dry matter production in some crops plant increased when the soil amended with Fe-EDDHA (16).

Data present in table (3) illustrate the effect of the interaction between varieties and iron levels on some growth characters. As seen in this table the character plant height respond high significantly to interaction effect, while the character chlorophyll content showed significant response to interaction effect, but the other character respond non significantly (Appendix 1). Concerning to plant height maximum value due to this character was (89.890cm) recorded by the interaction between Arivat variety under the application of (40kg/ha) iron. The lowest value was (59.890cm) recorded by Zabad variety compeld with no application of iron. Respect to the character chlorophyll content it was observed that the highest content was (63.100) recorded by the interaction between Arivat variety and the application of (40kg/ha), but the lowest content was (39.200) recorded by Lignee variety compled with not iron application.

Data in table (4) explain the means of varieties for grain yield and its components. As seen in this table there were highly significant differences among varieties for all characters except the characters biomass yield, grain yield and harvest index, which present significant differences among varieties (Appendix 2). Maximum number of spikes/m^2 was (734.889) spike recorded by Lignee variety. Maximum value for the characters spike length, 1000 grain weight and harvest index were (7.533cm, 53.447 and 0.414) respectively recorded by Tadmor variety. The highest number of grains/ spike and biomass yield were (39.933g and 17.5 T/ha) recorded by Arivat variety. The Zabad variety recorded maximum weight of grains/ spike and maximum grain yield value reached (1.953g and 6.054 T/ha) respectively. Similar results reported previously indicated to the presences of significant differences among barley genotypes, this due to genetic performance of different genotypes for grain yield and most of its components (5, 17, 13, 14).

Data in table (5) indicate to the effect of iron levels on grain yield and its components. The characters number of grains/ spike, weight of grains /spike, 1000 grain weight, biomass yield and grain yield reacted high significantly to iron application, recording (3.817, 1.55g, 47.23g, 16.833 T/ha and 6.199 T/ha) respectively as (40 kg/ha) iron were applied. The other characters responded not significantly to iron application (Appendix 2). Similar results recorded previously by (18,19,20,21) they reported that Fe plays crucial role in plant respiration, photosynthetic reactions and chlorophyll synthesis and decrease in level of Fe reduces

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plant growth as a result diminishes food production, addition of Fe improves the grain yield components.

Data recorded in table (6) indicate to the interaction effect between varieties and iron levels on grain yield and its components. It was confirmed that the characters 1000 grain weight and biomass yield reacted high significantly to this interaction effect, while the grain yield showed significant react to this effect (Appendix 2). Regarding to 1000 grain weight maximum value was (54.060g) recorded by the variety Tadmor under the application of 940kg/ha) iron, but the lowest value was (37.512g) recorded by Arivat variety compled with not iron application concerning to biomass yield the highest value was (20.000t) recorded by the association of Arivat variety with application of (40kg/ha) iron, but the lowest value was (13.500t) exhibited by the association of Tadmor variety with not iron application. The highest grain yield value was (6.333t) recorded by the interaction of Lignee variety under (40kg/ha) iron application, but the lowest value was 94.984t) recorded by the association of Arivat variety with not iron application. The similar result (22) indicated that the application of Fe-EDDHA caused an increase of grain yield in barley.

Correlation and path analysis:

- Correlation among characters:

Data in table (7) reveal that the spike number/ m2 recorded highly significant and negative correlation with number of grains/ spike and weight of grains/ spike (-0.789 and -0.8%) respectively. Spike length exhibited highly significant and negative correlation with number of grains/ spike (-0.846), while it recorded significant and negative correlation with weight of grains/ spike (-0.682) and significant and positive correlation with 1000 grain weight and harvest index (0.672, 0.614) respectively. Number of grains /spike recorded highly significant and positive correlation with weight of grains/ spike (0.914), and recorded significant and negative correlation with harvest index (-0.622). 1000 grain weight showed highly significant and positive correlation with harvest index (0.785). Highly significant and negative correlation was recorded between biomass yield and harvest index (-0.845). Previous workers confirmed positive and significant correlation coefficients between grain weight and the yield components such as spike length, grain number/ spike, grain weight/ spike, spike number/ plant (23, 24, 25 and 26). (27) observed positive and significant correlations between grain yield and yield components such as plant height, spike length and spike number per m2, while they found negative and non significant correlations between grain yield and grain number /spike. Positive and significant correlations of grain yield with spike number per m2 and 1000 grain weight were reported by (28). While (24) found no significant correlation between grain yield and 1000 grain weight. The direct effects obtained from path coefficient analysis indicated that grain yields of barley cultivars were significantly and positively affected by yield components such as spike length, grain number/ spike, grain weight/ spike, and spike number/ m^2, indicating that an increase in any of these yield components causes some increase in grain yield (23). Similar results were reported by other researchers who conducted studied on different plant species and determined the direct effects of different yield components on grain yield (29, 30) for plant height (28, 30, and 31) for grain number/ spike (30) for grain weight/ spike and spike number/ m^2, (29, 32 and 33)for harvest index. It was demonstrated that the grain yield of barley had significant and positive correlations with plant height, spike length, grain number/ spike, grain weight/ plant, spike number/ m2 and harvest index. These relations mean that any increase in any one of the yield components caused some increase in grain yield (23). Positive and significant correlations of grains weight/ plant with each character of spike length, number of grain /spike, number of spike/ plant, grain weight /spike, 1000 grain weight, biological weight were recorded by (13).

- Path analysis:

Data in table (8) illustrate the path analysis, indicating to the direct and indirect effects in

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grain yield. Path – coefficient analysis is one of the reliable statistical techniques which allow quantifying the interrelationships of different components and their direct and indirect effects on grain yield through correlation estimates (34). Maximum positive direct effect was (1.551) recorded by biomass yield and followed by (1.347) for harvest index. Maximum negative direct effect was (-0.754) for number of grains/spike. The highest positive indirect effect was (1.058) recorded by harvest index via 1000 grain weight, but the highest negative indirect effect was (-1.134) recorded by harvest index via biomass yield. (35) found that grain number/ plant and 1000 grain weight had the greatest direct effect on grain weight/ plant.

Table (1): Means of the growth characters:

Variety	Days to flowering	Days to heading	Plant height (cm)	No. of tillers/ plant	Flag leaf area (cm^2)	Chlorophyll mg/g
Tadmor	113.444	106.111	64.223	4.409	5.282	44.978
Zabad	116.556	107.333	63.260	4.703	3.784	51.678
Lignee 527	114.333	105.333	69.038	3.592	5.893	52.633
Arivat	127.778	119.333	87.852	4.333	7.833	55.156
LSD (P≤0.05)	1.408**	0.693**	1.241**	0.678*	0.849**	5.973 *

Table (2): Effect of iron on growth characters:

Iron	Days to flowering	Days to heading	Plant height (cm)	No. of tillers/ plant	Flag leaf area (cm^2)	Chlorophyll mg/g
0	118.833	109.5	68.973	4.416	4.946	42.475
20	117.75	109.583	71.584	4.278	5.628	52.633
40	117.5	109.5	72.723	4.085	6.522	58.225
LSD (P≤0.05)	0.695**	n.s	0.645**	n.s	0.461**	2.962 **

Table (3): Effect of the interaction between variety and iron levels on growth characters:

interaction		Days to flowering	Days to heading	Plant height (cm)	No. of tillers/ plant	Flag leaf area (cm^2)	Chlorophyll mg/g
Tadmor	0	114.333	106.3	63.333	4.223	4.213	40.733
	20	113.000	106.3	64.223	4.557	5.103	45.267
	40	113.000	105.667	65.113	4.447	6.530	48.933
Zabad	0	117.000	107.333	59.890	5.11	3.360	40.933
	20	116.667	107	64.557	4.667	3.527	53.033
	40	116.000	107.667	65.333	4.333	4.467	61.067
Lignee	0	115.667	105	67.447	3.443	5.573	39.200
	20	113.667	105.667	69.113	3.443	5.797	58.900
	40	113.667	105.333	70.553	3.89	6.310	59.800
Arivat	0	128.333	119.333	85.223	4.887	6.637	49.033
	20	127.667	119.333	88.443	4.443	8.083	53.333
	40	127.333	119.333	89.890	3.67	8.780	63.100
LSD .05		n.s	n.s	1.289**	n.s	n.s	5.925 *

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Table (4): Means of yield and its component characters for the studied varieties.

Variety	No. of spike	Spike length (cm)	No. of grains/ spike	Wt. grains/ spike (g)	1000 grain weight (g)	Biomass yield T/h	Grain yield T/h	Harvest index
Tadmor	538.056	7.533	18.911	1.104	53.447	14.167	5.843	0.414
Zabad	734.889	6.659	17.867	0.868	45.663	15	5.905	0.399
Lignee 527	352.778	5.7	39.511	1.953	48.582	15.278	6.054	0.397
Arivat	483.611	5.644	39.933	1.58	39.015	17.5	5.639	0.326
LSD .05	94.158**	0.631**	2.791**	0.336**	0.970**	2.046*	0.2696*	0.062 *

Table (5): Effect of irons element on yield and its components.

Iron effect	No. of spike	Spike length (cm)	No. of grains/ spike	Wt. grains/ spike (g)	1000 grain weight (g)	Biomass yieldT/h	Grain yield T/h	Harvest index
0	530.625	6.448	27.067	1.191	45.756	14.167	5.492	0.389
20	552.042	6.269	29.283	1.384	46.345	15.458	5.889	0.387
40	499.333	6.435	30.817	1.554	47.93	16.833	6.199	0.374
LSD .05	n.s	n.s	1.017**	0.123**	0.586**	0.723**	0.151**	n.s

Table (6): Effect of the interaction between varieties and iron element on yield and its components.

Interaction	No. of spike	Spike length (cm)	No. of grains/ spike	Wt. grains/ spike (g)	1000 grain weight (g)	Biomass yield T/h	Grain yield T/h	Harvest index
A1b1	530.833	7.567	17.600	0.936	53.009	13.500	5.477	0.4069
A1b2	538.333	6.933	19.400	1.115	53.272	14.167	5.869	0.4181
A1b3	545	8.100	19.733	1.260	54.060	14.833	6.183	0.4168
A2b1	717.5	6.833	17.133	0.777	44.609	14.167	5.675	0.4035
A2b1	788.167	6.810	17.667	0.803	45.727	14.167	5.923	0.4213
A2b3	699	6.333	18.800	1.023	46.653	16.667	6.116	0.3693
A3b1	388.333	5.833	36.733	1.693	47.892	14.833	5.833	0.3933
A3b2	340	5.600	39.467	1.983	48.613	15.167	5.994	0.3953
A3b3	330	5.667	42.333	2.183	49.241	15.833	6.333	0.4024
A4b1	485.833	5.560	36.800	1.359	37.512	14.167	4.984	0.3542
A4b2	541.667	5.733	40.600	1.633	37.768	18.333	5.768	0.3150
A4b3	423.333	5.6400	42.400	1.748	41.765	20.000	6.165	0.3083
LSD .05	n.s	n.s	n.s	n.s	1.173**	1.447**	0.301*	n.s

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Table (7): Simple Correlation coefficient among characters.

Variables	*No. of spike*	*Spike length*	*No. of grains/ spike*	*Wt. grains/ spike*	*1000 grain weight*	*Biomass yield T/h*	*Harvest index*	*grain yield T/h*
No. of spikes /m²	**1**							-0.138
Spike length	0.498	**1**						0.047
No. of grains/ spike	**-0.789**	**-0.846**	**1**					0.085
Wt. of grains / spike	**-0.896**	**-0.682**	**0.914**	**1**				0.357
1000 grain weight	-0.077	**0.672**	-0.498	-0.136	**1**			0.407
Biomass T/h	-0.226	-0.498	0.575	0.471	-0.485	**1**		0.435
Harvest index	0.206	**0.614**	**-0.622**	-0.356	**0.785**	**-0.845**	**1**	0.105
Grain yieldT/h	-0.138	0.047	0.085	0.357	0.407	0.435	0.105	**1**

Table (8): Path analysis indicated to direct and indirect effect in grain yield.

Variables	*No. of spike*	*Spike length*	*No. of grains/ spike*	*Wt. grains/ spike*	*1000 grain weight*	*Biomass yield T/h*	*Harvest index*	*grain yield T/h*
No. of spikes /m²	***0.125856***	**-0.019**	0.595	**-0.776**	**0.009**	-0.351	0.277	-0.138
Spike length	**0.063**	***-0.03834***	**0.638**	**-0.590**	**-0.081**	-0.772	0.828	0.047
No. of grains/ spike	-0.099	**0.032**	***-0.75428***	**0.792**	**0.060**	**0.892**	-0.838	0.085
Wt. of grains / spike	**-0.113**	**0.026**	**-0.690**	***0.865963***	**0.016**	**0.731**	-0.479	0.357
1000 grain weight	**-0.010**	**-0.026**	**0.375**	**-0.118**	***-0.12046***	-0.753	1.058	0.407
Biomass T/h	-0.028	0.019	**-0.434**	**0.408**	0.058	***1.550754***	-1.139	0.435
Harvest index	0.026	-0.024	0.469	-0.308	-0.095	-1.311	***1.347339***	0.105

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Appendix (1): Mean squares of variance analysis for growth characters:

S.O.V	d.f	M.S					
		Days to flowering	**Days to heading**	**Plant height (cm)**	**No. of tillers/ plant**	**Flag leaf area (cm^2)**	**Chlorophyll**
Blocks	2	3.528	0.028	2.526	0.040	0.963	9.102
A	3	395.657	390.694	1180.931	2.010	25.297	169.841
Error (a)	6	1.491	0.361	1.158	0.345	0.542	26.814
B	2	6.028	0.028	44.337	0.331	7.495	765.042
AB	6	0.435	0.361	2.805	0.516	0.561	52.076
Error (b)	12	0.611	0.704	0.525	0.394	0.268	11.092
Total	35						

Appendix (2): Mean squares of variance analysis for yield characters:

S.O.V	d.f	M.S							
		No. of spike/m^2	**Spike length (cm)**	**No. of grains/ spike**	**Wt. of grains/ spike (g)**	**1000 grain weight (g)**	**Biomass yieldT/h**	**Grain yield T/h**	**Harvest index**
Blocks	2	724.646	0.098	9.434	0.083	1.987	0.924	0.075	0.0015
A	3	226726.648	7.234	1367.237	2.119	327.590	18.229	0.266	0.0139
Error (a)	6	6663.350	0.230	5.854	0.085	0.708	3.146	0.055	0.0029
B	2	8432.021	0.120	42.654	0.395	15.175	21.340	1.506	0.0008
AB	6	3931.558	0.403	3.838	0.014	2.433	4.701	0.098	0.0011
Error (b)	12	12670.981	0.153	1.307	0.019	0.435	0.662	0.029	0.0006
Total	35								

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