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THE RESPONSE OF DIFFERENT VARIETIES OF HORDEUM VULGARE L. CROP TO THE IRON FOLIAR NUTRITION

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Abstract
A field experiment was conducted during the 2022-2023 agricultural season to study the effect of foliar application of iron (0, 100, 200 ppm) on some growth traits, yield, and its components for five barley varieties (Sameer, Ebaa 99, Ebaa 256, Ebaa 249, Amal).
The experiment was conducted using a randomized complete block design (RCBD), and treatments were distributed using a split-plot design with three replications. The iron concentrations were in the main plots, and the barley varieties were in the subplots. Iron was sprayed in two equal doses, the first at the tillering stage and the second at the elongation stage.
The results indicated that the Ebaa 256 excelled in plant height, 1000-grain weight, and biological yield, while the Ebaa 249 outperformed in flag leaf area, number of tillers, number of spikes per square meter, spike length, and grain yield, which reached (4.82 tons. ha-1
The level 200 ppm recorded the highest values for most of the studied parameters, recording the highest grain yield of 4.57 tons. ha-1. However, iron had no significant effect on biological yield. Ebaa 256 at the 200-ppm level achieved the highest values in plant height, 1000-grain weight, and biological yield, while the Ebaa 249 at the 200 ppm level showed significant superiority in the remaining studied parameters, recording the highest averages and the highest yield of 4.99 ton. ha-1.

Keywords: The Response, Hordeum vulgare, the Iron Foliar Nutrition.

Introduction

Hordeum vulgare L. considered one of the most important grain crops in Iraq, it's used in various countries around the world as a forage crop, green forage, or its grains in the forage mixture. Hordeum vulgare is also used in making malts and other medical applications as a laxative, demulcent, nutrition for diabetics, and reducing cholesterol, as well as in the vinegar and yeast industries due to its high levels of dietary fiber and selenium. It's characterized by its high salinity tolerance and drought tolerance, due to that, it's suitable for planting in most areas of Iraq. Hordeum vulgare L occupies fourth place after wheat, rice, and corn in terms of area under cultivation (Abu Dahi 2009). The cultivation area in Iraq is estimated at 2309 thousand acres for the barely crop in 2022, and the production rate is about 144 thousand tons (the Central Bureau of

Statistics ,2022).

Grain crops with barley being one of the most important, are among the field crops that humans have cultivated since ancient times. This is due to their inclusion in the list of crops that contribute to global food security, particularly in Iraq. Iraq still faces a significant gap between production capacity and consumption, due to climatic factors on one hand and a lack of control over production techniques on the other. As a result, it became important to come up with new methods to achieve the expected goals and increase the area unit. One of these methods is the use of foliar technique with micronutrients and fertilizer recommendations with macronutrients in order to improve growth and production. The nutrients spraying method on the vegetative parts is one of the methods used in farming operations, it is highly efficient in providing the plants with the needed elements. The spraying method helps limit drought, salinity, fungi, and bacteria, which have a negative impact on farming operations such as fertilization (Romhold and Fouly, 2000). Besides reducing environmental pollution and providing a complementary method to soil fertilization (Al-Akabi, 2016), it also provides the plants with the major elements (Muhsin and others, 2014). Spraying methods help increase the vegetative growth period and delay aging by increasing photosynthesis rates (Silberbush,2002). Iron is considered an important element that the plant needs in small amounts, it is part of the chlorophyll molecule, accounting for about 80% of the total chloroplast composition (Ibrahim, 2010), besides, it's supporting the Nitrite reductase enzyme (Ali, 2012), and it is part in cytochromes, which are important for the breathing process and photosynthesis. Oxidase cytochromes enzymes contribute to electronic transfer, alpha-amylin stores iron in the chloroplasts, and ferredoxin is an iron-sulfur protein found in chloroplasts (Focus, 2003). That's why many researchers were interested in finding new ways to increase and develop production. Accordingly, many varieties were used with different levels of iron.

Materials and research methods:

The experiment was conducted in the agricultural research station of the agriculture department /university of Basra during winter 2022-2023, to study the effect of spraying with three concentrations of iron (0, 100, and 200 ppm) chelated (Fe-EDTA) symbolized by F0, F1, F2, and five varieties of barley (Samir ,Ipaa 99, Ipaa265, Ipaa 249, and Amal) on yield and its components for the barley crop. Soil has been prepared by tillage, grinding, and leveling, divided into 6 m2 boards with 1 m space left between the experimental units and 2 m between replicates. The experiment has been applied split plot design using a randomized complete design with three replicates. The main plots included iron concentrations, and the sub-plots included the varieties. The planting was done November 15, 2022, at a seeding rate 120 KG ha-1. urea fertilizer 120 KG ha-1 was added in two stages, the first one after a month of planting, and the second after two weeks of the first stage. Phosphatic fertilizer was also added in the planting stage at a 100 KG rate as a DAP fertilizer (46% P2O5). Finally, the potassium fertilizer was added with a 120 KG ha-1 rate, as potassium sulfate (K2O %52), in two stages, the first one added after the emergence stage, and the second in the elongation stage (Ali, 2012). A composite sample was taken for the soil field with three replicates, for chemical and physical examinations in the central laboratory-department of Agriculture- university of Basra, as shown in Table 1 according to Page et al. (1982), Black (1965).

The iron was spread in two equal doses, the first in the branching stage, and the second in the elongation stage. The process was done at night to avoid high temperatures and sunlight. A spreader was added with a 1.5 cm3 rate for 10 L water to ensure complete wetness. As for the control treatment, it was only sprayed with distilled water, the following characteristics were studied:

The plant height (cm): Is calculated from the average of ten plants randomly selected from the experimental plots

The leaf area (cm2): Is calculated from the average of ten plats randomly selected from the experimental unit in the flowering stage, according to the following equation: leaf area= leaf length x maximum width x 0.95 (Hunt et al., 2000)

Shoots number (shoots per m-2): calculated at harvest from an area of m-2

Spikes number (spikes per m-2): calculated at harvest from an area of m-2

Number of grains per spike (grain per spike-1): calculated from the average of the grain number for ten random spikes from the harvest square meter.

Weight of 1000 grains (g): the weight of 1000 grains was calculated randomly from the grain yield per harvested square meter

Yield (ton ha-1): calculated from an area m-2 and converted to ton ha-1

Biological yield (ton ha-1): calculated from an area m-2 and converted to ton ha-1

Protein percentage (%)

Statistical analysis of all traits was conducted by using the GenStat statistical software, and means were compared using the Least Significant Difference (L.S.D) method at a 0.05% probability level. (Al Rawi and Kalaf Allah, 2000).

Table 1. Some chemical and physical properties of the study soil before planting.

Character	PH	E.C.	Available				Organic matter	clay	silt	sand	Soil texture
			N	P	K	Fe		335	585	80	Silty clay loam
Value	7.50	5.83	31.16	17.30	116.11	2.17	2.30				
unit		dSm-1	Mg Kg^{-1} soil				gm Kg-1 soil	gm Kg^{-1} soil			

Results and Discussion:

Statistical analysis results shows that the IPAA265 variety considerably excelled, recording the highest plant height (78.56 cm), while the Amel variety had the lowest plant height at 62.18 cm (Table 2). All varieties (IPAA 99, IPAA 265, IPAA 249, Amel) significantly outperformed the Samer variety in terms of leaf area, with measurements of 22.06, 20.72, 22.84, and 21.27 cm², respectively, compared to Samer's 17.46 cm². The IPAA 249 variety showed a notable rise in the quantity of spikes (426.94 spikes per m²) and shoots (444.89 shoots per m²). The Samer variety, on the other hand, has the lowest spikes and shoots (357.86 shoots per m2). Variations in the genetic variables controlling the physiological features of the kinds can be linked to the variances seen between them. Differences in a variety's genetic composition, ability to photosynthesises and the activity and efficiency of chemicals and enzymes involved in cell division might also be the

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cause of the variations. Variations in the amounts of auxin and gibberellin, the hormones that cause cell expansion and elongation, might potentially be involved. With the greatest amount of spikes (329.33 spikes.m-²), IPAA 249 variety performed really well. The variation among varieties may be caused to genetic factors and their role in determining the variety's ability to branch and subsequently convert these shoots into fertile spikes, depending on its capacity to produce photosynthetic materials (Al-azawi et al., 2018). This capacity is influenced by the variety's genetic traits. IPAA 249 variety, being highly branched, showed superiority in the number of grains per spike without a significant difference compared to the IPAA 265 variety, recording 53.05 and 52.28 grains per spike, respectively, while the Samer variety had the lowest with 36.05 grains per spike. The IPAA 265 variety also excelled in 1000-grain weight with 41.13 grams, whereas Samer had the lowest at 32.68 grams. Differences among varieties are due to their efficiency in utilizing photosynthetic products, which affects nutrient accumulation in grains and thus their weight (Al-Halfi and Faleh, 2017). The IPAA 249 and IPAA 265 varieties significantly outperformed others in grain yield, with 4.82 and 4.75 tons per hectare, respectively, showing no significant difference between them, while Amel had the lowest yield at 3.23 tons per hectare. The variation in grain yield is attributed to differences in yield components. IPAA 265 recorded the highest biological yield (14.92 tons per hectare), significantly outperforming all other varieties, while Amel had the lowest biological yield at 10.74 tons per hectare, with no significant difference from IPAA 249 (11.31 tons per hectare). This superiority in biological yield is attributed to its performance in growth traits and grain yield.

Table 2 results shows that the F2 level (200 ppm) excelled in all studied traits, recording the highest plant height (81.61 cm), leaf area (28.18 cm²), and number of shoots (396.92 shoots per m²), showing no significant difference from the F1 level (100 ppm) which recorded 393.95 shoots per m². This can be attributed to the critical role of iron in forming various cytochrome and ferredoxin compounds essential for photosynthesis, leading to increased photosynthesis rates and efficiency. Iron also contributes to chlorophyll formation, energy compound synthesis, and enzyme activation in photosynthesis, enhancing growth and reducing competition among growth components, reflecting improved growth indicators. This aligns with Jalal (2020) and Alabdalsayid & Al-Freeh (2021). The F2 level (200 ppm) showed significant superiority in all yield components, including number of spikes (371.65 spikes per m²), number of grains per spike (52.02 grains per spike), and 1000-grain weight (38.09 grams). The increased yield components at higher iron levels are due to iron's role in activating enzymes involved in vital processes like photosynthesis and protein synthesis, and plant hormones that enhance reproductive growth, leading to increased grain number per spike and growth components. This is consistent with findings from Sher et al. (2020) and Alabdalsayid & Al-Freeh (2021). The F2 level (200 ppm) also significantly yielded the highest grain yield (4.57 tons per ha-1), attributed to the highest average of yield components (number of spikes, grains per spike, and 1000-grain weight). However, there was no significant effect of iron levels on biological yield.

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Table 2 The effect of cultivars and spraying with iron on some growth parameters and yield of Barly (Hordeum vulgare L.)

Treatment		P H Cm	F L A Cm^2	Tiller No. Tiller m^{-2}	Spik No. Spik m^{-2}	Seed No. Seed $spik^{-1}$	1000 Seed wight g	G Y ton ha^{-1}	Bio Y ton ha^{-1}	Pro %
Cultivars	Samer	67.40	17.46	357.86	329.33	36.05	32.68	3.93	13.95	
	IPAA 99	75.28	22.06	365.41	344.85	44.50	35.82	3.78	12.54	
	IPAA 265	78.56	20.72	415.65	378.65	52.28	41.13	4.75	14.92	
	IPAA249	72.22	22.84	444.89	426.94	53.05	36.12	4.82	11.31	
	Amel	62.18	21.27	360.38	335.03	43.38	35.70	3.23	10.74	
LSD (P<0.05)		2.73	3.77	10.82	20.27	3.64	3.79	0.13	0.98	
Iron conc. Ppm	F0	59.22	23.66	375.65	358.04	40.44	34.71	3.75	12.68	
	F1	72.56	25.95	393.95	359.19	45.09	36.08	3.98	12.61	
	F2	81.61	28.18	396.92	371.65	52.02	38.09	4.57	12.79	
LSD (P<0.05)		3.51	0.55	13.45.	10.60	5.15	1.89	0.09	ns	

PH=plant height, FLA=Flag leaf area, Tiller No.= Tiller number M-2, Seed No.= seed number M-2, GY= Grain yield, Bio Y= Biological yield, Pro= Protein%

The results of Table 3 indicate that the interaction between barley varieties and iron spraying had a significant effect on all studied traits. The combination IPAA 265 × F2 was superior, recording the highest plant height of 93.88 cm, while the combination IPAA 249 × F2 was superior, giving the largest flag leaf area (33.68 cm2), number of shoots (484.87 shoots m-2), number of spikes (40.37 spikes m-2), and number of grains per spike (59.53 grains spike-1). The seed did not differ significantly from the combinations IPAA 265 × F2 (57.36 grains spike-1) and IPAA 99 × F2 (56.50 grains spike-1). As for the 1000-grain weight trait, the combination IPAA 265 × F2 was superior, recording the highest weight. It reached 41.53 g without a significant difference from the combination IPAA 265 × F0 (41.43 g), the varieties IPAA 249, IPAA 265, IPAA 99 and Samer outperformed at the F2 level (200 Ppm) with the highest yield reaching 5.321, 4.998, 4.254 and 4.642 tons h-1 respectively without a significant difference from the variety Samer and at the F0 (0 Ppm) and F1 (100 Ppm) levels and reached 4.230 and 4.592 tons h-1 respectively and the variety IPAA 265 at the F0 (0 Ppm) and F1 (100 Ppm) levels and reached 4.592 and 4.550 tons h-1. The IPAA 265 variety showed significant superiority at the F0 (0Ppm), F1 (100Ppm) and F2 (200Ppm) levels, recording the highest biological yield of 14.902, 14.873 and 14.987 tons ha-1, respectively, without significant difference from the Samer variety at the F2 (200Ppm) level, which reached 14.213 tons ha-1.

The increase in leaf area can be attributed to the positive effect of the interaction between the variance in the response of varieties to biofertilizers may be due to the fact that varieties differ from each other in their ability to utilize the fertilizer contents depending on their genetic nature.

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Table 3 The effect of the interaction between cultivars and spraying with iron on some growth parameters and yield of Barly (Hordeum vulgare L.)

Iron conc. Ppm	Cultivars	P H Cm	F L A Cm^2	Tiller No. Tiller m^{-2}	Spik No. Spik m^{-2}	Seed No. Seed spik^{-1}	1000 Seed wight g	G Y ton ha^{-1}	Bio Y ton ha^{-1}	Pro %
0	Samer	52.34	18.45	354.59	336.95	33.60	29.77	4.230	13.709	
	IPAA 99	64.22	24.59	360.59	345.70	35.16	33.77	3.589	12.515	
	IPAA 265	63.21	26.07	415.65	368.23	47.20	41.43	4.691	14.902	
	IPAA249	65.68	24.88	400.97	414.17	46.56	34.97	3.451	11.591	
	Amel	50.66	24.33	346.44	325.16	39.66	33.59	2.811	10.695	
100	Samer	72.42	20.93	362.67	314.80	36.05	32.68	4.592	13.941	
	IPAA 99	77.35	28.59	376.23	349.33	41.83	35.60	3.489	12.453	
	IPAA 265	78.59	23.09	419.13	389.07	52.28	40.83	4.550	14.873	
	IPAA249	73.75	30.64	448.83	416.27	53.05	36.12	4.010	10.978	
200	Amel	60.68	26.49	362.87	326.48	42.25	35.19	3.240	10.781	
	Samer	77.45	23.45	356.33	336.23	38.50	35.60	5.642	14.213	
	IPAA 99	84.27	30.99	359.40	339.52	56.50	38.10	4.254	12.654	
	IPAA 265	93.88	25.46	412.17	378.65	57.36	41.13	4.998	14.987	
	IPAA249	77.24	33.68	484.87	450.37	59.53	37.27	4.321	11.354	
	Amel	75.21	27.33	371.83	353.46	48.23	38.33	3.652	10.760	
Lsd		1.02	1.10	19.96	13.21	7.28	1.27	1.29	1.57	

PH=plant height, FLA=Flag leaf area, Tiller No.= Tiller number M-2, Seed No.= seed number M-2, GY= Grain yield, Bio Y= Biological yield, Pro= Protein%.

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