Evaluating performance of bread wheat cultivars (*Triticum aestivum* L.) in growth traits and yield at different levels of foliar fertilization

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Abstract:
A field experiment was conducted to grow the wheat crop (*Triticum aestivum* L.) in a farmer's field in Babylon province/ Al-Musayyib District / Mashrou' Al-Musayyib District on 11/19/2023 in soil with a loamy silty texture for the purpose of studying and evaluating the performance of three local cultivars of wheat for growth traits and yield and the effect of foliar fertilization for the winter season (2023/2024). Based on the Randomized Complete Block Design (RCBD) according to the factorial experiment system and with three factors, the first is three types (IPA 99, Bohouth 22, and Adina), and the second is three concentrations of (chelated iron) (0, 50, 100) mg L-1 (Fe0, Fe1, and Fe2), while the third is three spraying times (tillering, elongation, booting) (S1, S2, S3). The results show that there are significant differences for the cultivars, as the Adina cultivar excelled and gave the highest average in the traits (spike length, number of spike, number of grains, grain yield, and biological yield) amounting to (12.878 cm, 156.56 spike m^{-2}, 74.67 grain . spike $^{-1}$, and 4.3391 tons . ha^{-1} and 15.3833 tons ha^{-1}) respectively, while the Bohouth 22 cultivar was significantly excelled in the attribute (weight of 1000 grains) and reached (41.567 g). Iron concentrations (100 mg L^{-1}) gave a significant increase in the traits of (spike length, number of spike , number of grains, weight of 1000 grains, grain yield, and biological yield) amounting to (12.496 cm, 153.48 spike m-2, 75.44 spike m^{-1}, 40.244 g and 4. 3083 t/h-1 and 14.7005 t/h-1) respectively. Spraying date S3 gave a significantly excelled in the traits of (spike length, number of grains, weight of 1000 grains, grain yield, and biological yield) amounting to (12.215 cm, 72.44 spike grains^{-1}, 39.596 g, 4.2094 tons ha^{-1}, and 14.196 tons ha^{-1}), respectively. While the spraying date S1 was significantly excelled in traits (number of spike) reaching (148.26 spike m^{-2}). The two- and three-way interactions gave significant differences in most of the studied traits.

Key Words: Wheat, cultivars, chelated iron, concentrations, spraying times

introduction:

Bread wheat (*Triticum aestivum* L.), which belongs to the Poaceae family, is one of the most important strategic crops due to its high nutritional value and containing protein, fats, vitamins, and some mineral salts, in addition to the amino acids that humans need in their food [33] Therefore, wheat occupies the first place in the world in terms of cultivated area and production, and statistical expectations indicate that global production will reach about 985.75 million tons in 2024 [24] The world's population depends on it, and the importance of wheat in human food is due to wheat gluten, which produces the best types of bread [34]. Iraq is the original homeland of wheat, but its productivity is still below the required level due to the lack of modern techniques and management in serving this crop during the growth period in general and during the critical stages of its life cycle in

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particular [17]. The estimated wheat production in Iraq is 2985 thousand tons per area. The total cultivated area is 7,687 thousand dunums for the winter season of 2023, which estimated the average yield per dunum at 383.7 kg dunum^{-1}, where the total cultivated area was distributed among the irrigated areas at 3,936 thousand dunums, and the average yield per dunum was estimated at 695.8 kg dunum^{-1}, while the cultivated area in the regions amounted to 7,687 thousand dunums. The average yield is 3,551 thousand dunams, which estimated the average yield per dunam to be 7.3 kg [23].

Improving the reality of cultivating this crop in order to achieve a quantitative and qualitative improvement in its productivity requires continuous scientific research. Many research centers have worked in this field and have achieved the adoption of a number of cultivars with good productivity. Accordingly, it is necessary to know the appropriate service processes for them, with which we guarantee good performance. For these cultivars, the cultivars play an important role in producing high wheat yields because different cultivars respond differently to the prevailing environment in different locations during the growing season [30]. Cultivars also play an important role in determining the percentage of protein, as choosing the appropriate cultivars for the growing region increases the percentage of protein, gluten, and specific yield of grains [6]. Many researchers have shown that there is no benefit in adding micronutrients to the soil as mineral salts under the conditions of Iraqi soil due to their rapid exposure to adsorption and sedimentation processes. Therefore, adding microelements through the leaves in the form of diluted solutions on plant leaves at the appropriate times and concentrations is one of the successful and modern methods for blocking The plant needs them, and the most efficient and quickest way to add these nutrients is to spray diluted solutions of these elements directly on the vegetative system. This is known as foliar feeding, which is the best fertilization technique for micronutrients due to the high utilization of nutrients and the lack of pollution [29]. [27] found that foliar feeding has faster results than ground fertilization by 8-20 times with foliar fertilization compared to ground fertilization, in addition to securing the plant's nutrient requirements during critical growth stages, which the roots may be unable to achieve or meet. Iron is an important micronutrient in the processes of redox and chlorophyll formation, in addition to its importance in the process of photosynthesis, and the formation of many cytochromes and ferredoxin compounds that are important in the process of photosynthesis, which leads to increased growth rates [19]. In light of the above, this study aims to evaluate the performance of the cultivars used in the research for yield traits per unit area, determine the best concentration for foliar fertilization that gives the highest growth and production, determine the best date for spraying, and determine the best interaction between the cultivars, concentrations, and dates that give the best growth and highest yield per unit area.

Materials and methods

A field experiment was conducted to grow the wheat crop (*Triticum aestivum* L.) in a farmer's field in Babylon province / Al-Musayyib District / Mashrou' Al-Musayyib District on 11/19/2023 in soil with a loamy silty texture for the purpose of studying and evaluating the performance of three local cultivars of wheat for growth traits and yield

and to estimate some of its genetic parameters through the effect of foliar fertilization for the winter season (2023/2024). The experiment included three factors: the first factor was the cultivation of three cultivars of wheat (IPA 99, Bohouth 22, and Adina), which were obtained from the Department of Agricultural Research / Abu Ghraib, and the second factor was It is three concentrations of foliar fertilizer (chelated iron element) (0, 50, 100) mg L^{-1}, and the symbols were given (Fe0, Fe1, and Fe2). The third factor is three spraying dates (tillering, elongation and booting). The symbols were given (S1, S2, S3) and according to the Zadoks scale (Zadoks et al., 1974). Soil analysis operations were conducted in the laboratory complex in the Najaf Agriculture Directorate, while the iron element analysis was conducted in the Fadak Central Laboratory for Analysis of the Holy Attiya Al-Alawiyah after soil samples were taken from the field before planting from different locations (3) locations for each location separately from a depth of (0- 30 cm using an Auger soil drill. Table (1) shows the soil properties of the physical and chemical properties of the study soil before cultivation.

Table (1): Some physical and chemical traits of the study soil before cultivation

The country that manufactured the device	Device used for measurement	units	traits
American	PH meter	7.8	PH of soil
Romanian	Conductivity meter	7.4	PH of water
Romanian	Conductivity meter	2.6	Ec for soil DS/m
Romanian	Conductivity meter	2.25	EC waterproof DS/m
Korean	Keldal	1.18	N%
Korean	Uv-visible spectro photometer	0.23	P%
German	spectro photometer	158	K ppm
Indian	FLAME PHOTOMETER	2.15	Fe ppm
		2	Gypsum meg/L
Korean	Muffle furnace	5.6	Organic matter %
	Hydro meter	70	Silt %
	Hydro meter	10	clay %
	Hydro meter	20	sand %
	Hydro meter	Silty loam	Soil texture

The experimental land was plowed twice perpendicularly using a flip plow, then smoothed using disc harrows and leveled manually. The panels (experimental units) were made according to the design used, and the fertilization process was carried out, where phosphate fertilizer was added in one go when preparing the soil after plowing and before smoothing from a source of triple superphosphate P2O5 45%.)) At a rate of 100

kg ha^{-1}, it is added according to the recommendation of [5]. As for nitrogen fertilizer, it was added at a rate of (200) kg N ha^{-1} according to the recommendation of [8] It was added in three equal batches at three stages of wheat crop growth (tillering phase, elongation phase, and booting phase). The wheat grains of the three cultivars (IPA 99, bohuth 22 and Adina) were planted on 11/19/2023, at a rate of (2.4) g of grain per line in order to achieve a plant density of (120 kg ha^{-1}) . The grains were spread within the lines, then a germination rate was given, after which irrigation continued using the irrigation method, as it was carried out regularly and depending on the moisture condition of the field and the needs of the plant. The wheat grains were germinated on 11/28/2023, and weed control and weeding were also done manually in a homogeneous manner for all experimental units. . The experiment was carried out based on a Randomized Complete Block Design (RCBD) according to the factorial experiment system and with three replicates. The experimental factors (cultivars, foliar fertilization, spraying stages) were distributed randomly among the experimental units, which amounted to (81) experimental units for each replicate. (36) experimental units after placing significant marks on them in each replicate. The area of the experimental unit reached 2 m (1*2) m, meaning the experimental unit contains (5) lines and a length of (2) m, and the distance between one line and another is (20) cm, using a manual machine. In order to control the distance between the planting lines, a distance was also left between one experimental unit and another (0.75) m and between one replicate and another (1.5) m. Foliar fertilization was prepared in which chelated iron (Ethylenediaminedihydroxyphyenylaceticacid) Fe-EDTA (6% iron) was sprayed on the shoots according to the concentrations used in the experiment (0, 50 and 100) mg L^{-1} in the growth stages of the shoots of the wheat crop (Tillering stage, elongation stage, booting stage) using a 15 liter backpack sprinkler after adding (0.15 cm3 L-1) as a dispersing agent to reduce the surface tension of the water, ensure complete wetness of the leaves, and increase the process of absorption of the spray solution through the surface. The outer layer of the leaf [3] and the comparison treatment was sprayed with plain water only. Harvested on 4/25/2024.

The studied traits of the product and its components:

1- Spike length (cm):

2- Number of spike m2

3- Number of spike:.

4- Weight of 1000 grains (g)

5- Grain yield (tons ha^{-1})

6- Biological yield (ton ha-1

Statistical analysis: The data for the studied traits are analyzed statistically according to the analysis of variance method for a completely randomized block design (factorial experiments), and the least significant difference (L.S.D) test is used to compare the arithmetic means at the probability level (5%) [32] The GenStat statistical program was used for statistical analysis.

Results and discussion :

The spike length (cm)

The results of Table (2) showed that there were significant differences between the cultivars in the traits of spike length, cm, for the cultivars (IPA 99, Bohouth 22, and Adina), whose averages reached (11.722, 10.696, and 12.878) cm, respectively, where the cultivar

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(Adina) gave the highest average in trait of spike length, amounting to (12.878) cm, with an increase rate for the two cultivars (IPA 99 and Adina) of (9.592 and 20.4)%, respectively, compared to the cultivar (Bohouth 22), which gave the lowest average for this traits, amounting to (10.696) cm. The reason may be due to a compensation in the science paper, Table (5), which was confirmed by [2] who showed that the cultivars differed among themselves in the length of the spike. These results are also consistent with the findings of [12] that the reason for the differences between cultivars and genotype in the traits of spike length is more due to the genetic nature of the cultivar than the influence of the environmental factor.

The results in Table (2) show that spraying chelated iron Fe-EDTA (6% iron) on the vegetative part of the plant led to significant differences in each of the added iron concentrations (Fe1, Fe2), which averaged (11.767 and 12.496) cm, respectively and in proportions. An increase in iron concentrations of (6.652 and 13.26)%, respectively, over the control treatment (Fe0) spraying with distilled water only, which averaged (11.033) cm in spike length cm. These increases in spike length cm can be due to the role of iron in conducting the reactions. Various biological organisms, directly or indirectly, through their activation of various enzymes responsible for the metabolic reactions coundected by the plant, especially in its effective growth areas, which helps in cell division and elongation, which led to an increase in the length of the spike, [9] This is consistent with what they found[18]on wheat, and [17] on barley.It is clear from the results of Table (2) that there are significant differences between the spraying dates (tillering phase S1, elongation phase S2, and booting phase S3), which averaged (11.322, 11.759, and 12.215) cm, with the highest average reaching (12.215) cm, with an increase in the dates (S2 and S3) amounted to (3.859, 7.887)%, respectively, on the comparison treatment (S1), which averaged (11.322) cm in the traits of spike length. The reason is that the addition of iron and spraying coincided with the stages of spike development, which means a better incentive for the growth and development of the spike due to the availability of a continuous food supply on the one hand, and the role of these nutrients in raising the efficiency of the photosynthesis process on the other hand, which encouraged better growth of the spike, which was clearly reflected in its increased length. [26]. These results are consistent with the findings of [25].The results of Table (2) showed that there were significant differences between bi-interactions between the cultivars and the iron concentrations in the trait of spike length, cm. The combination (V3Fe2) was excelled and gave the highest average amounting to (13.633) cm compared to the combination (V2Fe0) which gave the lowest average for that traits, which was (10) cm. The results of Table (2) indicate that there are significant differences between bi-interactions between the cultivars and spraying dates in the trait of spike length, as the combination (V3S3) excelled and gave the highest average amounting to (13.433) cm compared to the combination (V2S1) which gave the lowest average for that traits amounting to (10.256 cm.

The results of Table (7) showed that there were significant differences between bi-interactions between iron concentrations and spraying dates in the traits of spike length, as the combination (Fe2S3) excelled and gave the highest average of (13.611) cm compared

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to the combination (Fe0S1), which gave the lowest average for that traits of (13.611) cm. (11.1) cm.

It is clear from the results of Table (2) that there are significant differences between the triple interactions between the cultivars, iron concentrations, and spraying dates in the traits of spike length, cm. The combination (V3Fe2S3) excelled and gave the highest average of (14.9) cm compared to the combination (V2Fe0S2), which gave the lowest average of those. The traits reached (9.933) cm.

Table (2) Evaluation of the performance of three local wheat cultivars for growth traits and yield as a result of the effect of foliar fertilization on the average spike length, cm, for the agricultural season 2023-2024

Interaction between cultivar and iron concentrations	Spraying dates			Iron concentrations)mg.L^{-1}(	cultivar
	booting S3	elongation S2	tillering S1		
11.1	10.4	11.667	11.233	**Fe0**	**IPA 99 V1**
11.6	11.8	11.6	11.4	**Fe1**	
12.467	13.6	12.2	11.6	**Fe2**	
10	10	9.933	10.067	**Fe0**	**Bohouth 22 V2**
10.7	11.5	10.4	10.2	**Fe1**	
11.389	12.333	11.333	10.5	**Fe2**	
12	11.6	12.4	12	**Fe0**	**Adina V3**
13	13.8	12.9	12.3	**Fe1**	
13.633	14.9	13.4	12.6	**Fe2**	
0.6075	**1.0523**			**L.S.D 5%**	
cultivar	**booting S3**	**elongation S2**	**tillering S1**	**Spraying dates / cultivar**	**interaction between cultivar and spraying dates**
11.722	11.933	11.822	11.411	**V1**	
10.696	11.278	10.556	10.256	**V2**	
12.878	13.433	12.9	12.3	**V3**	
0.3508	**0.6075**			**L.S.D 5%**	
Iron concentrations	**booting S3**	**elongation S2**	**tillering S1**	**Spraying dates / Iron concentrations**	**Interaction between Iron concentrations and Spraying dates**
11.033	10.667	11.333	11.1	**Fe0**	
11.767	12.367	11.633	11.3	**Fe1**	

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12.496	13.611	12.311	11.567	**Fe2**	
0.3508	**0.6075**			**L.S.D 5%**	
booting S3	**elongation S2**	**tillering S1**		**Spraying dates**	
12.215	11.759	11.322			
0.3508				**L.S.D 5%**	

Number of spikes(spike.m^{-2})

The results of Table (3) showed that there were significant differences between the cultivars in the traits of the number of spike spike.m^{-2}, for the cultivars (IPA 99, Bohouth 22, and Adina), whose averages reached (142.96, 133.67, and 156.56) spike m^{-2}, respectively, where the cultivar (Adina) gave the highest average in the trait. The number of spike , spike m^{-2}, reached (156.56 spike m^{-2}), with an increase rate for the two cultivars (IPA 99 and Adina) of (6.949 and 17.124)%, respectively, compared to the cultivar (Bohouth 22), which gave the lowest average for that trait, which amounted to (133.67) spikes m^{-2}. The reason is due to the genetic factor and its role in determining the cultivar's ability to split and the ability of each cultivar later to transform the shoots into fertile spike , depending on its ability to produce the largest amount of acting materials. Hucl and Baker (1988). Perhaps owning a cultivar (Bohouth 22) is a large cultivar. Beaching, Table (4), in addition to the increase in its chlorophyll content, Table (6), which results in a positive role in increasing the efficiency of the photosynthesis process, which led to excelled of the cultivar in the production of spike . This result is consistent with the findings of [5,7] who stated that the difference between cultivars is due to the difference in their ability to form and maintain membranes.

The results in Table (3) show that spraying chelated iron Fe-EDTA (6% iron) on the vegetative part of the plant led to significant differences in each of the added iron concentrations (Fe1, Fe2), whose averages reached (145.37 and 153.48) spike m^{-2}., with percentages of increase in iron concentrations of (8.218 and 14.255)%, respectively, on the control treatment (Fe0) spraying with distilled water only, which averaged (134.33) spike m^{-2} in terms of the number of spikes, spike m-2, and it is possible that the reason for this is due to the role it plays. Iron increases the chlorophyll content in leaves, Table (6), which means an increase in the efficiency of the photosynthesis process and thus an increase in the rate of production and accumulation of dry matter during the critical period in which the formation of the maximum number of spike coincides with the start of elongation [10] which is a period The emergence and growth of spikelet starters, which reduces the state of competition between parts of a single plant and pushes towards providing a better opportunity to produce the maximum possible number of spike.m^{-2}. This result agreed with what was mentioned by [4,13] who showed that increasing the concentration of iron in the spray solution led to a linear increase in the number of spike.m^{-2}.

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The results of Table (3) indicate that there are significant differences between the spraying dates (tillering phase S1, elongation phase S2, and booting phase S3), which averaged (148.26, 141.04, and 143.89) spike m-2, with the highest average reaching (148.26) spike m-2, with a percentage An increase for the dates (S1 and S3) amounted to (5.119, 2.020)%, respectively, over the treatment (S2), which averaged (39.3) spike .m-2 in of the number of spike .m-2. This spraying date exceeding the tillering phase (S1) led to the stimulation of vegetative plant growth as a result of increased photosynthesis processes, which led to the development of shoot growth and increased fertility, and thus this was reflected in an increase in the number of spike per unit area Kadry (1984). This result is consistent with [25]

The results of Table (3) showed that there were significant differences between bi-interactions between the cultivars and iron concentrations in the number of spike , spike m-2, where the combination (V3Fe2) was excelled and gave the highest average of (162.89) spikes m-2 compared to the combination (V2Fe0), which gave the lowest average. For this traits, it reached (124) spikes m^{-2}.

The results of Table (3) indicate that there are significant differences between bi-interactions between the cultivars and spraying dates in terms of the number of spike , spike m-2, as the combination (V3S1) excelled and gave the highest average of (159.67) spikes m-2 compared to the combination (V2S2), which gave the lowest average. For this traits, it reached (130.22) spike m-2.

The results of Table (3) showed that there were significant differences between bi-interactions between iron concentrations and spraying dates in terms of the number of spike , spike m-2. The combination (Fe2S1) was excelled and gave the highest average of (161.11) spikes m-2 compared to the combination (Fe0S1), which gave the lowest. The average for this trait was (134) spike m-2.

It is clear from the results of Table (3) that there are significant differences between the triple interactions between the cultivars, iron concentrations, and spraying dates in terms of the number of spike , spike m^{-2}, where the combination (V3Fe2S1) excelled and gave the highest average of (168) spikes m-2, respectively, compared to the combination (V2Fe0S1). Which gave the lowest average for this trait, which was (123) spikes m^{-2}.

Table (3) Evaluation of the performance of three local wheat cultivars for yield traits based on the effect of foliar fertilization on the average number of spike , spike m^{-2}, for the agricultural season 2023-2024

Interaction between cultivar and iron concentrations	Spraying dates			Iron concentrations)mg.L-1(	cultivar
	booting S3	elongation S2	tillering S1		
130	130.33	129.67	130	**Fe0**	**IPA 99 V1**
144.11	143	139.33	150	**Fe1**	
154.78	154	148	162.33	**Fe2**	
124	125	124	123	**Fe0**	**Bohouth 22**

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134.22	134.67	131	137	**Fe1**	**V2**
142.78	139.67	135.67	153	**Fe2**	
149	149	149	149	**Fe0**	**Adina V3**
157.78	157	154.33	162	**Fe1**	
162.89	162.33	158.33	168	**Fe2**	
1.047	**1.814**			**L.S.D 5%**	
cultivar	**booting S3**	**elongation S2**	**tillering S1**	**Spraying dates / cultivar**	**interaction between cultivar and spraying dates**
142.96	142.44	139	147.44	**V1**	
133.67	133.11	130.22	137.67	**V2**	
156.56	156.11	153.89	159.67	**V3**	
0.605	**1.047**			**L.S.D 5%**	
Iron concentrations	**booting S3**	**elongation S2**	**tillering S1**	**Spraying dates / Iron concentrations**	**Interaction between Iron concentrations and Spraying dates**
134.33	134.78	134.22	134	**Fe0**	
145.37	144.89	141.56	149.67	**Fe1**	
153.48	152	147.33	161.11	**Fe2**	
0.605	**1.047**			**L.S.D 5%**	
booting S3	**elongation S2**	**tillering S1**		**Spraying dates**	
143.89	141.04	148.26			
0.605				**L.S.D 5%**	

Number of grains. spike $^{-1}$

The results of Table (4) showed that there were significant differences between the cultivars in the number of grains, spike $^{-1}$, for the cultivars (IPA 99, Bohouth 22, and Adina), whose averages reached (69.78, 64.89, and 74.67) grains. spike $^{-1}$, respectively, as the cultivar (Adina) gave the highest average of the number of grains. spike $^{-1}$, it was (74.67) compared to the cultivar (Bohouth 22), which gave the lowest average for that traits, which was (64.89) grains. spike $^{-1}$, with increasing rates of (7.535 and 15.071)%, respectively, compared to the cultivar (Bohouth). 22). The variation between cultivars in this trait may be due to the difference in leaf area (Table 5), as well as the influence of the genetic factor, as the trait of the number of grains. spike $^{-1}$ is one of the genetically determined quantitative traits that have a high heritability coefficient [30] Environmental factors and their interaction with genetic factors may also have an impact on the difference between cultivars and their differences in the number of grains per spike, [1]. This result agreed with the findings of [8,9] who indicated that this trait is controlled by genetic factors specific to the

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cultivated cultivar. It is noted from the results in Table (4) that spraying chelated iron Fe-EDTA (6% iron) on the vegetative part of the plant led to significant differences in each of the added iron concentrations (Fe1, Fe2), whose averages reached (69.33 and 75.44) grains. spike $^{-1}$, respectively, over the control treatment (Fe0) spraying with distilled water only, which averaged (64.56) spike grains-1 in terms of the number of grains. spike $^{-1}$, with percentages higher than the comparison treatment (7.388 and 16.852)%, respectively. We can attribute the reason for the increase in the number of spikelets with the increase in iron concentration to the increase in the number of spikelets in the spikelet, Table (8). By increasing it, the probability of increasing the number of spikelets may increase as a natural result of increasing the chances of fertilization and turning each fertilized floret into a seed. Likewise, increasing the efficiency of the photosynthesis process due to increasing The chlorophyll content, Table (6), led to an increase in the production of metabolic materials, which provided an appropriate opportunity to reduce the incidence of miscarriage in florets as a result of reducing the state of competition among them for the food product during the stages of growth and development of these florets, which increased their number. This result agreed with what Al-Tahir indicated. (2005) and [4] who showed that there was a significant increase in the number of spike grains with increasing iron concentration in the spray solution.

It is clear from the results of Table (4) that there are significant differences between the spraying dates in trait of the number of grains. spike $^{-1}$wheat plant, according to the growth phases (tillering phase S1, elongation phase S2, booting phase S3), which averaged (67.22, 69.67, and 72.44). grains. spike $^{-1}$, where the spraying date (S3) gave the highest average for the number of grains. spike $^{-1}$, amounting to (72.44) grains. spike $^{-1}$, compared to the spraying date (S1), which gave the lowest average for that traits, amounting to (67.22) grains. spike $^{-1}$, with increasing percentages of (3.644 and 7.765)%, respectively, compared to the spraying date (S1).

The results of Table (4) showed that there were significant differences between bi-interactions between the cultivars and iron concentrations in the number of grains. spike $^{-1}$. The combination (V3Fe2) was excelled and gave the highest average of (81) spike-1 grains compared to the combination (V2Fe0), which gave The lowest average for this trait was (59.67) grains. spike $^{-1}$.

The results of Table (4) showed that there were significant differences between bi-interactions between the cultivars and spraying dates in terms of the number of grains. spike $^{-1}$, where the combination (V3S3) excelled and gave the highest average of (77.67) spike grains-1 compared to the combination (V2S1), which gave The lowest average for this trait was (61.67) grains. spike $^{-1}$

The results of Table (4) showed that there were significant differences between bi-interactions between iron concentrations and spraying dates in the number of grains. spike $^{-1}$, where the combination (Fe2S3) excelled and gave the highest average of (80.44) grains. spike $^{-1}$compared to the two combinations (Fe0S1). And (Fe0S3), which gave the lowest average for this traits, amounting to (64.44 and 64.44) grains. spike $^{-1}$It is clear from the results of Table (4) that there are significant differences between the triple interactions between the cultivars, iron concentrations, and spraying dates in the number of grains. spike $^{-1}$, where the combination (V3Fe2S3) excelled

and gave the highest average of (86.67) grains. spike $^{-1}$compared to the combination (V2Fe1S1).) which gave the lowest average for this trait, amounting to (61) grains. spike $^{-1}$

Table (4) Evaluation of the performance of three local wheat cultivars for yield traits based on the effect of foliar fertilization on the average number of grains. spike $^{-1}$**for the agricultural season 2023-2024**

Interaction between cultivar and iron concentrations	**Spraying dates**			**Iron concentrations)mg.L-1(**	**cultivar**
	booting S3	**elongation S2**	**tillering S1**		
65.33	65	65.67	65.33	**Fe0**	**IPA 99 V1**
69.33	72	68.67	67.33	**Fe1**	
74.67	79	74.67	70.33	**Fe2**	
59.67	59.67	60.33	59	**Fe0**	**Bohouth 22 V2**
64.33	67.67	64.33	61	**Fe1**	
70.67	75.67	71.33	65	**Fe2**	
68.67	68.67	68.33	69	**Fe0**	**Adina V3**
74.33	77.67	73.33	72	**Fe1**	
81	86.67	80.33	76	**Fe2**	
1.480	**2.564**			**L.S.D 5%**	
cultivar	**booting S3**	**elongation S2**	**tillering S1**	**Spraying dates cultivar**	**interaction between cultivar and spraying dates**
69.78	72	69.67	67.67	**V1**	
64.89	67.67	65.33	61.67	**V2**	
74.67	77.67	74	72.33	**V3**	
0.855	**1.480**			**L.S.D 5%**	
Iron concentrations	**booting S3**	**elongation S2**	**tillering S1**	**Spraying dates Iron concentrations**	**Interaction between Iron concentrations and Spraying dates**
64.56	64.44	64.78	64.44	**Fe0**	
69.33	72.44	68.78	66.78	**Fe1**	
75.44	80.44	75.44	70.44	**Fe2**	
0.855	**1.480**			**L.S.D 5%**	
booting S3	**elongation S2**	**tillering S1**		**Spraying dates**	
72.44	69.67	67.22			
0.855				**L.S.D 5%**	

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weight of 1000 grain

The results of Table (5) showed that there were significant differences between the cultivars in the weight of 1000 grain of wheat plants for the cultivars (IPA 99, Bohouth 22, and Adina), whose averages reached (38.456, 41.567, and 36.056) g, respectively, where the cultivar (Bohouth 22) gave the highest average of (41.567) g compared to the cultivar (Adina), which gave the lowest average of (36.056) g, with percentage increases for the two cultivars (IPA 99 and Bohouth 22) amounting to (6.656 and 14.96)%, respectively, compared to the cultivar (Bohouth 22). This decrease in cultivars is due to the excelled in the number of spike and the high values of the number of grains per ear, Table (9) and Table (10), which led to the distribution of the products of photosynthesis over the largest number of grains and increased competition between them, which led to a decrease in the materials deposited in the grains and a decrease in Her weight. Similar results were obtained by [29] regarding the differences between cultivars in the weight of 1000 grains.

It is noted from the results in Table (5) that spraying chelated iron Fe-EDTA (6% iron) on the vegetative part of the plant led to significant differences in each of the added iron concentrations (Fe1, Fe2), which averaged (38.633 and 40.244) g, respectively. On the comparison treatment (Fe0), spraying with distilled water only, which averaged (37.2) g per weight of 1000 g, with percentages higher than the comparison treatment (3.852 and 8.182)%, respectively. This may be attributed to the role of effective iron in the synthesis and construction of many It is one of the basic components of plants and necessary enzymes, and this has been confirmed by several studies in plant physiology[21,28] . This result is consistent with [14] who indicated that increasing levels of iron addition led to a significant increase in the weight of 1000 grains [4].

It is clear from the results of Table (5) that there are significant differences between the spraying dates in the weight of 1000 g of wheat plants according to the growth phases (tillering phase S1, elongation phase S2, booting phase S3), which averaged (37.581, 38.9, and 39.596) g. Respectively, the spraying date (S3) gave the highest average of (39.596) g compared to the spraying date (S1), which gave the lowest average of (37.581) g, with percentages of increase compared to the spraying date (S1) (3.509 and 5.361)%, respectively. In general, the S3 spraying date gave an increase in this traits, which is one of the critical growth stages. This may be due to the increased efficiency of the photosynthesis process and the process of transporting the products of the metabolic process from their manufacturing site in the leaves to their storage sites in the grains, as well as increasing energy production, ATP formation, and building sugars, starch, and proteins. Lipids and the formation of nucleic acids that are stored in grains, leading to their weight gain [26] These results are consistent with the findings of [25].

The results of Table (5) showed that there were significant differences between bi-interactions between the cultivars and the iron concentrations in the weight traits of 1000 grains, as the combination (V2Fe2) excelled and gave the highest average of (43.433) g compared to the combination (V3Fe0) which gave the lowest average for that traits of (43.433) g. (34.9) gm.

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The results of Table (5) showed that there were significant differences between bi-interactions between the cultivars and spraying dates in the 1000 grain weight trait, as the combination (V2S3) excelled and gave the highest average of (42.333) g compared to the combination (V3S1) which gave the lowest average for that traits of (42.333) g. (35.067) gm.

The results of Table (5) showed that there were significant differences between bi-interactions between iron concentrations and spraying times in terms of the weight of 1000 grains, as the combination (Fe2S3) excelled and gave the highest average of (42.1) g compared to the combination (Fe0S1) which gave the lowest average for that. The traits reached (37.078) g.

It is clear from the results of Table (5) that there are significant differences between the triple interactions between the cultivars, iron concentrations, and spraying dates in terms of the weight of 1000 grains, where the combination (V2Fe2S3) excelled and gave the highest average amounting to (44.9) g compared to the combination (V3Fe0S1), which gave the lowest average. For this traits, it reached (34.6) g.

Table (5) Evaluation of the performance of three local wheat cultivars for yield traits due to the effect of foliar fertilization on the average weight of 1000 grains for the agricultural season 2023-2024

Interaction between cultivar and iron concentrations	Spraying dates			Iron concentrations)mg.L-1(	cultivar
	booting S3	elongation S2	tillering S1		
36.9	36.967	36.8	36.933	Fe0	IPA 99 V1
38.367	39.1	38.7	37.3	Fe1	
40.1	41.8	40.9	37.6	Fe2	
39.8	39.9	39.8	39.7	Fe0	Bohouth 22 V2
41.467	42.2	41.9	40.3	Fe1	
43.433	44.9	44.2	41.2	Fe2	
34.9	35	35.1	34.6	Fe0	Adina V3
36.067	36.9	35.8	35.5	Fe1	
37.2	39.6	36.9	35.1	Fe2	
0.2879	0.4987			L.S.D 5%	
cultivar	booting S3	elongation S2	tillering S1	Spraying dates / cultivar	interaction between cultivar and spraying dates
38.456	39.289	38.8	37.278	V1	
41.567	42.333	41.967	40.4	V2	
36.056	37.167	35.933	35.067	V3	
0.1662	0.2879			L.S.D 5%	

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Iron concentrations	booting S3	elongation S2	tillering S1	Spraying dates / Iron concentrations	Interaction between Iron concentrations and Spraying dates
37.2	37.289	37.233	37.078	**Fe0**	
38.633	39.4	38.8	37.7	**Fe1**	
40.244	42.1	40.667	37.967	**Fe2**	
0.1662	**0.2879**			**L.S.D 5%**	

booting S3	elongation S2	tillering S1	Spraying dates
39.596	38.9	37.581	
0.1662			**L.S.D 5%**

Grain yield tons ha^{-1}

The results of Table (6) show that there are significant differences in the traits of grain yield tons/ha for the cultivars (IPA 99, Bohouth 22, and Adina), whose averages reached (4.1167, 3.4073, and 4.3391) tons ha^{-1}, respectively, as the cultivar (Adina) gave the highest average in The grain yield traits reached (4.3391) tons ha-1, with an increase rate for the two cultivars (IPA 99 and Adina) of (20.820 and 27.347)%, respectively, compared to the cultivar (Bohouth 22), which gave the lowest average for that traits, amounting to (3.4073) tons ha-1. The reason for the increase in yield may be due to the increase in the number of spike , Table (9), and the number of grains per spike, Table (10). The reason for the excelled of the Adina cultivar in this trait is also attributed to genetic variation, and the reason for the excelled of a particular cultivar is due to its possession of genes. A preference that is not found in other classes, and thus reflects positively on its performance. [20]. This result was reinforced with the findings of [5,11] who found significant differences between the cultivars included in their study in grain yield .

The results in Table (6) show that spraying chelated iron Fe-EDTA (6% iron) on the vegetative part of the plant led to significant differences in each of the added iron concentrations (Fe1, Fe2), which averaged (4.0339 and 4.3083) tons.ha-1 and with rates of increase in iron concentrations of (14.570 and 22.363)% respectively over the comparison treatment (Fe0) spraying with distilled water only, which averaged (11.067) tons ha-1 in terms of grain yield tons ha-1. This increase in grain yield showed evidence of the crop's response to feeding with micronutrients and a reflection of the efficiency of the method used. The reason for the excelled of the two mentioned concentrations in grain yield is due to their excelled in the two components of the yield: the number of spikes, spike m2, Table (8), and the number of grains in the spike, Table (9). This is consistent with many studies that indicated a direct increase in grain yield with increasing iron concentrations in the pure spray solution (2005) and [4]

The results of Table (6) indicate that there are significant differences between the spraying dates (tillering phase S1, elongation phase S2, and booting phase S3), for which their averages reached (3.7247, 3.9289, and 4.2094) tons h-1, respectively, with the highest

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average reaching (4.2094) tons. h-1, with an increase rate for the dates (S2 and S3) of (5.482, 13.013)%, respectively, over the comparison treatment (S1), which averaged (3.7247) tons h-1 in terms of grain yield tons h-1. It is clear that the spraying treatments, especially at the booting stage (expulsion of spike), provided a better opportunity for growth, which was clearly reflected in the results of growth traits, which led to an increase in the accumulation of dry matter, and thus greater efficiency in transporting these materials from their places of manufacture (the source) towards the grains (the downstream), accompanied by Prolonging grain filling and thus increasing productivity [3,26] and [31]. These results are consistent with the findings of [25].

The results of Table (6) showed that there were significant differences between bi-interactions between the cultivars and the iron concentrations in the grain yield traits, tons of ha-1. The combination (V3Fe2) was excelled and gave the highest average of (4.7198) tons of ha-1 compared to the combination (V2Fe0), which gave The lowest average was (3.0827) tons ha-1.

The results of Table (6) indicate that there are significant differences between the bilateral interactions between the cultivars and spraying dates in the grain yield traits (tons.ha-1), as the combination (V3S3) excelled and gave the highest average amounting to (4.5573) tons.ha-1 compared to the combination (V2S1) which gave The lowest average was (3.149) tons ha-1.

The results of Table (6) showed that there were significant differences between bi-interactions between iron concentrations and spraying dates in grain yield (tons ha-1), as the combination (Fe2S3) excelled and gave the highest average of (4.7268) tons ha-1 compared to the combination (Fe0S1), which It gave the lowest average of (3.4977) tons ha-1.

It is clear from the results of Table (6) that there are significant differences between the triple interactions between the cultivars, iron concentrations, and spraying dates in the grain yield traits tons ha-1, as the two combinations (V3Fe2S3) excelled, which gave the highest average of (5.166) tons ha-1, respectively, compared to the combination. (V2Fe0S1), which gave the lowest of the two averages, amounting to (3.0223) tons ha-1.

Table (6) Evaluation of the performance of three local wheat cultivars for yield traits based on the effect of foliar fertilization on the average grain yield 1 ton/h for the agricultural season 2023-2024

Interaction between cultivar and iron concentrations	Spraying dates			Iron concentrations)mg.L-1(	cultivar
	booting S3	elongation S2	tillering S1		
3.527	3.528	3.531	3.522	**Fe0**	**IPA 99 V1**
4.3213	4.701	4.312	3.951	**Fe1**	
4.5017	4.807	4.558	4.14	**Fe2**	
3.0827	3.1947	3.031	3.0223	**Fe0**	**Bohouth 22 V2**
3.4358	3.775	3.3813	3.151	**Fe1**	

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3.7033	4.2073	3.629	3.2737	**Fe2**	
3.953	3.9573	3.953	3.9487	**Fe0**	**Adina V3**
4.3444	4.5487	4.3187	4.166	**Fe1**	
4.7198	5.166	4.646	4.3473	**Fe2**	
0.05293	**0.09168**			**L.S.D 5%**	
cultivar	**booting S3**	**elongation S2**	**tillering S1**	**Spraying dates cultivar**	**interaction between cultivar and spraying dates**
4.1167	4.3453	4.1337	3.871	**V1**	
3.4073	3.7257	3.3471	3.149	**V2**	
4.3391	4.5573	4.3059	4.154	**V3**	
0.03056	**0.05293**			**L.S.D 5%**	
Iron concentrations	**booting S3**	**elongation S2**	**tillering S1**	**Spraying dates Iron concentrations**	**Interaction between Iron concentrations and Spraying dates**
3.5209	3.56	3.505	3.4977	**Fe0**	
4.0339	4.3416	4.004	3.756	**Fe1**	
4.3083	4.7268	4.2777	3.9203	**Fe2**	
0.03056	**0.05293**			**L.S.D 5%**	
booting S3	**elongation S2**	**tillering S1**		**Spraying dates**	
4.2094	3.9289	3.7247			
0.03056				**L.S.D 5%**	

Biological yield ton ha-1

The results of Table (7) show that there are significant differences in the biological yield (tons/h-1) for the cultivars (IPA 99, Bohouth 22, and Adina), whose averages reached (13.6913, 12.324, and 15.3833) tons/h-1, respectively, as the cultivar (Adina) gave the highest average of (15.3833) tons ha-1, with an increase rate for the two cultivars (IPA 99 and Adina) of (11.094 and 24.8237)%, respectively, compared to the cultivar (Bohouth 22), which gave the lowest average of (12.324) tons ha-1. The reason for this is attributed to the increase achieved by the excelled cultivar over the rest of the cultivars by giving it the highest biological yield, which is due to its high growth rates during the period from planting to sprout, which is the area of the flag leaf, Table (5), and the number of branches, Table (4), in addition to the increase in grain yield, Table No. (12). This result was consistent with the findings of [5,11] who found significant differences between the cultivars that were included in their study in terms of biological yield.

The results in Table (7) show that spraying chelated iron Fe-EDTA (6% iron) on the vegetative part of the plant led to significant differences in each of the added iron concentrations (Fe1, Fe2), which averaged (13.8029 and 14.7005) tons.ha. 1 respectively, with percentages of increase in iron concentrations of (7.039 and 13.999%) respectively over the comparison treatment (Fe0) spraying with distilled water only, which averaged (12.8952) tons ha-1 in terms of biological yield tons ha-1. This increase in biological yield is due to the role of iron in increasing the dry matter (grains + straw), and these results are consistent with the findings of [5,11].The results of Table (7) indicate that there are significant differences between the spraying dates (tillering phase S1, elongation phase S2, and booting phase S3), whose averages reached (13.3729, 13.8297, and 14.196) tons h-1, respectively, with the highest average reaching (14.196) tons. E-1, with an increase rate for the dates (S2 and S3) of (3.415, 6.154)%, respectively, over the comparison treatment (S1), which averaged (13.3729) tons ha-1 in terms of the biological yield, tons ha-1. This supports the role of foliar fertilization with iron in increasing the weight of the vegetative parts, which led to an increase in the height of the plant, Table (3), the area of the flag leaf, Table (5), the number of branches, Table (4), the number of spike , Table (9), and grain yield, Table (12) As these components are reflected in an increase in biological yield, this means that foliar feeding is effective and beneficial under conditions of absorption limitations represented by unsuitable soil conditions [31]. These results agreed with [25].

The results of Table (7) showed that there were significant differences between bi-interactions between the cultivars and the iron concentrations in the biological yield (tons ha-1), as the combination (V3Fe2) excelled and gave the highest average of (16.6208) tons (tons) ha-1 compared to the combination (V2Fe0) which gave The lowest average was (11.5544) tons ha-1.

The results of Table (7) indicate that there are significant differences between the bilateral interactions between the cultivars and spraying dates in terms of the biological yield (tons ha-1), as the combination (V3S3) excelled and gave the highest average of (15.7372) tons ha-1 compared to the combination (V2S1) which gave The lowest average was (11.9307) tons ha-1.

The results of Table (7) showed that there were significant differences between bi-interactions between iron concentrations and spraying dates in terms of biological yield (tons ha-1). The combination (Fe2S3) excelled and gave the highest average of (15.5) tons ha-1 compared to the combination (Fe0S2), which It gave the lowest average of (12.8934) tons ha-1.

It is clear from the results of Table (7) that there are significant differences between the triple interactions between the cultivars, iron concentrations, and spraying dates in the biological yield traits tons ha-1, as the two combinations (V3Fe2S3) excelled, which gave the highest average amounting to (17.386) tons ha-1, respectively, compared to the combination. (V2Fe0S1), which gave the lowest of the two averages, amounting to (11.5467) tons ha-1.

Table (7) Evaluation of the performance of three local wheat cultivars for yield traits based on the effect of foliar fertilization on the average biological yield 1 ton/ha for the agricultural season 2023-2024

Interaction between cultivar and iron concentrations	Spraying dates			Iron concentrations)mg.L-1(	cultivar
	booting S3	elongation S2	tillering S1		
12.91	12.907	12.9103	12.9127	Fe0	IPA 99 V1
13.7424	14.3	13.6103	13.317	Fe1	
14.4213	15.288	14.411	13.565	Fe2	
11.5544	11.56	11.5567	11.5467	Fe0	Bohouth 22 V2
12.3581	12.671	12.4017	12.0017	Fe1	
13.0594	13.826	13.1087	12.2437	Fe2	
14.2211	14.22	14.2133	14.23	Fe0	Adina V3
15.308	15.6057	15.3553	14.963	Fe1	
16.6208	17.386	16.9003	15.576	Fe2	
0.05822	0.10084			L.S.D 5%	

cultivar	booting S3	elongation S2	tillering S1	Spraying dates cultivar	interaction between cultivar and spraying dates
13.6913	14.165	13.6439	13.2649	V1	
12.324	12.6857	12.3557	11.9307	V2	
15.3833	15.7372	15.4897	14.923	V3	
0.03361	0.05822			L.S.D 5%	

Iron concentrations	booting S3	elongation S2	tillering S1	Spraying dates Iron concentrations	Interaction between Iron concentrations and Spraying dates
12.8952	12.8957	12.8934	12.8964	Fe0	
13.8029	14.1922	13.7891	13.4272	Fe1	
14.7005	15.5	14.8067	13.7949	Fe2	
0.03361	0.05822			L.S.D 5%	

booting S3	elongation S2	tillering S1	Spraying dates
14.196	13.8297	13.3729	
0.03361			L.S.D 5%

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