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Article

Effect of foliar fertilization (FULARTAL) on the growth and yield of three wheat cultivars

Raghad Katran Hassan[1*], Rasha Adel Abdul-Nabi[1], Zahraa Aqil Hassan[2]
[1]Technical College of Musayyib, Iraq.
[2]Karbala Agriculture Directorate, Iraq.
*Correspondence: raghadkkk2017@yahoo.com
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Abstract: A field experiment was carried out in the Experimental Field of Field Crops Department of the College of Agriculture - University of Baghdad during the winter of 2019-2020. To study the effect of foliar fertilization (FULARTAL) on the growth and yield of three wheat cultivars. A factorial experiment was applied by designing complete randomized plots with three replications. The first factor included cultivars (Abu-Ghraib, Fateh, Sham 6) symbolized by (F1, F2, F3); the second factor included three levels of fertilizer (0, 2, 4) l ha^{-1}, and the following symbols were taken (M0, M1, M2). The results showed there were significant differences between the levels of factors in the studied traits. There was a significant difference between cultivars, as Abu-Ghraib (F1) outperformed in some features, including plant height, tillers number, and spikes number by giving the highest averages at (107.77 cm, 434.00 spikes. m^2 and 383.88 spikes. m^2). Sham 6 cultivar (F3) showed the highest average in the flag leaf area, spike length, and the number of days from planting until 50% of flowering appeared (37.11 cm^2, 9.55 cm and 110.33 days). The concentration of 4 l ha^{-1}(M2) gave the highest average in the trait: plant height, tillers number, flag leaf area, spike length, and spikes number, reaching (109.89 cm, 430.89 tillers. m^2, 36.11 cm^2, 9.41 cm and 382.44 spikes m^2). The concentration of 2 l ha^{-1} (M1) gave the least days from planting until 50% of flowering appeared (107.89 days).

Keywords: FULARTAL fertilizer; wheat; growth and yield characteristics; foliar fertilizers.

Introduction

The human need for grains is estimated at 75% of his food, and the wheat crop Triticum aestivum L is at the forefront, one of the most important strategic crops in the world, as it comes primarily in terms of cultivated area and production. It is directly in its food due to its high nutritional value due to its high content of carbohydrates, proteins and starch, which makes it play a significant role in international trade and balancing the global economy [1].

Foliar nutrition plays an important role when sprayed in the form of nutrient solutions on the vegetative system of the plant, and it is of great importance in obtaining higher yields. An appropriate feeding system is necessary to meet the plant's requirements of nutrients through the leaves because their transport through the roots requires a long time compared to direct addition through the leaves, as the nutrition of the plant affects many physiological and biochemical processes that affect growth, development and outcome [2]. The absorption of the elements through the leaves occurs in two ways: 1- Apoplast: through the stomata

and the spaces between the cells of the leaf until it reaches the transporting vessels and then to the other parts of the plant. 2- Symplast: through cytoplasmic bridges or tubes located under the cuticle layer of the epidermal cells of the leaves and then through the cytoplasm and from there to other parts of the plant [3, 4]. [5] found that the components of fertilizer are of great importance, including the elements nitrogen and phosphorous, which are considered essential for the growth and yield of wheat, especially their use in the form of compound fertilizer (DAP) to ensure their readiness and reduce losses and fixation to make optimal use of this fertilizer. It was also found that fertilizing with phosphorus and potassium together increases the absorption of essential elements and their content in the plant and increases the yield of wheat grains to a better degree than if the component was added to unit [6]. Also, [7] found that the spraying dates have a significant effect when studying the spraying dates on the wheat plant. Several researchers[8, 9, 10] through their studies on different cultivars of wheat, indicated the cultivars differed from each other in most growth characteristics and yield according to the type of foliar fertilizer used, including spikes number, grains number of spike-1, weight of 1000 grains, and grain yield.

Materials and Methods

A field experiment was conducted in the Experimental Field of Field Crops Department of College of Agriculture - University of Baghdad during the winter of 2019-2020. To study the effect of foliar fertilization (FULARTAL) on the growth and yield of three wheat cultivars. A factorial experiment was applied by designing complete randomized plots with three replications. The experiment included two factors. The first factor was cultivars (Abu-Ghraib, Fateh, Sham 6) symbolized by (F1, F2, F3), and the second factor included three levels of fertilizer (0, 2, 4) l ha^{-1}, and the following symbols were taken (M0, M1 and M2).

The experimental land was prepared after being plowed on two orthogonal plows by the inverted plow. After plowing, the land was smoothed using disc harrows and leveled manually. Another 20 cm, leaving a distance of (50) cm between one panel and another and a distance of (1 m) between the repetitions and between the main plots, and a space of (10) cm was left on both sides; after that, the plots were manually planted with grains of the used cultivars (sourced from the General Authority for Agricultural Research - Baghdad - Abu Ghraib on 20/11/2019). Then, it was given irrigation for germination, which continued according to soil moisture and plant needs.

Nitrogen fertilizer was added in the form of urea (N 46%) according to the scale of [11] in four batches (cultivation and when 3 entire leaves appear: (13 Zadoks) when the second node appears: (32 Zadoks), and at the booting: (40 Zadoks). Phosphate fertilizer was added at once when planting in triple superphosphate (20% P) [12]. In contrast, potassium fertilizer was added in three batches when planting, telling, and booting in potassium sulfate (41.5% K) [13]. The plants were sprayed until the leaves were completely wet in the early morning using a 20-liter dorsal sprinkler. As for the control treatment, it was sprayed with distilled water only.

According to the recommendations, crop service operations were carried out, including irrigation, fertilization and weeding. After the plants reached the stage of full maturity, they were harvested on 14.05.2020, and then some field characteristics were studied. The data were statistically analyzed according to the design used according to the program (Genstat), and the averages were compared using the least significant difference test (LSD) at the probability level of 0.05 [14].

Characteristics	Value
pH	7.44
EC	4.26
Total nitrogen g kg^{-1}	0.21
Available phosphorous g kg^{-1}	0.019
Available Potassium g kg^{-1}	0.024
Organic matter g kg^{-1}	7.68
Soil Separators	
Clay %	251
Sand %	323
Silt %	426
Soil texture	Sandy loam

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

Element	Ratio
N	14 % w/w = 17.86% w/v
P	6 % w/w = 7.66% w/v
K	5 % 6.38 % w/v
Fe	0.10 % Weight/weight soluble in water
Mn	0.06 % Weight/weight soluble in water
Cu	0.05 % Weight/weight soluble in water
B	0.02 % Weight/weight soluble in water
Mo	0.002 % Weight/weight soluble in water
Zn	0.05 % Weight/weight soluble in water
Mg	2.00 % Weight/weight soluble in water

Table 2. The chemical composition of the fertilizer used in the study.

Results

Number of days from planting until 50% flowering

The results showed in Table 3 that the studied wheat cultivars differed in the number of days from planting until the emergence of 50% of spikes. The F3 cultivar significantly outperformed the two other cultivars by giving it the shortest period of 108.44 days.

The foliar fertilizer concentrations also affected this trait significantly, as the M1 concentration gave the shortest planting period to 50% flowering, which amounted to 107.89 days, while the M0 concentration gave the highest rate of 110.44 days. The reason for this may be due to the composition of the fertilizer from the elements, including the element phosphorous, which plays an essential

role in the process of respiration and thus increases the production of hydrogen peroxide, which works to increase ethylene in the plant, which helps to age leaves by preventing the transfer of auxin from the leaf blade to its base, thus producing an auxin gradient In the area of separation. The area of separation is formed.

The same table results also show a significant interaction between F and M, as the combination F3M0 gave the highest rate of 112.33 days, while F1M0 and F2M1 gave the lowest rate of 107.33 days Table 3.

Cultivars (F)	Concentrations of foliar fertilizer FulArtal (l ha^{-1})			Average (F)
	M0	M1	M2	
F1	107.33	108.67	109.33	108.44
F2	111.67	107.33	108.00	109.00
F3	112.33	107.67	111.00	110.33
Average (M)	110.44	107.89	109.44	
L. S. D $_{0.05}$		F= 1.49	M= 1.49	M*F= 2.98

Table 3. Effect of cultivars and foliar nutrient spray and their interaction on the number of days from planting until 50% flowering.

Plant height (cm)

It is clear from the data in Table 4 that there are significant differences between the cultivars and the concentrations of the foliar fertilizer used and their interaction with this trait. The F1 cultivar excelled by giving the highest average plant height of 107.77 cm, while the F2 cultivar showed the lowest rate of 103.11 cm for this trait. This may be due to genetic differences between the cultivars, which was reflected in their different response to the surrounding environmental conditions and their difference in the height of the plant.

The interaction between the cultivars and the concentrations of foliar fertilizer (F, M) also significantly affected the plant height. The interaction between the F3 cultivar and M2 fertilizer level achieved the highest average of 114.00 cm, while the F3 cultivar and the control treatment M0 gave the lowest average of 97.67 cm.

Cultivars (F)	Concentrations of foliar fertilizer FulArtal (l ha^{-1})			Average (F)
	M0	M1	M2	
F1	105.33	107.33	110.67	107.77
F2	99.67	104.67	105.00	103.11
F3	97.67	101.67	114.00	104.44
Average (M)	100.89	104.55	109.89	
L. S. D $_{0.05}$		F= 3.55	M= 3.55	M*F= 7.1

Table *4.* Effect of cultivars and foliar nutrient spray and their interaction on plant height. Cm.

Tillers number .m²

Table 5 results indicate significant differences between the cultivars in tillers number (m^2). F1 cultivar achieved the highest rate of 434.00 tillers m^2, significantly superior to F2 and F3 cultivars, each of which gave an average number of 423.44 and 427.55 tillers m^2.

The results also showed a significant effect on the levels of foliar fertilizer used, as the number of tillers per m^2 was 430.89 when treated with the fertilizer level M2, compared to the control treatment M0 (without fertilization), which gave the lowest average number amounted to 426.11. The increase may be due to some components of the foliar fertilizer used, which have a role in encouraging meristematic tissues and the crown-generating area of the branches. These results are consistent with what was found by [22]. As for the interaction between the cultivars and the levels of fertilizer (F, M), it showed a significant effect for this trait, as the combination F1M2 gave the highest average number of tillers, amounting to 437.33, while the combination F2M0 gave it did not differ from the combination F3M0 by giving them the lowest rate of the number of tillers amounted to 422.33 Table 5.

Cultivars (F)	Concentrations of foliar fertilizer FulArtal (l ha^{-1})			Average (F)
	M0	M1	M2	
F1	433.67	431.00	437.33	434.00
F2	422.33	423.33	424.67	423.44
F3	422.33	429.67	430.67	427.55
Average (M)	426.11	428.00	430.89	
L. S. D $_{0.05}$		F= 2.31	M= 2.31	M*F= 4.62

Table 5. Effect of cultivars and foliar nutrient spray and their interaction on tillers number. m2.

Flag leaf area. cm²

The cultivars and levels of foliar fertilizer spraying had a significant effect on the flag leaf area. Table 6 showed the superiority of the F3 cultivar with the highest average flag leaf area, which amounted to 37.11 cm^2, significantly outperforming F2 and F2 cultivars, each of which gave 34.55 and 31.78 cm^2.

Table 6 shows that when the added fertilizers increased, the flag leaf area increased, as level M2 gave the highest average, amounting to 36.11 cm2. In comparison, the control treatment M0 gave the lowest average at 32.55 cm^2. The reason, in addition to the role of these elements in increasing growth (flag leaf area), may be attributed to the fact that the content of the soil of the experiment land Table 1 of these elements was sufficient to cause this increase in the flag leaf area. As well as the role of nitrogen in the formation of chlorophyll.

The interaction between the factors F and M significantly affected this trait, as the F3 cultivar with the M2 fertilizer level gave the highest rate of 41.00 cm^2. In contrast, the F1 variety with the comparison treatment M0 gave the lowest rate for this trait, amounting to 30.67 cm^2.

Cultivars (F)	Concentrations of foliar fertilizer FulArtal (l ha^{-1})			Average (F)
	M0	M1	M2	
F1	30.67	32.00	32.67	31.78

F2	33.00	36.00	34.67	34.55
F3	34.00	36.33	41.00	37.11
Average (M)	32.55	34.77	36.11	
L. S. D $_{0.05}$		**F= 1.40**	**M= 1.40**	**M*F= 2.8**

Table 6. Effect of cultivars and foliar nutrient spray and their interaction on flag leaf area. cm2.

Spike length .cm

The spike in wheat is a source and a sink simultaneously, as its green parts by photosynthesis are a source of the products of this process to the grain [27]. The statistical analysis results in Table 7 indicated significant differences between the cultivars in the average spike length (cm). The F3 cultivar excelled by giving the highest average of 9.55 cm, while the F1 cultivar showed the lowest average of 9.03 cm.

The foliar fertilizer spray concentrations showed significant differences; m2 concentration gave this trait the highest mean of 9.41 cm, while the control treatment M0 gave the lowest average of 9.09 cm.

The interaction between the cultivars and the foliar fertilizer concentrations showed significant differences; the F3 cultivar with M2 concentration gave the highest average of 10.10 cm for this trait, while the F1 variety with the control treatment M0 gave the lowest average of 8.97 cm Table 7.

Cultivars (F)	**Concentrations of foliar fertilizer FulArtal (l ha^{-1})**			**Average (F)**
	M0	**M1**	**M2**	
F1	8.97	9.13	9.00	9.03
F2	9.13	9.27	9.13	9.17
F3	9.17	9.40	10.10	9.55
Average (M)	9.09	9.26	9.41	
L. S. D $_{0.05}$		**F= 0.22**	**M= 0.22**	**M*F= 0.44**

Table 7. Effect of cultivars and foliar nutrient spray and their interaction on.

Spikes number. m^2

The number of spikes is determined in the early stages of the plant's life, in the tiller production and spike formation period, which is an essential component among the yield components [30]. The results of Table 8 indicate the presence of significant differences between the cultivars in the number of spikes m^2. The F1 cultivar excelled in this trait by giving it the highest rate of 383.88 spikes m^2, while the F2 cultivar gave the lowest average of 376.77 spikes m2, which did not differ significantly from F3.

The results show a significant effect of the concentrations of foliar fertilizer spraying; M2 concentration led to a significant increase in the number of spikes m^2, which amounted to 382.44 spikes m^2, while the control treatment M0 gave the lowest average for this trait, which was 377.66 spikes m^2.

As for the effect of the interaction between the two factors of the study, there was a significant interaction in this trait, as the combination F1M0 outperformed the rest of the combinations by giving it the highest rate of this trait, which amounted to 388.33 spikes. m^2, while the combination F3M0 gave the lowest average of 369.67 spikes m^2 Table 8.

Cultivars (F)	Concentrations of foliar fertilizer FulArtal (l ha^{-1})			Average (F)
	M0	**M1**	**M2**	
F1	388.33	380.33	383.00	383.88
F2	375.00	377.00	378.33	376.77
F3	369.67	380.33	386.00	378.66
Average (M)	377.66	379.22	382.44	
L. S. D $_{0.05}$		**F= 3.25**	**M= 3.25**	**M*F= 6.5**

Table 8. Effect of cultivars and foliar nutrient spray and their interaction on spikes number. m^2

Discussion

The reason for the occurrence of such an acceleration in the processes of growth and development of wheat plants under certain conditions may be attributed to the differentiation of cultivars from each other in this trait to their genetic factor or the intense competition for external growth factors (climate and soil) and internal growth factors for the genetic structure of the variety. The results agree with what was found by [15 and 16].

The foliar fertilizer concentrations also affected the days from planting until 50% f. The concentrations of foliar fertilizer (filarial) had a significant effect on plant height. M2 level gave the highest rate for the trait, which reached 109.89 cm, while the non-fertilization treatment (control treatment) M0 gave the lowest rate for the trait, which reached 100.89 cm. The reason for this is due to the components of the foliar fertilizer used, including the nitrogen element, which had a role in the division and expansion of cells and their elongation through its role in the formation of amino acids necessary in the elongation of plant cells such as tryptophan and thus led to an increase in plant height. The soil, in general, is of nutrients, and this level of fertilizer has provided sufficient nutritional requirements in agreement[18, 19].

Lowering significantly, these results agreed with what was stated [17].

The reason for the variation of cultivars in the number of tillers is due to the genetic differences between them as well as the nature of their growth, as it was found that branching and early ripening are among the characteristics associated with the genetic structure and affected to varying degrees in the surrounding environment. These results agreed with the results of [20 and 21].

The cultivars and levels of foliar fertilizer spraying had a significant effect on the flag leaf area; the reason may be attributed to the fact that the F3 cultivar exploited its genetic and physiological capabilities with high efficiency to obtain the growth requirements better than the other cultivars; this was reflected in the increase of the flag leaf area. This result is consistent with what [23] found, which saw a significant difference between wheat cultivars in the flag leaf area.

The part of potassium also comes by activating these enzymes in the process and the transfer of its products, which are used in the growth of the leaf, as well as the transfer of nutrients from the roots to the leaves, and then increasing the growth of the leaves and their area. [24] These results agree with the findings by [25,26]; they indicated the significant effect of these foliar fertilizers in increasing the flag leaf area.

The reason for the superiority of the F3 cultivar in the length of the spike is due to its superiority in the flag leaf area, which positively affected the processing of the developing cells with their requirements of processed food necessary for their division and elongation, which was thus reflected in the increase in the length of

the spike. This was confirmed by the highly significant positive correlation between flag leaf area and length of the spike, as well as cultivars' differences in their genetic structure; this result agreed with [28].

The foliar fertilizer spray concentrations showed significant differences; the reason for this may be due to the content of the fertilizer used on a group of micro-elements that have a role in carrying out various vital reactions, directly or indirectly, through their activation of the various enzymes responsible for the metabolic responses carried out by the areas of active growth, especially in the increase of the plant's division. Furthermore, its elongation led to an increase in the spike length. These results agree with the findings by [29].

The reason for the variation of cultivars in the number of spikes is attributed to their association with the nature of the genotypes and their ability to form and preserve fertile tillers. These results are consistent with the findings by [31 of 32].

The results show a significant effect of the concentrations of foliar fertilizer spraying; the reason may be that potassium is one of the fertilizer components that have a role in increasing the number of tillers in the plant and thus increasing the number of spikes in the unit area [33], in addition to the role of potassium in improving growth by expanding the content of chlorophyll in leaves and increasing the period of Vegetative growth and raising the efficiency of the photosynthesis process and then increasing the products of photosynthesis, in addition to the role of potassium in the hormonal balance process between auxins and cytokines, which reduced the apical dominance in favor of a more significant number of fertile spikes [34]. These results agreed with [35].

Conclusion

This study concluded the effect of the amount of foliar fertilizer added and the interest in mineral nutrition by using modern techniques because of its significant role in improving the growth and productivity of this crop.

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