

RESEARCH PAPER

Effect of Foliar Application of Some Micronutrients at Two Growth Stages on Growth, Yield and Yield Components of Two Bread Wheat (*Triticum aestivum* L.) Varieties

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ABSTRACT:

A field experiment was conducted during the growing season of 2018-2019 at the experimental farm of the college of Agricultural Engineering Sciences/ Salahaddin University- Erbil (Latitude 36°4' N and Longitude 44°2' E) to study the effect of Zn, Fe foliar application and their combination at two growth stages on growth and yield of two wheat varieties (*Triticum aestivum* L.). A factorial experiment (2×2×4) was conducted using randomized complete block design (RCBD) with three replicates. The research was included two wheat varieties (Hawler 2 and Hawler 4), foliar fertilization at two growth stages (Tillering GS Z25 and booting GS Z45) and four fertilizers treatments which include F₁(control), F₂ (134 mg/L Fe as (FeSO₄.7 H₂O), F₃ (270.01 mg/L Zn) as ZnSO₄ and F₄ ((134 mg/L Fe + 270.01 mg/L Zn) combination of (F₂.7H₂O + ZnSO₄). The results indicated that the treatment combination of V₁ × S₂ × F₀ recorded highest values for no. of spike plant⁻¹, no. of spikelet spike⁻¹ and no. of seed spike⁻¹ (4.25, 51.51 and 54.27) respectively. While the highest seed weight spike⁻¹, seed index (22.71 and 45.41) were recorded for the combination treatment of V₁ × S₁ × F₄ the results also revealed that the treatment combinations (V₂ × S₁ × F₄) and (V₁ × S₁ × F₁) offered the highest and lowest seed yield respectively. The treatment combinations (V₂ × S₁ × F₄) resulted in higher seed yield by 69% compared to (V₁ × S₁ × F₁).

KEY WORDS: Wheat varieties, Foliar application, Micronutrients, stage of fertilization.

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1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is an annual herbaceous crop which belongs to the poaceae

family it is regarded as one of the most important crop over the world and it is the third major

cereal produced after maize and rice (FAO, 2013). Wheat is the major source for human nutrition and a part of daily dietary need in different forms. According to FAO reports wheat contributes 28% of the world's edible dry matter and 60% daily calorie intake in several developing countries.

The low wheat production is due to use of low seed quality, insufficient use of fertilizers, water shortage and no use of micronutrients (Khan et al., 1999). Micronutrients are playing a pivotal role in the yield improvement (Rehm and Sims, 2006).

Micronutrients play an important role in the increase of wheat production (Nadim et al., 2011). According to Narimani et al. (2010) lack of micronutrient effect on the quantity of wheat. Genetically cereals are low in Zn and Fe concentrations which caused reduce of bioavailability (Graham et al., 2001; Cakmak, 2002). In many Asian countries the deficiency of micronutrients is widespread because of the calcareous soils, low organic matter, high pH and high amount of bicarbonate in irrigation water

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(Narimani et al., 2010). Foliar application of micronutrients increases the rate of absorption by leaf epidermis of plant and reach to other parts of plant through xylem and phloem (Hasslett et al., 2001).

Zinc is an essential micronutrient which has an important role in the growth of plants. It is required in many enzymatic reactions, metabolic processes and oxidation reduction reactions. According to Cakmak (2008) foliar application of Zn has an effective practice to improve production. Foliar application of Zn has significant effect on wheat grain yield (Bameri et al., 2012; El-Habbasha et al., 2015; Esfandiari et al., 2016).

Similarly, iron is one of the important micronutrients and considered the most abundant element on the earth as a whole. Iron is essentially participating in the process of plant photosynthesis and plays an important role in respiration, the oxidation process which releases energy from sugars and starches and the production of healthy green leaves. It also plays an essential role in metabolism of nucleic acid (Havlin et al., 2014). Since the soil of Iraqi Kurdistan region is calcareous which causes precipitation of micro nutrients (Zn and Fe) in the form of hydroxyl or carbonate which are unavailable for plants at the same time soil application of them in a mineral form are useless, for this reason the foliar application of them was selected in order to study the effect of Zn, Fe and their combinations on wheat crop performance and grain yield quantity.

1. MATERIALS AND METHODS

The study was conducted at the experimental farm of the college of Agricultural Engineering Science at Grdarasha site (Latitude 36°4 N and Longitude 44°2 E) during the growing season of 2018-2019 to study the effect of foliar application of Zn, Fe and their combination at two growth stages on growth, yield and quality of two wheat varieties (*Triticum aestivum* L.).

A factorial experiment based on randomized completely block design (RCBD) with three replicates was used. The first factor comprised two varieties (Hawler 2 and Hawler 4) imported from Agriculture Research Center/ Erbil. The second factor included F₁ (control), F₂ (0.5 g) as

(FeSO₄.7H₂O), F₃ (0.5 g) as (ZnSO₄) and F₄ (0.5+0.5 g) as (combination of FeSO₄.7H₂O and ZnSO₄) per 750 ml distilled water for each experimental unit. The third factor included two growth stages (tillering and booting).

The field was first prepared by flooded up on 10th September, and subjected to evaporation the soil was plowed by mold board plow and rotivator to soften the soil. Table (1) exhibits some selected physical and chemical properties of the soil of the experimental site (Qadir, 2017).

Table (1): physical and chemical properties of the soil of the experimental site.

Site	Soil property	Unit	Average value	
Grdarasha	Particle size distribution	Sand	g/kg	128.0
		Slit	g/kg	521.4
		Clay	g/kg	350.6
	Textural name		SiCL	
	Organic matter content	g/kg	9.3	
	ECe	dSm ⁻¹	0.56	
	pH		7.57	
	Calcium carbonate equivalent	g/kg	339.0	

The land was divided into plots, each block consisted of 16 experimental units, the dimensions of each unit was (1m×1m), each unit contained four rows, with row spacing of 20 cm. On 4th November, the seeds were sown manually at the rate of 100 kg ha⁻¹ on a silty clay loam soil. Table (2) also shows some metrological parameters during the growing season.

Table (2): Metrological data for Grdarasha field during growing season of (2018-2019):

Month	Air temperature in (°C)			Monthly precipitation (mm)	Relative humidity (%)
	Max	Min	Mean		
October	38.70	11.40	25.30	22.60	35.30
November	28.20	6.30	15.60	113.50	65.80
December	21.69	13.81	17.70	0.51	35.19
January	18.50	-0.90	8.60	96.30	71.70

February	18.50	2.80	10.00	42.40	69.30
March	21.54	0.48	11.01	173.60	72.25
April	26.62	3.51	15.06	105.50	69.57
May	39.70	10.80	25.90	5.80	39.30
Total	26.68	6.03	16.15	70.02	57.30

Studied Characters:

The studied characters included the following:

Characteristics that Studied at Flowering Stage:

Random representative samples of ten plants were used at full maturity stages from each experimental unit to stimulate the following characters:

- Total leaf area per plant (LA) cm^2 :

Fifteen leaves were selected at each experimental unit to study the leaf area by the following formula:

$$\text{Leaf area} = (\text{leaf length} * \text{leaf width} * 0.905) \quad (\text{Kemp, 1960}).$$

- Flag leaf area: Flag leaf area was determined from ten leaves of ten randomly selected plants at each experimental unit.
- Chlorophyll content:

The SPAD reading was recorded as an index of chlorophyll content three times with 10 days' interval using chlorophyll meter model (Vol 1.0) from five labeled plants at three locations on three leaves which equivalent to 45 readings for each experimental unit (Biber, 2007).

Measurements at maturity stage:

Representative samples were taken from the plants of the two inner rows from each experimental unit during physiological maturity stage. The samples were used to study the following characters:

Number of spike plant^{-1} , Number of spikelet spike^{-1} , Number of seed spike spike^{-1} : spikes were taken randomly from each experimental unit and shattered by hand then number of seeds per spike was calculated.

Weight of seed spike spike^{-1} (g), Seed index: 1000-seed weight (g)

The wheat plant was harvested from the whole plot to determine:

Seed yield (Mg ha^{-1}): the seeds of harvested plants were threshed, cleaned and sieved to remove the impurities and weighed. The weight was converted to Mg ha^{-1} .

Statistical analysis:

The data were statistically analyzed according to the technique of analysis of variance (ANOVA) for randomized complete block design (RCBD) using SPSS program version (22) the difference among means of treatments were tested using Duncan's multiple range test at level of significant 5% 0.05 (Duncan, 1955).

2. RESULTS AND DISCUSSION

Effect of variety, growth stages, fertilizer and their treatment combinations on growth characteristics of wheat:

Leaf Area ($\text{cm}^2 \cdot \text{Plant}^{-1}$):

Table (3) Shows a significant effect of variety on plant leaf area. The highest leaf area (32.48 cm^2) was obtained from first variety (V_1). This result indicates that (V_1) is higher than (V_2) and this may be due to the genetic behavior of the variety and its adaptation to the local climatic conditions.

Additionally, Table (3) indicates that there was a positive influence of different fertilizer on leaf area of wheat. (F_3) treatment shows the highest leaf area (33.95 cm^2) than other fertilizer as well as F_1 treatment that obtained the smallest leaf area (29.09)

F	S ₁	S ₂	Mean of Fertilizer
F ₁	30.38 ab	27.79 b	29.09 b
F ₂	31.38 ab	29.51 ab	30.44 ab
F ₃	32.83 ab	35.08 a	33.95 a
F ₄	32.09 ab	30.02 ab	31.06 ab

cm^2 .

The statistical analysis of the data revealed that the combination treatment between variety and growth stage ($V \times S$) had a significant influence on wheat leaf area. The largest leaf area (34.89 cm^2) attained from ($V_1 \times S_1$), and the minimum leaf area (28.45 cm^2) recorded from ($V_2 \times S_1$). These results obtained that there was no significant difference between the growth stages.

Leaf area was significantly affected by the combination treatment between variety and fertilizer ($V \times F$). ($V_1 \times F_3$) treatment shows the maximum leaf area (35.05 cm^2) whereas the smallest leaf area

(27.28) cm² was recorded from V₂ at F₁ treatment. This differences may be due to the genetic background for the variety and its behavior under these conditions in which Zn foliar application effect on growth. The results are in accordance with El-Dahshouri (2018).

Furthermore, the impact of combination treatment between growth stage and fertilizer (S × F) was significant for this trait. (S₂ × F₃) performs the best results which was (35.08) cm² and the smallest leaf area (27.79) cm² was attained from (S₂ × F₁). This result shows that F3 fertilizer affects the leaf area at S2 more than other treatments. The combination treatment among the three studied factor variety, growth stage and fertilizer (V × S × F) showed a positive effect on area of leaf. The maximum leaf area (37.73) cm² was recorded from the interaction (V₂ × S₂ × F₃) whereas the smallest leaf area (26.71) cm² was obtained from the interaction (V₂ × S₁ × F₂).

Table (3): Effect of variety, growth stage, fertilizer and their treatment combinations on Leaf Area (cm².Plant⁻¹):

Variety (V)	Fertilizer (F)	Growth stage (S)		Variety × Fertilizer
		S ₁	S ₂	
V ₁ (Hawler 2)	F ₁	33.61 ab	28.19 b	30.90 ab
	F ₂	36.05 ab	29.03	32.54 ab
	F ₃	37.66 a	32.43	35.05 a
	F ₄	32.24 ab	30.63	31.43 ab
V ₂ (Hawler 4)	F ₁	27.16 b	27.39 b	27.28 b
	F ₂	26.71 b	29.98	28.35 ab
	F ₃	27.99 b	37.73 a	32.86 ab
	F ₄	31.94 ab	29.42	30.68 ab

V	S ₁	S ₂	Mean of Variety
V ₁ (Hawler 2)	34.89 a	30.07 b	32.48 a
V ₂ (Hawler 4)	28.45 b	31.13 ab	29.79 b
Mean of growth stages	31.67 a	30.60 a	

Flag Leaf Area (cm². Plant⁻¹):

Flag leaf contributes to most photosynthetic assimilates in wheat and thus it assumes greatest importance from grain yield. Figure (1) shows the combination treatment effect of the studied factors (V × S × F) on flag leaf, the highest value (57.48) cm² was obtained from the treatment combination (V₁ × S₂ × F₂) while the lowest value (33.43) cm² were recorded from the combination treatment

treatments (V₂ × S₁ × F₁). Similar results were also obtained by Rawashdeh and Sala (2015). Fe when applied alone as foliar spray increased the area of flag leaf as well as broader flag leaves help in greater yield (Singh et al., 2015). This can be due to the positive effect of Fe foliar application and it can increase growth, thereby increase the length of flag leaf of wheat. Kahrariyan et al. (2013) reported the same results.

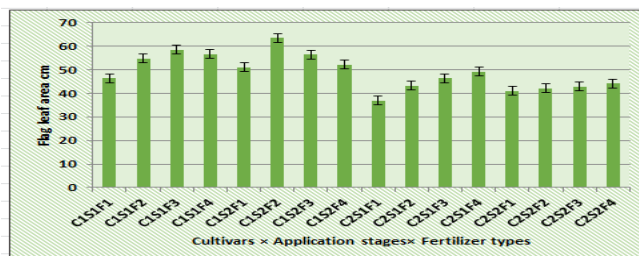


Figure (1) Effect of the treatment combinations among (V, S and F) on flag leaf cm².

Chlorophyll Content (SPAD):

Figure (2) presents the effect of treatment combination varieties, application stages and fertilizer types (V × S × F) on chlorophyll content the highest value (29.42 SPAD) was recorded from (V₁ × S₁ × F₃). While, the lowest value (20.50 SPAD) was obtained from (V₂ × S₁ × F₁). This demonstrates the role of treatment combination in creating different conditions for plant growth.

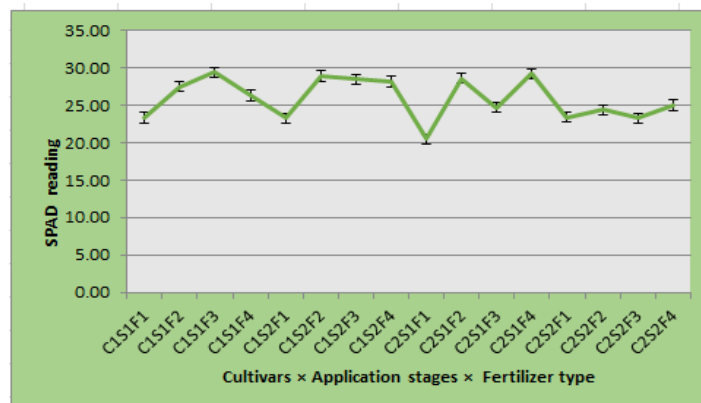


Figure (2): Leaf chlorophyll content as influenced by the interactions among (V × S × F).

Effect of variety, growth stages, fertilizer and their treatment combinations on yield and yield parameters of wheat:

Spike Length (cm):

The results displayed in Table (4) indicates that the spike length was significantly affected by only

the combination treatment treatments ($V \times F \times S$), ($F \times S$) and ($V \times S$) were affected significantly on spike length. The highest and lowest values were (9.94, 10.03 and 10.23) cm which recorded from ($V_2 \times S_2$), ($S_2 \times F_4$) and ($V_2 \times S_2 \times F_4$) respectively, while the lowest values (9.14, 8.69 and 8.52) cm were obtained from ($V_2 \times S_1$), ($S_1 \times F_1$) and ($(S_1 \times V_1 \times F_1)$) respectively.

This may be due to the role of varieties, fertilization and stage of fertilization application in creating different growth conditions for plant growth as mentioned by Darwesh (2007) and Kahriyan et al. (2013).

Table (4): Effect of variety, growth stage, fertilizer and their treatment combinations on Spike Length (cm):

Variety (V)	Fertilizer (F)	Growth stages		Variety \times Fertilizer
		S ₁	S ₂	
V ₁ (Hawler 2)	F ₁	8.52 a	9.25 a	8.88 a
	F ₂	9.21 a	9.34 a	9.28 a
	F ₃	9.81 a	8.99 a	9.40 a
	F ₄	9.18 a	9.83 a	9.51 a
V ₂ (Hawler 4)	F ₁	8.85 a	9.88 a	9.36 a
	F ₂	9.29 a	9.55 a	9.42 a
	F ₃	9.16 a	10.09 a	9.63 a
	F ₄	9.25 a	10.23 a	9.74 a

F	S ₁	S ₂	Mean of Fertilizer
F ₁	8.69 b	9.56 ab	9.12 a
F ₂	9.25 ab	9.45 ab	9.35 a
F ₃	9.49 ab	9.54 ab	9.51 a
F ₄	9.21 ab	10.03 a	9.62 a

V	S ₁	S ₂	Mean of Variety
V ₁ (Hawler 2)	9.18 ab	9.35 ab	9.27 a
V ₂ (Hawler 4)	9.14 b	9.94 a	9.54 a
Mean of growth stages	9.16 a	9.64 a	

Number of Spike Plant⁻¹:

Data in table (5) explained that the number of spikes plant⁻¹ was significantly affected by wheat varieties. The highest number of spike (3.67) was recorded from (V₁) variety. This result was in agreement with those reported by Ozturk et al. (2006), they concluded the maximum wheat yield is closely associated to the variety potential to give high number of spikes plant⁻¹. The results of the same table show that the significant differences of Zn and Fe spray on the number of spike plant⁻¹. The maximum amount of spike plant⁻¹ (3.75) was obtained from the combination treatment of (F₂ + F₃) Whereas, the lowest number of spike (2.79) was recorded from F1 treatment.

Regarding the effect of combination treatment between variety and fertilizer ($V \times F$) on the number of spike plant⁻¹ it showed significant differences. V₁ variety and (F₂ + F₃) spraying showed the highest number of spike plant⁻¹ (4.02) however, V₂ at F₁ treatment recorded the minimum amount of spike plant⁻¹ (2.77). This may be due to the different growth characteristics and capabilities of high yielding quantity of varieties.

The same table also indicates to significant effect of combination treatment between growth stage \times fertilizer ($S \times F$) on the same trait. The largest amount of spike plant⁻¹ (3.91) was obtained from (S₂ \times F₂) whereas the lowest amount of spike (2.74) noted from (S₂ \times F₁).

Furthermore, the combination treatment among the three studied factors variety, growth stage and fertilizer ($V \times S \times F$) had a positive combination treatment on number of spike plant⁻¹. (V₁ \times S₂ \times F₂) showed the highest amount of spike (4.25). The combination treatment among (V₁ \times S₂ \times F₁) recorded the smallest number of spike plant⁻¹ (2.60). The results indicate that same variety at same growth stages by applying different fertilizer shows different amount of spike plant⁻¹. The present results are similar to that of Singh et al. (2015) in which they stated that maximum number of spikes per plant were obtained when FeSO₄ applied alone.

Table (5): Effect of variety, growth stage, fertilizer and their treatment combinations on Number of Spike Plant⁻¹:

Variety (V)	Fertilizer (F)	Growth stages (S)		Variety × Fertilizer
		S ₁	S ₂	
V ₁ (Hawler 2)	F ₁	3.00 cde	2.60 e	2.80 c
	F ₂	3.68 a-d	4.25 a	3.97 a
	F ₃	3.96 ab	3.82 abc	3.89 ab
	F ₄	4.04 ab	4.00 ab	4.02 a
V ₂ (Hawler 4)	F ₁	2.66 e	2.88 de	2.77 c
	F ₂	3.38 a-e	3.31 b-e	3.34 bc
	F ₃	3.85 abc	3.11 b-e	3.48 ab
	F ₄	3.48 a-e	3.47 a-e	3.48 ab

F	S ₁	S ₂	Mean of Fertilizer
F ₁	2.83 b	2.74 b	2.79 b
F ₂	3.53 a	3.78 a	3.66 a
F ₃	3.91 a	3.47 a	3.69 a
F ₄	3.76 a	3.74 a	3.75 a

V	S ₁	S ₂	Mean of Variety
V ₁ (Hawler 2)	3.67 a	3.68 a	3.67 a
V ₂ (Hawler 4)	3.34 a	3.19 a	3.27 b
Mean of growth stages	3.51 a	3.43 a	

Number of Spikelet Spike⁻¹:

The presented results in the table (6) indicated to significant effect of Zn and Fe spraying on number of spikelet spike⁻¹. The highest number of spikelet (47.30) was obtained from F₃ fertilizer while the lowest number (40.48) was noted from F₁ treatment. This is because ZnSO₄ is known to have an essential role as a metal component of enzymes or as a functional, structural or regulatory co-factor of a large number of enzymes (Hotz and Braun, 2004). Data in the same table illustrated that (V₁ × F₂) treatment significantly had highest number of spikelet spike⁻¹. Whereas, the lowest number of spikelet spike⁻¹ (38.66) was attained from (V₁ × F₁) treatment, it means that application of F₂ alone is more effective for this trait. This results are in accordance with those obtained by Zain et al. (2015) they reported that the application of Fe micronutrient substantially improved number of spikelet spike⁻¹. Although, there was a significant difference of combination treatment between the growth stage and fertilizer on the same trait. The largest number of spikelet spike⁻¹ (48.29) was noted from (S₁ × F₃) combination treatment.

Furthermore, the combination treatment between the three factors Variety, growth stage and fertilizer (V × S × F) spraying affected positively on number the number of spikelet spike⁻¹. (V₁ × S₂ × F₂) was showed the highest number of spikelet (51.51) while the combination treatment (V₁ × S₂ × F₁) was recorded the minimum amount of spikelet spike⁻¹ (37.09). The results are in accordance with those founded by Patel et al. (2009) they showed the increase in yield by spraying FeSO₄ as foliar application.

Table (6): Effect of variety, growth stage, fertilizer and their treatment combinations on Number of Spikelet Spike⁻¹:

Variety (V)	Fertilizer (F)	Growth stages (S)		Variety × Fertilizer
		S ₁	S ₂	
V ₁ (Hawler 2)	F ₁	40.23 ab	37.09 b	38.66 c
	F ₂	47.82 ab	51.51 a	49.66 a
	F ₃	47.92 ab	45.74 ab	46.83 ab
	F ₄	40.49 ab	42.11 ab	41.30 bc
V ₂	F ₁	42.61 ab	41.99 ab	42.30 bc
	F ₂	40.78 ab	43.95 ab	42.36 bc
(Hawler 4)	F ₃	48.67 ab	46.88 ab	47.77 ab
	F ₄	49.16 a	45.07 ab	47.12 ab

F	S ₁	S ₂	Mean of Fertilizer
F ₁	41.42 ab	39.54 b	40.48 b
F ₂	44.30 ab	47.73 a	46.01 a
F ₃	48.29 a	46.31 ab	47.30 a

V	S ₁	S ₂	Mean of Variety
V ₁ (Hawler 2)	44.11 a	44.11 a	44.11 a
V ₂ (Hawler 4)	45.30 a	44.47 a	44.89 a
Mean of growth stages	44.71 a	44.27 a	
F ₄	44.83 ab	43.59 ab	44.21 ab

Number of Seed Spike⁻¹:

Table (7) Explained that there was a significant difference between the varieties used in the study as well as the combination treatment between variety and growth stage on number of seed spike⁻¹. The highest number of seeds spike⁻¹ (46.94) and (48.26) were attained from (V₁) and the combination treatment of (V₁ × S₂) respectively. While the minimum values (41.22) and (41.06) were recorded from (V₂) and (V₂ × S₂) treatments. The results indicated to that the varieties used had different growth characteristics and ability of seed production

whereas there was no significant difference between the growth stages regarding the number of seed spike⁻¹.

The results revealed that combination treatment between variety and fertilizer spraying had significant influence on the same trait. (V₁) at (F₂) treatment obtained the maximum number of seed spike⁻¹ (51.65). In addition, the combination treatment among all the studied factor variety, growth stage and fertilizer (V × S × F) significantly different on the number of seed spike⁻¹, which were (54.27 and 36.00) seed spike⁻¹ for the combination treatment treatments (V₁ × S₂ × F₂) and (V₂ × S₁ × F₂) respectively. This shows that F₂ fertilizer was more effective when applied at booting and this may due to the favorable conditions at this stage and let the plants absorb it. The quantity of seed related to the number of spike plant⁻¹ (table 5) which shows that V₁ at S₂ with application of F₂ has significant effect regarding the spike production. The results of this study might be because of Fe had critical role in crop growth, involving in photosynthesis processes, respiration and other biochemical and physiological activates and thus their importance in achieving higher yields (Salih, 2013).

Table (7): Effect of variety, growth stage, fertilizer and their treatment combinations on Number of Seed Spike⁻¹:

Variety (V)	Fertilizer (F)	Growth stages (S)		Variety × Fertilizer
		S ₁	S ₂	
V ₁ (Hawler 2)	F ₁	40.38 ab	46.93 ab	43.66 ab
	F ₂	49.03 ab	54.27 a	51.65 a
	F ₃	45.40 ab	48.70 ab	47.05 ab
	F ₄	47.65 ab	43.13ab	45.38 ab
V ₂ (Hawler 4)	F ₁	39.43 b	41.68 ab	40.56 b
	F ₂	36.00 b	42.35 ab	39.18 b
	F ₃	45.55 ab	38.78 b	42.17 b
	F ₄	44.55 ab	41.42 ab	42.98 ab

F	S ₁	S ₂	Mean of Fertilizer
F ₁	39.91a	44.31 a	42.11 a
F ₂	42.52 a	38.31 a	45.41 a
F ₃	45.48 a	43.74a	44.61 a
F ₄	46.10 a	42.27 a	44.19 a

V	S ₁	S ₂	Mean of Variety
V ₁ (Hawler 2)	45.61 ab	48.26 a	46.94 a

V ₂ (Hawler 4)	41.38 b	41.06 b	41.22 b
Mean of growth stages	43.50 a	44.66 a	

Seed Weight Spike⁻¹ (g):

Table (8) showed the existence of a significant effect of varieties on the seed weight spike⁻¹. (V₂) showed higher results (29.26) g than (V₁). It seems that (V₂) profit from existing conditions due to compatibility with climate of Kurdistan region which may cause increasing in seed weight spike⁻¹.

On the other hand, the seed weight spike⁻¹ significantly affected by the combination treatment (variety and growth stage) (V × S) and (Variety and fertilizer) (V × F). The maximum seed weight (29.61) g and (29.89) g were attained from (V₂ × S₁) and (V₂ × F₂ + F₃) combination treatment whereas, the lowest seed weight spike⁻¹ (24.94) g and (24.39) g were recorded from (V₁ × S₂) and (V₁ × F₂ + F₃) combination treatment respectively.

This may be due to the foliar application with micronutrient (Fe+Zn) had critical role in crop growth, involving in photosynthesis, respiration, and other biochemical and physiological processes as well as their importance in achieving higher yields. The similar trend was also determined by Zeidan et al (2010).

As well as, the combination treatment between variety, growth stage and fertilizer (V × S × F) had a significant effect on the seed weight spike⁻¹. The highest seed weight (29.97) g was obtained from (V₂ × S₂ × F₂ + F₃) while the minimum seed weight (22.71) g was noted from (V₁ × S₂ × F₂ + F₃). This results indicated that there was no significant difference among the growth stages as well as fertilizers, the significance is due to the different varieties and this may be because of the genetic variation and the ability of the variety to produce high amount of seeds.

Table (8): Effect of variety, growth stage, fertilizer and their treatment combinations on Seed Weight Spike⁻¹ (g):

Variety (V)	Fertilizer (F)	Growth stages (S)		Variety × Fertilizer
		S ₁	S ₂	
V ₁ (Hawler 2)	F ₁	24.30 bc	26.30 abc	25.30 c
	F ₂	26.08 abc	24.98 abc	25.53 c
	F ₃	26.48 abc	25.78 abc	26.13 bc
	F ₄	26.08 abc	22.71 c	24.39 c
V ₂ (Hawler 4)	F ₁	29.67 a	29.21 ab	29.44 a
	F ₂	29.59 a	28.43 ab	29.01 ab
	F ₃	29.36 a	28.02 ab	28.69 ab
	F ₄	29.82 a	29.97 a	29.89 a

F	S ₁	S ₂	Mean of Fertilizer
F ₁	26.99 a	27.76 a	27.37 a
F ₂	27.83 a	26.70 a	27.27 a
F ₃	27.92 a	26.90 a	27.41 a
F ₄	27.95 a	26.34 a	27.14 a

V	S ₁	S ₂	Mean of Variety
V ₁ (Hawler 2)	25.74 b	24.94 b	25.34 b
V ₂ (Hawler 4)	29.61 a	28.91 a	29.26 a
Mean of growth stages	27.67 a	26.92 a	

1000-Seed Weight (g):

As shown from table (9), the 1000 seed weight of V₂ (58.51g) was significantly higher than that of V₁ (50.68g). This result indicated that this difference may be due to the higher adaptation to the conditions of the study area. Zarin and Ehsan (2004) stated that there is genetic variation between wheat traits and in wheat breeding programs.

In addition, significant differences were observed from the treatment combinations (variety × growth stage) (V × S), (variety × fertilizer) (V × F) and (variety × growth stage × fertilizer) (V × S × F) on 1000- seed weight. The highest amounts (59.22, 59.79 and 59.93) g were obtained from the treatment combinations (V₂ × S₁), (V₂ × F₄) and (V₂ × S₂ × F₄). The mentioned treatment combinations may create the best environmental conditions for plant growth. The current results are in accordance to those reported by Habib (2012) in which it was stated that significant increase in 1000- seed weight when (Zn+Fe) applied on foliage at the late period of wheat growth. Additionally, Zeidan et al. (2010) recorded the same results they stated that there was a

significant increase in all grain yield parameters when Zn + Fe were sprayed on foliage at tillering and booting stages.

Table (9): Effect of variety, growth stage, fertilizer and their treatment combinations on 1000-Seed Weight (g):

Variety (V)	Fertilizer (F)	Growth stages (S)		Variety × Fertilizer
		S ₁	S ₂	
V ₁ (Hawler 2)	F ₁	48.61 bc	52.60 abc	50.60 c
	F ₂	52.15 abc	49.95 abc	51.06 c
	F ₃	52.97 abc	51.56 abc	52.26 bc
	F ₄	52.15 abc	45.41 c	48.78 c
V ₂ (Hawler 4)	F ₁	59.34 a	58.42 ab	58.88 a
	F ₂	59.17 a	56.85 ab	58.01 ab
	F ₃	58.71 a	56.04 ab	57.38 ab
	F ₄	59.64 a	59.93 a	59.79 a

F	S ₁	S ₂	Mean of Fertilizer
F ₁	53.97 a	55.51 a	54.74 a
F ₂	55.66 a	53.40 a	54.53 a
F ₃	55.84 a	53.80 a	54.82 a
F ₄	55.90 a	52.67 a	54.29 a

V	S ₁	S ₂	Mean of Variety
V ₁ (Hawler 2)	51.47 b	49.88 b	50.68 b
V ₂ (Hawler 4)	59.22 a	57.81 a	58.51 a
Mean of growth stages	55.34 a	53.85 a	

Seed Yield (Mg ha⁻¹):

The results in Table (10) indicate that the seed yield was significantly affected by type of applied fertilizer. The highest seed yield (2.58) Mg ha⁻¹ was obtained from (F₄) application. This support the fact that wheat crop was responded to application of both Fe and Zn nutrients.

As well as, the seed yield significantly affected by the combination treatment between variety and fertilizer (V × F) on this trait. Same variety at different fertilizer treatments gave different mean values of seed yield, (2.79 and 1.86) Mg ha⁻¹ were obtained from (F₄ and F₁) respectively. Broader flag leaves help in greater yield Singh et al. (2015) as well as it was observed from the flag leaf area (figure 1) of this investigation.

As shown in the table (10), there was a significant influence of combination treatment between growth stage and fertilizer (S × F) on seed yield. The maximum quantity of seed yield (2.81) Mg ha⁻¹ was

recorded from the combination treatment ($S_1 \times F_4$). Whereas the lowest seed yield of $(2.10) \text{ Mg ha}^{-1}$ was attained from ($S_2 \times F_1$) treatment. Seed yield related to number of seed spike⁻¹ (table 7) as well as seed weight spike⁻¹ (table 8) that they had the highest mean value at S1 with combination of fertilizers (F_4). Although, the treatment combination of all studied factors variety, growth stage and fertilizer ($V \times S \times F$) had positive effect on seed yield. The highest seed yield $(2.99) \text{ Mg ha}^{-1}$ was recorded from ($V_1 \times S_1 \times F_4$). While the minimum amount of seed yield $(1.77) \text{ Mg ha}^{-1}$ was achieved from ($V_1 \times S_1 \times F_1$), from the results we concluded that variety and growth stage had no significant effect on seed yield. Similarly, Zeidan et al. (2010) recorded the same results they stated that there was a significant increase in seed yield when (Zn + Fe) were sprayed on foliage at tillering stage.

Table (10): Effect of variety, growth stage, fertilizer and their treatment combinations on Seed Yield (Mg ha^{-1}):

Variety (V)	Fertilizer (F)	Growth stages (S)		Variety × Fertilizer
		S ₁	S ₂	
V ₁ (Hawler 2)	F ₁	1.77 d	1.95 cd	1.86 d
	F ₂	2.39 bc	2.58 ab	2.49 ab
	F ₃	2.47 abc	2.56 ab	2.52 ab
	F ₄	2.99 a	2.59 ab	2.79 a
V ₂ (Hawler 4)	F ₁	2.47 abc	2.24 b-d	2.36 bc
	F ₂	2.40b c	2.17 b-d	2.29 bc
	F ₃	1.95 cd	2.10 b-d	2.03 cd
	F ₄	2.62 ab	2.10 b-d	2.36 bc

F	S ₁	S ₂	Mean of Fertilizer
F ₁	2.12 b	2.10 b	2.11 c
F ₂	2.40 ab	2.38 ab	2.39 ab
F ₃	2.21b	2.33 b	2.27 bc
F ₄	2.81 a	2.35 b	2.58 a

V	S ₁	S ₂	Mean of Variety
V ₁ (Hawler 2)	2.41 a	2.42 a	2.41 a
V ₂ (Hawler 4)	2.36 a	2.16 a	2.26 a
Mean of growth stages	2.38 a	2.29 a	

Conclusions:

Judging from seed yield, it can be concluded that the wheat crop grown in the calcareous soil responded to application of both Fe and Zn. The Hawler 2 variety performed better than Hawler 4.

Additionally, it can be noticed that critical stage for foliar application of the applied nutrients is tillering stage.

References

- Bameri, M., Abdolshahi, R., Mohammadi-Nejad, G., Yousefi, K., & Tabatabaie, S. M. (2012). Effect of different microelement treatment on wheat (*Triticum aestivum* L.) growth and yield. *International Research Journal of Applied and Basic Sciences*, 3(1), 219-223.
- Biber, K., Neumann, H., Inoue, K., & Boddeke, H. W. (2007). Neuronal 'On' and 'Off' signals F1 microglia. *Trends in neurosciences*, 30(11), 596-602.
- C.D. Kemp Methods of Estimating the Leaf Area of Grasses from L. Vol. 24, No. 96 (October 1960), pp. 491-499.
- Cakmak, I. (2002). Plant nutrition research: Priorities to meet human needs for food in sustainable ways. *Plant and soil*, 247(1), 3-24.
- Cakmak, I. (2008). Enrichment of cereal grains with zinc: agronomic or genetic biofortification? *Plant and soil*, 302(1-2), 1-17.
- Darwesh, D. A. (2007). *Role of supplemental irrigation and fertilizer treatments on yield and nutrients balance in wheat by using modified DRIS* (Doctoral dissertation, Ph. D. Thesis. College of Agriculture. University of Salahaddin/Erbil-Iraq).
- Duncan, D. B. (1955). Multiple range and multiple F tests. *Biometrics*, 11(1), 1-42.
- El-Dahshouri, M. F. (2018). Effect of zinc foliar application at different physiological growth stages on yield and quality of wheat under sandy soil conditions. *Agricultural Engineering International: CIGR Journal*, 19(5), 193-200.
- El-Habbasha, E. S., Badr, E. A., & Latef, E. A. (2015). Effect of zinc foliar application on growth characteristics and Grain yield of some wheat varieties under Zn deficient sandy soil condition. *International Journal Chemtech Research*, 8(6), 452-458.
- Esfandiari, E., Abdoli, M., Mousavi, S. B., & Sadeghzadeh, B. (2016). Impact of foliar zinc application on agronomic traits and grain quality parameters of wheat grown in zinc deficient soil. *Indian Journal of Plant Physiology*, 21(3), 263-270.
- FAO Statistical (2013). World Food and Agriculture. Food and Agriculture Organization of the United Nations. Rome, pp 289.
- Graham, R. D., Welch, R. M., & Bouis, H. E. (2001). Addressing micronutrient malnutrition through enhancing the nutritional quality of staple foods: principles, perspectives and knowledge gaps.
- Habib, M. (2012). Effect of supplementary nutrition with Fe, Zn chelates and urea on wheat quality and quantity. *African Journal of Biotechnology*, 11(11), 2661-2665.
- Haslett, B. S., Reid, R. J., & Rengel, Z. (2001). Zinc mobility in wheat: uptake and distribution of zinc applied to leaves or roots. *Annals of Botany*, 87(3), 379-386.
- Havlin, J. L. (2014). Soil: Fertility and Nutrient Management. In *Encyclopedia of Natural Resources: Land* (pp. 460-469).

- Hotz, C., & Brown, K. H. (2004). Assessment of the risk of zinc deficiency in populations and options for its F1.
- Kahrariyan, B., Yeganehpoor, F., Beyginiya, V., & Samadiyan, F. (2013). Effect of Fe foliar application on morphological and physiological traits of different dryland wheat varieties. *International journal of Advanced Biological and Biomedical Research*, 1(12), 1583-1589.
- Khan, Z. A., Khan, M. A., & Baloch, M. S. (1999). Effect of different manures on the yield of wheat. *Scientific Khyber*, 12(1), 41-46.
- Nadim, M. A., Awan, I. U., Baloch, M. S., Khan, E. A., Naveed, K., Khan, M. A., ... & Hussain, N. (2011). Effect of micronutrients on growth and yield of wheat. *Pak. J. Agri. Sci*, 48(3), 191-196.
- Narimani, H., Rahimi, M. M., Ahmadikhah, A., & Vaezi, B. (2010). Study on the effects of foliar spray of micronutrient on yield and yield components of durum wheat. *Archives of Applied Science Research*, 2(6), 168-176.
- Ozturk, L., Yazici, M. A., Yucel, C., Torun, A., Cekic, C., Bagci, A., ... & Cakmak, I. (2006). Concentration and localization of zinc during seed development and germination in wheat. *Physiologia Plantarum*, 128(1), 144-152.
- Patel, M.M., Patel, I.C., Patel, P.H., Patel, A.G., Acharya, S. and Tikka, S.B.S. (2009). Impact of foliar nutrition of zinc and iron on the productivity of cowpea (*Vigna unguiculata* L.) under rain fed conditions. *J. Arid Legumes*, 6(1): 49-51.
- Qadir, D. J. (2017). Soil physical properties, soil loss and runoff rate as influenced by rock fragments in Erbil province. MSc thesis. College of Agriculture, University of Salahaddin.
- Rawashdeh, H. M., & Sala, F. (2015). Effect of some micronutrients on growth and yield of wheat and its leaves and grain content of iron and boron. *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Agriculture*, 72(2), 503-508.
- Rehm, G., & Albert, S. (2006). Micronutrients and Production of quality crop of sesame. *Minnesota Crop News*, 1-3.
- Salih, H. O. (2013). Effect of foliar fertilization of Fe, B and Zn on nutrient concentration and seed protein of Cowpea "*Vigna unguiculata*". *Journal of Agriculture and Veterinary Science*, 6(3), 42-46.
- Shweta, M., & Agrawal, S. B. (2006). Interactive effects between supplemental ultra-violet -B radiation and heavy metals on the growth and biochemical characteristics of *Spinacia oleracea* L. *Brazilian Journal of Plant Physiology*, 18(2), 307-314.
- Singh, V., Ali, J., Kumar, A., & Chauhan, T. M. (2015). Productivity, nutrient uptake and economics of wheat (*Triticum aestivum*) under potassium and zinc nutrition. *Indian Journal of Agronomy*, 60(3), 426-430.
- Zadoks, J.C., T.t. Chang and C.f. Zonzak. (1974). A decimal code for the growth stages of cereals. *Weed Res.* 14: 415 – 421).
- Zain, M., Khan, I., Qadri, R. W. K., Ashraf, U., Hussain, S., Minhas, S., ... & Bashir, M. (2015). Foliar application of micronutrients enhances wheat growth, yield and related attributes. *American Journal of Plant Sciences*, 6(07), 864.
- Zarin A. A., Ehsan Z. P. (2004). Growth, yield and yield components of three durum wheat genotypes under different planting densities in Isfahan. *Science and Technology of Agriculture and Natural Resources*, pp. 140-129.
- Zeidan, M. S., Mohamed, M. F., & Hamouda, H. A. (2010). Effect of foliar fertilization of Fe, Mn and Zn on wheat yield and quality in low sandy soils fertility. *World J. Agric. Sci*, 6(6), 696-699.