Accentuating the role of Nanoelements iron, copper and zinc in increasing yield of two varieties of Wheat and the contents of these elements in grains

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Abstract:

This study was conducted in the winter season 2022- 2023 to find out influence of various fertilizer elements in their nano form by spraying method on two varieties of bread wheat, the first (Al-Fayyad V1) is early-growing and the second (Dijla V2) is late-growing, and the randomized complete block design (RCBD) at the research station of the Faculty of Agriculture of Kirkuk University included: nine treatments with three replications of each one, and the study is used nanomicroelements (Fe) , (Zn) and (Cu) individually and intraction , the results showed that there are no significant differences in grain yield between the two varieties , but there are significant differences between them in the grain content of nitrogen, phosphorus, potassium, iron, copper and zinc. As for the fertilizer treatments, the triple treatment T9 gave the highest nitrogen, phosphorus and potassium content (2.356, 0.400, 5.400, 5.000). 356, 0.400, 5.713) PPM in the grain, T3 the highest iron content (43.660) PPM, T4 the highest copper content (4.908) PPM, T5 the highest zinc content (48.511) PPM and T1 the lowest values. As for the interaction, the varieties' response to the fertilizer treatments varied significantly for the grain yield trait, as the interaction between Dijla x T9 gave the highest mean trait of 7. 96 tons. Ha^{-1}, and did not differ significantly in the al-Fayyad x T9, and recorded 7.82 tons. Ha^{-1}. while the al-Fayyad x T1 gave the lowest value of 3.38 tons. Ha^{-1}.

Keywords: Wheat, nano-micronutrients, microelements, varieties, mineral

Introduction :

The wheat quality improvement is a continuous process employing various techniques such as development of new varieties with plant breeding and biotechnology. The demand for various industrial end products such as bread, biscuits, cake, pasta is also increasing day by day in the modern world. Alternatively, agronomic methods such as fertilising crops through soil/foliar methods at critical growth stages can be used for enhancing uptake and assimilation of minerals in wheat grains for qualitative improvement in bread wheat as a short-term, rapid and complementary strategy [1]**,** The mineral content in agricultural crops, including grains that are used in the diet, increases their importance. Therefore, grains must contain a sufficient content of nutritional elements, including minerals that are important for human health, such as iron, copper, zinc, and manganese [2],

The agricultural technology of nanomaterials has helped to improve the productivity [3] and nanoparticles of mentals have increased the nitrogen metabolism and photosynthesis , including the wheat plant, where these particles work on the plant nutrition to improve productivity and quality of wheat [4], the wheat (Triticum aestivum L.) is an important food crop that has been domesticated before thousands of years in the ancient civilizations of Western Asia, North America and Europe [7]. There are several of wheat varieties adopted to different climatic conditions gave wheat to grown in wide range of the world . [8]. The cultivation of agricultural crops in the world is used a large

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amount of chemical fertilizers, to achieve more production per unit area, but the use of large doses leads to many issues such as environmental pollution (soil, water and air pollution), low efficiency of the use of those inputs, and low quality of foods . Nano fertilizers reduce the negative effects of conventional fertilizers on the environment as Nano fertilizers are used in small amounts because it reactive, they penetrate the epidermis allowing gradual diffusion and thus reducing nutrient surplus, and NP play a role in reducing stress and toxicity of heavy metals [7]. The search for alternative methods to compensate for the fertilization process, including the use of nano-fertilizers sprayed on the leaves, has become a necessity that must be researched due to the damage that comes from fertilizing the soil with large quantities of traditional fertilizers, as well as to improve the yield and quality of the yield and increase the content of some mineral elements in grains for healthly food . Humans follow correct scientific methods in the fertilization process through foliar application , as well as knowing the effect of these elements and their interactions on growth characteristics and yield. Between [8],Foliar spraying of nutrients to crops can increase the economic yield. Among the main nutrients, nitrogen plays a vital role in increasing crop productivity. Phosphorus is an essential part of many physiological functions such as energy accumulation and transfer, photosynthesis, respiration, and cell differentiation and expansion. It is also fundamentally involved in the synthesis of A phosphate compound rich in energy, such as ATP, ADP, phosphorylated proteins, nucleic acids, nucleotides, and phospholipids. Potassium is considered an important plant nutrient because it is not bound to any specific plant compound and is called the "work horse." It is free to move and work within the plant, and its deficiency inevitably leads to a decrease in yield and poor quality. And its economic return [9], It plays an important role in metabolic processes such as DNA synthesis, respiration, and photosynthesis. Moreover, several metabolic pathways are activated by iron [10]. It plays an important role in vital processes such as respiration, photosynthesis, carbohydrate metabolism, and the formation of vitamins P and B, and also interacts with amino acids, carboxylic acids, and nitrogenous bases [11]. [12] also pointed out in their study the role of zinc in reducing the accumulation of cadmium in the tissues of the wheat crop, which is harmful to consumer health, as well as enhancing the growth efficiency of wheat and increasing the zinc content of the grain.

Materials and Methods :

A field experiment was carried out during the season (2022-2023 AD) at the research station of the Faculty of Agriculture at Kirkuk University located at longitude (044° 23' 29") east and latitude (35° 28' 06") north. Soil samples were taken randomly before planting at a depth of 0) - 30) Laboratory analyses were conducted in the laboratories of the Department of Soil and Water Sciences at the Faculty of Agriculture, Tikrit University, as shown in Table (1).

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Table (1) Soil analysis of physical and chemical properties before planting at a depth of (0-30) cm.

Title		Unit	Form/Concentration
pH			7.49
Electrical conductivity C.E.		Desi Siemens $^{M-1}$	1.07
Ready nitrogen		mg $^{kg-1}$ soil	27
Ready phosphorus		mg $^{kg-1}$ soil	9
Ready Potassium		mg $^{kg-1}$ soil	106
Organic matter		g kg^{-1} soil	2.25
Soil	Sand	g kg^{-1} soil	53%
	Silt	g kg^{-1} soil	39%
	Clay	g kg^{-1} soil	8%
Structure			Clay soil sandy

The land was prepared for planting by conducting two perpendicular plowing of the soil and then smoothing and leveling it, then the process of dividing the experimental land into 9 experimental units, each unit consisting of two wheat varieties planted manually with four lines, each line is three meters long, the distance between one line and another is 20 cm and between one variety and another is 40 cm in the same treatment and the distance between one experimental unit and another is 1 meter, then two seed varieties of bread wheat (Triticum aestivum L.) were planted, namely (the Fayadh and the Dijla al-Khair variety), the seeds of which were obtained at the Faculty of Agriculture at Tikrit University. (Al-Fayyad variety and Dijla Al-Khair variety), whose seeds were obtained at the Faculty of Agriculture, Tikrit University, and NPK nanofertilizers were bring from Turkish company Vitagroup and nano-micronutrients from the Iranian company Khazra. The seeds were planted on (November 20, 2022) with nine treatments from T1 to T9 and each treatment with three repetitions R1 to R3 in the form of boards with dimensions of 1 meter by 3 meters and four planting lines with a depth of 5 cm and a seed quantity of 48 g per variety (3 $meters^2$), or 160 $kg.ha^{-1}$.

The field experiment was carried out at the research station according to the RCBD design with three replications, where the main treatments included the two varieties Al-Fayyad and Dijla Al-Khair and the secondary treatments were the treatment with NPK nanofertilizers as a supplementary fertilizer for the treatments from T2 to T9 that were fertilized with half the fertilizer recommendation of the NPK compound fertilizer (15- 15-15), in addition to spraying nano-micronutrients (Fe, Cu, and Zn) on the leaves at three stages (the beginning of tillering , the second at the beginning of elongation at the first node, and the third the stage before expelling the panicle).

The nano microelement were prepared for the experimental units as follows:

T1- 320 kg /ha^{-1} NPK Ground fertilization.

T2 - 0.75 g L^{-1} nano NPK Foliar spray with half T1.

T3- 2 g L^{-1} nano Fe + T2.

T4- 1 g L^{-1} nano Cu + T2.

T5- 1.5 g L^{-1} nano Zn+ T2.

T6- 2 g L^{-1} nano Fe + T2.

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T7- 2 g L^{-1} nano Fe + 1.5 g nano Zn + T2.
T8- 1 g L^{-1} nano Cu + 1.5 g nano Zn + T2.
T9- 2 g L^{-1} nano Fe + 1g nano Cu + 1.5 g nano Zn + T2.

With the addition of urea fertilizer to all treatments at the plant tillering stage with a amount of 200 kg ha^{-1}

Foliar spraying with nano-micronutrients was carried out at the beginning of branching as a first dose, at the beginning of elongation at the first node as a second dose, and at the stage before expelling the spike as the last dose, and the spraying was carried out in the morning after the dew was gone using a backpack sprayer with a capacity of (8 liters).

The process of separating the grains from the spike was carried out and calculated based on the weight of the grains per square meter area and then converted the weight to (tons.ha^{-1}).

Grain content of elements: (PPM) Zn- Cu- Fe-K expresses the granular content of the mentioned elements in parts per million and was prepared and analyzed at the Iraq-Iran border customs laboratory (Bashmakh) by iCAP 7600 ICP-OES, a high-precision device manufactured by Thermo Fisher, which examines the physical content of sixteen metallic elements simultaneously for more than one sample with high accuracy.

Results and discussion:

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

Grain yield is the product of the final result of its three components, the number of spikes per unit area, the number of grains in the spike, and the weight of the grain. The results of table (2) show that there were no significant differences between varieties in the grain yield trait, as the Dijla variety gave the highest mean of the trait (5.68 tons. ha^{-1}), while the Fayyad variety gave the lowest mean of the trait (5.66 tons. ha^{-1}).

It is noted in the same table that there are significant differences between the fertilizer treatments, as the T9 treatment gave the highest mean grain yield of (7.891 tons. ha^{-1}), while the T1 treatment gave the lowest mean grain yield (3.510). The superiority of the T9 treatment may be attributed to the effect of the fertilizer combinationto increasing cell division and leaf area, which positively affected the stages of plant growth, which led to an increase in the accumulation of photosynthetic products, and thus reflected positively that the increase in the number of plants per unit area, spike length and 1000 grains weight Tables (1, 6 and 11) led to increased grain yield.

As for the interaction, it is clear from the data of Table (10) that the response of the varieties to the fertilizer treatments differed significantly for the grain yield, as the interaction between the Dijla variety and the T9 fertilizer treatment gave the highest mean yield of 7.96 tons H^{-1}, and did not differ significantly from the Fayyad variety with the T9 treatment that recorded an mean of 7.82 tons H^{-1}, while the Fayyad variety gave the lowest mean yield of (3.38) tons. ha^{-1} with the T1 fertilizer treatment.

Table (2) Effect of varieties and different fertilizer treatments on the grain yield (tons ha^{-1})

Treats / Variety	T1	T2	T3	T4	T5	T6	T7	T8	T9	LSD 5%	Effect ofVariety	LSD 5%
Dijla	3.38	4.12	5.66	4.59	5.45	6.11	7.28	6.54	7.82	0.584	5.66a	0.557
Faiadh	3.63	4.07	4.28	5.07	5.56	6.61	7.64	6.29	7.96		5.68a	
Effect of treats	3.510	4.095	4.973	4.833	5.505	6.366	7.461	6.415	7.891	0.413		

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Nitrogen content in grains (%) :

The results of table (3) show that there are significant differences between the varieties in the nitrogen percentage in grains, as the Fayyad variety gave the highest mean of the trait (2.217%), while the Dijla variety gave the lowest mean of the trait (2.154%), the superiority of the variety in this test can be attributed to the nature of the genetic varieties and this result is consistent with [13]. It is noted that there are significant differences between the fertilizer treatments, as T9 treatment gave the highest mean trait (2.356%) The reason is due to the role of the fertilizer combination (T9) in encouraging important biological processes in the plant such as transportation, absorption and synthesis of amino acids, as well as activating the plant roots in the soil to absorb nutrients, which leads to an increase in the proportion of nitrogen in the leaves (source) and then later transferred to the grains (sink).

As for the interaction, it is clear from the data in Table (3) that the response of the varieties to the fertilizer treatments differed significantly for the nitrogen percentage in the grain, as the interaction between the Fayyad variety and the T9 fertilizer treatment gave the highest mean value of 2.416%, while the Dijla variety gave the lowest mean value of 1.823% at the T1 fertilizer treatment.

Table (3) The effect of varieties and different fertilizer treatments on the nitrogen percentage (%)

Treats Variety	T1	T2	T3	T4	T5	T6	T7	T8	T9	LSD	Effect ofVariety	LSD
Dijla	1.943	2.380	2.103	2.273	2.0170	2.123	2.270	2.276	2.416	0.068	2.217	0.057
Faiadh	1.823	2.156	2.153	2.133	2.253	2.170	2.216	2.186	2.296		2.154	
Effect of treats	1.883	2.268	2.128	2.203	2.211	2.146	2.243	2.231	2.356	0.048		

Percentage of phosphorus in grains (%) :

The results of table (4) show that the varieties differed significantly among them in the trait of phosphorus content in cereals crop , as the Fayyad variety gave the highest mean of the trait (0.328%), while the Dijla variety gave the lowest mean of the trait (0.304%), perhaps due to the superiority of the Fayyad variety in the trait of flag leaf area and chlorophyll content, thus increasing the source which leads to an increase in the accumulation of nutrients in the plant.

As for the effect of fertilizer treatments, the T9 treatment gave the highest mean value of 0.400) While T1 treatment gave the lowest mean of 0.240%, the reason is due to the role of mineral fertilizers in encouraging plant biological processes that increase the synthesis of various elements in the plant and thus the accumulation of these substances in the grain estuaries.

As for the interaction, it is clear from the data in Table (4) that the response of varieties to fertilizer treatments differed significantly for the phosphorus ratio trait, as the interaction between the Fayyad x T9 gave the highest mean trait of 0.416%, while the Dijla variety

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gave the lowest mean trait of 0.236% in the T1 fertilizer treatment.

Table (4) The effect of varieties and different fertilizer treatments on the phosphorus content (%)

Treats / Variety	T1	T2	T3	T4	T5	T6	T7	T8	T9	LSD	Effect ofVariety	LSD
Dijla	0.243	0.276	0.313	0.286	0.326	0.320	0.400	0.383	0.416	0.033	0.328	0.024
Faiadh	0.236	0.283	0.283	0.266	0.306	0.306	0.310	0.353	0.383		0.304	
Effect of treats	0.240	0.280	0.298	0.276	0.316	0.313	0.355	0.368	0.400	0.023		

2- Percentage of potassium in grains (%):

It is observed from the results of table (5) there are significant differences between varieties in the potassium percentage in the grain, the Dijla gave the highest mean of the trait (5.162%), while the variety Al-Fayyad gave the lowest mean of the trait (5.033%), the reason for the variability of varieties in this trait may be due to their variation in most growth and yield characteristics as well as this variation between varieties in this trait gives an indication of their variation in genetic nature

It is noted that there are significant differences between the fertilizer treatments, as the T9 treatment gave the highest mean for the trait (5.713%) The superiority of the T9 treatment may be attributed to the effect of the fertilizer combination in increasing cell division of leaves , which is a positively affected of plant growth stages, which led to an increase in the accumulation of photosynthetic products, which led to an increase in potassium content in the leaves (source), and finally an increase in grain.

As for the l interaction between varieties and fertilizer s a potassium content in the grain, it is clear from the data of Table (5) that the variety Al-Fayyad and fertilizer treatment T9 recorded the highest mean value of 5.880% and did not differ significantly from treatment T8 with the same variety, while the variety Dijla gave the lowest mean value of 4.670% at fertilizer treatment T1.

Table (5) Effect of varieties and different fertilizer treatments on potassium content (%)

Treats Variety	T1	T2	T3	T4	T5	T6	T7	T8	T9	LSD 5%	Effect ofVariety	LSD 5%
Dijla	4.896	4.873	4.680	4.700	4.680	4.830	5.120	5.870	5.880	0.015	5.033	0.054
Faiadh	4.670	5.120	5.040	5.246	5.043	5.133	5.100	5.336	5.546		5.162	
Effect of treats	4.783	4.996	4.855	4.793	4.861	4.981	5.110	5.603	5.713	0.011		

3- Iron content in grains (ppm):

The data in table (6) showed the differed significantly between in the characteristic rate of iron in the grain, as the variety Al-Fayyad gave the highest mean of the characteristic (41.354 ppm), while the variety

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Dijla gave the lowest mean of the characteristic (37.005) ppm, and that the difference between the varieties in this characteristic is due to the nature of the genetic of the variety and its efficiency in converting food material into grains.

As for the effect of fertilizer treatments, treatment T3 gave the highest value of 43.221 ppm and did not differ significantly of treatment T9, which is recorded a value of 43.160 ppm, while T1 gave a lowest value of (34.516 ppm). This resulted in line with the findings of [14] and [15] who found that the addition of iron by spraying on the leaves , increase the concentration of iron in the plant.

As for the interaction, it is clear from the data in Table (6) that the response of varieties to fertilizer treatments differed significantly for the trait of iron content in grains, as the interaction between the Fayyad variety and T3 fertilizer treatment gave the highest value about 44.833 ppm, while the Dijla variety gave the lowest value about 31.036 ppm at T1 treatment.

Table (6) Effect of varieties and different fertilizer treatments on iron content (ppm)

Treats Variety	T1	T2	T3	T4	T5	T6	T7	T8	T9	LSD 5%	Effect ofVariety	LSD 5%
Dijla	37.996	41.793	44.833	39.343	39.216	41.520	42.600	41.060	43.826	0.170	41.354	0.628
Faiadh	31.036	41.576	42.486	35.496	33.316	36.586	32.806	38.126	41.616		37.005	
Effect of treats	34.516	41.685	43.660	37.420	36.266	39.053	37.703	39.593	42.721		0.120	

4- Copper content in grains (ppm):

The results of table (7) show that there were significant differences between varieties in the trait of copper content in grains, as the Fayyad variety gave the highest mean trait of (4.944) ppm, while the Dijla variety gave the lowest mean trait of (3.442) %, and the reason for the difference between varieties in this trait may be due to the difference in their genetic nature , as a certain may have the ability to express itself under the influence of factors better, while the other structure is not able to do so. These results are consistent with [16].

It is noted that there are significant differences between the fertilizer treatments. T4 treatment gave the highest mean percentage of copper in grains (4.908) ppm, while T1 gave the lowest mean of the trait (3.513) ppm. The reason for the increase in copper concentration of leaves because of increase in the amount of copper supplied in the spray solution and then increase the amount absorbed leaves [17].

As for the interaction, it is clear from the data in Table (7) that the response of the varieties to the fertilizer treatments differed significantly for the copper content in the grain, as the interaction between the Fayyad variety and the T4 fertilizer treatment gave the highest mean value of 6.200 ppm, while the Dijla variety gave the lowest value 3.066 ppm at the T7 treatment.

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Table (7) The effect of varieties and different fertilizer treatments on the copper content (ppm)

Treats / Variety	T1	T2	T3	T4	T5	T6	T7	T8	T9	LSD 5%	Effect ofVariety	LSD 5%
Dijla	3.910	4.330	4.420	6.200	4.200	5.700	4.300	5.840	5.600	0.141	4.944	0.192
Faiadh	3.116	3.376	3.676	3.616	3.476	3.786	3.066	3.446	3.416		3.442	
Effect of treats	3.513	3.853	4.048	4.908	3.838	4.743	3.683	4.643	4.508	0.1		

5- Percentage of zinc in grains (ppm):

The results of table (8) showed that the varieties differed significantly among them in the trait of Zinc content in grains in the plant, as the Fayyad variety gave the highest mean of the trait (42.615 ppm), while the Dijla variety gave the lowest value (35.870 ppm), the reason for the variability of varieties among them can be attributed to their different genetic nature, these results agreed with the findings of [18].

As for the effect of fertilizer treatments, the T5 treatment gave the highest mean value of 48.51 ppm, while the T1 treatment gave the lowest mean value of 32.16 ppm, and the reason for the superiority may be due to the positive effect of spraying nutrients, including (zinc) in the early stages of plant growth due to its integral role in activating plant growth and stimulating its vegetative growth, which is led to increased accumulation of these substances in the leaves [19].

As for the interaction, it is clear from the data in Table (8) that the response of the varieties to the fertilizer treatments differed significantly for the trait of zinc content in grains, as the interaction between the Fayyad variety and the T5 fertilizer treatment gave the highest mean trait of 55.976 ppm, while the Dijla variety gave the lowest mean trait of 30.756 ppm at the T1 treatment.

Table (8) Effect of varieties and different fertilizer treatments on Zinc percentage (ppm)

Treats / Variety	T1	T2	T3	T4	T5	T6	T7	T8	T9	LSD 5%	Effect ofVariety	LSD 5%
Dijla	33.566	37.310	32.906	40.416	55.976	40.266	44.966	49.046	50.086	0.266	42.615	0.187
Faiadh	30.756	35.266	33.526	33.916	41.046	36.496	35.466	37.576	38.776		35.870	
Effect of treats	32.161	36.288	33.216	37.166	48.511	38.381	40.216	43.311	44.431		0.188	

Conclusion

We conclude from this study that the supplied of trace elements (iron, copper and zinc) in the spraying method leads to an increase in the grain yield and quality of the wheat crop by increasing the content of mineral elements

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beneficial to human health within the components of the grain and it is recommendedto suppied these elements because they increase the yield in the quantity and quality.

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