International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(Research Article)

Check for updates

The effect of nano-fertilizer on the growth and yield of several wheat varieties and their quality

Hassan Abbas Fadel *

Department of Field Crops, College of Agriculture, Al-Muthanna University, Iraq.

International Journal of Science and Research Archive, 2026, 19(02), 501-508

Publication history: Received on 25 March 2026; revised on 28 April 2026; accepted on 01 May 2026

Article DOI: https://doi.org/10.30574/ijsra.2026.19.2.0953

Abstract

Wheat represents one of the most significant agricultural crops globally. The importance of examining wheat varieties in relation to nano-micronutrients lies in the potential of these elements to significantly enhance agricultural productivity and plant health. Nano-micronutrients may offer a more efficient method for nutrient delivery to plants. To this end, a field experiment will be conducted over the years 2024-2025 at the second research and experimental station of the Al Muthanna University's Faculty of Agriculture. This experiment will be implemented by dividing the field into experimental units, each measuring 1 square meter. The experimental design will be based on a factorial arrangement within a Randomized Complete Block Design (RCBD) with three replications. The treatments under study derive from two factors: the first includes three wheat varieties (V1 Ebba99, V2 Aksad, and V3 Sheema), and the second consists of foliar application of nano-micronutrients zinc, iron, and copper at concentrations of 0 (control), 12, and 24 ppm. Seeds required for the experiment will be supplied by the General Directorate of Agricultural Research, Ministry of Agriculture, and distributed across the experimental units. The variety Ebba 99 outperformed and gave the highest number of grains, reaching 458.9 grains, while the variety Aksad gave the lowest number of grains, 73.56 grains. The variety Ebba 99 outperformed and gave the highest number of spikes per square meter, reaching 458.9 spikes The Al-Shaima variety was superior and gave the highest weight of 1000 grains, reaching 43.04 grams and gave the lowest falling number 330.6. and gave Flexibility and Texture mg/kg 1450.60 mg/kg, the variety Aksad outperformed in Elasticity and gave the 86.82 BU,

Keywords: Nano-fertilizer; Wheat varieties; Aksad; Micronutrients; Wheat quality

1. Introduction

Wheat, a staple crop worldwide, accounts for a significant portion of agricultural production, producing 752 million tonnes on 165/222 million hectares, meeting 20% of the global population's protein and calorie needs (FAO, 2018). Projections indicate that the global population will increase to over nine billion by 2050, requiring a substantial increase of 110 to 70 percent in agricultural production on a global scale. To meet the nutritional needs of this growing population, an increase of approximately 70 percent in wheat production is essential. To achieve this level of production, the annual increase in wheat yield must reach 2.4 percent, as the current annual growth rate is 0.9 percent. As a result, on the current trajectory, achieving a 70 percent increase in production appears unattainable, with a maximum potential increase in production of around 38 percent (Jaggard et al., 2010; Lobell and Gourdji, 2012; Ray et al., 2013). Conversely, predictive models suggest that with continued use of current input and cropping practices, a decrease of over 30 percent in wheat yields is predicted for specific regions such as South Asia by 2050, attributed to rising temperatures and increased climate variability. Conversely, the prevalence of optimum wheat performance has remained stagnant within the range of 24-39 percent of major wheat growing areas. Therefore, increasing wheat production in the coming decades emerges as a critical goal in agriculture to secure the nutritional needs of future generations (Gourdji, 2012; Lin and

* Corresponding author: Hassan Abbas Fadel

Huybers, 2012; Ray et al., 2013). In this context, the use of breeding and agronomic approaches to enhance yield per unit area is essential.

Zinc, iron, and copper nanoparticles exhibit remarkable and diverse functions in the realm of wheat cultivation. Specifically, zinc and iron contribute to enhanced growth characteristics, yield, yield components, and iron and zinc content in wheat (Jalal et al., 2020). Copper deficiency in cereals leads to symptoms such as twisting of younger leaves, particularly the upper leaves, wrinkling of leaf nodes, bleaching of stem nodes, reduced internode length, chlorosis, and leaf burn. This deficiency results in reduced plant growth, which can affect flowering and pollination processes, consequently hindering spikelet formation or causing incomplete grain formation at the tip of the spike. Secondary signs of copper deficiency in cereals include increased numbers of tillers and adventitious roots in dicotyledons (Bergmann, 1992). Iron, and zinc are recognized as essential micronutrients with low consumption levels in human diets. Consequently, the cultivation of iron- and zinc-fortified wheat varieties is highly beneficial, increasing the nutritional quality of the final product (Balk et al., 2019; Radawiec et al., 2021).

The advent of nanotechnology has opened up new avenues for humans to enhance nutrient use efficiency and reduce environmental preservation costs (Naderi and Abedi, 2012). Converting matter to the nanoscale alters the chemical, physical, biological, and catalytic properties of these materials. Additionally, enhanced solubility, chemical responses, and the ability to penetrate cell membranes are observed in these nanoparticles (Mazaherinia et al., 2010). The application of nanofertilizers, due to the precise control of nutrient release, can be an effective step towards achieving sustainable and environmentally friendly agriculture (Cui et al., 2010). Nanofertilizers have advantages over conventional fertilizers because they release nutrients in a precise and gradual manner, consequently ensuring more effective nutrient delivery to the plant (Würth, 2007).

Iraq was rich in water resources until a few decades ago, but the current climate of this country is semi-arid temperate. Climate change, the construction of many dams on the Tigris and Euphrates rivers in neighboring countries, water wastage, and mismanagement have led to water scarcity in Iraq. Muthanna province is located in southwestern Iraq and borders Saudi Arabia. Muthanna has a desert climate; in summer, temperatures easily exceed 40 °C, while rainfall is very limited and restricted to the winter months (Dhuha et al., 2022).

There are several reasons for the decline in wheat productivity per unit area in Iraq, especially Muthanna province. Among these problems are the climatic and weather conditions of this province. In line with increasing crop yield per unit area in the mentioned region, the use of modern and new methods is required. Among these methods is the foliar application of micronutrients such as zinc, iron, and copper, which increase crop yield. Therefore, the present experiment is designed and implemented for this purpose.

2. Material and methods

During the winter agricultural season 2024-2025, a field experiment was conducted at the second agricultural research and experiment station of the College of Agriculture at the University of Al-Muthanna, which is located southwest of al Muthanna Governorate.

The experiment was conducted by dividing the field into experimental units with an area of (1 x 1 m^2), and the factorial treatments was planted on them randomly according to siplt plot experiment's method using a randomized complete block design (RCBD) with three replications. Seeds was provided by the General Authority for Crops Research- Ministry of Agriculture and distributed to the experimental units, which included 10 lines, with a length of 2 meters for each line, and a distance of 20 cm between lines.

The seeds was sown with a seed rate of 120 kg ha^{-1}. Before planting, phosphate fertilizer was added in the form of P_2O_5 46% at an amount of 100 kg ha^{-1}, and urea fertilizer (N 46%) at 120 kg ha^{-1} in the first four batches (emergence, branching, elongation, and boot) Jadoua and Saleh, 2013. Irrigation and weeding was carried out according to the needs of the plant. In the days to 75% flowering stage, some growth characteristics was calculated as an average for ten plants chosen randomly, which are the plant height (cm) and the area of the flag leaf (cm^2), while, at the stage of physiological maturity, the number of tillers per plant, the length of the spike, the number of grains per spike, the weight of a thousand grains (g), the grain yield from an area of 2 m^2 and then converted to ton ha^{-1}, the biological yield ton ha^{-1}, and the harvest index was calculated. After completing the data collection, it was classified, arranged and analyzed statistically according to the statistical program (Genstat version 12) and a comparison of the averages of the transactions was conducted at the probability level of 0.05.

2.1. Study factor

The experiment was conducted according to a randomized complete block design (RCBD) for experiments Factorial with three replications,

First: the first factor is three varieties of wheat

- V1 Ebba 99 Variety
- 2-V2 AksadVariety
- V3 Sheema Variety

Second: leaf addition of Zn, Cu, Fe three concentrations of nano

- 1-B0 without addition
- 2-B1 12 ppm
- 3-B2 24 ppm

Table 1 Some physical and chemical properties of field soil before planting was studied in the research

Items		Value	Unit
pH		7.12	
ECe (1:1)		2.88	dSc.m^{-1}
Organic Mater		1.7	%
Available nitrogen		18	mg.kg^{-1}soil
Available phosphorus		14.11	
Available Potassium		135	
Available Micro- elements			
Cu		0.10 ppm	
Fe		2.00ppm	
Zn		1.45ppm	
Soil properties	Clay	115	mg.kg^{-1}soil
	Silt	365	
	Sand	520	
Soil texture			

*The analyzes were conducted in the soil physics laboratory, College of Agriculture, Al-Muthanna University

2.2. Characteristics that were studied in the research

product and its components

- Number of fertile spikes m2
- The number of grains per spikes
- Weight of 1000 grains (gm)

Quality and quality checks for wheat flour:

- Specific weight (Hectoliter weight)
- Wet Gluten %
- Sedimentation value (zeleny)
- Falling number
- Elasticity

- Flexibility and Texture

3. Results and discussion

3.1. Number of grains, grain/spikes

The results of Table (2) show that there are significant differences between the varieties, and no significant differences between the levels of nanofertilizer and the interaction between the two factors (varieties and nanofertilizer) on the Number of grains, grain/spikes.

From the results of Table (2), it was shown that there were significant differences between the varieties. The variety Ebba 99 outperformed and gave the highest number of grains, reaching 458.9 grains, while the variety Aksad gave the lowest number of grains, 73.6 grains. The reason for the difference in the varieties may be due to the difference in their genetic composition, this result agreed with the findings of Parveen et al. 2010, who showed the differences between the varieties in the number of grains in spike.

Table 2 Effect of levels of varieties and nanofertilizers and their interaction on the Number of grains, grain/spike

varieties	**Nanofertilizers P.P.M**			**the average**
	0	**12**	**24**	
Ebba 99	79.33	78.67	77	78.33
Al Shaima	74.67	71	77.33	74.33
Aksad	74	72	74.67	73.6
Average	76	73.89	76.33	
L.S.D(0.05)		varieties	nanofertilizers	VarietiesX nanofertilizers
		5.51	NS	NS

3.2. Number of spikes, spike/m²

The results of Table (3) show that there are significant differences between the varieties, and no significant differences between the levels of nanofertilizer and the interaction between the two factors (varieties and nanofertilizer).

From the results of Table (3), it was shown that there were significant differences between the varieties. The variety Ebba 99 outperformed and gave the highest number of spikes per square meter, reaching 458.9 spikes, while the variety Research gave the lowest number of spikes, 397.8 spikes/m2. The reason for the difference in the varieties may be due to their ability to branch. Because of the difference in their genetic composition, this result agreed with the findings of Parveen et al. 2010, who showed the differences between the varieties in the number of branches per unit area.

Table 3 Effect of levels of varieties and nanofertilizers and their interaction on the number of spikes/m2

varieties	**Nanofertilizers P.P.M**			**the average**
	0	**12**	**24**	
Ebba 99	503.3	413.3	460.0	458.9
Al Shaima	463.3	463.3	416.7	447.8
Aksad	406.7	400.0	386.7	397.8
Average	457.8	425.6	421.1	
L.S.D(0.05)		varieties	nanofertilizers	VarietiesX nanofertilizers
		43.12	NS	NS

3.3. Weight of 1000 grains

The results of Table (4) show that there are significant differences between the varieties in the weight of 1000 grains, and there were no significant differences between the levels of nanofertilizer and the interaction between the two factors (varieties and nanofertilizer).

From the results of Table (4), it was shown that there were significant differences between the varieties. The Al-Shaima variety was superior and gave the highest weight of 1000 grains, reaching 43.04 grams, while the variety Abaa99 gave the lowest weight of 1000 grains, reaching 39.01 grams. The difference in wheat varieties in this trait may be due to genetic differences in the varieties, as well as the difference in the ability of the varieties to benefit from the products of the carbon assimilation process and their accumulation in the grain. The reason for the superiority of the Shayma variety may be attributed to the decrease in the number of ears per square meter, which in turn led to a lack of competition between manufactured carbohydrates. From the source: The reason for the superiority of the Shaima variety may be due to the existence of the principle of compensation in wheat and barley, as a decrease in one of the components of the yield is offset by an increase in the rest of the components of the yield. This result agreed with what was found by Kotal et al. (2010) who indicated that wheat varieties differed among themselves in the weight of 1000 grains.

Table 4 Effect of levels of varieties and nanofertilizers and the interaction between them on the weight of 1000 grains

varieties	**Nanofertilizers P.P.M**			**the average**
	0	**12**	**24**	
Ebba 99	39.43	40.17	37.43	39.01
Al Shaima	42.87	43.37	42.90	43.04
Aksad	43.77	41.90	42.13	42.60
Average	42.02	41.81	40.82	
L.S.D(0.05)		varieties	nanofertilizers	VarietiesX nanofertilizers
		1.97	NS	NS

3.4. Specific weight (Hectoliter weight)

The results of Table (5) show that there are no significant differences between the varieties and nanofertilizer levels and the interaction between the two factors (varieties and nanofertilizer) in the characteristic of Specific weight.

Table 5 Effect of levels of varieties and nano fertilizers and the interaction between them on **wieght_spa :**

varieties	**Nanofertilizers P.P.M**			**the average**
	0	**12**	**24**	
Ebba 99	81.20	79.97	80.07	80.4
Al Shaima	80.60	78.67	80.87	80.72
Aksad	81.33	80.23	80.60	80.04
Average	81.04	79.62	80.51	
(0.05) L. S. D		varieties	nanofertilizers	VarietiesX nanofertilizers
		NS	NS	NS

3.5. Wet Gluten%

The results of Table (6) show that there are no significant differences between the varieties and nanofertilizer levels and the interaction between the two factors (varieties and nanofertilizer) in the characteristic of Wet Gluten

Table 6 Effect of levels of varieties and nano fertilizers and the interaction between them on Wet Gluten %

varieties	**Nanofertilizers P.P.M**			**the average**
	0	**12**	**24**	
Ebba 99	30.53	31.20	30.63	30.79
Al Shaima	31.63	30.97	30.67	30.09
Aksad	29.70	30.50	30.67	30.29
Average	30.62	30.89	30.66	
(0.05) L.S.D		varieties	nanofertilizers	VarietiesX nanofertilizers
		NS	NS	NS

3.6. Sedimentation value (Zeleny)

The results of Table (7) show that there are no significant differences between the varieties and nanofertilizer levels and the interaction between the two factors (varieties and nanofertilizer) in the characteristic of Sedimentation value.

Table 7 Effect of levels of varieties and nano fertilizers and the interaction between them on Sedimentation value (zeleny)

varieties	**Nanofertilizers P.P.M**			**the average**
	0	**12**	**24**	
Ebba 99	66	55	60	60.33
Al Shaima	55	55	55	55
Aksad	57	54	56	55.67
Average	59.33	54.33	57.00	
(0.05) L.S. D		varieties	nanofertilizers	VarietiesX nanofertilizers
		NS	NS	NS

3.7. Falling number

The results of Table (8) show that there are significant differences between the levels of nanofertilizer and the

interaction between the two factors (varieties and nanofertilizer), and no significant differences between the varieties.

From the results of Table (8), it was shown that there were significant differences between the varieties, the variety Al Shaima gave the lowest falling number 330.6.

From the results of Table (8), it was shown that there were significant differences between the levels of nanofertilizer. The levels of 6 and 9 mg/L gave the lowest falling number 337.8 and 337.1 respectively while the level 0 gave 350.8.

From the results of Table (8), the interaction between the levels of the study factors had a significant effect on the interaction between the varieties and the levels of nanofertilizer, the 6 * Ebba 99 treatment gave the lowest falling number 317.

Table 8 Effect of levels of varieties and nano fertilizers and the interaction between them on Falling number

varieties	Nanofertilizers P.P.M			the average
	0	12	24	
Ebba 99	350.7	317.0	356.7	341.4
Al Shaima	343.3	331.0	317.3	330.6
Aksad	358.3	365.3	337.3	353.7
Average	350.8	337.8	337.1	
(0.05) L.S.D		varieties	nanofertilizers	VarietiesX nanofertilizers
		8.35	8.35	14.46

3.8. Elasticity (BU)

The results of Table (9) show significant differences between varieties, and no significant differences appeared between the levels of nano fertilizer and the interaction between the two factors (varieties and nano fertilizer)

From the results of Table (9), it was shown that there were significant differences between varieties, as the variety Aksad outperformed and gave the 86.82 BU, while the variety Al Shaima gave the lowest value 80.81 BU.

Table 9 Effect of levels of varieties and nano fertilizers and the interaction between them on Elasticity (BU)

varieties	Nanofertilizers P.P.M			the average
	0	12	24	
Ebba 99	82.3	83.55	79.2	81.68
Al Shaima	80.12	83.7	78.6	80.81
Aksad	86.11	86.11	88.25	86.82
Average	82.84	84.45	82.02	
(0.05) L.S.D		varieties	nanofertilizers	VarietiesX nanofertilizers
		1.351	NS	NS

3.9. Flexibility and Texture mg/kg

The results of Table (10) show significant differences between varieties, and no significant differences appeared between the levels of nano fertilizer and the interaction between the two factors (varieties and nano fertilizer)

Table 10 Effect of levels of varieties and nano fertilizers and the interaction between them on Flexibility and Texture mg/kg

varieties	Nanofertilizers P.P.M			the average
	0	12	24	
Ebba 99	1257.23	1259.33	1490.32	1335.63
Al Shaima	1520.5	1251.20	1580.11	1450.60
Aksad	950.58	960.5	955.12	955.40
Average	1242.77	1157.01	1341.85	
(0.05) L. S. D		varieties	nanofertilizers	VarietiesX nanofertilizers
		145.15	NS	NS

From the results of Table (10), it was shown that there were significant differences between varieties, as the variety Al Shaima outperformed and gave the 1450.60 mg/kg, while the variety Aksad gave the lowest value 955.40 mg/kg.

4. Conclusion

Wheat varieties differed significantly in their response to micronutrient nutrient requirements. The 'Ibaa 99' variety showed the best performance in grain count and spike count per square meter, while the 'Shaymaa' variety excelled in some qualitative traits such as Flexibility and Texture and falling number. Therefore, we recommend planting 'Ibaa 99' and the 'Shaymaa' variety in the study area.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Balk J., Connorton J.M., Wan Y., Lovegrove A., Moore K.L., Uauy C., Sharp P.A. and Shewry

[2] P.R. 2019. Improving wheat as a source of iron and zinc for global nutrition. Nutrition bulletin, 44(1): 53-59.

[3] Cui H.X., Sun C.J., Liu Q., Jiang J. and Gu W. 2010. June. Applications of nanotechnology in agrochemical formulation, perspectives, challenges and strategies. In international conference on Nanoagri, Sao pedro, Brazil, 28-33.

[4] Bergmann W. 1992. Nutritional disorders of plants. Development, vissual and analytical diagnosis. Gustav Fischer. Verlag Jena. Stuttgart. New York.

[5] Dhuha S.A., Asraa K.A. and Qusai Y.A. 2022. Iraqi Journal of Science, 63(6): 2755-2763.

[6] Jalal A., Shah S., Teixeira Filho M.C.M., Khan A., Shah T., Ilyas M. and Rosa P.A.L. 2020. Agro-biofortification of zinc and iron in wheat grains. Gesunde Pflanzen, 72(3): 227-236.

[7] Lin M. and Huybers P. 2012. Reckoning wheat yield trends. Environmental Research Letters, 7 (2): 024016.

[8] Giraldo J.P., Landry M.P., Faltermeier S.M., McNicholas T.P., Iverson N.M., Boghossian A.A., Reuel N.F., Hilmer A.J., Sen F., Brew J.A. and Strano M.S. 2014. Plant nanobionics approach to augment photosynthesis and biochemical sensing. Nature materials, 13(4): 400-408. FAO. 2018. FAOSTAT. http://Faostat.Fao.Org

[9] Jaggard K.W., Qi M. and Ober E.S. 2010. Possible changes to arable crop yields by 2050. Philosophical Transactions of the Royal Society B Biological Sciences, 365(1554): 2835-2851.

[10] Mazaherinia S., Astaraei A.R., Fotovat A. and Monshi A. 2010. Nano iron oxide particles efficiency on Fe, Mn, Zn and Cu concentrations in wheat plant. World Applied Sciences Journal, 7.

[11] Naderi M.R. and Abedi A. 2012. Application of nanotechnology in agriculture and refinement of environmental pollutants. Journal of Nanotechnology, 11(1): 18-26.

[12] Radawiec A., Szulc W. and Rutkowska B. 2021. Selenium Biofortification of Wheat as a Strategy to Improve Human Nutrition. Agriculture, 11(2): 144.

[13] Ray D.K., Mueller N.D., West P.C. and Foley J.A. 2013. Yield trends are insufficient to double global crop production by 2050. PLoS ONE, 8: e66428.

[14] Würth B. 2007. Emissions of engineered and unintentionally produced nanoparticles to the soil: an exposure assessment for Switzerland (Master's thesis, ETH Zurich Department of Environmental Sciences).