Response of Growth, Yield and Chemical Content of Table Beet to Organic Fertilization and Spraying with Nano- Iron

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Abstract

A factorial experiment was conducted at the research station (Al-Buaitha area) affiliated to the College of Agriculture, University of Anbar, located at longitude 43.32.65E and latitude 33.45.37N, 110 km west of the capital Baghdad, for the growing season 2024-2025 to study the response of sugar beet plant to adding three levels of organic fertilizer 0, 2.5, 5 kg / each experimental unit and spraying with three concentrations of nano iron 0, 80, 160 mg L-1 with nano iron and their effect on growth and yield. The experiment was designed according to the randomized complete block design (RCBD), the experimental treatments were distributed randomly with three replicates for each treatment, the results showed the highest rate of interaction treatment between the highest level of organic fertilizer and the highest concentration of spraying with nano iron for leaf yield 57.59 tons. ha-1, leaf chlorophyll content 124.44 mg. 100g-1, total root yield 6.60 t.ha-1, protein percentage 10.63%, total soluble solids percentage 14.67%, carbohydrate percentage 15.97%, as well as an increase in nitrogen percentage 1.700%, phosphorus percentage 0.363%, potassium percentage 3.587%, iron percentage in roots 768.22 mg. kg-1. A factorial experiment was conducted at the research station (Al-Buaitha area) affiliated to the College of Agriculture, University of Anbar, located at longitude 43.32.65E and latitude 33.45.37N, 110 km west of the capital Baghdad, for the growing season 2024-2025 to study the response of sugar beet plant to adding three levels of organic fertilizer 0, 2.5, 5 kg / each experimental unit and spraying with three concentrations of nano iron 0, 80, 160 mg L-1 with nano iron and their effect on growth and yield. The experiment was designed according to the randomized complete block design (RCBD), the experimental treatments were distributed randomly with three replicates for each treatment, the results showed the highest rate of interaction treatment between the highest level of organic fertilizer and the highest concentration of spraying with nano iron for leaf yield 57.59 tons. ha-1, leaf chlorophyll content 124.44 mg. 100g-1, total root yield 6.60 t.ha-1, protein percentage 10.63%, total soluble solids percentage 14.67%, carbohydrate percentage 15.97%, as well as an increase in nitrogen percentage 1.700%, phosphorus percentage 0.363%, potassium percentage 3.587%, iron percentage in roots 768.22 mg. kg-1.

Keywords: Beta vulgaris, Yield enhancement, Chemical composition, total soluble solids.

Introduction

The Tale Beet Beta vulgaris L (, Chenopodiaceae), an annual root vegetable. The only edible portion of this plant is the top of the taproot and the swollen lower hypocotyl. Beetroots are a high source of nutrients, these include important elements – potassium, iron, zinc, sulfur, copper, silicon, phosphorous, magnesium, nitrates, and manganese. They are good source of important vitamins (A, B1, B2, B6 and C), cellulose, folic acid, and carbohydrates (sucrose, glucose, and fructose) and non-protein and protein amino acids (15.(

Adequate supply of essential nutrients is crucial for plant growth, because the elements are directly or indirectly involved in a vast number of physiological processes. Shortages of any of these nutrients can cause significant growth disorders that can reduce both the quantity and quality of the crop. Nutrient

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availability is determined by the combined effect of factors such as soil organic matter content, contents of clay and interaction with carbonate minerals. Under some soil conditions, the mobility of nutrients may be limited and the plant cannot uptake them efficiently. In addition, traditional fertilizers don't always result in the desired outcome as a result of depletion of soil nutrients and/or decrease in nutrient uptake efficacy. Consequently, alternative fertilization methods (organic) are becoming more popular, because they remarkably improve crop quality and productivity up to 50% (2.(

According to Wang et al. (26), organic components refer to animal manure and plant-based residues. Organic matter is estimated to be composed of about 75% water, and the rest of the dry matter is made up of plant tissues and animal excretions. Organic matter consists chemically of carbon, oxygen, hydrogen, nitrogen and such minerals as are necessary for the nutrition of plants. It is present mostly in the three compound groups: polysaccharides, proteins, and lignin. Organic fertilizers are not only nutrient supplier to the crop but also contribute to the improvement of physical and chemical properties of soil like water holding capacity. Organic fertilizers also provide an effective means of recycling farm wastes, animal residues which are collected and fermented to reduce the volume would therefore be easier to handle and apply.

Organic fertilization is a primary agricultural practice, in which the large amount of macro and micronutrients is essential during these practice for promoting plant growth and high yielding (Tisdale et al., 2002). It also makes a vital contribution to the improving physical and chemical properties of the soils. It increases the water holding capacity and aeration and reduces pH of the soil, and thus the availability of the nutrients for the plants (20.(

The decomposition of organic matter is one of the primary ways to increase nutrient availability in the soil, Nitrogen in particular. It is therefore indispensable in poor soils for plant nutrition. It also helps condition the soil and provides good structure, aeration, and water retention for the soil. The organic fertilizers value cannot be measured in terms of nutrient concentrations only, but in the process of making available the nutrients and in dissolving some organic complex thereby improving soil efficiency and promoting plant growth. Although foliar application using nano-particles has shown benefits in enhancing crop growth and improving product quality, many of the metabolic pathways associated with this process are still not fully understood (27). Nanoparticles have, however, proven effective in promoting germination, increasing plant resistance to stress, and improving nutrient uptake—ultimately supporting healthier plant development (28). Nano-iron particles, in particular, offer an efficient way to boost both crop yield and quality, especially when applied through foliar spraying. This method reduces the environmental impact of chemical substances. A study showed that applying nano-iron fertilizer at a concentration vegetative growth and yield traits, (24) 1. Studying the effect of organic fertilizer application on enhancing the growth and productivity of sugar beet.

.2Evaluating the impact of different foliar iron levels on plant growth and yield improvement.

.3Highlighting the medical and nutritional importance of sugar beet, with a focus on improving both quantitative and qualitative production..

Materials and Methods

A field experiment was conducted during the 2024–2025 growing season at the agricultural research field of the College of Agriculture, University of Anbar, located in the Al-Buaitha

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region. The land was plowed, leveled, and prepared into raised beds measuring 2.5 meters in length and 1 meter in width. Seeds were sown at a spacing of 15 cm between plants, with 1 meter between rows.

Garden beet seeds, in 1/10/2024 obtained from a commercial agricultural supplier (variety: Detroit Dark Red2 Christel, with an 85% germination rate and 99% purity), supplied by the Dutch company Bakker Brothers, were directly sown in the field at a depth of 1.5–2 cm. Prior to the application of fertilizers, the physical and chemical properties of the experimental soil were analyzed using composite soil samples collected from the field site.

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

Unit	Value	Property
-	7.12	Soil pH (1:1)
dS m-1	2.47	Electrical conductivity (EC
g kg-1	5.40	Soil organic matter (SOM)
%	0.81	Gypsum (CaSO4)
%	10.30	Calcium carbonate
Mg m-3	1.30	Bulk density
cmol(+) kg-1 soil	23.80	Cation exchange capacity
meq L-1		Soluble cations
	6.23	Ca2+
	7.23	Mg2+
	3.89	Na+
	6.60	K+
		Soluble anions
	2.39	SO4-2
	9.95	CO3-
	2.69	HCO3-
	5.99	Cl-
mg kg-1 soil	8.96	Available nitrogen (N)
	10.30	Available phosphorus (P)
	90.80	Available potassium (K)
	21.60	Available zinc (Zn)
g kg-1 soil		soil separates
	684	Sand
	112	Silt
	204	Clay
	Sandy clay loam	Soil texture class

*analyzed at the laboratories of the College of Agriculture, University of Anbar.

The organic fertilizer used in this study was ITALPOLLINA, a high-quality organic product derived from certified poultry waste. It is processed in accordance with European Union standards and under the supervision of Italian veterinary authorities. This makes it a high-quality, natural soil enhancer that effectively improves soil fertility and supports plant growth. It was applied before sowing directly to the experimental plots.
In contrast, the nano iron Five foliar sprays were applied. was applied as a foliar spray, carried out early in the morning to maximize absorption and minimize environmental stress. Standard agronomic practices were followed throughout the growing season in accordance with established recommendations.

The experiment was laid out as a factorial trial using a split-plot arrangement within a randomized complete block design (RCBD),

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with three replicates(LSD). The main factor (designated as O) was the organic fertilizer applied at three levels: 0, 2.5, and 5 kg per experimental unit (3). The sub-factor (designated as N) was the foliar application of nano iron at concentrations of 0, 80, and 160 mg L^{-1} (Yaseen, 2021.(

Experiment indicators

The following parameters were evaluated during the study after ripening:

Leaf yield (g $plant^{-1}$) was recorded to assess the aboveground biomass productivity.

Total Chlorophyll content in leaves was estimated using the method described by (14.(

Total root yield (tons ha^{-1}) was measured at harvest to evaluate productivity.

Protein percentage in both roots was determined according to the procedures of the Association of Official Analytical Chemists (1.(

Total soluble solids (T.S.S %) were estimated following the method outlined by (4.(

Total sugars (%) were calculated using the protocol described by (18.(

Nitrogen content in roots % was determined following (16.(

Phosphorus content in roots % was analyzed based on the method of Olsen and (21.(

Potassium and iron concentrations in roots % were both measured following the procedures reported by (11.(

Results and Discussion

Leaf Yield (g $plant^{-1}$(

Data presented in Table (2) show that the application of organic fertilizer at the highest level (O2) significantly outperformed the control (O0), producing the highest leaf yield of 51.35 tons ha^{-1}, compared to 31.95 tons ha^{-1} in the unfertilized treatment. Similarly, the nano iron treatment N2 resulted in the highest leaf yield (45.65 tons ha^{-1}) compared to the lowest yield of 40.56 tons ha^{-1} recorded under the N1 treatment. Furthermore, the two-way interaction between organic fertilizer and nano iron (O2N2) recorded the highest average leaf yield of 57.59 tons ha^{-1}, while the lowest yield (30.84 tons ha^{-1}) was observed in the interaction treatment O0N1, which received no organic fertilizer and the lower level of nano iron.

Table 2. The effect of organic fertilizer and nano-iron application on Leaf yield and interaction (g $plant^{-1}$(

Mean N	Organic fertilizer			Nano-iron
	O_2(5 kg)	O_1(2.5 kg)	O_0	
40.78	48.16	42.41	31.77	**N_0(control)**
40.56	48.30	42.55	30.84	**N_1(80 mg**
45.65	57.59	46.11	33.25	**N_2(160)**
	51.35	**43.69**	**31.95**	**Mean O**
	O * N	**N**	**O**	**LSD 0.05**
	3.14	1.81	1.81	

Leaf Chlorophyll Content cm2

The results indicate that the organic fertilizer treatment O_2 (5 kg per experimental unit) achieved the highest chlorophyll content in leaves, reaching 118.08 mg per 100 g of fresh weight , compared to the control treatment O0 (no organic fertilizer), which recorded the lowest value at 73.94 mg (Table 3). Likewise, the nano-iron treatment N_2 (160 mg/L) showed the greatest improvement in chlorophyll content, with a value of 106.34 mg, this was notably better than the N0 treatment (no nano-iron), which showed the lowest content at 87.49 mg. Regarding the interaction between organic fertilizer and nano iron, the combination treatment O2N2 (optimal organic fertilizer with optimal nano-iron) produced the highest average chlorophyll

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content, reaching 124.44 mg. In contrast, the control treatment (O0N0), with no added organic fertilizer or nano-iron, had the lowest average chlorophyll content at 63.87 mg.

Table (3). The effect of organic fertilizer and nano iron application on chlorophyll content in leaves and interaction (mg 100 g^{-1} fresh weight

Mean N	Organic fertilizer O_2	O_1	O_0	Nano-iron
87.49	106.81	91.78	63.87	**N_0**
100.19	122.99	104.53	73.04	**N_1**
106.34	124.44	109.66	84.91	**N_2**
	118.08	**101.99**	**73.94**	**Mean O**
	O * N	**N**	**O**	**LSD 0.05**
	N.S	12.58	12.58	

Total Root Yield (ton ha-1(

According to the results shown in Table 4, the organic fertilizer treatment O_2 (5 kg per experimental unit) recorded the highest root yield at 6.08 tons per hectare , compared to the control treatment O_0 (no organic fertilizer), which yielded the lowest value of 4.65 tons ha-1. Similarly, the nano-iron treatment N_2 (160 mg L-1) produced the highest yield among the foliar treatments, reaching 5.61 tons ha-1 , whereas the control treatment N_0 (no nano-iron application) gave the lowest yield at 5.07 tons ha-1. The interaction between organic fertilizer and nano iron (O2N2) produced the highest root yield overall, reaching 6.60 tons ha^{-1}, while the lowest average yield (4.48 tons ha^{-1}) was recorded in the control treatment (O0N0.(

Table (4): The effect of organic fertilizer and nano iron application on Total Root Yield and interaction (tons ha^{-1}(

Mean N	Organic fertilizer O_2	O_1	O_0	Nano-iron
5.07	5.55	5.20	4.48	**N_0**
5.32	6.10	5.31	4.56	**N_1**
5.61	6.60	5.34	4.91	**N_2**
	6.08	**5.28**	**4.65**	**Mean O**
	O * N	**N**	**O**	**LSD 0.05**
	0.38	0.22	0.22	

Protein Percentage in Roots and Leaves(%)

Result shows that the highest protein percentage was recorded in the organic fertilizer treatment O2, reaching 10.42%, while the lowest value (8.47%) was observed in the unfertilized control (O0) (Table 5). Similarly, the nano iron treatment N2 produced the highest protein content (9.86%) compared to the control (N0), which gave the lowest percentage (9.17%). The interaction treatment O2N2 was superior to all other combinations, achieving the highest protein content of 10.63%, whereas the lowest mean protein percentage (8.33%) was recorded in the control treatment O0N0.

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Table (5): The effect of organic fertilizer and nano iron application on protein percentage in roots (%)and interaction

Mean N	Organic fertilizer O_2	O_1	O_0	Nano-iron
9.17	10.00	9.17	8.33	**N_0**
9.58	10.63	9.79	8.33	**N_1**
9.86	10.63	10.21	8.75	**N_2**
	10.42	**9.72**	**8.47**	**Mean O**
	O * N	**N**	**O**	**LSD 0.05**
	N.S	0.51	0.51	

Total Dissolved Solids (T.S.S (%.

The results indicate that the organic fertilizer O2 treatment was superior, yielding the highest percentage of total dissolved solids (TDS) at 13.22%, compared to the O0 equation without additions, which yielded the lowest percentage of dissolved solids at 10.89% (Table 6),. The nano-iron treatment outperformed the N2 treatment, yielding the highest percentage at 12.78%, compared to the N0 equation without additions, which yielded the lowest percentage at 11.33%. The average value of the interaction between organic fertilizer and nano-iron (O2N2) was 14.67%, while the lowest average was for the O0N0 treatment, which yielded 10.67%.

Table (6): The effect of organic fertilizer and nano iron application on total dissolved solids (T.S.S. %) and interaction

Mean N	Organic fertilizer O_2	O_1	O_0	Nano-iron
11.33	12.00	11.33	10.67	**N_0**
12.00	13.00	12.33	10.67	**N_1**
12.78	14.67	12.33	11.33	**N_2**
	13.22	**12.00**	**10.89**	**Mean O**
	O * N	**N**	**O**	**LSD 0.05**
	1.03	0.60	0.60	

Carbohydrate percentage in Roots%

The result indicates the superiority of the organic fertilizer O2 treatment, which yielded the highest carbohydrate percentage of 15.33%, compared to the O0 treatment without additions, which yielded the lowest carbohydrate percentage of 14.08% (Table 7). Nano-iron N2 yielded the highest carbohydrate percentage of 15.56%, compared to the N0 treatment, which yielded the lowest percentage of 14.28%. The interaction treatment O2N2 resulted in the highest mean carbohydrate percentage reaching 15.97%, while the lowest average was for the (O0N0) treatment, reaching 13.20%.

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Table (7): The effect of organic fertilizer and nano iron application on carbohydrate percentage and interaction

Mean N	Organic fertilizer			Nano-iron
	O_2	O_1	O_0	
14.28	14.50	15.13	13.20	N_0
14.80	15.53	15.10	13.77	N_1
15.56	15.97	15.43	15.27	N_2
	15.33	**15.22**	**14.08**	**Mean O**
	O * N	**N**	**O**	**LSD 0.05**
	0.66	0.38	0.38	

Nitrogen Percentage (N) in Roots

Table (8) shows that the highest nitrogen concentration in roots was recorded under the organic fertilizer treatment O2, reaching 1.667%, while the lowest value (1.356%) was observed in the unfertilized control (O0). Regarding nano iron, the N2 treatment gave the highest nitrogen percentage (1.578%), whereas the lowest (1.467%) was found in the control (N0). The combined treatment (O2N2) recorded the highest mean nitrogen percentage at 1.700%, while the lowest mean value (1.333%) was associated with the control treatment (O0N0.(

Table (8): The effect of organic fertilizer and nano iron application on nitrogen percentage (N) in roots and interaction

Mean N	Organic fertilizer			Nano-iron
	O_2	O_1	O_0	
1.467	1.600	1.467	1.333	N_0
1.533	1.700	1.567	1.333	N_1
1.578	1.700	1.633	1.400	N_2
	1.667	**1.556**	**1.356**	**Mean O**
	O * N	**N**	**O**	**LSD 0.05**
	N.S	0.082	0.082	

Phosphorus Percentage (P) in Roots

The results indicated the superiority of the organic fertilizer (O2) treatment, yielding the highest phosphorus percentage of 0.343%, compared to the O0 treatment without additions, which yielded the lowest percentage of 0.298% (Table 9). As for the nano-iron, the N2 treatment outperformed, yielding the highest percentage of 0.331%, compared to the N0 treatment without additions, which yielded the lowest percentage of 0.307 mg. The combined treatment (O2N2) showed the highest mean phosphorus content at 0.363%, whereas the lowest mean value (0.292%) was observed under the control treatment (O0N0.(

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Table (9): The effect of organic fertilizer and nano iron application phosphorus percentage (P) in roots and interaction

Mean N	Organic fertilizer O_2	O_1	O_0	Nano-iron
0.307	0.331	0.298	0.292	**N_0**
0.319	0.336	0.322	0.299	**N_1**
0.331	0.363	0.326	0.302	**N_2**
	0.343	**0.315**	**0.298**	**Mean O**
	O * N N.S	**N** 0.013	**O** 0.013	**LSD 0.05**

Potassium Percentage (K) in Roots

The results indicate that the organic fertilizer treatment O2 resulted in the highest potassium concentration in roots, reaching 3.471%, while the lowest value (2.893%) was recorded in the control treatment (O0) (Table 10). Similarly, the nano iron treatment N2 showed superiority by recording the highest potassium percentage (3.257%), compared to the control (N0), which had the lowest value of 3.059%. The interaction treatment O2N2 (organic fertilizer × nano iron) produced the highest mean potassium content at 3.587%, while the treatment O0N2 recorded the lowest mean value of3.007%.

Table (10): The effect of organic fertilizer and nano iron application on potassium percentage (K) in roots and interaction

Mean N	Organic fertilizer O_2	O_1	O_0	Nano-iron
3.059	3.287	3.167	2.723	**N_0**
3.222	3.540	3.177	2.950	**N_1**
3.257	3.587	3.177	3.007	**N_2**
	3.471	**3.173**	**2.893**	**Mean O**
	O * N 0.150	**N** 0.087	**O** 0.087	**LSD 0.05**

Iron Content (Fe) in Roots (mg kg^{-1}(

Table (11) shows that the organic fertilizer treatment O2 resulted in the highest iron concentration in roots, reaching 709.93 mg kg^{-1}, while the control treatment O0 recorded the lowest value at 414.71 mg kg^{-1}. Nano-iron application, treatment N_2 (160 mg L-1) also showed superior performance, resulting in an iron content of 665.22 mg kg^{-1} , compared to treatment N_0 (no nano-iron), which gave the lowest value at 494.25 mg kg^{-1} . The interaction between organic fertilizer and nano-iron, showed that the combined treatment O_2 N_2 (organic fertilizer + nano-iron) produced the highest average iron content of 768.22 mg kg^{-1} , while the control treatment O_0 N_0 (no fertilizer or nano-iron) recorded the lowest mean value at 293.09 mg kg^{-1}.

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Table (11): The effect of organic fertilizer and nano iron application on iron content (fe) in roots (mg kg^{-1}) and interaction

Mean N	Organic fertilizer O$_2$	O$_1$	O$_0$	Nano-iron
494.25	671.84	517.81	293.09	**N$_0$**
550.45	689.74	555.31	406.30	**N$_1$**
665.22	768.22	682.72	544.73	**N$_2$**
	709.93	**585.28**	**414.71**	**Mean O**
	O * N	**N**	**O**	
	62.04	35.82	35.82	**LSD 0.05**

DISCUSSION

Clean agricultural technologies with less pollution emissions and low consumption of resources, can be found globally, with the goal to reduce pollution, protect ecosystems and plant tolerance to biotic and abiotic stresses. All these practices eventually enhance the crop yield and quality. In such direction researchers and agricultural scientists all over the world have been striving to modernize farming methods and encourage the contamination free cropping system by means of natural resources like Organic and Biofertilizers. These inputs serve as sustainable complements to chemical fertilizers.

The significant improvements observed in growth indicators following organic fertilizer application can be attributed to the nitrogen and amino acids it contains. These components play vital roles in the synthesis of proteins and various enzymes involved in carbon metabolism, in addition to supplying nitrogen directly to the plant (8.(

Nano fertilizers are also applicable for crop growth. However, excessive doses can result in phytotoxicity, which can damage plants growth by nutrient toxicity. Nanofertilizers in the right perspective, provide an extensive reactive surface area that makes available the required metabolites for the plant. This helps in better photosynthetic efficiency, more dry matter accumulation and ultimately higher yield. Furthermore, they play a crucial role in mitigating the adverse effects of both biotic and abiotic stresses (6.(

The results regarding the impact of organic fertilizers highlighted their effective role in enhancing soil fertility, leading to increased nutrient availability and improved water retention capacity, in addition to their positive influence on plant biological processes such as cell division, elongation, and protein synthesis, which positively reflected on most studied traits (5), consistent with findings by (9). The results also show that nano-fertilization contributed to significant improvements in most of the measured parameters. This can be attributed to the unique properties of nano-fertilizers, particularly their ability to interact with ion transporters, which enables them to penetrate plant cells more effectively and enhance water uptake—ultimately promoting and stimulating plant growth (23.(

Nano-iron particles play an effective role in promoting the accumulation of salicylic acid within the plant, contributing to improved growth and increased resistance to environmental and biotic stresses, while also reducing the bioavailability of chromium, leading to enhanced plant growth, biomass, and productivity. Furthermore, they enhance carbon metabolism efficiency by increasing chlorophyll levels and reducing oxidative stress (10), consistent with findings by. (17)on Potatoes (19)on table beet, and (12)(on table beet .(

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Conclusion

The findings of our study, however, evidently indicated the positive impact of application of both organic fertilizer and nano iron on sugar beet growth and yield as well as its chemical content. Soil fertility, nutrient availability, and plant physiological performance benefited significantly from organic fertilizer, and nutrient up-take and important metabolic activities was promoted by nano iron. Values of the combined treatment (O2N2) were always higher than those of the others in most traits measured, providing evidence in favor of an additive effect of organic and nano-(carbon) fertilization protocols. These findings highlight the importance of integrating sustainable agricultural inputs to optimize crop productivity and quality under field conditions.

References

.1
A.O.A.C. (1970). Official Methods of Analysis (11th Ed.). Association of Official Analytical Chemists, Washington, D.C.

.2 Abdel Wahab, M., Attia, M., Hassan, A., & Salem, A. (2017). Nitrate and ammonium balance in fertilizing wheat grown on sand soil. Journal of Soil Sciences and Agricultural Engineering, 8(5), 183–188.

.3 Abdul-Hussain, H. H. S. (2021). Effect of Bio and Organic Fertilizers on Growth, Yield, and Enzymatic Antioxidant Activity in Tomato under Salt Stress (Master’s thesis). College of Agriculture, Al-Qasim Green University.

.4 Al-Ani, A. M. (1985). Postharvest Physiology of Horticultural Crops. University of Baghdad, Ministry of Higher Education and Scientific Research, Iraq.

.5 Al-Habar, M. T. A.,&Alsheikh, M. A. A. (2017). Effect of planting dates, organic and chemical fertilizers and humic acid on some yield characteristics of table beet (Beta vulgaris L. ssp vulgaris). Tikrit Journal for Agricultural Sciences, 17(4.(

.6 Ali Jasim, H. (2019). Effect of Phosphorus Levels Added to Soil and Foliar Application on Plant Growth (Master’s thesis). College of Agriculture and Marshes.

.7 Almohammedi, A. N. A., & Yaseen, A. L. Y. (2021). Effect of foliar application of chelated nano iron, phosphorus, and Pseudomonas bacteria on physiological traits of fenugreek (Trigonella foenum-graecum L.). Journal of Educational and Scientific Studies – College of Education – Iraqi University, 17(3), 97–116.

.8 Almohammedi, O. H., & Kokaz, N. M. (2021, June). Effect of adding the biological fertilizer Fulzyme Plus and spraying $CaCl_2$ on efficiency of the Rhizoctonia fungus and the quality of potato (Solanum tuberosum L.). IOP Conference Series: Earth and Environmental Science, 790(1), 012060. https://doi.org/10.1088/1755-1315/790/1/012060

.9 Almohammedi, O. H.,&Musleh, S. H. (2024). Response of potato to organic fertilizer and zinc spraying on some growth characteristics and yield. Sciences, 22(1), 383–397.

.10 Almohammedi, O., Sekhi, Y., & Ismail, M. (2023). A review of nano fertilization and its role on growth, yield and quality characteristics of fruit trees. Tikrit Journal for Agricultural Sciences, 23(1), 158–167.

.11 Al-Sahhaf, F. H. (1989). Applied Plant Nutrition. University of Baghdad, Ministry of Higher Education and Scientific Research, House of Wisdom for Publishing and

Translation, Higher Education Printing Press, Mosul, Iraq. p. 260.

.12 Al-Silawi, A. H. S. (2024). The Role of Boron Application and Foliar Spraying of Tyrosine on Growth, Productivity, and Quality of Two Sugar Beet Cultivars (Master's thesis). College of Agriculture, University of Karbala.

.13 Duhana, J. S., Kumara, R., Kumara, N., Kaura, P., Nehrab, K., & Duhanc, N. (2017). Nanotechnology: The new perspective in precision agriculture. Biotechnology Reports, 15(1), 11–23.

.14 Goodwin, T. W. (1976). Chemistry and Biochemistry of Plant Pigments (2nd ed.). Academic Press.

.15 Hasan, G.,&Alwan, O. K. (2004). Effect of foliar application of iron and zinc on some vegetative growth traits and yield in tomato (Lycopersicon esculentum Mill) cv. Al-Wadi. Tikrit University Journal for Agricultural Sciences, 4(2), 182–190.

.16 Jackson, M. L. (1958). Soil Chemical Analysis. Prentice Hall.

.17 JALAL, V. J., Almohammedi, O. H. M., & Mohammed, K. A. (2022). The effect of using the nanocomposite fertilizer (NPK) technology on the growth and yield of two varieties of the potato plant Solanum tuberosum L. grown in the autumn season. Kirkuk University Journal for Agricultural Sciences (KUJAS), 13(3.(

.18 Joslyn, M. A. (1970). Methods in Food Analysis: Physical and Instrumental Methods of Analysis (2nd Ed.). Academic Press.

.19 Majid, R. G. M. (2023). Effect of Organic Fertilizer and Plant Extracts on Growth, Yield, and Quality of Three Sugar Beet Cultivars (Doctoral dissertation). Department of Horticulture and Landscape Engineering, College of Agricultural Engineering Sciences, University of Baghdad, Iraq.

.20 Muslat, M. M., & Musleh, O. H. (2015). Principles in Organic Farming (1st ed.). Al-Semaa Publisher.

.21 Olsen, S. R.,&Sommers, L. E. (1982). Phosphorus. In A. L. Page (Ed.), Methods of Soil Analysis: Part 2. Chemical and Microbiological Properties (2nd Ed., Pp. 403–430). American Society of Agronomy, Soil Science Society of America.

.22 Ruengsitagoon, W.,&Hattanat, N. (2012). Simple spectrophotometric method for determination of folic acid. 4th Annual Northeast Pharmacy Research Conference of Pharmacy Profession in Harmony, 11–12 February 2012, 281.

.23 Schwab, F., Zhai, G., Kern, M., Turner, A., Schnoor, J. L.,&Wiesner, M. R. (2016). Barriers, pathways and processes for uptake, translocation and accumulation of nanomaterials in plants – Critical review. Nano toxicology, 10(3), 257–278.

.24 Sega, D., Baldan, B., Zamboni, A., & Varanini, Z. (2020). $FePO_4$ NPs are an efficient nutritional source for plants: Combination of nano-material properties and metabolic responses to nutritional deficiencies. Frontiers in Plant Science, 11, 586470. https://doi.org/10.3389/fpls.2020.586470

.25 Shayaa, A. H.,&Hussein, W. A. (2019). Effect of neem leaves extract and organic fertilizer in the productivity and quality of two potato cultivars. The Iraqi Journal of Agricultural Science, 50(1), 275–285.

.26 Wang, Y. T., Zhang, T. Q., O'Halloran, I. P., Tan, C. S., & Hu, Q. C. (2016). A phosphorus sorption index and its use to estimate leaching of dissolved phosphorus from agricultural soils in Ontario. Geoderma, 274, 79–87. https://doi.org/10.1016/j.geoderma.2016.03.016

.27 Xiong, T., Dumat, C., Dappe, V., Vezin, H., Schreck, E., Shahid, M. ...&Sobanska, S. (2017). Copper oxide nanoparticle foliar uptake, phytotoxicity, and consequences for sustainable urban agriculture. Environmental Science&Technology, 51(9), 5242–5251.

.28 Yusefi-Tanha, E., Fallah, S., Rostamnejadi, A.,&Pokhrel, L. R. (2020). Zinc oxide nanoparticles (ZnONPs) as a novel nanofertilizer: Influence on seed yield and antioxidant

.29 Yaseen, Y. A. L. 2021. Effect of Spraying Nano-Iron Addition, phosphorous and Pseudomonas bacteria on the Physiological qualities of fenugreek plant (Trigonella foenum-graecum L). Journal of Education and Scientific Studies, 3(17.(

.30 defense system in soil-grown soybean (Glycine max cv. Kowsar). Science of the Total Environment, 738, 140240. https://doi.org/10.1016/j.scitotenv.2020.140240

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