

Reveal the Role of Foliar Fertilization with Zinc, Iron, And Water Type on the Productive Characteristics of Vicia Faba

Azheen Othman Mohammed

Department of Horticulture and Landscape Design, College of Agriculture, University of Kirkuk, Iraq

Received: 2025 19, Aug

Accepted: 2025 28, Sep

Published: 2025 08, Oct

Copyright © 2025 by author(s) and BioScience Academic Publishing. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).



Open Access

<http://creativecommons.org/licenses/by/4.0/>

Annotation: Background & aim: Several researchers studied the effect of iron and zinc fertilization in different types of plant. Therefore, the study aimed to reveal the role of foliar fertilization with zinc, iron, and water type on the productive characteristics of fava beans.

Materials & Methods: The laboratory experiment was conducted in the Horticulture Department / College of Agriculture / University of Kirkuk, where different concentrations of iron were prepared in the form of iron chelate (0, 2, 4) % and different concentrations of zinc were prepared in the form of zinc chelate (0, 2, 4) %. Spraying was done during the cool hours of the day to obtain the maximum absorption of these two micronutrients. Plants were planted during the 2024-2025 season according to a randomized complete block design (RCBD) with three replicates for each treatment in plastic pots with a capacity of 10 kg of soil.

Results: The results showed that irrigation with tap water significantly increased plant height (12.38 cm), leaf area (4.21 cm² plant⁻¹), and chlorophyll content (10.6); while irrigation with gray water increased protein content (20.78). Foliar application of zinc (4%) increased leaf area (3.52 cm² plant⁻¹), chlorophyll content index (12.39 CCI), and protein content index (23.89 PI). Meanwhile, spraying with

2% iron significantly increased plant height (13.01 cm). Regarding interactions, irrigation with tap water and 4% zinc application increased plant height, leaf area, and chlorophyll content index. Gray water with 2 g. 4% iron spray recorded the highest protein content (28.16) in the two-way interactions. The interaction between 2% zinc and 2% iron sprays showed the highest protein content (23.51).

Conclusions: The study indicates the importance of appropriate combinations of irrigation water quality and foliar treatments to improve the growth and productivity of *Vicia faba*.

Keywords: *Vicia faba*., Foliar application, zinc, iron.

Introduction

The faba bean crop holds significant global importance as a food source for humans and animal feed. Its seeds have high protein content of up to 38% and high carbohydrate content of 40–46%. They also contain a variety of essential vitamins, amino acids, and mineral components [1]. Furthermore, faba beans are utilized as organic fertilizer in poor soils and have a biological effect due to the activity of rhizobia bacteria, which improves the physical and chemical characteristics of soils. They also aid in the process of nitrogen fixation in the soil [2,3]. One of the primary legume crops farmed in many parts of Iraq is the faba bean (*Vicia faba* L.), also known as the wide bean, horse bean, field bean, or tic bean [4]. It is utilized in the majority of animal feeds as well as human diet. Its seeds have a high protein content, estimated at 25–40% [5], in addition to a high proportion of carbohydrates, which in most cultivars reached 56% [6]. Moreover, if its roots have root nodes, it fixes atmospheric nitrogen in the soil, improving the soil's characteristics [7]. The lower yield is typically caused by a number of factors that increase the crop's productivity, such as the good varieties that can invest the resources available, as well as soil-related elements like the soil's nutrient availability [8]. Micronutrients enhance the quantity of crude protein, amino acids, total lipids, energy value, and other nutrients in chickpeas, soybeans, black gramme, and other crops in addition to agricultural production. The most effective method of increasing output is foliar fertilization, which has been demonstrated to enhance yield by 12 to 25% in comparison to traditional fertilization [9]. Iron is a crucial co-factor for key enzymes that plays a variety of roles in hormone breakdown and in other chemical events that occur in plants [10]. Although iron is not a component of chlorophyll, it is necessary for its production. Consequently, chlorotic plants and iron insufficiency are brought on by a shortage of chlorophyll [11]. The micronutrient that crops, particularly pulses, have needed in adequate proportions is zinc [12]. "Plants need zinc for hormone biosynthesis" [13]. Zinc plays a role in the formation of nodules, which fix nitrogen, and is necessary for metabolism [14]. Zinc provides the structural stability of ribosomes and is an essential part of RNA polymers [12]. Zinc is necessary for pollen function and fertilization [15], as it is necessary for the synthesis of tryptophan [16, 17]. Therefore, the study aimed to reveal the role of foliar fertilization with zinc, iron, and water type on the productive characteristics of fava beans.

Materials & Methods

The laboratory experiment was conducted in the Horticulture Department / College of Agriculture / University of Kirkuk, where different concentrations of iron were prepared in the form of iron chelate (0, 2, 4) % and different concentrations of zinc were prepared in the form of

zinc chelate (0, 2, 4) %. Spraying was done during the cool hours of the day to obtain the maximum absorption of these two micronutrients.

Agricultural Experiment

This study was conducted in the laboratories of the Department of Horticulture, College of Agriculture, University of Kirkuk, to evaluate the effect of using two types of irrigation water (run-off and gray water), as well as foliar spraying with iron at concentrations of (0, 2, and 4%) and zinc at concentrations of (0, 2, and 4%) on some morphological and physiological traits of *Vicia faba*. Plants were planted during the 2024-2025 season according to a randomized complete block design (RCBD) with three replicates for each treatment in plastic pots with a capacity of 10 kg of soil. Ten days after germination, the plants were thinned to five plants per pot. They were planted in plastic pots 25 cm high and 30 cm in diameter, filled with 10 kg of soil taken from a nursery. Thirty days after planting, the plants were sprayed with iron and zinc at the above-mentioned concentrations, and after 30 days of treatment and after the plants had matured. To characterize the initial properties of the growth medium, a representative composite sample of the soil used was analyzed prior to sowing in the laboratories of the Kirkuk Directorate of Agriculture to determine its key physical and chemical indicators (Table 1)

Table (1): Physical and chemical properties of the experimental soil

Parameter	Value
EC	1.157 ms.cm-1
TDS	613.25
PH	7.267
Total Nitrogen	872.13 mg.kg-1
Soil Texture	Sandy loam
Clay	5%
Sand	54%
Silt	41%

Studied Traits and Measurement Methods

After the plants reached full maturity and were harvested, the following measurements were taken on a random sample of five plants from each experimental unit (pot), and the average was calculated to represent that unit:

- Plant Height (cm): The height of each selected plant was measured from the soil surface to the highest growing tip using a graduated measuring tape, and the average height was then calculated.
- Leaf Area (cm²): The third fully expanded leaf from the apex of each selected plant was chosen, and its area was estimated using a ruler by measuring the maximum length and maximum width of the lamina. The area was then calculated using the formula: (maximum length × maximum width × 0.66), where 0.66 represents the correction factor for mung bean as indicated by Baskaran et al. [18].
- Chlorophyll Content Index (CCI): The Chlorophyll Content Index (CCI) was measured in the third fully expanded leaf from the apex of each plant using a portable chlorophyll meter (CCM-200plus, Opti-Sciences, USA). An average of three readings from different parts of the lamina of each leaf was taken to represent the chlorophyll content of that leaf.
- Protein content: The protein content of fava beans was estimated using the method of Herbert and Knecht [19].

Statistical Analysis of Data

The SAS software program (USA) was used to statistically analyze all of the data that was gathered. To determine the significance of the effects of the factors under study and their

interactions, the data was subjected to Analysis of Variance (ANOVA) in accordance with the guidelines of the Randomized Complete Block Design (RCBD), which was employed in the experiment. Duncan's Multiple Range Test (DMRT) was used to examine treatment mean differences that showed significant effects at a $P \leq 0.05$ probability level [20,21].

Results & Discussion

Plant Height (cm)

Table 2 shows the response of *Vicia faba* to irrigation with tap water and gray water, and foliar fertilization with zinc and iron, and their interactions on plant height. The data indicate that irrigation with tap water resulted in a significant increase ($P \leq 0.05$) in average plant height (12.38 cm) compared to irrigation with gray water (10.75 cm). Foliar fertilization with zinc also showed a significant effect ($P \leq 0.05$), with the 100 mg/L concentration recording the highest average plant height (12.07 cm). Spraying with iron concentrations also resulted in a significant increase ($P \leq 0.05$) in plant height, with 4% and 2% iron concentrations producing the highest averages (12.57 and 13.01 cm, respectively) compared to the control treatment (no iron spray), which recorded 9.47 cm. Regarding two-way interactions, Table (2) shows that the interaction between irrigation water type and zinc spraying indicates that the highest average plant height (15.15 cm) was recorded with tap water irrigation and 4% zinc spraying, while the lowest average (9.3 cm) was recorded with gray water irrigation and 4% zinc spraying. The interaction between irrigation water type and iron spraying, as shown in Table (2), indicated that tap water irrigation with 4% iron spraying gave the highest average plant height (12.76 cm), while the lowest average (9.14 cm) was recorded with gray water irrigation without iron addition (iron control). As for the interaction between zinc and iron spraying, the data in Table (2) indicate that the highest average plant height (13.15 cm) resulted from 4% zinc spraying and 2% iron spraying. The lowest average (9.14 cm³) was recorded when no zinc spraying and no iron addition was added (control sample).

Table (2): Response of *Vicia faba* to two types of irrigation water and spraying with zinc and iron, and their interaction on plant height (cm).

Water type	Iron concentrations	Zinc concentrations			The effect of the average interaction between the type of
		0	2	4	
Tap	0	8.35	11.17	11.49	10.34
	2	8.5	13.06	15.15	12.23
	4	11.86	11.59	14.84	12.76
Gray	0	9.28	9.45	9.3	9.34
	2	14.62	9.67	10.92	11.73
	4	15.81	10.65	11.15	12.53
The effect of the average zinc		11.53	11.41	12.07	
The effect of the average interaction between water type and zinc					
Water type		Zinc concentrations			Impact of average irrigation water
		0	2	4	
Tap		10.42	12.08	14.65	12.38
Gray		13.63	9.11	9.52	10.75
The effect of the average interaction between zinc and iron					
iron concentrations		Zinc concentrations			Effect of average iron concentrations
		0	2	4	
0		9.14	9.47	9.81	9.47
2		12.89	12.97	13.15	13.01
4		12.52	12.64	12.57	12.57

According to the current study, zinc and iron cause plants to grow longer. According to Alam et al. [22], A 2.5 kg Zn ha⁻¹ spray generated the longest plant in a previous trial. The application of 10 kg Zn ha⁻¹ in summer mungbean had a significant effect on plant height (47.76 cm and 47.88 cm) [23]. According to El Sayed Hameda et al. [24], the yield components measured by plant height were considerably raised by adding a combination of microelements (such as iron and zinc) to the leaves of pea plants. Auxin combination containing zinc [25]. By adding 5 mg kg⁻¹ of zinc to the soil, the pigeonpea crop's plant height rose [26]. The stem height rose as a result of zinc activating certain enzymes that play important roles in cell division and lengthening [27]. According to Habbasha et al. [28], applying 0.2% ZnSO₄ to chickpeas at the seed filling stage results in noticeably taller plants (81.43 cm). Given their significance in respiration, photosynthesis, and other biochemical and physiological activities, as well as their role in boosting yields [29,30], zinc and iron may be beneficial when applied topically, which is consistent with the findings of the current study.

Table 3 shows the response of *Vicia faba* to irrigation with tap water and gray water, foliar application of zinc and iron, and their interactions on leaf area. The data indicate that irrigation with tap water resulted in a significant ($P \leq 0.05$) increase in average leaf area (4.21 cm². Plant⁻¹) compared to irrigation with gray water (3.15 cm². Plant⁻¹). Foliar application of zinc also showed a significant effect ($P \leq 0.05$), with the 4% concentration recording the highest average leaf area (3.52 cm². Plant⁻¹). Spraying with iron concentrations also resulted in a significant ($P \leq 0.05$) increase in leaf area, with 2% and 4% iron concentrations producing the highest averages (2.91 and 3.35 cm². Plant⁻¹, respectively) compared to the control treatment (no iron application), which recorded 3.49 cm. Regarding two-way interactions, Table (2) shows that the interaction between irrigation water type and zinc spray indicates that the highest average leaf area (3.67 cm². Plant⁻¹) was recorded with tap water irrigation and 4% zinc spray, while the lowest average (3.17 cm) was recorded with gray water irrigation and 4% zinc spray. The interaction between irrigation water type and iron spray, as shown in Table (3), indicated that tap water irrigation with 4% iron spray gave the highest average leaf area (12.76 cm². Plant⁻¹), while the lowest average (9.34 cm². Plant⁻¹) was recorded with gray water irrigation without iron addition (control sample). As for the interaction between zinc and iron spray, the data in Table (3) indicate that the highest average leaf area (4.15 cm². Plant⁻¹) resulted from 4% zinc spray and 4% iron spray. The lowest average (2.51 cm². Plant⁻¹) was recorded with 2% zinc spray and no iron addition (control sample).

Table (3): Response of *Vicia faba* to two types of irrigation water and spraying with zinc and iron, and their interaction on leaf area (cm². Plant⁻¹).

Water type	Iron concentrations	Zinc concentrations			The effect of the average interaction between the type of
		0	2	4	
Tap	0	2.15	3.17	3.85	3.056
	2	2.05	3.13	3.67	2.95
	4	2.87	3.19	3.26	3.11
Gray	0	2.58	2.95	3.17	2.9
	2	2.41	2.86	3.52	2.93
	4	2.67	3.32	3.17	3.05
The effect of the average zinc		2.89	3.05	3.52	
The effect of the average interaction between water type and zinc					
Water type		Zinc concentrations			Impact of average irrigation water
		0	2	4	
Tap		2.89	4.62	5.11	4.21
Gray		3.61	3.03	2.81	3.15
The effect of the average interaction between zinc and iron					

iron concentrations	Zinc concentrations			Effect of average iron concentrations
	0	2	4	
0	2.85	3.67	3.94	3.49
2	2.51	2.94	3.27	2.91
4	2.73	3.18	4.15	3.35

According to the current study, zinc and iron cause plants to grow longer. According to Togay et al. [31], molybdenum enhanced the number of leaves and pods per plant. Zn treatment increased leaf area and pod number plant⁻¹, according to Valenciano et al. [32]. Ram and Katiyar [23] discovered that "mungbean's leaf area and seed number significantly improved when 10 kg Zn ha⁻¹ was applied." According to a publication, micronutrient foliar spraying enhanced the number of pods per plant and the leaf area in lentils, which is consistent with our findings [33], which is consistent with the findings of the current study.

Table 4 shows the response of *Vicia faba* to irrigation with tap water and gray water, foliar application of zinc and iron, and their interactions on chlorophyll content. The data indicate that irrigation with tap water resulted in a significant increase ($P \leq 0.05$) in the average chlorophyll content (10.6 CCI) compared to irrigation with gray water (9.61 CCI). Foliar application of zinc also showed a significant effect ($P \leq 0.05$), with the 4% concentration recording the highest average chlorophyll content (12.39 CCI). Spraying with iron concentrations also resulted in a significant increase ($P \leq 0.05$) in chlorophyll content, with 4% and 2% iron concentrations producing the highest averages (10.74 and 11.3 CCI, respectively) compared to the control treatment (no iron application), which recorded 10.5 CCI. Regarding two-way interactions, Table (4) shows that the interaction between irrigation water type and zinc spray indicates that the highest average chlorophyll content (13.27 CCI) was recorded with tap water irrigation and 4% zinc spray, while the lowest average (10.51 CCI) was recorded with gray water irrigation and 4% zinc spray. The interaction between irrigation water type and iron spray, as shown in Table (4), indicated that tap water irrigation with 4% iron spray gave the highest average chlorophyll content (3.11 CCI), while the lowest average (2.9 CCI) was recorded with gray water irrigation without iron addition (control sample). As for the interaction between zinc and iron spray, the data in Table (4) indicate that the highest average chlorophyll content (12.67 CCI) resulted from 4% zinc spray and 2% iron spray. The lowest average (9.71 CCI) was recorded when no zinc spray was applied and 2% iron was added (control sample).

Table (4): Response of *Vicia faba* to two types of irrigation water and spraying with zinc and iron, and their interaction on chlorophyll content (CCI).

Water type	Iron concentrations	Zinc concentrations			The effect of the average interaction between the type of
		0	2	4	
Tap	0	11.41	12.64	13.27	12.44
	2	10.95	12.51	12.34	11.93
	4	11.58	10.53	11.95	11.35
Gray	0	10.52	9.85	10.67	10.34
	2	11.04	11.63	12.04	11.57
	4	10.72	9.92	10.51	10.38
The effect of the average zinc		11.18	11.84	12.39	
The effect of the average interaction between water type and zinc					
Water type		Zinc concentrations			Impact of average irrigation water
		0	2	4	
Tap		9.51	10.45	11.84	10.6
Gray		9.14	9.62	10.07	9.61
The effect of the average interaction between zinc and iron					
iron concentrations		Zinc concentrations			Effect of average

	0	2	4	iron concentrations
0	10.05	10.22	11.24	10.5
2	9.71	11.52	12.67	11.3
4	10.82	11.28	10.12	10.74

According to the current study, zinc and iron cause elevated in the chlorophyll. Perhaps the reason for increasing total chlorophyll is due to the effective role of both zinc and iron, especially iron, due to its role in the synthesis of chlorophyll pigment [34].

Table 5 shows the response of *Vicia faba* to irrigation with tap water and gray water, foliar application of zinc and iron, and their interactions on protein content. The data indicate that irrigation with tap water resulted in a significant increase ($P \leq 0.05$) in the average protein content (21.62 cm) compared to irrigation with gray water (20.78 cm). Foliar application of zinc also showed a significant effect ($P \leq 0.05$), with the 4% concentration recording the highest average protein content (23.89 cm). Spraying with iron concentrations also resulted in a significant increase ($P \leq 0.05$) in plant height, with 4% and 2% iron concentrations achieving the highest averages (20.11 and 21.46 cm, respectively) compared to the control treatment (without iron application), which recorded 22.45 cm. Regarding two-way interactions, Table 5 shows that the interaction between irrigation water type and zinc spray indicates that the highest average protein content (26.14 cm³) was recorded with tap water irrigation and 4% zinc spray, while the lowest average (23.51 cm³) was recorded with gray water irrigation and 4% zinc spray. The interaction between irrigation water type and iron spray, as shown in Table 5, indicated that gray water irrigation with 4% iron spray gave the highest average protein content (28.16 cm³), while the lowest average (19.98 cm³) was recorded with tap water irrigation without iron addition (control sample). As for the interaction between zinc and iron spray, the data in Table 4 indicate that the highest average protein content (23.51 cm³) resulted from 2% zinc spray and 2% iron spray. The lowest average (19.46 cm³) was recorded when no zinc spray and 2% iron were added (control sample).

Table (5): Response of *Vicia faba* to two types of irrigation water and spraying with zinc and iron, and their interaction on protein content (CCI).

Water type	Iron concentrations	Zinc concentrations			The effect of the average interaction between the type of
		0	2	4	
Tap	0	19.48	21.95	18.52	19.98
	2	18.41	19.44	22.45	20.1
	4	20.67	20.95	21.52	21.04
Gray	0	24.11	25.21	26.14	25.15
	2	27.35	28.91	24.12	26.79
	4	31.52	29.45	23.51	28.16
The effect of the average zinc		19.36	23.12	23.89	
The effect of the average interaction between water type and zinc					
Water type		Zinc concentrations			Impact of average irrigation water
		0	2	4	
Tap		19.41	22.51	20.43	20.78
Gray		18.52	24.17	22.18	21.62
The effect of the average interaction between zinc and iron					
iron concentrations		Zinc concentrations			Effect of average iron concentrations
		0	2	4	
0		21.29	20.75	22.41	21.48
2		19.46	23.51	21.41	21.46
4		20.67	20.12	19.53	20.11

in current study, zinc and iron lead to raised the protein content plant, Zinc treatment to the leaves led to greater levels of protein as a result of better physiological characteristics and protease enzyme activity Usman and colleagues [35], Lokhande and colleagues [36], and Nandan and colleagues [37]. Additionally, Singh and Singh [38] observed that applying 10 kg of zinc per hectare increased the protein content of chickpea grain by 20.2%. In their study on zinc application in chickpeas, Khrogamy and Farnia [39] found that applying ZnSO₄ 20 kg ha⁻¹ increased the protein content of the legumes by 24.02%. According to Imsande [40], iron plays a crucial part in the production of chlorophyll and aids in the absorption of other nutrients. Oguz [41] found that "the protein content in chickpeas was significantly affected by increasing Mo application up to 6 g kg⁻¹." "The combined application of 5.5 kg Zn ha⁻¹ + 0.1% Zn as foliar spray improved the seed crude protein content by 26.9% over control," according to Roy et al. [42]. In line with the findings of the present investigation, Sharma et al. [43] [46] revealed that the application of chelated iron (1 or 2 kg ha⁻¹) significantly increased the protein content in seed and all yied.

Conclusions

The study indicates the importance of appropriate combinations of irrigation water quality and foliar treatments to improve the growth and productivity of *Vicia faba*.

References

1. Khalil, N.A.; Metwally, A.M.; Magdy, M.S. and Morshedi, O.A. (2015). Cereal crops and pulses. Faculty of Agriculture. Cairo University. 186.
2. Chafi, M.H. and Bensoltane, A. (2009). A source of organic and biological manure for the arid region(*Vicia faba* L.). World J. Agric. Sci., 5(6): 698-706.
3. Hassan, R.K. (2019). Effect of the concentrations and dates of leave fertilization in the growth and yield of two varieties of Broad Bean. Master Thesis, Al-Musaib Technical College At Al-Furat Al-Awsat Technical University In Partial Fulfillment.
4. Singh, A.K., N. Chandra, R.C. Bharati and S.K. Dimree (2010) Effect of seed size and seeding depth on Fava bean (*Vicia faba* L.) productivity. Environmental Ecology, 28(3A), 1722-1527.
5. Natalia Gutierrez, C.M. Avila., M.T. Moreno and A.M. Torres (2008). Development of SCAR markers linked to *zt-2*, one of the genes controlling absence of tannins in faba bean. Aust. J. of Agric. Res., 59, 62-68.
6. Carmen, M.A., Z.J. Carmen, S. Salvador, N. Diego, R.M. Maria Teresa and T. Maria (2005). Detection for agronomic traits in faba bean (*Vicia faba* L.). Agric. Conspec. Sci., 70(3), 17-20.
7. Mona, A.M., M.A. Sabah and A.M. Rehab (2011). Influence of potassium sulfate on faba bean yield and quality. Australian Journal of Basic and Applied Sciences, 5(3), 87-95.
8. Havlin, J.L., J.D. Beaton, S.L. Tisdale and W.L. Nelson (1999). Soil Fertility and Fertilizers: 6th Edition. Prentice Hall. Upper Saddle River, NJ.
9. Deshmukh MS, Zade SP, Gourkhede PH, Inamke PS. Effect of high-p-chelated micronutrient foliar spray on yield and quality of Chickpea. International Journal of Tropical Agriculture, 2017;35(3):707- 712.
10. Kerkeb L, Connolly E. Iron transport and metabolism in plants. J. Gent. Eng. 2006; 27:119-140.
11. Katyal JC, Randhawa NS. Micronutrient. F.A.O. Fertilizer and plant nutrition. Bulletin No. 7. United Nation; 1983.

12. Yashona DS, Mishra US, Aher SB. Response of pulse crop to sole and combined mode of zinc application. *Journal of Soils and Crops*. 2018;28(2): 249–258
13. Kudi S, Swaroop N, David AA, Thomas T, Hasan A, Rao S. Effect of different levels of sulphur and zinc on soil health and yield of Greengram (*Vigna radiata* L.) Var. Patidar111. *Journal of Pharmacognosy and Phytochemistry*. 2018;7(3):2271–2274.
14. Patel MM, Patel IC, Patel RI, Acharya S. Effect of Zinc and Iron on yield and yield attributes of rainfed cowpea (*Vigna unguiculata* L. Walp). *Annals of Arid Zone*. 2011;50(1):17–19.
15. Ali A, Ahmad B, Hussain I, Ali A, Shah FA. Effect of phosphorus and zinc on yield of lentil. *Pure and Applied Biology*. 2017;6(4): 1397–1402.
16. Brown PH, Cakmak I, Zhang Q. Form and function of zinc in plants. Chap. 7, In A.D. Robson (Ed). *Zinc in Soils and Plants*, Kluwer Academic Publishers, Dordrecht. 1993;90-106.
17. Alloway BJ. *Zinc in Soils and Crop Nutrition*. Publ. of International Zinc Association; 2004. Available:http://www.iza.com/Documents/Communications/Publications/ALLOWAY_PRINT.pdf
18. Herbert D, Knecht E. A method for the estimation of protein content. *Biochemical Journal*. 1971;121(4):711–720.
19. Baskaran L, Sundaramoorthy P, Chidambaram ALA, Ganesh KS. Growth and physiological activity of greengram (*Vigna radiata* L.) under effluent stress. *Botanical Research International*. 2009;2:107-114.
20. Ahmed K.O., Saleh A.H. Effects of Estrogen in Treating Myocardial Damages Caused by Ischemia in Adult Female Rats. *International Journal of Drug Delivery Technology*, 2021; 11(4): 1474–1477.
21. Saleh A.H., Aldulaimi L.H., Ahmed N.M. Potential of nanoemulsion of spiramycin in alleviating histological and embryonic changes in Swiss albino mice infected with congenital toxoplasmosis. *Journal of Applied and Natural Science*, 2024; 16(4): 1842–1848.
22. Alam MK, Uddin MM, Ahmed M, Latif MA, Rahman MM. Growth and green pod yield of garden pea varieties under different nutrient levels. *Journal of Agroforestry and Environment*. 2010;4(1):105–107.
23. Ram S, Katiyar TPS. Effect of sulphur and zinc on the seed yield and protein content of summer mungbean under arid climate. *Int. J. Sci. Nature*. 2013;4(3):563- 566.
24. El Sayed Hamed EA, Amen El-Sh A, ElMorsy AH, Tolba MH. Effects of foliar spraying with microelements and different fertilizer sources on quality and yield of *Pisum sativum* L. plant. *International Research Journal of Agricultural Science and Soil Science*. 2012;21(1):17–24.
25. Basavarajeswari. Expression profiling of zinc transporter genes in tomato grown under different concentrations of zinc. *International Journal of Microbiology Research*. 2018;10(6):1252-1255.
26. Dube BK, Sharma CP, Chatterjee C. Response of Pigeonpea to Applied Zinc in Ustifluent Soils of Western Uttar Pradesh. *J. Indian Soc. Soil Sci*. 2001;49(3):471- 475.
27. Seifi Nadergholi M, Yarnia M, Rahimzade Khoei F. Effect of zinc and manganese and their application method on yield and yield components of common bean (*Phaseolus vulgaris* L. CV. Khomein). *Middle-East Journal of Science and Research*. 2011; 8(5):859-865.

28. Habbasha SF, Mohamed MH, Abd ElLateef EM, Mekki BB, Ibrahim ME. Effect of combined zinc and nitrogen on yield, chemical constituents and nitrogen use efficiency of some chickpea cultivars under sandy soil conditions. *World J. Agric. Sci.* 2013;9(4):354-360.
29. Rietra RP, Heinen M, Dimkpa CO, Bindraban PS. Effects of nutrient antagonism and synergism on yield and fertilizer use efficiency. *Communications in Soil Science and Plant Analysis.* 2017;48: 1895–1920.
30. Khan MMH, Ahmed N, Naqvi SAH, Ahmad B, Dawar K, Rahie AA, Danish S. Synchronization of zinc and boron application methods and rates for improving the quality and yield attributes of *Mangifera indica* L. on sustainable basis. *Journal of King Saud University – Science.* 2022;34(8):102280
31. Togay Y, Togay N, Dogan Y. Research on the effect of phosphorus and molybdenum applications on the yield and yield parameters in lentil (*Lens culinaris Medic.*). *African Journal of Biotechnology.* 2008; 7(9):1256–1260
32. Valenciano JB, Miguélez-Frade MM, Marcelo V, Reinoso B. Response of irrigated common bean (*Phaseolus vulgaris*) yield to foliar zinc application in Spain. *New Zealand Journal of Crop and Horticultural Science.* 2010;35(3):325-330.
33. Zeidan MS, Hozayn M, Abd-El-Salam MEE. Yield and quality of lentil as affected by micronutrient deficiencies in sandy soils. *Journal of Applied Sciences Research.* 2006;2(12):1342- 1345.
34. AL-Hasany, A. R. K. (2018). Effect of foliar nutrition of proline and mixture of nutrients on growth and yield of different varieties of Broad Bean (*Vicia faba* L.). Ph.D. Thesis, Fac. of Agric. Univ of Muthanna, Iraq
35. Usman M, Tahir M, Majeed MA. Effect of zinc sulphate as soil application and seed treatment on greengram (*Vigna radiata* L.). *Pakistan Journal of Life and Social Sciences.* 2014;12(2):87-91.
36. Lokhande PB, Indulkar BS, Vaidya PH, Padghan AD, Wagh CB, Ingole AJ, Patil NM, Aundhkar A. Effect of phosphorus and zinc on yield and quality of greengram (*Vigna radiata* L.) in inceptisol. *International Journal of Engineering Science and Computing.* 2018;8(7):18647- 18649.
37. Nandan B, Sharma BC, Chand G, Bazgalia K, Kumar R, Banotra M. Agronomic fortification of Zn and Fe in chickpea an emerging tool for nutritional security - A global perspective. *Acta Scientific Nutritional Health.* 2018;2(4):12-19.
38. Singh G, Sekhon HS, Harpreet Kaur. Effect of farmyard manure, vermicompost and chemical nutrients on growth and yield of chickpea (*Cicer arietinum* L.). *Int. J. Agric. Res.* 2012;7(2):93-99.
39. Khorgamy A, Farina A. Effect of phosphorus and zinc fertilisation on yield and yield components of chick pea cultivars. *African Crop Science Conference Proceedings.* 2009;9:205-208.
40. Imsande J. Iron, sulphur and chlorophyll deficiencies: A need for an integrative approach in plant physiology. *Plant Physiology.* 1998;103:139-144.
41. Oguz F. Research on the effects of different levels Molybdenum application on the yield and some yield components in Chickpea varieties on dry and irrigation conditions. M.Sc. Thesis, YuzuncuYil University Van, Turkey (unpublished); 2004.

42. Roy PD, Narwal RP, Malik RS, Saha BN, Kumar S. Impact of zinc application methods on green gram (*Vigna radiata* L.) productivity and grain zinc fortification. *J. Environ. Biol.* 2014;35(5): 851-855.
43. Sharma A, Nakul HT, Jelgeri BR, Surwenshi A. Effect of micronutrients on growth, yield and yield components in pigeon pea (*Cajanus cajan* L.). *Res. J. Agric. Sci.* 2010;1:142-144.
44. Palani, P. M. R. (2025). Residential Crisis in Iraq: The Current Trends and Future Prospectus: A Review. *Spanish Journal of Innovation and Integrity*, 38, 121–128.
45. Rafiq, E., & Al-Jobouri, K. (2020). The effect of humic acid and foliar spray with iron and zinc on the characteristics of three genotypes of *Vicia faba* L.. *Kirkuk University Journal for Agricultural Sciences*, 11(3), 75-87. doi: 10.58928/ku20.11309
46. Al- Baytiel, M., & Aljabary, A. (2019). Physiological role of Pruning, Fertilization with Humic Acid and Spraying with Gibberellic Acid in Mineral Content of Grapevine Bea-denk cultivars *Vitis vinifera* L.. *Kirkuk University Journal for Agricultural Sciences*, 10(2), 48-57. doi: 10.58928/ku19.10206