

Article

The Impact of Incorporating Humic Acid and Poultry Manure Fertilizer on the Growth and Yield of Kale Plants

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Abstract: The research aimed to investigate the effects of humic acid and poultry manure on the growth and yield of kale plants throughout the growing season. Two concentrations of humic acid (4 and 6 g L⁻¹) and two levels of poultry manure (100 and 200 g m⁻²), in addition to the control, were used. The findings revealed notable variations in the vegetative, quantitative, and qualitative traits of kale plants in response to humic acid. The incorporation of 6 g L⁻¹ humic acid markedly enhanced all vegetative and quantitative traits, including leaf weight, leaf count, average yield per plant, and total yield, which were recorded at 8.55 g, 30.87 leaves per plant, 265.9 g per plant, and 10.63 tons ha⁻¹, respectively. The application of poultry manure at a rate of 200 g m² significantly influenced all vegetative and quantitative traits, including leaf weight, leaf count, average yield per plant, and total yield, except leaf chlorophyll content, which measured 9.55 g, 30.90 leaves per plant, 299.3 g per plant⁻¹, and 11.93 tons per hectare, respectively. The interaction outcomes revealed substantial disparities in the examined characteristics. The two-way interaction treatment (6 g L⁻¹ humic acid and 200 g m² poultry manure) significantly enhanced the majority of vegetative, quantitative, and qualitative attributes of kale, including leaf weight, leaf count, average yield per plant, total yield, and percentages of NPK, protein, and vitamin C, in contrast to the control treatment, which exhibited the lowest values, as well as the other treatments..

Keywords: Kale, Crop Production, Organic Fertilizer

Introduction

Kale (*Brassica oleracea* var. *sabellica*) is a member of the Brassicaceae family, generally referred to as curly cabbage or kale. This winter vegetable, native to Turkey, holds significant economic importance and is consumed globally [1]. It was ranked 14th among 47 potent fruits and vegetables associated with a decreased risk of heart disease and other ailments [2]. Kale is rich in minerals, fiber, proteins, and vitamins, including vitamin A, vitamin C, niacin, riboflavin, iron, calcium, and iodine. Sixty-seven grams of kale provides seven times the recommended daily allowance of vitamin K, along with 3 grams of protein, 6 grams of carbs, 2 grams of fiber, and 33 calories [3]. The use of natural and safe substitutes for mineral

fertilizers, such as extracts and organic fertilizers, aims to enhance plant growth and quality while increasing total yield through soil incorporation or foliar application on vegetable crops [4], [5].

The use of humic compounds and their acids, including humic acid, with plant and seaweed extracts, constitutes a kind of organic nutrition [6], [7]. Research by Abd Al-Hseen and Manea [8] showed that organic fertilizers and extracts, including humic acid, amino acids, and seaweed extract, significantly enhanced the growth and yield of vegetable crops compared to the control treatment. Ali [9] illustrated the impact of various organic extracts and fertilizer sources on the chemical parameters of the harissa plant, revealing considerable disparities relative to untreated controls. Ali [9] conducted a field experiment on cabbage plants using various organic fertilizers, revealing that the incorporation of granular humic acid significantly enhanced plant height and relative leaf chlorophyll content, measuring 20.77 cm and 55.73 SPAD, respectively.

The bidirectional interaction between poultry manure combined with amino acid spraying, compared to the absence of amino acid spraying, surpassed the control treatment and other treatments in leaf vitamin C concentrations (484.6 and 472.1 mmol/L fresh weight). The reciprocal interaction between poultry dung and seaweed produced a total of 29.98 tons per hectare. The findings of research by Al-Gubouri [4] indicated that the Folozyme + Humic treatment surpassed the nitrogen content in leaves (2.793%) and the phosphorus content in leaves (0.703%). The Biohealth + Humec treatment enhanced the iron content to 194.2 mg kg⁻¹ dry weight and the zinc content in leaves to 97.22 mg kg⁻¹ dry weight. Fadhlurohman [10] discovered that humic acid treatment enhanced leaf height, leaf area, chlorophyll levels, vitamin C content, yield, and polyphenol concentration in both cultivars.

The incorporation of organic fertilizers into soils enhances their characteristics, resulting in medium texture, improved permeability, and increased capacity for water and moisture retention. It stimulates soil aeration, promotes beneficial bacterial activity, and facilitates essential air exchange, thereby activating biological processes in soil organisms. All of these mechanisms are vital for the decomposition and transformation of nutrients into water-soluble components. Consequently, plants may assimilate them through their roots, leading to the production of superior, dependable products for customers [11]. Ali [9] demonstrated that the application of granulated humic acid (75 g per plant) significantly enhanced plant height and nutrient content. The relative chlorophyll content in leaves was 20.77 cm and 57.95, respectively. The application of processed poultry manure (75 g per plant) considerably enhanced the percentage of dry matter in leaves, leaf width, and carbohydrate content by 19.69%, 13.188 cm, and 17.86 mg 100 g, respectively. The experiment conducted by Verruma Bernardi [12] showed that the treatment with poultry manure yielded the most outstanding overall output of 28.997 tons ha⁻¹, compared to the control treatment. The findings of Al-Hussainy and Manea [13] indicated that organic fertilization using rice and poultry manure did not substantially differ from chemical fertilizer in terms of plant height and chlorophyll content.

Materials and Methods

The experiment was conducted in a field at the College of Agriculture, Al-Qasim University, located in Hillah, Babylon, to investigate the impact of humic acid and poultry manure on the development and yield of kale during the winter agricultural season of 2021-2022. The experiment was conducted using a randomized complete block design (RCBD) with three replications. The treatment means were compared using the least significant difference (LSD) test at a significance threshold of 0.05.

The experimental variables were as follows: The first component was the incorporation of humic acid at three concentrations: A1 (control), A2 (4 g/L), and A3 (6 g/L). The second element was the incorporation of poultry manure at two levels: B1 at 100 g/m² and B2 at 200 g/m². The treatment means were analyzed using the least significant difference (LSD) method. At a significance threshold of 0.05 [14]. Random soil samples were collected from several locations before planting, at a depth of 0-30 cm. The

components were amalgamated to create a homogenous sample, thereafter coarsely pulverized, and sieved through a 2 mm diameter mesh for examination to ascertain the physical and chemical characteristics, as shown in Table 1.

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

Characteristics	Standard unit	Values
Soil reaction pH		7.9
Electrical conductivity (EC)	m ³ ds	3.5
Organic matter	g kg ⁻¹	11.3
Available nitrogen	mg kg ⁻¹	13.4
Available phosphorus	mg kg ⁻¹	5.6
Available potassium	mg kg ⁻¹	192.0
Bulk density	g cm ³	1.13
Sand percentage	g kg ⁻¹	155
Silt percentage	g kg ⁻¹	600
Clay percentage	g kg ⁻¹	245
Soil texture		mixed silty clay

* The chemical and physical properties were analyzed at the Muradiyah Laboratory of the Babylon Agriculture Directorate.

Table 2. Components of organic fertilizers used in the experiment.

Chemical Composition	Unit	Poultry Waste Compost	Granulated Humic Acid
Organic Materials	%	65	60-65
Organic Nitrogen	%	4.2	1-1.5
Potassium Oxide	%	2.8	0.3-0.5
Phosphorus	%	3.0	0.2-0.3
Calcium	%	9.0	0.5-1
Magnesium	%	1.0	---
Iron	PPM	---	1.1
pH	%	6.4	5-6
Origin	-	Van Yperen Company	Humintec

The trial field was cultivated with a rotary plough and then smoothed and leveled using a grader. The experimental area was divided into three terraces, each measuring 35 meters in length and 1 meter in width. Each terrace had nine experimental units, each measuring 3 m in length and 1 m in width, resulting in an area of 3 m² per unit. The total number of experimental units was 27, with a spacing of 1 meter between each unit and 1.5 meters between terraces. Seeds of the "Dwarf Green" kale cultivar were planted on September 2, 2022, in cork trays containing peat moss. Upon reaching the 3-4 true leaf stage, the seedlings were relocated to the designated planting and testing area. They were sown on October 13, 2022, in two rows, including 12 seedlings per experimental unit. The distance between each row was 60 cm, while the spacing between each plant was 50 cm. One seedling was inserted into each hole, and a drip irrigation system was used to irrigate the plant. All various agricultural operations, including irrigation, weeding,

and pest control, were carried out identically for all treatments and as necessary throughout the experiment's duration. Eight plants were randomly assigned to each experimental unit for measurements: leaf weight, number of leaves, leaf chlorophyll content, plant yield, total yield, leaf nitrogen, phosphorus, and potassium content, protein content, and leaf vitamin C content.

Results

Leaf Weight (g)

The findings in Table 3 indicate a considerable variation in leaf weight due to the addition of humic acid and poultry manure fertilizer, as well as their interaction. The humic acid spray treatment (A3) yielded a significant superiority over the other treatments, at 8.55 g leaf⁻¹. The poultry manure treatment (B3) achieved the highest average of 9.55 g leaf⁻¹, compared to the different treatments and the control treatment. The interaction treatments A2B3 and A3B3 had the greatest average leaf weights, measuring 9.90 and 10.59 g leaf⁻¹, respectively, surpassing all other treatments, including the control treatment, which had the lowest average at 4.67 g leaf⁻¹.

Number of plant leaves (leaf plant⁻¹)

The findings in Table 3 indicate a substantial variation in the number of plant leaves due to the addition of humic acid, poultry manure fertilizer, and their interaction. Treatment A3 demonstrated a significant increase over the other treatments, yielding 30.87 leaves per plant. Treatment B3 had the highest average leaf count, measuring 30.90 leaves per plant, compared to the different treatments and the control. Treatment A3B3 had the greatest average leaf count, with 33.77 leaves per plant, surpassing all other treatments, including the control, which yielded the lowest average of 21.43 leaves per plant.

Chlorophyll content in leaves (SPAD)

Table 3 indicates that there were no significant variations in leaf chlorophyll content between the application of humic acid and poultry manure fertilizer, nor in their interaction.

Plant yield (g plant⁻¹)

The findings in Table 3 indicate a substantial difference in plant yield between the application of humic acid and poultry manure fertilizer, as well as their interaction. Treatment A3 demonstrated a considerable increase over the other treatments, yielding 265.9 g per plant. Treatment B3 yielded the most substantial meaningful difference, measuring 299.3 g per plant, in contrast to the different treatments and the control, which exhibited the lowest values at 151.7 g per plant. The A3B3 binary interaction treatment yielded the greatest average per plant, at 356.8 g plant⁻¹, surpassing all other treatments, including the control, which had the lowest average at 101.7 g plant⁻¹.

Total yield (tons ha⁻¹)

The findings in Table 3 indicate a substantial difference in total yield between the application of humic acid and poultry manure fertilizer, as well as their interaction. Treatment A3 demonstrated a significant superiority compared to the other treatments, yielding 10.63 tons per hectare. Treatment B3, supplemented with poultry manure, yielded the highest rate at 11.93 tons per hectare. Treatment A3B3 had the most significant overall yield rate of 14.27 tons per hectare, surpassing all other treatments, while the control treatment yielded the lowest at 4.06 tons per hectare. The incorporation of organic fertilizer markedly influenced all vegetative growth characteristics, except leaf chlorophyll concentration. This augmentation may result from the influence of humic acid, which enhances the soil's chemical and physical qualities, fertility, and biological traits. It also influences the exchange capacity, which escalates. The availability of nutrients improves, and the structure and aeration of the soil increase, facilitating easier respiration for roots. The increased soil surface area enhances root development and infiltration into the soil. This enhanced root development is correlated with augmented vegetative growth [15], [16]. This may be attributed to the incorporation of granulated humic acid, known for its capacity to create an acidic

environment and generate chelating compounds that retain cationic ions, crucial for micronutrients. These chemicals sequester cations and shield them from sedimentation. Moreover, the degradation of humic acid in the soil generates carbonic acid, a weak acid that dissociates into H^+ and HCO_3^- ions.

This alters the soil pH and facilitates the dissolution of some insoluble minerals that are not easily accessible for plant uptake, including phosphorus, potassium, magnesium, and calcium. This enhances the availability of micronutrients by lowering the soil solution's pH, facilitating their absorption by the plant. It also enhances physiological processes inside the plant, such as photosynthesis, thereby augmenting plant activity. This leads to a physiological equilibrium in the plant, enhancing its vegetative development [17]. The beneficial impact of organic fertilizers on plant vegetative traits may be attributed to their involvement in improving leaf iron levels, carbohydrate concentration, and vitamin C content. This aligns with the research of Pujiastuti [18] on kale, Uddain [19] on radish, Al-Hussainy and Manea [13] on broccoli, and Verruma-Bernardi [12] on kale, which demonstrated enhancement and augmentation of vegetative growth traits through the application of organic fertilizers.

Table 3. Impact of humic acid and poultry manure application, together with their interactions, on the vegetative growth traits and yield of kale.

Treatment	Leaf weight g leaf	Number of leaves leaf plant ⁻¹	Chlorophyll content in leaves	Yield per plant g plant ⁻¹	Total yield tons h ⁻¹
A1 (0)	7.18	25.04	50.8	186.6	7.46
A2 (4 g)	7.82	28.77	58.1	228.9	9.11
A3 (6 g)	8.55	30.87	45.0	265.9	10.63
L.S.D 0.05	1.209	2.995	N.S	37.81	1.550
B1 (0)	5.97	24.90	47.8	151.7	6.06
B2 (100 g m ²)	8.04	28.88	53.1	230.5	9.21
B3 (200 g m ²)	9.55	30.90	53.0	299.3	11.93
L.S.D 0.05	1.209	2.995	N.S	37.81	1.550
A1B1	4.67	21.43	42.0	101.7	4.06
A1B2	8.73	24.79	60.3	219.5	8.77
A1B3	8.15	28.90	50.1	238.8	9.55
A2B1	5.67	26.74	56.4	151.6	6.06
A2B2	7.89	29.55	49.4	232.8	9.31
A2B3	9.90	30.02	68.4	302.3	11.98
A3B1	7.57	26.54	45.0	201.8	8.07
A3B2	7.48	32.28	49.5	239.2	9.56
A3B3	10.59	33.77	40.6	356.8	14.27
L.S.D 0.05	2.095	5.188	26.71	65.49	2.684

Nitrogen Content (%)

The findings in Table 4 indicate a considerable difference in leaf nitrogen content between the application of humic acid and poultry manure fertilizer, as well as their interaction. Treatment A3 demonstrated a substantial increase over the other treatments, with a margin of 2.448%. Treatment B36 showed the most substantial and meaningful difference, at 2.022%, compared to the other treatments and

the control therapy. The A3B3 binary interaction treatment yielded the greatest nitrogen content at 2.733%, surpassing all other treatments, while the control treatment exhibited the lowest rate at 1.117%.

Phosphorus Content (%)

The findings in Table 3 indicate a considerable variation in leaf phosphorus content due to the addition of humic acid and poultry manure fertilizer, as well as their interaction. Treatment A3 showed a significant increase compared to the other therapies, at 0.616%. While treatment B36 recorded the highest considerable difference of 0.519% compared to the remaining treatments and the comparison treatment. The A3B3 dual interaction treatment also recorded the highest content rate of 0.662%, outperforming all treatments and the comparison treatment, which recorded the lowest rate of 0.221%.

Potassium (%)

The results in Table 3 indicate a significant difference in potassium percentage in leaves due to the addition of humic acid and poultry manure fertilizer, as well as their interaction. Treatment A3 exhibited the greatest significant value among all treatments, with a value of 2.383%. In the meantime, the B3 poultry manure addition treatment exhibited the most significant difference, at 2.240%, relative to the other treatments and the control group. The A3B3 dual interaction treatment showed the highest content rate of 2.783%, surpassing all other treatments, while the comparator treatment recorded the lowest rate of 1.150%.

Vitamin C (mg 100g fresh weight)

The results in Table 3 indicate a significant difference in leaf vitamin C content due to the addition of humic acid and poultry manure fertilizer, as well as their interaction. Treatment A3 had a marked superiority over the other treatments, yielding 45.33 mg 100g of fresh weight. Treatment B3 produced the highest level, at 37.11 mg/100g fresh weight, compared to the other treatments and the control treatment. The A3B3 dual interaction treatment also recorded the highest vitamin C content, at 50.67 mg/100 g fresh weight, outperforming all other treatments and the control treatment, which recorded the lowest content, 15.00 mg/100 g fresh weight.

Table 4. Effect of spraying with humic acid and poultry manure fertilizer, and their interactions, on the qualitative characteristics of kale plants.

Treatment	Nitrogen %	Phosphorus %	Potassium %	Vitamin C mg 100 g fresh weight	Protein %
A1 (0)	1.350	0.271	1.380	17.61	8.44
A2 (4 g)	1.939	0.491	2.259	37.11	12.12
A3 (6 g)	2.448	0.616	2.383	45.33	15.30
L.S.D 0.05	0.149	0.039	0.178	2.802	0.934
B1 (0)	1.698	0.401	1.776	29.44	10.61
B2 (100 g m ²)	2.017	0.459	2.007	33.50	12.60
B3 (200 g m ²)	2.022	0.519	2.240	37.11	12.64
L.S.D 0.05	0.149	0.039	0.178	2.802	0.934
A1B1	1.117	0.221	1.150	15.00	6.98
A1B2	1.400	0.283	1.263	17.50	8.75
A1B3	1.533	0.310	1.727	20.33	9.58
A2B1	1.867	0.408	2.117	32.67	11.67
A2B2	2.150	0.481	2.450	38.33	13.44

A2B3	1.800	0.585	2.210	40.33	11.25
A3B1	2.110	0.574	2.060	40.67	13.19
A3B2	2.500	0.612	2.307	44.67	15.62
A3B3	2.733	0.662	2.783	50.67	17.08
L.S.D 0.05	0.258	0.069	0.309	4.854	1.618

Protein%

The results in Table 3 indicate a considerable difference in leaf protein content due to the addition of humic acid and poultry manure fertilizer, as well as their interaction. Treatment A3 showed a significant increase over the other treatments, achieving 15.30%. In contrast, treatments B2 and B3, which included poultry manure, exhibited the most considerable significant differences at 12.60% and 12.64%, respectively, compared to the control treatment. Treatment A3 and B3, by their two-way interaction, yielded the highest protein content at 17.08%, surpassing all other treatments, while the control treatment exhibited the lowest level at 6.98%.

Organic matter serves as a reservoir for plant nutrients, inhibiting the leaching of essential elements necessary for plant growth. It also fosters an ecosystem that promotes beneficial soil organisms, like earthworms. Organic matter undergoes mineralization, releasing substantial quantities of nitrogen, phosphorus, sulfur, and a limited array of micronutrients [20], [21]. Poultry manure is among the most critical animal wastes, providing sufficient nutrients for plant growth [22]. Comparative analyses of poultry manure reveal its efficacy as an organic fertilizer and a significant source of plant nutrients. Poultry manure enhances the physical qualities of soil while simultaneously releasing nutrients [23], [24]. Approximately 30% of the nitrogen in poultry manure exists as urea or ammonium, rendering it readily accessible. The mean primary nutritional composition of poultry is 3.03% nitrogen, 2.63% phosphorus, and 1.4% potassium. It is advisable to use 15 tons of poultry manure daily to enhance vegetable harvests.

The use of humic extract enhanced the levels of nitrogen, phosphorus, potassium, protein, and vitamin C. This may be attributed to humic's function in providing the soil with vitamins and minerals, particularly iron. It also enhances the permeability of cell membranes and expedites nutritional absorption [25], [26]. It enhances plant and root development, augments microbial activity and nutrient availability in the soil, and improves soil water retention, hence fostering plant growth. It additionally promotes plant hormonal activity and affects the production of proteins and vitamins [27], [28]. This aligns with the findings of Saber [29] about radish plants, which highlighted the impact of organic extracts on the concentration of chemical markers within the plant. The beneficial, notable effects of organic fertilizers can be ascribed to the water-soluble organic compounds they encompass, derived from many sources, including sugars, proteins, amino acids, and both humic and non-humic organic acids. All of these compounds contribute, either directly or indirectly, to plant growth and development. They can either promote growth via enzymatic or hormonal mechanisms, as they possess essential nutrients for the plant, or they can enhance the availability of existing soil nutrients by optimizing pH, resulting in improved plant productivity, which is directly manifested in heightened overall production [30], [31].

Discussion

This study recommends the application of 6 g/L of humic acid and 200 g/L of poultry manure, as well as their combination, due to their marked superiority in all examined vegetative, quantitative, and qualitative traits. We advocate for the growth and dissemination of this crop in Iraq owing to its considerable nutritional and therapeutic benefits.

Conclusion

The results demonstrated that humic acid and poultry manure significantly improved the growth, yield, and nutritional quality of kale. The combined application of 6 g/L humic acid and 200 g/m² poultry manure (A3B3) produced the best overall results, including the highest total yield of 14.27 tons/ha, leaf nitrogen content of 2.733%, phosphorus content of 0.662%, potassium content of 2.783%, vitamin C content of 50.67 mg/100 g fresh weight, and protein content of 17.08%. However, leaf chlorophyll content was not significantly affected by the treatments. Therefore, the combined application of humic acid and poultry manure is recommended to improve kale productivity and quality, supporting its wider cultivation in Iraq.

References

- [1] J. Di Noia, "Defining powerhouse fruits and vegetables: A nutrient density approach," *Prev. Chronic Dis.*, vol. 11, Art. no. E95, 2014.
- [2] M. Działo, J. Mierziak, U. Korzun, M. Preisner, J. Szopa, and A. Kulma, "The potential of plant phenolics in prevention and therapy of skin disorders," *Int. J. Mol. Sci.*, vol. 17, no. 2, Art. no. 160, 2016.
- [3] K. Gunnars, "10 health benefits of kale," Healthline, 2018. [Online]. Available: <https://www.healthline.com/nutrition/10proven-benefits-of-Kale>. [Accessed: Nov. 3].
- [4] M. N. Al-Gubouri, A. I. Manea, and Z. K. Al-Mussawi, "The role of biostimulants and organic extracts in the qualitative," *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 1262, Art. no. 042023, 2023, doi: 10.1088/1755-1315/1262/4/042023.
- [5] M. S. M. Al-Baldawy, H. A. Abd Ali, and H. M. Khaeim, "Antifungal inhibitory activity of *Thymus vulgaris* L. and *Artemisia herba-alba* powder and its constituent phytochemicals against *Aspergillus ochraceus* and *Fusarium graminearum* growth," *Plant Arch.*, vol. 19, no. 1, pp. 801–804, 2019.
- [6] A. I. Manea, "Fertilizer type on cabbage growth and yield," *Int. J. Veg. Sci.*, vol. 23, no. 6, pp. 567–574, 2017.
- [7] L. Alabadi, W. S. A. Alawsy, H. M. Khaeim, and A. H. AL-Hadithy, "Utilization of treated wastewater in irrigation and growth of *Jatropha* plant to protect the environment from pollution and combating desertification," *Plant Arch.*, vol. 18, no. 2, pp. 2429–2434, 2018.
- [8] Z. E. Abd AL-Hseen and A. I. Manea, "Effect of bio fertilizer and extracts in two hybrids of cauliflower (*Brassica oleracea* var. *botrytis*)," *Int. J. Agric. Stat. Sci.*, vol. 16, suppl. 1, pp. 1651–1659, 2020.
- [9] N. F. Ali, A. I. Manea, and W. M. Laftta, "Effect of spraying with organic extracts and adding organic fertilizers on the growth and yield of kale plant (curly cabbage)," *Int. J. Agric. Stat. Sci.*, vol. 18, pp. 2135–2145, 2022.
- [10] M. F. Fadhllurohman, E. Prok amasiningsih, and N. D. Sasongko, "Growth and polyphenols content of kale in growing media with humic acid addition," *J. Ilm. Biol. Unsoed*, vol. 4, no. 2, pp. 109–115, 2022.
- [11] A. G. Gunesh Gurkan, *Organic Living Healthy Living*. Cairo, Egypt: Nile Arab Group for Publishing, 2020, pp. 68–12.
- [12] M. R. Verruma-Bernardi, D. M. Pimenta, G. R. Evreo, V. A. Fortl, S. D. S. Medeiros, S. R. Ceccato-Antoninl, E. A. Covre, M. D. Ferreira, R. Moret, A. C. Bernardi, and F. C. Sala, "Yield and quality of curly kale grown using organic fertilizers," *Hortic. Bras.*, vol. 39, pp. 112–121, 2021.

- [13] E. J. Al-Hussainy and A. I. Manea, "Effect of planting distance and organic fertilization on growth and yield of broccoli (*Brassica oleracea* var. *italica*)," *Euphrates J. Agric. Sci.*, vol. 11, no. 4, pp. 13–21, 2019.
- [14] M. M. Al-Sahouki and K. M. Wahib, *Applications in Experimental Design and Analysis*. Baghdad, Iraq: Ministry of Higher Education and Scientific Research, University of Baghdad, Dar Al-Hikma for Printing and Publishing, University of Mosul, 1990.
- [15] J. Y. A. Al-Tamimi, "Study of the factors affecting the biological fixation of atmospheric nitrogen in leguminous vegetable plants," Ph.D. dissertation, College of Agriculture, Univ. Baghdad, Ministry of Higher Education and Scientific Research, Republic of Iraq, 1998.
- [16] S. Omar, R. Abd Ghani, H. Khaeim, A. H. Sghaier, and M. Jolánkai, "The effect of nitrogen fertilization on yield and quality of maize (*Zea mays* L.)," *Acta Aliment.*, vol. 51, no. 2, pp. 249–258, 2022, doi: 10.1556/066.2022.00022.
- [17] J. Y. A. Al-Tamimi and T. S. A. Al-Douri, "The effect of micronutrient spraying on the growth, chemical content, and active substance of celery (*Apium graveolens* L.)," in *Proc. 7th Sci. Conf., Dept. Life Sci., College of Education, Tikrit Univ.*, Iraq, 2012.
- [18] E. Pujiastuti, J. R. Tarigan, E. Sianturi, and B. B. Ginting, "The effect of chicken manure and beneficial microorganisms of EM-4 on growth and yield of kale (*Brassica oleraceae acephala*) grown on Andisol," in *Proc. Int. Conf. Agribusiness, Food and Agro-Technology, IOP Conf. Ser.: Earth Environ. Sci.*, vol. 205, 2018.
- [19] J. Uddain, S. Chowdhury, and M. J. Rahman, "Efficacy of different organic manures on growth and productivity of radish (*Raphanus sativus* L.)," *Int. J. Agric. Environ. Biotechnol.*, vol. 3, no. 1, pp. 1–5, 2019.
- [20] S. Kumazr, K. D. Prosanta, A. Bipradas, and Abdul Mannan, "Yield performance of cabbage under different combinations of manures and fertilizers," *World J. Agric. Sci.*, vol. 11, no. 6, pp. 411–422, 2015.
- [21] H. W. Al-Juthery, A. H. Hassan, F. K. Kareem, R. F. Musa, and H. M. Khaeim, "The response of wheat to foliar application of nano-micro nutrients," *Plant Arch.*, vol. 19, no. 2, pp. 827–831, 2019.
- [22] T. Y. Reddy and G. H. Reddi, *Principles of Agronomy*, 2nd ed. New Delhi, India: Kalyani Publishers, 1995, p. 223.
- [23] S. Sunassee, "Use of litter for vegetable production," in *Proc. AMAS 2001*, Food and Agricultural Research Council, Reduit, Mauritius, 2001, pp. 259–263.
- [24] Z. Kende, P. Piroška, G. E. Szemők, H. Khaeim, A. H. Sghaier, C. Gyuricza, and Á. Tarnawa, "Optimizing water, temperature, and density conditions for in vitro pea (*Pisum sativum* L.) germination," *Plants*, vol. 13, no. 19, Art. no. 2776, 2024, doi: 10.3390/plants13192776.
- [25] M. Kaya, M. Atak, K. M. Knawar, C. Y. Ciftici, and S. Ozcan, "Effect of presowing seed treatment with zinc and foliar spray of humic acid on yield of common bean (*Phaseolus vulgaris* L.)," *Int. J. Agric. Biol.*, vol. 7, no. 6, pp. 875–878, 2005.
- [26] A. K. Ali Al-Husseni, L. A. Sagban Alabadi, and H. M. Khaeim, "Chemical and mineralogical nature of the sediments of Sawa Lake in Muthanna Governorate, Southwestern Iraq," *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 735, no. 1, Art. no. 012054, 2021.
- [27] R. H. Faust, *Humate and Humic Acid Agriculture User Guide*. Australian Humates: Novaco Marketing and Management Services, 1998.
- [28] B. Bozóki, H. Khaeim, A. H. Sghaier, Z. Kende, Z. Balla, G. Kovács, and C. Gyuricza, "Effect of temperature stress on seed germination and growth index of peanut (*Arachis hypogaea* L.) and chickpea (*Cicer arietinum* L.)," *Res. Crops*, vol. 26, no. 1, pp. 38–45, 2025.

- [29] S. F. Saber, E. J. Adbeeb, and A. D. Khalaf, "A study of the effect of humic acid on the growth and yield of two radish cultivars, *Raphanus sativus* L.," *J. College Agric. Marshes, Dhi Qar Univ.*, vol. 1, no. 6, pp. 178–172, 2017.
- [30] B. W. Murphy, "Impact of soil organic matter on soil properties—a review with emphasis on Australian soils," *Soil Res.*, vol. 53, pp. 605–635, 2015.
- [31] A. A. Waheed, A. A. Dahham, E. K. Azra, J. A. Kamal, and H. M. Khaeim, "Concentrations effect of some salts on growth of *Aspergillus niger* and *Penicillium oxalicum*," *Plant Arch.*, vol. 19, no. 2, pp. 310–312, 2019.