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Effect of Using Different Levels of Commercial Micronutrients Complex and Humic Acid on Some Growth and Yield Attributes of Barley Crop *Hordeum Vulgare* L

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Annotation: A field experiment was carried out of the winter agricultural season 2024-2025 of the winter agricultural season in Shafi'iyya city to know the effect of using a commercial micronutrient mixture and humic acid and their interaction on some growth characteristics and yield of the local barley crop. The experiment was conducted according to factorial experiments with two factors and three replicates. The first factor was spraying with a commercial micronutrient mixture (M0: without spraying, M1: 50 ml/L-1, M2: 100 ml/L-1). The second factor was spraying with humic acid (H0: without spraying, H1: 100 ml/L-1, H2: 150 ml/L-1). The results of the statistical analysis showed that spraying of a commercial micronutrient mixture and humic acid, each separately, recorded significant differences on all studied characteristics such as plant height, spike length, leaf area, number of spikes per plant, weight of 1000 grains, grain yield, and yield. Straw and biological yield As for the interaction between the commercial micronutrient mixture and humic acid, the M2H2 treatment was one of the best experimental treatments, as it exceeded on them significantly and recorded the highest values for all the mentioned traits. Hence, we conclude that the use of the commercial micronutrient mixture and humic acid had a clear effect on the growth performance and yield of local barley.

Keywords: commercial micronutrients complex, Humic acid, Barley crop, growth, yield. Hordeum vulgare L.

Introduction

The cereal crop barley, Hordeum vulgare L. , is a member of the Poaceae family. After rice, wheat, and maize, it is regarded as the fourth most significant crop globally. It is not cultivated in the tropical regions' warm, humid climate. (Goswami and Pandey, 2018) It is among Iraq's most significant grain crops. It is used primarily in most countries of the world as a fodder crop, either as green fodder or its grains are used in concentrated feed mixtures. It is characterized by its rapid growth, high resistance to salinity, and drought tolerance, so most areas of Iraq are suitable in terms of area (Al-Baldawi *et al.* , 2014). The crop requires less water and is more tolerant to salinity and alkalinity than other winter grains (Singh, 2017). In addition to being used as grain in various businesses, barley is also used as green animal feed (Al-Atabi, 2011). In certain dry and/or saline soils, barley is a good substitute due to its high tolerance to drought and salinity. Barley is regarded as a low-yielding crop in Iraq. with a yield of 1. 28 tons per hectare compared to the global average yield of 7. 14 tons per hectare (FAO, 2014). Micronutrients are vital components that plants utilize in trace amounts. In order to protect the health of humans and animals, micronutrients are used to increase the yield and quality of agricultural products. Fertilized plant materials should only be fed when each essential element can fulfill its function of feeding the plant properly, ensuring that the other necessary elements are available to the plant in balanced proportions. (Tavakoli *et al.* , 2014). Plants do not need a lot of them even when all other nutrients are present in sufficient quantities, and a deficiency of any of the micronutrients in the soil can limit plant growth (Singh *et al.* , 2021). Organic compounds called humic acids are essential for enhancing plant development, soil quality, and agricultural standards. Humic acids can be found in soil, lignite, coal, and organic materials. In order to guarantee sustainable agricultural production, humic acid-based products have been utilized in crop production in recent years. The physical, chemical, and biological characteristics of soil, such as its structure, texture, pH, cation exchange capacity, water-holding capacity, soil carbon, enzymes, nitrogen cycle, and nutrient availability, can all be improved by humic acids (Ampong et al. , 2022). The purpose of this study is to determine how the combination of humic acid and microelements affects certain barley growth traits and yield.

Materials and methods

A field test for the winter farming season was carried out. 2024-2025 in the Shafi'iyya city, which is located at 5 km west of AL-Diwaniyah city, about 18 km of the winter season to know the effect of using a commercial micronutrient mixture consisting of (zinc 3%, iron 2%, manganese 1%, boron 0. 5%, amino acids 2%, nitrogen 5%, Tonic 50 ppm, Indole Butyric acid 50 ppm, Naphthyl acetic acid 50 ppm, and gibberellic acid 50 ppm) and humic acid on some growth characteristics and yield of the local barley crop. The experiment was conducted according to factorial experiments with two factors and three replicates. The first factor was spraying with a commercial micronutrient mixture (M0: without spraying, M1: 50 ml/L^{-1}, M2: 100 ml/L^{-1}). The second factor was the application of acid humic spray (H0: no spraying, H1: 100 ml/L-1, and H2: 150 ml/L-1) and how these factors interacted to affect the local barley crop's growth characteristics, yield, and constituent parts. The soil was prepared by plowing, smoothing, and amendment, and then random samples were taken from it to measure some physical and chemical properties based on the methods described by Page *et al.* , (1982) and Black (1965). As shown in Table (1), the field was divided into panels with dimensions of 2×2 m and a distance of 50 cm between each panel and the other. The panel was divided into lines with 15 lines and Each line was 2 meters long, with 20 centimeters separating them from one another. With a seed amount of 100 kg ha-1, the seeds were sown 6 cm deep. At a rate of 80 kg ha-1, phosphate fertilizer was applied in the form of triple calcium superphosphate (46% P2O5). Urea (46% N) was used as nitrogen fertilizer in two batches at a rate of 120 kg ha-1. The first batch was applied after 15 days of planting (germination stage), and the second batch was added 45 days following the first batch. Until the end of the season, hoeing and weeding were done as needed.

Table (1) Some physical and chemical properties of the soil at the experimental location

Traits		Value
E. C (ds/m^{-1})		6 .3
pH		4 .7
Available potassium ($mg.\ kg^{-1}$)		154
Available phosphor ($mg.\ kg^{-1}$)		71 .10
Available nitrogen ($mg.\ kg^{-1}$)		51 .11
Soil separators ($g.\ kg^{-1}$)	clay	481
	silt	354
	sand	153
Soil texture		Silt clay loam

The Studied Traits

Plant Height

Ten plants from each experimental unit were measured for height using a metric ruler, starting from the soil surface and ending at random when the plants reached the blooming stage..

Leaf area (cm^2)

After flowering was finished, the leaf area was determined using the formula Liang et al. (1973) described. Leaf length * leaf width * 0. 75 equals leaf area.

Spike Length

For 10 randomly chosen plants, it was measured by taking the average distance between the base of the spike and the end of the terminal spike, omitting the terminal spike. Number of spikes ($spike.\ m^{-2}$)

When the crop reached full maturity and the number of spikes was determined, a square meter of each experimental unit was randomly taken from the guarded lines.

Weight of 1000 grains (g)

A seed counter was used to randomly count a thousand grains from the yield of a square meter in order to quantify it. Each sample from each experimental unit was then weighed. Grain yield ($tons\ ha^{-1}$)

Each experimental unit's collected square meter was the subject of a manual investigation. The grains were weighed after the straw was separated from them, and the weight of the grains was added to determine the weight of 1000 grains for the same treatment. Then, using 14% moisture, it was transformed from $gm.\ m^{-2}$ to $ton.\ ha^{-1}$.

Biological yield (tons ha⁻¹)

It was calculated from the harvested plants to estimate the grain yield. The entire plants were weighed (grains + straw) and then converted from gm. m^{-2} to ton. ha^{-1}.

Straw yield (tons ha⁻¹)

Straw yield was calculated by subtracting the weight of the grains from the weight of the total biomass.

Result and Discussion

The results of Table (1) show that the spray treatments with different levels of the mixture of micronutrients M1 and M2 had a significant effect (P≤0. 05) on all the studied traits, as they outperformed, especially the M2 level, significantly and recorded the highest values and a significant difference for all the studied traits at the M0 level. The reason for the superiority may be attributed to the fact that most of The micronutrients function as cofactors in numerous enzymes that are involved in the plant's numerous metabolic processes, including photosynthetic activity, protein metabolism, and carbohydrate metabolism. In addition to zinc's ability to act as an electron carrier in the enzyme systems that are in charge of the oxidation and reduction processes that take place in plants, they also contribute to the improvement of the protein content, total dissolved solids, and other quality criteria, which in turn improves the quality and availability of other micronutrients, such as iron, which is necessary for the production of chlorophyll and photosynthesis (Singh et al. , 2021). Suri et al. indicated this. (2011). Considering micronutrients as the building blocks of enzymes as well as enzyme cofactors, they found that there is a significant negative impact on the growth, production, and quality of the crop in general if one or all of the micronutrients are ignored. This opinion was reinforced by Zaib *et al*. (2023), considering micronutrients as essential for regulating nutrient intake, plant metabolism, chlorophyll synthesis, seed development, reproduction, and carbohydrate production. Their impact on the quality of the plant product makes their importance clear, as each element is considered crucial in plants and is responsible for a distinct set of functions, which was reflected in recording the highest values for the studied traits with a significant difference (P≤0. 05) for the M2 level treatment, which came in first place, followed by the M1 level treatment, which was higher than the M0 level treatment ,The results obtained of the M2 level treatment for most of the studied traits were consistent with what was recorded in the results of the study of Khalil *et al*. (2023), as they obtained the highest values for most of the studied traits at a concentration of 400 g/dm^{-1} of spraying with microelement

Table (1) Effect of spraying with a commercial mixture of microelements on some growth characteristics and yield of local barley crop

Treatment	Plant Height (cm)	Leaf area (cm^2)	Spike length (cm)	Spikes number per plant	Weight of 1000 grain (g)	Grain yield (ton/ha^{-1})	Straw yield (ton/ha^{-1})	Biological yield (ton/ha^{-1})
M0	70.12±0.74 c	14.77±0.31 c	9.97±0.22 c	3.71±0.12 c	20.52±0.35 c	1.93±0.08 c	0.84±0.02 b	2.62±0.10 b
M1	73.32±1.49 b	15.87±0.46 b	10.18±0.19 b	4.21±0.21 b	22.72±0.63 b	2.42±0.15 b	0.91±0.01 b	2.91±0.05 b
M2	84.33±1.14 a	19.35±0.46 a	11.92±0.22 a	4.92±0.14 a	29.05±0.68 a	2.81±0.09 a	1.17±0.10 a	3.39±0.16 a

* M0: without spraying, M1: spraying 50 ml/L^{-1} of trace elements, M2: spraying 100 ml/L^{-1} of trace elements.

* Different letters indicate significant differences between experimental treatments within the same column according to Duncan's multiple range test (Duncan,1955).

According to Table (2), the spray treatments with varying levels of humic acid H1 and H2 had a significant (P≤0. 05) impact on the majority of the traits that were studied. For example, the treatment of level H2 was significantly better (P≤0. 05) than the other levels on traits like plant height, spike length, leaf area, number of spikes per plant, weight of 1000 grains, straw yield, and biological yield, and the treatment of level H1 differed significantly from it (P≤0. 05), trailing level H0 in terms of the aforementioned traits. Regarding the grain yield trait, there were no discernible variations (P≤0. 05) between the three levels of treatment (H0, H1, and H2). The reason for the superiority of level H2 significantly (P≤0. 05) over the treatments of the other levels for the above-mentioned traits may be attributed to the roles that humic acids are crucial for raising the amount of addition, since they enhance the soil's texture and structure, its ability to retain water, and its symbiotic organism community, all of which increase the soil's physical and biochemical activity. (Nardi et al. , 2021By binding and co-transporting micronutrients to plants, so boosting the availability of nutrients in the soil, particularly micronutrients. (Yang et al. , 2021), as well as precipitating toxic heavy metals and thus reducing their transport, which reduces the consumption of these materials by the plant (Wu et al. , 2017). Humic acids also stimulate increased growth of field crops by increasing plant growth hormones such as auxin and cytokinin, which help in stress resistance, nutrient metabolism, and photosynthesis (Van Tol de Castro et al. , 2021). This view was supported by what Ampong et al. (2022) and Makan (2022) indicated: that humic acids play a fundamental role in improving soil properties, quality, and fertility by increasing its water retention capacity and stabilizing the structure. Soil and soil symbiont activity and plant physiology also affect nutrient uptake and root structure and act as plant hormones for phosphorus uptake and improved plant adaptation to saline conditions. This opinion was agreed with what Wali et al. (2018) reached when they studied the response of barley varieties to humic acid, minerals and biofertilization. It is also agreed with what was stated in the study of Tahir et al. (2011), who indicated that adding humic acid enhanced wheat growth and nutrient absorption in both calcareous and non-calcareous soils

Table (2) Effect of spraying with humic acid on some growth characteristics and yield of local barley crop

Treatment	Plant Height (cm)	Leaf area (cm^2)	Spike length (cm)	Spikes number per plant	Weight of 1000 grain (g)	Grain yield (ton/ha^{-1})	Straw yield (ton/ha^{-1})	Biological yield (ton/ha^{-1})
H0	72.76±2.10 c	15.55±0.61 c	10.24±0.34 b	4.01±0.24 b	22.40±1.14 c	2.28±0.15	0.87±0.02 b	2.76±0.11 b
H1	74.99±2.12 b	16.55±0.69 b	10.73±0.31 ab	4.35±0.23 ab	23.89±1.29 b	2.32±0.16	0.95±0.04 b	2.98±0.16 ab
H2	80.03±2.35 a	17.89±0.86 a	11.11±0.39 a	4.51±0.21 a	26.00±1.44 a	2.56±0.13	1.10±0.11 a	3.18±0.15 a

*H0: Without spraying, H1: Spraying 100 ml/L^{-1} of humic acid, H2: Spraying 150 ml/L^{-1} of humic acid

* Different letters indicate significant differences between experimental treatments within the same column according to Duncan's multiple range test (Duncan,1955).

The results of Table (3) show that the M2H2 interaction treatment was one of the best interaction treatments, as it significantly outperformed (P≤0. 05) all experimental interaction treatments for all studied traits, as it recorded a value of (88. 52±0. 86) cm for plant height, (20. 95±0. 05) cm^2 for leaf area, (12. 59±0. 27) cm for spike length, (5. 17±0. 16) spikes for number of spikes per plant, (31. 33±0. 66) gm for 1000 grains, (2. 96±0. 03) tons/ha^{-1} for grain yield, (1. 47±0. 20) tons/ha^{-1} for straw yield, and (3. 66±0. 33) tons/ha^{-1} for biological yield. The reason for the M2H2 level's significant (P≤0. 05) superiority over the other level treatments for the traits may be attributed to the above-mentioned combination of commercial micronutrients and humic acid at the highest levels, which reflected the high performance of the plant, which was evident by recording the highest values for the M2H2 treatment for the above-mentioned traits as a result of the synergistic effect of both the commercial micronutrients and humic acid. Rahman *et al.* (2021) indicated that if micronutrients are present in sufficient quantities for the plantplay a significant part in the growth and development of plants, enhancing their metabolism, controlling growth and nutrients, generating carbohydrates, synthesizing chlorophyll, and producing fruits and seeds, among other useful tasks carried out by micronutrients. Additionally, they enhance the physiological, biochemical, and metabolic characteristics of plants, whereas their absence encourages aberrant plant growth. According to Bhatt and Singh (2022), the incorporation of humic acid into the synergistic mixture's composition had an impact on a number of soil quality parameters, including content, microbial activity, pH, electrical conductivity, apparent density, particle density, porosity, and water retention capacity. The agricultural performance of various crops, including plant height, dry matter accumulation, crop growth rate, relative growth rate, number of nodes, dry node weight, nutrient content, yield components, yield, and quality, was significantly influenced by NPK, organic matter content, and cation exchange capacity.

Table (3) Effect of the interaction between spraying with a mixture of microelements and humic acid on some growth characteristics and yield of the local barley crop

Treatment		Plant Height (cm)	Leaf area (cm^2)	Spike length (cm)	Spikes number per plant	Weight of 1000 grain (g)	Grain yield (ton/ha^{-1})	Straw yield (ton/ha^{-1})	Biological yield (ton/ha^{-1})
M0	H0	67.50±0.50 g	13.98±0.56 e	9.96±0.48 d	3.54±0.26 c	19.46±0.30 g	1.91±0.21 c	0.77±0.01 c	2.47±0.24 c
	H1	70.47±0.29 f	15.17±0.44 de	10.27±0.30 d	3.59±0.23 c	20.45±0.31 fg	1.83±0.16 c	0.87±0.02 bc	2.50±0.00 c
	H2	72.40±0.39 e	15.17±0.43 de	10.30±0.30 d	3.99±0.00 bc	21±67±0.33 ef	2.05±0.02 bc	0.89±0.01 bc	2.90±0.10 c
M1	H0	69.73±0.26 f	14.80±0.15 de	9.42±0.31 d	3.86±0.45 bc	20.88±0.11 f	2.10±0.15 bc	0.88±0.01 bc	2.83±0.16 c
	H1	71.07±0.55 ef	15.26±0.25 d	10.06±0.37 d	4.50±0.29 ab	22.27±0.37 e	2.49±0.27 abc	0.91±0.01 bc	2.94±0.06 bc
	H2	79.17±0.60 d	17.55±0.55 c	10.43±0.28 cd	4.30±0.30 abc	25.00±0.57 d	2.67±0.33 ab	0.94±0.00 bc	2.97±0.02 bc
M2	H0	81.04±0.54 c	17.87±0.12 c	11.33±0.32 bc	4.64±0.31 ab	26.87±0.46 c	2.83±0.16 a	0.96±0.00 bc	3.00±0.00 bc
	H1	83.45±0.28 b	19.22±0.40 b	11.85±0.15 ab	4.96±0.18 a	28.95±0.08 b	2.62±0.23 ab	1.08±0.12 b	3.50±0.28 ab
	H2	88.52±0.86 a	20.95±0.05 a	12.59±0.27 a	5.17±0.16 a	31.33±0.66 a	2.96±0.03 a	1.47±0.20 a	3.66±0.33 a

* M0: without spraying, M1: spraying 50 ml/L^{-1} of trace elements, M2: spraying 100 ml/L^{-1} of trace elements.

*H0: Without spraying, H1: Spraying 100 ml/L^{-1} of humic acid, H2: Spraying 150 ml/L^{-1} of humic acid.

* Different letters indicate significant differences between experimental treatments within the same column according to Duncan's

multiple range test (Duncan,1955).

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