Effect of adding humic acid and spraying with potassium silicate on growth indicators and yield of local garlic plants (*Allium sativum* L.)

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Abstract

A field experiment was conducted at the College of Agriculture, Al-Qasim Green University within longitude E 44 and latitude N 32, for the agricultural season 2022-2023 to study the effect of adding humic acid and spraying potassium silicate on the growth, yield and content of some nutritional elements of local garlic. The first factor included three levels of humic acid (0, 500, 1000) kg. ha^{-1} and the second three levels of potassium silicate 0, 2 and 4 ml. L^{-1}. The experiment was carried out according to a randomized complete block design (RCBD). The results showed that the treatment (1000 kg.ha^{-1} humic acid) was significantly superior to the rest of the treatments in terms of the number of cloves per head, which amounted to 29.83 cloves.$head^{-1}$. The treatment also achieved a double interaction between (0 kg.ha^{-1} humic acid and 2 ml.l^{-1} potassium silicate) excelled in traits of bulb neck length and plant height, which amounted to 38.7 cm and 93.2 cm, respectively, while the double interaction treatment was recorded between (1000 kg.ha^{-1} humic acid and 2 ml. L^{-1} of potassium silicate) had the highest values for traits of head weight and total yield, which amounted to 47.3 g and 12.62 tons.ha^{-1}, respectively.

introduction

Garlic (Allium sativum L.) is one of the most important vegetable crops in the world. It is a herbaceous plant belonging to the Allium family Aliaceae and is widely used as a nutritional crop and spice all over the world (Barche et al., 2013). Garlic is a bulb composed of several cloves with high nutritional value, containing 62.8% moisture, 6.3% proteins, $13g^{-1}$ vitamin C, 29% carbohydrates, 0.03% calcium, 0.31% phosphorus, and 0.0031% iron, in addition to its medicinal value. and therapeutic (Magray et al., 2017). Garlic and its extracts are characterized by being antioxidants, as this property is due to sulfur compounds, including allicin, which is the basic compound for many sulfur compounds responsible for the taste, flavor, and medicinal and therapeutic properties of garlic, as garlic contains more than thirty-three sulfur compounds such as allin, allicin, ajoene, and s- allyl propyl disulfide, diallyl trisulfide, and others (Fojlaley et al., 2020). Despite the nutritional, health and medicinal importance of garlic, its cultivation in Iraq is still limited due to farmers' ignorance of the nutritional, economic and medicinal value of the crop, as well as the lack of studies that determine fertilizer recommendations and service operations necessary for the crop. Many local and imported cultivars are spread in Iraq, and the local variety is considered one of the best cultivars spread in Iraq, but it is criticized for the small size of the heads and cloves and the low yield per unit area, despite the quality of cultivar and the high content of its fruits of dry matter and chemical and therapeutic elements compared to the imported cultivars, so thinking began. Using nutrients that improve the growth and productivity of this variety, and at the forefront of these nutrients is potassium, which is one of the most important macronutrients necessary for plant growth after nitrogen and phosphorus (Fageria, 2016). Potassium plays an essential role in the

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physiological and chemical processes that occur within the plant, such as protein synthesis, ion absorption and transport, photosynthesis, the respiratory process, and increasing plant resistance to diseases and pests (Saud et al., 2013). Barakat et al. (2019) found, through their study to determine the effect of adding potassium fertilizer to garlic plants at four levels, that there was a significant increase in plant height, number of leaves, bulb weight, and number of cloves in the bulb compared to control treatment, where Mohsen et al. (2017) recommended through the study that was conducted. To determine the effect of spraying with potassium humate on garlic at two concentrations (0 and 5 $g.L^{-1}$) to a significant increase in plant height, number of leaves, bulb diameter, and yield per plant at the concentration of 5 $g.L^{-1}$ compared to control treatment. Both (Hafez et al., 2020) and (Elshahid et al., 2022) also found in their studies that spraying with potassium silicate increases the growth, productivity, and quality of garlic bulbs and enhances the ability of garlic to store and the garlic's resistance to infection with rotting fungi. Humic acid is a commercial product that contains many elements necessary for the development of plant life (El-Sharkawy and Abdel-Razzak, 2010). Through the adoption of foliar spraying, humic substances are increasingly used in agricultural practice, which is a growth mechanism promoting effect on plant growth, which is usually attributed to a hormone-like effect, activating photosynthesis, accelerating cell division, increasing the permeability of plant cell membranes and improving nutrient absorption. , reducing the absorption of toxic elements and improving plant response to salinity (Verlinden et al., 2009). Also, humic acid (HA) is one of the main components of humus. Application of HA has many benefits and growers around the world are accepting HA as an integral part of their fertilizer program (Moradi and Zeinali, 2015). They found that spraying humic acid on leaves had positive effects on plant growth and improved production of garlic plants. Both (Rizk and Deshesh, 2021) and (Al-Obeid and Al-Obeid, 2023) studied the effect of humic treatment on garlic plants.

Materials and methods

A field experiment was conducted at the College of Agriculture - Al-Qasim Green University for the agricultural season 2022-2023 to determine the effect of adding granulated humic and spraying with potassium silicate on the growth and yield of local garlic plants. The experiment was divided using a randomized block design (RCBD), and the field was divided into three replicates, and each replicate contained 9 experimental units with dimensions of 1 m x 3 m. The cloves were planted on September 15, 2022 at a depth of 5 cm under the drip irrigation system and in lines, where each terrace contained two lines, the distance between one line and another was 20 cm and between one plant and another was 10 cm. Crop service operations were carried out, including irrigation, weeding, and preventive control.

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Table 1: Some physicochemical traits of field soil before planting

Values	units	Traits
7.03	---	**pH**
3.73	dc/m)(	**EC electrical conductivity**
1.4	$g.kg^{-1}$	**Organic matter**
31.11	mg.kg-1	**Available nitrogen**
7.6	mg.kg-1	**Available phosphorus**
98	mg.kg-1	**Available potassium**
335	$g.kg^{-1}$	**Sand**
334	$g.kg^{-1}$	**silt**
331	$g.kg^{-1}$	**Clay**
Loam clay	**Soil texture**	

The chemical and physical traits of the soil were analyzed in the laboratory of the College of Agriculture - Al-Qasim Green University

Study factors:

1. Ground fertilization: Granulated humic fertilizer was added on 12-1-2022 at three levels (0, 500, 1000) kg.ha-1, which are designated as A1, A2, and A3, respectively.

2. Foliar nutrition with potassium: Potassium silicate was sprayed on the shoots in the morning until completely wet, at three concentrations: 0 and 2 ml. L^{-1} and 4ml. L^{-1}, which are designated as B1, B2, and B3, respectively.

Studied traits:

First: Vegetative growth traits: Vegetative growth traits were measured on 4/15/2023, when a sample was selected.

A random sample of 8 plants from each experimental unit was performed, and the following traits were estimated:

1. Plant height (cm): The plant leaves were collected in a bundle, and the height was measured from the area where the pseudostem connects with the soil to the highest leaf on the plant using a tape measure.

2. Number of leaves ($leaf.plant^{-1}$): As an average number of leaves for a random sample of plants.

3. Leaf length (cm^{-1}): A prepared measurement of leaf length was made for a random sample of a number of plants using a tape measure.

4. Plant length (bulb neck) (cm): Plant length was measured from the bulb neck for a number of plants taken at random.

5. Leaf area ($dm^2.plant^{-1}$): The leaf area of a random sample of a number of plants in the experimental unit was calculated according to the following equation:

$A= -93.1+1.83L+38.6C25$

Second: traits of the yield: After uprooting the crop, a random sample of plants was selected from the center of each experimental unit and the following measurements were taken:

1. Diameter of the bulb or head (cm): It was measured using Vernier plants randomly and was measured from the widest area of the garlic heads.

2. Number of cloves per head ($cloves.head^{-1}$): The average number of cloves in plants taken at random was calculated for the purpose of calculating the number of cloves per head.

3. Yield of one plant or head weight (g): The weight of a group of heads from each experimental unit was calculated and the average was taken for them.

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4. Weight of one clove (g. clove^{-1}): The average was taken by dividing the number of cloves by the weight of the heads.
5. Total yield (tons ha^{-1})

Experimental design and statistical analysis

The data were analyzed within a randomized complete block design (RCBD) in combinations, and the results were analyzed statistically using the (Genstat) program, and the means were compared according to the LSD test at the probability level of 0.05 (AL-Mohammdi and AL-Mohammdi, 2012).

Results and discussion

vegetative growth traits:

1. Bulb neck length (cm)/ The results of Table 2 indicated the effect of fertilizing with granulated humic fertilizer and spraying with potassium silicate and the interaction between them on the length of the plant (bulb neck). We note that from the table that adding granulated humic fertilizer had a significant effect, where the A1 treatment recorded a higher An average of 34.4 cm compared to the A2 treatment, which recorded the lowest height of 32 cm, while the potassium silicate spraying treatment B2 gave the highest value in this trait, amounting to 35.1 cm compared to control treatment. As for the bi-interaction between granulated humic and spraying with potassium silicate, the A1B2 interaction treatment gave the highest value. The value reached 38.7 cm, as well as the A2B3 and A3B2 treatments, which amounted to 34.3 and 34.9 cm, respectively, as measured by control treatment and the rest of treatments.

2. Plant height cm/ The results of Table 2 indicate that the treatment of adding granulated humic A3 was excelled in plant height, which amounted to 86.3 cm compared to control treatment, which amounted to 85.4 cm. The spraying treatment with potassium silicate B2 also excelled in this trait, which amounted to 89.1 cm compared to control treatment. As for the dual interaction between humic and spraying with potassium silicate, the interaction treatment A1B2, A2B3, and A3B2 gave the highest plant heights, reaching 93.2, 88.9, and 90.7 cm, respectively, compared to control treatment and the rest of the treatments.

3. Number of plant leaves: The results of Table 2 indicate that the A3 granulated humic addition treatment was excelled in terms of the number of plant leaves, which amounted to 6.45 leaves.plant^{-1} compared to control treatment, which amounted to 6.08 leaves.plant^{-1}. The spraying treatment with potassium silicate B3 also excelled in this regard. The trait reached 6.48 leaves.plant^{-1} as measured by control treatment. As for the double interaction between humic and spraying with potassium silicate, the interaction treatments a2b3 and a3b2 gave the highest average number of leaves on the plant, amounting to 6.73 and 6.83 leaves.plant-1, respectively, compared to control treatment and the rest treatments.The increase in vegetative growth can be explained by the role of potassium fertilization by increasing the activity of various enzymes and increasing the process of photosynthesis, thus stimulating and increasing plant growth (EI Sayed and EL Morsy, 2012). These results are consistent with the findings of Barakat and others (2019).

Yield traits

The results of Table 3 indicated that there were significant differences in head weight and total yield when using fertilization with granulated humic acid fertilizer and spraying with potassium silicate, where treatment A3 achieved the highest results in the above traits, which amounted to 36.6 grams and 9.85 tons.ha^{-1}, and treatment B2 36.5 grams and 9.73 tons. ha^{-1}, respectively. This increase in

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yield traits is due to the presence of potassium improving the process of transporting carbohydrates from the leaves to the storage areas. Also, spraying potassium in the early stages of the plant's life led to the storage of dry matter in the bulbs, which caused an increase in yield and improved quality. Shafeek et al., 2016). These results are consistent with the findings of Barakat et al. and Mohsen et al. (2017), who showed that garlic yield traits increase with increasing potassium levels, whether by ground addition or foliar spraying. As for the interaction between fertilization with granulated humic and spraying with potassium silicate, the results of Table 3 indicate that the treatments A1B3, A2B3, and a3b2 were excelled in head weight and total yield, which amounted to 35.2, 36.2, and 47.3 cm, and 9.38, 9.64, and 12.62 tons.ha^{-1}, respectively. This applies to the control treatment and the rest of treatment. Foliar spraying of potassium causes an increase in the absorption of this element by the leaves, which then transports it and increases its concentration within the bulbs (Behair et al., 2015). These results are consistent with the findings of Jiku et al. (2020).

Conclusions/

From the results of the study, we conclude that increasing the levels of fertilization with humic and potassium fertilizers gave a significant increase in traits of vegetative growth, which was reflected positively on the components of yield and total yield, as well as improving the quality of the resulting bulbs, which was evident through increasing the concentration of potassium in the bulbs, and that foliar fertilization with potassium, especially in the stages The advanced age of the plants was effective in increasing the vegetative growth and yield of the plants. Therefore, we recommend increasing the levels of fertilization with humic and potassium elements in order to obtain the best growth, yield and quality of the bulbs.

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Table 2: The effect of adding humic acid, spraying with potassium silicate, and their interaction on the vegetative growth traits of garlic.

Leaf area ($dm^2.plant^{-1}$)	leaf length(cm)	Number of leaves ($leaf.plant^{-1}$)	Plant height (cm)	Bulb neck length(cm)	Treatments
271.	51.3	6.08	85.4	34.4	A1
311.	53.1	6.23	85.6	32.0	A2
327.	53.8	6.45	86.3	32.9	A3
Ns	Ns	Ns	Ns	2.1	L.S.D 0.05
286.	52.5	6.24	83.2	31.1	B1
307.	53.9	6.03	89.1	35.1	B2
316.	51.8	6.48	85.0	33.1	B3
Ns	Ns	Ns	2.6	2.1	L.S.D 0.05
interaction					Treatments
247.	51.9	5.80	82.4	32.8	A1B1
258.	52.1	5.85	93.2	38.7	A1B2
310.	49.9	6.58	80.7	31.7	A1B3
311.	52.1	6.53	84.4	30.1	A2B1
266.	53.0	5.42	83.6	31.7	A2B2
355.	54.1	6.73	88.9	34.3	A2B3
300.	53.4	6.39	82.8	30.3	A3B1
398.	56.7	6.83	90.7	34.9	A3B2
282.	51.3	6.13	85.4	33.4	A3B3
232.0	13.16	1.808	4.2	3.9	L.S.D 0.05

Table 3: The effect of adding humic acid and spraying with potassium silicate and their interaction on the yield traits of garlic plants

Total yield ($tons.ha^{-1}$)	**Head diameter(cm)**	**Weight of one clove ($g.\ clove^{-1}$)**	**Head weight (g)**	**Number of cloves per head ($clove.\ head^{-1}$)**	**Treatments**
8.96	4.03	1.369	33.6	25.02	A1
9.05	3.86	1.264	33.9	26.50	A2
9.85	3.88	1.218	36.9	29.83	A3
3.051	0.565	0.4344	11.44	5.188	L.S.D 0.05
9.19	4.08	1.183	34.4	28.13	B1
9.73	3.91	1.352	36.5	27.17	B2
8.95	3.78	1.316	33.6	26.06	B3
3.051	0.565	0.4344	11.44	5.188	L.S.D 0.05
interaction					**Treatments**
8.89	4.38	1.287	33.3	25.57	A1B1
8.62	3.85	1.320	32.3	25.33	A1B2
9.38	3.85	1.500	35.2	24.17	A1B3
9.56	4.00	1.110	35.8	29.50	A2B1
7.96	3.65	1.307	29.8	23.50	A2B2
9.64	3.92	1.377	36.2	26.50	A2B3
9.11	3.85	1.153	34.2	29.33	A3B1
12.62	4.22	1.430	47.3	32.67	A3B2
7.82	3.58	1.070	29.3	27.50	A3B3
5.284	0.978	0.7523	19.81	8.985	L.S.D 0.05

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