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# Evaluation of the Efficiency of Humic and Agricultural Sulfur on the Growth of Date Palm Tissue offshoots of Barhi cv., irrigated with Saline Water from Shatt Al-Arab River.

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**Abstract**

The aim of this study was to evaluate the combined and individual effects of agricultural sulfur and humic acid on growth and some physiological traits of Barhi date palm offshoots irrigated with saline water of Shatt Al-Arab river. A field experiment was conducted using a factorial design that included ten treatments with different concentrations of humic acid (0, 25, 50, 75, and 100 g palm$^{-1}$) and sulfur (0 and 200 g palm$^{-1}$). The results showed that the combined treatment of 100 g humic acid + 200 g sulfur recorded the highest number of leaves (7 leaves) and the highest leaf area (2.28 m$^2$), compared to the control, which recorded the lowest values (3 leaves, 1.29 m$^2$). The contents of chloride and sodium in the leaves decreased to 0.20 and 0.21 mg g$^{-1}$, respectively, while the leaf calcium (60.1 mg g$^{-1}$), potassium (4.55 mg g$^{-1}$), and phosphorus (60.34 mg g$^{-1}$) increased. Furthermore, the K/Na ratio increased to 22.75. Humic treatments led to increased chlorophyll content (the highest value was 4.214 mg L$^{-1}$), while proline decreased to 13.98 µg g$^{-1}$ at the highest humic and sulfur concentrations. The results indicated that, the interaction between sulfur and humic was effective in reducing the salinity stress and improving the physiological traits in date palms.

**Keywords**: Mineral elements; Pigments; Proline; Salt stress

## Introduction

Date palm (*Phoenix dactylifera* L.) is a perennial fruit tree belonging to the family Arecaceae, it holds significant economic importance and is a key component of food systems. Iraq is one of the leading countries in date production in the world, with more than 600 varieties of date palm. The Barhi cultivar is considered one of the best commercial varieties due to its excellent flavor and is consumed at the khalal, rutab, and date stages. However, the productivity of palm trees in the Arab countries, particularly in Iraq, has been declining. Advanced technologies and inadequate agricultural services are among the most significant factors affecting the success of palm cultivation (Krueger, 2021; Al-Karmadi and Okoh, 2024). A major problem in agricultural development is salinity, as saline water is the most abundant water source in arid and semi-arid regions. Salinity directly affects plants through toxic and osmotic effects, and nutrient imbalances within plant tissues. These effects occur when date palms are irrigated with high-salinity water, leading to an increase salt concentration (Gabash, et. al., 2024). The soil's physical, chemical, and biological properties, which are key sources of nitrogen, are effected most by organic substances. Adding the necessary organic substances enhance soil vitality, it is an important means in increasing the availability of both major and minor nutrients. Therefore, organic material is considered both improver of soil properties and a fertilizer. (Al-Hamdani, 2008; Țopa, et. al., 2025). Humic compounds, including humic acid (HA), are natural organic substances extracted from special mines that have been fossilized for thousands of years (Al-Zoubi et al., 2022). HA works directly improves plant growth characteristics, such as plant height and the number of leaves. It increases the availability of phosphorus, especially in basic soils, by enhancing plant absorption of phosphorus from compound fertilizers (Thompson, 2002; Bhatt and Singh, 2022). Several studies have indicated that humic substances, including HA, are the main components of organic matter. Plants getting treated with these substances improve growth in many plant species, that is by regulating the release of mineral nutrients and increasing nutrient absorption. The effect of humic substances varies according to their type, concentration, method of use, the type of plant grown, its age, and the surrounding environmental conditions (Arancon et al., 2004; Odongo et al., 2008; Yildirim, 2007; Hussein and Safaa, 2014; Bhatt and Singh, 2022). The study by Zare (2011) indicated that treating chicory plants with HA at a concentration of 1.5 g $L^{-1}$ led to a significant increase in crown elongation and leaf area. Al-Tamimi et al. (2017) confirmed that spraying date palm leaves with HA at a concentration of 18 ml $L^{-1}$ resulted in an increase in leaf chlorophyll A content, as well as an increase in the concentration of nitrogen, phosphorus, potassium, and total protein in the leaves. The availability of micronutrients decreases in the soils of arid and semi-arid regions, including those in Iraq, because of the high pH in soil that tends to be alkaline. That is due to the high calcium carbonate content. Therefore adding agricultural sulfur to the soil, which participates in many soil reactions, will increase the availability of these elements, which are important for enhancing plant physiology and growth. These microorganisms are responsible for converting organic sulfur forms into mineral forms that are readily available to plants (Joseph et al., 2013; He et al., 2010). Sulfur is one of the major nutrients necessary for plants, especially fruit-bearing ones. It is a yellow powder used as a soil fertility improver and is often added with basic fertilization before tillage. Sulfur is essential for plant growth due to its role in the synthesis of some amino acids (Tisdale et al., 1997). Adding sulfur can improve growth in saline soils by lowering soil pH, facilitating the uptake of elements, especially phosphorus, and increasing soil revitalization (Abbey et al., 2002). Several researchers have observed an increase in the amount of available phosphorus in the soil with addition of sulfur (El-Fahdawi, et. al., 2020; Mahmood, et. al., 2020). Elgala et al. (1998) stated that the availability of nutrients in the soil increases with the addition of sulfur, as the available percentage of nitrogen, phosphorus, and potassium increased two months after the addition. The results of Jasim and Tuaema (2016) showed a significant decrease in the sodium and chloride content of leaves when adding sulfur at the level of 100 and 200 g per tree. for the elements potassium and calcium, and the ratio between potassium and sodium, there was a significant increase when adding sulfur at the level of 200 g per tree. Due to the lack of studies in Iraq on the addition of HA and sulfur directly to the root system of date palm offshoots, this study was conducted in one of the orchards in Al-Deir district to investigate the effects of different concentrations of HA and Sulfur on the morphological and physiological characteristics of date palm tissue offshoots of the Barhi cultivar cultivated on permanent land.

## Materials and Methods

### Study area and sampling

The current study was conducted from January, 2023, to December, 2024, in one of the private orchards in Al-Mustafa district of Al-Dair district in Basrah Governorate, southern Iraq. To represent the irrigation water in the study area, a water sample was collected. The Chemical properties of irrigation water were analyzed at the laboratories of Date palm Research Center and Marine Sciences Center in University of Basrah (Table, 1).

**Treatment of Barhi Date Palms with Sulfur and Humic Acid**

A total of thirty offshoots (four years old) from Barhi cultivar date palms, similar in size and height, were selected for the experiment. These offshoots were planted in an orchard with dimensions of 6×6 meter. Ten treatments were arranged in a factorial design, each treatments assigned to three plots, and ten trees per plot. The first factor was sulfur, applied in the form of agricultural yellow sulfur at concentrations of 0 and 200g. per tree. The second factor was Humic, applied at concentrations of 0, 25, 50, 75, and 100 g per tree. This was done by creating a trench around each offshoot, with a diameter of 50 cm wide and a depth of 30 cm. Treatments were applied twice: the first in early January and the second in early April. The treatments were added to the trench, then soil was filled in and the area was watered directly.

The experimental treatments were as follows:

1. Control treatment free of HA and S.
2. 25 g per tree HA + 0 g per tree S.
3. 50 g per tree HA + 0 g per tree S.
4. 75 g per tree HA + 0 g per tree S.
5. 100 g per tree HA + 0 g per tree S.
6. 0 g per tree HA + 200 g per tree S.
7. 25 g per tree HA + 200 g per tree S.
8. 50 g per tree HA + 200 g per tree S.
9. 75 g per tree HA + 200 g per tree S.
10. 100 g per tree HA + 200 g per tree S.

The orchard service processes were conducted consistently, with irrigation occurring twice a week.

**Measurement of growth parameters in Barhi offshoots**

Measurements of vegetative traits, leaf area was calculated by selecting four leaflets from four fronds in the second row and determining the average maximum length and width per leaflets. The average area of one frond was then calculated using the following equation, based on Ahmed and Morsy (1999).

$$Leaf\ area = \frac{0.37(L) \times (W) + 10.29 \times N}{1000}$$

Where:

L= length of leaflets.

W= width of leaflets.

N= number of leaflets.

The increase in the number of new leaves was calculated as difference between the mean number of leaves per offshoot recorded after treatment and that recorded before treatment.

### Estimating Minerals and Proline in Leaves

Sodium, calcium, potassium, chloride, and phosphorus were estimated. Plant samples (leaves) were collected and dried in an electric oven at 70°C for 72 hours. The dried samples were then digested using an acidic mixture (concentrated sulfuric acid + perchloric acid) following the method of Cresser and Parsons (1979). Sodium, potassium, and calcium in the digestion solution were estimated using a flame photometer, while chloride was determined by leaching with silver nitrate ($AgNO_3$) according to Kalra (1998).

The potassium to sodium ratio was calculated by dividing the potassium content by the sodium content in the leaves. Phosphorus content was determined using the method of Murphy and Riley (1962), where the development of blue color was measured using a spectrophotometer at 700 nm. The concentration of free proline in the plant tissue was determined according to Bates et al. (1973).

### Estimation of Chlorophyll and Carotenoids in the Leaves

Total chlorophyll and carotenoids in the leaves were estimated for each treatment, 0.5 g of leaves was mixed with 15 $cm^3$ of 80% acetone for analysis. The leaves were thoroughly crushed using a ceramic mortar, and the sample was then centrifuged for 10 minutes to separate the liquid.

Absorbance readings were taken using a spectrophotometer at wavelengths of 645 nm, 663 nm, and 480 nm. The concentrations of chlorophyll and carotenoids were estimated using the following equations, as well as carotenoid pigments in the leaves, was calculated based on (Howertiz, 1975).

Total chlorophyll ( mg $L^{-1}$) = 20.2 ( O.D. 645 ) + 8.02 ( O.D. 663 )

$$X = \frac{EY}{e\,100} \times 1000\,mg$$

Where:

O.D = optical density reading of the extracted chlorophyll.

X = the number of mg of carotenoids in 3 cm of solution.

E = device reading at 480 nm wavelength.

Y = volume of final solution after dilution with acetone.

e = carotenoid constant 2300.

**Table 1. Chemical properties of irrigation water for the 2023 growing seasons.**

| Property | Months | | | |
|---|---|---|---|---|
| | January | April | July | November |
| E.C $ds.m^{-1}$ | 2.87 | 3.14 | 3.70 | 3.18 |
| pH water | 6.30 | 6.74 | 6.95 | 6.80 |
| K mg $L^{-1}$ | 14.22 | 13.48 | 13.16 | 14.73 |
| Na mg $L^{-1}$ | 328.60 | 299.50 | 266.32 | 270.40 |
| Ca mg $L^{-1}$ | 22.25 | 17.73 | 16.90 | 16.12 |
| Cl mg $L^{-1}$ | 196.54 | 120.97 | 133.44 | 186.55 |

## Statistical analysis

All data were analyzed using SPSS software. Means were compared using the least significant difference (LSD) test at the 0.05 significance level.

## Results and Discussion

### Vegetative Traits

The results showed that the combined treatment of 100 g humic acid and 200 g sulfur achieved the highest number of leaves (7 leaves) and did not differ significantly from the treatment with 75 g humic acid at the same sulfur level. In contrast, the control treatment (0 humic acid and 0 sulfur) recorded the lowest value, with an average of only 3 leaves. Additionally, there were no significant differences between the control and the treatment with 25 g humic acid without sulfur. However, the treatment with 50 g humic acid + 200 g sulfur (6 leaves) significantly outperformed the treatment with 50 g humic acid alone (4 leaves) (Figure, 1). There was a gradual increase in leaf area with a rise of humic acid concentrations, with this increase being more pronounced in treatments that included sulfur additions, as indicated by the results. The highest leaf area value was recorded in the treatment with 100 g humic acid and 200 g sulfur, reaching 2.28 $m^2$, and significantly outperforming all other treatments. This was followed by the 75 g humic acid + 200 g sulfur treatment (2.14 $m^2$), while the lowest value was recorded in the control treatment without any additions (1.29 $m^2$). Notably, the addition of sulfur at a rate of 200 g/tree led to a significant increase in leaf area across all humic acid levels compared to treatments without sulfur. Moreover, there was no significant difference between the treatments 0 g humic acid + 0 g sulfur and 50 g humic acid + 0 g sulfur, and that indicates the effect of humic acid alone was limited in the absence of sulfur. In contrast, treatments that involved the interaction between humic acid and sulfur demonstrated significant superiority (Figure 2). Humic acid enhances soil properties as well as the ability of plant to absorb nutrients. On the other hand, sulfur improves photosynthetic efficiency and enzyme activity related to vegetative growth. This leads to an increase in the number of leaves. Thus, to enhance vegetative growth, applying humic acid and agricultural sulfur represents an effective strategy. When the interaction between them is applied at moderate to high levels, the effect is more pronounced as shown by the results. Havlin et al., 2005 and Havlin and Schlegel (2021) state that, the role of sulfur in protein formation through the amino acids it contains, the vital role sulfur plays in plant processes. Additionally, humic also play an important role in activating physiological processes of plant by stimulating enzyme action. This, in turn, boosts growth, increases the number of leaves, and expands leaf area (Zhang and Ervin, 2004; Bera, et. al., 2024).

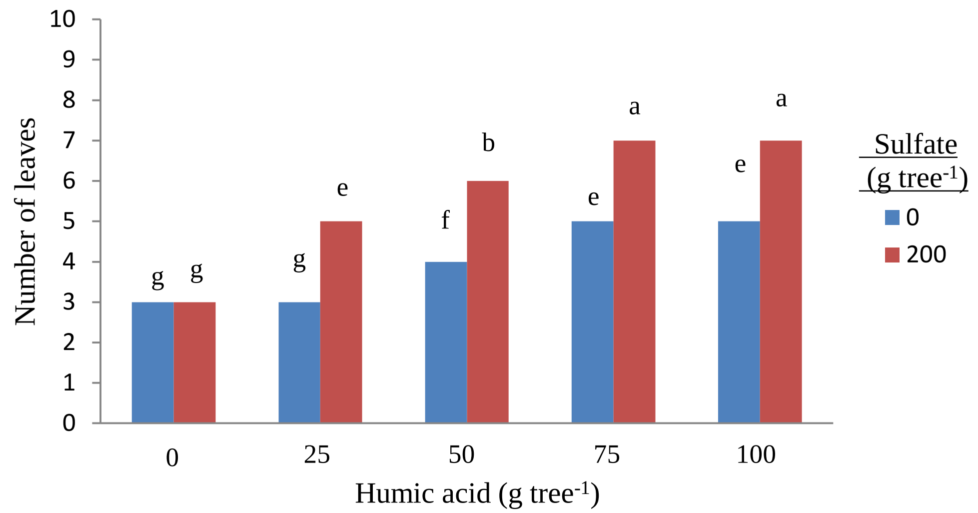


**Figure 1. Effect of humic acid and sulfur on number of leaves of Barhi date palm offshoots**

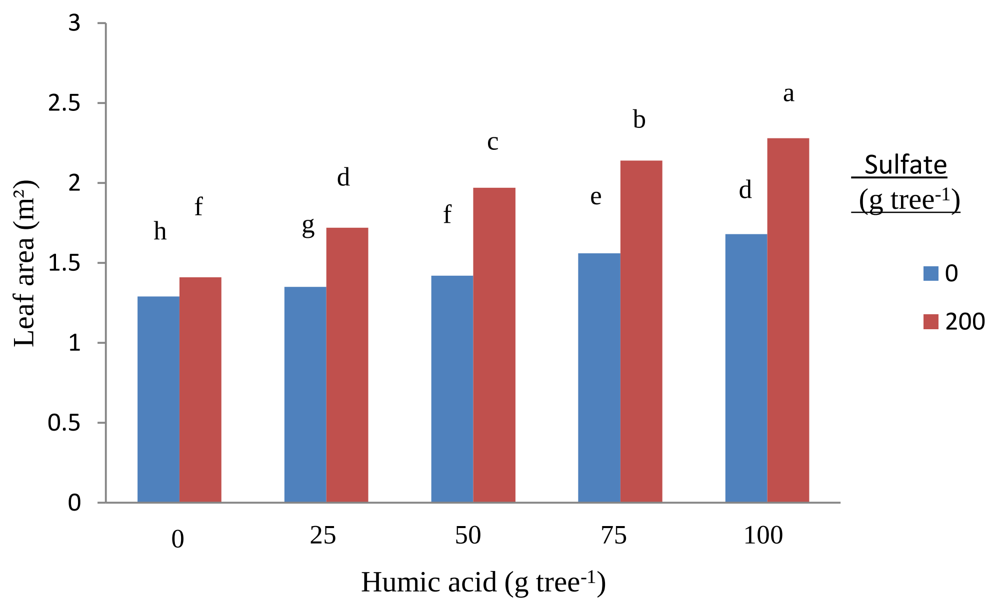


**Figure 2. Effect of humic acid and sulfur on leaf area ($m^2$) of Barhi date palm offshoots**

## The leaf content of chlorophyll, carotene and the proline

The highest content of chlorophyll was recorded in the treatment with 100 grams of humic acid without sulfur addition, reaching 4.214 mg $L^{-1}$, and significantly outperforming all other treatments, as the results showed . In contrast, the lowest value was observed in the treatment with 100 grams of humic acid combined with 200 grams of sulfur, reaching 2.11 mg $L^{-1}$. On the other hand, some treatments that included sulfur showed significant increases in chlorophyll content compared to their sulfur-free counterparts, particularly at the 0 g humic acid level. For example, the addition of sulfur raised the chlorophyll content from 2.298 to 3.569 mg $L^{-1}$, a significant increase. The treatment with 75 grams of humic acid and no sulfur (3.824 mg $L^{-1}$) also recorded a significantly higher value than the same level of humic acid combined with sulfur (2.97 mg $L^{-1}$) (Figure 3). Improving content of chlorophyll may attributed to the effect of humic acid in enhancing the absorption of micronutrients such as iron and magnesium, which are essential building blocks of the chlorophyll molecule, while sulfur plays a role in activating some enzymes involved in photosynthesis. Muhsen et al. (2013) and Baker (2019) mentioned that the increase in leaf chlorophyll content with use of humic substances compared to control treatments can be explained by humic materials enriching root zone nutrients like nitrogen and calcium, which are crucial for photosynthesis. This enhances the accumulation of chlorophyll and the synthesis of carbohydrates and proteins in the leaves. Also, protein is considered very important in protecting chlorophyll from sunlight. The highest carotenoid content was recorded in the 75 and 100 g humic acid treatments without sulfur, with values reaching 0.010 mg $100g^{-1}$, significantly superior to most other treatments, as the results showed. In contrast, the lowest carotenoid pigment value was recorded in the 100 g humic acid + 200 g sulfur treatment, reaching 0.005 mg $100g^{-1}$, indicating a significant decrease in content compared to the other treatments. The results also showed that some treatments containing sulfur did not lead to an improvement in carotenoid content; on the contrary, they showed a slight decrease or stability compared to similar treatments without sulfur, such as the 75 g humic acid + 200 g sulfur treatment (0.007 mg) compared to the same level of humic acid without sulfur (0.010 mg) (Figure 4). This means that humic acid helps plants to absorb important nutrients, which are considered essential for vital processes and enzymes in the plant, and for formation of pigments. On the other hand, applying sulfer excessively or in combination with high concentrations of humic acid may have adverse effects on physiological balance, negatively impacting carotenoid production. As for proline, it's concentration gradually decreased with increasing the level of humic, and these decreases were more pronounced in treatments that included sulfur addition. The highest proline value was recorded in the control treatment (0 humic + 0 sulfur), reaching 36.51 µg $g^{-1}$, significantly outperforming all other treatments (letter a). The lowest value was recorded in the 100 g humic + 200 g sulfur treatment, reaching 13.98 µg $g^{-1}$, a significantly lower value. Adding sulfur at a rate of 200 g/tree at all humic acid levels resulted in a significant decrease in proline concentrations compared to not adding sulfur, as the results showed. For example, proline concentration decreased from 36.51 to 28.37 µg $g^{-1}$at 0 humic level with and without sulfur, and from 33.18 to 22 µg $g^{-1}$ at 50 g humic level (Figure 5). These decreases in proline content may be attributed to the improved physiological condition of the plants as a result of the treatments used, as proline is a compound that accumulates in response to environmental stresses such as drought or salinity. Since its concentrations were higher in the control treatment and lower in the combined treatment (humic acid + sulfur), this indicates the role of these two compounds in mitigating stress and improving plant growth. Therefore, it is likely that humic acid contributed to improving soil structure and increasing the efficiency of water and nutrient absorption, while sulfur enhanced the biosynthesis of enzymes and hormones, reducing the need for proline accumulation as a defensive response. Therefore, the interaction between humic acid and sulfur could be an indicator of improved plant physiological condition and reduced stress symptoms.

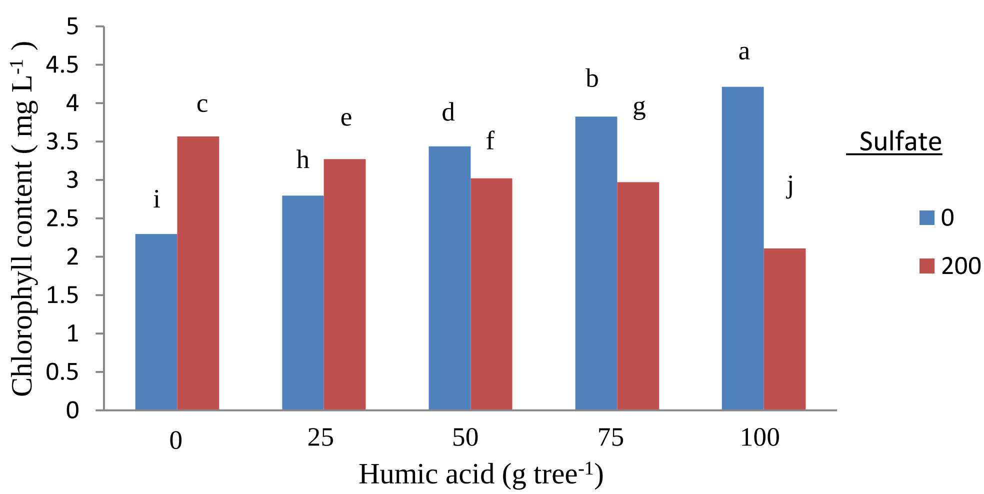


**Figure 3. Effect of humic acid and sulfur on chlorophyll content in date palm offshoots (Barhi cv.)**

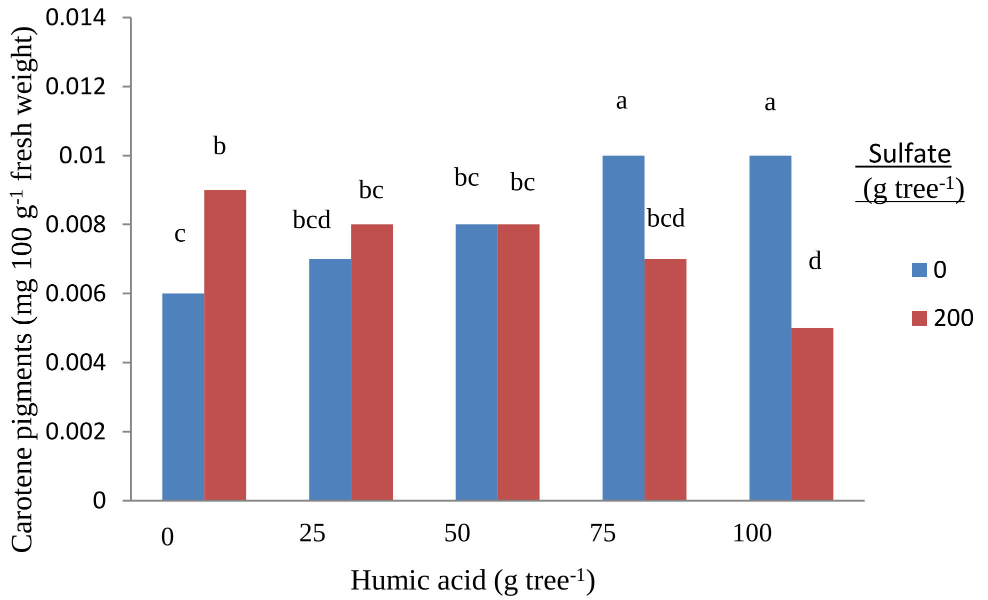


**Figure 4. Effect of humic acid and sulfur on carotene content in date palm offshoots (Barhi cv.)**

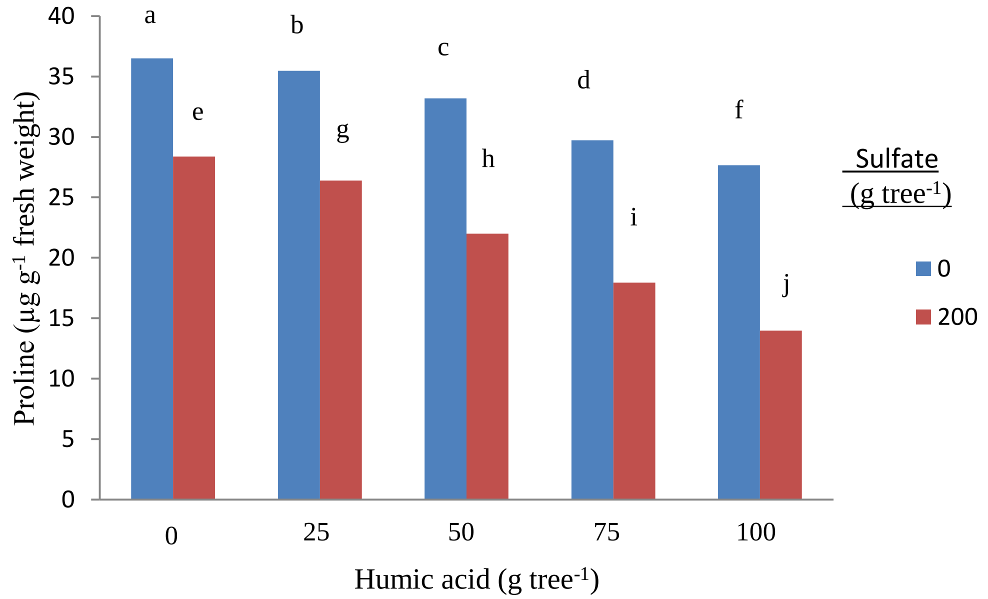


**Figure 5. Effect of humic acid and sulfur on Proline content in date palm offshoots (Barhi cv.)**

## The mineral content

A gradual decrease in foliar sodium content was observed with increasing humic acid concentration, and this decrease was more pronounced in treatments that included sulfur addition, as the results showed. The highest sodium content value was recorded in the control treatment (0 humic + 0 sulfur), reaching 0.81 mg $g^{-1}$, a value significantly higher than all other treatments. In contrast, the lowest value was recorded in the 100 g humic + 200 g sulfur treatment, reaching 0.20 mg $g^{-1}$, a significantly lower value. All treatments containing sulfur (200 g/tree) also showed a significant decrease in sodium content compared to their counterparts with the same humic level without sulfur addition. For example, the value decreased from 0.70 to 0.42 mg $g^{-1}$at the 50 g humic level, and from 0.62 to 0.34 mg $g^{-1}$ at the 75 g humic level (Figure 6). The results showed that leaf calcium content gradually increased with increasing humic acid levels, and this improvement was most evident in treatments that included sulfur. The highest value was recorded in the 100 g humic + 200 g sulfur treatment, reaching 60.1 mg $g^{-1}$, significantly outperforming all other treatments. This was followed by the 75 g humic + 200 g sulfur treatment (58.9 mg $g^{-1}$), while the lowest value was recorded in the control treatment (0 humic + 0 sulfur), reaching 39.12 mg $g^{-1}$. All treatments that included sulfur showed a clear superiority in calcium content compared to treatments with the same level of humic acid without sulfur. For example, calcium content increased from 43.2 to 50.61 mg $g^{-1}$ at the 25 g humic level, and from 45.37 to 55.44 mg $g^{-1}$at the 50 g humic level (Figure 7). The content of potassium gradually increased with increasing humic acid levels, with this increase being more pronounced in treatments that included sulfur. The highest value was recorded in the 100 g humic + 200 g sulfur treatment, reaching 4.55 mg $g^{-1}$, significantly outperforming all other treatments. This was followed by the 75 g humic + 200 g sulfur treatment (4.12 mg $g^{-1}$), while the lowest value was recorded in the control treatment (0 humic + 0 sulfur), reaching 2.43 mg $g^{-1}$. All treatments containing sulfur also showed significant increases in potassium content compared to their counterparts without sulfur at the same humic acid level. For example, the content increased from 2.86 to 3.68 mg g-1at the 50 g humic level, and from 2.95 to 4.12 mg $g^{-1}$at the 75 g humic level (Figure 8). A gradual decrease in leaf chloride content was observed as humic acid levels increased, and this decrease was more pronounced with the addition of sulfur. The highest value was recorded in the control treatment (0 humic + 0 sulfur), reaching 0.75 mg $g^{-1}$, significantly outperforming all other treatments. The lowest value was recorded in the 100 g humic + 200 g sulfur treatment, reaching

0.21 mg $g^{-1}$. All treatments that included sulfur also showed a significant decrease in chloride content compared to their counterparts without sulfur. Chloride content decreased from 0.67 to 0.39 mg $g^{-1}$ at 25 g humic and from 0.58 to 0.32 mg $g^{-1}$ at 50 g humic (Figure 9). The content of phosphorus gradually increased with increasing humic acid levels, and this improvement was most pronounced with the addition of sulfur. The highest value was recorded in the 100 g humic acid + 200 g sulfur treatment, reaching 60.34 mg g-1, significantly outperforming all other treatments. This was followed by the 75 g humic acid + 200 g sulfur treatment (56.9 mg $g^{-1}$), while the lowest value was recorded in the control treatment (0 humic acid + 0 sulfur), reaching 36.18 mg $g^{-1}$. All treatments that included sulfur also showed significant increases in phosphorus content compared to treatments with the same humic level without sulfur. The value increased from 41.22 to 52.82 mg $g^{-1}$at the 50 g humic acid level, and from 45 to 56.9 mg $g^{-1}$ at the 75 g humic acid level (Figure 10). A gradual increases in the K/Na ratio was observed with increasing humic acid levels, and this increase was more pronounced in treatments that included sulfur. The highest value was recorded in the 100 g humic + 200 g sulfur treatment, reaching 22.75 mg $g^{-1}$, significantly outperforming all other treatments. This was followed by the 75 g humic + 200 g sulfur treatment (12.12 mg $g^{-1}$), while the lowest value was recorded in the control treatment (0 humic + 0 sulfur), reaching 3 mg $g^{-1}$. The interaction between humic acid and sulfur resulted in a significant increase in the K/Na ratio compared to treatments without sulfur. For example, the ratio increased from 4.08 to 8.76 mg $g^{-1}$ at 50 g humic, and from 4.76 to 12.12 mg $g^{-1}$ at 75 g humic (Figure 11). The improved nutrient uptake and ion balance within the plant can be explained by the complementary role of humic acid and sulfur. Applying humic acid to soil improves the soil properties. The supply of nutrients to plants are increased due to this improvement. Less absorption of harmful ions like sodium and chloride are reduced by humic acid. This is due to improving the ionic balance in the root zone. The absorption of important nutrients like potassium, phosphorus, and calcium are increased by sulfur. Adjusting soil acidity is how this effect occurs. The enzyme systems responsible for absorption is also activated by sulfur. The reduction in sodium accumulation in leaves when sulfur is added is attributed to its role in reducing soil salinity. Potassium is especially increased among the availability of nutrients. This creates competition between potassium and sodium ions through selective potassium channels in the root plasma membrane, thereby reducing sodium ion affinity (Taster and Davenport, 2003; Assaha, et. al., 2017). As for the reduction in chloride ions in the leaves, it may be due to sulfur’s role in mitigating the negative effects of salinity and improving plant conditions by reducing soil salinity and increasing nutrient availability, thereby enhancing nutrient absorption (Jasim and Tuaema, 2016). Sulfur contributes to reducing the accumulation of sodium by inhibiting its uptake and activating ion-balancing enzymes. The increased accumulation of phosphorus, potassium, and calcium in the leaves may be attributed to the humic materials added to the soil, which contain these elements. This increased availability of nutrients enabled the plant to absorb sufficient amounts of calcium, potassium, and phosphorus, leading to higher concentrations in the leaves (Mengel and Kirkby, 2002; Havlin, 2014; Muhsen et al., 2020). These combined effects are clearly reflected in the increased the content of calcium, potassium, and phosphorus, the reduced concentrations of sodium and chloride, improved K/Na ratios, and enhanced plant physiological efficiency and ionic stability.

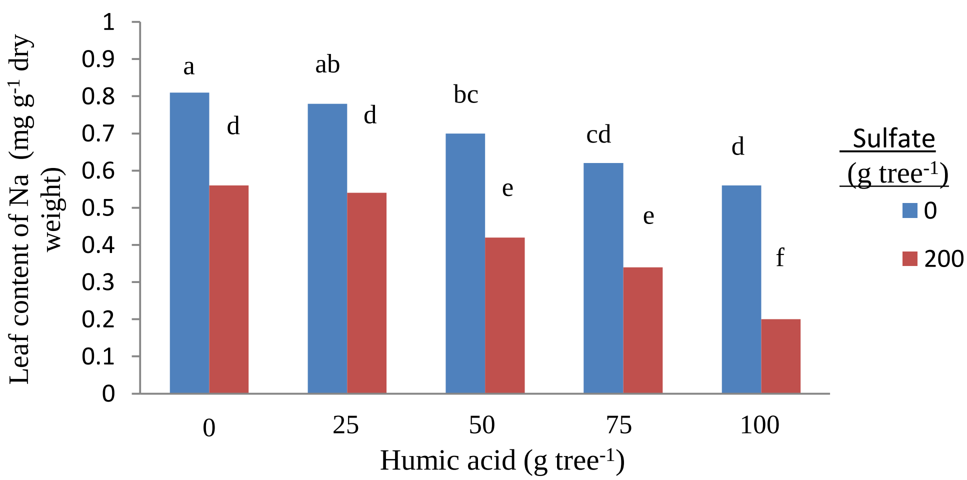


**Figure 6. Effect of humic acid and sulfur on Na content in date palm offshoots (Barhi cv.)**

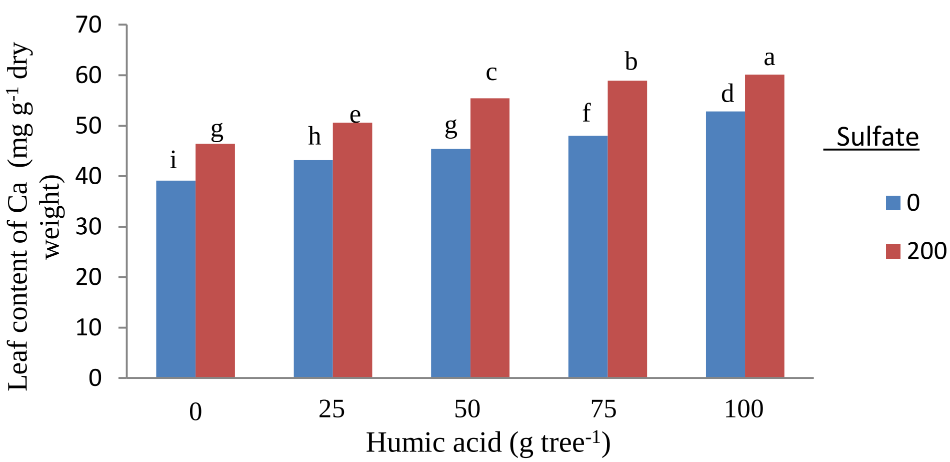


**Figure 7. Effect of humic acid and sulfur on Ca content in date palm offshoots (Barhi cv.)**

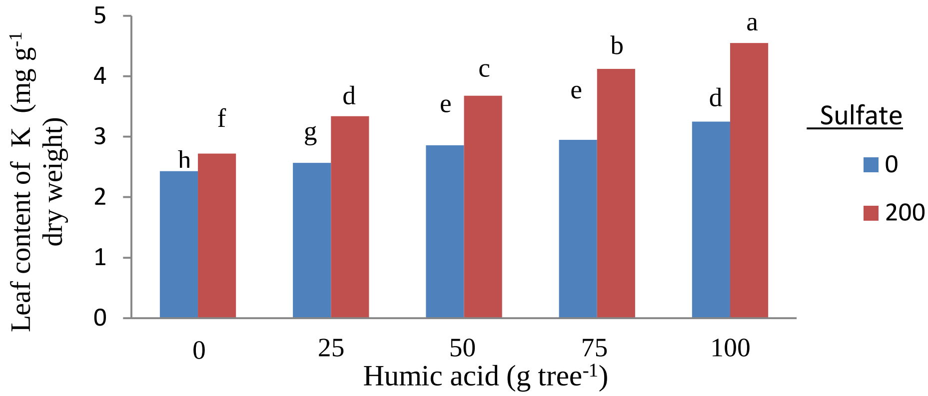


**Figure 8. Effect of humic acid and sulfur on K content in date palm offshoots (Barhi cv.)**

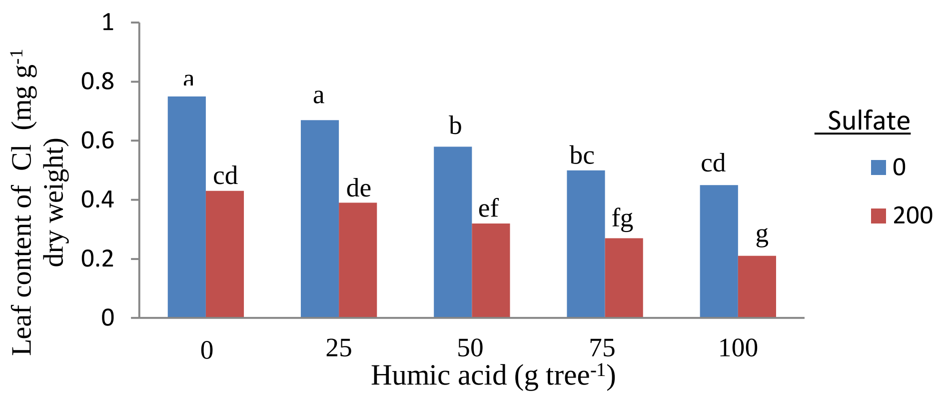


**Figure 9. Effect of humic acid and sulfur on Cl content in date palm offshoots (Barhi cv.)**

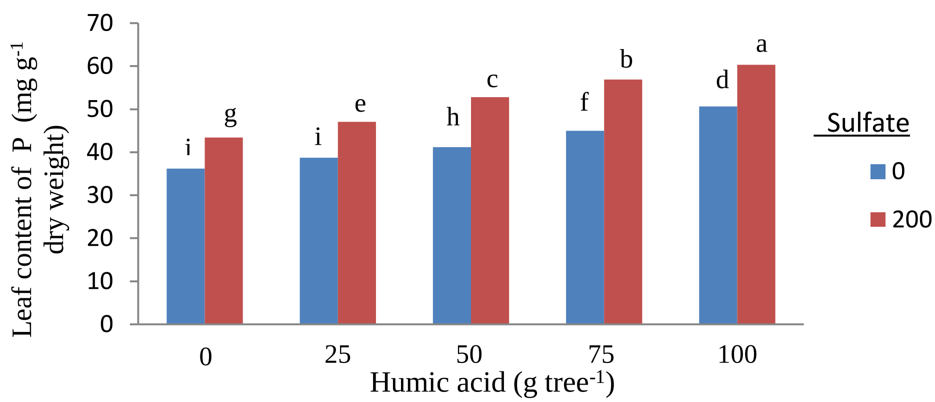


**Figure 10. Effect of humic acid and sulfur on P content in date palm offshoots (Barhi cv.)**

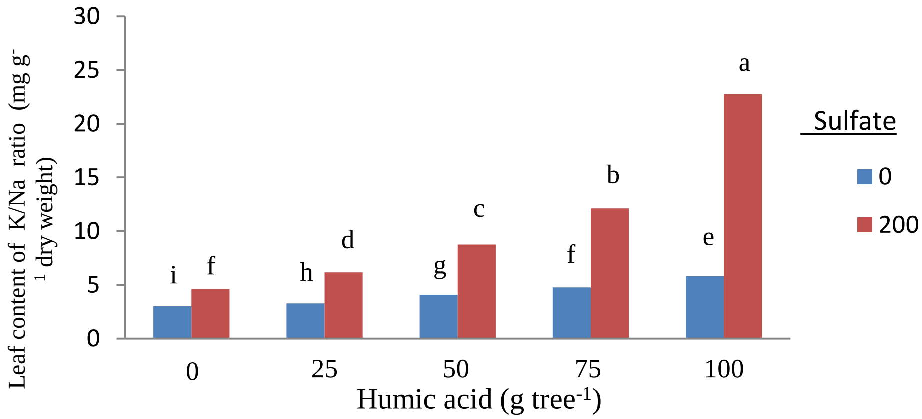


**Figure 11. Effect of humic acid and sulfur on K/Na ratio in date palm offshoots (Barhi cv.)**

## Conclusion

The results of this study demonstrated that the combined application of humic acid and agricultural sulfur significantly improved the vegetative growth, nutrient uptake, and physiological performance of Barhi date palm offshoots irrigated with saline water from the Shatt Al-Arab River. The treatment with 100 g humic acid and 200 g sulfur recorded the best performance in terms of leaf number, leaf area, and the accumulation of essential nutrients such as potassium, calcium, and phosphorus, while reducing the concentrations of sodium, chloride, and proline. Notably, the K/Na ratio improved markedly, reflecting enhanced ionic balance under saline conditions. These findings confirm the synergistic role of humic acid and sulfur in mitigating salinity stress and enhancing the adaptability of date palms to challenging environmental conditions. Therefore, their integrated use may represent an effective and sustainable strategy for improving date palm cultivation in salt-affected regions such as southern Iraq

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# تقييم كفاءة حامض الهيوميك والكبريت الزراعي في نمو فسائل نخيل التمر النسيجية صنف البرحي المروية بمياه مالحة من نهر شط العرب

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**الخلاصة**

هدفَت هذه الدراسة إلى تقييم التأثيرات الفردية والمشتركة لكل من الكبريت الزراعي وحامض الهيومك في نمو بعض الصفات الفسيولوجية لفسائل نخيل التمر صنف البرحي، والمروية بمياه مالحة من نهر شط العرب. نُفّذت تجربة حقلية باستخدام تصميم عاملي شملت عشر معاملات بتراكيز مختلفة من حامض الهيومك (0، 25، 50، 75، و100 غم.نخلة$^{-1}$) والكبريت (0 و200 غم.نخلة$^{-1}$). أظهرت النتائج أن المعاملة المشتركة 100 غم حامض هيومك + 200 غم كبريت سجلت أعلى عدد من الأوراق (7 أوراق) وأكبر مساحة ورقية (2.28 م²)، مقارنةً بمعاملة المقارنة التي سجلت أقل القيم (3 أوراق، 1.29 م²). كما انخفض محتوى الكلوريد والصوديوم في الأوراق إلى 0.20 و0.21 ملغم.غم$^{-1}$ على التوالي، في حين ارتفع محتوى الكالسيوم (60.1 ملغم.غم$^{-1}$)، والبوتاسيوم (4.55 ملغم.غم$^{-1}$)، والفوسفور (60.34 ملغم.غم$^{-1}$). كذلك ارتفعت نسبة K/Na إلى 22.75. أدت معاملات حامض الهيومك إلى زيادة محتوى الكلوروفيل (أعلى قيمة بلغت 4.214 ملغم.لتر$^{-1}$)، بينما انخفض محتوى البرولين إلى 13.98 مايكروغرام.غم$^{-1}$ عند أعلى تراكيز لحامض الهيومك والكبريت. وقد أشارت النتائج إلى أن التداخل بين الكبريت وحامض الهيومك كان فعّالاً في تقليل تأثير الإجهاد الملحي وتحسين الصفات الفسيولوجية لنخيل التمر.

**الكلمات المفتاحية:** اجهاد ملحي؛ صبغات ؛ برولين؛ عناصر معدنية