

## Effect of foliar application of seaweed extract , nano fertilizer, and addition of humic acid on the chemical traits of fig seedling.

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### Abstract

*A factorial experiment was conducted according to the complete Random Block Design (CRBD) in Babil Governorate during the 2025 growing season to study the effect of soil application of humic acid (0 and 10 g pot<sup>-1</sup>), foliar spraying with nano ferrous oxide fertilizer (0, 1000, and 2000 mg L<sup>-1</sup>), and seaweed extract at concentrations of (0, 4, and 8 mL L<sup>-1</sup>) on some vegetative and chemical traits of the fig cultivar (Aswad Diyala). After the experiment ended on 10/11/2025, the results were analyzed using the GenStat program, and means were compared using the Least Significant Difference (LSD) test at a probability level of 0.05. The results showed that the treatment of humic acid application at 10 g pot<sup>-1</sup> significantly outperformed the other treatments in the studied vegetative traits. The foliar spraying with nano fertilizer at a concentration of 2000 mg L<sup>-1</sup> showed significant superiority in all studied traits. Likewise, foliar spraying with seaweed extract at a concentration of 8 mL L<sup>-1</sup> resulted in significant superiority in all studied traits*

**Keywords:** fig , Humic acid , Nano fertilizer, Seaweed extract.

### 1- Introduction

The fig (*Ficus carica* L.) is considered one of the deciduous fruit trees and is widely cultivated in regions of West Asia and the Middle East, while its original habitat extends from Turkey to northern India. Agricultural statistics indicate that the production of fig fruits in Iraq reached about 9,457 tons, contributing approximately 1.67%, whereas the production in Babil Province reached about 10,086 tons with a contribution of 1.7% [1]. Fig fruits are characterized by their high nutritional value, as they are a rich source of vitamins, minerals, and dietary fiber, in addition to containing high levels of sugars and essential mineral salts such as calcium and phosphorus. Fig fruits also possess several health benefits, including helping to reduce acne and pimples, preventing constipation, lowering blood pressure, and reducing the risk of prostate cancer [2]. Fig fruits show superiority in their mineral content, as they contain amounts of iron and copper that are about four times

higher compared with some fresh and dried fruits and vegetables. They are also characterized by containing vitamin C, which is essential for enhancing iron absorption, as well as vitamin E and antioxidant compounds such as phenols and anthocyanins, which are found in higher concentrations in dark-colored cultivars[3];[4]. Providing strong seedlings is considered one of the basic requirements for the successful cultivation of fruit trees and for increasing their productivity. Therefore, many studies have focused on using materials and treatments that contribute to accelerating the growth of seedlings until they reach the appropriate size. Foliar spraying with plant extracts, particularly seaweed extract, is considered one of the effective methods for improving plant growth[5]. Foliar nutrition plays an important role in supplying plants with the necessary nutrients required for growth, whether macronutrients or micronutrients. These nutrients contribute to the formation of essential growth compounds such as carbohydrates, proteins, and amino acids, and their deficiency leads to weak plant growth and may result in plant deterioration in cases of severe deficiency [6]. Seaweed extract is also characterized by containing several nutrients and plant growth regulators such as auxins, gibberellins, and cytokinins, in addition to amino acids, which collectively enhance vegetative growth, increase the efficiency of nutrient absorption, and improve plant resistance to diseases, thereby positively affecting yield and improving its quality[7].

### Materials And Methods

The experiment was carried out in lath house of the Department of Plant Production at Al-Musaib Technical College during 2025 growing season to study the effect soil application of humic acid (0 and 10 g pot<sup>-1</sup>) And a symbol, foliar spraying with Nano fertilizer (0, 1000, and 2000 mg L<sup>-1</sup>), And a symbol and seaweed extract at concentrations of (0, 4, and 8 mL L<sup>-1</sup>) And a symbol on some vegetative and traits of the fig seedling . on two-year-old fig seedlings (*Ficus carica* L.) of the cultivar Aswad Diyala. The seedlings were nearly uniform in height and were obtained from the Horticulture Station in Al-Hindiya District, Karbala Governor. The seedlings were initially grown in plastic bags, and 162 seedlings with uniform growth and size, as much as possible, were selected. The selected seedlings were then transplanted into larger plastic pots with a capacity of 8 kg after filling them with the growing media according to the experimental treatments. The pots were randomly distributed among the treatments inside the lath house . All cultural practices were applied equally to all seedlings inside the shade house covered with saran. The complete Random Block Design (CRBD) with three factors and three replications. The averages were compared using the lowest significant differences (LSD) at P>0.05%. After the experiment was completed, the following measurements were taken : (Nitrogen %) , (Phosphorus %), (Potassium %), (protein %) and Leaf iron content (mg kg<sup>-1</sup>) in leaves.

## 3-RESULTS AND DISCUSSION

### 3.1.Results:

#### 1 -Nitrogen (%) in leaves

The results presented in Table (1) showed that humic acid application had a significant effect on nitrogen percentage in fig seedlings. The treatment with humic acid at a rate of 10 g pot<sup>-1</sup> significantly outperformed the control treatment (without application), recording the highest nitrogen percentage of 1.63% compared with 1.39% for the control. The results also indicated that The treatment with seaweed extract at a concentration of 8 mL L<sup>-1</sup> showed significant superiority, recording 2.02% compared with 1.17% for the control treatment (without seaweed extract spraying). In addition, foliar spraying with nano iron at a concentration of 2000 mg L<sup>-1</sup>

resulted in a significant increase in nitrogen percentage, recording 1.73% compared with 1.30% for the control treatment without nano iron spraying. The results in the same table also showed that the bi interactions between the experimental factors had a significant effect on nitrogen percentage in fig seedlings. The interaction treatment of humic acid at 10 g pot<sup>-1</sup> combined with seaweed extract at 8 mL L<sup>-1</sup> showed significant superiority, recording 2.27% compared with the control treatment (without humic acid application and spraying with distilled water only), which recorded 1.51%. Similarly, the binary interaction between humic acid at 10 g pot<sup>-1</sup> and nano iron spraying at 2000 mg L<sup>-1</sup> showed significant superiority, recording 1.76% compared with the corresponding control treatment (without humic acid application and without nano iron spraying), which recorded 1.21%. The interaction between seaweed extract spraying at 8 mL L<sup>-1</sup> and nano fertilizer at 2000 mg L<sup>-1</sup> also showed significant superiority, recording 2.54% compared with the control treatment without seaweed extract and nano fertilizer spraying, which recorded 1.09%. Furthermore, the triple interactions among the studied factors showed significant superiority in nitrogen percentage.

The triple treatment consisting of (humic acid application at 10 g pot<sup>-1</sup> + seaweed extract at 8 mL L<sup>-1</sup> + nano iron at 2000 mg L<sup>-1</sup>) recorded the highest nitrogen percentage of 2.64% compared with the triple control treatment (without humic acid application, without seaweed extract spraying, and without nano iron spraying), which recorded 1.09%.

**Table (1): Effect of humic acid , seaweed extract , nano iron, and their interactions on Nitrogen percentage (%)**

| humic acid (g L <sup>-1</sup> ) | Seaweed extract (mL L <sup>-1</sup> ) | Nano iron (mg L <sup>-1</sup> ) |      |      | Mean A*C                     |
|---------------------------------|---------------------------------------|---------------------------------|------|------|------------------------------|
|                                 |                                       | N0                              | N1   | N2   |                              |
| A0                              | C0                                    | 1.09                            | 1.14 | 1.21 | 1.15                         |
|                                 | C1                                    | 1.10                            | 1.31 | 1.36 | 1.26                         |
|                                 | C2                                    | 1.45                            | 1.39 | 2.50 | 1.78                         |
| A1                              | C0                                    | 1.10                            | 1.16 | 1.31 | 1.19                         |
|                                 | C1                                    | 1.44                            | 1.37 | 1.45 | 1.42                         |
|                                 | C2                                    | 1.64                            | 2.64 | 2.53 | 2.27                         |
| L.S.D (0.05)                    |                                       | 0.2405                          |      |      | 0.1388                       |
| Humic acid × nano iron A*N      |                                       |                                 |      |      | Mean of humic acid (A)       |
| A0                              |                                       | 1.21                            | 1.28 | 1.69 | 1.39                         |
| A1                              |                                       | 1.39                            | 1.72 | 1.76 | 1.63                         |
| L.S.D (0.05)                    |                                       | 880.13                          |      |      | 0.0802                       |
| Seaweed extract × nano iron C*N |                                       |                                 |      |      | Mean of seaweed extract( C ) |
| C0                              |                                       | 1.09                            | 1.15 | 1.26 | 1.17                         |
| C1                              |                                       | 1.27                            | 1.34 | 1.41 | 1.34                         |
| C2                              |                                       | 1.54                            | 2.01 | 2.51 | 2.02                         |
| L.S.D (0.05)                    |                                       | 000.17                          |      |      | 0.0982                       |
| Mean of nano iron               |                                       | 1.30                            | 1.50 | 1.73 |                              |
| LSD 0.05                        |                                       | 820.09                          |      |      |                              |

## 2-Phosphorus (%) in leaves

The results presented in Table (2) showed that humic acid application had a significant effect on phosphorus percentage in fig seedlings. The treatment with humic acid at a rate of 10 g pot<sup>-1</sup> significantly outperformed the control treatment (without application), recording the highest phosphorus percentage of 0.39% compared with 0.22% for the control. The results also indicated

that foliar spraying with seaweed extract had a significant effect on phosphorus percentage. The treatment with seaweed extract at a concentration of 8 mL L<sup>-1</sup> showed significant superiority, recording 0.43% compared with 0.19% for the control treatment (without seaweed extract spraying). In addition, foliar spraying with nano iron fertilizer (nano ferrous oxide, Fe<sub>2</sub>O<sub>3</sub>) at a concentration of 2000 mg L<sup>-1</sup> resulted in a significant increase in phosphorus percentage, recording 0.36% compared with 0.24% for the control treatment without nano iron spraying. The results in the same table also showed that the binary interactions between the experimental factors had a significant effect on phosphorus percentage of fig seedlings. The interaction treatment of humic acid at 10 g pot<sup>-1</sup> combined with seaweed extract at 8 mL L<sup>-1</sup> showed significant superiority, recording 0.57% compared with the control treatment (without humic acid application and spraying with distilled water only), which recorded 0.40%. Similarly, the binary interaction between humic acid at 10 g pot<sup>-1</sup> and nano iron spraying at 2000 mg L<sup>-1</sup> showed significant superiority, recording 0.46% compared with the corresponding control treatment (without humic acid application and without nano iron spraying), which recorded 0.16%. The interaction between seaweed extract spraying at 8 mL L<sup>-1</sup> and nano fertilizer at 2000 mg L<sup>-1</sup> also showed significant superiority, recording 0.46% compared with the control treatment without seaweed extract and nano fertilizer spraying, which recorded 0.147%. Furthermore, the triple interactions among the studied factors showed significant superiority in phosphorus percentage. The triple treatment consisting of humic acid application at 10 g pot<sup>-1</sup> combined with foliar spraying of seaweed extract at 8 mL L<sup>-1</sup> and nano iron at 2000 mg L<sup>-1</sup> recorded the highest phosphorus percentage of 0.59% compared with the triple control treatment (without humic acid application, without seaweed extract spraying, and without nano iron spraying), which recorded 0.14%.

**Table (2): Effect of humic acid , seaweed extract , nano iron, and their interactions on fig on phosphorus percentage in leaves**

| humic acid<br>(g L <sup>-1</sup> ) | Seaweed extract<br>(mL L <sup>-1</sup> ) | Nano iron (mg L <sup>-1</sup> ) |      |      | Mean<br>A*C                    |
|------------------------------------|------------------------------------------|---------------------------------|------|------|--------------------------------|
|                                    |                                          | N0                              | N1   | N2   |                                |
| A0                                 | C0                                       | 0.15                            | 0.14 | 0.14 | 0.14                           |
|                                    | C1                                       | 0.15                            | 0.19 | 0.32 | 0.22                           |
|                                    | C2                                       | 0.19                            | 0.36 | 0.34 | 0.30                           |
| A1                                 | C0                                       | 0.14                            | 0.25 | 0.30 | 0.23                           |
|                                    | C1                                       | 0.26                            | 0.38 | 0.49 | 0.38                           |
|                                    | C2                                       | 0.59                            | 0.54 | 0.58 | 0.57                           |
| L.S.D (0.05)                       |                                          | 0.13                            |      |      | 0.07                           |
| Humic acid × nano iron<br>A*N      |                                          |                                 |      |      | Mean of humic<br>acid (A)      |
| A0                                 |                                          | 0.16                            | 0.23 | 0.27 | 0.22                           |
| A1                                 |                                          | 0.33                            | 0.39 | 0.46 | 0.39                           |
| L.S.D (0.05)'                      |                                          | 0.07                            |      |      | 0.04                           |
| Seaweed extract × nano iron C*N    |                                          |                                 |      |      | Mean of seaweed<br>extract( C) |
| C0                                 |                                          | 0.14                            | 0.20 | 0.22 | 0.19                           |
| C1                                 |                                          | 0.21                            | 0.29 | 0.41 | 0.30                           |
| C2                                 |                                          | 0.39                            | 0.45 | 0.46 | 0.43                           |
| L.S.D (0.05)                       |                                          | 0.09                            |      |      | 0.05                           |
| Mean of nano iron                  |                                          | 0.24                            | 0.36 | 0.31 |                                |
| LSD 0.05                           |                                          | 0.05                            |      |      |                                |

### 3 -Potassium (%)in leaves

Table (3) showed that humic acid application had a significant effect on potassium percentage in fig seedlings. The treatment with humic acid at a rate of 10 g pot<sup>-1</sup> significantly outperformed the control treatment (without application), recording the highest potassium percentage of 2.56% compared with 2.20% for the control. The results also indicated that foliar spraying with seaweed extract had a significant effect on potassium percentage. The treatment with seaweed extract at a concentration of 8 mL L<sup>-1</sup> showed significant superiority, recording 2.83% compared with 1.94% for the control treatment (without seaweed extract spraying). In addition, foliar spraying with nano iron fertilizer (nano ferrous oxide, Fe<sub>2</sub>O<sub>3</sub>) at a concentration of 2000 mg L<sup>-1</sup> resulted in a significant increase in potassium percentage, recording 2.63% compared with 1.97% for the control treatment without nano iron spraying. The results in the same table also showed that the binary interactions between the experimental factors had a significant effect on potassium percentage in fig seedlings. The interaction treatment of humic acid at 10 g pot<sup>-1</sup> combined with seaweed extract at 8 mL L<sup>-1</sup> showed significant superiority, recording 3.25% compared with the control treatment (without humic acid application and spraying with distilled water only), which recorded 1.89%. Similarly, the binary interaction between humic acid at 10 g pot<sup>-1</sup> and nano iron spraying at 2000 mg L<sup>-1</sup> showed significant superiority, recording 2.88% compared with the corresponding control treatment (without humic acid application and without nano iron spraying), which recorded 1.90%. The interaction between seaweed extract spraying at 8 mL L<sup>-1</sup> and nano fertilizer at 2000 mg L<sup>-1</sup> also showed significant superiority, recording 3.43% compared with the control treatment without seaweed extract and nano fertilizer spraying, which recorded 1.58%. Furthermore, the triple interactions among the studied factors showed significant superiority in potassium percentage. The triple treatment consisting of humic acid application at 10 g pot<sup>-1</sup> combined with foliar spraying of seaweed extract at 8 mL L<sup>-1</sup> and nano iron at 2000 mg L<sup>-1</sup> recorded the highest potassium percentage of 2.95% compared with the triple control treatment (without humic acid application, without seaweed extract spraying, and without nano iron spraying), which recorded 1.55%.

**Table (3): Effect of humic acid , seaweed extract , nano iron, and their interactions on fig potassium percentage in leaves**

| humic acid<br>(g L <sup>-1</sup> ) | Seaweed extract<br>(mL L <sup>-1</sup> ) | Nano iron (mg L <sup>-1</sup> ) |      |      | Mean<br>A*C                    |
|------------------------------------|------------------------------------------|---------------------------------|------|------|--------------------------------|
|                                    |                                          | N0                              | N1   | N2   |                                |
| A0                                 | C0                                       | 1.55                            | 2.03 | 2.08 | 1.89                           |
|                                    | C1                                       | 2.09                            | 2.35 | 2.10 | 2.18                           |
|                                    | C2                                       | 2.07                            | 2.55 | 2.95 | 2.52                           |
| A1                                 | C0                                       | 1.61                            | 2.25 | 2.12 | 1.99                           |
|                                    | C1                                       | 2.10                            | 2.60 | 2.62 | 2.44                           |
|                                    | C2                                       | 2.38                            | 3.47 | 3.91 | 3.25                           |
| L.S.D (0.05)                       |                                          | 0.599                           |      |      | 0.345                          |
| Humic acid × nano iron<br>A*N      |                                          |                                 |      |      | Mean of humic<br>acid (A)      |
| A0                                 |                                          | 1.90                            | 2.31 | 2.38 | 2.20                           |
| A1                                 |                                          | 2.03                            | 2.77 | 2.88 | 2.56                           |
| L.S.D (0.05)                       |                                          | 0.345                           |      |      | 0.199                          |
| Seaweed extract × nano iron C*N    |                                          |                                 |      |      | Mean of seaweed<br>extract( C) |
| C0                                 |                                          | 1.58                            | 2.14 | 1.58 | 1.94                           |
| C1                                 |                                          | 2.09                            | 2.47 | 2.09 | 2.31                           |
| C2                                 |                                          | 2.23                            | 3.01 | 2.23 | 2.89                           |
| L.S.D (0.05)                       |                                          | 0.423                           |      |      | 0.244                          |
| Mean of nano iron                  |                                          | 1.97                            | 2.54 | 2.63 |                                |

| humic acid | Seaweed extract | Nano iron (mg L <sup>-1</sup> ) | Mean |
|------------|-----------------|---------------------------------|------|
| LSD 0.05   |                 | 0.244                           |      |

#### 4 -Leaf iron content (mg kg<sup>-1</sup>)

The results presented in Table (4) showed that humic acid application had a significant effect on leaf iron content in fig seedlings. The treatment with humic acid at 10 g pot<sup>-1</sup> significantly outperformed the control (without application), recording the highest leaf iron content of 135.1 mg kg<sup>-1</sup> compared with 124.3 mg kg<sup>-1</sup> for the control. Foliar spraying with seaweed extract also had a significant effect on leaf iron content. The treatment with seaweed extract at a concentration of 8 mL L<sup>-1</sup> showed significant superiority, recording 139.2 mg kg<sup>-1</sup> compared with 120.1 mg kg<sup>-1</sup> for the control (without seaweed extract). Foliar spraying with nano iron fertilizer (nano ferrous oxide, Fe<sub>2</sub>O<sub>3</sub>) at 2000 mg L<sup>-1</sup> also significantly increased leaf iron content, recording 135.7 mg kg<sup>-1</sup> compared with 124.3 mg kg<sup>-1</sup> for the control without nano iron. The binary interactions between the experimental factors had a significant effect on leaf iron content. The interaction of humic acid (10 g pot<sup>-1</sup>) + seaweed extract (8 mL L<sup>-1</sup>) recorded 146.6 mg kg<sup>-1</sup> compared with 117.2 mg kg<sup>-1</sup> for the control (without humic acid and sprayed only with distilled water). The binary interaction of humic acid (10 g pot<sup>-1</sup>) + nano iron (2000 mg L<sup>-1</sup>) showed 140.6 mg kg<sup>-1</sup> compared with 120.6 mg kg<sup>-1</sup> for the corresponding control (without humic acid and nano iron). The interaction of seaweed extract (8 mL L<sup>-1</sup>) + nano fertilizer (2000 mg L<sup>-1</sup>) recorded 148.1 mg kg<sup>-1</sup> compared with 121.6 mg kg<sup>-1</sup> for the control without seaweed extract and nano fertilizer. Furthermore, the triple interaction among the studied factors showed significant superiority in leaf iron content. The triple treatment of humic acid (10 g pot<sup>-1</sup>) + seaweed extract (8 mL L<sup>-1</sup>) + nano iron (2000 mg L<sup>-1</sup>) recorded 150.8 mg kg<sup>-1</sup> compared with the triple control treatment (without humic acid, without seaweed extract, and without nano iron), which recorded 111.9 mg kg<sup>-1</sup>.

**Table (4): Effect of humic acid , seaweed extract , nano iron, and their interactions on fig seedling leaf iron content (mg kg<sup>-1</sup>)**

| humic acid<br>(g L <sup>-1</sup> ) | Seaweed extract<br>(mL L <sup>-1</sup> ) | Nano iron (mg L <sup>-1</sup> ) |       |       | Mean<br>A*C                    |
|------------------------------------|------------------------------------------|---------------------------------|-------|-------|--------------------------------|
|                                    |                                          | N0                              | N1    | N2    |                                |
| A0                                 | C0                                       | 125.3                           | 111.9 | 114.5 | 117.2                          |
|                                    | C1                                       | 120.4                           | 118.2 | 132.8 | 123.8                          |
|                                    | C2                                       | 116.3                           | 134.0 | 145.3 | 131.8                          |
| A1                                 | C0                                       | 117.9                           | 120.9 | 129.9 | 122.9                          |
|                                    | C1                                       | 123.3                           | 143.0 | 141.0 | 135.8                          |
|                                    | C2                                       | 142.8                           | 146.0 | 150.8 | 146.6                          |
| L.S.D (0.05)                       |                                          | 13.59                           |       |       | 7.84                           |
| Humic acid × nano iron<br>A*N      |                                          |                                 |       |       | Mean of humic acid<br>(A)      |
| A0                                 |                                          | 120.6                           | 121.3 | 130.9 | 124.3                          |
| A1                                 |                                          | 128.0                           | 136.6 | 140.6 | 135.1                          |
| L.S.D (0.05)                       |                                          | 7.84                            |       |       | 4.53                           |
| Seaweed extract × nano iron C*N    |                                          |                                 |       |       | Mean of seaweed<br>extract( C) |
| C0                                 |                                          | 121.6                           | 116.4 | 122.2 | 120.1                          |
| C1                                 |                                          | 121.8                           | 130.6 | 136.9 | 129.8                          |
| C2                                 |                                          | 129.5                           | 140.0 | 148.1 | 139.2                          |
| L.S.D (0.05)                       |                                          | 9.61                            |       |       | 5.55                           |
| Mean of nano iron                  |                                          | 124.3                           | 129.0 | 135.7 |                                |
| LSD 0.05                           |                                          | 5.55                            |       |       |                                |

## 5 - protein (%) in leaves

The results presented in Table (5) showed that humic acid application had a significant effect on the protein percentage in fig seedlings. The treatment with humic acid at 10 g pot<sup>-1</sup> significantly outperformed the control (without application), recording the highest protein content of 9.34% compared with 8.66% for the control. Foliar spraying with seaweed extract also had a significant effect on protein percentage. The treatment with seaweed extract at a concentration of 8 mL L<sup>-1</sup> showed significant superiority, recording 11.42% compared with 7.31% for the control (without seaweed extract). Foliar spraying with nano iron fertilizer (nano ferrous oxide, Fe<sub>2</sub>O<sub>3</sub>) at 2000 mg L<sup>-1</sup> significantly increased protein percentage, recording 10.79% compared with 7.87% for the control without nano iron. The binary interactions between the experimental factors had a significant effect on protein percentage in fig seedlings. The interaction of humic acid (10 g pot<sup>-1</sup>) + seaweed extract (8 mL L<sup>-1</sup>) recorded 11.95% compared with 7.16% for the control (without humic acid and sprayed only with distilled water).

The binary interaction of humic acid (10 g pot<sup>-1</sup>) + nano iron (2000 mg L<sup>-1</sup>) showed 11.03% compared with 7.29% for the corresponding control (without humic acid and nano iron). The interaction of seaweed extract (8 mL L<sup>-1</sup>) + nano fertilizer (2000 mg L<sup>-1</sup>) recorded 15.69% compared with 6.72% for the control without seaweed extract and nano fertilizer. Furthermore, the triple interaction among the studied factors showed significant superiority in protein percentage. The triple treatment of humic acid (10 g pot<sup>-1</sup>) + seaweed extract (8 mL L<sup>-1</sup>) + nano iron (2000 mg L<sup>-1</sup>) recorded 15.70% compared with the triple control treatment (without humic acid, without seaweed extract, and without nano iron), which recorded 6.72%.

**Table (5): Effect of humic acid , seaweed extract , nano iron, and their interactions on seedling on protein (%)in leaves**

| humic acid<br>(g L <sup>-1</sup> ) | Seaweed extract<br>(mL L <sup>-1</sup> ) | Nano iron (mg L <sup>-1</sup> ) |      |       | Mean<br>A*C                    |
|------------------------------------|------------------------------------------|---------------------------------|------|-------|--------------------------------|
|                                    |                                          | N0                              | N1   | N2    |                                |
| A0                                 | C0                                       | 6.72                            | 7.14 | 7.61  | 7.16                           |
|                                    | C1                                       | 6.91                            | 8.47 | 8.37  | 7.92                           |
|                                    | C2                                       | 15.67                           | 8.24 | 8.77  | 10.89                          |
| A1                                 | C0                                       | 6.72                            | 7.29 | 8.39  | 7.47                           |
|                                    | C1                                       | 8.41                            | 8.45 | 8.98  | 8.62                           |
|                                    | C2                                       | 10.17                           | 9.97 | 15.70 | 11.95                          |
| L.S.D (0.05)                       |                                          | 2.550                           |      |       | 1.472                          |
| Humic acid × nano iron<br>A*N      |                                          |                                 |      |       | Mean of humic acid<br>(A)      |
| A0                                 |                                          | 7.29                            | 8.13 | 10.55 | 8.66                           |
| A1                                 |                                          | 8.44                            | 8.57 | 11.03 | 9.34                           |
| L.S.D (0.05)                       |                                          | 1.472                           |      |       | 0.850                          |
| Seaweed extract × nano iron C*N    |                                          |                                 |      |       | Mean of seaweed<br>extract( C) |
| C0                                 |                                          | 6.72                            | 7.22 | 8.00  | 7.31                           |
| C1                                 |                                          | 7.66                            | 8.46 | 8.68  | 8.27                           |
| C2                                 |                                          | 9.21                            | 9.37 | 15.69 | 11.42                          |
| L.S.D (0.05)                       |                                          | 1.803                           |      |       | 1.041                          |

| humic acid        | Seaweed extract | Nano iron (mg L <sup>-1</sup> ) |      |       | Mean |
|-------------------|-----------------|---------------------------------|------|-------|------|
| Mean of nano iron |                 | 7.87                            | 8.35 | 10.79 |      |
| LSD 0.05          |                 | 1.041                           |      |       |      |

### 3.2. –Discussion

The increase in the content of nitrogen, phosphorus, and potassium in the leaves (Tables 1, 2, and 3) may be attributed to the fact that humic acid is rich in nitrogen, or that humic acid increases the permeability of cell membranes and facilitates the transfer of nutrients, particularly nitrogen, phosphorus, and potassium. This leads to an increase in the efficiency of plants in absorbing these elements and accumulating them in the leaves [8]. Humic acid also increases the percentage of absorbed elements due to its activation of the H<sup>+</sup>-ATPase enzyme in the cellular membrane. This enzyme enhances the absorption and transport of nutrients and amino acids through the xylem and phloem [9]. Regarding micronutrients such as iron (Fe) and zinc (Zn), humic acid plays an important role in increasing their availability by forming chelate complexes that prevent the precipitation of these elements in the soil and maintain their availability. The results of Table (4) showed a significant increase in the iron content of the leaves. This increase may be attributed to the organic acids present in humic acid, which increase the permeability of cell membranes. These acids modify the phospholipids of the cell membranes, making the membrane more efficient in transporting nutrients from outside the cell to the cytoplasm, thus improving the nutritional status and the absorption of elements [10]. The increase in protein content may also be attributed to the presence of nitrogen in humic acid, which leads to the formation of a dense vegetative growth. The effect of seaweed extract on increasing the concentrations of nutrients (NPK) may be due to the presence of nitrogen and amino acids in the extract, which act as a source of nitrogen and consequently increase its concentration in the leaves, leading to an increase in protein content [11]. The increase in phosphorus and potassium in the leaves may be due to the enhancement of vegetative growth and the increase in the surface area of the root system, which is reflected in the increased absorption of nutrients including phosphorus and potassium [12]. The tables also showed an increase in zinc and iron in the leaves. This increase may be due to the improvement in vegetative and root growth characteristics, which resulted in increased absorption of zinc to meet the plant's requirement for this element. Zinc participates in the formation of the amino acid tryptophan, which is important in the synthesis of auxins, and also activates several enzymes involved in vital processes. In addition, seaweed extract contains both zinc and iron. Iron also participates in chlorophyll formation, electron transport, and the formation of energy compounds [13]. The foliar application of nano-iron on seedlings caused a significant increase in the concentration of elements in the leaves, including nitrogen, phosphorus, zinc, and iron. This may be attributed to the role of nano-iron at different concentrations in enhancing vegetative and root growth, as it facilitates the penetration of nutrients into the vegetative and root systems, thereby increasing the absorption of nutrients from the soil. This is in agreement with the findings of [14]. The increase in protein percentage in the leaves may also be due to the increase in nitrogen percentage, since nitrogen is involved in protein synthesis through its combination with organic acids to produce amino acids, which are the fundamental building blocks of proteins. Potassium also plays an important role in protein synthesis by facilitating the formation of new proteins through the separation of newly formed proteins [15]. Foliar spraying with seaweed extract also caused an increase in the percentage of NPK nutrients and protein in the leaves, thanks to their natural hormones (auxins and cytokinins) that enhance nutrient absorption and stimulate vegetative and root growth, thus improving seedling quality [16]. The reason for the increased nitrogen content in leaves when treated with seaweed extract is due to the seaweed extract containing organic nitrogen, which is absorbed directly, thus increasing its quantity within the

leaves. The increased potassium and phosphorus content in leaves is likely due to the importance of marine extracts in providing the plant with nutrients, thus increasing the plant's utilization of potassium, phosphorus and nitrogen fertilizers [17].

#### 4. Conclusions

The results showed that the humic acid had a significant effect due to This effect is attributed to considered an effective organic biostimulant for soil and plants ,and spraying with Nano iron attributed to the vital role of iron in physiological processes within the plant, particularly its involvement in the formation of enzymes responsible for respiration . Foliar spraying with seaweed extract also caused an increase in the percentage of NPK nutrients and protein in the leaves, thanks to their natural hormones (auxins and cytokinins) that enhance nutrient absorption and stimulate vegetative and root growth, thus improving seedling quality.

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