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# GROWTH INDICATORS OF OLIVE SEEDLINGS UNDER THE INFLUENCE OF SEAWEED AND HUMUS BIOFERTILIZERS

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## SUMMARY

A field experiment on olive (*Olea europaea* L.) saplings examined the influence of the Acadian seaweed extract and organic humic acid, carried out from March to November 2022 in an orchard located in Jazirah, Ramadi Region, Iraq. The study aimed to determine effects of foliar application of seaweed extract Acadian and organic fertilizer humic acid with concentrations of 0, 250, 500, 750, and 1000 mg $L^{-1}$ on olive saplings' foliage. Results showed spraying coefficients with individual treatments of Acadian and Humic fertilizers at the concentration of 1000 mg $L^{-1}$ significantly outperformed most studied traits. These provided the highest averages for main stem height (92.93 and 98.67 cm), main stem diameter (6.193 and 6.060 mm), leaf number (479.2 and 397.7), leaf area (602.4 and 455.1 $cm^2$), leaf chlorophyll content (73.60 and 75.73 SPAD), dry weight of vegetative parts (97.87 and 91.40 g), and root system (23.13 and 18.07 g), respectively. The interactions of both factors at 1000 mg $L^{-l}$ concentration were superior on olive saplings for the main stem height (131.00 cm), main stem diameter (7.067 mm), leaves seedling$^{-1}$ (670.3), leaf area (689.0 $cm^2$), leaf chlorophyll content (83.67 SPAD), dry weight of vegetative parts (122.33 g), and root system (28.33 g). The study concluded, based on results, that foliar fertilization, whether with biological or organic fertilizer, contributes positively and effectively to improving olive seedlings' growth.

**Keywords:** Olive (*O. europaea* L.), Acadian seaweed extract, organic Humic, nutrients, vegetative, root system

**Key findings:** The results revealed a greater improvement in growth and morphological traits of olive (*O. europaea* L.) saplings with foliar application of organic fertilizers at a concentration of 1000 mg $L^{-l}$.

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## INTRODUCTION

Although a large area is environmentally suitable for better production of olive (*Olea europaea* L.) in Iraq, however, olive production only amounted to 12,292 tons during 2018, with a mean production of 25.31 kg per tree in Iraq (COSIT, 2018). Albeit, the said production does not cover Iraq's need for this crop consumption. Olive trees have been an important source throughout history for the finest types of oil and for the pickles' industry (Al-Asadi, 2016). Given that its oil contains oleic acid, which is a major fatty acid in olive oil (55%–83%), whereas linoleic acid accounts for 3.5%–21% and α-linolenic acid at <1% (Al-Janabi and Al-Rawi, 2018).

Although olive is characteristically tolerant to harsh conditions, such as, lack of moisture content and high temperatures and grows in diverse soil conditions for fertility and quality, it can tolerate heavy, light, and calcareous soil with good permeability (Ben-Rouina and Boukhris, 2002). However, it suffers from low productivity in Iraq compared with neighboring countries, which is one of the most critical hindrances to the expansion of olive cultivation. Lack of securing good saplings suitable for cultivation, high fertilizer prices, and farmers' reluctance to appropriate fertilization processes, led to emergence of deficiency symptoms of some elements in local olive orchards. Insufficient machinery and equipment for the crop also led to high production costs (Hussein and Shaba, 2017).

Olive saplings are slow to grow and take a long time to become desired trees and ready for sale (Al-Dulaimi *et al*., 2016). Therefore, olive needs more attention for well-managed fertilization operations to increase transplants' growth. As fertilization is one of the most crucial means for its spread and cultivation development, especially fertilization of the right method at the right time and quantity for early growth and fruiting (Walaga, 2005).

In present agricultural systems, one of the relevant attempts to accelerate the growth of olive saplings is foliar fertilization, which improves maturity and also enhances productivity of its trees. In addition, efficient fertilizer use stimulates vegetative growth by ensuring timely arrival of nutrients absorbed through the leaves, which is one of the vital and simplest ways to determine nutritional status of trees to analyze their leaves (Fernandez-Escobar and Marin, 1999). Several studies reported that fulfilling 85% of plant needs can be through foliar nutrients (Abdul, 1988), and by spraying organic fertilizers (Acadian and humic acid), positively influencing plants because they contain various dissolved compounds (Mustafa and Cheyed, 2018).

Humic acid is an essential organic fertilizer effective in improving plant qualities because it contains numerous macronutrients and plays a positive role in nutrient absorption. Similarly, seaweed extracts contain plant hormones and growth regulators, such as, cytokinins and auxins, which equip the plant with necessary elements, positively reflecting in an enhanced growth and development (Vessey, 2003; Mustafa and Cheyed, 2019). Based on the foregoing discussion, the promising study aimed to determine improvements in olive saplings' strength for growth and morphological traits with foliar application of organic fertilizers.

## MATERIALS AND METHODS

A field experiment on olive (*Olea europaea* L.) saplings examined the influence of Acadian seaweed extract and organic Humic, carried out from March to November 2022, in an orchard in Jazirah, Ramadi Region, Iraq. The study aimed to determine the effects of foliar application of seaweed extract (Acadian) and organic fertilizer (humic acid), with various concentrations (0, 250, 500, 750, and 1000 mg $L^{-1}$) on olive saplings' foliage.

The homogeneous saplings in height of olive cultivar 'Shami' were choices for possible planting in plastic bags of 5-kg capacity. The experiment layout in randomized complete block design (RCBD) had a factorial arrangement, with two factors and three replications. Retaining 10 saplings per experimental unit comprised the study of both factors, with a total number of 75 transplants per experimental unit. The Acadian seaweed extract and humic acid fertilizer treatments with foliar application had the concentrations of 0, 250, 500, 750, and 1000 mg $L^{-1}$ each. The spraying process ensued in three batches for all concentrations of both fertilizers. The first, second, and third sprays commenced on March 2, April 2, and May 2, 2022, respectively, with simultaneous spraying of all concentrations for each date. The foliar application succeeded, after preparing the required concentrations of both fertilizers by dissolving them in the prescribed volume of water. All sprays transpired in the early morning using a hand sprinkler until reaching the stage of complete wetness.

**Studied characteristics**

The data recording continued for the following growth and morphological traits on olive saplings. The average main stem height (cm), measured with a ruler, began from the soil's surface to the top of the stem of five saplings, and then averaged. The recorded mean main stem diameter (mm) at the height of 5 cm from the soil surface proceeded in five randomly selected seedlings. Calculating the mean number of leaves per sapling occurred for five seedlings in each experimental unit. Leaf area ($cm^2$) calculations of the olive saplings followed the method mentioned by Saieed (1990). Estimating the olive leaves' chlorophyll index (SPAD) continued through a chlorophyll meter, with a reading of four leaves per sapling and a mean of five saplings per experimental unit. As for the vegetative (stem, branches, and leaves) and total system dry weights (g), these parts of the seedling and roots, placed in perforated paper bags, sustained drying in the oven at a temperature of 70 °C for 48 h until the weight stabilizes. Then, computing the mean dry weight of the shoot and the dry weight of the root total ensued for each experimental unit (Al-Sahhaf, 1989).

**Statistical analysis**

All the data for the olive's studied traits underwent analysis according to the randomized complete block design (RCBD) arranged with two factors. The least significant difference ($LSD_{0.05}$) test served to compare the arithmetic means (Kadem and Abed, 2018).

## RESULTS

**Main stem height**

Results showed a significant effect of both fertilizers (seaweed extract and humic acid) and their interaction coefficients on main stem height in olive saplings (Table 1). Acadian fertilizer at 1000 mg $L^{-1}$ displayed a substantial superiority by giving the maximum main stem height of saplings (92.93 cm), compared with the control treatment recorded with the lowest mean stem height (53.73 cm). The olive saplings' increase in the main stem height can be due to the effects of the Acadian seaweed extract. It encourages plant growth by increasing the percentage of nutrient entry to the plant because it contains various elements and acids needed by plants (Weaver, 1971). Humic fertilizer with the same concentration (1000 mg $L^{-1}$) also recorded a considerable better performance over all other levels of fertilizer, showing the topmost main stem height (98.67 cm), while the control treatment gave the lowest mean of 57.93 cm. These results were consistent with the findings of Ali *et al.* (2012), who reported a significant positive impact of Humic fertilizer on stem height characteristics of olive saplings.

The superiority of olive saplings treated with Humic fertilizer was due to the mineral elements contained by organic fertilizers, enriching cell membranes and the transfer of nutrient elements. This reflected in the size of cells, their division, and elongation, and thus, boosting stem growth. The interaction of both

**Table 1.** Effect of foliar application of seaweed acadian and humic acid on the main stem height of olive saplings.

| Acadian (mg $L^{-1}$) | Humic acid (mg $L^{-1}$) | | | | | Means (cm) |
|---|---|---|---|---|---|---|
| | 0 | 250 | 500 | 750 | 1000 | |
| 0 | 41.33 | 52.33 | 52.33 | 58.33 | 64.33 | 53.73 |
| 250 | 53.33 | 69.00 | 77.67 | 83.67 | 93.00 | 75.33 |
| 500 | 62.33 | 76.33 | 80.00 | 88.33 | 100.00 | 81.40 |
| 750 | 61.00 | 79.67 | 84.33 | 86.00 | 105.00 | 83.20 |
| 1000 | 71.67 | 74.67 | 86.67 | 100.67 | 131.00 | 92.93 |
| Means (cm) | 57.93 | 70.40 | 76.20 | 83.40 | 98.67 | |
| $LSD_{0.05}$ Acadian: 3.00, Humic acid: 3.00, Acadian x Humic acid: 6.70 | | | | | | |

**Table 2.** Effect of foliar application of seaweed acadian and humic acid on the stem diameter of olive saplings.

| Acadian (mg $L^{-1}$) | Humic acid (mg $L^{-1}$) | | | | | Means (mm) |
|---|---|---|---|---|---|---|
| | 0 | 250 | 500 | 750 | 1000 | |
| 0 | 3.800 | 4.633 | 5.033 | 5.167 | 5.367 | 4.800 |
| 250 | 4.967 | 5.267 | 5.533 | 5.633 | 5.700 | 5.420 |
| 500 | 5.300 | 5.733 | 5.800 | 6.067 | 6.067 | 5.793 |
| 750 | 5.633 | 5.867 | 5.933 | 6.000 | 6.100 | 5.907 |
| 1000 | 5.500 | 6.000 | 6.000 | 6.400 | 7.067 | 6.193 |
| Means (mm) | 5.040 | 5.500 | 5.660 | 5.853 | 6.060 | |
| $LSD_{0.05}$ Acadian: 3.00, Humic acid: 3.00, Acadian x Humic acid: 6.70 | | | | | | |

fertilizers at the concentration of 1000 mg $L^{-l}$ was also superior in performance for main stem height (131.00 cm), compared with the control treatment, which recorded with the lowest mean (41.33 cm).

**Stem diameter**

The results indicated a significant effect of both fertilizers (Acadian and Humic) on stem diameter of olive saplings (Table 2). Seaweed extract at 1000 mg $L^{-1}$ appeared with a remarkable superiority by recording the maximum mean of stem diameter (6.193 mm), while untreated saplings were visible with the lowest stem diameter (4.800 mm). The results further showed foliar application of humic acid fertilizer (1000 mg $L^{-1}$) revealed the highest mean stem diameter (6.060 mm), while unsprayed treatment gave the least mean (5.040 mm).

The interaction effects of foliar application of Acadian seaweed extract, and humic acid were superior at the concentration of 1000 mg $L^{-1}$ for main stem diameter (7.067 mm), compared with the control treatment with the minimum mean value (3.800 mm). The superiority of olive saplings treated with Humic and Acadian fertilizers was due to their mineral elements that increase the permeability of membranes (Al-Asadi, 2016; Al-Dulaimi *et al*., 2016). Cellular and elements' transition, which are evident in cells size and their division, thus, lead to increased growth.

**Leaves per seedling**

For leaves per plant in olive saplings, the significant effect of the biological and organic fertilizers, as well as, their interaction coefficients were notable (Table 3). The foliar application of seaweed extract (1000 mg $L^{-1}$) emerged with the highest average of leaves per sapling (479.2 leaves $plant^{-1}$), while the control treatment provided the lowest mean number of leaves in the olive sapling (232.9). The Humic fertilizer (1000 mg $L^{-1}$) was also markedly superior over all other levels of fertilizer and showed the most number of leaves per sapling (397.7 leaves $plant^{-1}$) compared with the control treatment (296.7 leaves $plant^{-1}$). The interaction of both

**Table 3.** Effect of foliar application of seaweed acadian and humic acid on the number of leaves per olive saplings.

| Acadian (mg $L^{-1}$) | Humic acid (mg $L^{-1}$) (H) | | | | | Means (#) |
|---|---|---|---|---|---|---|
| | 0 | 250 | 500 | 750 | 1000 | |
| 0 | 192.3 | 220.0 | 242.3 | 257.3 | 252.7 | 232.9 |
| 250 | 278.7 | 273.3 | 295.0 | 300.3 | 315.7 | 292.6 |
| 500 | 301.3 | 315.7 | 322.0 | 325.0 | 355.7 | 323.9 |
| 750 | 341.0 | 344.0 | 346.0 | 378.0 | 394.0 | 360.6 |
| 1000 (#) | 370.0 | 399.3 | 462.7 | 493.7 | 670.3 | |
| $LSD_{0.05}$ Acadian: 17.3, Humic acid: 17.3, Acadian x Humic acid: 38.8 | | | | | | |

**Table 4.** Effect of foliar application of seaweed acadian and humic acid on the leaf area of olive saplings.

| Acadian (mg $L^{-1}$) | Humic acid (mg $L^{-1}$) | | | | | Means ($cm^2$) |
|---|---|---|---|---|---|---|
| | 0 | 250 | 500 | 750 | 1000 | |
| 0 | 221.3 | 274.7 | 268.7 | 296.0 | 300.7 | 272.3 |
| 250 | 307.0 | 327.3 | 345.0 | 359.0 | 368.0 | 341.3 |
| 500 | 385.0 | 383.3 | 393.7 | 403.3 | 401.7 | 393.4 |
| 750 | 400.3 | 404.0 | 425.3 | 483.7 | 516.0 | 445.9 |
| 1000 | 529.3 | 577.3 | 597.7 | 618.7 | 689.0 | 602.4 |
| Means ($cm^2$) | 368.6 | 393.3 | 406.1 | 432.1 | 455.1 | |
| $LSD_{0.05}$ Acadian: 7.9, Humic acid: 7.9, Acadian x Humic acid: 17.7 | | | | | | |

fertilizers (1000 mg $L^{-1}$) also exhibited a noteworthy superiority for leaves per sapling (670.3 leaves $plant^{-1}$) versus the control treatment, recording with the lowest value (192.3 leaves $plant^{-1}$).

The presented results agreed with the findings of Ali *et al.* (2012), who also reported a significant effect of Humic fertilizer on the number of leaves in olive sapling. This superiority refers to the vital role of Humic fertilizer, which contains humic acid and fulvic and high concentrations of nitrogen, enhancing stored carbohydrates, thereby raising photosynthesis' efficiency and vegetative growth (Keller and Kolet, 1995). Superiority can also be because of the presence of mineral elements in both fertilizers and their stimulation of carbon metabolism, metabolic processes, and respiration. These reflected in increased vegetative growth, resulting from enhanced cell division and number of leaves. The promising outcomes were also in analogy with the findings of Al-Shabani and Al-Janabi (2017) on orange saplings and what Al-Khafaji and Al-Ali (2021) obtained on olive saplings. They reported a significant enhancement in the number of leaves per sapling treated with seaweed extract.

**Leaf area**

The results showed a significant effect of seaweed extract (Acadian) and organic Humic fertilizers and their interaction on the leaf area in olive saplings (Table 4). The foliar application of Acadian fertilizer (1000 mg $L^{-1}$) demonstrated the best performance by giving the highest mean leaf area (602.4 $cm^2$), while the control treatment only amounted to 272.3 $cm^2$. The superiority of the Acadian fertilizer was due to it contains macro elements, a group of micro elements, growth regulators and vitamins entering plant nutrition. These improved the vegetative growth qualities, which positively appeared in increasing the leaf area of crop plants (Karthikeyan and Shanmugam, 2015).

With the same concentration (1000 mg $L^{-1}$), spraying with Humic fertilizer significantly excelled over all other levels of fertilizer by giving the highest mean leaf area (455.1 $cm^2$), compared with unsprayed treatments, which gave the lowest mean (368.6 $cm^2$). Interaction between Acadian and humic acid fertilizers at the concentration of 1000 mg $L^{-1}$ also emerged with the maximum mean leaf area (689.0 $cm^2$), compared with the control treatment, recording the minimum mean (221.3 $cm^2$). Kazem *et al.* (2017) reported foliar application of organic fertilizer (Humic) has a considerable role in enhancing the leaf area in apricot trees.

**Chlorophyll index**

Findings revealed a substantial effect of both fertilizers (Acadian and Humic) individually and their combined application on the leaf chlorophyll index (Table 5). The Acadian biofertilizer (1000 mg $L^{-1}$) showed markedly the highest leaf chlorophyll index (73.60 SPAD), versus the control treatment, observed with the lowest mean chlorophyll index (62.87 SPAD). This may be due to the content of the Acadian fertilizer with different compounds and growth regulators, positively affecting an increased leaf chlorophyll index. Likewise, the foliar application of the Humic fertilizer (1000 mg $L^{-1}$) significantly exhibited superior performance with the utmost leaf chlorophyll index (75.73 SPAD), compared with the control treatment (57.13 SPAD). The interaction of both fertilizers (Acadian and Humic at the rate of 1000 mg $L^{-1}$) displayed with a significant superiority over all other interactions by recording the highest leaf chlorophyll index in olive saplings (83.67 SPAD), versus the control treatment, recording with a minimum mean (39.67 SPAD).

The presence of amino acids in Humic fertilizer activates and influences the basic nutrients, including iron and nitrogen, which has an effective role in the process of carbon metabolism and the construction of chlorophyll (Abu-Dahi and Younes, 1988). The presented results were also consistent with the findings of Ali *et al.* (2012) and Badrani (2017), as they reported significantly increased leaf chlorophyll index after the application of Humic fertilizer to olive saplings. The increased total chlorophyll index was evident with foliar application of marine algae extract in loquat trees (Al-Hawezy, 2014) and in summer orange trees (Amro, 2015).

**Dry weight of vegetative total**

For dry weight of vegetative total, both fertilizers and their interaction revealed significant differences (Table 6). The Acadian biofertilizer (1000 mg $L^{-1}$) was prominent with a significant superiority for the highest dry weight of vegetative total (97.87 g), compared with the control treatment, recording with the lowest mean of the vegetative total's dry weight (64.00 g). This superiority of the Acadian fertilizer refers to various nutrients found in it, which support and nourish the plant, as well as, enhance the strength of vegetative growth, leading to an improved growth of the vegetative and root system (Sultana *et al.*, 2005). The Humic fertilizer at 1000 mg $L^{-1}$ exhibited a significant superiority over all other levels of fertilizer with the topmost mean dry weight of the vegetative total (91.40 g), compared with the comparison treatment, observed with the lowest mean for the said trait (64.47 g). This superiority may be due to the Humic fertilizer contains organic acids (humic acid and volvic) and mineral elements in appropriate quantities absorbed by the crop plant through foliar spraying, causing an increased vegetative growth.

The necessary processes for vitality, such as, carbon metabolism and the construction of products necessary for metabolism to build and divide cells, positively reflected in the increased number of leaves and the enhanced accumulation of processed nutrients. In turn, these manifested in the increased dry weight of the vegetative growth total. The presented results were also consistent with past findings (Ali *et al.*, 2012; Al-Khafaji and Al-Ali, 2021). The significant superiority of the bilateral interaction of both fertilizers (Acadian and humic acid) at the concentration of 1000 mg $L^{-1}$ was evident for enhanced dry weight of the vegetative total (122.33 g), compared with the control treatment, providing the lowest mean for the said variable (40.00 g).

**Table 5.** Effect of foliar application of seaweed acadian and humic acid on the leaf chlorophyll content of olive saplings.

| Acadian (mg $L^{-1}$) | Humic acid (mg $L^{-1}$) | | | | | Means (SPAD) |
|---|---|---|---|---|---|---|
| | 0 | 250 | 500 | 750 | 1000 | |
| 0 | 39.67 | 65.00 | 68.33 | 68.67 | 72.67 | 62.87 |
| 250 | 47.33 | 68.00 | 65.00 | 75.33 | 76.33 | 66.40 |
| 500 | 66.67 | 62.00 | 66.00 | 65.67 | 72.00 | 66.47 |
| 750 | 61.00 | 71.00 | 72.00 | 75.67 | 74.00 | 70.73 |
| 1000 | 71.00 | 67.67 | 72.00 | 73.67 | 83.67 | 73.60 |
| Means (SPAD) | 57.13 | 66.73 | 68.67 | 71.80 | 75.73 | |
| $LSD_{0.05}$ Acadian: 2.60, Humic acid: 2.60, Acadian x Humic acid: 5.81 | | | | | | |

**Table 6.** Effect of foliar application of seaweed acadian and humic acid on the dry weight of vegetative total of olive saplings.

| Acadian (mg $L^{-1}$) | Humic acid (mg $L^{-1}$) | | | | | Means (g) |
|---|---|---|---|---|---|---|
| | 0 | 250 | 500 | 750 | 1000 | |
| 0 | 40.00 | 62.00 | 66.67 | 74.00 | 77.33 | 64.00 |
| 250 | 65.00 | 68.00 | 76.67 | 78.33 | 77.00 | 73.00 |
| 500 | 63.67 | 74.33 | 74.33 | 77.67 | 79.33 | 73.87 |
| 750 | 72.33 | 76.67 | 84.67 | 92.00 | 101.00 | 85.33 |
| 1000 | 81.33 | 91.67 | 95.67 | 98.33 | 122.33 | 97.87 |
| Means (g) | 64.47 | 74.53 | 79.60 | 84.07 | 91.40 | |
| $LSD_{0.05}$ Acadian: 2.92, Humic acid: 2.92, Acadian x Humic acid: 6.53 | | | | | | |

**Table 7.** Effect of foliar application of seaweed acadian and humic acid on the dry weight of root system of olive saplings.

| Acadian (mg $L^{-1}$) | Humic acid (mg $L^{-1}$) | | | | | Means (g) |
|---|---|---|---|---|---|---|
| | 0 | 250 | 500 | 750 | 1000 | |
| 0 | 7.67 | 8.67 | 9.33 | 9.00 | 10.00 | 8.93 |
| 250 | 9.67 | 12.00 | 11.33 | 13.67 | 13.33 | 12.00 |
| 500 | 12.00 | 15.00 | 14.33 | 15.00 | 18.00 | 14.87 |
| 750 | 13.67 | 15.67 | 18.00 | 21.67 | 20.67 | 17.93 |
| 1000 | 18.00 | 20.67 | 22.00 | 26.67 | 28.33 | 23.13 |
| Means (g) | 12.20 | 14.40 | 15.00 | 17.20 | 18.07 | |
| $LSD_{0.05}$ Acadian: 0.96, Humic acid: 0.96, Acadian x Humic acid: 2.14 | | | | | | |

**Dry weight of the root system**

The results showed a meaningful effect of the biological and organic fertilizers and their interaction coefficients on the dry weight of the olive root system (Table 7). The Acadian biofertilizer (1000 mg $L^{-1}$) significantly exceeded all other levels by recording the highest mean dry weight of the root total (23.13 g), versus the comparison treatment (8.93 g). This superiority was due to the Acadian fertilizer because it is a rich source of various nutrients supporting and nourishing crop plants. It also enhanced the strength of vegetative growth, which leads to improved growth of vegetative and root system (Sultana *et al*., 2005). The two treatments of Humic fertilizer (1000 and 750 mg $L^{-1}$) also displayed the maximum and at par values of the root dry weight (18.07 and 17.20 g, respectively), compared with the control treatment, observed with the lowest mean dry weight of the root system (12.20 g). The reason for the superiority of the humic acid was organic acids and nutrients help form a strong vegetative total, which resulted in an increased root dry weight of the olive seedlings.

The interaction between the Acadian and Humic biofertilizers at the concentration of 1000 mg $L^{-1}$ also appeared with the maximum mean dry weight of the root system (28.33 g). However, it did not differ significantly with the interaction of the biofertilizer (750 mg $L^{-1}$) and humic acid (1000 mg $L^{-1}$) (26.67 g). The lowest mean dry weight (7.67 g) was notable in the control interaction, which did not differ significantly from the control treatment of the Humic fertilizer and Acadian biofertilizer's three concentrations (250, 500, and 750 mg $L^{-1}$), with values of 8.67, 9.33, and 9.00 g respectively. The latest results were in agreement with past findings on studying the effect of fertilization with humus acid on the growth of olive seedlings (Ali *et al.*, 2012).

## DISCUSSION

The Acadian seaweed extract encourages plant growth by increasing the percentage of nutrient entry in plants because it already contains various macro- and micro-elements and acids required by plants (Weaver, 1971). It also contains growth regulators and vitamins entering into plant nutrition and improving the vegetative growth qualities, as well as, enhancing the strength of vegetative growth, causing an increased growth of the vegetative and root system (Sultana *et al.,* 2005). Thus, this positively reflected in increasing the main stem height, leaf area, and leaf chlorophyll index in the olive saplings (Karthikeyan and Shanmugam, 2015).

The Humic fertilizer contains organic fertilizers and mineral elements, which enhances the permeability of cell membranes and the transfer of elements, as reflected in cell sizes, their division, and elongation, and thus, boosting stem growth (Ali *et al.,* 2012). Past studies also revealed a significant effect of Humic fertilizer on the main stem height and number of leaves in olive seedlings (Ali *et al*., 2012). This superiority was due to the Humic fertilizer containing the humic acid and the fulvic and high concentrations of nitrogen, also enhancing stored carbohydrates, causing an increase in the strength and efficiency of photosynthesis and vegetative growth (Keller and Kolet, 1995).

The supremacy of interaction of both fertilizers may be because of the stimulation of carbon metabolism, metabolic processes, and respiration, as reflected in the increased vegetative growth, resulting from enhanced cell division, and thus, raising the number of leaves. The presented results were analogous to past findings about orange seedlings (Al-Shabani and Al-Janabi, 2017) and olive saplings (Al-Khafaji and Al-Ali, 2021). These plants demonstrated a significant increase in the number of leaves treated with marine algae extract. Moreover, the Humic fertilizer has a significant effect in increasing the leaf area of trees (Kadhim *et al.,* 2017). This may be due to the organic and amino acids found in Humic fertilizer, activating the basic nutrients, including iron and nitrogen, and the construction of leaf chlorophyll content (Abu-Dahi and Younes, 1988).

The pertinent results about the increased leaf chlorophyll index in the olive seedlings were consistent with past findings by getting the enhanced chlorophyll index with spraying of Humic fertilizer in olive seedlings (Ali *et al.*, 2012; Badrani, 2017). Previous studies of Al-Hawezy (2014) in Loquat trees and Amro (2015) in summer orange trees, also observed enhanced total chlorophyll content with foliar application of seaweed extract. The necessary processes for vitality, such as, carbon metabolism and the construction of products necessary for metabolism to build and divide cells, positively reflected in the increased number of leaves and accumulation of processed nutrients. These positively manifested in enhancing the root system and dry weight of olive saplings. The results about the increased dry weight of the vegetative total were consistent with past findings in the olive saplings (Al-Khafaji and Al-Ali, 2021).

Therefore, the study concluded foliar fertilization, whether with seaweed extract or organic, contributes positively and effectively to improving the growth of olive saplings. Spraying both fertilizers together at the higher concentration (1000 mg $L^{-1}$) showed a better response in the growth characteristics of olive saplings than their individual application. It is a clear indication of the ability of olive seedlings to respond to high concentrations of both fertilizers. Therefore, its recommendation to spraying the olive saplings, especially at the beginning of spring, with both fertilizers, is a must. Future studies with higher concentrations of both fertilizers for determining the best stage and dose for foliar fertilization will also be fruitful.

## CONCLUSIONS

Foliar fertilization, whether with organic fertilizer, contributes positively and effectively to improving the growth of olive saplings. Combined application of both fertilizers with a higher concentration (1000 mg $L^{-1}$) provides a better response in the growth characteristics of olive seedlings than individual application. The study recommends spraying olive saplings, especially at the beginning of spring, with both fertilizers. Moreover, the authors suggest to conduct further studies with higher concentrations of both fertilizers.

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