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Impact of *Ascophyllum nodosum* Marine Algae Extract on the Sesame Crop (*Sesamum indicum* L.) Growth Indicators

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ABSTRACT

This study was carried out on sesame crops at the College of Agriculture and Marshlands, Dhi Qar University in south of Iraq, during the 2023 agricultural season to assess the impact of marine algae extract *Ascophyllum nodosum* (Seamac Power) on the growth indicators of the sesame crop in Dhi Qar Governorate. The research involved two treatments: soaking with herbal extract solutions at concentrations of 0.5, 1, 1.5, and 2g. L^{-1}, and spraying with the same extract at the same concentrations, plus a control treatment for both methods. Various growth indicators were examined, including absolute growth rate, biomass sustainability, leaf water content, and average dry weights of the root and shoot systems. The study found that soaking seeds in a 1-1.5g. L^{-1} solution and spraying with a 1.5g. L^{-1} solution of marine algae extract significantly improved most growth indicators.

INTRODUCTION

Sesame is one of the globally important oil and food crops since its seeds contain a high percentage of oil ranging between 45-60%, protein between 20-25%, and carbohydrates of 15% **(Paul *et al*., 2018)**, as well as vitamins, phosphorus and calcium elements, which all of them are affected by the species and the environment. Sesame is rich in fatty acids and antioxidants that strengthen the human body's immune system and protect it from diseases. Sesame has anti-inflammatory properties thanks to its containment of sesamin, as several experiments have shown that it helps relieve joint and knee inflammation and cartilage pain and contains a good percentage of minerals such as calcium, magnesium, and zinc **(Aydar *et al*., 2020)**. Sesame seeds contain an amount of fiber, which helps improve the health of the digestive system and relieve digestive disorders. It has medical uses in treating dizziness, blurred vision, and tinnitus. Its seeds soften the digestive system and treat constipation. Moreover, it is also used in cosmetics. Sesame seeds are rich in unsaturated fats and antioxidants, and the leaves are used to treat kidney problems. Sesame oil is used to treat psoriasis **(Mitra & Rangesh, 2003)**. These extracts contain many macro- and micronutrients, as well as amino acids and growth

regulators such as gibberellins and cytokinins, which are easily absorbed by the plant, stimulate root growth and vegetative growth, increase yield characteristics and plant resistance to diseases, insects, drought, water stress and freezing **(Thomas, 2004)**. Many studies have been conducted on the effect of marine algae extracts on the growth and production of vegetable crops in particular. For example, spraying bean plants with the extract of the sea weed *Ascophyllum nodosum* caused a significant increase in the average dry weight of leaves, stems and roots **(Reitz 7 Trumble, 1996)**. **Sheekh and Saied (2000)** noted that using Cladophara dalmatica algae extracts as sprays on bean plants led to an acceleration in seed germination, an increase in the length of the main root, an increase in the number of lateral roots, and an elevation in the chlorophyll content in the leaves.

O'Dell (2003) found that spraying marine algal extract on plants increases the plant's resistance to drought, increases the growth and development of the root and shoot systems, increases the efficiency of photosynthesis, delays aging, and increases the size and weight of fruits and overall yield. This study was conducted using seamac power marine algae extract as a soaking of seeds and spraying on plants at different intervals and concentrations with the aim of:

1- Choosing the appropriate concentration for soaking the seeds with marine algae extract, which achieves the best rates of growth indicators for the crop.
2- Choosing the appropriate concentration for spraying with marine algae extract, which achieves the best rates of growth indicators for the crop.
3- Choosing the appropriate combination of soaking and spraying with marine algae extract that achieves the best rates of growth indicators for the crop.

MATERIALS AND METHODS

This study was conducted in the fields of the College of Agriculture and Marshlands-Dhi Qar University during the spring season of the year 2023. The study included two factors. The first factor was soaking sesame seeds with Seamac Power marine algae extract at four concentrations (0.5, 1, 1.5, and 2g. L^{-1}) to the control treatment for two hours before planting, while the second factor included spraying the plants with Seamac Power extract at four concentrations (0.5, 1, 1.5, and 2g. L^{-1}) to the comparison treatment for two times, the first and second three weeks after germination.

Marine algae extract is a concentrated soluble fertilizer extracted from marine algae *Ascophyllum nodosum*. It contains a balanced composition of macro- and microelements and natural hormones (Auxins, Gibberellins, Cytokinins and Betainins) and also contains amino acids and other organic substances.

The experiment was applied according to a randomized complete block design (R.C.B.D) with three replications. The acidity and salinity of the soil and irrigation water were measured, as shown in Table (1).

Table 1. Physical and chemical characteristics of soil and irrigation water

Soil				Water		
pH	**E.C milimos. $^{cm-}$**	**C.E.C meq/100 g so**	**O.M %**	**Soil texture**	**pH**	**E.C milimos. $^{cm-1}$**
7.99	**6.199**	**1.63**	**2.05**	**Silty clay loar**	**8.24**	**1.351**

Nitrogen fertilizer (urea 46% N) was added in two batches, as well as triple superphosphate fertilizer in one batch, according to the recommended quantities. A local variety of sesame seeds were planted, which is part of the 2022 agricultural season. They were irrigated immediately after planting, then watering continued after the germination stage according to the plant's need. Spraying treatments were applied at a time before sunset in order to ensure that the material did not evaporate from the surfaces of the leaves, and a dispersing agent (a teaspoon of soap) was added (liquid) to the spray solution to overcome the surface tension of the solution drops and to ensure complete contact between the solution and the leaf surface to achieve full benefit. After 6 weeks from the date of planting, a number of plants from each treatment were carefully removed for assessing their characteristics.

1. Growth traits

1.1 Absolute growth rate of the plant g. day^{-1}

Absolute growth rate of plant (AGR) is defined as the production of dry matter over a period of time, and it was calculated by calculating the average dry weight of three plants over two time periods (the first 6 weeks after germination and the second 8 weeks after germination (experiment period)) **(Monteith, 1978)** using the following equation:

$$\mathbf{AGR= (DW2-DW1)/ (T2-T1)}$$

DW1= dry weight of plants at the first time period.
DW2= dry weight of plants at the second time period.
T1= Plant age (day) at the first time period.
T2= Plant age (days) at the second time period.

1.2 Biomass sustainability (g. day $^{-1}$)

Biomass sustainability was calculated according to the method of **Kvent *et al*. (1969)** based on the dry weight of the shoots at the specified age of the plant for both periods and according to the following equation:

$$\textbf{B. D (g. day}^{-1}\textbf{)= ((w2-w1)(T2-T1))/2}$$

W1= dry weight of plants at the first time period.
DW2= dry weight of plants at the second time period.
T1= Plant age (day) at the first time period.
T2= Plant age (day) at the second time period.

After the plants reached eight weeks of age, the plants were uprooted to calculate the following characteristics:

1.3 Relative water content of the leaves

The relative water content of the leaves was estimated after isolating them and taking their fresh weights directly using a sensitive electric balance. Then, they were cut into small parts and placed in test tubes containing distilled water and left in the dark for 4 hours. After that, the samples were extracted and the water was removed using filter paper, and their weights were measured again, which represents their weight at saturation (TW), then their dry weights (DW) were calculated after drying them in an electric oven at a temperature of 70°C for 48 hours, and the relative water content was estimated using the following equation **(Barr & Weatherly 1962)**:

R.W= ((fresh weight of sample - dry weight of sample)/(weight of sample at saturation - dry weight of sample))*100

1.4 Dry weight of roots and shoot (g)

Dry weight of roots and shoot (g) were calculated by weighing the roots and shoot of ten plants from each replicate after cleaning them with tap water and then drying them in an electric oven for 72 hours at a temperature of 70°C.

2. Physiological traits

2.1 Chlorophyll a and b

The concentration of chlorophyll a and b pigments was estimated according to the method **(Makinny, 1941; Arnon, 1949)** by crushing a sample of plant leaves weighing 0.5 grams with a ceramic mortar and using acetone at a concentration of 80%. The extract was obtained after being placed in a centrifuge at 3000rpm for 15 minutes, succeeded by reading using a spectrophotometer at a wavelength of 663 and 645nm to calculate chlorophyll a and chlorophyll b according to the following equations:

Chlorophyll a (mg/L) = (12.7*D 663) – (2.69*D 645)
Chlorophyll b (mg/L)= (22.9*D 645) – (4.68*D 663)

2.2 Carotene

About 0.1g of leaves were weighed and crushed in a ceramic mortar with 20ml of acetone at a concentration of 80% and placed in a centrifuge at 3000 rpm for 15 minutes. Then the supernatant was taken and the extraction was repeated by adding 5ml of acetone each time until the filtrate became colorless. Then, the filtrate was collected and used to estimate the carotene concentration. The absorbance was measured at the wavelengths of 480, 645, and 663nm using a spectrophotometer to estimate the carotene content **(Kirk & Allen 1965)**, according to the following equation:

Carotene mg.g-1= (A645 0.638 – (0.114 A663 + A480)/ (W*1000*a)

A = the length of the light path in the cell.
V= volume of extract.
W= fresh weight of sample (mg).

3. Statistical analysis

The experiment was applied according to a Randomized Complete Block Design (R.C.B.D). The experiment included two factors: The first included four concentrations in addition to the comparison treatment, and the second included four concentrations in addition to the comparison treatment, so that the number of experimental units was 25. It was applied with three replications. The experiment was analyzed using the statistical program SPSS (V23). Moreover, the averages were compared using the least significant difference (L.S.D) test at a probability level of 0.05.

RESULTS

1. Growth traits

1.1 The absolute growth rate of the plant (g. day^{-1})

The rate values in Table (2) and the results of the statistical analysis indicate a significant increase in the absolute growth rate of the plant due to the effect of increasing the concentrations of soaking with marine algae extract, reaching a concentration of 1.5g. L^{-1}. This concentration achieved the highest rates, amounted to 0.28g. day $^{-1}$ compared to the rest of the treatments, while the comparison treatment had the lowest amount of 0.21g. day^{-1}. Increasing spraying concentrations with the extract had a significant effect in increasing the absolute growth rate of the plant, as spraying at a concentration of 1.5g.L^{-1} achieved the highest rates reaching 0.35g. day^{-1}, while 0.5 concentration recored the lowest value which reached 0.17g. day^{-1}. The

interaction of the two factors had a significant effect on the absolute growth rate of the plant, as the treatment (soaking at a concentration of 1.5 g. L^{-1} x spraying at a concentration of 1.5 g. L^{-1}) had the highest averages, reaching 0.46g. day^{-1}, while the treatment which involved soaking at a concentration of 0 g.L^{-1} x spraying at a concentration of 0.5 g.L^{-1} had the lowest rate of 0.12g. day^{-1}.

Table 2. Effect of soaking seeds and spraying with marine algae extract on the absolute growth rate of the plant g. day^{-1}

Soaking concentration g. L^{-1}	**Spray concentrations g. L^{-1}**					**Mean**
	0	**0.5**	**1**	**1.5**	**2**	
0	0.17±0.02	0.12±0.02	0.22±0.05	0.32±0.01	0.24±0.02	**0.21**
0.5	0.21±0.01	0.16±0.03	0.25±0.01	0.28±0.05	0.27±0.04	**0.23**
1	0.20±0.01	0.14±0.02	0.27±0.05	0.38±0.02	0.27±0.05	**0.25**
1.5	0.19±0.03	0.22±0.01	0.28±0.02	0.46±0.01	0.25±0.01	**0.28**
2	0.22±0.06	0.19±0.04	0.25±0.09	0.31±0.04	0.27±0.02	**0.25**
Mean	**0.20**	**0.17**	**0.25**	**0.35**	**0.26**	
	L.S.D (A)= 0.02		**L.S.D(B)= 0.09**		**L.S.D(AxB)= 0.11**	

A= Soak the seeds with the extract.
B= Spraying with extract.

1.2 Sustainability of plant biomass (g. day^{-1})

The average values in Table (3) and the results of the statistical analysis indicate that there is a significant increase in the rate of plant biomass sustainability as a result of increasing the concentrations of soaking with marine algae extract, where the concentration exceeds 1.5g. L^{-1} over the rest of the concentrations used and achieved the highest rates of 90.35g. day^{-1}, while the comparison treatment had the lowest amount to 62.54g. day^{-1}. Increasing spraying concentrations with marine algae extract had a significant effect on increasing the rate of plant biomass sustainability, as spraying at a concentration of 1.5g.L^{-1} achieved the highest rate reaching 120.13g. day^{-1}, while the comparison treatment had the lowest amount of 44.40g. day^{-1}. The interaction of the two factors had a significant effect on the rate of sustainability of plant biomass, as the combination which involved soaking at a concentration of 2g. L^{-1} x spraying at a concentration of 1.5g. L^{-1} excelled, giving the highest averages of 147.06g. day^{-1}, while the treatment which involved soaking at a concentration of 0.5g. L^{-1} x spraying with distilled water, had the lowest rate of 29.05g. day^{-1}.

Table 3. Effect of soaking seeds and spraying with marine algae extract on biomass sustainability (g. day^{-1})

Soaking concentration g. L^{-1}	Spray concentrations gm. L^{-1}					Mean
	0	0.5	1	1.5	2	
0	32.11±4.25	35.77±3.36	44.08±1.12	78.22±3.13	122.52±6.03	**62.54**
0.5	29.05±2.61	38.90±1.55	56.15±4.21	101.34±6.22	109.14±5.24	**66.92**
1	35.26±3.33	44.13±2.37	61.33±3.33	133.01±8.14	120.10±3.08	**78.77**
1.5	58.82±5.12	59.02±3.29	67.03±2.12	141.02±9.44	111.08±4.16	**87.39**
2	66.78±2.12	61.04±4.08	77.12±2.13	147.06±4.91	99.76±3.65	**90.35**
Mean	**44.40**	**47.77**	**61.14**	**120.13**	**112.52**	
	L.S.D (A)= 6.83		**L.S.D(B)= 13.44**		**L.S.D(AxB)= 21.04**	

A= Soak the seeds with the extract.
B= Spraying with extract.

1.3 Relative water content of leaves %

The average values in Table (4) and the results of the statistical analysis indicate that a significant increase was detected in the average relative water content of the leaves in response to increasing concentrations of soaking with marine algae extract, where the concentration exceeded 1.5g. L^{-1} compared to the rest of the concentrations used and achieved the highest rates of 73.0%, while the concentration of 1g. L^{-1}, amounted for the lowest percentage of 70.2%. Increasing the spraying concentrations with marine algae extract had a significant effect on increasing the relative water content of the leaves, as spraying achieved a concentration of 2g. L^{-1} had the highest rates of 75.8%, while the comparison treatment had the lowest of 67%. The interaction of the soaking and spraying factors had a significant effect on the average relative water content of the leaves, as the combination which involved soaking at a concentration of 2g. L^{-1} x spraying at a concentration of 1.5g. L^{-1} excelled in giving the highest rates of 79%, while the treatment which involved soaking with a concentration of 1g. L^{-1} x spraying with distilled water, amounted for the lowest percentage of 63%.

Table 4. Effect of soaking seeds and spraying with marine algae extract on relative water content of leaves %

Soaking concentration g. L^{-1}	Spray concentrations gm. L^{-1}					Mean
	0	0.5	1	1.5	2	
0	66±2.12	71±2.12	74±1.02	71±3.22	71±2.02	**0**
0.5	65±3.62	73±3.52	75±4.27	73±2.25	68±3.42	**0.5**

1	63±2.31	71±2.34	73±2.27	77±3.13	67±2.07	**1**
1.5	69±1.13	70±1.08	74±3.09	79±2.35	73±0.16	**1.5**
2	72±1.13	68±0.15	72±2.23	79±3.21	70±0.06	**2**
Mean	**67**	**70.6**	**73.6**	**75.8**	**69.8**	
	L.S.D (A)= 1.36		**L.S.D(B)= 4.63**		**L.S.D(AxB)= 6.33**	

A= Soak the seeds with the extract.
B= Spraying with extract.

1.4 Dry weight of roots (gm)

The averages in Table (5) and the results of the statistical analysis reveal that there is a significant increase in the average dry weight of the plant roots by increasing the concentrations of soaking with marine algae extract to a concentration of 1g. L^{-1}. Then, it began to decline in the average root dry weight, as the weight at this concentration reached 2.26g, while the comparison treatment had a minimum of 2.04g. Increasing the concentrations of spraying with marine algae extract had a significant effect on increasing the average root dry weight, as spraying achieved a concentration of 1.5g. L^{-1} had the highest rates of 2.86g, while the concentration of 0.5g. L^{-1}, resulted in the least value of 1.69g. The interaction had a significant effect on the average root dry weight, as the treatment which involved soaking at a concentration of 1g. L^{-1} x spraying at a concentration of 1.5g. L^{-1} outperformed by giving the highest rates of 3.35g, while the treatment which involved soaking at a concentration of 1g. L^{-1} was superior.

1.5 Dry weight of shoots (gm)

The values of the dry weight rates of the shoots in Table (6) and the results of the statistical analysis indicate that there is a significant effect of the difference in the concentrations of soaking with marine algae extract on this trait, as the concentration of 1g. L^{-1} had the highest average of 7.77g, while the concentration of 0.5g. L^{-1}, resulted in the lowest amount of 6.62g. L^{-1}. Increasing spraying concentrations with the extract had a significant effect on increasing the average dry weight of the plant's shoots, as spraying achieved at a concentration of 1.5g. L^{-1} had the highest rates of 9.77g, while for the comparison treatment the lowest was 5.57g. The interaction of the two experimental factors had a significant effect on the average dry weight of the shoots, as the treatment which involved soaking at a concentration of 1g. L^{-1} x spraying with distilled water, resulted in the lowest value of 5.22g.

Table 5. Effect of soaking seeds and spraying with marine algae extract on average dry weight of roots (g)

Soaking concentration g. L^{-1}	Spray concentrations g. L^{-1}					Mean
	0	**0.5**	**1**	**1.5**	**2**	
0	1.71±0.12	1.78±0.02	1.66±0.01	2.15±0.06	2.88±0.03	**2.04**
0.5	1.73±0.17	1.87±0.04	1.78±0.05	2.36±0.17	2.70±0.52	**2.08**
1	1.87±0.31	1.53±0.02	1.80±0.02	3.35±0.10	2.75±0.80	**2.26**
1.5	2.03±0.15	1.68±0.03	2.14±0.06	3.27±0.23	1.74±0.15	**2.17**
2	2.11±0.02	1.60±0.05	2.19±0.04	3.19±0.14	1.53±0.51	**2.12**
Mean	**1.89**	**1.69**	**1.91**	**2.86**	**2.32**	
	L.S.D (A)= 0.09		**L.S.D(B)= 0.42**		**L.S.D(AxB)= 0.58**	

A= Soak the seeds with the extract.
B= Spraying with extract.

T**able 6.** Effect of soaking seeds and spraying with marine algae extract on average dry weight of shoots (g)

Soaking concentration g. L^{-1}	Spray concentrations g. L^{-1}					Mean
	0	**0.5**	**1**	**1.5**	**2**	
0	5.22±1.61	5.78±0.19	5.92±2.20	9.48±0.60	7.26±1.02	**6.73**
0.5	5.66±2.24	5.33±1.70	6.33±0.01	7.51±1.11	8.27±0.06	**6.62**
1	6.73±0.33	6.03±0.06	7.33±1.02	11.78±2.12	7.02±1.07	**7.77**
1.5	5.23±1.21	5.26±1.03	6.37±0.12	10.44±0.34	6.73±0.19	**6.81**
2	5.02±0.42	6.03±0.11	7.27±0.10	9.62±1.19	6.11±0.05	**6.81**
Mean	**5.57**	**5.69**	**6.64**	**9.77**	**7.08**	
	L.S.D (A)= 0.74		**L.S.D(B)= 2.25**		**L.S.D(AxB)= 3.15**	

A== Soak the seeds with the extract.
B= Spraying with extract.

1.6 Average total dry weight of the plant (gm)

The average values in Table (7) and the results of the statistical analysis indicate that there is a significant increase in the average total dry weight of the plant by increasing the concentrations of soaking with marine algae extract to a concentration of 1g. L^{-1}, and this increase is followed by a decline in the average total dry weight of the plant. The weight at this concentration reached 9.66g, while the comparison treatment had the lowest amount of 8.73g.

Increasing the spraying concentrations with marine algae extract had a significant effect on increasing the average total dry weight of the plant, as spraying achieved at a concentration of 1.5g. L^{-1} had the highest rates of 12.63g, while the comparison treatment had the lowest value of 7.09g. The interaction had a significant effect on the average total dry weight of the plant, as the treatment which involved soaking at a concentration of 1g. L^{-1} x spraying with distilled water, resulted in the lowest value of 6.60g.

Table 7. Effect of soaking seeds and spraying with Marine algae extract on average total dry weight of the plant (g)

Soaking concentration g. L^{-1}	**Spray concentrations g. L^{-1}**					**Mean**
	0	**0.5**	**1**	**1.5**	**2**	
0	7.73±1.20	7.11±1.11	7.99±1.03	9.66±2.01	11.15±1.01	**8.73**
0.5	6.75±0.63	7.65±0.39	8.70±1.20	11.84±1.33	9.96±1.22	**8.78**
1	6.60±1.31	7.68±1.31	9.13±1.07	15.13±1.12	9.77±0.82	**9.66**
1.5	7.26±1.10	7.94±1.03	8.51±1.14	13.71±1.34	8.47±0.10	**9.18**
2	7.13±1.09	7.74±0.08	9.46±0.13	12.81±1.01	7.64±1.18	**8.96**
Mean	**7.09**	**7.62**	**8.76**	**12.63**	**9.40**	
	L.S.D (A)= 0.41		**L.S.D(B)= 2.27**		**L.S.D(AxB)= 2.93**	

A= Soak the seeds with the extract.
B= Spraying with extract.

1.7 Percentage of root system weight/shoot

The average weight ratio% values in Table (8) and the results of the statistical analysis show that there is a significant difference in concentrations of soaking with marine algae extract at the ratio of dry root weight/dry shoot weight, where the concentration exceeded 1g. L^{-1} giving the highest averages for the trait, reaching 31.81%. After that, the rate of root system weight/vegetative weight ratio began to decline with increasing the concentration of the soaking solution to 1.5g. L^{-1}, and the apparent increase at the concentration was recorded at 2g. L^{-1}, while the concentration of 0.5g. L^{-1} resulted in the lowest percentage of 29.89%. The different concentrations of spraying with marine algae extract had a significant effect on the average ratio of root shoot/shoot weight, where soaking with distilled water only had the highest rates (35.98%), while the concentration of 1g. L^{-1} resulted in the lowest amounted of 28.04%. The interaction had a significant effect on the rate of root system weight/vegetative weight ratio, as the treatment which involved soaking at a concentration of 2g. L^{-1} x spraying with distilled water only excelled and achieved the highest rates of 42.03%, while the treatment which involved

soaking at a concentration of 1g. L^{-1} x spraying at a concentration of 1g.L^{-1} resulted in the lowest percentage of 24.55%.

2. Physiological traits

2.1 Chlorophyll a concentration (mg.g^{-1})

The results shown in Table (9) and the results of the statistical analysis indicate that the character of chlorophyll a was not significantly affected by the effect of the different concentrations used in soaking sesame seeds with marine algae extract, as the differences between them were apparent and did not reach the limits of significance. Increasing spraying concentrations with marine algae extract had a significant effect on increasing the concentration of chlorophyll a in plant leaves, as spraying with a 1.5g. L^{-1} concentration, resulted in the highest rates of 2.46milligrams. gm^{-1}, while the comparison treatment had the lowest amount of 1.88 milligrams. gm^{-1}. The interaction of the soaking and spraying agents had a significant effect on the average concentration of chlorophyll a in the plant leaves, as the treatment which incoloved soaking at a concentration of 1.5g. L^{-1} x spraying at a concentration of 1.5g. L^{-1} excelled in giving the highest rates of 2.86 milligrams.g-1, while the comparison treatment had a minimum of 1.77 milligrams. g^{-1}.

Table 8. Effect of soaking seeds and spraying with marine algae extract on the percentage of dry root weight/dry shoot weight %

Soaking concentration g. L^{-1}	**Spray concentrations g. L^{-1}**					**Mean**
	0	**0.5**	**1**	**1.5**	**2**	
0	30.21±4.12	33.39±3.14	26.22±1.04	28.62±2.36	34.82±2.07	**30.65**
0.5	29.31±1.61	32.35±4.51	25.72±3.02	24.89±3.64	37.19±1.62	**29.89**
1	39.53±3.33	27.36±2.86	24.55±1.37	28.44±0.12	39.17±4.06	**31.81**
1.5	38.81±1.17	26.83±1.03	33.59±0.13	31.32±3.30	25.85±2.13	**31.28**
2	42.03±3.42	28.35±2.13	30.12±0.17	33.16±2.01	25.04±1.11	**31.74**
Mean	**35.98**	**29.66**	**28.04**	**29.29**	**32.41**	
	L.S.D (A)= 0.74		**L.S.D(B)= 2.41**		**L.S.D(AxB)=3.23**	

A== Soak the seeds with the extract.

B= Spraying with extract.

Table 9. Effect of soaking seeds and spraying with marine algae extract on the concentration of chlorophyll a (mg.g^{-1})

Soaking concentration g. L^{-1}	**Spray concentrations g. L^{-1}**					**Mean**
	0	**0.5**	**1**	**1.5**	**2**	
0	1.77±0.12	1.97±0.12	1.86±0.02	2.07±0.12	2.41±0.03	**2.02**
0.5	1.95±0.61	1.85±0.59	1.96±0.23	2.13±0.60	2.13±0.32	**2.00**
1	1.84±0.30	1.93±0.01	1.87±0.07	2.77±0.12	1.75±0.03	**2.03**
1.5	2.02±1.61	1.89±0.11	2.11±0.13	2.86±0.02	2.05±0.13	**2.19**
2	1.86±0.12	2.05±0.08	2.31±0.12	2.45±0.05	1.78±0.16	**2.09**
Mean	**1.88**	**1.94**	**2.02**	**2.46**	**2.02**	
	L.S.D (A)= N.S		**L.S.D(B)=0.45**		**L.S.D(AxB)=0.51**	

A== Soak the seeds with the extract.
B= Spraying with extract.

2.2 Chlorophyll b concentration (mg.g^{-1})

The average values in Table (10) and the results of the statistical analysis verify that the character of chlorophyll b was significantly affected by the effect of the different concentrations used in soaking sesame seeds with marine algae extract, where the concentration of 1.5 grams. L^{-1} gave the highest rates, reaching 1.05 milligrams.g^{-1}, while soaking with distilled water only had the lowest rates (0.95), which did not differ significantly from the chlorophyll concentration rates at concentrations of 0.5, 1, and 2g. L^{-1}. Increasing spraying concentrations with marine algae extract had a significant effect on increasing the concentration of chlorophyll b in plant leaves, as spraying at a 1.5 g. L^{-1} concentration, resulted in the highest rates reaching 1.32 milligrams. g^{-1}, while the comparison treatment had the lowest amount of 0.64 milligrams. g^{-1}. The interaction of the two experimental factors had a significant effect on the average concentration of chlorophyll b in the plant leaves, where the treatment which involved soaking at a concentration of 1.5g. L^{-1} x spraying at a concentration of 1.5g. L^{-1} excelled by giving the highest rates of 1.47 milligrams. g^{-1}, while the treatment which involved soaking at a concentration of 1g.l^{-1} x spraying with distilled water only, recorded the lowest value of 0.62milligrams. g^{-1}.

Table 10. Effect of soaking seeds and spraying with marine algae extract on chlorophyll b concentration (mg.g^{-1})

Soaking concentration g. L^{-1}	Spray concentrations g. L^{-1}					Mean
	0	0.5	1	1.5	2	
0	0.64±0.02	0.68±0.16	0.89±0.05	1.23±0.71	1.33±0.04	**0.95**
0.5	0.65±0.07	0.63±0.02	0.94±0.50	1.22±0.07	1.35±0.21	**0.96**
1	0.62±0.15	0.68±0.31	1.34±0.07	1.36±0.10	1.21±0.17	**0.97**
1.5	0.64±0.13	0.69±0.02	1.36±0.07	1.47±0.14	1.07±0.12	**1.05**
2	0.67±0.16	0.74±0.13	1.22±0.11	1.31±0.01	0.85±0.10	**0.96**
Mean	**0.64**	**0.68**	**1.15**	**1.32**	**1.16**	
	L.S.D (A)= 0.03		**L.S.D(B)=0.12**		**L.S.D(AxB)=0.18**	

2.3 Carotene concentration (µg.g^{-1})

The averages in Table (11) and the results of the statistical analysis indicate that there is a significant increase in the average concentration of carotene in plant leaves in response to increasing concentrations of soaking with marine algae extract, where the concentration exceeded 1.5g. L^{-1} over the rest of the concentrations used and achieved the highest rates of 13.03 micrograms. g^{-1}, while the treatment with distilled water only had the lowest level of 10.96 micrograms. g^{-1}. Increasing spraying concentrations with marine algae extract achieved a significant increase in the rate of carotene concentration in plant leaves, as spraying at a concentration of 2g. L^{-1} had the highest rates of 15.21, while the 0.5 g. L^{-1} concentration, recorded a minimum value of 8.20 micrograms. g^{-1}. The interaction of the two factors had a significant effect on the rate of carotene concentration in the plant leaves, as the treatment which involved soaking at a concentration of 1.5g. L^{-1} x spraying at a concentration of 2g. L^{-1} was superior in giving the highest rates of 16.95 micrograms. g^{-1}, while the treatment which involved soaking at a concentration of 1g.l^{-1} x spraying with distilled water, recorded the lowest rate of 6.34 micrograms. g^{-1}.

Table 11. Effect of soaking seeds and spraying with marine algae extract on carotene concentration (µg.g^{-1})

Soaking concentration g. L^{-1}	Spray concentrations g. L^{-1}					Mean
	0	0.5	1	1.5	2	
0	10.03±1.21	7.32±0.11	9.25±0.01	14.55±1.06	13.67±2.01	**10.96**
0.5	11.34±1.66	7.33±1.59	9.34±0.52	13.87±0.07	14.53±0.12	**11.28**

1	6.34±1.34	8.55±0.46	11.67±1.80	13.66±0.18	15.22±1.07	**11.09**
1.5	8.13±0.13	9.44±1.09	13.76±0.10	16.87±1.44	16.95±1.12	**13.03**
2	9.11±0.12	8.37±0.18	15.88±0.13	14.78±1.81	15.66±0.13	**12.76**
Mean	**8.99**	**8.20**	**11.98**	**14.75**	**15.21**	
	L.S.D (A)= 1.58		**L.S.D(B)=2.73**		**L.S.D(AxB)=4.53**	

A= Soak the seeds with the extract.

B= Spraying with extract.

DISCUSSION

The statistical analysis and average values indicated that soaking sesame seeds and spraying plants with different concentrations of marine algae extract had a significant impact on most of the traits studied. Soaking the seeds and spraying the plants with a concentration of 1.5g. L^{-1} notably improved the absolute growth rate, biomass sustainability, relative water content of leaves, and chlorophyll a, b, and carotene content. Additionally, a concentration of 1g. L^{-1} was the most effective for the dry weight of roots, shoots, and total dry weight of the plant.

The results revealed that increasing the concentration of the extract improved these characteristics up to a point, after which further increases led to a decline. This improvement in growth indicators is likely due to the marine algae extract promoting cell division through the activation of cytokinin, enhancing nutrient absorption, and stimulating vegetative and root growth. Additionally, the extract contains growth regulators and essential nutrients that aid in increasing cell division, expansion, and photosynthetic efficiency.

However, high concentrations (above 1.5g/ L) caused ionic stress and free radical accumulation, leading to reduced enzymatic activity, chlorophyll formation, and overall plant growth. The accumulation of carotene at high extract concentrations may be an attempt to boost oxidative defense systems, countering stress caused by high element accumulation. This balance of concentration is crucial for maintaining the plant's vitality and growth.

CONCLUSION

Based on this study, it can be concluded that using seamac power marine algae extract at a concentration of 1 - 1.5g. L^{-1} for soaking seeds and spraying on sesame plant leaves can significantly improve growth indicators, which will likely enhance the plant's yield. We recommend further research on the use of this extract at various concentrations for soaking or spraying, especially under the conditions of Dhi Qar Governorate - Iraq. The extract appears to enhance the plant's ability to resist soil and irrigation water salinity

by increasing the activity of antioxidant enzymes such as glutathione reductase and superoxide dismutase.

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