Effect of seaweed extracts on the growth and flowering of Statice plant (*Limonium sinuatum*) growing in saline soil

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Abstract:

The experiment was conducted in lathhouse of the Department of Plant Production Technologies/Al-Musayyib Technical College for autumn season of 2022 and the spring season of 2023 to study the effect of the plant Statis, Limonium sinuatum good uniformity, and seaweed extracts in the bioremediation of saline soils. Plastic pots with a diameter of 27 cm were used filled with an agricultural medium composed of river soil. + Compost (palm waste) in a ratio of 1:3 . The experiment included two factors. The first factor used seaweed extracts and is symbolized by the symbol ((B). It included three levels: without addition (the control treatment) and symbolized by B0 and B1. Spraying at a concentration of 1 g.L^{-1} and B2. Spraying at a concentration of 2 g. L^{-1}. As for the second factor, it includes salinity and is symbolized by the symbol (S). It has four levels S0: soil salted with sodium chloride at a concentration of 3 dS.m^{-1} (comparison treatment) and S1, salted soil at a concentration of 5 dS.m^{-1}. S2 is salted soil with a concentration of 7 dS.$m^{-1}$and S3 is salted soil with a concentration of 9 ds.m^{-1}.The experiment was conducted as a factorial experiment according to a completely randomized design (C.R.D) with three replications, and the means were compared according to the least significant difference (L.S.D) test under the probability level of 0.05.The results were as follows: The triple interaction treatment between the study factors resulted in a significant increase in the studied traits. The interaction treatment (S0B2) outperformed the rest of the other interaction treatments and gave the highest values for the traits of plant height, chlorophyll, number of flowering stalks, vase life , carotene pigment, and proline. Compared to the no-additive treatment of seaweed extracts, salinity caused a significant reduction in the studied traits.

introduction:

The Statice plant belongs to the Plumbaginaceae family and the genus Limonium. Its scientific name is Limonium Sinuatum. It is an annual or perennial herbaceous plant, depending on the species and the environment in which it grows. Its native habitat is the Mediterranean basin, southern Spain, North Africa, the Canary Islands, and even in Palestine[7,17,22] It usually grows in sandy lands and tolerates salinity, so it is suitable for cultivation on seashores. It also tolerates cultivation in dry conditions[8] Seaweed extracts, including Ascophyllum Nodsom algae, are among the organic biostimulants that have been commonly used in recent years, as these extracts contain many important compounds such as vitamins, plant hormones, and some organic compounds that contribute to increasing and improving plant growth [2]

Soil degradation caused by salinization has become a global problem that most countries of the world suffer from. It is a major abiotic stress factor that leads to a reduction in the area of arable agricultural land, approximately 10% of all soil types and 50% of irrigated land around the world.[12,21,24] By 2050, half of the world's arable land may disappear if current trends continue in the same direction [13] . The initial symptoms of salt toxicity in plants include ion damage, osmotic stress, and oxidative stress [18] which negatively affects plant growth. And its development, and salinity can cause physiological drought, which occurs when plant roots respond to environmental conditions such as a lack of water and an increase in salt ions in the soil. This lack of water has harmful effects on plants, including the accumulation of reactive oxygen species, oxidative stress, and decreased rates of carbon synthesis[4]Salinity in soil is divided into primary and secondary

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salinity depending on the sources from which it was formed in the soil. Primary salinity is formed as a result of the weathering of primary minerals or the parent material. Secondary salinity is formed as a result of the incorrect use of soil and irrigation practices that lead to the rise of highly salinity groundwater and its contribution to the process of salinity. Salinization [5]

Material and methods

The experiment was conducted in the canopy of the Department of Plant Production Technologies / Al-Musayyib Technical College for autumn season of 2022 and the spring season of 2023 to study the effect of the Limonium Sinuatum good uniformity plant and seaweed extracts in the bioremediation of saline soils. The experiment included two factors: the first factor was seaweed extracts at three levels (without addition Spraying at a concentration of 1 $ml.L^{-1}$, spraying at a concentration of 2 $ml.L^{-1}$, and the second factor is salinity at four levels (salted soil at a concentration of 3 $dS.m^{-1}$ (control treatment), soil salted with sodium chloride at a concentration of 5 $dS.m^{-1}$, soil salted with sodium chloride At a concentration of 7 dSm^{-1}, soil salted with sodium chloride at a concentration of 9 dSm^{-1}, the research was conducted as a factorial experiment (1*3*4) with a Completely Randomized Design (CRD) with three replicates, each replicate containing 24 treatment, thus the number of experimental units was (72) and with 7 plants for each experimental unit, the number of plants was (504). The averages were compared according to the least significant difference (L.S.D) test under the 5% probability level [3] then the data was analyzed using the statistical program. Genstat.

Table (1) shows the chemical trait of palm frond compost:

EC(ds\ m) 1:10	PH 1:10	N-Total (%)	K (mg\kg)	O.M (%)	C (%)	C\N Ratio
4.75	7.4	2.17	228	76.6	44.42	1\20

Table (2) shows the chemical and physical traits of the medium used in the study: -

P H	EC 1-ds. m	Organic matter	available nitrogen	available Phosphorus mg kg-1	available potassium mg kg-1	Size distribution of soil particles			Soil texture
						Clay percentage g kg-1	percentage of silt, g kg-1	Sand percentage, gm kg-1	Sandy loam
7.3	3.00	28.7	17.9	11.6	165.3	%15	%23	%62	

Table (3) shows the components of seaweed extract Flowering Setting

Nutrients	%
Seaweed extract from (Ascophyllum NodoSum)	26.30
Free anino acide	8.70
Phosphorus (P2O5)	10.00
Zinc (zn chelated with EDTA)	1.71
Boron (B)	0.85
Molybdenum (Mo)	0.27
Vitamius (B group)	0.30
Pio Saccharides	5.50

Studied traits: 1- Plant height (cm)

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Plant height was measured from the soil surface to the top of the flower inflorescence on the plant using a metric tape measure for three plants, then the averages were calculated for each treatment.

2- Intensity of chlorophyll pigment in leaves (SPAD Unit)

Three pairs of leaves were collected from the bottom, middle and top of the plant and were estimated using a device (Chlorophyllcontent meter SPAD-2252) for three plants, then the averages were calculated.

3- Number of flower stalks (stalk. plant^{-1})

I calculated the number of flowering stalks formed for three plants, then calculated the average for each treatment.

4- vase life (days)

Nine flower stalks and their inflorescences were collected from each treatment, 3 flower stalks. replicate $^{-1}$ When the inflorescences fully opened, the flower stalks were cut early in the morning, obliquely, at a length of 30 cm. Then they were placed in plastic containers with a capacity of 300 ml containing 250 ml of distilled water. Then the flowers were transferred to a cooled room using a cooling device, and the temperature was adjusted. At 2 +- 30 °C by controlling the temperature of the device, the humidity 5 - 40%, and the number of hours of lighting 14 hours under fluorescent candles, and the vase life was calculated until the signs of wilting, drought, and falling flower inflorescences appeared[9] . The number of stalks was calculated. The flower size formed for three plants, then the rate was calculated for each treatment.

5- Determination of anthocyanin pigment in flowers (mg 100 gm^{-1} dry weight)

The anthocyanin pigment content of violet Statis flowers was estimated by taking 1 g of dry plant tissue from the flower petals and crushing it in acidified ethanol (Hel 1.5 and ethyl alcohol 95%). The mixture was filtered and 1 ml of it was taken and the volume was increased to 15 ml, then it was measured using a spectrophotometer at a wavelength. 535 nm[20]

Anthocyanin pigment=

$$\frac{\textit{Optical density at a wavelength of } 535 \textit{ x the volume of solution us}}{\textit{Sample weight } x\ 98.20}$$

It was evaluated in the laboratories of the Department of Plant Production Technologies/Al-Musayyib Technical College.

6_ Estimation of the percentage of proline:

Proline was determined according to the method of [6]

Results :

1- Plant height (cm)

The results of Table (4) indicate that salt stress caused a significant decrease in plant height, as it reached 71.19 cm when treated with a salinity level of 9 dSm^{-1}, compared to the treatment with a salinity level of 3 dSm^{-1}, which gave the highest average plant height of 84.50 cm, as the results show. The use of seaweed extracts significantly reduced the effects of salinity, which had a positive impact on plant height, as the spraying treatment at a concentration of 2 ml L^{-1} achieved the highest rate of plant height, reaching 84.80 cm. As for the bi-interaction between salinity and seaweed extract, the (3 dSm-1 + 2 ml L^{-1}) treatment significantly excelled by recording the highest rate of plant height, amounting to 88.23 cm, compared to the (9 dSm^{-1} + spraying at a concentration of 1 ml L^{-1}) treatment, which recorded the lowest rates of 65.60. poison .

Table (4) Effect of soil salinity and seaweed extract on plant height (cm)

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Average	Seaweed extract ml.L-1			Soil salinity dS m^{-1}
	2	**1**	**0**	
84.50	88.23	85.14	77.13	3
83.45	85.67	84.70	83.00	5
74.10	74.92	74.18	73.47	7
71.19	73.22	74.47	65.60	9
	80.51	79.62	84.80	Average
	interaction	Extract	Salinity	LSD*0.05*
	2.208	1.108	1.289	

2- Leaf chlorophyll (spad)

The results of Table (5) indicate that salt stress caused a significant decrease in the leaves' chlorophyll content, as it reached 47.89 spad in the 9 ds m^{-1} treatment, compared to the 3 ds m^{-1} treatment and the 5 ds m^{-1} treatment, which gave the highest rate of chlorophyll content in the leaves. Chlorophyll reached 54.78 spad. The results also show that the use of seaweed extracts significantly reduced the effects of salinity, which reflected positively on the chlorophyll content of the leaves, as the spraying treatment at a concentration of 2 ml L^{-1} achieved the highest chlorophyll rate of 54.67 spad. As for the bi- interaction between salinity and seaweed extract, the treatment (3 dSm-1 + 2 ml L^{-1}) was significantly excelled, recording the highest rate of plant chlorophyll, amounting to 57.67 SPAD, compared to the treatment (9 dSm^{-1} + not adding the extract), which recorded the lowest rates, amounting to 45.00 SPAD. .

Table (5) Effect of soil salinity and seaweed extract on leaf chlorophyll (spad)

Average	Seaweed extract ml.L-1			Soil salinity dS m^{-1}
	2	**1**	**0**	
54.78	57.67	54.67	52.00	3
54.78	56.67	53.67	54.00	5
50.22	53.00	50.33	47.33	7
47.89	51.33	47.33	45.00	9
	54.67	51.50	49.58	Average
	interaction	Extract	Salinity	LSD*0.05*
	2.566	1.304	1.543	

3- Number of flower stalk (stalk. $plant^{-1}$)

The results of Table (6) show that salt stress caused a significant decrease in the number of flower stalk, as it reached 5.94 stalks when treated with a salinity level of 9 dSm^{-1}, compared to the 3 dSm^{-1} treatment, which gave the highest average number of flower stalk, amounting to 8.31 stalks, as shown. The results were that the use of seaweed extracts significantly reduced the effects of salinity, which had a positive effect on the number of flower stalks, as the spraying treatment at a concentration of 2 ml L^{-1} achieved the highest average number of flower stalk, reaching 8.02 stalks.As for the bilateral interaction between salinity and seaweed extract, the treatment (3 dSm-1 + 2 ml L) was significantly excelled, recording the highest average number of flower stalk, amounting to 9.27 stalks, compared to the treatment (9 dSm^{-1} + not adding the extract), which recorded the lowest rates, amounting to 5.39 flower stalks.

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Table (6) Effect of soil salinity and seaweed extract on the number of flower stalk (flower stalk. Plant^{-1})

Average	Seaweed extract ml.L-1			Soil salinity dS m^{-1}
	2	1	0	
8.31	9.27	8.04	7.63	3
8.06	8.53	8.03	7.60	5
7.17	7.70	7.20	6.60	7
5.94	6.57	5.87	5.39	9
	8.02	7.29	6.81	Average
	interaction	Extract	Salinity	LSD*0.05*
	0.253	0.131	0.147	

4- Vase life (days)

The results of Table (7) show that salt stress caused a significant decrease in vase life, as it reached 7.37 days when treated with a salinity level of 9 dSm^{-1}, compared to the 3 dSm-1 treatment, which gave the highest average vase life of 8.43 days. The results also show that The use of seaweed extracts significantly reduced the effects of salinity, which had a positive effect on the number of flower stalk, where the spraying treatment at a concentration of 2 ml L^{-1} achieved the highest average flower life of 8.41 days.As for the bi-interaction between salinity and seaweed extract, the treatment (3 dSm^{-1} + 2 ml L^{-1}) significantly excelled by recording the highest rate of vase life, amounting to 8.87 days, compared to the treatment (9 dSm^{-1} + not adding the extract), which recorded the lowest rates, amounting to 6.43 days.

Table (7) Effect of soil salinity and seaweed extract on vase life (days)

Average	Seaweed extract ml.L-1			Soil salinity dS m^{-1}
	2	1	0	
8.43	8.87	8.37	8.07	3
8.37	8.82	8.30	8.00	5
7.50	7.83	7.63	7.03	7
7.37	8.13	7.53	6.43	9
	8.41	7.96	7.38	Average
	interaction	Extract	Salinity	LSD*0.05*
	0.127	0.061	0.072	

5- Number of secondary roots

The results of Table (8) indicate that salt stress caused a significant decrease in the number of secondary roots, as it reached 5.70 roots in the treatment with a salinity level of 9 dSm^{-1}, compared to the S1 treatment, which gave the highest average number of secondary roots, amounting to 7.23 roots. The results also show that the use of seaweed extracts It significantly reduced the effects of salinity, which had a positive impact on the number of secondary roots, as the spraying treatment at a concentration of 2 ml L^{-1} achieved the highest average number of roots, reaching 7.30 roots.As for the bi-interaction between salinity and seaweed extract, the treatment (3 dSm-1 + 2 ml L) significantly excelled by recording the highest rate of the number of secondary roots, amounting to 8.27 roots, compared to the treatment (9 dSm^{-1} + not adding the extract),

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which recorded the lowest rates, amounting to 5.07 roots. .

Table (8) Effect of soil salinity and seaweed extract on the number of secondary roots

Average	Seaweed extract ml.L-1			Soil salinity dS m^{-1}
	2	**1**	**0**	
7.23	8.27	7.07	6.37	3
7.11	8.27	7.00	6.07	5
5.90	6.37	5.77	5.57	7
5.70	6.27	5.77	5.07	9
	7.30	6.40	5.77	Average
	interaction	Extract	Salinity	LSD*0.05*
	0.207	0.089	0.134	

6- Estimation of the percentage of proline:

The results of Table (9) show that salt stress caused a significant decrease in the percentage of proline, as it reached 0.52% when treated with a salinity level of 3 dSm^{-1}, compared to the treatment of 9 dSm^{-1}, which gave the highest rate of proline percentage in the leaves, reaching 0.70%. It also shows The results were that the use of seaweed extracts significantly reduced the effects of salinity, which reflected positively on the percentage of proline, as the non-spraying treatment of the seaweed extract achieved the highest rate of proline in the leaves, reaching 0.64%.As for the bi-interaction between salinity and seaweed extract, the treatment (9 dSm^{-1} + no addition of seaweed extract) was significantly excelled, recording the highest rate of proline, amounting to 0.77%, compared to the treatment (3 dSm^{-1} + 2 ml of seaweed extract), which recorded the lowest rates, amounting to 0.46. %.

Table (9) Effect of soil salinity and seaweed extract on the determination of proline percentage

Average	Seaweed extract ml.L-1			Soil salinity dS m^{-1}
	2	**1**	**0**	
0.52	0.46	0.52	0.58	3
0.53	0.50	0.53	0.57	5
0.57	0.53	0.56	0.63	7
0.70	0.61	0.70	0.77	9
	0.53	0.58	0.64	Average
	interaction	Extract	Salinity	LSD*0.05*
	0.117	0.057	0.066	

Discussion :

A review of the previous results showed a significant effect on the characteristics of vegetative growth. The results showed that the seaweed extract treatment at a concentration of 2 ml L-1 was superior in giving it the highest values for the characteristics of vegetative growth. This may be attributed to the importance of seaweed algae extracts, as it contains a flower stimulant containing Ascophyium algae extract. nodosum, phosphorus, zinc, amino acids, molybdenum, and a group of B vitamins, in addition to containing various growth regulators such as auxins, gibberellins, and cytokinins that work to increase cell division and elongation. Also, seaweed extracts have an important role in the

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process of carbon synthesis and transfer of electrons, and they contain large amounts of organic matter that preserves With moisture, which helps increase the availability of nutrients and facilitate their absorption by the roots, which is reflected in an increase in the building of chlorophyll and thus activating various metabolic processes and thus increasing the plant's content of the necessary elements that directly affected the improvement and increase of the characteristics of vegetative and root growth [1,23]

As for the reason for the decrease in vegetative growth indicators in the current study with the increase in the level of salts from Nacl, it can be attributed to the negative cycle in disrupting physiological activities, in addition to its direct effect on the nutritional and hormonal balance of vegetative growth, leading to determining the number and size of cells in the transmitting vascular bundles represented by xylem and phloem [19] thanks to the compounds they contain, seaweed algae extracts have increased the plant's metabolic efficiency, which is reflected in an increase in flowering lifespan. Also, the positive effect of spraying with seaweed extracts at concentrations of 1 and 2 ml L-1 in improving flower growth characteristics may be attributed to this. The stimulant contains organic compounds that have a vital effect on plant growth and development, in addition to its content of vitamins, major elements, some minor elements and amino acids. It may have a role in controlling and regulating biochemical and physiological activities and building carbon skeleton compounds in photosynthesis and the resulting formation of metabolic compounds. Primary and secondary, and the production of energy compounds ATP that is important in the vital processes of plants, and the nucleic acids DNA and RNA necessary in cell division[11,15] .The increase in chemical characteristics may be attributed to the role of the flower stimulant containing extracts of the seaweed Ascophyllum Nodosum in increasing the plant's metabolic efficiency, which was reflected in the increase of the carotene pigment. It is clear from the results of the tables above that the proline content increased when increasing salt concentrations were used, as the reason is due to the ability of many plants (as a response to stresses) Abiotics) increase proline production through the induction of the enzyme responsible for proline synthesis, P5Cs, which subsequently stimulates genes for tolerance to abiotic stresses [10,14] as proline production increases in tissues exposed to salt stress in order to confront it. The osmotic imbalance between the vacuole and the cytoplasm increases the effectiveness of enzymes involved in proline synthesis[16]

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