Studying the Effect of Foliar-Applied Seaweed Extract on Growth and Yield of Greenhouse-Grown 'Barcelona' Eggplant

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Abstract

The experiment of the present study was conducted in the winter season of 2024-2025 in one of the farms belonging to Al-Faris Agricultural Company in Safwan District/Basra, to determine the effect of some spraying treatments with Acadian seaweed extract to reconcile between two concentrations (0.5, 1) ml/L^{-1} and different numbers of sprays (one spray, two sprays, three sprays) in addition to the control treatment (no spray). A Factorial Experiment was performed in seven treatments employing a totally randomized block design with three replicates in the greenhouse for hybrid eggplant plants (cv. Barcelona). The results showed that the plants sprayed with seaweed extract three times at 1 ml/L^{-1} concentration significantly excelled over the control treatment in stem diameter, leaf area, number of fruits, fruit weight, single plant yield, early yield, and total yield (1.62 cm, 27.99 dm^2, 7.37 fruits, 305 g, 2.247 kg, 0.476 kg m^{-2}, 5.284 kg m^{-2}), respectively.

Keywords: Eggplant, Barcelona Hybrid, Seaweed Extract, Acadian, Number of sprays - Concentrations, Growth, Yield, Greenhouses, Desert Areas.

1.Introduction

The nightshade family includes the summer vegetable crop eggplant, Solanum melogena. It has a great nutritional content and may be consumed pickled or cooked. Every 100 grams of fresh fruit contains 92.7 grams of water, 4 grams of carbohydrates, 1.4 grams of protein, 1.3 grams of fiber, 0.3 grams of fat, 0.4 mg of vitamin B1, 0.1 mg of vitamin B2, 12 mg of vitamin C, and many minerals including potassium and iron [1]. Additionally, it has medicinal value in treating arteriosclerosis, preventing obesity, reducing fat, and combating cancer [2], as well as in the treatment of bronchitis, asthma, diabetes, and lowering blood cholesterol [3].

In the summer, eggplant is cultivated in open fields, while in the winter, it is cultivated in protected agricultural facilities that have been widely adopted. It is ranked

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third, following cucumbers and tomatoes [4]. The area planted with eggplant in Iraq in 2023 was approximately 16,595 dunams, with a total production of 63,170 tonnes and a yield rate of 3.806 tonnes per dunam. [5]. Due to the importance of the crop, the need to cultivate its production was among the main motivations for using natural biostimulants, as they contribute to improving production and maintaining environmental health and safety [6].

Sustainable agriculture uses it because it decreases chemical fertilizer usage and is ecologically benign [7]. Among these are seaweed extracts, which are an important source of organic matter, nutrients, essential growth regulators, organic and amino acids, and vitamins that influence the vital activities of plants [8]. They regulate the osmotic pressure of the cell, delay ageing, and increase the chlorophyll content, antioxidants, phenolic compounds, and flavonoids in the leaves [9].

[10] discovered that applying varying concentrations of seaweed extract (0, 500, 1000, 2000) g/L^{-1} through five sprays, initiated after 20 days in the seedling phase and subsequently at monthly intervals, resulted in a notable enhancement in plant height, leaf count, leaf area, yield per plant, and overall yield for both experimental seasons at the 1000 mg/L^{-1} concentration compared to the control group. [11] discovered that a concentration of 1 ml/L^{-1} led to a significant enhancement in plant height, leaf count, leaf area, stem thickness, fruit weight, length, diameter, and early yield when eggplant plants were treated with three concentrations of the seaweed extract Tecamin Algac (0, 0.75, 1) ml/L^{-1} across two applications, the first occurring four weeks post-planting and the second 15 days after the initial spray. This augmentation was relative to the control treatment [12].

When spraying the hybrid eggplant Barcelona grown in greenhouses with three concentrations of the seaweed extract Tecamin Algac (0, 2, 4) ml/L^{-1} in three applications, the first after 25 days in the seedling stage and the others with a 25-day interval between them, the 4 ml/L^{-1} concentration significantly increased plant height, stem diameter, number of leaves, fruits, single plant yield, early yield, and total yield compared to the control treatment. [13] indicated that spraying eggplant plants with seaweed extract at three concentrations (0, 1, 2) ml/L^{-1} in three applications, the first after 15 days from planting, the second after 15 days from the first, and the third at the flowering stage, caused the 2 ml/L^{-1} concentration to significantly increase the number of leaves, leaf area, and number of fruits compared to the control treatment. [14] confirmed that spraying a local eggplant variety grown in salty conditions with seaweed extract at concentrations of (0,2,4) ml/L^{-1} increased plant height, leaf area, fruit weight, single plant yield, total yield, and the percentage of total soluble solids in the fruits compared to the control treatment. The 4 ml/L^{-1} concentration had the biggest effect. This study found the best concentration and number of sprays for Barcelona hybrid eggplant grown in greenhouses in Basra's desert to test the Acadian seaweed extract's effectiveness.

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2.Material and Methods

The study was carried out in the winter of 2024-2025 at a farm owned by Al-Faris Agricultural Company in the Safwan District of Basra, inside a greenhouse of 450 m² (9x50 m). The objective was to investigate the impact of applying the seaweed extract Acadian at two concentrations (0.5, 1) ml/liter and varying spray frequencies (one, two, and three sprays), culminating in six treatment combinations alongside a control, on the growth and yield of the hybrid eggplant Barcelona from Semillas Fito, Spain. The physical and chemical characteristics of the greenhouse soil, which was prepared by plowing, leveling, and dividing it into five lines, each 49 m long, 1.5 m apart, 30 cm deep, and 50 cm wide, are shown in Table (1). A sterilizer and 10 tons of decomposed cow dung per dunam were applied to the soil. In the middle of the lines, sunk 15 cm deep and covered in black plastic mulch, was a drip irrigation system.

Table (1). Selected Chemical and Physical Properties of the Experimental Soil

Unit	Value	Property
-	7.43	(pH)
dS m^{-1}	5.22	Electrical Conductivity EC_e
Mg kg^{-1}	76.90	Available Phosphorus
g kg^{-1}	180	Total Nitrogen
Mg kg-1	185.4	Available Potassium
Mmol L-1		Soluble Cations
	21	Ca ++
	30	Na+
	13	Mg ++
Mmol L-1		Soluble Anions
	65	Cl^-
	13.14	SO_4^{--}
	2.8	HCO_3--
g kg^{-1}		Soil Separates
	820	Sand
	46	Silt
	134	Clay
	Loamy Sand	Soil Texture

Hybrid eggplant seedlings of the Barcelona variety were produced in the nursery using 200-cell polystyrene trays filled with German Kias-mar peat moss. The seeds were distributed on 2024/9/5, and when they reached the 4-5 leaf stage, they

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were transferred to the greenhouse on 2024/10/8. One plot was tallied for each of the three center rows. The seven treatments were dispersed randomly using the fully randomised block design (RCBD) and 7-meter experimental units. The seedlings were planted at a distance of 28 cm, with a total of 25 plants in the experimental unit. All agricultural operations for crop production inside the greenhouses were carried out, including patching, irrigation, fertilisation, training the plants on two stems tied with cotton threads, pest control, and harvesting. The experimental treatments included spraying with Acadian seaweed extract.

1- Control treatment (without spraying)
2- One spray at a concentration of 0.5 ml/L^{-1}
3- Two sprays with a concentration of 0.5 ml/L^{-1}
4- Three sprays at a concentration of 0.5 ml/L^{-1}
5- One spray with a concentration of 1 ml/L^{-1}
6- Two sprays with a concentration of 1 ml/L^{-1}
7- Three sprays at a concentration of 1ml/L^{-1}

Then, Tween 20 as a spreading agent for the spray solutions was added. The first spray was applied 40 days after transplanting, and the second with a two-week interval between them. Table (2) shows the chemical components of the seaweed extract derived from the algae Ascophyllum nodosum, produced by the Canadian company Acadian Seaplants Limited. The vegetative growth indicators were assessed at the end of the season by randomly choosing six plants per experimental unit. [15] approach measured plant height, stem diameter, leaf count, and leaf area in cm². [16] was used to analyze quantitative yield components like the number of fruits, weight of a single fruit (g), yield per plant (kg), early yield (kg m^{-2}), and total yield (kg m^{-2}) and qualitative yield components like fruit length (cm), diameter (cm), percentage of dry matter in fruits, and total soluble solids (TSS) in fruits. According to the design and Genstat statistical tool, the Least Significant Difference (LSD) test was used to compare treatment means at a significance level of 0.05.

Table (2). Chemical Composition of Acadian Seaweed Extract

Percentage	Component
45–55%	NPK and minerals (ash)
60%	Moisture
10%	Alginic acid
4%	Mannitol
4%	Amino acids
20%	Other organic matter derived from seaweed

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3.Results and Discussion

Table(3) demonstrates that applying the seaweed extract Acadian to the plants had a significant impact on vegetative growth indices, but not on the total number of leaves. The plant reached a height of 105.0 cm after being treated with a single spray of the extract at a dosage of 0.5 ml/L^{-1}. The only other treatment that produced a height of 100.03 cm was the one that used three sprays at a dosage of 0.5 ml/L^{-1}. All spraying treatments performed much better than the control treatment, with the exception of the treatment using a single spray at a dose of 1 ml/L^{-1}.In comparison to the other treatments, the treatment that used three sprays at a dosage of 1 ml/L^{-1} also performed very well in terms of stem diameter, yielding the biggest diameter of 1.62 cm. The same treatment also significantly excelled in leaf area, giving the largest area of 27.99 dm^2 compared to the control treatment, the treatment with one spray at a concentration of 0.5 ml liter-1, the treatment with three sprays at a concentration of 0.5 ml/L^{-1}, and the treatment with two sprays at a concentration of 1 ml/L^{-1}, which were (22.77, 23.77, 24.77, 22.19) dm^2, respectively. The significant increase in vegetative growth indicators when spraying with seaweed extract can be attributed to its hormonal nature, which led to an increase in those hormones within the necessary structures for cell division and specialisation in the plant [17]. Furthermore, the extract contributes to raising the amount of chlorophyll in the leaves, which improves photosynthetic efficiency and promotes the plant's vegetative development [18]. These findings align with those of [11,18,12, ,13,14,10]. All of the seaweed extract treatments had a substantial impact on the outcomes, as Table (4) demonstrates.

Table (3). Effect of Selected Foliar Applications of Acadian Seaweed Extract on Vegetative Growth Parameters of the Barcelona Eggplant Hybrid

Leaf area (dm^2)	Number of leaves	Stem diameter (cm)	Plant height (cm)	Treatment Seaweed extract
22.77	30.17	1.35	86.50	Control (no spray)
23.77	33.33	1.28	105.0	One spray at 0.1 mL L^{-1}
26.17	32.33	1.38	99.03	Two sprays at 0.5 mL L^{-1}
24.77	33.17	1.35	100.03	Three sprays at 0.5 mL L^{-1}
25.97	31.00	1.36	88.83	One spray at 1 mL L^{-1}
22.18	34.17	1.36	99.50	Two sprays at 1 mL L^{-1}
27.99	31.17	1.62	96.67	Three sprays at 1 mL L^{-1}
3.18	NS	0.17	5.16	LSD (0.05)

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Table (4). Effect of Selected Foliar Applications of Acadian Seaweed Extract on Yield

Total yield (kg m^{-2})	Total yield (kg m^{-2})	Yield per plant (kg)	Fruit weight (g)	Number of fruits	Treatment Seaweed extract
3.598	0.286	1.530	233	6.57	Control (no spray)
3.739	0.245	1.590	271	5.87	One spray at 0.5 mL L^{-1}
4.748	0.432	2.019	273	7.40	Two sprays at 0.5 mL L^{-1}
4.698	0.418	1.998	306	6.53	Three sprays at 0.5 mL L^{-1}
3.386	0.228	1.440	240	6.00	One spray at 1 mL L^{-1}
3.896	0.340	1.657	255	6.50	Two sprays at 1 mL L^{-1}
5.284	0.476	2.247	305	7.37	Three sprays at 1 mL L^{-1}
0.694	0.157	0.295	69.4	1.27	LSD (0.05)

The treatments of spraying twice with a concentration of 0.5 ml/L^{-1} and spraying three times with a concentration of 1 ml/L^{-1} performed exceptionally well in all quantitative yield components, including the number of fruits per plant (7.37, 7.40) fruit, the yield per plant (2.247, 2.019) kg, the early yield (0.476, 0.432) kg m^{-2}, and the total yield (5.284, 4.748) kg/m^{-2}. Meanwhile, the treatments of spraying three times with concentrations of 0.5 and 1 ml/L^{-1} significantly excelled in the weight of a single fruit, reaching (305, 306) grams compared to the control treatment. The treatments of spraying with a concentration of 1 ml/L^{-1}, two sprays and three sprays gave the lowest values for the weight of a single fruit, reaching (233, 240, 255) grams, respectively. The treatment of spraying three times with a concentration of 1 ml/L-1 showed a significant superiority compared to the control treatment in the weight of the fruit, the yield per plant, the early yield, and the total yield, with an increase rate of (30.90, 46.86, 66.43, 46.86)%, respectively. The efficacy of the photosynthesis process is significantly enhanced by seaweed extract, as evidenced by the positive increase in stem diameter and leaf area. This is the reason why the quantitative yield increased significantly when it was sprayed three times at a concentration of 1 ml/L^{-1} (Table 3). Consequently, an abundance of produced elements was transferred to the fruits, increasing yield and its constituent parts. These findings align with those of[10,12,14].

Table (5) shows that seaweed extract spraying considerably altered qualitative yield characteristics, except for fruit TSS. Fruit length and diameter were greatest (6.12, 22.76) in plants sprayed twice with the extract at 0.5 ml/L^{-1}. On the other hand, the plants that were sprayed once with a concentration of 0.5 ml/L^{-1} had the shortest fruit length (21.0 cm), while the non-sprayed control plants had the lowest fruit diameter (5.09 cm). The spraying once with a

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concentration of 0.5 ml/L^{-1} was found to be very effective as compared to other treatments. It produced the highest percentage of dry matter, which was 12.64%. All other treatments produced a higher percentage of dry matter except for the plants sprayed twice with a concentration of 0.5 ml/L^{-1}, which produced a percentage of 12.58%. Seaweed extract improved several indices of vegetative growth and quantitative yield (Tables 3 and 4). This, in turn, favourably affected the rise in fruit length, diameter, and dry matter content. This is why spraying with seaweed extract resulted in a significant increase in the qualitative yield. This outcome aligns with the findings of [11].

Table (5). Effect of Selected Foliar Applications of Acadian Seaweed Extract on Fruit Quality Attributes of the Barcelona Eggplant Hybrid

Total soluble solids (%)	Fruit dry matter (%)	Fruit diameter (cm)	Fruit length (cm)	Treatment Seaweed extract
4.4	12.08	5.09	21.33	Control (no spray)
4.1	12.64	5.92	21.00	One spray at 0.5 mL L^{-1}
4.3	12.58	6.12	22.76	Two sprays at 0.5 mL L^{-1}
4.5	11.68	5.87	22.00	Three sprays at 0.5 mL L^{-1}
4.4	11.94	6.09	21.80	One spray at 1 mL L^{-1}
4.5	12.18	5.97	21.73	Two sprays at 1 mL L^{-1}
4.4	11.94	5.84	22.33	Three sprays at 1 mL L^{-1}
NS	0.40	0.03	0.11	LSD (0.05)

4.Conclusion

We conclude from this study that to achieve optimal growth and good quantitative and qualitative yield for the hybrid eggplant plants Barcelona grown in greenhouses in the desert areas of Basra, they must be sprayed with Acedian seaweed extract three times at a concentration of 1 ml/L^{-1}
, with the first spray after one month of transplanting and the others with a two-week interval between them.

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