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Enhancing Cowpea Seedling Growth and Salt Stress Tolerance

Using *Sargassum latifolium* L. Extract as a Bio-stimulant Authors

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Abstract

Seaweed extracts have been used as growth promoters. However, in many plants, the methods of preparing the extracts can be complex. In this study, we tested aqueous extract in low concentrations from the widely available brown alga, *Sargassum latifolium*. We applied it to Cowpea as an economically important crop with high nutritional value and protein content. The study was conducted at the biology laboratory at Aldarb College, Jazan, Saudi Arabia. The effect of *S. latifolium* extract on the germination of seeds and vegetative growth of cowpea plants was studied. The seeds were soaked in the extract for 6 h before sowing before being applied weekly as a foliar spray at two concentrations of 0.5% and 1% for four weeks. The extracts were also sprayed onto plants growing under salinity stress (100 mM, 200 mM NaCl). Seeds soaked in seaweed extract gave higher values for all measured traits than the control. Spraying the plant with 0.5% and 1% seaweed was significantly higher than the control. The 1% concentration was more suitable for the cowpea plant than the 0.5% concentration, which also helped the plant mitigate the harmful effects of salt.

Keywords: Bio fertilizer, Bio stimulator, Brown algae, Cowpea, *Sargassum*, Seaweed extract.

Introduction

Cowpea (*Vigna unguiculata*) is a vital legume in arid regions. All parts of the crop, including the leaves, green pods, dry pods, and green grains, and dry grains can be consumed as food due to its rich protein content of approximately 26% in dried seed (Ubini et al., 2016), soluble sugar content of 54.5 mg/g (Weng et al., 2018) vitamins, minerals, and dietary fiber. Bio-stimulants such as seaweed extract have been used to improve crop growth and yields by influence plant respiration, photosynthesis, nucleic acid synthesis, and ion uptake (Saravaiya and Tandel, 2021). Seaweeds are widely recognized for their polysaccharide-rich extracts, and also other organic compounds (Salem et al., 2025). These extracts enhance seed germination (Castellanos-Barriga et al., 2017; Jebasingh et al., 2015), plant growth (AlAbdallah et al., 2017; Punitha et al., 2024), biochemical constituents (AlAbdallah et al., 2017; Punitha et al., 2024), pigment content (Santhosh et al., 2021), and plant yield (Salah El Din et al., 2008) (Jesvanthini et al., 2024). Seaweed also can improve nutrient uptake by plants. Salinity is a major abiotic stress factor that strongly impacts the growth and yield of cowpea (*Vigna unguiculata*) in arid and semi-arid regions worldwide (Gogile et al., 2013). Soil salinity limits root growth and the development of aboveground plant parts. This can lead to leaf browning, suppress flowering, cause cellular dehydration, and result in the death of species that are less tolerant to salinity stress (Kumar et al., 2020; Syed et al., 2021).

Germination and plant growth reduction under saline conditions are influenced by a combination of three factors, that is, the type of salt, salt concentration, and the plant growth stage (Zahedi et al., 2012). Cowpea varieties differ in their susceptibility to salinity damage. The variety 'Ekomcalle' was less affected by the impacts of salinity compared to 'Mouala GG' including at the level of growth or agronomic parameters (Nouok et al., 2022).

The methods used to help plants resist the harmful effects of salinity include magnetic treatment of saline water. This reduces the harmful effects of salt stress on the growth and yield of cowpea plants (Qandil et al., 2023). Seaweed extracts can be beneficial as a growth biostimulator in addition to helping the plants resist salinity (Afeeza and Dilipan, 2024; AlAbdallah et al., 2017; Bahmani Jafarlou et al., 2021; Gharib et al., 2014; Hamouda et al., 2023; Kasim et al., 2016; Khan et al., 2022;. Saravaiya and Tandel, 2021).

In our study, we used a simple method to prepare *Sargassum* extract, which is abundant on the beaches of the Jazan region. It can easily be collected and used by farmers and can avoid chemical use. Therefore, we investigated the extent to which these extracts, when used in low concentrations

and applied in two ways, namely, soaking the seeds before planting and foliar spraying on the plant, can enhance germination and growth and contribute to helping the plant withstand salt stress that occurs as a result of drought and climate changes.

Material and methods

Seaweed collection

The seaweed samples were collected from the coastal region of Alsomirat, (17°31'17.0"N, 42°13'37.4"E) in Aldarb College, Jazan. The harvested seaweed was thoroughly rinsed with fresh water and then dried in a hot air oven at 50 °C for 4 d.

Preparation of seaweed extract

The seaweed extract was prepared by putting 20 gm in 2L of distilled water overnight at 60 °C and then filtered. The prepared extract was considered the 2% concentration and the 1% and 0.5% concentrations were prepared by diluting the 2% concentration extract.

Experimental design

Seedling germination assays

Samples of uniform healthy seeds without any imperfections and of similar weight were selected. Ten seeds with homogeneous definite distance were used in each treatment and the seeds watched with 1% sodium hypochlorite.

Water absorbance capacity

To determine the best time for seed soaking we performed an experiment to show the water absorbance capacity of 20 seeds for each treatment recorded at seven time intervals, that is, 1 h, 2 h, 4 h, 6 h, 12 h, 20 h, and 24 h. The three treatments used were soaking seeds in water (control), soaking seeds in 0.5% *Sargassum* extract, and soaking the seeds in 1.0% *Sargassum* extract.

Germination index

Forty cowpea seeds were soaked separately for 6 h in either water (control) or 0.5% and 1.0% *Sargassum* extracts. Following this, the seeds were placed in 90 mm Petri dishes lined with two layers of moistened filter paper. The dishes were kept at a temperature of 25 ± 1 °C for 6 d and all the seeds that emerged with a 3 mm radicle were monitored. The germination percentage (GP) = (number of germinated seeds/total number of seeds) × 100 and the relative seed germination (RSG) = (number of seeds germinated in test solution/number of seeds germinated in control) × 100 were recorded (Teacă and Bodîrlău, 2008)

Seed soaking experiment

The experiment was conducted over 30 d after planting the seeds after they had been soaked for 6 h. The percentage of seed germination and seedling growth parameters, namely, the root, shoot length, and fresh and dry weights were measured.

Foliar application and salinity experiment

The sequence and application of extracts as foliar spray were illustrated in Figure 1.

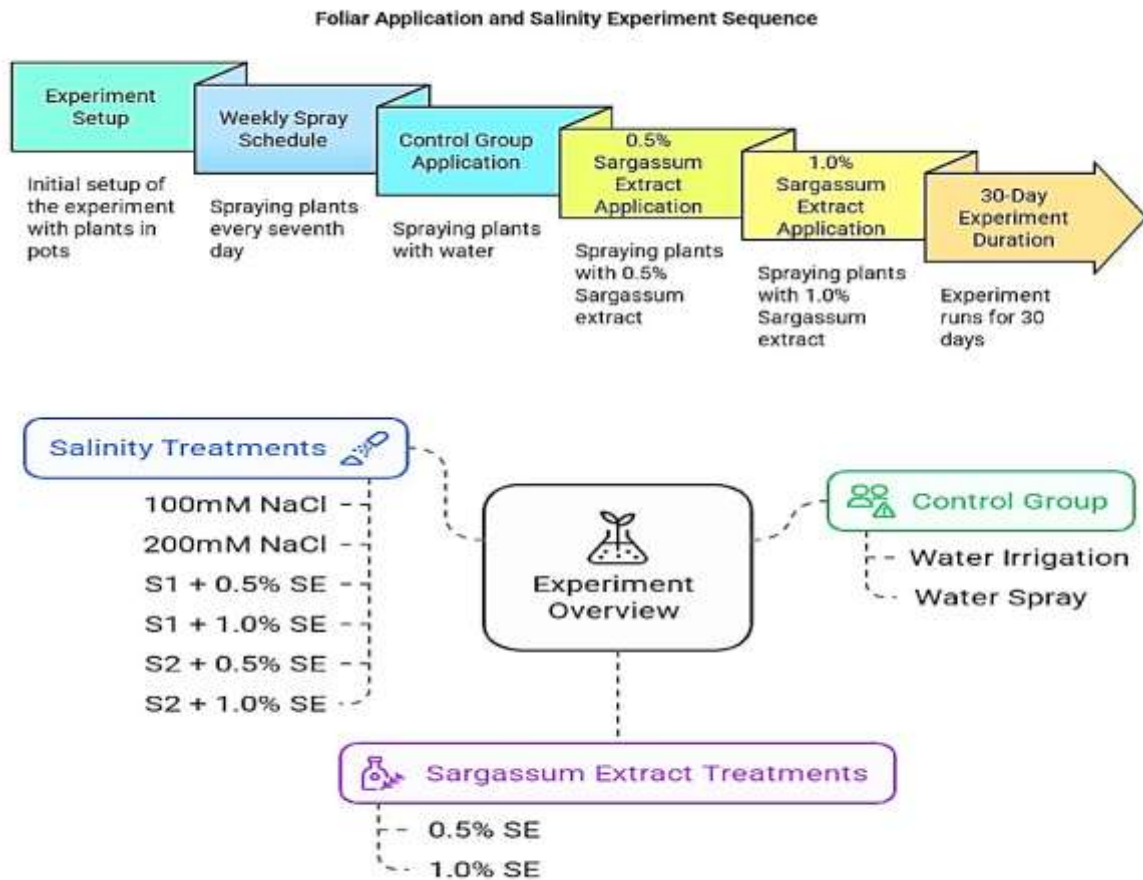


Figure 1: Foliar application and Salinity experiment sequence and design SE= *Sargassum* extract, S1=100mM NaCl and S2=200mM NaCl

Recording sample data 1. Morphological characteristics

Six plants were selected for each treatment 30 d after sowing. The different morphological characteristics such as root length, shoot length, and plant fresh weight were measured. The plants were then dried in an oven at 70 °C for 48 h until they reached constant dry weight, and the number of leaves, and leaf area (cm²) were measured.

2. Chlorophyll content (mg g⁻¹ F.W)

Chlorophyll a, b, and total carotenoids in fresh leaves were determined according to (Shereen et al., 2009)

3. Statistical analyses

The data obtained were statistically analyzed using a one-way ANOVA test followed by Duncan's Multiple Range Test ($\alpha = 0.05$) (Duncan, 1955).

Results

Seed water absorption capacity

As shown in Table 1, the water absorbance capacity of water (control) in different time intervals was the highest followed by 0.5% and then 1%. The water absorbance capacity of all the treatments reached more than 70% after 2 h. For 6 h, the mean of the water absorbance capacity was 1336.37 ± 7.1 mg/g which represents more than 88% of the water absorbance capacity after 24 h (1516.67 ± 15.3) in the control. This was the same for the two extract concentrations.

Table 1: Water absorbance capacity of *Vigna* seeds as influenced by different *Sargassum* extract concentrations. Data represent mean \pm SD, n = 20.

Hours	Water absorbance capacity Mg/g		
	Control	0.5%	1%
1	674.7 ± 5.5	476.2 ± 10.5	357.7 ± 6.8
2	1111 ± 10.1	833 ± 6.25	726.37 ± 6
4	12967 ± 15.3	1110 ± 10	954 ± 6
6	1336.37 ± 7.1	1194 ± 5.6	1134.7 ± 6.1
12	1458.373 ± 7.6	1263 ± 4.4	1179 ± 2.6
20	1516.67 ± 15.3	1304.3 ± 4.54	1225.4 ± 5.1
24	1516.67 ± 15.3	1358.7 ± 8.1	1240.7 ± 27.4

Germination index

Sargassum extract of 0.5% resulted in the highest germination percentage (GP), and relative seed germination (RSG) followed by 1% and finally the control as shown in Table 2.

Table 2: GP and the RSG of 40 seeds as influenced by the two extract concentrations.

	Number of germinated seeds	GP	RSG
Control	37	92.5	100
0.5% SE	40	100	108
1.0% SE	39	97.5	105.4

The different morphological parameters in Table 3 showed that 0.5% SE gave the highest values in all parameters, that is, fresh and dry weight, leaf area followed by 1% SE and the two more than the control.

Table 3: Effects of two concentrations of *Sargassum* extract applied as seed soaking on the morphological parameters of the Cowpea plant. Data are expressed as mean \pm SD.

	Number of leaves	Leaf area	Root length	Shoot length	Fresh weight	Dry weight
Control	15 \pm 1.5	3.36 \pm 0.18	7.6 \pm 0.18	22 \pm 0.9	15.7 \pm 0.8	3.6 \pm 0.5
0.5% SE	18 \pm 1.5	3.75 \pm 0.17	8.03 \pm 0.16	22.6 \pm 1	16.5 \pm 1.5	3.8 \pm 0.5
1.0% SE	18 \pm 1.5	3.45 \pm 0.15	8.18 \pm 0.5	22.8 \pm 0.9	16 \pm 1.5	3.78 \pm 0.4

Shoot and root length gave the highest value in plants treated with 1% followed by 0.5%. The number of leaves was similar in the two treatments.

The pigment content, Chl.-a, Chl.-b, and carotenoids in Figure 2 represented by mean value \pm SD showed an increase in Chl. -a content of the treated plants above the control. Meanwhile, Chl.- b and carotenoids were not significant and the concentrations of Chl.-a were higher than Chl.-b and carotenoids in all treatments.

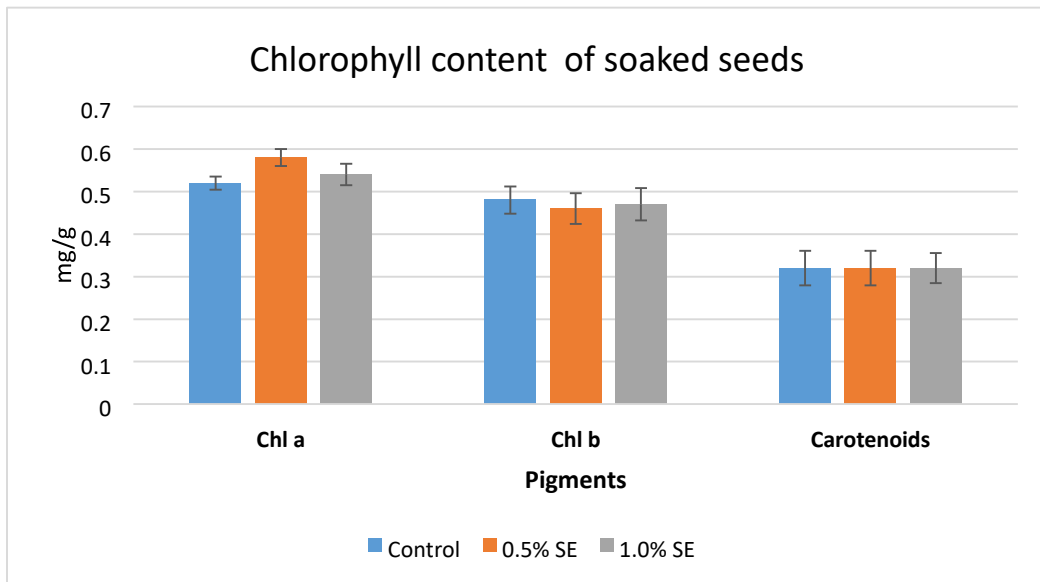


Figure. 2: Pigment content of soaked seeds in *Sargassum* extracts (0.5% and 1%)

Foliar application and salinity experiment

The application of *Sargassum* extract on the plant as shown in Figure 3 shows that the root length increased in plants treated with 0.5, and 1.0%SE compared with the control. Plants irrigated with S1 and S2 had root lengths of 6.75 and 6.5 cm, respectively, which represented the lowest values in all the treated plants.

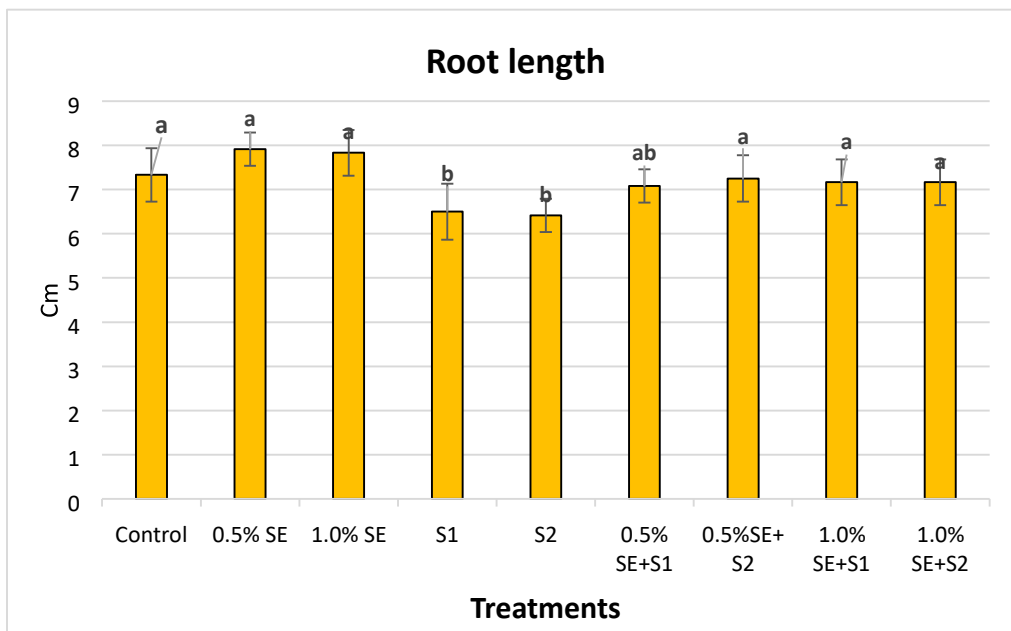


Figure 3: The average of root length of *Vigna* treated with *Sargassum* extracts (0.5% and 1%) under stress

The treatment of plants with extract under salinity stress increases the root length to values close to the control.

The foliar spray of *Sargassum* extract on the plant (Figure 4) showed that the shoot length increased more than the control (20.16 cm) in plants treated with 0.5, and 1.0% SE (23.16, 23.3 cm). Meanwhile, plants irrigated with S1, and S2 had shoot lengths of 18.1 cm and 17.25 cm, respectively.

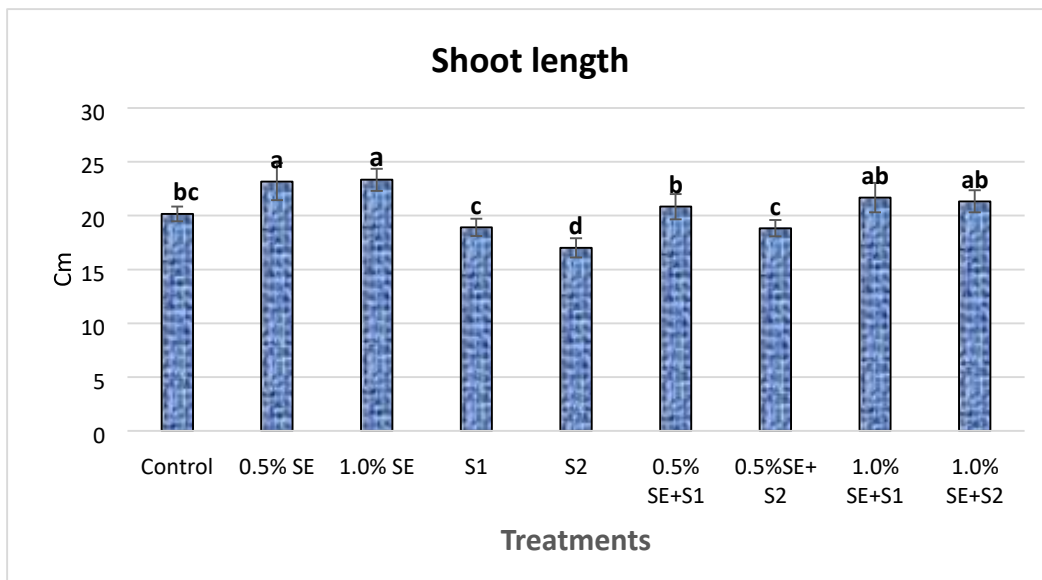


Figure 4: The average shoot length of *Vigna* treated with *Sargassum* extracts (0.5% and 1%) under stress

The treatment of plants with 0.5% under salinity stress increased the shoot length to values close to the control, and in cases of 1.0% SE, the shoot length increased more than the control. The fresh weight of plants treated with foliar spray of *Sargassum* extract shown in Figure 5 showed a significant increase in fresh weight in plants treated with extract more than the control. The plants treated under stress significantly increased in fresh weight from 7,6 g in S1 and S2, respectively, to 11 g.

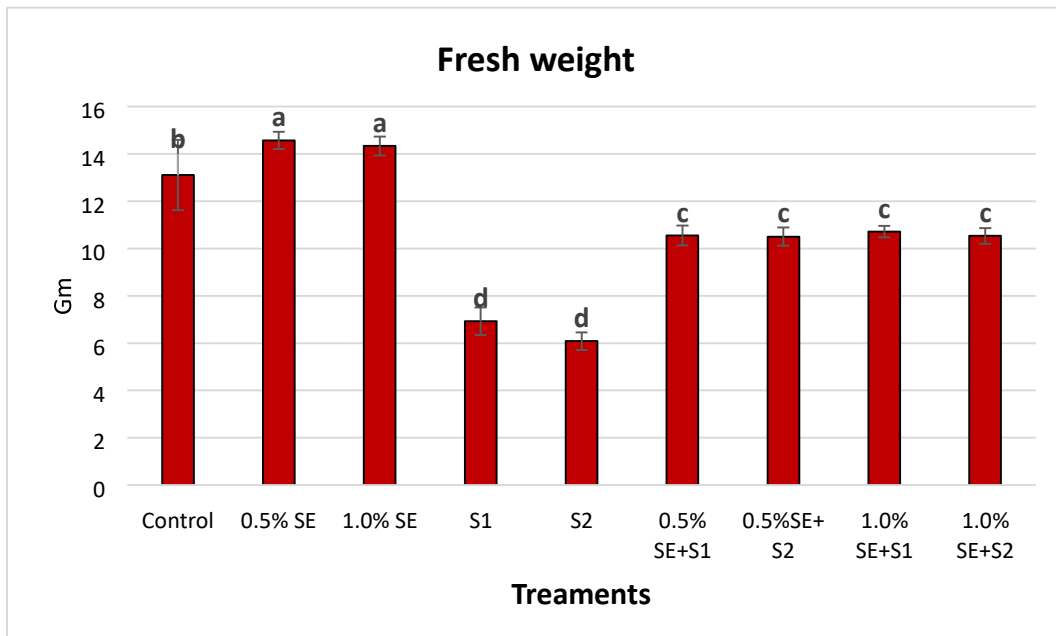


Figure 5: The fresh weight of *Vigna* treated with *Sargassum* extracts (0.5% and 1%) under stress

The dry weight of plants treated with foliar spray of *Sargassum* extract shown in Figure 6 showed a significant increase in fresh weight in plants treated with extracts, especially 0.5% above the control. The plants treated under stress showed a significant increase in dry weight.

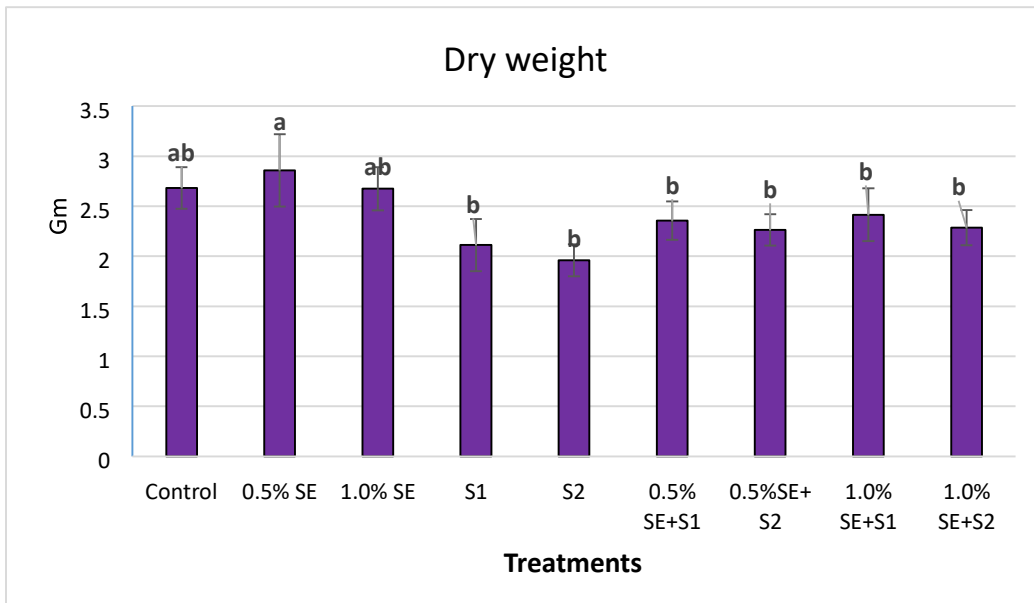


Figure 6: The dry weight of *Vigna* treated with *Sargassum* extracts (0.5% and 1%) under stress

The foliar sprayed plants showed differences in the number of leaves/plants and leaf area as shown in Table 4.

Table 4: Leaf area and number of leaves per plant in plants treated with *Sargassum* extract foliar spray. Data are expressed as means \pm SD.

	Leaf area cm ²	Number of leaves
Control	3.8 \pm 0.1 ^a	14.5 \pm 1.2 ^b
0.5% SE	4 \pm 0.19 ^a	16.5 \pm 1.2 ^{ab}
1.0% SE	3.95 \pm 0.19 ^a	17 \pm 1.9 ^a
S1	3.05 \pm 0.12 ^c	11.5 \pm 1.2 ^b
S2	3 \pm 0.18 ^c	12 \pm 1.5 ^b
0.5% SE + S1	3.55 \pm 0.06 ^b	14 \pm 1.9 ^b
0.5%SE + S2	3.48 \pm 0.16 ^b	14.5 \pm 1.2 ^b
1.0% SE + S1	3.58 \pm 0.07 ^b	13 \pm 1.5 ^b
1.0% SE + S2	3.6 \pm 0.09 ^b	13 \pm 1.5 ^b

The foliar sprayed plants showed differences in chlorophyll content as shown in Table 5 in the control. chl. A had the highest value 0.59 followed by chl. b (0.37) and finally carotenoids at 0.28. In the plants treated under salt stress, that is, S1 and S2, the carotenoids increased and chl. a decreased. Spraying the extract helped the plant to show an increase in chl. a and b and decreased the carotenoids.

Table 5: Chlorophyll content of Cowpea leaves influenced by seed soaking before sowing in *Sargassum* extracts. Data expressed as mean \pm SD

	Chl. a	Chl. b	Carotenoids
Control	0.59 \pm 0.012	0.37 \pm 0.01	0.28 \pm 0.012
0.5% SE	0.79 \pm 0.03	0.56 \pm 0.02	0.28 \pm 0.01
1.0% SE	0.7 \pm 0.02	0.68 \pm 0.15	0.29 \pm 0.01
S1	0.48 \pm 0.01	0.39 \pm 0.01	0.39 \pm 0.01
S2	0.46 \pm 0.01	0.39 \pm 0.01	0.41 \pm 0.02
0.5% SE + S1	0.50 \pm 0.02	0.36 \pm 0.02	0.36 \pm 0.01
0.5%SE + S2	0.48 \pm 0.01	0.32 \pm 0.02	0.36 \pm 0.02
1.0% SE + S1	0.58 \pm 0.01	0.53 \pm 0.03	0.30 \pm 0.02
1.0% SE + S2	0.48 \pm 0.02	0.47 \pm 0.03	0.30 \pm 0.02

Discussion

Distilled water extraction methods can effectively obtain essential nutrients for plant growth. Seaweeds have been analyzed using boiling extraction techniques. The boiling method resulted in higher concentrations of phosphorus (P), sulfur (S), and boron (B) (Godlewska et al., 2016)

In our experiment, we used lower concentrations of SLE applied on seedlings to show the increase in chl. a content and also induce plant growth. A concentration of 0.5% resulted in the highest germination percentage, followed by 1%, and finally the control, with similar results to Jebasingh et al. (2015). Brown seaweed applied on *V. radiata* (L) plants resulted in a significant increase in the chlorophyll a and chlorophyll b content. The increase in pigment concentration was caused by the action of cytokinin in the *T. ornata* extract (Punitha et al., 2024).

Therefore, soaking for 6 h is a more suitable duration for soaking (Jebasingh et al., 2015). This is because it minimizes the chances of fungal growth or stimulation of some enzymes inside the seeds, which may inhibit the growth process.

Applying seaweed extract as foliar spray produced better results than soaking the seeds in the context of the root and shoot length. This is consistent with the results recorded for treating plants through foliar application with *Sargassum wightii* than from other algal taxa (Jayasinghe et al., 2016). This may be attributed to the presence of auxins and carbohydrates that help the root and vegetative system to grow. The 0.5% and 1% concentration extracts made a significant difference

in the fresh and dry weight, in line with those on tomato plants by Sasikala et al. (2016). This showed that the 0.6% concentration was effective as a biofertilizer. Algae extracts are beneficial to plants as a growth stimulant and can help the plant overcome some types of stress such as salt stress (Gharib et al., 2014; Hussein et al., 2021).

Treating plants under salt stress with algae extracts, especially *Sargassum*, can help the plant resist the harmful effects of salt stress on the cells, growth stages, and plant productivity (Qandil et al., 2023).

The positive effects of *Sargassum* species extracts can be attributed to their content of phytohormones (IAA, kinetin, GA3, and NAA) and essential micronutrients (N, P, K, Ca, Fe, and manganese) that support plant growth (Sunarpi et al., 2021). Given the different responses of different plant taxa to applying algae extract and the time of application in addition to the application rate, the response of *Vigna* used in our study is more suitable as a spraying method than soaking the seeds in the extracts. This is consistent with the findings of Salah El Din et al. (2008) with broad bean. Meanwhile, for red radish plants, soaking the seeds was more effective (Mahmoud et al., 2019)

Conclusion

Seeds soaked in seaweed gave higher values for all measured traits than the control. Spraying the plant with 0.5% and 1% seaweed significantly increased plant growth compared with the control. A concentration of 1% was more suitable for the cowpea plant than 0.5%. Treatment with foliar spray was more effective than the seed soaking method in increasing growth in cowpeas and it also helped the plant mitigate the harmful effect of salt.

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References

- Afeeza, K. L. G., and Dilipan, E. (2024). Enhancing salt stress tolerance in black gram (*Vigna mungo* L.) through the exogenous application of seaweed liquid fertilizer derived from *Sargassum* sp. *Algal Research*, 103588.

- AlAbdallah, N. M., Basalah, M. O., and Roushdy, S. S. (2017). The promotive effect of algal biofertilizers on growth and some metabolic activities of *Vigna unguiculata* L. under salt stress conditions. *Egyptian Journal of Experimental Biology (Zoology)*, 13(2), 187–195.
- Bahmani Jafarlou, M., Pilehvar, B., Modarresi, M., and Mohammadi, M. (2021). Performance of algae extracts priming for enhancing seed germination indices and salt tolerance in *Calotropis procera* (Aiton) WT. *Iranian Journal of Science and Technology, Transactions A: Science*, 45, 493–502.
- Castellanos-Barriga, L. G., Santacruz-Ruvalcaba, F., Hernández-Carmona, G., Ramírez-Briones, E., and Hernández-Herrera, R. M. (2017). Effect of seaweed liquid extracts from *Ulva lactuca* on seedling growth of mung bean (*Vigna radiata*). *Journal of Applied Phycology*, 29, 2479–2488.
- Duncan, D. B. (1955). Multiple range and multiple F tests. *Biometrics*, 11(1), 1–42.
- Gharib, F., Zeid, I. M., Salem, O., and Ahmed, E. Z. (2014). Effects of *Sargassum latifolium* extract on growth, oil content and enzymatic activities of rosemary plants under salinity stress. *Life Sci. J*, 11(10), 933–945.
- Godlewska, K., Michalak, I., Tuhy, L., and Chojnacka, K. (2016). Plant Growth Biostimulants Based on Different Methods of Seaweed Extraction with Water. *BioMed Research International*, 2016. <https://doi.org/10.1155/2016/5973760>
- Gogile, A., Andargie, M., and Muthuswamy, M. (2013). The Response of Some Cowpea (*Vigna unguiculata* (L.) Walp.) Genotypes for Salt Stress during Germination and Seedling Stage. *Original Text Journal of stress physiology and biochemistry*, 9(4), 73–84.
- Hamouda, M. M., Badr, A., Ali, S. S., Adham, A. M., Ahmed, H. I. S., and Saad-Allah, K. M. (2023). Growth, physiological, and molecular responses of three phaeophyte extracts on salt-stressed pea (*Pisum sativum* L.) seedlings. *Journal of Genetic Engineering and Biotechnology*, 21(1), 32.
- Hussein, M. H., Eltanahy, E., Al Bakry, A. F., Elsafty, N., and Elshamy, M. M. (2021). Seaweed extracts as prospective plant growth bio-stimulant and salinity stress alleviator for *Vigna sinensis* and *Zea mays*. *Journal of Applied Phycology*, 33, 1273–1291.
- Jayasinghe, P. S., Pahalawattaarachchi, V., and Kkds, R. (2016). Fertilizer on plant growth of *Capsicum annum*. *Discovery*, 52, 723–734.

- Jebasingh, S. E. J., Lakshmikandan, M., Vasanthakumar, P., and Sivaraman, K. (2015). Improved Seedling Growth and Seed Germination in Legume Crop *Vigna mungo* (L.) Hepper Utilizing Marine Macro Algal Extracts. *Proceedings of the National Academy of Sciences India Section B - Biological Sciences*, 85(2), 643–651.
<https://doi.org/10.1007/s40011-014-0374-z>
- Jesvanthini, R. K. S., Baradhan, G., Kumar, S. M. S., Sathyanarayanan, G., and Immanuel, R. R. (2024). Evaluating the Impact of Combined Application of Seed Dressing and Foliar Application of Sea Weed Extracts on Growth Attributes of Black Gram (*Vigna mungo*). *Environment and Ecology*, 42(3A), 1186–1190.
- Kasim, W. A. E.-A., Saad-Allah, K. M., and Hamouda, M. (2016). Seed priming with extracts of two seaweeds alleviates the physiological and molecular impacts of salinity stress on radish (*Raphanus sativus*). *International Journal of Agriculture and Biology*, 18, 653–660.
- Khan, Z., Gul, H., Rauf, M., Arif, M., Hamayun, M., Ud-Din, A., Sajid, Z. A., Khilji, S. A., Rehman, A., and Tabassum, A. (2022). *Sargassum wightii* aqueous extract improved salt stress tolerance in *Abelmoschus esculentus* by mediating metabolic and ionic rebalance. *Frontiers in Marine Science*, 9:853272. doi: 10.3389/fmars.2022.853272
- Kumar, A., Singh, S., Gaurav, A. K., Srivastava, S., and Verma, J. P. (2020). Plant Growth Promoting Bacteria: Biological Tools for the Mitigation of Salinity Stress in Plants. *Frontiers in Microbiology*, 11(July), 1–15. <https://doi.org/10.3389/fmicb.2020.01216>
- Mahmoud, S. H., Salama, D. M., El-Tanahy, A. M. M., and Abd El-Samad, E. H. (2019). Utilization of seaweed (*Sargassum vulgare*) extract to enhance growth, yield and nutritional quality of red radish plants. *Annals of Agricultural Sciences*, 64(2), 167–175.
<https://doi.org/10.1016/j.aoas.2019.11.002>
- Nouok, A. E., Mbouobda, H. D., Nzouakeu, M. C. L., Choula, F., Ndouma, M. C., Erica, W. S., and Taffouo, V. D. (2022). Variation of some growth, agronomical and biochemical parameters of *Vigna unguiculata* (L. Walp) under salinity stress. *African Journal of Agricultural Research*, 18(11), 956–966. <https://doi.org/10.5897/ajar2022.16097>
- Punitha, P., Priyadharshini, P., Nanthini Devi, K., Dinesh Kumar, S., Roopavathy, J., Begum, A., Santhanam, P., and Perumal, P. (2024). Effect of seaweed liquid extract as an organic biostimulant on the growth, fatty acids and high-value pigment production of *Vigna radiata*.

In *Biomass Conversion and Biorefinery* ,14(6),7345–7357.

<https://doi.org/10.1007/s13399022-03048-1>

Qandil, A., El-Emary, F., and Saber, S. (2023). Effect of irrigation using saline and magnetized water on some botanical characteristics of cowpea plant (*Vigna unguiculata* L. Walp).

Archives of Agriculture Sciences Journal, 6(1), 14–31.

<https://doi.org/10.21608/aasj.2023.287577>

S. N. Saravaiya, J. P. S., and Y. N. Tandel, H. S. P. (2021). Response of Vegetable Cowpea [*Vigna unguiculata* (L.) Walp.] to Foliar Application of PGRs. *International Journal of Current Microbiology and Applied Sciences*, 10(7), 293–300.

<https://doi.org/10.20546/ijcmas.2021.1007.031>

Salah El Din, R. A., Elbakry, A. A., Ghazi, S. M., and Abdel Hamid, O. M. (2008). Effect of seaweed extract on the growth and yield of faba bean (*Vicia faba* l.). *Egyptian Journal of Phycology*, 9(1), 25–38.

Salem, O. M. A., Abbes, I. M., Mohsen, A. A., and Awad, S. A. (2025). *Biochemical investigation of some Mediterranean seaweeds*. 10(2), 25–29.

Santhosh, C., Vino, P., and Maruthupandian, A. (2021). Effect of *Padina tetrastromatica* and *Cymodocea serrulata* using different methods extract on growth and pigments of black gram (*Vigna mungo* L.). *Indian Journal of Natural Products and Resources*, 12(2), 300– 306.

Sasikala, M., Indumathi, E., Radhika, S., and Sasireka, R. (2016). Effect of seaweed extract (*Sargassum tenerrimum*) on seed germination and growth of tomato plant (*Solanum lycopersicum*). *International Journal of ChemTech Research*, 9(9), 285–293.

Shereen, A., Ansari, R., Mumtaz, S., Bughio, H. R., Mujtaba, S. M., Shirazi, M. U., and Khan, M. A. (2009). Impact of Gamma irradiation induced changes on growth and physiological responses of rice under saline conditions. *Pakistan Journal of Botany*, 41(5), 2487–2495.

Sunarpi, H., Nikmatullah, A., Ambana, Y., Ilhami, B. T. K., Abidin, A. S., Ardiana, N., Kirana, I. A. P., Kurniawan, N. S. H., Rinaldi, R., Jihadi, A., and Prasedya, E. S. (2021).

Phytohormone content in brown macroalgae *Sargassum* from Lombok coast, Indonesia.

IOP Conference Series: Earth and Environmental Science, 712(1).

<https://doi.org/10.1088/1755-1315/712/1/012042>

- Syed, A., Sarwar, G., Shah, S. H., and Muhammad, S. (2021). Soil Salinity Research in 21st Century in Pakistan: Its Impact on Availability of Plant Nutrients, Growth and Yield of Crops. *Communications in Soil Science and Plant Analysis*, 52(3), 183–200.
<https://doi.org/10.1080/00103624.2020.1854294>
- Teacă, C. A., and Bodîrlău, R. (2008). Assessment of toxicity of industrial wastes using crop plant assays. *BioResources*, 3(4), 1130–1145. <https://doi.org/10.15376/biores.3.4.1130-1145>
- Ubini, A. R., Idegba, C. M., Isaac, I. E., Ileleji, A., and Bozeinghien, H. (2016). Seed protein content variation in cowpea genotypes. *African Journal of Plant Breeding*, 3(1), 143–147.
- Weng, Y., Ravelombola, W. S., Yang, W., Qin, J., Zhou, W., Wang, Y.-J., Mou, B., and Shi, A. (2018). Screening of seed soluble sugar content in cowpea (*Vigna unguiculata* (L.) Walp). *American Journal of Plant Sciences*, 9(7), 1455–1466.
- Zahedi, S. M., Ansari, A., and Azizi, M. (2012). The study of the effect of salinity stress on the germination and the initial growth of cowpea (*Vigna unguiculata* L. Walp). *Journal of Agricultural Technology*, 8(7), 2363. <http://www.ijat-aatsea.com>