Seaweed Extract as A Biostimulant Ameliorate Wheat Growth Under Drought Stress

Fatma K. Sherif [1], Hoda A. Argeaa[2], and Aly S. Mostafa[1]

ABSTRACT

Seaweed extract (SE) is an effective strategy for reducing drought stress and increasing crop productivity. Wheat is the most widely farmed and consumed crop in the world. This study aims to determine how SE mitigates the effects of water stress on wheat plants. The concentrations of SE used were 0, 0.2, 0.5, and 1 g SE/500 g soil. Three different levels of field capacity (FC) were applied (50, 75, and 100%) to investigate the effect of water stress. The results demonstrated that morphological parameters declined when wheat plants exposed to water stress. Relative water content (RWC), potassium and phosphorus uptake, and chlorophyll content also decreased during drought stress, whereas soluble sugar, proline, and peroxidase enzyme activity (POX) increased. On the other hand, morphological characteristics, chlorophyll, RWC, soluble sugar, potassium and phosphorus uptake, chlorophyll content, and POX were all improved by SE application, especially at 0.5g SE/500 g soil concentration. According to the current study, drought stress can be reduced by applying SE at a concentration of 0.5 g SE/500 g soil.

Keywords: Wheat plant, Drought stress, Seaweed extract, Marine algae, Peroxidase, Soluble sugar.

INTRODUCTION

Agriculture has long been the primary driver of economic growth in Egypt since about 40% of all jobs in Egypt come from this sector and 20% of growth domestic product (MWRI, 2014). Approximately 55% of the population depends on Agriculture for their food requirements and means of subsistence (Elkholy, 2021). Food demands have increased dramatically in light of the existing circumstances and the growing world population (Pouratashi and Iravani, 2012). A new United Nations assessment projects that the world's population will reach 8.5 billion by 2030 and approximately 9 billion by 2050 (https://population.un.org/wpp/Publications/Files/WPP2019). Therefore, to meet the demands of the constantly growing population, food production must be increased by more than 50% (Mittal *et al.,* 2020).

Water is necessary for agricultural and industrial production, cattle feeding, food security, biodiversity preservation, and environmental preservation. Concern over water scarcity is developing globally. It is among the most difficult problems of the twenty-first century. In many nations around the world, the availability of water has reached critical levels, and the largest problem going forward is the growing demand for water and output across all sectors. According to WWF (World Wildlife Fund), 2.7 billion people worldwide suffer from water scarcity for at least one month of the year, while approximately 1.1 billion people lack access to water (Chakkaravarthy and Balakrishnan, 2019). Food consumption is predicted to rise in the future as a result of the high growth of the population, which will have a direct impact on water quantity used in Agriculture (Doll *et al.*, 2015). Given the significant amounts of water needed for crop production, various actions targeted at simplifying and increasing the agricultural sector's water consumption efficiency are essential to addressing future projections of water shortages.

The Mediterranean region focuses heavily on the production and cultivation of wheat (Shaukat *et al.*, 2024 and Lamlom *et al.*, 2023, 2025) since it is the most significant, nutrient-dense, extensively grown, and most consumed crop worldwide (Arzani and Ashraf, 2017). According to Ahmad *et al.* (2022), it contains 1.8% fiber, 9.4% protein, 69% carbs, and 2.5% fat. The importance of the wheat crop is further increased by the rising need for food and nutrition brought on by population growth (Solangi *et al.*, 2021). It also makes a significant contribution to the animal feed industries and livestock industry with great historical and cultural significance (Nyaupane *et al.,* 2024).

In arid and semi-arid locations, abiotic stressors are the primary factor limiting agricultural output (Lehari *et al.,* 2019 and Bhandari *et al.,* 2021). Drought stress is one of the primary abiotic stresses that farmers throughout the world are coping with as a result of climate change (Mansour *et al.*, 2020). As global temperatures continue to rise, drought stress has increased in frequency and severity. According to a report published by the Intergovernmental Panel on Climate Change (IPCC), the average global temperature is rising by 0.6°C to 1°C per year, (Pant *et al*., 2021). Continuous warming trend aids in the growth of uncultivable land and exposes plants to extended drought and water stress. Drought stress poses a serious threat to crop productivity worldwide (Ali *et al.,* 2024). Wheat crops need 300–500 mm of water, which is

DOI: 10.21608/asejaiqjsae.2025.443509

[1] Soil and Water Sciences Dept., Agriculture College, Alexandria University.
[2] Higher Institute of Science and Technology, Elmerj.

Received, May 30, 2025, Accepted, June 30, 2025.

significantly more compared to other crops like maize (Poudel *et al.,* 2020). Lack of irrigation was the main reason why wheat production was lower in underdeveloped nations than in industrialized ones (Shiferaw *et al.*, 2013 and Nyaupane *et al.*, 2024). In some areas, protracted drought episodes lower agricultural output and seed quality (Ahmed *et al.*, 2021 and Elmahdy *et al.,* 2023).

Drought also affects negatively physiological processes as it results in decreased chlorophyll content, decreased photosynthetic efficiency, and poor nutrient uptake because of slower root growth and less water availability (Ghanem & Al-Farouk, 2024 and Nyaupane *et al.,* 2024). During crucial developmental phases, from flowering to seed set, this stress is especially harmful because it interferes with gametogenesis and endosperm development, which eventually results in decreased grain yields (Nyaupane *et al.,* 2024 and Lamlom *et al.,* 2025).

Significant drought problems and the growing salinization of farmed areas should be kept in mind (Shrivastava and Kumar, 2015). New strategies should be taken while creating creative agro-solutions to offset the negative consequences of drought. Seaweed extracts (SE) stand out as a new class of agro-inputs in this pool of advances, coming from the horticultural sector. Seaweed contains a variety of bioactive substances as well as essential nutrients. Seaweed has been used as a food source by coastal cultures in many nations because of its high content of essential nutrients. Furthermore, by integrating ecosystem services in natural habitats or aquaculture activities, this resource provides crucial environmental benefits (Dmytryk & Chojnacka, 2018 and El Boukhari *et al.,* 2020). Because of its high protein, low fat, low sugar, and low cholesterol content, the United Nations Food and Agriculture Organization (FAO) considers it the perfect diet of the twenty-first century. According to Battacharyya *et al.* (2015), seaweed can be used as a horticultural stimulant that promotes and enhances all facets of plant growth and development as well as a disease protector (Zhang *et al.,* 2022).

Extracts from seaweed have been widely used in agriculture in recent years to boost yields. SE are naturally occurring biostimulants that come from a variety of seaweed species (Ali *et al.,* 2021). SE contains many bioactive substances, such as plant growth regulators, amino acids, vitamins, and antioxidants. These substances can improve a plant's resistance to drought stress in several ways (Khan *et al.,* 2009). Numerous physiological processes involved in plant growth and development are stimulated, and the end product's quality is enhanced (El Boukhari *et al.,* 2020). SE encourages the buildup of osmolytes and osmoprotectants such as free amino acids and soluble sugar in plant tissues (Ali *et al.*, 2022). Under water-limited circumstances, these substances shield plants from dehydration by preserving cellular turgor and membrane integrity (Chaves and Oliveira, 2004). SE improves the plant's capacity to scavenge ROS and reduce oxidative stress by inducing the synthesis of phenolic compounds and antioxidant enzymes (Begum *et al.,* 2021 and Fozi *et al.,* 2024). When seaweed extracts are used as fertilizer, they stimulate plants and support their growth parameters, such as increased root system development, faster seed germination rate, increased leaf and fruit area and number, plant weight, and plant strength. These days, when the need for inorganic fertilizers is declining, seaweed's potential as an environmentally friendly commercial product shines out (Wang *et al.,* 2018; Gao *et al.,* 2020 and Nobile *et al.,* 2020). Researchers are currently looking for various extraction techniques to create liquid seaweed fertilizer that may increase its efficacy on seed germination and plant growth (Yoruklu *et al.,* 2022). Seaweed extracts increased germination rate and wheat tolerance towards salinity (Sherif *et al.,* 2024). Indeed, Sherif *et al.* (2025) observed that sprayed tomato plants with SE had increased significantly morphological parameters and decreased antioxidant enzyme, proline and lycopene under salinity stress.

This study aims to evaluate the effectiveness of different concentrations of seaweed extract in mitigating the effect of water stress on wheat plants, by estimating growth parameters and various physiological responses.

MATERIAL AND METHODS

1. Location of experiment:

This research was carried out at 403 soil fertility and plant nutrition lab, faculty of Agriculture, Alexandria University, Egypt (31°12'21.7"N, 29°55'09.8"E) during the winter season of 2024-2025.

2. Analysis of physicochemical properties of soil:

A sample of soil was taken from village 27 Bangar ElSokar-ElHamam, Matrouh, and prepared for analysis. A saturated soil paste extract was prepared, and electrical conductivity (EC) was measured using an EC meter (Carter and Gregorich, 2007). pH was determined using a pH meter. Calcium (Ca^{2+}) and magnesium (Mg^{2+}), as well as carbonates (CO_3^{2-}) and bicarbonates (HCO_3^-) were analyzed through titration. Chloride (Cl^-) was determined using the Mohr method, and sodium (Na^+) and soluble potassium (K^+) concentrations were measured using a flame photometer. Soil texture was determined by the Hydrometer method (Gee and Bauder, 1986), calcium carbonate by the gasometric method, organic carbon by the Walkely- black method (Tandon, 1998), nitrogen by Kjeldahl method (Bremner, 1965), Available potassium by the ammonium acetate method (Chapman and Pratt, 1962), and available phosphorus by the blue method (Olsen & Sommers, 1982 and Najafi Vafa *et al.*, 2022).

Table 1. Soil Chemical analysis

Items	Result	Items	Result
EC ($dS.m^{-1}$)	3.4	Soluble ions^{+} ($meq.L^{-1}$)	
pH	8.5	Ca^{2+}	10
$CaCO_3$(%)	31.8	Mg^{2+}	6.5
Organic matter (%)	1.28	Na^{+}	16.8
Texture	Loamy sand	K	1.6
Available nutrients (ppm)		CO_3^{2-}	3.5
NH_4^{+}	70	HCO_3^{-}	4
NO_3^{-}	140	Cl^{-}	7.3
P	45	SO_4^{2-} ($meq.L^{-1}$)	18.5
K	80		

To calculate field capacity, the weight difference between a soil sample at saturation and air-drying conditions after 24 hours was measured using the following field capacity formula:

$$F.C = \frac{Wet\ weight - Air\ dried\ weight}{Wet\ weight} * 100$$

$$= \frac{435.74 - 328.98}{435.74} * 100 = 24.5\%$$

3. Seaweed extract preparation:

Seaweed extract (SE) was prepared as described by Mostafa (2024). After adding 250 grams of seaweed powder made by harvesting and drying algae (*Ulva sp.*) to 1500 ml of potassium hydroxide solution (5 M), the mixture was heated until it boiled. Then, it was allowed to cool for seventy-two hours at room temperature. The supernatant was used as a seaweed extract. The extract was then dried for 72 hours at 60°C in the oven.

4. Experimental design:

Two ways factorial in completely randomized design (CRD) with triplicates was used. To optimize soil fertility, a fertilization program was designed using an N-P-K 15-15-15 nutrient ratio. A total of 0.54 g of potassium sulfate, 2.16 g of superphosphate, and 0.81 g of ammonium nitrate were carefully measured and incorporated into 18 kg of calcareous soil. The components were mixed thoroughly to ensure even nutrient distribution, thereby enhancing soil quality and nutrient availability. Each plastic pot was packed with 500 g of calcareous soil prior to cultivation. Thirty-six plastic pots were used and the pots were devoted to four concentrations of dried seaweed extract (0, 0.2, 0.5, 1 g seaweed/ 500 g soil) before sowing.

To attain varying percentages of field capacity during the plant growth phases pots were irrigated with varying amounts of water. The pots were allocated into groups: the first group of pots were irrigated with 100% of field capacity (122.5 ml), the second were irrigated with 75% of field capacity (91.9 ml), and the third group were irrigated with 50% of field capacity (61.2 ml) representing no stress, mild stress, and high stress treatments respectively.

The soil was watered and subsequently allowed to dry for three weeks to ensure it underwent systematic wetting and drying cycles, facilitating a controlled experimental process.

Wheat seeds (SDS 14) were manually grown tightly (5 seeds/pot) to guarantee that at least 3 seeds germinated in each pot. The seeds were planted two centimeters deep in the ground. After that, the specified amount of water was given to each pot. Then, the pots were placed in a dark location for four days until germination occurred and covered with black plastic bags. After germination, a thinning process was performed for pots containing more than 3 seedlings and the pots were moved to a sunny place, and the treatments were watered to maintain the field capacity of each treatment.

The experiment was conducted in mid-December and harvested by mid-February.

5. Plant analysis

Before harvesting, plant height was measured. A leaf was taken from each plant to measure leaf area (LA) and relative water content (RWC).

LA was measured by hand as a leaf sample was collected from each plant, and each sample's dimensions were measured. This was accomplished by placing a flag leaf on a plane page and measuring its length and widest point (Ahmed *et al.*, 2015). Then, LA was determined using the formula:

Leaf Area = (length x width) x correction factor (0.75)

Where the correction factor accounts for leaf shape (Schrader *et al.*, 2021).

Leaf fresh weight (LFW) was recorded for each leaf, then each leaf was soaked in tap water for 24 hours in the dark and the saturated weight (LTW) was recorded. It was then oven-dried at 75°C for 72 hours and the dry weight (LDW) was recorded. Then, relative water content (RWC) was calculated by the following equation (Karimi *et al.*, 2018):

$$RWC\ (\%) = \frac{LFW - LDW}{LTW - LDW} * 100$$

To determine chlorophyll content, a leaf was taken from each treatment to measure chlorophyll A and B content. Chlorophyll A and B content in leaves was determined by the N, N, Dimethylformamide (DMF) method as described by Lichtenthaler & Wellburn (1983) and Porra *et al.* (1989).

Peroxidase activity (POX) was determined using Kar and Mishra (1976) method. 0.5 g of shoot fresh plant was collected from each treatment, weighted and homogenized in 5 ml 0.1M phosphate buffer to determine peroxidase activity in the shoot. The extract was kept in ice-cold water to preserve enzyme activity. The enzymatic estimation then involved, mixing 0.1 mL of the extract with 2.9 mL of buffer solution, 1.0 mL of pyrogallol, and 1.0 mL of hydrogen peroxide (H_2O_2).

Following the harvest, the fresh weight of both the shoot and root were measured, along with the root length (RL, m). RL was measured according to Tennant method (1975). Then, Root radius (R_r, mm) and root surface area (RSA, m^2) were calculated according to Hallmark and Barber (1984).

The collected samples from all treatments were then dried in an oven at 80°C for 72 hours to ensure complete moisture removal. Once dried, the dry weight was measured. The concentration of phosphorus (P) was estimated by yellow method, and potassium (K) was estimated by flame photometer.

Soluble sugar content was estimated using phenol and sulfuric acid method. (DuBois, *et al.*, 1956).

Proline content determined in 0.20 g of dry leaves by colorimetric method described by Bates *et al.* (1973).

7. Statistical analysis:

The CoStat Software package (CoHort, 2004) was used to statistically evaluate all of the data gathered in accordance with the experimental design. The least square difference technique at a significance level of 0.05 (LDS 0.05) was used to compare the means of the various treatments.

RESULTS AND DISCUSSION

Data in Table (2) and Figs. (1, 2, and 3) explained that most important parameters recorded the highest at 0.5g seaweed/500g soil when compared to other seaweed treatments. In comparison to the control, it was shown that plant parameters increased as seaweed content rose to 0.5g seaweed/500g soil. As seaweed content increased to 1 g seaweed/500 g soil, plant parameters declined.

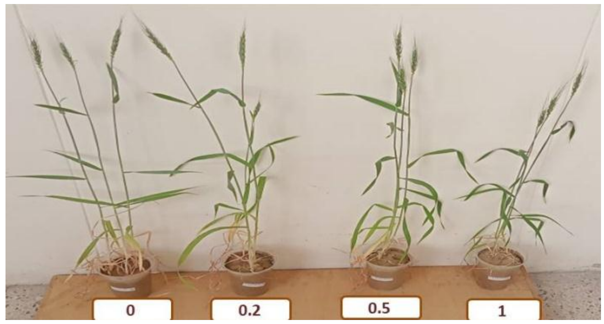

Fig. 1. Effect of different Concentrations of SE on wheat plants at 100% level of field capacity

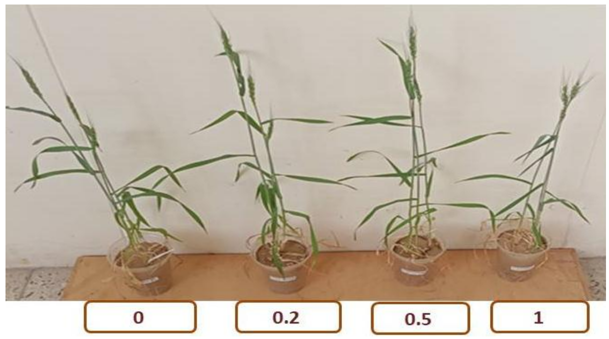

Fig. 2. Effect of different Concentrations of SE on wheat plants at 75% level of field capacity

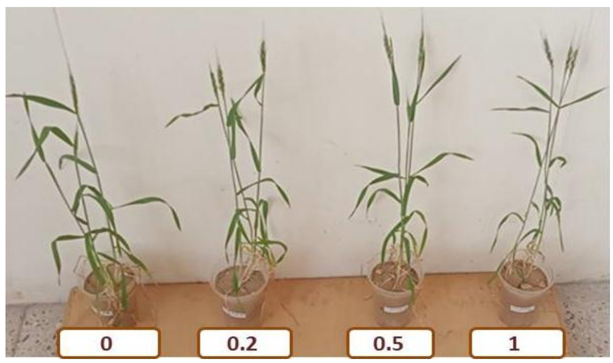

Fig. 3. Effect of different Concentrations of SE on wheat plants at 50% level of field capacity

Data in Table (2) and Figs. (4 and 5) demonstrated that, in comparison to other levels of field capacity, the most significant values were observed at the 100% field capacity level. The plant parameters declined when the field capacity was reduced. Figs. (4 and 5) demonstrated that even at 50% field capacity, the addition of seaweed increased plant parameters.

Table 2. Effect of different concentration of SE on plant height, leaf area, fresh weight (FW), root fresh weight (RFW) and root dry weight (RDW) of wheat plants grown under water stress

SE conc. (g/500g soil)	0	0.2	0.5	1	Mean of SE
FC.(%)			Height(cm)		
100	65.1	69.1	70.3	63.6	67 a
75	51.9	52.3	57.1	51.7	53.2 b
50	45.1	48.8	55.4	51.4	50.2 c
Mean of FC	54 c	56.7 b	60.9 a	55.6 bc	
			Leaf area (cm^2)		
100	11.74 b	14.3 a	15.77 a	9.2 d	12.75 a
75	9.53 cd	11.05 bc	11.48 b	7.36 ef	9.85 b
50	7.93 de	8.32 de	8.77 de	6.17 f	7.79 c
Mean of FC	9.73 b	11.22 a	12 a	7.57 c	
			FW(g)		
100	2.78 b	2.95 ab	3.05 a	2.4 c	2.79 a
75	1.9 ef	2.03 de	2.1 d	1.6 gh	1.91 b
50	1.47 h	1.56 gh	1.74 fg	1.57 gh	1.58 c
Mean of FC	2.05 c	2.18 b	2.29 a	1.85 d	
			DW(g)		
100	0.6	0.61	0.64	0.44	0.57 a
75	0.36	0.42	0.44	0.27	0.37 b
50	0.3	0.33	0.35	0.25	0.3 c
Mean of FC	0.42 b	0.45 ab	0.47 a	0.31 c	
			RFW(g)		
100	1.17 bcd	1.27 b	1.47 a	1.14 cd	1.26 a
75	1.07 d	1.24 bc	1.25 bc	0.73 ef	1.07 b
50	0.54 g	0.64 fg	0.77 e	0.71 ef	0.67 c
Mean of FC	0.93 c	1.05 b	1.16 a	0.86 d	
			RDW(g)		
100	0.24 b	0.25 b	0.27 a	0.18 c	0.23 a
75	0.12 e	0.15 d	0.15 d	0.09 f	0.12 b
50	0.05 i	0.05 hi	0.08 fg	0.07 gh	0.06 c
Mean of FC	0.13 c	0.15 b	0.17 a	0.11 d	

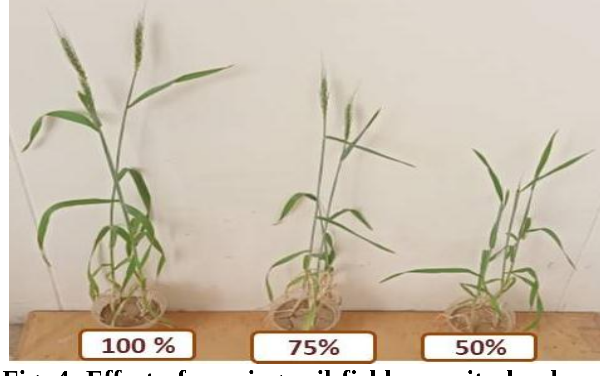

Fig. 4. Effect of varying soil field capacity levels on wheat plants at 0 SE application

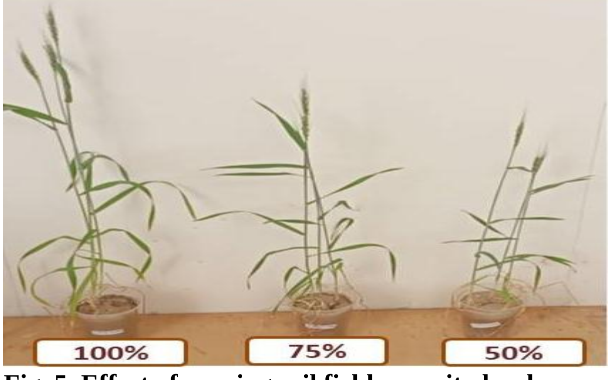

Fig. 5. Effect of varying soil field capacity levels on wheat plants at 0.5g SE application

Data shown in Fig. (6) exhibited that the 1 g seaweed/500 g soil group recorded the highest significant RWC. It is evident that even though the field capacity decreased, the RWC increased as the concentration of seaweed increased. Field capacity at 100% recorded the highest RWC compared to 75% & 50% levels.

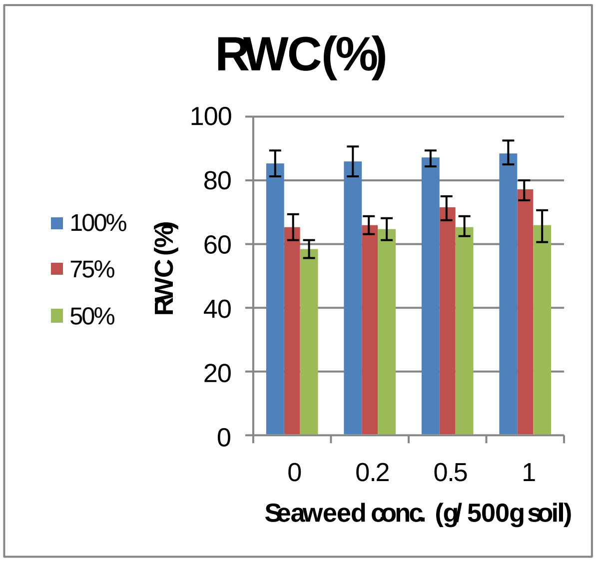

Fig. 6 Effect of different concentration of SE on RWC of wheat plants grown under water stress

Data in Table (3) demonstrated that, in comparison to the control, the means of root length (RL) and RSA were raised when it was treated with low and medium concentrations of SE. The most significant RL and RSA were recorded at 0.5g seaweed/ 500g soil. Mean RL and RSA values were increased by increasing SE concentration up to 0.5 g/500 g soil. Mean RL and RSA values decreased when seaweed concentration increased up to 1 g seaweed/ 500g soil. Data in Table (3) also clarified that the control group had the greatest significant R_r in comparison to other seaweed treatments. Meanwhile, increasing water stress increased root radius. It was observed also, that R_r dramatically dropped with the addition of seaweed extract.

Data in Table (4) indicated that 0.5 g seaweed/500 g soil group had the maximum uptake of potassium and the highest content of soluble sugar. It was shown that the soluble sugar content and potassium and uptake rose as the quantity of seaweed increased up to 0.5g seaweed/500g soil. When the concentration of seaweed is raised to 1g seaweed/500g soil, the soluble sugar content and the uptake of potassium are reduced. Phosphorus uptake was considerably enhanced by the administration of 0.2g seaweed/ 500g soil. However, increasing the concentration over 0.2g/500g soil did not result in any additional statistically significant improvement. Remarkably, the plants with the highest significant means of soluble sugar concentration were those under water stress.

Data in Figs. (7 and 8) showed that the maximum significant level of chlorophyll A and B was found at 1g seaweed/500g soil. It was observed that the amount of chlorophyll A and B was increased as the concentration of seaweed increased at all levels of field capacity.

Table 3. Effect of different concentration of SE on RL, RSA, and R_r of wheat plants grown under water stress

SE conc. (g/500g soil)	0	0.2	0.5	1	Mean of SE Conc.
FC(%)			RL (m)		
100	20.54 bcd	22.94 b	30.24 a	19.38 cd	23.27 a
75	18.12 d	21.05 bc	21.71 bc	12.82 e	18.48 b
50	4.42 h	9.32 fg	11.45 ef	7.63 g	8.2 c
Mean of FC	14.35 c	17.84 b	21.13 a	13.28 c	
			R_r (mm)		
100	0.08 ef	0.07 f	0.06 g	0.08 ef	0.07 c
75	0.08 e	0.07 ef	0.07 ef	0.1 d	0.08 b
50	0.17 a	0.11 c	0.1 d	0.13 b	0.13 a
Mean of FC	0.11 a	0.09 c	0.08 d	0.1 b	
			RSA (m^2)		
100	10.4 bcd	10.9 b	12.6 a	10.1 cd	11 a
75	9.7 d	10.5 bc	10.6 bc	8.19 e	9.7 b
50	4.8 g	7 f	7.7 e	6.34 f	6.4 c
Mean of FC	8.3 c	9.5 b	10.3 a	8.2 c	

Table 4. Effect of different contraction of seaweed extraction on carbohydrates content and phosphorous and potassium uptake of wheat plants grown under water stress

SE conc. (g/500g soil)	0	0.2	0.5	1	Mean of SE Conc.
FC. (%)			Soluble sugar (mg/g)		
100	57.8 d	58.5 d	59.8 d	59.6 d	58.9 c
75	59.6 d	67.9 c	92.1 a	81.1 b	75.1 b
50	70.1 c	78.8 b	95.2 a	81.6 b	81.4 a
Mean of FC	62.5 d	68.4 c	82.4 a	74.1 b	
			P uptake (mg/g)		
100	0.88 c	1.19 b	1.51 a	1.3 b	1.22 a
75	0.37 de	0.52 d	0.55 d	0.48 d	0.48 b
50	0.2 e	0.4 d	0.44 d	0.42 d	0.37 c
Mean of FC	0.48 b	0.71 a	0.83 a	0.73 a	
			K uptake (mg/g)		
100	11.5 bc	12.25 ab	13.96 a	10.46c	12.04 a
75	5.09 f	6.62 def	7.76 d	7.05 de	6.63 b
50	1.5 g	3.26 g	5.56 ef	5.52 ef	3.96 c
Mean of FC	6.02 c	7.37 b	9.09 a	7.67 b	

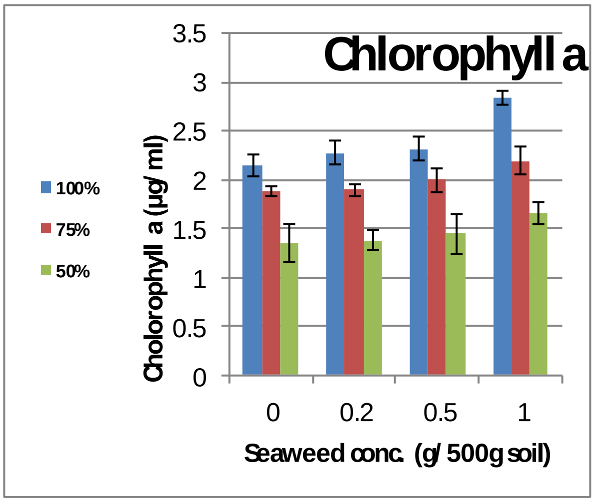

Fig. 7. Effect of different concentration of SE on chlorophyll a content of wheat plants grown under water stress

Fig. (9) showed that all treatments significantly affected the activity of the peroxidase enzyme (POX). At 50% field capacity, the greatest significant POX was seen. POX increased when the plants were exposed to water stress. It was observed that POX increased as seaweed concentration rose.

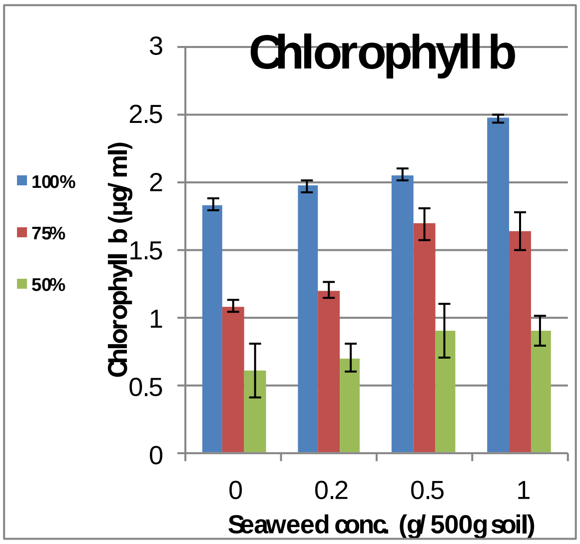

Fig. 8. Effect of different concentration of SE on chlorophyll b content of wheat plants grown under water stress

Data in Fig. (10) showed that when field capacity decreased, the proline content rose. Compared to other field capacity levels, the largest significant proline content was recorded at 50% of field capacity. The mean values of proline content decreased as seaweed concentration rose. At 1g seaweed/500g soil, the least significant proline concentration was found.

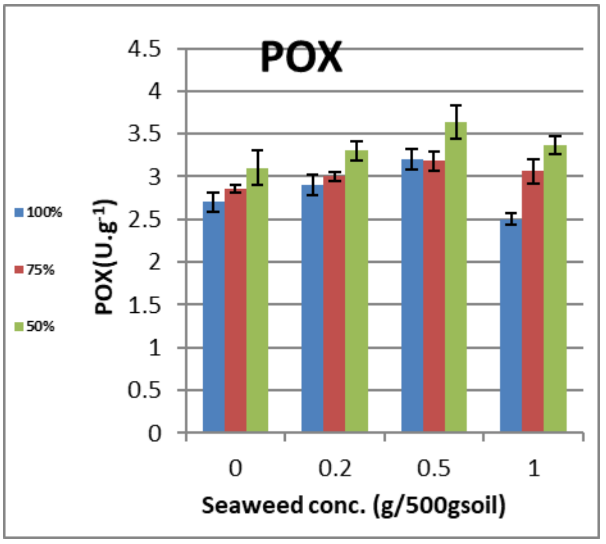

Fig. 9. Effect of different concentration of SE on POX of wheat plants grown under water stress

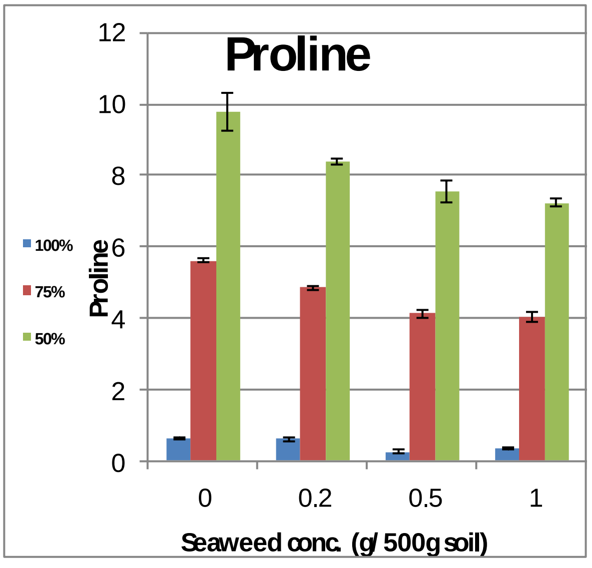

Fig. 10. Effect of different concentration of SE on proline of wheat plants grown under water stress

DISCUSSIONS

According to Mostafa (2024), the richness of seaweed of organic compounds and vital nutrients is significantly responsible for the improvement in morphological parameters of wheat plants under water stress up to treatment with 0.5 g/500 g soil. Auxins, gibberellin, and cytokinin are among the plant hormones detected in seaweed extract (Sherif *et al.*, 2025). Cytokinin has a significant impact on physiological and biochemical processes and stimulates cell division (Wang *et al.*, 2023). Plant parameters reduced as seaweed concentration increased to 1g seaweed/500g soil; this may be explained by an overabundance of certain components (Mostafa, 2024). It's interesting to note that leaf RWC and leaf area can be utilized as tolerance indicators (Silva *et al.*, 2007). RWC and leaf area were reduced under water stress; the plants that received 50% of their field capacity had the least significant mean of leaf RWC and leaf area. Plants treated with varying doses of seaweed showed increases in leaf area and leaf RWC. These findings are in line with those of Khan *et al.* (2009); Rathore *et al.* (2009) and Roussos *et al.* (2009), who found that applying marine algae extracts enhanced yield.

The largest root diameter was found at the 50% field capacity level, which was followed by the 75% level. Plants used root radius as a mechanism to increase their endurance to water stress (Sherif *et al.*, 2025). Reducing field capacity levels resulted in a considerable rise in root radius. The largest root diameter was found at the 50% field capacity level, which was followed by the 75% level. These findings concur with those of Sherif (1996), who discovered that under stressful circumstances, roots undergo an increase in intercellular thickness. It is evident that root radius reduced at every field capacity level when seaweed was increased to 0.5g seaweed/500g soil. Plants with small root radius invest their root biomass more efficiently because they have larger root length and root surface area compared to plants with large diameters (Eissenstat, 1992).

The use of seaweed extract caused the buildup of potassium and phosphorus. These findings align with those of Mancuso *et al.* (2006) which showed that applying seaweed extract to grapevines enhanced the accumulation of N, P, K, Zn, and Mg. Rathore *et al.* (2009) also demonstrated that soybean seeds treated with algal biostimulants had higher levels of N, P, K, and S. As seaweed concentration rose to 0.5 g seaweed/500 g soil, phosphorus and potassium uptake increased. This was caused by an increase in dry weight and phosphorus and potassium buildup. Potassium and phosphorus uptake was reduced at 1g seaweed/500g soil because of a decrease in dry weight despite increasing phosphorus and potassium buildup.

Under water stress, soluble sugar content increased noticeably. These findings are in line with those of Marcek *et al.* (2019), who found that drought stress caused wheat plants to accumulate a significant content of sucrose along with glucose and fructose. The buildup of soluble sugar during water stress may be a component of a drought adaptation mechanism (Marček *et al.*, 2019). The soluble sugar content rose as seaweed concentration rose. These findings are in line with Ziaei and Pazoki (2022)'s findings who explained that foliar application of seaweed extract to beans enhanced the accumulation of total soluble sugar.

The amount of chlorophyll A and B in leaves was positively impacted by SE. These findings align with those of Sivasankari *et al.* (2006); Mancuso *et al.* (2006) and Spinelli *et al.* (2010), who found that applying algae preparation to grapevine and strawberry improved the amount of chlorophyll.

As a first reaction to abiotic stress, plants undergo internal oxidative stress, which is defined by an excess of reactive oxygen species (ROS) produced by the photosynthetic electron transport chain in the chloroplasts (Mittler, 2002). Increased ROS levels have the potential to cause structural harm to proteins and DNA, inhibit antioxidant enzymes, and trigger programmed cell death (Huang *et al.*, 2019). They also cause Lipid peroxidation and cell wall damage (Molassiotis *et al.*, 2006 and Ashraf, 2009). In response, the plant produces large quantities of the peroxidase enzyme, which aids in detoxification and the removal of intermediate chemicals. It has been observed that peroxidase activity significantly improves plants' ability to withstand water stress as POX is the most effective ROS scavenger, transforming superoxide (O_2^-) into hydrogen peroxide (H_2O_2), which is then detoxified to produce water (H_2O) (Yang and Guo, 2018). Biostimulants including marine algae extracts are plant-supporting preparations in the event of drought stress, according to numerous scientific researches (Spann & Little, 2011; Elansary *et al.*, 2016; Goñi *et al.*, 2016 and Santaniello *et al.*, 2017), the use of seaweed extract enhanced the activity of oxidation and reduction enzymes. Moreover, the study of Lola-Luz *et al.* (2014) showed that POX activity was significantly increased in wheat shoot treated with seaweed extract. These results are consistent with those of Lenart *et al.* (2024), who concluded that treating blueberry plants with a seaweed extract-based biostimulant under water stress increases peroxidase activity.

Remarkably, the content of proline can also be employed as a negative measure of tolerance. Proline is a metabolic solute which rises in plants exposed to unfavorable environmental circumstances. Proline accumulation increased dramatically under water stress. proline levels dropped in plants treated with varying quantities of seaweed extract under water stress, demonstrating the potential of seaweed extract to mitigate water-deficit stress. These findings are in line with those of Ali *et al.* (2022), who found that foliar treatments with algal extract decreased proline in wheat plants.

CONCLUSION

The current study showed that seaweed extract is a useful tool for reducing the negative effects of water stress on wheat. When it came to increasing plant productivity during drought, the application of 0.5 g seaweed extract outperformed all other tested concentrations. These results corroborate other studies showing the beneficial effects of seaweed biostimulants in boosting plant resistance to water stress.

REFERENCES

Ahmad, A., Z.Aslam, T.Javed, S.Hussain, A.Raza, R.Shabbir and M. Tauseef. 2022. Screening of wheat (*Triticum aestivum* L.) genotypes for drought tolerance through agronomic and physiological response. Agronomy. 12(2): 287.

Ahmad, S., I.Muhammad, G. Y.Wang, M.Zeeshan, L.Yang, I.Ali and X. B. Zhou. 2021. Ameliorative effect of melatonin improves drought tolerance by regulating growth, photosynthetic traits and leaf ultrastructure of maize seedlings. BMC Plant Biology. 21(1):368.

Ahmad, S., H. Ali, A. Ur Rehman, R. J. Z. Khan, W. Ahmad, Z. Fatima and M. Hasanuzzaman. 2015. Measuring leaf area of winter cereals by different techniques: A comparison. Pak. *J.* Life Soc. *Sci.* 13(2): 117-125.

Ali AA, S.F. Lamlom, G.A. El-Sorady, A.M. Elmahdy, S. Abd Elghany, M. Usman, A. Alamri, H. Shaghaleh, Y.A. Hamoud and A.M. Abdelghany. 2024. Boosting resilience and yields in water-stressed sunflower through coordinated irrigation scheduling and silica gel applications. Heliyon. 10(20).

Ali, A. H., E. M. Said and Z. A. Abdelgawad. 2022. The role of seaweed extract on improvement drought tolerance of wheat revealed by osmoprotectants and DNA (cpDNA) markers. Brazilian *J.* of Botany. 45(3): 857-867.

Ali, O., A. Ramsubhag and J. Jayaraman. 2021. Biostimulant properties of seaweed extracts in plants: Implications towards sustainable crop production. Plants. 10(3): 531.

Arzani, A. and M. Ashraf. 2017. Cultivated ancient wheats (Triticum spp.): A potential source of health-beneficial food products. Comprehensive Reviews in Food *Sci.* and Food Safety. 16(3): 477-488.

Ashraf, M. J. B. A. 2009. Biotechnological approach of improving plant salt tolerance using antioxidants as markers. Biotechnology advances. 27(1): 84-93.

Bates, L.S., R.P.A. Waldren and I.D. Teare. 1973. Rapid determination of free proline for water-stress studies. Plant Soil. 39: 205-207.

Battacharyya, D., M. Z. Babgohari, P. Rathor and B. Prithiviraj. 2015. Seaweed extracts as biostimulants in horticulture. Scientia horticulturae. 196: 39-48.

Begum, R., S. Howlader, A. N. M. Mamun-Or-Rashid, S. M. Rafiquzzaman, G. M. Ashraf, G. M. Albadrani and M. S. Uddin. 2021. Antioxidant and Signal-Modulating Effects of Brown Seaweed-Derived Compounds against Oxidative Stress-Associated Pathology. Oxidative Medicine and cellular longevity. 2021(1): 9974890.

Bhandari, R., S. Gnawali, S. Nyaupane, S. Kharel, M. Poudel and P. Panth. 2021. Effect of drought & irrigated environmental condition on yield & yield attributing characteristic of bread wheat-a review. Reviews in food and agriculture. 2(2): 59-62.

Bremner, J. M. 1965. Total nitrogen. Methods of soil analysis: part 2 chemical and microbiological properties. 9: 1149-1178.

Carter, M. R. and E. G. Gregorich. 2007. Soil sampling and methods of analysis. CRC press.

Chakkaravarthy, D. N. and T. Balakrishnan. 2019. Water scarcity-challenging the future. International *J.* of agriculture, environment and Biotechnology. 12(3): 187-193.

Chapman, H. D. and P. F. Pratt. 1962. Methods of analysis for soils, plants and waters. Soil *Sci.* 93(1): 68.

Chaves, M. M. and M. M. Oliveira. 2004. Mechanisms underlying plant resilience to water deficits: prospects for water-saving agriculture. *J.* of experimental botany. 55(407): 2365-2384.

CoHort. 2004. Statistical analysis package, Version 6.303. CoHort Software, Monterey, CA, 93940, USA.

Dmytryk, A. and K. Chojnacka. 2018. Algae as fertilizers, biostimulants, and regulators of plant growth. Algae biomass: characteristics and applications: towards algae-based products. 115-122.

Döll, P., B. Jiménez-Cisneros, T. Oki, N. W. Arnell, G. Benito, J. G. Cogley and A. Nishijima. 2015. Integrating risks of climate change into water management. Hydrological *Sci. J.* 60(1): 4-13.

DuBois, M., K. A. Gilles, J. K. Hamilton, P. A. Rebers and F. Smith. 1956. Colorimetric method for determination of sugars and related substances. Analytical chemistry. 28(3): 350-356.

Eissenstat, D. M. 1992. Costs and benefits of constructing roots of small diameter. *J.* of plant nutrition. 15(6-7): 763-782.

Elansary, H. O., K. Skalicka-Woźniak and I. W. King. 2016. Enhancing stress growth traits as well as phytochemical and antioxidant contents of Spiraea and Pittosporum under seaweed extract treatments. Plant Physiology and Biochemistry. 105: 310-320.

El Boukhari, M. E. M., M. Barakate, Y. Bouhia and K. Lyamlouli. 2020. Trends in seaweed extract based biostimulants: Manufacturing process and beneficial effect on soil-plant systems. Plants. 9(3): 359.

Elkholy, M. 2021. Assessment of water resources in Egypt: Current status and future plan. Groundwater in Egypt's Deserts. 395-423.

Elmahdy, A. M., Y. M. Ahmed, A. A. Bakr, A. M. Abdallah, A. M. Abdelghany, G. A. El-Sorady and S. F. Lamlom. 2023. Revolutionizing maize farming with potassium silicate foliar spray and water management techniques. Silicon. 15(16): 7121-7135.

Fozi, V., H. Esmaeili, A. Alizadeh, G. Eghlima and M. H. Mirjalili. 2024. The interaction effect of water deficit stress and seaweed extract on phytochemical characteristics and antioxidant activity of licorice (Glycyrrhiza glabra L.). Frontiers in Plant *Sci.* 15: 1474399.

Gao, H., W. Dai, K. Fang, X. Yi, N. Chen, P. Penttinen and L. Cao. 2020. Rice-duck co-culture integrated different fertilizers reduce P losses and Pb accumulation in subtropical China. Chemosphere. 245: 125571.

Gee, G. W. and J. W. Bauder. 1986. Particle-size analysis. Methods of soil analysis: Part 1 Physical and mineralogical methods. 5: 383-411.

Ghanem, H. E. and M. O. Al-Farouk. 2024. Wheat Drought Tolerance: Morpho-physiological criteria, stress indexes, and yield responses in newly sand soils. *J.* of Plant Growth Regulation. 43(7): 2234-2250.

Goni, O., A. Fort, P. Quille, P. C. McKeown, C. Spillane and S. O'Connell. 2016. Comparative transcriptome analysis of two Ascophyllum nodosum extract biostimulants: same seaweed but different. *J.* of agricultural and food chemistry. 64(14): 2980-2989.

Hallmark, W.B. and S.A. Barber. 1984. Root growth and morphology, nutrient uptake, and nutrient status of early growth of soybeans as affected by soil P and K 1. Agron. *J.* 76: 209-212.

Huang, H., F. Ullah, D.X. Zhou, M. Yi and Y. Zhao. 2019. Mechanisms of ROS regulation of plant development and stress responses. Front. Plant *Sci.* 10: 800.

Kar, M. and D. Mishra. 1976. Catalase, peroxidase, and polyphenoloxidase activities during rice leaf senescence. Plant physiology. 57 (2): 315-319.

Karimi, S., M. Rahemi, A. A. Rostami and S. Sedaghat. 2018. Drought effects on growth, water content and osmoprotectants in four olive cultivars with different drought tolerance. International *J.* of Fruit *Sci.* 18(3): 254-267.

Khan, W., U. P. Rayirath, S. Subramanian, M. N. Jithesh, P. Rayorath, D. M. Hodges and B. Prithiviraj. 2009. Seaweed extracts as biostimulants of plant growth and development. *J.* of plant growth regulation. 28: 386-399.

Lamlom SF, A. Irshad and W. F. Mosa. 2023. The biological and biochemical composition of wheat (Triticum aestivum) as affected by the bio and organic fertilizers. BMC Plant Biol. 23(1):111.

Lamlom, S. F., A. M. Abdelghany, A. S. Farouk, E. S. Alwakel, K. M. Makled, N. A. Bukhari and A. A. Shehab. 2025. Biochemical and yield response of spring wheat to drought stress through gibberellic and abscisic acids. BMC Plant Biology. 25(1): 5.

Lehari, K., M. Kumar, V. Burman, V. Aastha, P. Chand and R. Singh. 2019. Morphological, physiological and biochemical analysis of wheat genotypes under drought stress. *J.* of Pharmacognosy and Phytochemistry. 8(2S): 1026-1030.

Lenart, A., D. Wrona and T. Krupa. 2024. Biostimulators with marine algae extracts and their role in increasing tolerance to drought stress in highbush blueberry cultivation. PloS one. 19(9): e0306831.

Lichtenthaler, H. K. and A. R. Wellburn. 1983. Determinations of total carotenoids and chlorophylls a and b of leaf extracts in different solvents.

Lola-Luz, T., F. Hennequart and M. Gaffney. 2014. Effect on health promoting phytochemicals following seaweed application, in potato and onion crops grown under a low input agricultural system. Scientia Horticulturae. 170: 224-227.

Mancuso, S., X. Briand, S. Mugnai and E. Azzarello. 2006. Marine bioactive substances (IPA extract) improve foliar ion uptake and water stress tolerance in potted" Vitis vinifera" plants. Advances in horticultural *sci.* [rivista dell'ortofloroftutticoltura italiana]. 20 (N. 2): 1000-1006.

Mansour, H. A., S. El, S. Mohamed and D. A. Lightfoot. 2020. Molecular studies for drought tolerance in some Egyptian wheat genotypes under different irrigation systems. Open Agriculture. 5(1): 280–290.

Marček, T., K. A. Hamow, B. Végh, T. Janda and E. Darko. 2019. Metabolic response to drought in six winter wheat genotypes. PLoS one. 14(2): e0212411.

Mittal, D., G. Kaur, P. Singh, K. Yadav and S. A. Ali. 2020. Nanoparticle-based sustainable agriculture and food *sci.*: Recent advances and future outlook. Frontiers in Nanotechnology. 2: 579954.

Mittler, R. 2002. Oxidative stress, antioxidants and stress tolerance. Trends Plant *Sci.* 7: 405-410.

Molassiotis, A., T. Sotiropoulos, G. Tanou, G. Diamantidis and I. Therios. 2006. Boron-induced oxidative damage and antioxidant and nucleolytic responses in shoot tips culture of the apple rootstock EM 9 (Malus domestica Borkh). Environmental and Experimental Botany. 56(1): 54-62.

Mostafa, A. S. 2024. Simple and economical methods for producing a nano-algae fertilizer and its efficacy for germination of cucumber seeds. Alexandria *Sci.* Exch. *J.* 45(3): 563-570.

MWRI. 2014. Water Scarcity in Egypt: The Urgent Need for Regional Cooperation among the Nile Basin Countries. Ministry of Water Resources and Irrigation, Water Scaricity. 1-5.

Najafi Vafa, Z., Y. Sohrabi, G. Mirzaghaderi and G. Heidari. 2022. Soil microorganisms and seaweed application with supplementary irrigation improved physiological traits and yield of two dryland wheat cultivars. Frontiers in Plant *Sci.* 13: 855090.

Nobile, C. M., M. N. Bravin, T. Becquer and J. M. Paillat. 2020. Phosphorus sorption and availability in an andosol after a decade of organic or mineral fertilizer applications: Importance of pH and organic carbon modifications in soil as compared to phosphorus accumulation. Chemosphere. 239: 124709.

Nyaupane, S., M. R. Poudel, B. Panthi, A. Dhakal, H. Paudel and R. Bhandari. 2024. Drought stress effect, tolerance, and management in wheat–a review. Cogent Food & Agriculture. 10(1): 2296094.

Olsen, S. R. and E. L. Sommers. 1982. Phosphorus soluble in sodium bicarbonate. Methods of soil analysis, part. 2: 404-430.

Pant, P., S. Pandey and S. Dall'Acqua. 2021. The influence of environmental conditions on secondary metabolites in medicinal plants: A literature review. Chemistry & Biodiversity. 18(11): e2100345.

Porra, R. J., W. A. Thompson and P. E. Kriedemann. 1989. Determination of accurate extinction coefficients and simultaneous equations for assaying chlorophylls a and b extracted with four different solvents: verification of the concentration of chlorophyll standards by atomic absorption spectroscopy. Biochimica et Biophysica Acta (BBA)-Bioenergetics. 975(3): 384-394.

Poudel, M. R., S. Ghimire, M. P. Pandey, K. H. Dhakal and D. B. Thapa. 2020. Evaluation of wheat genotypes under irrigated, heat stress and drought conditions. *J.* of Biology and Today’s World. 9: 212.

Pouratashi, M. and H. Iravani. 2012. Farmers’ knowledge of integrated pest management and learning style preferences: Implications for information delivery. International *J.* of Pest Management. 58(4): 347-353.

Rathore, S. S., D. R. Chaudhary, G. N. Boricha, A. Ghosh, B. P. Bhatt, S. T. Zodape and J. S. Patolia. 2009. Effect of seaweed extract on the growth, yield and nutrient uptake of soybean (Glycine max) under rainfed conditions. South African *J.* of Botany. 75(2): 351-355.

Roussos, P. A., N. Denaxa and T. Damvakaris. 2009. Strawberry fruit quality attributes after application of plant growth stimulating compounds. Scientia Horticulturae. 119(2): 138-146.

Santaniello, A., A. Scartazza, F. Gresta, E. Loreti, A. Biasone, D. Di Tommaso and P. Perata. 2017. Ascophyllum nodosum seaweed extract alleviates drought stress in Arabidopsis by affecting photosynthetic performance and related gene expression. Frontiers in plant *Sci.* 8: 1362.

Schrader, J., P. Shi, D. L. Royer, D. J. Peppe, R. V. Gallagher, Y. Li and I. J. Wright. 2021. Leaf size estimation based on leaf length, width and shape. Annals of Botany. 128(4): 395-406.

Shaukat, M., A. Abbasi, K. Ramzan, A. Hina, S. Q. Memon, Z. Maqsood and S. F. Lamlom. 2024. Ameliorating heat stressed conditions in wheat by altering its physiological and phenotypic traits associated with varying nitrogen levels. Notulae Botanicae Horti Agrobotanici Cluj-Napoca. 52(1): 13471-13471.

Sherif, F.K. 1996. Phytoavailability of zinc and copper by soybean and wheat growing in sand culture and sewage sludge amended soil in relation to growth and metal mobility in sandy soil. Ph.D thesis. Faculty of Agriculture, Alexandria University, Egypt.

Sherif, F. K., H. A. Argeaa and A. S. Mostafa. 2024. Green synthesized nanocellulose enhanced germination, morphology roots, nutrients influx of wheat seedlings under salinity stress. Alex. *Sci.* Exch. 45(2):251-261.

Sherif, F. K., H. A. Argeaa and A. S. Mostafa. 2025. Does Seaweed Extract as a Biostimulant Ameliorate Tomato Plant’s Salt Stress Tolerance?. Alexandria *Sci.* Exchange *J.* 46(1): 43-56.

Shiferaw, B., M. Smale, H. J. Braun, E. Duveiller, M. Reynolds and G. Muricho. 2013. Crops that feed the world 10. Past successes and future challenges to the role played by wheat in global food security. Food security. 5: 291-317.

Shrivastava, P. and R. Kumar. 2015. Soil salinity: a serious environmental issue and plant growth promoting bacteria as one of the tools for its alleviation. Saudi *J.* Biol *Sci.* 22: 123–131.

Silva, M. D. A., J. L. Jifon, J. A. Da Silva and V. Sharma. 2007. Use of physiological parameters as fast tools to screen for drought tolerance in sugarcane. Brazilian *J.* of Plant Physiology. 19: 193-201.

Sivasankari, S., V. Venkatesalu, M. Anantharaj and M. Chandrasekaran. 2006. Effect of seaweed extracts on the growth and biochemical constituents of Vigna sinensis. Bioresource technology. 97(14): 1745-1751.

Solangi, A. H., N. U. S. R. A. T. Solongi, W. A. Jatoi, M. K. Solangi, S. K. Solangi, S. H. A. H. N. A. Z. Memom and S. H. A. K. E. E. L. Soomro. 2021. Drought tolerance indices of wheat (Triticum aestivum L.) genotypes under water deficit conditions. Plant Cell Biotechnol Mol Biol. 22(29–30): 1-19.

Spann, T. M. and H. A. Little. 2011. Applications of a commercial extract of the brown seaweed Ascophyllum nodosum increases drought tolerance in container-grown 'Hamlin'SEet orange nursery trees. Hort*Sci.* 46(4): 577-582.

Spinelli, F., G. Fiori, M. Noferini, M. Sprocatti and G. Costa. 2010. A novel type of seaweed extract as a natural alternative to the use of iron chelates in strawberry production. Scientia horticulturae. 125(3): 263-269.

Tandon, H. L. S. 1998. Method of Analysis of Soil. Plant. Waters and Fertilizer. New Delhi: Development and Consultation Organization. 144.

Tennant, D. 1975. A test of a modified line intersect method of estimating root length. *J.* Ecol. 63: 995-1001.

Wang, M., L. Chen, Y. Li, L. Chen, Z. Liu, X. Wang and S. Qin. 2018. Responses of soil microbial communities to a short-term application of seaweed fertilizer revealed by deep amplicon sequencing. Applied Soil Ecology. 125: 288-296.

Wang, Y., J. Li, L. Yang and Z. Chan. 2023. Melatonin antagonizes cytokinin responses to stimulate root growth in Arabidopsis. *J.* of Plant Growth Regulation. 42(3): 1833-1845.

Yoruklu, H. C., B. Ozkaya and A. Demir. 2022. Optimization of liquid fertilizer production from waste seaweed: A design of experiment based statistical approach. Chemosphere. 286: 131882.

Yang, Y. and Y. Guo. 2018. Elucidating the molecular mechanisms mediating plant salt-stress responses. New Phytol. 217: 523-539.

Zhang, L., W. Liao, Y. Huang, Y. Wen, Y. Chu and C. Zhao. 2022. Global seaweed farming and processing in the past 20 years. Food Production, Processing and Nutrition. 4(1): 23.

Ziaei, M. and A. Pazoki. 2022. Foliar-applied seaweed extract improves yield of common bean (Phaseolus vulgaris L.) cultivars through changes in biochemical and fatty acid profile under irrigation regimes. *J.* of Soil *Sci.* and Plant Nutrition. 22(3): 2969-2979.

الملخص العربي

مستخلص الأعشاب البحرية كمحفز حيوي لتحسين نمو القمح في ظل الإجهاد المائي

فاطمة كمال شريف، هدى أحمد أرجيعة، علي سعيد مصطفى

يُعد مستخلص الأعشاب البحرية استراتيجية فعالة للحد من إجهاد الجفاف وزيادة إنتاجية المحاصيل. يُعد القمح المحصول الأكثر زراعةً واستهلاكًا في العالم. تهدف هذه الدراسة إلى تحديد كيفية تخفيف مستخلص الأعشاب البحرية لآثار الإجهاد المائي على نبات القمح. كانت تركيزات مستخلص الأعشاب البحرية المستخدمة ٠ و٠,٢ و٠,٥ و ١ جم من مستخلص الأعشاب البحرية/٥٠٠ جم من التربة. تم تطبيق السعة الحقلية على ثلاثة مستويات مختلفة (٥٠ و٧٥ و١٠٠%) لدراسة تأثير الإجهاد المائي. أظهرت النتائج أنه عند التعرض للإجهاد المائي، انخفضت المعايير المورفولوجية، كما انخفض المحتوى الرطوبي النسبي وامتصاص البوتاسيوم والفوسفور ومحتوى الكلوروفيل، بينما زادت كمية السكريات الذائية والبرولين وزاد نشاط إنزيم البيروكسيديز. من ناحية أخرى، تحسّنت المعايير المورفولوجية، والكلوروفيل، والمحتوى الرطوبي النسبي، والسكريات الذائبة، وامتصاص البوتاسيوم والفوسفور، ومحتوى الكلوروفيل، ونشاط إنزيم البيزوكسيديز عند تطبيق مستخلص الأعشاب البحرية، خاصةً عند تركيز ٠,٥ جم من مستخلص الأعشاب البحرية / ٥٠٠ جم تربة. ووفقًا للدراسة الحالية، يمكن تخفيف إجهاد الجفاف باستخدام مستخلص الأعشاب البحرية بتركيز ٠,٥ جم/ ٥٠٠ جم تربة.

الكلمات المفتاحية: نبات القمح، إجهاد الجفاف، مستخلص الأعشاب البحرية، الطحالب البحرية، بيروكسيديز، السكريات الذائبة.