African J. Biol. Sci., 20 (2): 247-261(2024)
ISSN 1687-4870 **e- ISSN 2314-5501 (online)**
www.ajbs.journals.ekb.eg **E-mail:**aasdjournal@yahoo.com

Impact of foliar application of humic acid and seaweed on growth and quality of wheat

Ibrahim F.M. Ahmed
Faculty of Agriculture, Bani Walid - University of Bani Walid

Received: October 22, 2024; Accepted: November 25, 2024; Online: November 25, 2024

ABSTRACT

A field experiment was conducted in Sof Al-Jin Farm in Bani Walid, Libya, during the agricultural winter season 2023/2024 to study the effect of humic acid and seaweed *Ulva* SLE at different concentrations on vegetative growth, yield and yield components and chemical compositions of wheat cv. "Kufra". The experiment was applied according to Randomized complete Block Design (RCBD) with 12 treatments was applied and each treatment contented of three replicates. The treatments were humic acid at four concentrations (2, 4, 6, 8 g/l), seaweed application at four concentrations (3, 6, 9, 12 g/ l), HA 6g/l + SLE 9g/l, HA 8g/l + SLE 12 g/l and control treatment. Results showed that, increasing foliar application of humic acid and seaweed concentrations significantly increased all vegetative growth were studied, which mixed of HA 8g/l + SLE 12 g/l recorded the higher plant height, shoot fresh weight, leaf area, total chlorophyll, number of tillers/ plant, followed by mixed of HA 6g/l + SLE 9 g/l, *Ulva* SLE at 12g/l and HA at 8g/l, also recorded the yield and yield components i.e. spike length, number of grain/ spike, 1000-grain weight, grain yield, biological yield, harvest index and chemical composition traits i.e. nitrogen, phosphorus, potassium, total carbohydrates, protein percentages, respectively, as compared with control treatment which recorded the lower all vegetative growth, yield and yield components and chemical composition of wheat. In conclusion, the majority of wheat growth parameters, yield and yield components and chemical composition were all raised by foliar application of humic acid and seaweed extract (*Ulva SLE*) of spring wheat.

Keywords**:** Wheat (*Triticum aestivum* L.), humic acid, seaweed, vegetative growth, yield and yield components, chemical compositions.

INTRODUCTION

One of the most important and traditional cereal crops in the world is wheat (*Triticum aestivum* L.), a member of the Poaceae family. Thirty-three percent of the cereal planted area is used for wheat production (Al-Hamd and Al-Jarbou, 2021). Cereal crops are the primary staple food in the world, accounting for almost half of all human daily staple foods (El-Hashash *et al.,* 2022, Salihi, 2024). Wheat is one of the most important crops, providing 20% of the world's calories (Awad *et al.,* 2022). Wheat also provides the world's population with essential amino acids, vitamins, minerals, beneficial phytochemicals, and dietary fibers. Humans consume the majority of wheat, which is farmed in more than 100 nations worldwide (Shewry, 2009). According to Sharma *et al.* (2015), the world needs about 840 million tonnes of wheat by 2050, compared to the current production level of 642 million tonnes. This needs to be accomplished with less land and resources by means of agronomic, physiological, and genetic interventions, especially resource conservation technologies. The most popular staple food crop in the world is wheat (Ramadas *et al.,* 2020). Water stress, however, lowers its output by 20–30% per year (Daryanto *et al.,* 2016). The most frequent abiotic stressor endangering agricultural sustainability is water scarcity (Alam *et al.,* 2022; Talaat, 2023). More than half of the world's areas are predicted to experience water scarcity by 2050 (Gupta *et al.,* 2020). It can interfere with photosynthetic activities, change the metabolism of carbon and nitrogen, and disturb water relations. A vital crop, wheat accounts for 20% of the caloric intake of many people globally. An important component of soil, soil organic matter has a direct impact on the texture and fertility of the soil. The physical, chemical, and microbiological modification of biomolecules produces humic compounds, which are essential components of soil humus. The use of humic acid to improve soil fertility, crop development, and yield has become commonplace. The best kind and application technique for growing wheat are still unknown, despite the fact that the effects of humic acid on wheat have been thoroughly investigated (Salihi *et al.,* 2024). The quality of the land, air, and water can all deteriorate due to environmental contamination. When agricultural and food processing plant waste is disposed of improperly, it can lead to major environmental contamination and health issues (Khedr *et al.,* 2019). Additionally, it increases the production of reactive oxygen species (ROS), which damages cellular membranes and biomolecules, resulting in oxidative damage (Kaur *et al.,* 2021; Talaat *et al.,* 2022). Furthermore, plants produce a range of osmoprotectants in response to drought stress, such as proline, glycine-betaine, free amino acids, and soluble sugars, which help osmotic adjustment, maintain cellular integrity, control redox potential, and maintain cell turgor pressure (Wang *et al.,* 2019; Zhang *et al.,* 2020). It is more difficult to provide water and nutrients in dry and semiarid regions while adhering to sustainable agriculture principles (Talaat and Shawky, 2017). One of the most important components of soil is organic matter, which has a direct impact on soil fertility and texture. The physical, chemical, and microbiological transformation of biomolecules results in humic substances, which are a component of humus in soil organic matter (Mindari *et al.,* 2019). A vital component of soil, humic acids can influence other significant chemical, biological, and physical characteristics of soils as well as increase nutrient availability. A common technique for enhancing soil fertility, crop growth, and yield is the incorporation of humic acid fertilizer (Zheng *et al.,* 2022).

A naturally occurring macromolecular organic compound that is extensively found in soil, sediment, and water bodies, humic acid (HA) makes up 60–70% of soil organic matter. A variety of reactive functional groups, including carboxyl, phenolic hydroxyl, quinone carbonyl, and nitrogen-containing groups, are abundant in its highly complex and heterogeneous molecular structure, which also includes aromatic nuclei and aliphatic side chains (Lal, 2016). Furthermore, HA has been shown to enhance soil moisture retention in regions with high precipitation, possibly as a result of its effects on the soil's structure and water-holding ability. Better moisture retention can increase nutrient availability and encourage root development, which will help plants absorb nutrients more effectively. Additionally, HA can improve soil porosity and water infiltration rates by up to 20% by increasing soil aggregate stability (Olk *et al.,* 2018). Increased plant metabolic activity may also be the cause of HA's improved efficacy in warmer climates. Accordingly, higher temperatures typically encourage quicker rates for physiological and biochemical reactions in plants (Olaetxea *et al.,* 2017).

By boosting wheat biomass and grain yield, adding these minerals to wheat crops through seaweed extract encourages healthier plant growth (Wedad *et al.,* 2015). Seaweed extract contains natural plant growth regulators such as auxins, cytokinins, and gibberellins. It is crucial that these compounds be able to shield wheat plants from environmental stresses like drought, salt, and high temperatures.

By facilitating more efficient nutrient and water uptake, seaweed extract may help wheat plant roots grow (Castlehouse *et al.,* 2003). Because of their many applications, seaweed liquid extracts are particularly useful for increasing yield, boosting disease and stress resistance, and extending the post-harvest shelf life of a variety of agricultural crops (Shukla *et al.,* 2019; Hurtado *et al.,* 2021).

The bioactive substances found in seaweeds, including carotenoids, phenolics, micro- and macronutrients, and plant growth regulators, are frequently connected to these kinds of activities (Benítez García *et al.,* 2020). Additionally, Ali *et al.* (2021) claimed that because algal extracts can boost plant growth and defense responses even in small amounts, they are frequently referred to as biostimulants rather than fertilizers. Wheat development can be enhanced by seaweed extract, which is derived from various marine algae. Seaweed extract has several uses for wheat crops, including as a biostimulant and fertilizer. A variety of micronutrients, including numerous trace elements that can be an excellent source of vital nutrients for plant growth, are also present in seaweed extract (Panda *et al.,* 2022).

A variety of bioactive substances, including proteins, lipids, carbohydrates, amino acids, phytohormones, and antimicrobials, are found in seaweeds, a naturally occurring marine resource. Seaweeds have been utilized for centuries in a variety of industries, such as food, medicine, and cosmetics. Seaweeds are currently a viable substitute to lessen the use of dangerous chemicals in farming. Products made from seaweed have been used to boost immunity, promote plant growth, and lessen biotic and abiotic stressors (Kumar *et al.,* 2024). Seaweeds can lessen the negative effects of salinity stress because they are an inexpensive, environmentally friendly, and abundant source of plant growth stimulators (Derafshi *et al.,* 2024).

Many physical and chemical characteristics, including pH, time, temperature, pressure, particle size, solvent, sample-to-solvent ratio, and agitation speed, can influence the chemical structure of seaweed extracts made using conventional techniques. In addition, recent years have seen the study and application of novel seaweed extraction methods like pressured liquid extraction and microwave-assisted extraction (Dobriṅci´c *et al.,* 2020). Seaweed preparation, pretreatment, extraction (conventional or advanced), and purification are the steps involved in the complex and time-consuming process of extracting seaweed polysaccharides (Colusse *et al.,* 2022). Biological activity tests that assess the potential industrial use of seaweed polysaccharides usually come after these (Dobriṅci´c *et al.,* 2020). According to Zhang *et al.* (2023) polysaccharide extraction is typically carried out with hot aqueous or acidic solutions at high temperatures for a few hours.

One possible explanation for its improved growth and direct regeneration of *E. denticulatum* in Ulva SLE could be its presence. In addition to nitrogen, the Ulva SLE also contained compounds such as crude protein, sodium chloride, and potassium oxide, as well as trace elements such as calcium, sodium, iron, copper, manganese, and zinc. Numerous studies that demonstrated the presence of mineral nutrients in extracts from different Ulva species were in agreement with these observations (Castellanos-Barriga *et al.,* 2017; Latique *et al.,* 2021). However, due to variations in algal biomass (including spatiotemporal variations) and extraction techniques for these seaweed-derived biostimulants, it is challenging to compare the proximate and nutrient composition results of earlier studies to the current study. The seaweeds may naturally contain the various bioactive compounds found in seaweed extracts, or they may be new products of the hydrolytic processes that took place during extraction (Vaghela *et al.,* 2023). Sea lettuce, or Ulva, is a genus of green macroalgae that has long been known for its nutritional value in food and feed. Alternative, plant-based protein sources are becoming more and more popular as the need for sustainable food and feed sources increases. *Ulva spp.* have become promising candidates due to their high protein content and abundance along coastal waters. Although there are difficulties with using Ulva in food and feed, Ulva is increasingly being used in other industries, such as biomaterials, biostimulants, and biorefineries (Hofmann *et al.*, 2024).

Therefore, the main objective of this research was to Impact of foliar application of humic acid and seaweed on growth and quality of wheat cv."Sids 12".

MATERIALS AND METHODS

This study was carried out in Sof Al-Jin Farm in Bani Walid, Libya, during the agricultural winter sea during the agricultural winter season 2023/ 2024.

- **Experimental design**

The experiment was applied according to Randomized complete Block Design (RCBD) with 12 treatments. Each treatment was repeated three times.

The treatments of this experiment could be summarized as follows:

1. Control
2. Humic acid (HA) at 2g/l
3. Humic acid (HA) at 4g/l
4. Humic acid (HA) at 6g/l
5. Humic acid (HA) at 8g/l
6. *Ulva* SLE at 3g/l
7. *Ulva* SLE at 6g/l
8. *Ulva* SLE at 6g/l
9. *Ulva* SLE at 9g/l
10. *Ulva* SLE at 12g/l
11. HA 6g/l + SLE 9g/l
12. HA 8g/l + SLE 12 g/l

Data recorded

A) Vegetative growth:

- Plant height (cm)
- Shoot fresh weight (g)
- Leaf area (cm^2): Leaf area estimation was determined at harvest using the leaf disk method (Hafez *et al.,* 2018). Ten leaf disks were taken per plant with the aid of a cylindrical soil core (19.625 cm^2). After determining the fresh and dry weight of the ten leaf disks, the following equation was used to determine the total leaf area per plant: $Leaf\ area$ = weight of total leaves (g/plant) × 10 n / Weight of 10 leaf disks (g/plant) Where n = area of one disk
- Total chlorophyll (SPAD)
- No. of tillers/plant

B) Yield and yield components

- Spike length (cm)
- No. of grains/ spike
- 1000-grains weight (g)
- Grain yield (t/ha)
- Biological yield (t/ha)
- Harvest index (%)

C) Chemical composition

- Nitrogen (N %): Total nitrogen was determined by the Kjeldahl method (Jackson, 1973).
- Phosphorus: It was determined by using molybdovanadate-yellow colorimetry, nitrate-perchloric acid digests of the ground blades (Kitson and Mellon, 1944).
- Potassium: It was determined using the flame photometric method (Chapman and Pratt, 1982).
- Total carbohydrates (%)
- Protein (%)

Statistical analysis:

Results of the measured parameters were subjected to computerized statistical analysis using MSTAT package for analysis of variance (ANOVA) and means of treatments were compared using LSD at 0.05 according to Snedecor and Cochran (1990).

RESULTS AND DISCUSSION

A) Vegetative growth:

Results presented in Table (1) and Figure (1) revealed the effect of humic acid at concentrations (2, 4, 6 & 8 g/l) and seaweed application at concentrations (3, 6, 9 & 12 g/ l) on plant height, shoot fresh weight, leaf area, total chlorophyll, number of tillers/plant of wheat cv."Kufra". Results showed that, increasing foliar application of humic acid and seaweed concentrations significantly increased all vegetative growth and the mixture of HA 8g/l + SLE 12 g/l recorded the highest plant height (108.06 cm), shoot fresh weight (70.25g), leaf area (49.55 cm^2), total chlorophyll (57.33 SPAD), number of tillers/ plant (9.66), followed by mixture of HA 6g/l + SLE 9 g/l, plant height (106.70 cm), shoot fresh weight (65.70g), leaf area (47.00cm^2), total chlorophyll (55.63 SPAD), number of tillers/ plant (8.50), *Ulva* SLE at 12g/l, plant height (103.85 cm), shoot fresh weight (59.55g), leaf area (46.25 cm^2), total chlorophyll (52.25SPAD), number of tillers/ plant (7.49) and HA at 8g/l, plant height (98.47cm), shoot fresh weight (56.57g), leaf area (44.97cm^2), total chlorophyll (49.64 SPAD), number of tillers/ plant (7.12), as compared with control treatment which recorded the lower plant height (78.00 cm), shoot fresh weight (39.03 g), leaf area (31.90 cm^2), total chlorophyll (38.56 SPAD), number of tillers/ plant (3.33).

Increased microbial activity may hasten the breakdown and incorporation of HA into soil organic matter under warmer, wetter conditions (Piccolo *et al.,* 2004). Auxin-like compounds and low-molecular-weight organic acids, which have been demonstrated to promote plant growth and nutrient uptake, may be released from HA more easily as a result of this improved microbial processing (Nardi *et al.,* 2002). Certain bioactive molecules in HA, such as polyamines and phenolic compounds, have been found in recent research to have a direct impact on plant physiological functions and nutrient acquisition mechanisms (Canellas *et al.,* 2015). Through its effects on the structure and water-holding capacity of soil, HA has also been shown to improve soil moisture retention in high-precipitation areas (Young *et al.,* 1998). By encouraging root development and increasing nutrient availability, this enhanced moisture retention can help plants absorb nutrients more effectively. Additionally, according to Olk *et al.* (2018), HA can improve soil porosity and water infiltration rates by up to 20% by increasing soil aggregate stability. The increased nutrient availability and growth-promoting effects linked to HA applications may be better utilized by plants as a result of this elevated metabolic state. Further explaining the enhanced NUE seen in these conditions, recent metabolomics research has also shown that an HA application in warmer temperatures significantly up-regulates the essential enzymes involved in carbon and nitrogen metabolism, such as glutamine synthetase and nitrate reductase (Atkin and Tjoelker, 2003). The phytohormones found in the algae extract, particularly auxins that oversee root initiation and branching may stimulate the growth of the spring wheat root system (Kurepin *et al.,* 2014). The stimulating effect of growth-promoting substances like IUA, IMA, gibberellins, cytokinins, vitamins, amino acids, and trace elements may be the cause of this. According to the findings of Shah *et al.* (2012), Biswajit *et al.* (2013), and Devi and Mani (2015), this increase might be brought on by the extract's inclusion of plant growth regulators like cytokinin, gibberellin, trace elements, and vitamins. Foliar feeding of seaweed juice thus induced physiological responses that enhanced nutrient partitioning and mobilization, increased leaf area, dry matter production, and crop growth rate.

Table (1): Effect of foliar application of humic acid and *Ulva* SLE at different concentrations on vegetative growth of wheat cv. "Kufra" during 2023/ 2024 season.

Treatments	Plant height (cm)	Shoot fresh weight (g)	Leaf area (cm^2)	Total chlorophyll (SPAD)	No. of tillers/ plant
Control	78.00	39.03	31.90	38.56	3.33
HA at 2g/l	85.67	43.56	34.44	42.11	3.49
HA at 4g/l	91.67	46.15	37.92	45.08	4.11
HA at 6g/l	96.33	50.59	42.58	48.14	5.38
HA at 8g/l	98.47	56.57	44.97	49.64	7.12
Ulva SLE at 3g/l	94.63	45.85	36.25	44.33	3.67
Ulva SLE at 6g/l	97.53	48.58	39.92	47.45	4.33
Ulva SLE at 9g/l	101.33	53.25	43.77	50.67	5.66
Ulva SLE at 12g/l	103.85	59.55	46.25	52.25	7.49
HA 6g/l + SLE 9g/l	106.70	65.70	47.00	55.63	8.50
HA 8g/l + SLE 12 g/l	108.06	70.25	49.55	57.33	9.66
$LSD_{(0.05)}$	**9.43**	**23.36**	**10.10**	**5.41**	**1.83**

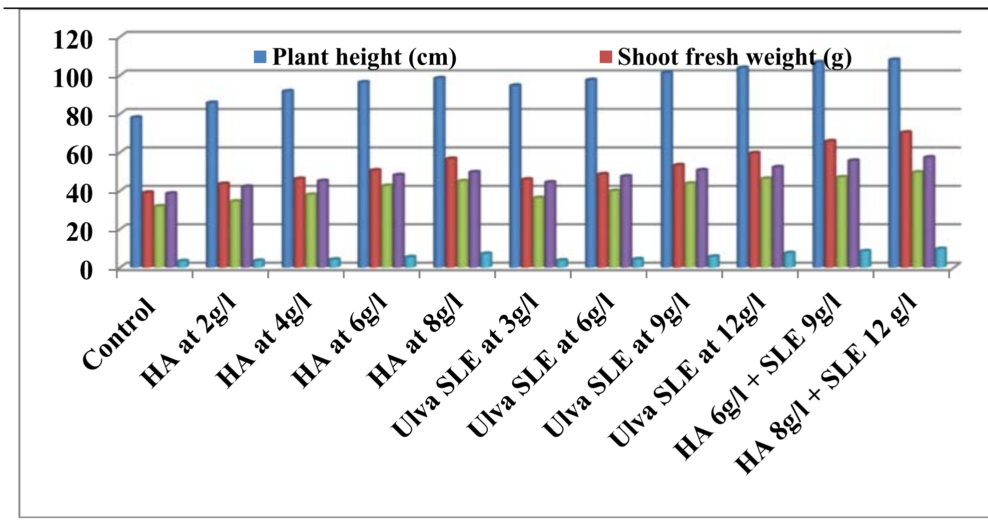

Fig. (1): Effect of foliar application of humic acid and *Ulva* SLE at different concentrations on vegetative growth of wheat cv. "Kufra " during 2023/ 2024 season.

B) Yield and yield Components:

Results in Table (2) and Figure (2) reported the effect of humic acid at concentrations (2, 4, 6 & 8 g/l) and seaweed application at concentrations (3, 6, 9 & 12 g/ l) on spike length, number of grain/ spike, 1000-grain weight, grain yield, biological yield, harvest index of wheat cv."Kufra". Results revealed that, increasing foliar application of humic acid and seaweed concentrations significantly increased all yield and yield components were studied, which mixed of HA 8g/l + SLE 12 g/l recorded the higher spike length (18.55 cm), number of grain/ spike (46.66), 1000-grain weight (45.52 g), grain yield (7.20 t/ha), biological yield (18.51t/ha), harvest index (38.90 %), followed by mixed of HA 6g/l + SLE 9 g/l, spike length (18.10 cm), number of grain/ spike (45.60), 1000-grain weight (43.20g), grain yield (6.87 t/ha), biological yield (17.88 t/ha), harvest index (38.42 %), *Ulva* SLE at 12g/l, spike length (17.54 cm), number of grain/ spike (45.10), 1000-grain weight (39.35 g), grain yield (6.61 t/ha), biological yield (17.37 t/ha), harvest index (38.05 %), and HA at 8g/l, spike length (16.66 cm), number of grain/ spike (44.15), 1000-grain weight (37.38 g), grain yield (6.28 t/ha), biological yield (16.50 t/ha), harvest index (38.06 %), as compared with control treatment which significantly decreased spike length (13.70 cm), number of grain/ spike (39.98), 1000-grain weight (30.02 g), grain yield (4.65 t/ha), biological yield (13.32 t/ha), harvest index (34.91 %)..

By improving the soil's structure, raising its capacity to exchange cations, and encouraging root growth, HA improves the uptake of mineral fertilizers (Rose *et al.,* 2014). Notably, HA can raise phosphorus availability and decrease nitrogen leaching, which could result in a 20–30% reduction in the use of chemical fertilizers (Olk *et al.,* 2018). However, soil characteristics have a major impact on how well HA fertilizers work on crop yield and NUE. The analysis's findings show that soils with moderate pH levels typically between 6.0 and 8.0 benefit greatly from HA applications. Micronutrients can be chelated by HA, increasing their solubility and bioavailability. According to Kahled and Fawy (2011), humic acid is a soil conditioner that is used in conjunction with fertilizer as a complementary measure, even though it is not technically a fertilizer.

Because it increases nutrient availability, humic acid promotes plant growth and has a beneficial effect on the characteristics of the soil. Tahir *et al.* (2011) reported similar results. Furthermore, because humic acid improves root development and soil nutrient absorption, it also influences plant growth and yield by promoting faster plant growth and higher yield. According to Nooroozisharaf and Kaviany (2018), humic acid had a positive impact on plant yield and growth. According to Carvalho *et al.* (2014), the application of an algae extracts increased wheat yields, but only when the preparation was used as soil irrigation; seed treatment was unaffected. Following the use of seaweed in Muhammad *et al.* (2013) is experiment

The number of branches and tiller length were both positively impacted by soaking seeds in an algae extract, according to a study by Kumar and Sahoo (2011). The number of grains per spike and the thousand grain weight are the yield structure elements in the current study that react to the algae extract. The study by Kumar and Sahoo (2011) also reports the impact of the algae-derived biostimulant on the dry weight of grain and the number of grains per spike.

Additionally, humic acids and algae extract applied together had a positive impact on the thousand seed weight (Muhammad *et al.,* 2013). In turn, Beckett and Van Staden (1989) reported that the foliar application of the seaweed preparation increased the average grain mass and the number of grains in the spike under conditions of potassium deficiency.

Table (2): Effect of foliar application of humic acid and *Ulva* SLE at different concentrations on yield and yield components of wheat cv. "Kufra" during 2023/ 2024 season.

Treatments	Spike length (cm)	No. of grain spike^{-1}	1000-grain Weight (g)	Grain yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
Control	13.70	39.98	30.02	4.65	13.32	34.91
HA at 2g/l	14.11	40.89	33.57	5.57	14.93	37.31
HA at 4g/l	15.10	41.69	34.25	5.89	15.62	37.71
HA at 6g/l	15.93	42.94	35.99	6.03	15.97	37.76
HA at 8g/l	16.66	44.15	37.38	6.28	16.50	38.06
Ulva SLE at 3g/l	14.85	43.39	35.34	5.86	15.72	37.28
Ulva SLE at 6g/l	15.89	44.17	36.86	6.20	16.44	37.71
Ulva SLE at 9g/l	16.77	44.73	37.88	6.35	16.81	37.78
Ulva SLE at 12g/l	17.54	45.10	39.35	6.61	17.37	38.05
HA 6g/l + SLE 9g/l	18.10	45.60	43.20	6.87	17.88	38.42
HA 8g/l + SLE 12 g/l	18.55	46.66	45.52	7.20	18.51	38.90
$LSD_{(0.05)}$	**0.17**	**0.13**	**1.36**	**0.06**	**0.09**	**0.24**

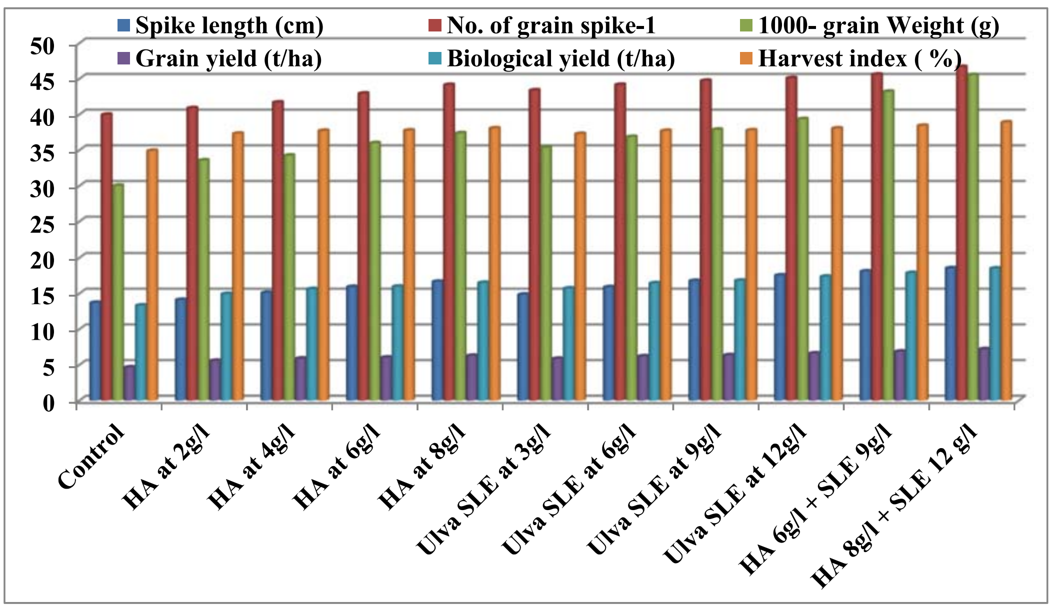

Fig. (2): Effect of foliar application of humic acid and *Ulva* SLE at different concentrations on yield and yield components of wheat cv." Kufra " during 2023/ 2024 season.

C) Chemical fruit characteristics:

Results in Table (3) and Figure (3) reported that, effect of humic acid at concentrations (2, 4, 6, 8 g/l) and seaweed application at concentrations (3, 6, 9, 12 g/ l) on nitrogen, phosphorus, potassium, total carbohydrates, protein percentages of wheat cv."Kufra". Results revealed that, increasing foliar application of humic acid and seaweed concentrations significantly increased all chemical composition were studied, which mixed of HA 8g/l + SLE 12 g/l recorded the higher nitrogen (2.80%), phosphorus (0.780%), potassium (3.14%), total carbohydrates (65.34%), protein (17.50 %), followed by mixed of HA 6g/l + SLE 9 g/l, nitrogen (2.45%), phosphorus (0.766%), potassium (2.74%), total carbohydrates (64.38%), protein (15.31 %), *Ulva* SLE at 12g/l, nitrogen (2.23%), phosphorus (0.720%), potassium (2.50%), total carbohydrates (63.77%), protein (13.94 %) and HA at 8g/l, nitrogen (2.12%), phosphorus (0.684%), potassium (2.37%), total carbohydrates (63.16%), protein (13.25 %), as compared with control treatment which significantly decreased nitrogen (1.40%), phosphorus (0.435%), potassium (1.57%), total carbohydrates (51.33%), protein (8.75 %).

The concentration of macro-elements in wheat grain may benefit from the use of algae preparations as well (Matysiak *et al.,* 2012). This might happen as a result of developing a greater root weight, which would facilitate the uptake of nutrients from the soil (Foulkes *et al.,* 2009). The application of algae preparations increased the expression of genes involved in nutrient uptake, according to a study by Jannin *et al.* (2012). Following Becket and Van Staden (1990), Shah *et al.* (2013) explain that an increase in the rate of photosynthesis or delayed senescence of the final two leaves is the cause of the increase in P and K concentration in wheat grain following the application of algae preparation.

Table (3): Effect of foliar application of humic acid and *Ulva* SLE at different concentrations on chemical composition of wheat cv."Kufra" during 2023/ 2024 season.

Treatments	N (%)	P (%)	K (%)	Carbohydrates (%)	Protein (%)
Control	1.40	0.435	1.57	51.33	8.75
HA at 2g/l	1.83	0.580	2.05	58.73	11.44
HA at 4g/l	1.88	0.627	2.11	59.37	11.75
HA at 6g/l	2.00	0.666	2.24	60.17	12.50
HA at 8g/l	2.12	0.684	2.37	63.16	13.25
Ulva SLE at 3g/l	1.93	0.610	2.16	61.53	12.06
Ulva SLE at 6g/l	1.98	0.660	2.22	61.89	12.38
Ulva SLE at 9g/l	2.11	0.701	2.36	62.32	13.19
Ulva SLE at 12g/l	2.23	0.720	2.50	63.77	13.94
HA 6g/l + SLE 9g/l	2.45	0.766	2.74	64.38	15.31
HA 8g/l + SLE 12 g/l	2.80	0.780	3.14	65.34	17.50
$LSD_{(0.05)}$	**0.14**	**0.04**	**0.16**	**1.01**	**0.09**

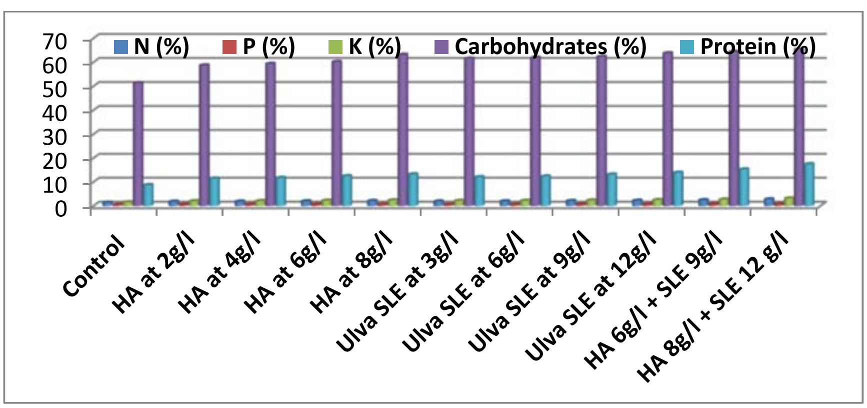

Fig. (3): Effect of foliar application of humic acid and *Ulva* SLE at different concentrations on chemical composition of wheat cv."Kufra" during 2023/ 2024 season.

Conclusion:

According to study observations, the soil properties, especially vegetative growth parameters like plant height, leaf area, spike length, 1000 grain weight, biological yield, and grain yield, could be significantly impacted by increasing the application of humic acid and seaweed extract (*Ulva SLE*). Applying humic acid to soil greatly improves its physico-chemical characteristics both before and after harvest. On the other hand, using humic acid and seaweed extract (*Ulva SLE*) may help to improve the soil's pH and EC levels. Therefore, to assess soil aggregate and aggregate stability, future research on humic acid might be carried out by applying humic acid and seaweed extract (*Ulva SLE*).

REFERENCES

Alam, M.U.; Fujita, M.; Nahar, K.; Rahman, A.; Anee, T.I.; Masud, A.A.C.; Amin, A.K. and Hasanuzzaman, M. (2022). Seed priming upregulates antioxidant defense and glyoxalase systems to conferring simulated drought tolerance in wheat seedlings. Plant Stress, 6: 100-120.

Al-Hamd, M. and Al-Jarbou, E. (2021). The effect of several levels of fermented sheep manure, nitrogen fertilization and their combination on growth and productivity of the wheat plant (*Triticum aestivum* L.) (variety: Sham.6). Syrian Soc. Agric. Res., 8 (3):220-235.

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

Ampong, K.; Thilakaranthna, M.S. and Gorim, L.Y. (2022). Understanding the role of humic acids on crop performance and soil health. Front. Agron., 4, 848621

Atkin, O.K. and Tjoelker, M.G. (2003). Thermal acclimation and the dynamic response of plant respiration to temperature. Trends Plant Sci., 8: 343–351

Awad, A.A.; El-Taib, A.B.; Sweed, A.A. and Omran, A.A. (2022). Nutrient contents and productivity of triticum aestivum plants grown in clay loam soil depending on humic substances and varieties and their interactions. Agron., 12(705).

Beckett, R.P. and Van Staden J. (1989). The effect of seaweed concentrates on the growth and yield of potassium stressed wheat. Plant and Soil, 116: 29-36.

Beckett, R.P. and Van Staden, J. (1990). The effect of seaweed concentrates on the yield of nutrient stressed wheat. Botanica Marina, 33: 147-152.

Benítez García, I.; Ledezma, D.A.K.; Montaño, M.E.; Leyva, S.J.A.; Carrera, E. and Osuna, R. I. (2020). Identification and quantification of plant growth regulators and antioxidant compounds in aqueous extracts of *Padina durvillaei* and *Ulva lactuca*. Agron., 10(6):866.

Biswajit, P.K.; Koushik, B.I. and Arup, G.H. (2013). Effect of seaweed saps on growth and yield improvement of green gram. Afri. J.Agric., 8(13):1180-1186

Canellas, L.P.; Olivares, F.L.; Aguiar, N.O.; Jones, D.L.; Nebbioso, A.; Mazzei, P. and Piccolo, A. (2015). Humic and fulvic acids as biostimulants in horticulture. Sci. Horti., 196: 15–27.

Carvalho, M.E.; Castro, P.R.; Gallo, L.A. and Ferraz, M.V. (2014). Seaweed extract provides development and production of wheat. Rev. Agrarian, 7(23): 166- 170.

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*). J. Appl. Phycol., 29(5): 2479–2488.

Castlehouse, H.; Smith, C.; Raab, A.; Deacon, C.; Meharg, A.A. and Feldmann, J. (2003). Biotransformation and accumulation of arsenic in soil amended with seaweed. Environ. Sci. Tech., 37: 951–957.

Chapman, H.D. and Pratt, P.F. (1982). Methods of Plant Analysis, In: 'Methods of Analysis for Soil, Plant and Water'. Chapman Publishers, Riverside, California, USA.

Colusse, G.A.; Carneiro, J.; Duarte, M.E.R.; Ranga Rao, A.; Ravishankar, G.A.; de Carvalho, J.C. and Noseda, M.D. (2022). Challenges and recent progress in seaweed polysaccharides for industrial purposes. In Sustainable Global Resources of Seaweeds Volume 2: Food, Pharmaceutical and Health Applications; Springer: Cham, Switzerland, 411–431.

Daryanto, S.; Wang, L. and Jacinthe P. A. (2016). Global synthesis of drought effects on maize and wheat production. PLoS ONE,11(5): e0156362.

Derafshi, M.; Hassani, A.; Amanifar, S.; Babaakbari, M.; Hematimatin, N.; Lajayer, A.B.; Astatkie, T. and Price, G.W. (2024). Optimization of *Sargassum bovianum* extraction techniques for germination of wheat, canola, and corn under different salinity stress. Agron., 14(2646): 1-18.

Devi, N.L. and Mani, S. (2015). Effect of seaweed saps *Kappaphycus alvarezii* and Gracilaria on growth, yield and quality of rice. Ind. J. Sci. Tech., 8(19):47610.

Dobrinˇci´c, A., Balbino, S., Zori´c, Z., Pedisi´c, S., Bursa´c Kovaˇcevi´c, D., Elez Garofuli´c, I. and Dragovi´c-Uzelac, V. (2020). Advanced technologies for the extraction of marine brown algal polysaccharides. Mar. Drugs, 18: 168.

El-Hashash, E. F., El-Enin, M. M. A., El-Mageed, T. A. A., Attia, M. A. E. H., El-Saadony, M. T., El-Tarabily, K. A. and Shaaban, A. (2022). Bread Wheat productivity in response to humic acid supply and supplementary irrigation mode in three northwestern coastal sites of Egypt. Agron., 12(7).

Foulkes, M.J., Hawkesford, M.J., Barraclough, P.B., Holdsworth, M.J., Kerri, S., Kightley, S. and Shewry, P.R. (2009). Identifying traits to improve the nitrogen economy of wheat: Recent advances and future prospects. Field Crops Res., 114: 329-342.

Gupta, A.; Rico-Medina, A. and Cano-Delgado, A.I. (2020). The physiology of plant responses to drought. Sci., 368: 266–269.

Hafez, Y.M.; El-Nagar, A.S.; Elzaawely, A.A.; Kamel, S. and Maswada, H.F. (2018). Biological control of *Podosphaera xanthii* the causal agent of squash powdery mildew disease by upregulation of defenserelated enzymes. Egyptian J. Biol. Pest Cont., 28: 57.

Hurtado, A.Q.; Neish, I.C.; Majahar, A.M.K.; Norrie, J.; Pereira, L.; Michalak, I.; Shukla, P.S. and Critchley, A.T. (2021). Extracts of seaweeds used as biostimulants on land and sea crops an efficacious, phyconomic, circular blue economy: with special reference to *Ascophyllum* (brown) and *Kappaphycus* (red) seaweeds. In: Gupta S, Van Staden, editors. Biostimulants for crops from seed germination to plant development.

Massachusetts: Acad. Press., 263–288.

Jackson, M.L. (1973). In: 'Soil Chemical Analysis'. Prentice Hall of India Pvt. Ltd., New Delhi.

Jannin, L.; Arkoun, M.; Etienne, P.; Laine, P.; Goux, D.; Garnica, M.; Fuentes, M.; San Francisco M.; Baigorri R.; Cruz F.; Houdusse F.; Gracia-Mina J.; Yvin, J. and Ourry, A. (2012). *Brassica napus* growth is promoted by *Ascophyllum nodosum* (L.) Le Jol. seaweed extract: Microarray analysis and physiological characterization of N, C, and S metabolisms. J. Plant Growth Reg., 32(1): 31-52.

Kaur, H.; Kohli, S.K.; Khanna, K. and Bhardwaj, R. (2021). Scrutinizing the impact of water deficit in plants: transcriptional regulation, signaling, photosynthetic efficacy, and management. Physiol. Plant, 172: 935–962.

Khaled, H. and Fawy, H. A. (2011). Effect of different levels of humic acids on the nutrient content, plant growth, and soil properties under conditions of salinity. Soil Water Res., 6(1): 21–29.

Khedr, M.E.; Nasseem, M.G.; Ali, W.H. and Rashad, M.A. (2019). Compost and vermicompost as soil amendments to immobilize Cu and Cd under wheat growth conditions. Alex. Sci. Exch. J., 40 (1): 705-716.

Kitson, R.E. and Mellon, M.G. (1944). Colorimetric determination of phosphorus as molybdovanado-phosphoric acid. Industrial Engineering Chemistry and Analytical Edition, 16: 379–383.

Kosem, H.; Kocak, M.Z.; Kaysim, M.G.; Celikcan, F. and Kulak, M. (2022). Liquid leachate produced from vermicompost effects on some agronomic attributes and secondary metabolites of sweet basil (*Ocimum basilicum* L.) exposed to severe water stress conditions. Horti., 8:1190.

Kumar, G. and Sahoo, D. (2011). Effect of seaweed liquid extract on growth and yield of Triticum aestivum var. Pusa Gold. J. Appli. Phyco., 23: 251- 255

Kumar, G.; Nanda, S.; Singh, S.K.; Kumar, S.; Singh, D.; Singh, B.N. and Mukherjee, A. (2024). Seaweed extracts: enhancing plant resilience to biotic and abiotic stresses. Front. Fronti. Marine Sci., 1-14

Kurepin, L.; Zaman, M. and Pharis, R.P. (2014). Phytohormonal basis for the plant growth promoting action of naturally occurring biostimulators. J. Sci. Food Agric., 94: 1715- 1722

Lal, R. (2016). Soil health and carbon management. Food Energy Secur., 5: 212–222.

Latique, S.; Ben Mrid, R.; Kabach, I.; Yasri, A.; Kchikich, A.; Nhiri, M.; El Kaoua, M.; Douira, A. and Selmaoui, K. (2021). The effect of foliar application of *Ulva rigida* extract on the growth and biochemical parameters of wheat plants. E3S Web Conf., 234: 00103.

Laurie, C.H.; Strauss, S.; Shpigel, M.; Guttman, L.; Stengel, D.B.; Rebours, C.; Gjorgovska, N.; Turan, G.; Balina, K.; Zammit, G. and Adams, J.M.M. (2024). The green seaweed *Ulva*: tomorrow's "wheat of the sea" in foods, feeds, nutrition, and biomaterials, Critical Rev. Food Sci. Nutri., 1-30.

Matysiak, K.; Kaczmarek, S. and Leszczyńska, D. (2012). Wpływ ekstraktu z alg morskich Ecklonia maxima napszenice ozimą odmiany Tonacja (Influence of liquid seaweed extract of Ecklonia maxima on winter wheat cv.

Tonacja). J. Res. Appli. Agric. Eng., 57(4): 44-47 (in Polish).

Mindari, W.; Sasongko, P.; Kusuma, E.; Syekhfani, Z. and Aini, N. (2019). Efficiency of various sources and doses of humic acid on physical and chemical properties of saline soil and growth and yield of rice. AIP Conf. Proceed.

Mohamed, F.; Manal, A.; Thalooth, T.; Tarek, A.E. and Amal, G.A. (2019). Yield and nutrient status of wheat plants (*Triticum aestivum* L.) as affected by sludge, compost, and biofertilizers under newly reclaimed soil. Bull. Nati. Res. Cent., 43: 31-36.

Muhammad, S.; Anjum, A.S.; Kasana, M.I. and Randhawa, M.A. (2013). Impact of organic fertilizer, humic acid and seaweed extract on wheat production in Pothowar region of Pakistan. Pak. J. Agric. Sci., 50(4): 677-681.

Nalina, M.; Saroja, S.; Chakravarthi, M.; Rajkumar, R. and Chandrashekara, K.N. (2021). Water deficit-induced oxidative stress and differential response in antioxidant enzymes of tolerant and susceptible tea cultivars under field condition. Acta Physi. Plant, 43:1-10.

Nardi, S.; Pizzeghello, D.; Muscolo, A. and Vianello, A. (2002). Physiological effects of humic substances on higher plants. Soil Biol. Biochem., 34: 1527–1536.

Noroozisharaf, A. and Kaviani, M. (2018). Effect of soil application of humic acid on nutrients uptake, essential oil, and chemical compositions of garden thyme (*Thymus vulgaris* L.) under greenhouse conditions. Physiol. Mol. Bio. Plants, 24(3): 423–431.

Olaetxea, M.; De Hita, D.; Garcia, C.A.; Fuentes, M.; Baigorri, R., Mora, V., Garnica, M.; Urrutia, O.; Erro, J. and Zamarreño, A.M. (2017). Hypothetical framework integrating the main mechanisms involved in the promoting action of rhizospheric humic substances on plant root-and shoot-growth. Appl. Soil Ecol., 123: 521–537.

Olk, D.C.; Dinnes, D.L.; Scoresby, J.R.; Callaway, C.R. and Darlington, J.W. (2018). Humic products in agriculture: Potential benefits and research challenges A review. J. Soils Sediments, 18: 2881–2891.

Panda, D.; Mondal, S. and Mishra, A. (2022). “Liquid biofertilizers from seaweeds: a critical review,” in Sustainable Global Resources of Seaweeds, 1, Eds. A. Ranga Rao, and G. A. Ravishankar (New York, NY: Springer), 485–501.

Piccolo, A.; Spaccini, R.; Nieder, R. and Richter, J. (2004). Sequestration of a biologically labile organic carbon in soils by humified organic matter. Clim. Chang., 67: 329–343.

Ramadas, S.; Kumar, T.K. and Singh, G.P. (2020). Wheat production in India: Trends and prospects. In: Recent Advances in Grain Crops Research. Intech Open. London, UK.

Rose, M.T.; Patti, A.F.; Little, K.R.; Brown, A.L.; Jackson, W.R. and Cavagnaro, T.R. (2014). A Meta-Analysis and review of plant-growth response to humic substances: practical implications for agriculture. Adv. Agron., 124: 37–89.

Salihi, M. S. (2024). Effects of Elevated CO_2 on rice seedling establishment of MR219 and Sri Malaysia1 Varieties. Pak. J. Bot., 56(3): 1–6.

Salihi, M.S.; Hamim, H. and Serat, S.M. (2024). Impacts of humic acid on growth and yield of wheat: A Review. J. Natural Sci. Rev., 2(3): 87-96.

Shah, M.T.; Zodape, S.T.; Chaudhary, D.R.; Eswaran, K. and Chikara, J. (2013). Seaweed SAP as an alternative liquid fertilizer for yield and quality improvement of wheat. J. Plant Nutri., 36(2), p. 192-200

Shah, M.T.; Zodape, S.T.; Chaudhary, D.R.; Eswaran, K. and Chikara, J. (2012). Seaweed sap as an alternative liquid fertilizer for yield and quality improvement of wheat. J. Plant Nut.;36(2):192-200.

Sharma, I.; Tyagi, B.; Singh, G. and Gupta, O. (2015). Enhancing wheat production- A global perspective. Indian J. Agric. Sci., 85(1): 3–13.

Shewry, P. R. (2009). Wheat. J. Exp. Bot., 60(6): 1537–1553.

Shukla, P.S.; Mantin, E.G.; Adil, M.; Bajpai, S.; Critchley, A.T. and Prithiviraj, B. (2019). *Ascophyllum nodosum*-based biostimulants: Sustainable applications in agriculture for the stimulation of plant growth, stress tolerance, and disease management. Front. Plant Sci., 10: 655

Tahir, M.M.; Khurshid, M.; Khan, M.Z.; Abbasi, M.K. and Kazmi, M.H. (2011). Lignitederived humic acid effect on growth of wheat plants in different soils. Pedosphere, 21(1):124–131.

Talaat, N.B. (2023). Drought stress alleviator melatonin reconfigures water-stressed barley (*Hordeum vulgare* L.) plants' photosynthetic efficiency, antioxidant capacity, and endogenous phytohormone profile. Int. J. Mol. Sci., 24:16228.

Talaat, N.B. and Shawky, B.T. (2017). Microbe-mediated induced abiotic stress tolerance responses in plants. In: Singh DP, Singh HB, Prabha R, editors. Plant-microbe interactions in agro-ecological perspectives, 2. Microbial interactions and agro-ecological impacts. Ltd: Springer Nature Singapore Pte., 101–33.

Talaat, N.B.; Ibrahim, A.S. and Shawky, B.T. (2022). Enhancement of the expression of *ZmBZR1* and *ZmBES1* regulatory genes and antioxidant defense genes triggers water stress mitigation in maize (*Zea mays* L.) plants treated with 24-epibrassinolide in combination with spermine. Agron., 12: 2517.

Vaghela, P.; Trivedi, K.; Anand, K.G.; Brahmbhatt, H.R.; Nayak, J.; Khandediya, K; Prasad, K.; Moradiya, K.; Kubavat, D.; Konwar, L.J.; Veeragurunathan, V.; Grace, P.G. and Ghosh, A. (2023). Scientific basis for the use of minimally processed homogenates of *Kappaphycus alvarezii* (red) and *Sargassum wightii* (brown) seaweeds as crop biostimulants. Alg. Res., 102969.

Wang, X.; Mao, Z.; Zhang, J.; Hemat, M.; Huang, M.; Cai, J.; Zhou, Q.; Dai, T. and Jiang, D. (2019). Osmolyte accumulation plays important roles in the drought priming induced tolerance to post-anthesis drought stress in winter wheat (*Triticum aestivum* L). Environ. Exp. Bot., 166: 103804.

Wedad, A.K.; Elsayed, A.M.H.; Nehal, G.S.E. and Salwa, K.E. (2015). Influence of seaweed extracts on the growth, some metabolic activities and yield of wheat grown under drought stress; IJAAR, 7: 173–189.

Young, C.C.; Chang, C.H.; Chen, L.F. and Chao, C.C. (1998). Characterization of the nitrogen fixation and ferric phosphate solubilizing bacteria isolated from a Taiwan soil. J. Chin. Chem. Soc. Taip., 36: 201–210.

Zhang, C.; Tang, L.; Su, X.; Li, Q.; Guo, H.; Liu, Z.; Wei, Z. and Wang, F. (2023). Research on the impact of deep eutectic solvent and hot-water extraction methods on the structure of *Polygonatum sibiricum* polysaccharides. Mole., 28: 6981.

Zhang, Y.B.; Yang, S.L.; Dao, J.M.; Deng, J.; Shahzad, A.N.; Fan, X.; Li, R.D.; Quan, Y.J.; Bukhari, S.A.H. and Zeng, Z.H. (2020). Drought-induced alterations in photosynthetic, ultrastructural and biochemical traits of contrasting sugarcane genotypes. PLoS ONE., 15: e0235845.

Zheng, E.; Qin, M.; Zhang, Z. and Xu, T. (2022). Humic acid fertilizer incorporation increases rice radiation use, growth, and yield: a case study on the Songnen Plain, China. Agric., 12(653): 1–13.

تأثير الرش بحمض الهيوميك والأعشاب البحرية على نمو وجودة القمح

إبراهيم فرج محمد أحمد
كلية الزراعة بني وليد - جامعة بني وليد

المستخلص

تم إجراء تجربة حقلية في مزرعة صوف الجين في بني وليد، ليبيا، خلال الموسم الزراعي الشتوي 2024/2023 لدراسة تأثير بحمض الهيوميك والأعشاب البحرية Ulva SLE بتركيزات مختلفة على النمو الخضري، والمحصول ومكونات المحصول، والمحتوى الكيمياوي للقمح صنف"Kufra". أجريت التجربة وفقًا لتصميم القطاعات العشوائية الكاملة (RCBD) مع 12 معاملة تم رشها وكل معاملة تحتوي على ثلاث مكررات. تكونت المعاملات من حمض الهيوميك بأربع تركيزات (2، 4، 6، 8 جم/لتر)، الطحالب البحرية Ulva SLE بأربع تركيزات (3، 6، 9، 12 جم/لتر)، الخليط HA 6g/l + SLE 9g/l، HA 8g/l + SLE 12، ومعاملة الكنترول . أظهرت النتائج ان الرش بالتركيزات العالية من حمض الجبريليك والأعشاب البحرية أدت إلي زيادة كل صفات النمو الخضري المدروسة حيث سجل الخليط بين 8 جم/لتر+12 جم/لترSLE أعلى القيم لإرتفاع النبات، الوزن الخضري الطازج، المساحة الورقية، الكلورفيل الكلي، عدد الأشطاء/ نبات، يليه الخليط 6 جم/لتر+9 جم/لترSLE، ايضاً سجلوا أعلى القيم للمحصول ومكونات المحصول وهي طول السنبلة، عدد الحبوب، وزن ألف حبة، محصول الحبوب، المحصول البيولوجي، دليل الحصاد، كذلك الصفات الكيمائية مثل النسب المئوية للنيتروجين والفوسفور والبوتاسيوم والكربوهيدرات والبروتين، على التوالي، مقارنة بمعاملة الكنترول التي سجلت أقل القيم لصفات النمو الخضري، المحصول ومكونات المحصول، الصفات الكيمائية لصنف القمح. الخلاصة: تم رفع معظم معايير نمو القمح، والمحصول ومكوناته، والتركيب الكيميائي من خلال الرش بحمض الهيوميك ومستخلص الطحالب (*Ulva SLE*) على أوراق القمح الربيعي.