The North African Journal of Scientific Publishing (NAJSP)
مجلة شمال إفريقيا للنشر العلمي (NAJSP)
E-ISSN: 2959-4820
Volume 2, Issue 3, July – September 2024, Page No: 290-298
Website: https://najsp.com/index.php/home/index
SJIFactor 2023: 3.733 معامل التأثير العربي (AIF) 2023: 0.63 ISI 2023: 0.383

Effect of Seaweed Extract on Vegetative Growth, Yield and Chemical Composition of Wheat

A. F. B. Embarek[1 *], S. I. J. Mumin[2]
[1] Environmental Science Department, Faculty of Natural Resources and Environmental Sciences, University of Tobruk, Libya
[2] Environmental Science Department, Faculty of Natural Resources and Environmental Sciences, University of Derna, Libya

تأثير مستخلص الطحالب البحرية على النمو الخضري والمحصول والتركيب الكيميائي لنبات القمح

أماني فرج بدر امبارك[1*]، سلمى إسماعيل جبريل مؤمن[2]
[1] قسم علوم البيئة، كلية الموارد الطبيعية وعلوم البيئة، جامعة طبرق، طبرق، ليبيا
[2] قسم علوم البيئة، كلية الموارد الطبيعية وعلوم البيئة، جامعة درنة، درنة، ليبيا

*Corresponding author: amanifaraq339@gmail.com

Received: July 29, 2024	Accepted: August 29, 2024	Published: September 19, 2024

Abstract:
The field experiment was conducted in the city flower nursery in the city of Tobruk during the winter season 2023-2024 to study the effect of seaweed on vegetative growth, yield and yield components and chemical composition of wheat cv. "Daman-98". The seaweed extract solutions has been sprayed on plants in three times, the first in the elongation phase, the second after 20 days from the first and the third after three days from the second time in a randomized complete block design (RCBD), with six treatments (control, 2, 4, 6, 8, 10ml/l) with three replicates. The result showed that increasing seaweed extract up to 10 ml/l recorded the significantly higher values of growth parameters (plant height, leaf area, chlorophyll reading, shoot fresh weight/ plant, tillers number/ plant), also, all yield attributes and yield i.e., spike length, number of spikes/m2, 100-grains weight, grain yield, biological yield and harvest index and chemical composition i.e., nitrogen, phosphorus, potassium, protein percentages, followed by seaweed extract 8 ml/l, as compared to control treatment which recorded significantly lower values of growth parameters (plant height, leaf area, chlorophyll reading, shoot fresh weight/ plant, tillers number/ plant), yield and yield components i.e., spike length, number of spikes/m2, 100-grains weight, grain yield, biological yield and harvest index and chemical composition nitrogen, phosphorus, potassium, protein percentages, respectively. In conclusion, use of bio-stimulants (seaweed), had a significant impact on improving majority of the studied characteristics related to wheat plant growth, yield and yield components and chemical composition.

Keywords: Wheat, Seaweed Extract, Vegetative Growth, Yield, Chemical Composition.

الملخص
أجريت التجربة الحقلية في مشتل زهور المدينة بمدينة طبرق خلال الموسم الشتوي 2023-2024 لدراسة تأثير الأعشاب البحرية في النمو الخضري والحاصل ومكونات المحصول والتركيب الكيميائي لصنف القمحDaman-98. تم رش مستخلص الطحالب البحرية على نباتات القمح على ثلاث مرات الأولى في مرحلة الاستطالة والثانية بعد 20 يوماً من الأولى والثالثة بعد ثلاثة أيام من المرة الثانية في تصميم القطاعات العشوائية الكاملة (RCBD) وست معاملات (كنترول، 2، 4، 6، 8، 10 مل/ لتر) مع ثلاث مكررات. أظهرت النتائج أن زيادة مستخلص الطحالب البحرية حتى 10 مل/ لتر سجلت أعلى قيم معنوية لمؤشرات النمو (ارتفاع النبات، المساحة الورقية، الكلوروفيل الكلي، الوزن الخضري/ نبات، عدد الأشطاء/ نبات)، وكذلك جميع صفات المحصول ومكونات

المحصول (طول السنبلة وعدد السنابل/م2 ووزن 100 حبة ومحصول الحبوب والمحصول البيولوجي ومؤشر الحصاد والتركيب الكيميائي، نسب النيتروجين، الفوسفور، البوتاسيوم، البروتين، يليها مستخلص الطحالب البحرية 8 مل/ لتر، مقارنة بمعاملة المقارنة التي سجلت قيم أقل معنوية لمؤشرات النمو (ارتفاع النبات، المساحة الورقية، قراءة الكلوروفيل، الوزن الرطب للنبات/ نبات، عدد الأشطاء/ نبات، صفات المحصول ومكونات المحصول (طول السنبلة، عدد السنابل/م2، وزن 100 حبة، محصول الحبوب، المحصول البيولوجي ومؤشر الحصاد والتركيب الكيميائي (النسب المئوية للنيتروجين والفوسفور والبوتاسيوم و البروتين)، على التوالي.

الكلمات المفتاحية: القمح، الأعشاب البحرية، النمو الخضري، المحصول، المحتوى الكيماوي.

1. Introduction

There are currently about 7 billion, 884 million people on the planet, up from a faster-than-average rate of growth in prior decades [1]. In order to counter the rising need for food production, numerous research studies have been conducted to boost the yield of food crops. One of the main foods in the human diet, wheat accounts for 19% of all calories accessible worldwide and is produced at a rate of 700 MT per year, making it a major cereal [2]. According to [2], China is the world's largest producer of wheat (112 MT), followed by India (78 MT). Cereals are essential for meeting the world's population growth's demand for food, especially in developing countries where cereal-based agricultural systems are the main source of calories, protein, and nutrition [3].

For most people on the planet, wheat (Triticum aestivum L.) is the most important cereal crop. With an output and productivity of roughly 731 million tonnes and 3.27 tonnes ha-1, respectively, it is grown on 217 million hectares of land [4]. Farmers' overuse of pesticides and artificial fertilizers to boost crop yields is bad for the environment and people's health. The use of biostimulants in agriculture, such as seaweed extract (SWE), may prove to be a cost-efficient and sustainable substitute for inorganic fertilizers. Biostimulants are chemical compounds that decompose naturally. When used in conjunction with fertilizers, their application provides crops with nutrients and may enhance growth and productivity [5]. Since almost all soils lack sufficient amounts of nitrogen (N), urea and other chemical fertilizers are employed as nitrogen supplements [6]. Plants store nitrogen as nitrates, which when ingested by humans are converted to nitrites, a poisonous material that causes methemoglobinemia [7]. Additionally, these chemical fertilizers harm the ecosystem by releasing greenhouse gases into the atmosphere, contaminating surface and groundwater, and more [8]. Therefore, the search for a suitable substitute for chemical fertilizers is vital.

An eco-friendly and sustainable alternative for increasing crop quality and yield is the use of biostimulants.9,10 In addition to altering root shape, plant biostimulants can also alter soil structure and nutrient solubility, which can further improve the amount of nutrition absorbed overall and promote plant growth and yield [9]. Additionally, according to [10], biostimulants aid in the enhancement of certain physiological parameters in plants, such as yield, growth, spike number/plants, and harvest index. One of the most significant forms of biostimulants is seaweed, which also includes brown algae (Ascophillum nodosum and Ecklonia maxima). These algae are beneficial because they are rich in betaines, polysaccharides, macro- and micronutrients, and several hormones [11]. Additionally rich in nitrogen, seaweed can be used in place of urea to improve crop quality, production, and N usage efficiency [12].

Seaweeds contain a wealth of important metabolites, including cellulose, proteins, lipids, natural colours, and minerals, all of which can be recovered and used in biorefinery processing techniques [13]. It has been demonstrated that liquid extracts are the most productive type of algae-based agricultural products [14]. Seaweed extracts at low concentrations are utilized as biostimulants in agriculture because they promote good plant growth responses and enhance plant resistance to a range of stressors. Direct and indirect stimulation mechanisms are responsible for the positive effects of seaweed extracts on plant growth [15]. According to [16], seaweed extracts can enhance crop growth as well as nutrient uptake, photosynthesis, yield, quality, and plant tolerance to biotic and abiotic stress. An environmentally friendly method of producing and using biostimulants during the growing of under-utilized crops to support food security and human health is to apply them [17].

Applying Kappaphycus alvarezii (k-sap) foliar improved growth in the meristematic area and led to higher growth character values. The presence of growth-promoting compounds including auxins, gibberellins, and phenyl acetic acid may be the cause of the increase in germination and seedling vigour at low concentrations of seaweed extracts [18]. The stimulating impact of compounds that stimulate growth, including as IUA, IMA, gibberellins, cytokinins, vitamins, amino acids, and trace elements, may be the cause of foliar spraying seaweed extract [19]. According to [20], applying seaweed extract (4 ml/l) at two distinct stages during the tillering and heading stages increased grain yield by improving the soil's nutrient availability and promoting higher root proliferation, which in turn improved nutrient and

moisture absorption. Wheat grain and straw yields will increase with 4 milliliters per litre due to the improved growth and yield characteristics of seaweed extract. The aforementioned assertion aligns with the conclusions made by references [21],[22].

Concentrates of seaweed extract (SWE) are known to have a variety of positive effects on plants. They also contain trace elements (Fe, Cu, Zn, Co, Mo, Mn, and Ni), vitamins, and amino acids, as well as growth-promoting hormones like indole-3-acetic acid (IAA), indole-3-butyric acid (IBA), and cytokinins [23]. According to reports, seaweed extracts increase plant tolerance to environmental stress, promote soil nutrient uptake and availability, and increase plant growth and yield [24]. The ability of the roots to grow and absorb nutrients is enhanced when they spray the plant. Furthermore, enhance the stem's strength and thickness, as well as the leaf area, to promote root and vegetative growth [25].

Furthermore, applying seaweed extract stimulates growth, postpones the senescence of leaves, and strengthens the plant because it contains nutrients, growth regulators, and certain amino acids that improve the plant's capacity to absorb nutrients and boost resistance to disease, resulting in higher yields and better quality [26]. The main objective of this work is to investigate the effect of seaweed on vegetative growth, yield and chemical composition of Wheat cv "Daman-98".

2. Material and Methods

The field experiment was conducted in the city flower nursery in the city of Tobruk during the winter season 2023-2024 to study the effect of seaweed on vegetative growth, yield and yield components and chemical composition of wheat cv. "Daman-98". The seaweed extract solutions has been sprayed on plants in three times, the first in the elongation phase, the second after 20 days from the first and the third after three days from the second time in a randomized complete block design (RCBD), with six treatments (control, 2, 4, 6, 8, 10ml/l) with three replicates. The seaweed extract solutions has been spired on plants in three times, the first in the elongation phase, the second after 20 days from the first and the third after three days from the second time. The spraying process was applied in the morning or evening to avoid high temperature.

Data recorded:

A) Vegetative growth

- Plant height (cm)
- Leaf area (cm2)
- Total Chlorophyll (SPAD)
- Shoot fresh weight/ plant (g)
- No. of tillers/plant

B) Yield and yield components

- Spike length (cm)
- No. of spikes/ m2
- 100-grains weight (g)
- Grain yield (t/ ha)
- Biological yield (t/ha)
- Harvest index (%)

C) Chemical composition

- N (%)
- P (%)
- K (%)
- Protein (%)

The nitrogen (N) content was determined by the semi-micro Kjeldahl method [27], method No. Ba 4b-87(90)), after the plant tissues (0.2 g) were oxidized and decomposed by concentrate sulphuric acid (10 ml) with digestion mixture (K_2SO_4:$CuSO_4$=5:1) heated at 400°C temperature for two and half hours. Phosphorus (P) content was determined by the vanado-molybdate yellow method, Potassium (K) content by flame photometry [28].

3. Statistical Analysis

The data were statistically analyzed according to the design used in the statistical program (GenStat12) and the statistical averages were compared according to the L.S.D test under the probability level of 5% [29].

4. Results and Discussion

A) Vegetative growth

Results presented in Table (1) and Figure (1) showed the effect of application with seaweed extract (SWE) at (0, 10, 20, 30, 40, 50 ml/l) on vegetative growth of wheat cv. Daman-98. These results included plant height, leaf area (cm2), chlorophyll reading, shoot fresh weight per plant, tillers number per plant. However, increasing concentration of seaweed extracts increasing all values of vegetative growth studied which seaweed extract at concentration 10 ml/l recorded the higher plant height (98.93 cm), leaf area (52.52 cm2), chlorophyll reading (59.71 SPAD) ,shoot fresh weight (74.47 g/ plant), tillers number (10.24/ plant), followed by concentration of 8 ml/l plant height (93.63cm), leaf area (49.82 cm2), chlorophyll reading (58.65 SPAD), shoot fresh weight (62.75 g/ plant), tillers number (9.12 / plant), as compared with control treatment which recorded the lowest mean values of plant height (68.19 cm), leaf area (38.16 cm2), chlorophyll reading (46.99 SPAD), shoot fresh weight (33.81 g/ plant), tillers number (3.53 / plant), respectively. Cajanus cajan has also been shown to respond to seaweed extracts attenuating at high concentrations and enhancing at low concentrations in terms of plant development [30].

Table 1: Effect of seaweed at different concentrations on vegetative growth of Wheat cv.

Seaweed conc. (ml/l)	Plant height (cm)	Leaf area (cm2)	Total Chlorophyll (SPAD)	Shoot fresh weight/ plant (g)	No. of tillers /Plant
Control	68.19	38.16	46.99	33.81	3.53
2	81.26	42.98	48.76	45.05	4.94
4	85.33	47.67	52.29	50.99	5.30
6	90.45	49.03	55.12	57.35	7.77
8	93.63	49.82	58.65	62.75	9.12
10	98.93	52.52	59.71	74.47	10.24
LSD (0.05)	9.99	10.68	5.73	24.76	2.32

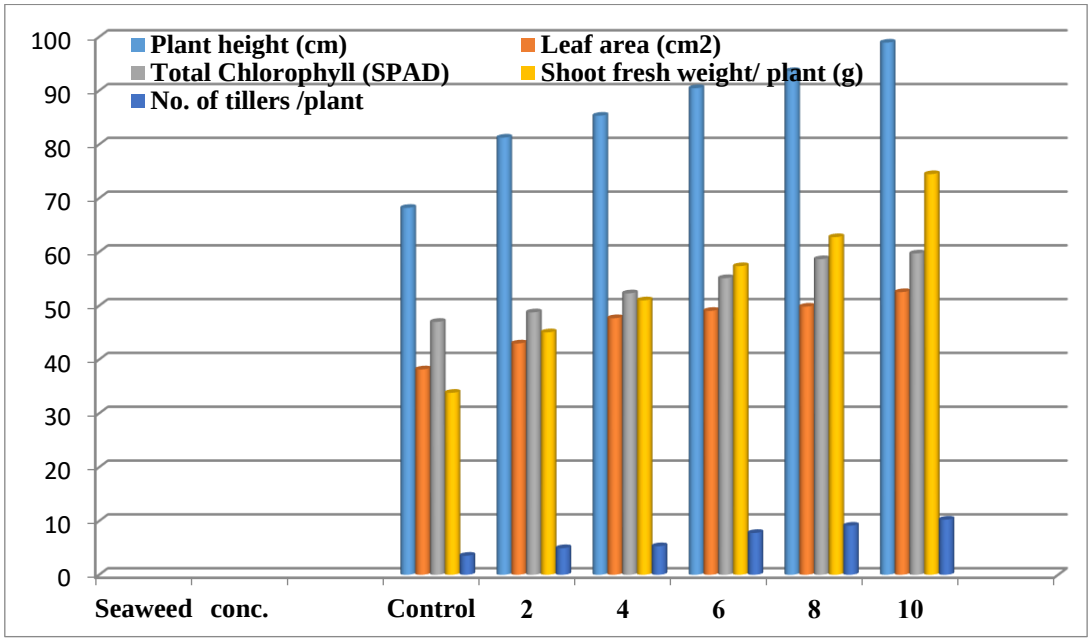

Figure 1: Effect of seaweed at different concentrations on vegetative growth of Wheat cv.

Notably, the inclusion of major and minor minerals, vitamins, cytokinins, auxins, and growth-promoting agents such abscisic acid in the seaweed extract is the cause of the taller plants [31]. Applying seaweed sap topically to rice plants resulted in increased plant height, tillers per square metre, and leaf area index, all of which indicated a higher photosynthetic efficiency. This eventually enhanced the amount

of dry matter that accumulated in the rice crop [32]. According to [33], the application of seaweed sap topically may be the cause of an increase in dry weight. This is because it enhances nutrient mobilization, leaf area partitioning, crop rate, and dry weight in wheat. Higher yield and growth traits with K-sap will result in higher rice grain and straw yield. The macro- and micronutrients and plant growth regulators found in seaweed extract help to promote overall plant growth, which is evident in the rise in plant height. This outcome is consistent with what Mohammed discovered throughout his research. The higher the seaweed extract spraying concentrations, the higher the plant height [34]. The elements in the extract, which are responsible for the formation and construction of the chlorophyll molecule, have a role in the activity of many important enzymes, including those that contribute to the increase in chlorophyll content in leaves. This result is consistent with previous research [35]. The function of marine extracts in promoting photosynthesis, which helps to increase the amount of products produced by this process and to better growth, which increases the area of the flag leaf, as well as the activity of numerous enzymes involved in phylogenetic processes [36].

Comparably, a different earlier study on maize discovered that adding seaweed extract increased several growth traits, like plant height and leaf count, by roughly 48.2 and 61.8%, respectively [37]. According to a different earlier study on maize, adding seaweed extract increased several aspects of the plant's growth, including its height and leaf count, by roughly 48.2 and 61.8%, respectively. As a result, crop yield and its constituent parts may improve. Biostimulants The following reasons why sea weed extract (SWE) can encourage plant growth:

- Stimulate the production of endogenous cytokinins from roots while simultaneously activating root cells [38].
- Improving the uptake of various plant nutrients, shoot growth, root pull strength, and leaf hydration status [39].
- Changing hormonal balances and promoting the production of auxins and cytokinins.
- Boosting antioxidant enzymes (SOD, GR, and ASP) to guard against unfavorable environmental circumstances.
- In order to protect the PSII photosynthetic system, stimulation of the manufacture of tocopherol, ascorbic acid, and carotenoids in chloroplasts [40].
- Defense of plant cells against lipid peroxidation and stress-induced enzyme activation.

B) Yield and yield components

Results presented in Table (2) and Figure (2) cleared the effect of application with seaweed extract (SWE) at (0, 10, 20, 30, 40, 50 ml/l) on yield and yield components of wheat cv. Daman-98. Results showed that increasing yield and yield components of wheat by increased seaweed extracts concentrations. However, increasing seaweed extracts concentrations up to 10 ml/l recorded the higher spike length (15.03 cm), number of spikes/m2 (300.48/ m2), 100-grains weight (41.18 g), grain yield (4.25 t/ ha), biological yield (10.40 t/ha) and harvest index (39.26 %), followed by concentration of 8 ml/l spike length (14.92 cm), number of spikes (295.68/ m2), 100-grains weight (40.18 g), grain yield (4.08 t/ ha), biological yield (10.08 t/ha) and harvest index (38.94 %), as compared with control treatment which recorded the lowest mean values of spike length (13.78 cm), number of spikes (264/ m2), 100-grains Weight (36.77 g), grain yield (3.83 t/ ha), biological yield (9.21 t/ha) and harvest index (39.90%), respectively.

The current study's findings corroborate the study [41], who discovered that using seaweed extract as an organic foliar fertilizer increased agricultural grain output. As a result, the extract can be employed as a useful stimulant to promote improved crop development and yield production. They reported that under salt stress circumstances, spraying wheat plants with SWE at a concentration of 2000 ppm increased the weight of 100 grains significantly and produced the highest significant values of grain production per plant. Seaweed components are an excellent source of bioactive chemicals, including vitamins, vital fatty acids, amino acids, and macro- and micronutrients. This explains why seaweed components are superior, growth promoting chemicals such as auxins and cytokinins influence cellular metabolism in treated plants, resulting in increased growth and production. The observed [41] that applying seaweed extract, which increases photosynthetic rate and delays leaf senescence, increased yield.

Regarding as plant growth regulators and possibly micronutrients have been linked to stimulating growth, yield characteristics, root growth, photosynthetic capacity, minerals uptake (macro- and micronutrients), and stress tolerance in various plants treated with seaweed extracts [42-44].

Furthermore, the addition of seaweed extract treatments a biostimulant has been used topically or as a soil conditioner to enhance plant development, yield, quality, and the activated antioxidant system. According [34], the use of Sargassum seaweed extract counteracts the oxidative damage caused by drought by activating antioxidant systems like catalase, peroxidase, and ascorbate as well as by supplying hormones and micronutrients that are crucial for wheat growth. In particular, the root depth, shoot height, and leaf area were increased in comparison to the single treatment of drought stress. Furthermore, seaweed extracts (SWE) enhance nutrient uptake through the roots, contributing to the plant's robust overall growth [45]. Also, the study [23] showed that plant growth regulators, which promote root development, mineral uptake, and photosynthetic capability, are responsible for the beneficial effects of seaweed extract treatments on plant growth.

According to [46], foliar sprays of an extract from Ascophyllum nodosum seaweed encouraged the plants to use the soil mineral N and probably other available nutrients more efficiently. This resulted in greater uptake of K in the grain and a 25% increase in wheat plant production. According to [47], applying seaweed concentrate greatly raised the K, Mg, and Ca concentrations in the leaves of lettuce plants that are getting enough nutrients, but had little effect on plants that are under nutrition stress. Furthermore, the algal extraction (0.1%) resulted in a substantial drop in calcium and an increase in nitrogen, phosphorus, and magnesium when compared to untreated and treated plants. Furthermore, the study [48] discovered comparable outcomes linking the enhancement of crop canopy growth features via seaweed extract application to the rise in rice output.

Table 2: Effect of seaweed at different concentrations on yield and yield components of Wheat cv.

Seaweed conc. (ml/l)	Spike length (cm)	No. of Spikes/ m^2	100-grains Weight (g)	Grain yield (t/ ha)	Biological yield (t/ha)	Harvest index (%)
Control	13.78	264	36.77	3.83	9.21	39.90
2	14.04	268.8	38.79	3.95	9.83	38.46
4	14.15	274.56	39.39	3.97	9.87	38.61
6	14.65	287.04	40.03	4.03	9.95	38.94
8	14.92	295.68	40.18	4.08	10.08	38.94
10	15.03	300.48	41.18	4.25	10.40	39.26
LSD (0.05)	0.43	20.16	1.05	0.12	0.22	1.28

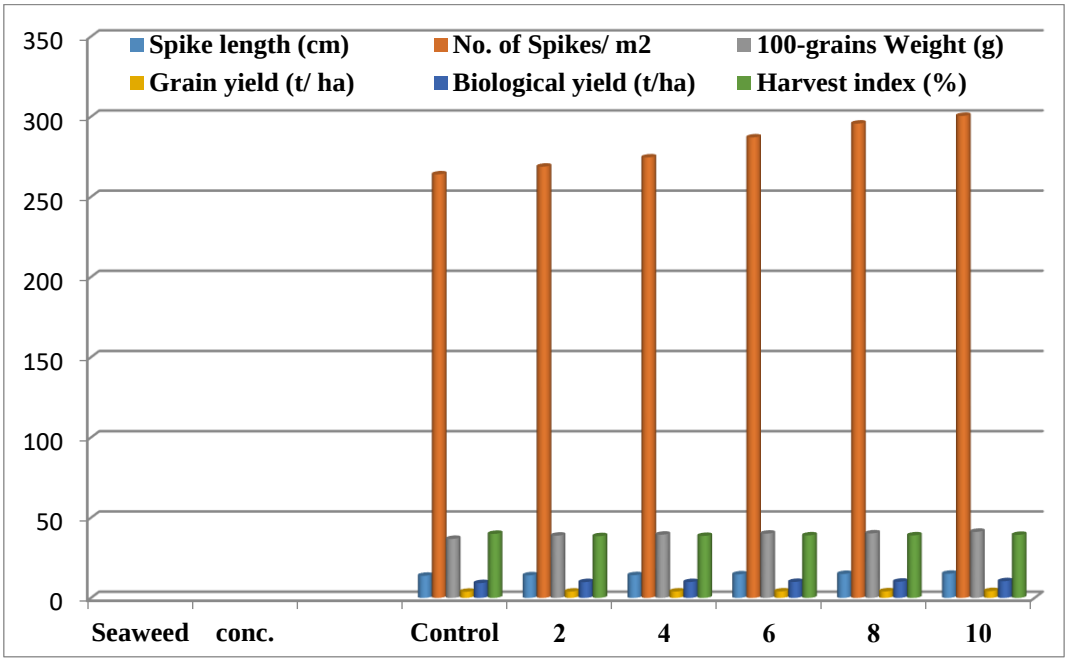

Figure 2: Effect of seaweed at different concentrations on yield and yield components of Wheat cv.

C) Chemical composition

Results in Table (3) and Figure (3) showed the effect of application with seaweed extract (SWE) at (0, 10, 20, 30, 40, 50 ml/l) on chemical composition of wheat cv. Daman-98. Results showed that increasing

nitrogen, phosphorus, potassium, protein percentages of wheat by increased seaweed extracts concentrations. However, increasing seaweed extracts concentrations up to 10 ml/l recorded the higher nitrogen (2.32%), phosphorus (0.44%), potassium (2.13%), protein (14.50%), followed by concentration of 8 ml/l which nitrogen recorded (2.25 %), phosphorus (0.41 %), potassium (2.09 %), protein (14.06%), as compared with control treatment which recorded the lowest mean values of nitrogen (1.43%), phosphorus (0.25%), potassium (1.92%), protein (8.94 %), respectively. Spraying seaweed extract topically. This could be because of the growth-promoting properties of chemicals such vitamins, amino acids, trace elements, gibberellins, cytokinins, IUA, and IMA [19]. According to [20], applying seaweed extract (4 ml/l) at two distinct stages during the tillering and heading stages increased grain yield by improving the soil's nutrient availability and promoting higher root proliferation, which in turn improved nutrient and moisture absorption. Wheat grain and straw yields will increase with 4 milliliters per litre due to the improved growth and yield characteristics of seaweed extract. The aforementioned assertion aligns with the conclusions made by [21]; [22]. The study [49] concluded that, the application of the biostimulants in small quantities has the effect on several metabolic processes and enhances plant growth and development via the increase of photosynthesis, endogenous hormones, nutrients uptake, and protein synthesis as well as with relatively higher ability for increasing available micronutrients in the soil. The study [50] reported that the seaweed extract is a significant source of some macronutrient such as P and some micronutrients such Zn, Cu and Fe and others that play an important role in plant growth.

Table 3: Effect of seaweed at different concentrations on chemical composition of Wheat cv.

Seaweed conc. (ml/l)	N (%)	P (%)	K (%)	Protein (%)
Control	1.43	0.25	1.92	8.94
2	1.95	0.28	1.97	12.19
4	2.13	0.32	2.04	13.31
6	2.18	0.38	2.06	13.63
8	2.25	0.41	2.09	14.06
10	2.32	0.44	2.13	14.50
LSD $_{(0.05)}$	0.10	0.04	0.01	0.21

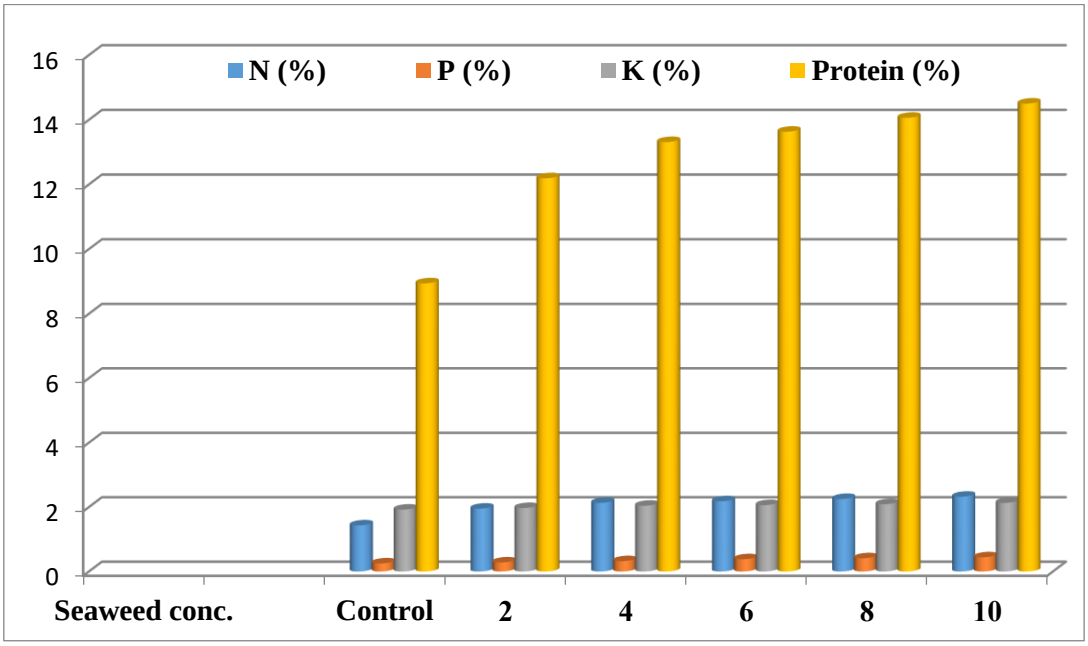

Figure 3: Effect of seaweed at different concentrations on chemical composition of Wheat cv.

5. Conclusion

The current study represents a significant advancement in the use of seaweed extracts to enhance wheat development. Because seaweeds include nitrogen, magnesium, potassium, and a few trace minerals, they are a great option for organic fertilizers. When seaweed liquid fertilizer was sprayed to agricultural plants, growth and pigmentation improved in every way. It is most likely because there are more nutrients and hormones that promote growth present. Therefore, growers are advised to apply eco-friendly seaweed extract to achieve improved wheat germination, growth, and crop production.

After more research, this study finds that seaweed liquid fertilizers are inexpensive, efficient fertilizers that can be marketed as environmentally acceptable bio-fertilizers all over the world.

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