



Impact of vermicompost and seaweed extract on Strawberry

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تأثير الفيرموكمبوست ومستخلص الطحالب على الفراولة

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Abstract:

A field experiment was conducted in 2024 at the private farm of Tajoura-Libya. It involved applying vermicompost and foliar spraying seaweed extracts on the strawberry crop variety "Festival" that was produced under experimental conditions. On October 15, 2023, strawberry seeds were sown. On December 15, 2023, the first spray of seaweed extracts and vermicompost was applied. The final spray was applied on April 1, 2024, while the second one was completed on December 25, 2023. Ten treatments were applied, and the experimental treatments were controlled using a split plot design with three repetitions. The following is the arrangement of the applied treatments: Seaweed extracts at concentrations of 0, 500, 1000, 1500, and 2000 mg/l as a subplot and vermicompost at concentrations of 0, 0.5, 1.0, 1.5, and 2 t/ha as the main plot. Plant height, number of leaves per plant, total chlorophyll, dry weight per plant, crown diameter, number of flowers, fruit length, fruit diameter, fruit weight, yield per plant, TSS, acidity, total sugars, vitamin C, anthocyanin, carbohydrates, nitrogen, phosphorus, potassium, calcium, and magnesium were all examined. Vermi-compost concentration at 2 t/ha recorded the highest values of plant height, number of leaves/plant, total chlorophyll, dry weight/plant, crown diameter, number of flowers, fruit length, fruit diameter, fruit weight, yield/plant, TSS, total sugars, vitamin C, anthocyanin, carbohydrates, nitrogen, phosphorus, potassium, calcium, and magnesium. Additionally, seaweed extracts at a concentration of 2000 mg/l showed higher values of these features than the control treatment, which showed lower values,

whereas the control treatment had the highest acidity levels. In conclusion, standardized testing, extraction, and analysis methods are necessary to compare different fertilizers. This research will surely help us understand the organic strawberry farming package as a holistic and sustainable strategy to improve soil health and increase the yield and profitability of high-quality fruits.

Keywords: Strawberry (*Fragaria × ananassa* Duch.), seaweed extract, vermicompost, vegetative growth, yield, chemical composition.

الملخص

تم إجراء تجربة حقلية خلال موسم 2024 في مزرعة خاصة في تاجوراء-ليبيا، تضمنت رش الأوراق بمستخلصات الطحالب وإضافة الفيرمي الكمبوست على محصول الفراولة من الصنف "فستيفال" المزروع تحت ظروف التجربة. تاريخ زراعة بذور الفراولة كان في 15 أكتوبر 2023. تم تنفيذ الرشوة الأولى لمستخلصات الطحالب وإضافة الفيرمي الكمبوست في

2023/12/15. كانت الرشّة الثانية في 2023/12/25 وتمت الرشّة الأخيرة في 2024/1/4. تم ترتيب المعاملات التجريبية وفقاً لتصميم القطع المنشقة مرة واحدة مع ثلاث مكررات حيث تم تطبيق 10 معاملات. تم ترتيب المعاملات المطبقة على النحو التالي: الفيرمي الكمبوست عند تركيزات (0، 0.5، 1.0، 1.5، 2 طن/هكتار) كقطع رئيسية ومستخلصات الطحالب عند تركيزات (0، 500، 1000، 1500، 2000 مجم/لتر) كقطع تحت رئيسية. كانت الصفات المدروسة هي: ارتفاع النبات، عدد الأوراق/نبات، الكلوروفيل الكلي، الوزن الجاف/النبات، قطر التاج، عدد الأزهار، طول الثمرة، قطر الثمرة، وزن الثمرة، المحصول/نبات، المواد الصلبة الذائبة الكلية، الحموضة، السكريات الكلية، فيتامين ج، الأنثوسيانين، الكربوهيدرات، النيتروجين، الفوسفور، البوتاسيوم، الكالسيوم، المغنيسيوم. أظهرت النتائج أن زيادة تركيز إضافة الفيرمي الكمبوست ومستخلصات الطحالب زادت بشكل كبير من جميع الصفات المدروسة، ومع ذلك، سجلت تركيزات الفيرميكمبوست عند 2 طن/هكتار أعلى القيم في ارتفاع النبات، عدد الأوراق/نبات، الكلوروفيل الكلي، الوزن الجاف/نبات، قطر التاج، عدد الأزهار، طول الثمرة، قطر الثمرة، وزن الثمرة، المحصول/نبات، المواد الصلبة الذائبة الكلية، السكريات الكلية، فيتامين C، الأنثوسيانين، الكربوهيدرات، النيتروجين، الفوسفور، البوتاسيوم، الكالسيوم، المغنيسيوم. كما سجلت مستخلصات الطحالب البحرية بتركيز 2000 مجم/لتر أعلى القيم لهذه الصفات، مقارنة بمعاملة الكنترول التي سجلت أقل القيم لهذه الصفات، بينما سجلت معاملة الكنترول أعلى القيم للحموضة. في الختام، نحتاج إلى بروتوكولات اختبار واستخراج وتحليل موحدة لمقارنة الأسمدة المختلفة. ستكون هذه الدراسة بالتأكيد مفيدة في فهم أفضل للزراعة العضوية للفراولة كنهج شامل ومستدام لتحسين صحة التربة وزيادة إنتاجية وربحية الفواكه عالية الجودة.

الكلمات المفتاحية: الفراولة (*Fragaria × ananassa* Duch)، مستخلص الطحالب، الفيرمي الكمبوست، النمو الخضري، المحصول، التركيب الكيميائي.

Introduction

The strawberry (*Fragaria × ananassa*), a plant that can be produced in many climates and has a high nutritional value in addition to its unique flavor and aroma, is a member of the Rosaceae family (Katel *et al.*, 2022). Fresh strawberries include a wide variety of vitamins, minerals, and phytochemicals. Polyphenolic compounds, particularly anthocyanins like cyanidin and pelargonidin, which are linked to potential health benefits and significantly enhance human health and sickness prevention, are what give strawberries their red color (Chen *et al.*, 2023).

The qualitative characteristics of strawberries are greatly influenced by both the cultivar's genetic characteristics and the surrounding environment (Simkova *et al.*, 2023). Optimal fertilization can also affect the quantity and quality of strawberry fruit (Wu *et al.*, 2020). The local population's health, the environment, and the economy can all benefit from strawberry planting. Worldwide, 389,665 hectares of planted land produce more than 9 million tons of strawberries each year. 49.4% of this product's global production comes from Asia (FAO, 2021). A crop with considerable socioeconomic significance is the strawberry, or *Fragaria × ananassa* Duch. The fruit is highly prized due to its nutritional, antioxidant, and organoleptic properties (González-Jiménez *et al.*, 2020; Hernández *et al.*, 2022; Mancini *et al.*, 2023). The strawberry is one of the most important and widely consumed little fruits in the world. Wahlang and Joseph, (2024) state that the fruit is renowned for its brilliant color, seductive aroma, and beautiful texture. It also has a number of health-promoting nutrients. The strawberry (*Fragaria × ananassa* Duch.) is one of the most popular soft berry fruits in the world (Thoudam, 2022). This temperate fruit can be grown in tropical and subtropical regions. The strawberry belongs to the Rosaceae family. A hybrid species of *Fragaria virginiana* x *Fragaria chiloensis*, the garden-cultivated strawberry, or Octoploid *Fragaria × ananassa* (2n=8x=56), is thought to have originated in Europe. Its basic chromosomal number is x=7 (Singh *et al.*, 2022; Unal 2023). Strawberries are a short-day herbaceous perennial that prefers daytime temperatures between 22°C and 25°C and nighttime temperatures between 7°C and 13°C (De and Bhattacharjee, 2012). It is commercially propagated by runners. Strawberries are valued for their flavor and essential nutrients. They are rich in anthocyanins, which give them their red color, and include a variety of phytochemicals such flavonoids, ellagic acid, and vitamin C. Vitamin C, also, referred to as ascorbic acid, is a vital antioxidant that is abundant in strawberries. It has a major effect on several physiological processes, including collagen production, immunological function, antioxidant defense, and the prevention of cardiovascular disease, inflammation, and some forms of cancer (Miao *et al.*, 2017; Walia, 2019). Around the world, strawberries are grown in a variety of environments, such as open fields and greenhouses. Plant development, fruit quality, and fruit performance are all greatly impacted by the choice of growing material. Historically, the most popular growth medium for strawberries has been soil. However, it might also harbor diseases and pests that are spread via the soil, which could hinder plant growth and productivity (Unal *et al.*, 2023). Strawberries are one of the most popular soft fruits. When eaten, they have a unique taste, are aesthetically pleasing, and are healthy. Strawberries' health-promoting properties come from phenolic compounds and anthocyanins, which have anticancer (Urün *et al.*, 2021) and cardiovascular disease-preventive (Mazzoni *et al.*, 2015; Giampieri *et al.*, 2015) properties. Strawberries have a relatively low energy value and are rich in B vitamins, polyphenolic chemicals, and readily

digested organic compounds (Muthukumaran *et al.*, 2017). Vitamin C is another naturally occurring antioxidant found in strawberries, along with anthocyanins and phenolic compounds. Per 100 g of fresh fruit, it can vary between 50 and 80 mg (Sapei and Hwa, 2014). It is even larger than a couple times.

Due to their unique health benefits (Cosme *et al.*, 2022; Huneif *et al.*, 2022) and global demand (FAO, 2019), strawberries are growing in popularity in modern markets, underscoring the need for berries that are aesthetically pleasing, incredibly nutritious, and of outstanding quality. These fruits are rich in organic acids, minerals, vitamins, and anti-carcinogens, and they also have cardiovascular advantages (Gundogdu *et al.*, 2020). Organic fertilizers have gained appeal as a way to improve strawberry growth, quality, and productivity because of their capacity to supply essential nutrients and promote faunal activity in the rhizosphere (Khalil and Agah, 2017; Negi *et al.*, 2021).

Grown all over the world, strawberries adapt to various climates and agricultural methods (Yamasaki, 2013). Strawberry yield is determined by the agricultural system and cultivar selection (Taghavi). Providing crops with sustenance ensures that they obtain essential nutrients, which facilitates the achievement of increased agricultural yields (Hasan *et al.*, 2020). Raising agricultural yield requires a certain micronutrient component. It is well accepted that the appropriate distribution of essential components is one of the most crucial elements in achieving the highest crop yields. Because foliar spraying minimizes losses during fertilizer application, it has been demonstrated to have a substantial impact on crop quality and yield (Al-Taey *et al.*, 2022). The strawberry plant requires a lot of fertilizer due to its ability to produce a lot of fruit despite its small size. Thus, foliar fertilization is recognized as an essential tactic to solve an excessive reliance on chemical fertilizers may damage the ecosystem and negatively impact human and animal health, according to study. Plant extracts are being sought after as substitutes for chemical fertilizers in plant nutrition since they are safer for humans, animals, and the environment (Al-Shatri *et al.*, 2020). Algae extracts are increasingly being used to improve plant development, quality, and yield (Mahmood and Al-Dulaimy, 2021; Hardan and Al-Dulaimy, 2022) they are considered a significant organic source for the production of crops free of chemicals, and about 15 million tons are utilized in agriculture annually. They successfully promote plant development even at low concentrations. These extracts also contain growth-promoting substances like cytokinins, auxins, gibberellins, vitamins, and complex carbohydrates.

Using natural organic fertilizers, such vermicompost, is essential for ecological safety in order to prevent pesticide contamination in agrocenoses (Lishchuk *et al.*, 2023). According to Abdullaev *et al.* (2023), there are nine genera and twenty-three species of earthworms in Uzbekistan. *Eisenia fetida*, which is extensively distributed throughout Uzbekistan and is renowned for its enormous biotechnological potential, was used to create vermicompost from animal organic waste that accumulates in large quantities in the livestock sector of agriculture (Khafiza *et al.*, 2024). Vermicompost is a result of organic waste that *Eisenia fetida* and other bacteria break down to a level that plants may absorb, according to Edwards *et al.* (2010). Vermicompost is an organic fertilizer that can be used instead of the common mineral fertilizers. It is now believed that vermicompost can be used as an additional organic fertilizer for substrates and to grow plants. Its environmental friendliness increases its use and appeal (Basheer and Agrawal, 2013). Numerous studies have shown that vermicompost accelerates vegetative organ growth and plant seed germination (Zaller, 2007). It also promotes plant productivity, extends the shelf life, and enhances fruit quality. Vermicompost's neutral pH environment, porous nature, population of helpful bacteria, sufficient aeration, and hygroscopic properties all promote plant growth (Lazcano *et al.*, 2011).

Vermicompost is an excellent alternative to artificial fertilizers for a range of crops. Vermicomposting is a non-thermophilic process that converts organic waste into beneficial fertilizer using worms and mesophilic microbes (Rehman *et al.*, 2023). Among the substances in vermicompost that control plant growth and yield include auxins, gibberellins, cytokinins, and humic acids (Cabilovski *et al.*, 2023). Compared to conventional composting, vermicompost has several advantages, such as the capacity to digest organic waste faster and generate manure compost with lower salinity levels. Therefore, using local earthworms for vermicomposting and determining the optimal mixtures of organic waste and manure have important implications for plant agriculture (Ergasheva *et al.*, 2024).

The purpose of this study was to determine how vermicompost and seaweed extract affected the growth characteristics, yield, and fruit quality of the strawberry variety Camarosa.

Materials and Methods

In order to compare the effects of applying vermicompost and foliar spraying seaweed extracts on the strawberry crop variety "Festival" produced under experimental conditions, a field experiment was conducted in 2024 at the private farm of Tajoura-Libya. On October 15, 2023, strawberry seeds were sown. On December 15, 2023, the first spray of seaweed extracts and vermicompost was applied. The final spray was applied on April 1, 2024, while the second one was completed on December 25, 2023.

Experimental design

Ten treatments were applied, and the experimental treatments were controlled using a split plot design with three repetitions. Vermicompost at concentrations of 0, 0.5, 1.0, 1.5, and 2 t/ha served as the main plot, whereas seaweed extracts at concentrations of 0, 500, 1000, 1500 and 2000 mg/l served as the sub-main plot.

Data recorded

A) Vegetative growth:

A random sample of ten plants from the two inner rows of each experimental plot was taken at 120 days after transplanting for vegetative growth data.

- Plant length and number of leaves/plant were recorded.
- Number of leaves per plant was calculated.
- Leaf area estimate to **Moursi et al. (1968)**, the disk method was used.
- Total chlorophyll recording by using a chlorophyll meter (SPAD-502 Konica Minolta), in the leaves of four completely developed plants from each experimental unit within the inner rows was measured, and the average was computed.
- Dry weight (g/plant)
- Crown diameter (cm)

B) Yield components:

- Number of flowers and fruits number per plant were calculated. The productivity (g/ plant) was estimated as well.
- Fruit size (cm³)
- The length and diameter of the fruits were measured using a digital caliper.
- Throughout the growing season, yield fruits were harvested every two to three days, counted, and weighed to determine the average fruit weight. The weights of all the fruit that was picked during the first four harvests were used to calculate the early yield/plant. The total yield per plant was computed.

C) Chemical composition

- Total Soluble Solids (TSS %) were measured in the juice using a determined using a digital refractometer (**A.O.A.C., 1980**)
- The titratable acidity was determined in triplicate with the method of **Horwitz and Latimer (2000)**
- **Total sugar (%)**: were ascertained using **Malik and Singh (1980)** phenol sulfuric acid technique. **Nelson (1944)** used calorimetric analysis to detect the fruit is reducing sugar content. The difference between total sugars and reducing sugars was used to compute non-reducing sugars.
- **Vitamin C (mg/100g f.w.)**: Spectrophotometric methods were employed with potassium permanganate as the chromogenic reagent to ascertain the ascorbic acid level. To create the ascorbic standard calibration curve, 10 mL of each standard solution was added to a test tube along with 1 ml of KMnO₄ solution (100 µg ml⁻¹), and the mixture was allowed to sit for five minutes. This standard solution's absorbance was measured at 530 nm compared to a blank. Then, the graph of the absorption rate of solutions was drawn based on concentration.
- Anthocyanin content (mg/100g F.W) method was used with some modifications to the measurement of anthocyanin content. Anthocyanins were extracted using acidified methanol and chloroform. Extracts were obtained by adding 20 mL of chloroform-methanol (2: 1 v/v, acidified with 0.1% HCl) to the strawberry samples **Solovchenko et al. (2001)**.
- **Total carbohydrate (mg/g D.W.)**: was determined at 120 days after planting using phenol sulphuric acid method (**Dubois et al., 1956**).
- Total nitrogen was determined using Kjeldahl method as described by **Piper (1950)**.
- Phosphorus content was measured spectrophotometrically using the ascorbic acid method (**AOAC, 2005**).
- Potassium was measured by flame photometer as described by **Page et al. (1982)**.
- Calcium and Magnesium were determined by versinate, using ammonium periorate and Eriochrome Black T as indicator, respectively, according to (**Jackson, 1967**) and calculated as % of dry weight.

Statistical analysis:

According to **Snedecor and Cochran (1990)**, the results of the measured parameters were subjected to computerized statistical analysis using the MSTAT software for analysis of variance (ANOVA), and means of treatments were compared using LSD at 0.05.

Results and Discussion

A) Vegetative growth characters

The results displayed in **Table (1)** and **Fig. (1)** demonstrated the impact of seaweed extract and vermin-compost on strawberry vegetative development in the 2024 season. On the other hand, when the quantity of vermicompost and seaweed extract was decreased, all of the investigated vegetative growth parameters sharply decreased. The mean values of the traits were lowest in untreated plants. However, when seaweed extract was sprayed at a dosage of 2000 mg/l, the higher values of plant height (25.58 cm), number of leaves/ plant (19.96), leaf area (72.42 cm²), total chlorophyll (57.65 SPAD), dry weight (4.84 g/plant), crown diameter (3.16 cm), followed by seaweed extract at concentration of 1500 mg/l which recorded plant height (23.83 cm), number of leaves/ plant (18.83), leaf area (69.51 cm²), total chlorophyll (56.72 SPAD), dry weight (4.80 g/plant), crown diameter (2.85 cm), as compared to control treatment which recorded the lower values of plant height (20.17 cm),

number of leaves/ plant (13.71), leaf area (60.53 cm²), total chlorophyll (51.51 SPAD), dry weight (3.11 g/ plant), crown diameter (1.69 cm), respectively.

On the other hand, vermicompostat concentration of 2 t/ha recorded the higher values of plant height (23.05 cm), number of leaves/ plant (17.98), leaf area (65.25 cm²), total chlorophyll (51.94 SPAD), dry weight (4.36 g/plant), crown diameter (2.85 cm), followed by vermicompostat at 1.5 t/ha which recorded plant height (21.47 cm), number of leaves/ plant (16.97), leaf area (62.62 cm²), total chlorophyll (51.10 SPAD), dry weight (4.32 g/plant), crown diameter (2.57 cm), as compared to control treatment which recorded the lower values of plant height (18.17 cm), number of leaves/ plant (12.35), leaf area (54.53 cm²), total chlorophyll (46.41 SPAD), dry weight (2.80 g/plant), crown diameter (1.52 cm), respectively.

Vermicomposts dramatically enhanced gibberellic acid in roots, breaking bud hibernation and increasing blooming buds and fruiting locales (**Tagliavini et al., 2005**). According to **Ogendo et al. (2008)**, the interaction of phosphorus and farm yard manure produced a high shoot to root ratio in comparison to the control, and the production of cytokinin in the roots of strawberries increased their vegetative development and leaf count. The crown diameter and leaf area both increase with the application of vermicompost. This may be due to increased soil microbial activity and cation exchange capacity (**Arancon et al., 2003**). **Ogendo et al. (2008)** reported that farm yard waste included a proportionate amount of potassium, which improved sugar accumulation and encouraged leaf growth, increasing leaf area. The low leaf area could be caused by inadequate macro and micronutrient proportions and their decreased availability in typical soil conditions. These results also agree with those of **Abu-Zahra and Tahboub (2009)**. Strawberry vegetative metrics and metabolic plant activities, such as cell division and enzyme activity, are positively impacted by organic amendments (**Ogendo et al., 2008**). **Arancon et al. (2004)** reported that strawberries' shoot and root biomass rose when vermicompost leachates were applied. Strawberries' fresh and dry weight increased because plants tended to increase the synthesis of carbohydrates or cellulose rather than amino acids, and high resource utilization led to a scarcity of essential nutrients (**Herencia et al., 2011**). **Odengo et al. (2008)** concluded that a high nitrogen percentage in manures restricted root growth by increasing vegetative growth after analyzing the nutritional value of farm yard manure. Because seaweed extract contains vitamins, polyamines, growth regulators, and macro- and micronutrients that improve nutritional status and vegetative growth, it may have positive effects (**Battacharyya et al., 2015**). Furthermore, **Alam et al. (2013)** found that applying *Ascophyllum* extract to strawberries greatly increased the number of roots per plant, total root length, total root surface area, and total root volume. As a result, there was an increase in the features of vegetative development and an increase in nutrient absorption. Furthermore, **El-Miniawy et al. (2014)** found that the seaweed extract-containing foliar spray enhanced the vegetative growth traits of strawberries, including plant length, leaf area, number of leaves per plant, and fresh weights of the roots and vegetative development. Biostimulants Seaweed extract (SWE) may have the following effects on plant growth: I) activating III) altering hormonal balance and promoting auxin and cytokinin production (**Schmidt 2005**). IV) Increasing antioxidant enzymes (SOD, GR, and ASP) to protect against damaging environmental elements (**Schmidt, 2005**). V)-promote the synthesis of carotenoids, ascorbic acid, and tocopherol in the chloroplast, protecting PSII's photosynthetic machinery (**Zhang and Schmidt 2000**). VI) Preventing stress-induced enzyme activation and lipid peroxidation in plant cells. The increase in chlorophyll content may be due to the physiological role of licorice extract in improving photosynthetic efficiency, which has a positive effect on chlorophyll percentage (**Kessel, 2006**). This was observed by **Zuhair (2010)**, who looked at how different licorice concentrations affected strawberries and showed that they greatly increased the amount of total chlorophyll.

Table (1): Impact of vermicompost and seaweed extract on vegetative growth of Strawberry in 2024 season.

Treatments	Plant height (cm)	No. of leaves/ plant	LA (cm ²)	Total chlorophyll (SPAD)	Dry weight (g/plant)	Crown diameter (cm)
A) Vermicompost						
Control	18.17	12.35	54.53	46.41	2.80	1.52
0.5 t/ha	19.44	14.82	58.81	47.95	3.28	1.90
1.0 t/ha	20.46	15.51	60.56	49.47	4.23	2.09
1.5 t/ha	21.47	16.97	62.62	51.10	4.32	2.57
2.0 t/ha	23.05	17.98	65.25	51.94	4.36	2.85
LSD_(0.05)	0.26	0.46	3.56	1.42	0.15	0.03
B) Seaweed extract (SWE)						
Control	20.17	13.71	60.53	51.51	3.11	1.69
500 mg/l	21.58	16.45	65.27	53.22	3.64	2.11
1000 mg/l	22.71	17.22	67.22	54.91	4.69	2.32
1500 mg/l	23.83	18.83	69.51	56.72	4.80	2.85
2000 mg/l	25.58	19.96	72.42	57.65	4.84	3.16
LSD_(0.05)	0.28	0.51	3.95	1.57	0.17	0.04

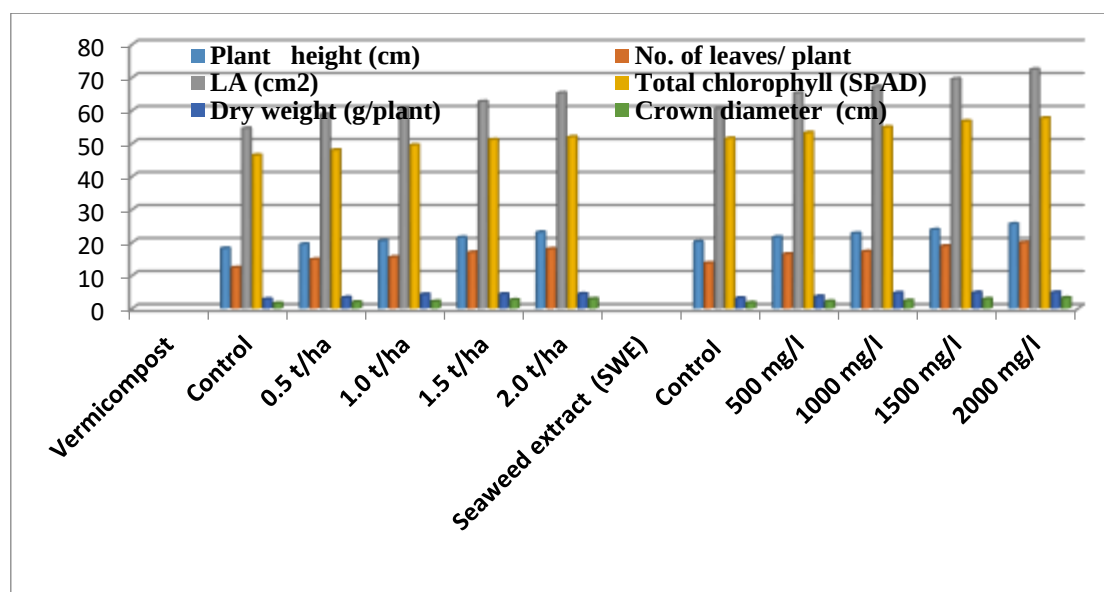


Fig. (1): Impact of vermicompost and seaweed extract on vegetative growth of Strawberry in 2024 season.

B) Yield and yield characters

The effects of vermicompost and seaweed extract on strawberry yield and yield characteristics in the 2024 season were demonstrated by the results shown in **Table (2)** and **Fig. (2)**. On the other hand, when the quantity of vermicompost and seaweed extract was decreased, all yield and yield parameters under examination sharply decreased. The mean values of yield and yield attributes were lowest for untreated plants. However, spraying of seaweed extract at concentration of 2000 mg/ l recorded the higher values of number of flowers (62.04), fruit length (3.18 cm), fruit diameter (3.69 cm), fruit size (3.64 cm³), fruit weight (14.50 g), yield/ plant (488.60 g), followed by seaweed extract at concentration of 1500 mg/l which recorded number of flowers (32.92), fruit length (3.36 cm), fruit diameter (3.06 cm), fruit size (2.88 cm³), fruit weight (13.29 g), yield/ plant (435.74 g), as compared to control treatment which recorded the lower values of number of flowers (21.20), fruit length (1.85 cm), fruit diameter (2.53 cm), fruit size (2.27 cm³), fruit weight (9.69 g), yield/ plant (396.42 g), respectively.

In this respective, vermicompostat concentration of 2 t/ha recorded the higher values of number of flowers (55.89), fruit length (3.13 cm), fruit diameter (3.33 cm), fruit size (3.28 cm³), fruit weight (13.06 g), yield/ plant (440.18 g), followed by seaweed extract at concentration of 1.5 t/ha which recorded number of flowers (29.66), fruit length (2.93 cm), fruit diameter (2.76 cm), fruit size (2.59 cm³), fruit weight (11.97 g), yield/ plant (392.56 g), as compared to control treatment which recorded the lower values of number of flowers (19.10), fruit length (1.76 cm), fruit diameter (2.28 cm), fruit size (2.04 cm³), fruit weight (8.73 g), yield/ plant (357.13 g), respectively. These increases in yields may be closely linked to the increase in vegetative growth characteristics and may be also linked to the increase in the crown carbohydrate content.

Seaweed products have growth-stimulating qualities, and their application as biostimulants in crop production is well acknowledged. Other than fertilizers, biostimulants also called metabolic enhancers are compounds that, when used in small quantities, promote plant growth (**Zhang and Schmidt, 1997**). Seaweed extract contains vitamins, amino acids, cytokinins, auxins, macro- and micro-element nutrients, and other growth compounds that affect cellular metabolism in treated plants, increasing crop growth and productivity. A commercial extract of *Ascophyllum nodosum* enhanced strawberry output, fruit diameter, fruit weight, number of cells per area of parenchymatous tissue, fruit yield, size, and total anthocyanin (**Alam et al., 2013**). Furthermore, using seaweed extract improved okra yield, chlorophyll, carotenoids, fruit length, fruit width, and nutritional quality (**Papenfus et al., 2013**). By boosting Mn, Zn, and Fe uptakes as well as chlorophyll content, seaweed extract enhanced tomato germination, plant height, fruit weight, and yield (**Hernández-Herrera et al., 2014**).

El Sagan (2015) reported significant improvements in cucumber plant length, plant weight, average leaf area, fruit weights, yield, and chemical content (N, P, and K content of leaves) when algal extract was applied topically at a dosage of 1.5 mg/l. **Abd El-Gawad and Osman (2014)** showed that *Ascophyllum nodosum* seaweed extract enhanced the vegetative development and yield of eggplant. Additionally, it increased the production of watermelon (**Abdel-Mawgoud et al., 2010**). Seaweed and licorice extracts include a variety of natural substances that imitate growth boosters, which may explain the improved plant output and quality (number of fruits per plant, fruit weight, plant yield, and total soluble solids). For instance, a variety of minerals (N, P, K, Mg, Fe, Zn, and Ca), amino acids (alanine, lysine, and arginine), vitamins B1, B2, and B6, carbohydrates, and mevalonic acid which is utilized in the production of gibberellins are abundant in licorice extract (**ALMarsoumi et al., 1999**).

Concurrently, it has been shown that seaweed extracts have a high concentration of nutrients and growth regulators, including auxins, gibberellins, cytokinins, and vitamins, which enhance flowering and flower quantity, increasing yield and quality (Al-Jubouri *et al.*, 2009; Spinelli *et al.*, 2009). Applying licorice and seaweed extracts to broad beans greatly enhanced the crop's growth and yield characteristics, claim Hamza and Abbas, (2020).

Table (2): Impact of vermicompost and seaweed extract on yield and yield characters of strawberry in 2024 season.

Treatments	No. of flowers	Fruit Length (cm)	Fruit diameter (cm)	Fruit size (cm ³)	Fruit weight (g)	Yield (g/ plant)
A) Vermicompost						
Control	19.10	1.76	2.28	2.04	8.73	357.13
0.5 t/ha	20.90	2.33	2.37	2.16	9.76	378.81
1.0 t/ha	25.89	2.52	2.57	2.24	11.35	385.75
1.5 t/ha	29.66	2.93	2.76	2.59	11.97	392.56
2.0 t/ha	55.89	3.13	3.33	3.28	13.06	440.18
LSD _(0.05)	1.09	0.02	0.07	0.05	0.68	17.78
B) Seaweed extract (SWE)						
Control	21.20	1.85	2.53	2.27	9.69	396.42
500 mg/l	23.20	2.37	2.68	2.39	10.83	420.48
1000 mg/l	28.74	2.63	2.85	2.49	12.60	428.18
1500 mg/l	32.92	3.36	3.06	2.88	13.29	435.74
2000 mg/l	62.04	3.18	3.69	3.64	14.50	488.60
LSD _(0.05)	1.21	0.02	0.07	0.05	0.76	19.74

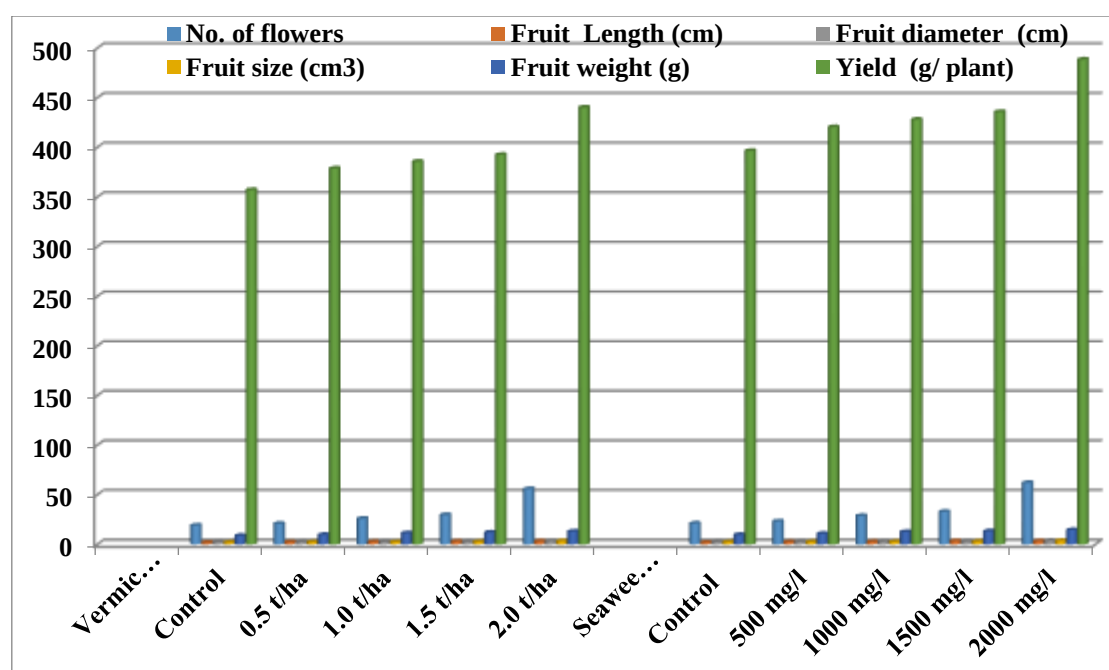


Fig. (2): Impact of vermicompost and seaweed extract on yield and yield characters of Strawberry in 2024 season.

C) Chemical composition:

The results displayed in **Tables (3 and 4)** and **Figs. (3 and 4)** demonstrated the impact of seaweed extract and vermicompost on the chemical composition of strawberries during the 2024 season. On the other hand, when the amount of vermicompost and seaweed extract was decreased, all of the chemical composition features that were studied significantly decreased. The mean values of chemical composition traits were lowest in untreated plants.

However, spraying of seaweed extract at concentration of 2000 mg/ l recorded the higher values of TSS (10.86 %), acidity (0.48 %), total sugar (4.01 cm), VC (69.30 mg/100 g F.W), anthocyanin (59.34 mg/100g F.W),

carbohydrates (249.62 mg/g D.W.), N (1.85 %), P (0.82 %), K (3.43%), Ca (2.25 %), Mg (0.91 %), followed by seaweed extract at concentration of 1500 mg/l which recorded TSS (10.01 %), acidity (0.62 %), total sugar (3.88 cm), VC (67.98 mg/100 g F.W), anthocyanin (58.65 mg/100g F.W), carbohydrates (242.72 mg/g D.W.), N (1.60 %), P (0.74 %), K (3.07 %), Ca (2.09 %), Mg (0.84 %), as compared to control treatment which recorded the lower values of TSS (6.19 %), acidity (0.74 %), total sugar (2.53 cm), VC (60.63 mg/100 g F.W), anthocyanin (53.16 mg/100g F.W), carbohydrates (187.19 mg/g D.W.), N (1.39 %), P (0.60 %), K (1.98 %), Ca (1.43 %), Mg (0.71 %), respectively.

In this respective, vermicompost concentration of 2 t/ha recorded the higher values of TSS (9.79 %), acidity (0.43 %), total sugar (3.61 cm), VC (62.43 mg/100 g F.W), anthocyanin (53.46 mg/100g F.W), carbohydrates (237.74 mg/g D.W.), N (1.66 %), P (0.74 %), K (3.09 %), Ca (2.02 %), Mg (0.82 %), followed by seaweed extract at concentration of 1.5 t/ha which recorded TSS (9.02 %), acidity (0.56 %), total sugar (3.50 cm), VC (61.25 mg/100 g F.W), anthocyanin (52.84 mg/100g F.W), carbohydrates (231.16 mg/g D.W.), N (1.44 %), P (0.67 %), K (2.76 %), Ca (1.88 %), Mg (0.76 %), as compared to control treatment which recorded the lower values of TSS (5.58%), acidity (0.67 %), total sugar (2.12 cm), VC (54.63 mg/100 g F.W), anthocyanin (47.89 mg/100g F.W), carbohydrates (178.28 mg/g D.W.), N (1.25 %), P (0.54 %), K (1.79 %), Ca (1.29 %), Mg (0.64 %), respectively.

According to **El Sagan (2015)**, applying algal extract topically at a concentration of 1.5 mg/l significantly increased the chemical content (N, P, and K content) of cucumber leaves. **Shafey et al. (1994)** and **Chhun et al. (2004)** suggest that a number of growth substances, such as auxins, which increase building metabolites, promote growth, delay senescence, improve cell division, increase chlorophyll accumulation, and stimulate dry matter production, may be responsible for the increase in these elements. This is due to the fact that enhanced translocation and accumulation of microelements in plant organs are caused by increased photosynthetic activity. It has been demonstrated that adding seaweed to wide beans increases their carbohydrate content. This could be due to the fact that seaweed contributes significantly to the biosynthesis of chlorophyll molecules, which in turn influences the total amount of carbohydrates by increasing the amount of different growth substances and the translocation of photosynthates from source to sink (**Thomas et al., 2009**).

Additionally, the most recent studies have focused on the nutritional and phytochemical components of strawberries as well as the factors affecting their composition. These studies led some scientists to conclude that strawberries, especially those produced organically, showed fruit quality characteristics that were on par with or better than those grown conventionally (**Baruzzi et al., 2009; Reganold et al., 2010**). The yield properties of strawberry cv. Albion berries (*Fragaria × ananassa* L.) are positively impacted by a number of natural fertilizers, according to **Ateş et al. (2015)**.

Organic strawberry farms produced higher-quality fruit, and their healthier soils may have greater microbial functional capacity and stress tolerance, according to **Reganol et al. (2010)**. Additionally, **Cayuela et al. (1997)** found that strawberries grown organically had higher sugar and dry matter (DM) levels; however, **Kobi et al. (2018)** found that strawberries produced conventionally and organically had similar sugar contents. Even though organic strawberries include more compounds that are essential to human health, there are still concerns about the systematic differences in nutrition and quality measures between conventionally grown and organic strawberry crops (**Sezer, 2010**). Additionally, the overuse of chemical pesticides and fertilizers may have been addressed by an organic agricultural system, particularly for fruits like strawberries that are edible without peeling (**Pokhrel et al., 2015; Campbell et al., 2021**). The amount of ascorbic acid in strawberries is increased by manure from the farm yard. Because organic fertilizers are hydrophilic, they take up moisture and nutrients and remain in the soil for a longer period of time. This improves soil structure and indirectly raises fruit quality and ascorbic acid levels (**Ali et al., 2003**).

Table (3): Impact of vermicompost and seaweed extract on chemical composition characters of strawberry in 2024 season

eatments	TSS (%)	Acidity (%)	Total sugar (%)	VC (mg/100 g F.W)	Anthocyanin (mg/100g F.W)	Carbohydrates (mg/g D.W.)
Vermicompost						
Control	5.58	0.67	2.12	54.63	47.89	178.28
0.5 t/ha	5.89	0.64	2.75	58.12	49.19	191.58
1.0 t/ha	7.41	0.61	3.22	59.54	51.29	205.68
1.5 t/ha	9.02	0.56	3.50	61.25	52.84	231.16
2.0 t/ha	9.79	0.43	3.61	62.43	53.46	237.74
LSD(0.05)	0.01	0.01	0.06	0.72	2.19	13.17
Seaweed extract (SWE)						
Control	6.19	0.74	2.35	60.63	53.16	187.19
500 mg/l	6.54	0.71	3.05	64.51	54.60	201.16

1000 mg/l	8.23	0.67	3.57	66.09	56.93	215.96
1500 mg/l	10.01	0.62	3.88	67.98	58.65	242.72
2000 mg/l	10.86	0.48	4.01	69.30	59.34	249.62
LSD(0.05)	0.01	0.01	0.06	0.80	2.21	13.24

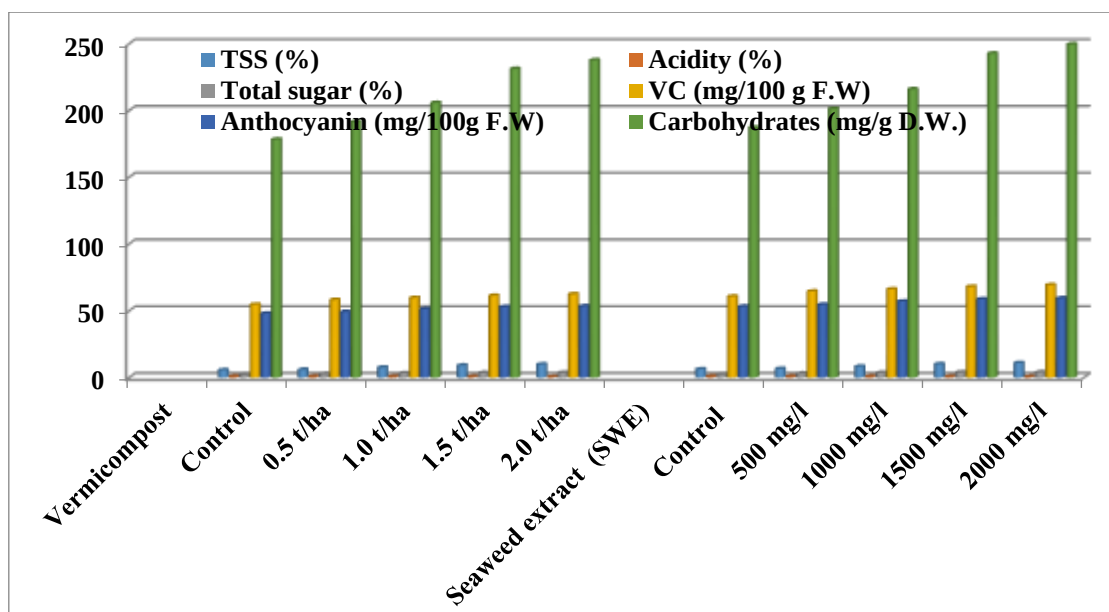


Fig. (3): Impact of vermicompost and seaweed extract on chemical composition characters of strawberry in 2024 season.

Table (4): Impact of vermicompost and seaweed extract on chemical composition characters of strawberry in 2024 season.

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
A) Vermicompost					
Control	1.25	0.54	1.79	1.29	0.64
0.5 t/ha	1.31	0.56	2.17	1.43	0.67
1.0 t/ha	1.37	0.61	2.53	1.67	0.71
1.5 t/ha	1.44	0.67	2.76	1.88	0.76
2.0 t/ha	1.66	0.74	3.09	2.02	0.82
LSD _(0.05)	0.23	0.02	0.22	0.02	0.02
B) Seaweed extract (SWE)					
Control	1.39	0.60	1.98	1.43	0.71
500 mg/l	1.46	0.62	2.40	1.59	0.74
1000 mg/l	1.52	0.67	2.80	1.86	0.79
1500 mg/l	1.60	0.74	3.07	2.09	0.84
2000 mg/l	1.85	0.82	3.43	2.25	0.91
LSD _(0.05)	0.28	0.05	0.31	0.05	0.04

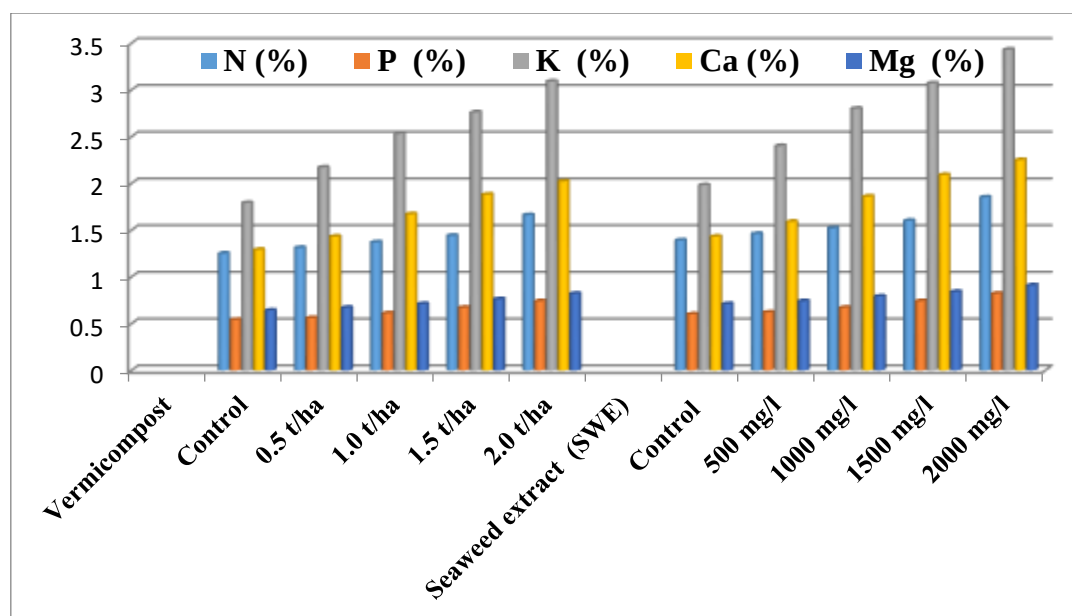


Fig. (4): Impact of vermicompost and seaweed extract on chemical composition characters of strawberry in 2024 season.

Conclusion

This study showed that applying seaweed extract topically improved strawberry plant growth, fruit production, and quality. Vermicompost application improved strawberry fruit quality metrics. It enables us to enhance the nutritional solutions and tailor them to the many physiological stages of the plant, including vegetative, flowering, fruit setting, magnification, and fruit maturity. In order to prevent the conflict, it also permits the correction of one of the elements' nutritional deficiencies. Additionally, it makes it possible to raise the pH and EC, which are essential for the highest organoleptic fruit quality and efficient absorption of macro and micronutrients.

References

- [1] Abdel-Mawgoud, A.M.R., Tantawy, A.S., El-Nemr, M.A. and Sassine Y.N. (2010). Growth and yield responses of strawberry plants to chitosan application. *Eur. J. Sci. Res.*, 39(1): 170-177.
- [2] Abdullaev, I., Bekchanova, M., Gandjaeva, L., Kholmatov, B., Raxmatullayev, A., Tajiye, Z., Razzakov, K., Matyakubov, Z., Doschanova, M. and Ruzmetov, R. (2023). Checklist of the earthworm fauna (Oligochaeta: Lumbricidae) of Uzbekistan. *Biodiversitas*, 24(8): 4392-4401.
- [3] Abu-Zahra, T. R., and Tahboub, A. A. (2009). Strawberry (*Fragaria ananassa* Duch.) fruit quality grown under different organic matter sources in a plastic house at Humrat Al-Sahen. *Acta Hort.*, 807: 353-358.
- [4] Alam, M.Z., Braun, G., Norrie, J. and Hodges, D. M. (2013). Effect of *Ascophyllum* extract application on plant growth, fruit yield and soil microbial communities of strawberry. *Can. J. Pl. Sci.*, 93: 23–36.
- [5] Ali, Y. M., Iqbal, S., Shah, Z. A. and Ahmed, M. J. (2003). Effect of different combinations of nitrogen, phosphorous and farm yard manure on yield and quality of strawberry. *Sarhad J. Agric.* 19: 185-188.
- [6] Al-Jubouri M. A. A. M. (2009). Effect of humic acid and sea algae on growth, flowering and yield of cucumber (*Cucumis sativus* L.), MSc. dissertation, Fac. Agric., Univ. Tikrit, Iraq.
- [7] Al-Marsoumi, H. G. K. (1999). Effect of some factors in recipes vegetative growth and flowering and hold seed in three varieties of onion (*Allium cepa* L.), Ph.D. dissertation, Fac. Agric. Univ. Baghdad, Iraq.
- [8] Al-Shatri, A.H.N., Pakyurek, M. and Yavic, A. (2020). Effect of seaweed application on nutrient uptake of strawberry cv. "Albion" grown under the environmental conditions of Northern Iraq. *Appli. Ecol. Environ. Res.*, 18(1): 1267-1279.
- [9] Al-Taey, D.K.A., Kamaluddin, Z.N. A. and Al-Kazemy, H. H. S. (2022). Impact of Zytonic-M and organic fertilizer on growth and yield of hybrid tomato Awahr (F1) under saline conditions. *Int. J. Vege. Sci.*, 28(4):1-6.
- [10] AOAC (2005). (Association of Official Analytical Chemists-International), Official Methods of Analysis. 18th edn., eds.: W. Hortwitz, G. W. Latimer, AOAC-Int. Suite 500, 481 North Frederick Avenue, Gaithersburg, Maryland, USA.

- [11] Arancon, N. Q., Edwards, C. A., Bierman, P., Welch, C. and Metzger, J. D. (2004). Influence of vermicomposts on field strawberries: 1. Effect on growth and yields. *Biores. Technol.*, 93: 145-153.
- [12] Arancon, N.Q., Edwards, C. A., Bierman, P., Metzger, L. D., Lee, S. and Welch, C. (2003). Effects of vermicomposts on growth and marketable fruits of field grown tomatoes, peppers and strawberries. *Pedobiologia*, 47: 731735.
- [13] Ates, S. (2015). Effects of several fertilizer kinds and mulch materials over yield and quality criteria of organic strawberry planting in Nevşehir Region. Ph.D. Thesis, Çukurova University, Inst. Nat. Appli. Sci. Dep. Horti., Adana, Turkey.
- [14] Atiyeh, R.M., Edwards, C.A., Subler, S. and Metzger, J.D. (2001). Pig manure vermicompost as a component of a horticultural bedding plant medium: Effects on physicochemical properties and plant growth. *Biores. Technol.*, 78: 11–20.
- [15] Baruzzi, G., Faedi, W., Lucchi, P., Migani, M., Sbrighi, P. and Turci, P. (2009). Performance of Italian strawberry genotypes on fumigated, non-fumigated soils and organic culture. *Acta Horti.*, 842: 553–556.
- [16] Basheer, M. and Agrawal, O.P. (2013). Effect of vermicompost on the growth and productivity of tomato plant (*Solanum lycopersicum*) under field conditions. *Int. J. Rec. Sci. Res.*, 4(3): 247–249.
- [17] Battacharyya, D., Babgohari, M. Z., Rathor, P. and Prithiviraj, B. (2015). Seaweed extracts as biostimulants in hortic. *Sci. Horti.*, <http://dx.doi.org/10.1016/j.scienta.2015.09.012>.
- [18] Cabilovski, R., Manojlovic, M.S., Popovic', B.M., Radojc'in, M.T., Magazin, N., Petkovi', C.K., Kovacevic, D. and Lakicevi, M.D. (2023). Vermicompost and vermicompost leachate application in strawberry production: impact on yield and fruit quality. *Horti.*, 9: 1–12.
- [19] Campbell, J., Sarkhosh, A., Habibi, F., Gajjar, P., Ismail, A., Tsoleva, V. and El-Sharkawy, I. (2021). Evaluation of biochemical juice attributes and color-related traits in muscadine grape population. *Foods*, 10: 1101.
- [20] Cayuela, A., Vidueira, M., Albi, M.A. and Gutie, F. (1997). Influence of the ecological cultivation of strawberries (*Fragaria ×ananassa* cv. Chandler) on the quality of the fruit and on their capacity for conservation. *J. Agric. Food Chem.*, 45: 1736–1740.
- [21] Chhun, T., Takcta, S., Tsurumi, S. and Masahiko, I. (2004). Different behaviour of indole-3-acetic acid and indole-3-butyric acid in stimulating lateral root development in rice (*Oryza sativa* L.). *Plant Growth Reg.*, 43: 135–143.
- [22] Cosme, F., Pinto, T., Aires, A., Morais, M.C., Bacelar, E. and Anjos, R. (2022). Red fruits composition and their health benefits -a review. *Foods*, 11.
- [23] De, L.C. and Bhattacharjee S.K. (2012). *Handbook of Edible Fruits*. Aavishkar Publishers, Jaipur - 302 003 (Rajasthan), India. 312p.
- [24] Demir, D., Günes, A., Inal, A. and Alpaslan, M. (2004). Effects of humic acids on the yield and mineral nutrition of cucumber (*Cucumis sativus* L.) grown with different salinity levels. *ishs acta horticulturae* 492.
- [25] Dubois, M., Gilles, K.A., Hamilton, J.K., Rebers, P.A. and Smith, F. (1956). Colorimetric method for determination of sugars and related substances. *Anal. Chem.*, 26: 350-356.
- [26] Edwards, C.A., Arancon, N.Q., Vasko-Bennett, M., Askar, A. and Keeney, G. (2010). Effect of aqueous extracts from vermicomposts on attacks by cucumber beetles (*Acalymna vittatum*) (Fabr.) on cucumbers and tobacco hornworm (*Manduca sexta*) (L.) on tomatoes. *Pedobiologia*, 53(2): 141–148.
- [27] El-Miniawy, S.M., Ragab, M.E., Youssef, S.M. and Metwally, A.A. (2014). Influence of foliar spraying of seaweed extract on growth, yield and quality of strawberry plants. *J. Appl. Sci. Res.*, 10(2): 88-94.
- [28] El-Miniawy, S.M., Ragab, M.E., Youssef, S.M. and Metwally, A.A. (2014). Influence of foliar spraying of seaweed extract on growth, yield and quality of strawberry plants. *J. Appl. Sci. Res.*, 10(2): 88-94
- [29] El-Sagan, M. A. M. (2015). Effect of some nutral extracts on growth and productivity of cucumber under sandy soil conditions. *Int. J. Adv. Res.*, 9 (3): 677686
- [30] Ergasheva, X. I., Ismailov, Z. F., Alikulov, B. S., Jo'raqulovna, N. X., Tillaeva, Z. F., Abdullaev, I. I., Raxmatullayev, A. Y. and Ergasheva, O. K. (2024). Biotechnological processing of organic and domestic waste and the effect of obtained vermicompost on soil fertility. *J. Ecol. Eng.*, 25(8): 119–129.
- [31] FAO, (2019). FAOSTAT-Food and Agriculture Organization Corporate Statistical Database. FAO Online Database.
- [32] Giampieri, F., Forbes-Hernandez, T.Y., Gasparrini, M., Alvarez-Suarez, J.M., Afrin, S., Bompadre, S., Quiles, J.L., Mezzetti, B. and Battino, M. (2015). Strawberry as a health promoter: An evidence based review. *Food Funct.*, 6: 1386–1398.

- [33] González-Jiménez, S.L., Castillo-González, A.M., García-Mateos, M., Valdez-Aguilar, L.A., Ybarra-Moncada, C. and Avitia-García, E. (2020). Response of strawberry cv. festival to salinity. *Revista Fitotecnia Mexicana* 43(1): 53-60.
- [34] Gundogdu, M., Berk, S.K., Yildiz, K., Canan, I., Ercisli, S. and Tuna, S. (2020). Effect of methyl jasmonate application on bioactive contents and agro-morphological properties of strawberry fruits. *Acta Sci. Pol. Hortorum Cultus*, 19: 133–142.
- [35] Hardan, M.H. and Al-Dulaimy, A.F.Z. (2022). Effect of humic acid addition and spraying with ginger rhizome extract on the growth and some chemical contents of apricot seedlings *Prunus armeniaca* L. cv. *Revis Bionatura*, 7(4): 1-6.
- [36] Hasan, A. M., Mohamed, A. T. J. and Al-Taey, D. K. A. (2020). Effects of winter foliar fertilizing and plant growth promoters on element and carbohydrate contents on the shoot of navel orange sapling. *Int. J. Fruit Sci.*, 19(1): 682-692.
- [37] Herencia, J. F., Garcia-Galavisa, P. A. Doradoa, J. A. R. and Maqueda, C. (2011). Comparison of nutritional quality of the crops grown in an organic and conventional fertilized soil. *Sci. Hort.*, 129: 882-888.
- [38] Hernández-Valencia, R.D., Juárez Maldonado, A., Pérez Hernández, A., Lozano Cavazos, C.J., Zermeño González, A. and González Fuentes, J.A. (2022). Influencia de fertilizantes orgánicos y del silicio sobre la fisiología, el rendimiento y la calidad nutracéutica del cultivo de fresa (Influence of organic fertilizers and silicon on the physiology, yield and nutraceutical quality of strawberry cultivation). *Nova Scientia*, 14(28):1-16.
- [39] Horwitz, W. and Latimer, G.W. (2000). Official methods of analysis of AOAC International. Gaithersburg: AOAC Int. (17th ed). Gaithersburg, Maryland.
- [40] Huneif, M.A., Alqahtani, S.M., Abdulwahab, A., Almedhesh, S.A., Mahnashi, M.H. and Riaz, M. (2022). α -Glucosidase, α -amylase and antioxidant evaluations of isolated bioactives from wild strawberry. *Mole.*, 27: 1–13.
- [41] Jackson, M.L. (1967). *Soil chemical analysis*, prentic hallpvt. Itd. India, 398.
- [42] Katel, S., Mandal, H. R., Kattel, S., Yadav, S. P. S. and Lamshal, B. S. (2022). Impacts of plant growth regulators in strawberry plant: A review. *Heliyon*, 8: 1-5.
- [43] Kessel, C. (2006). *Strawberry Diagnostic workshops: Nutrition*. Ministry of Agriculture, Food and Rural Affairs.
- [44] Khalil, N.H. and Agah, R.J. (2017). Effect of chemical, organic and bio fertilization on growth and yield of strawberry plant. *Adv. Chem. Biol. Sci.*, 4: 167–171.
- [45] Khan, W., Prithviraj, B. and Smith, D.L. (2003). Photosynthetic responses of corn and soybean to foliar application of salicylates. *J. Plant Physiol.*, 160: 485-492.
- [46] Khan, W., Rayirath, U.P., Subramanian, S., Jithesh, M.N., Rayorath, P., Hodges, D.M., Critchley, A.T., Craigie, J.S., Norrie, J. and Prithivira, B. (2009). Seaweed extracts as bio stimulants of plant growth and development”, *J. Plant Growth Regu.*, 28: 386-399.
- [47] Kobi, H.B., Martins, M.C., Silva, P.I., Souza, J.L., Carneiro, C.S., Heleno, F., Queiroz, M.E.L.R. and Costa, N.M.B. (2018). Organic and conventional strawberries: Nutritional quality, antioxidant characteristics and pesticide residues. *Fruits*, 73: 39–47.
- [48] Lazcano, C. and Domínguez, J. (2011). The use of vermicompost in sustainable agriculture: Impact on plant growth and soil fertility. In *Soil Nutrients*; Miransari, M., Ed.; Publisher Nova Sci.: Iran, 1–23.
- [49] Lishchuk, A., Parfenyk, A., Horodyska, I., Boroday, V., Ternovyi, Y. and Tymoshenko, L. (2023). Environmental risks of the pesticide use in agroecosystems and their management. *J. Ecol. Eng.*, 24(3): 199–212.
- [50] Mahmood, M.M. and Al-Dulaimy, A. F. (2021). Response of strawberry cv. “Festival” to culture media and foliar application of nano and normal micronutrients. *IOP Conf. Series: Earth Environ. Sci.*, 904: 1-11.
- [51] Malik, C.P. and Singh, M.B. (1980). Extraction and estimation of amino acids and keto acids. In: *Plant enzymology and histoenzymology*. (Eds.): CP. Malik, MB. Singh, Kalyani Publishers, New Delhi-Lud Hana, India, 286.
- [52] Mancini, M., Mazzoni, L., Leoni, E., Tonanni, V., Gagliardi, F., Qaderi, R. and Mezzetti, B. (2023). Application of near infrared spectroscopy for the rapid assessment of nutritional quality of different strawberry cultivars. *Foods*, 12(17): 3253.
- [53] Mazzoni, L., Di Vittori, L., Balducci, F., Forbes-Hernández, T.Y., Giampieri, F. and Battino, M. (2020). Sensorial and nutritional quality of inter and intraspecific strawberry genotypes selected in resilient conditions, *Sci. Horti.*, 261: 108945.

- [54] Mazzoni, L., Perez-Lopez, P., Giampieri, F., Alvarez-Suarez, J.M., Gasparrini, M., Forbes-Hernandez, T.Y., Quiles, J.L., Mezzett, B. and Battino, M. (2015). The genetic aspects of berries: From field to health. *J. Sci. Food Agric.*, 96: 365–371.
- [55] Miao, L., Zhang, Y., Yang, X., Xiao, J., Zhang, H., Jiang, M., Zhang, Z., Wang, Y. and Jiang, G. (2017). Fruit quality, antioxidant capacity, related genes and enzyme activities in strawberry (*Fragaria × ananassa*) grown under colored plastic film. *Horti. Sci.*, 52: 1241-1250.
- [56] Moursi, M.A., Tawfik, H.A. and Abdel Gawad, A. (1968). Principles of agricultural researches (in Arabic. Dar El-Hanna printing House, Cairo, 418.
- [57] Murad, H. J. and Al-Dulaimy, A.F.Z. (2021). Effects of spraying with urea and seaweed extract (Tecamin algae) on growth and chemical content of date palm tree cv. “Zahdi”. *IOP Conf. Series: Earth and Environ. Sci.*, 904: 1-7.
- [58] Muthukumaran, S., Tranchant, C., Shi, J., Ye, X. and Xue, S. J. (2017). Ellagic acid in strawberry (*Fragaria spp*): Biological, technological, stability, and human health aspects. *Food Qual. Saf.*, 1: 227–252.
- [59] Negi, Y.K., Sajwan, P., Uniyal, S. and Mishra, A.C. (2021). Enhancement in yield and nutritive qualities of strawberry fruits by the application of organic manures and biofertilizers, *Sci. Horti.*, 283: 110038.
- [60] Odongo, T., Isutsa, D. K. and Aguyoh, J. N. (2008). Effects of integrated nutrient sources on growth and yield of strawberry grown under tropical high altitude conditions. *Afr. J. Hort. Sci.* 1: 53-69.
- [61] Page, A.L., Miller, R.H. and Keeney, D.R. (1982). Methods of soil analysis-chemical and microbiology properties, SSSA Inc., Mad., WI., USA.
- [62] Papenfus, H.B., Kulkarni, M. G., Stirk, W. A., Finnie, J. F. and Van Staden, J. (2013). Effect of a commercial seaweed extract (Kelpak®) and polyamines on nutrient-deprived (N, P, K) okra seedlings. *Sci. Horti.*, 151: 142–146
- [63] Piper, C.S. (1950). Soil and plant analysis.1st Ed. Interscience Publishers Inc., New York, USA, 30-59.
- [64] Pokhrel, B., Laursen, K.H. and Petersen, K.K. (2015). Yield, quality, and nutrient concentrations of strawberry (*Fragaria × ananassa* Duch. cv. “Sonata”) grown with different organic fertilizer strategies. *J. Agric. Food Chem.*, 63: 5578–5586.
- [65] Reganold, J.P., Andrews, J.P., Reeve, J.R., Carpenter-Boggs, L., Schadt, W.C., Alldredge, J.R., Ross, C.F., Davies, N.M. and Zhou, J. (2010). Fruit and soil quality of organic and conventional strawberry agroecosystems. *PLoS One*, 5: e12346.
- [66] Rehman, S., Castro, F., Aprile, A., Benedetti, M. and Fanizzi F.P. (2023). Vermicompost: enhancing plant growth and combating abiotic and biotic stress. *Agron.*, 13: 1–25.
- [67] Santos, B.M. and Chandler, C. K. (2009). Influence of nitrogen fertilization rates on the performance of strawberry cultivars. *Int. J. Fruit Sci.*, 9: 126–135.
- [68] Sapei, L. and Hwa, L. (2014). Study on the kinetics of vitamin C degradation in fresh strawberry Juices. *Procedia Chem.*, 9: 62–68.
- [69] Schmidt, R.E. (2005). Biostimulants function in turfgrass nutrition. phd emeritus virginia tech.
- [70] Sezer, L. (2010). Mardin İli Kızıltepe İlçesinde Organik Çilek Yetiştiriciliği Olanaklarının Araştırılması. Master’s Thesis, Çukurova University, Fen Bilimleri Enstitüsü, Bahçe Bitkileri Anabilim Dalı, Adana, Turkey, (In Turkish).
- [71] Shafey, S.A., Salem, M.S.A. and Yassien, H.E. (1994). Harb OMS. Effect of indole 1-3 acetic acid (IAA) on growth and yield of some Egyptian wheat varieties. *J. Agric. Sci. Mansoura Univ.* 19(12): 4113-4120.
- [72] Simkova, K., Veberic, R., Hudina, M., Grohar, M. C., Ivancic, T., Smrke, T., Pelacci, M. and Jakopic, J. (2023). "Variability in ‘Capri’ everbearing strawberry quality during a harvest season. *Foods*, 12(6): 1349.
- [73] Singh, Amrit Kumar, Nayyer Md. Abu, Singh Anupam, Rai Devashish, Singh Aditya Pratap and Rai Ankur (2022). Effect of FYM and vermicompost on growth and yield on strawberry (*Fragaria × ananassa* Duch.) cv. “Camarosa”. *The Pharma Innov. J.*, 11(6): 1803-1806.
- [74] Solovchenko, A.E., Chivkunova, O.B., Merzlyak, M.N. and Gudkovsky, V. A. (2001). Spectrophotometric analysis of pigments in apples. *Russ. J. Plant. Physiol.*, 48: 693–700.
- [75] Spinelli, F., Giovanni, F., Massimo, N., Mattia, S. and Guglielmo, C. (2009). Perspectives on the use of a seaweed extract to moderate the negative effects of alternate bearing in apple trees, *J. Hort. Sci. Biotechn.*, 17(1): 131-137.
- [76] Taghavi, T., Dale, A., Hughes, B. and Zandstra, J. (2016). The performance of dayneutral strawberries differs between environments in Ontario, *Can. J. Plant Sci.*, 96: 662–669.

- [77] Tagliavini, M. E., Baldi, E., Lucchi, P., Antonelli, M., Sorrenti, G., Baruzzi, G. and Faedi, W. (2005). Dynamics of nutrient uptake by strawberry plants (*Fragaria x Ananassa* Duch.) grown in soil and soilless culture. *Eur. J. Agro.*, 23: 15–25.
- [78] Thirumaran, G., Arumugam, M. Arumugam, R. and Anantharaman, P. (2009). Effect of seaweed liquid fertilizer on growth and pigment concentration of *Abelmoschus esculentus* (1) medikos. *American-Eurasian J. Agron.*, 2(2): 57-66.
- [79] Thoudam, J. and Kotiyal, A. (2022). Effect of biofertilizers and organic fertilizers on growth and yield of strawberry cv. “Camarosa”. *The Pharma Innov. J.*, 11: 2324–2327.
- [80] Unal, N., Ibrahim, K., Seyed, H. H., Jale, B. and Volkan, O. (2023). Effect of different growing media on pomological and phytochemical parameters of *Fragaria vesca*» Yellow Wonder¹/₄ and *Fragaria x ananassa* ‘Camarosa’: A comparative study. *BMC Plant Biol.*, 23: 400.
- [81] Urün, I., Attar, S.H., Sönmez, D.A., Gündesli, M.A., Erci, S., Kafkas, N.E., Bandic, L.M. and Duralija, B. (2021). Comparison of polyphenol, sugar, organic acid, volatile compounds, and antioxidant capacity of commercially grown strawberry cultivars in Turkey. *Plants*, 10: 1654.
- [82] Wahlang, F. C. and Joseph, A. V. (2024). Effect of growing media and containers on the vegetative, biochemical and organoleptic parameters of strawberry (*Fragaria ananassa* Duch.) cv. winter dawn. *Plant Arch.*, 24(2): 1209-1219.
- [83] Walia, A, Gupta A.K. and Sharma V. (2019). Role of bioactive compounds in human health. *Acta Sci. Med. Sci.*, 3(9): 25–33.
- [84] Wu, Q., Zhou, W., Chen, D., Cai, A., Ao, J. and Huang, Z. (2020). Optimizing soil and fertilizer phosphorus management according to the yield response and phosphorus use efficiency of sugarcane in Southern China. *J. Soil Sci. Plant Nutri.*, 20: 1655–1664.
- [85] Yamasaki, A. (2013). Recent progress of strawberry year-round production technology in Japan, JARQ (Jpn. Agric. Res. Q.) 47: 37–42.
- [86] Zaller, J.G. (2007). Vermicompost in seedling potting media can affect germination, biomass allocation, yields and fruit quality of three tomato varieties. *Eur. J. Soil Biol.*, 43: 332–336.
- [87] Zhang, X. and Schmidt, R.E. (1997). The impact of growth regulators on the atocopherol status in water-stressed *Poa pratensis* L. *Int. Turfgrass Res. J.*, 8: 1364–1373.
- [88] Zhang, X. and Schmidt, R.E. (2000). Hormone-containing products’ impact on antioxidant status of tall fescue and creeping bentgrass subjected to drought. *Crop Sci.*, 40:1344-1349.
- [89] Zuhair, A. D. (2010). Effect of foliar spray of zinc and liquorice root extract on some vegetative and flowering growth parameters of two strawberry varieties (*Fragaria x ananassa* Duch.) Mesopotamia *J. Agric.*, 38:151-158.

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