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# Effect of Some Foliar Spray Plant Stimulants on Growth, Yield and Quality of Strawberry under Biochar and Fulvic Acid Application

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## ABSTRACT

Strawberry is one of the most Egyptian important vegetable crops for exports. So, a field experiment was conducted over two growing seasons (2021/2022 and 2022/2023) using a split-plot design to investigate the impact of two soil amendments as the main plots, including biochar at a rate of 5.0 $m^3$ $fed^{-1}$ and fulvic acid 10 kg $fed^{-1}$. Also, the study aimed to investigate the benefits of foliar applications, in the sub-main plots involving organic carbon (1.0 $cmL^{-1}$), seaweed extract (1.0 $cmL^{-1}$), and potassium silicate (2.0 $cmL^{-1}$), in addition to control. The study involved measuring some parameters, including foliage fresh and dry weights, no. of branches $plant^{-1}$, leaf area ($cm^2$ $plant^{-1}$), chlorophyll content, as well as the percentage of NPK in the leaves. Additionally, the research included the evaluation of fruit characteristics, such as average fruit weight, fruit dry matter, No. of fruits plant, fruit firmness, total soluble solids, total sugars, vitamin C content and anthocyanin. Results showed that plants grown in soil treated with fulvic acid were the best than biochar, while the control plants had the least effective results. As for the foliar applications, with potassium silicate demonstrated the best performance, followed by seaweed then organic carbon as compared with control. The combinations of fulvic acid and potassium silicate appear particularly promising for achieving optimal results and enhance strawberry production for local and export market growth.

**Keywords**: Strawberry -Potassium silicate- Organic carbon - Seaweed - Fruit characters

## INTRODUCTION

In Egypt, where strawberries are cultivated extensively, they represent a significant contribution to the agricultural export market. However, this agricultural treasure faces formidable environmental challenges, primarily driven by the degradation of arable lands and other adverse conditions that hinder their ideal cultivation (Abd-El-Kareem et al., 2022).

To combat these challenges and optimize the strawberry production, researchers have turned to innovative approaches. Among these, biochar, a carbon-rich material derived from the pyrolysis of organic matter (Weber and Quicker, 2018), plays a pivotal role in enhancing plant growth and improving soil properties (Das et al., 2020). Biochar is known for its ability to increase soil fertility, water, and nutrient holding, making it a valuable tool in sustainable agriculture and environmental management (Sanchez-Reinoso et al., 2020). It is produced by heating organic matter, such as agricultural residues or wood, in a low-oxygen environment, which prevents the material from fully combusting and results in the creation of a stable carbon-rich product that can be incorporated into the soil to improve its structure and nutrient-holding capacity (Elsherpiny, 2023).

Additionally, fulvic acid, a specialized soil conditioner, has gained prominence for its role in fostering both plant and soil health, contributing to the overall success of agricultural practices (Ukalska-Jaruga et al., 2018). Fulvic acid is a natural organic compound that is a component of humus, the organic component of soil (Ukalska-

Jaruga et al., 2022). It is formed through the decomposition of organic matter, such as dead plants and microorganisms, in the soil. It is characterized by its low molecular weight and high solubility in water. It plays a significant role in soil and plant health and is often used as a soil conditioner and plant growth promoter in agriculture (Liu et al., 2022). Fulvic acid is known for its ability to chelate, or bind to, minerals and nutrients, making them more readily available to plants. It also improve soil structure, increases nutrient uptake by plants, and enhances the overall fertility of the soil. Additionally, fulvic acid has been studied for its potential to stimulate plant growth, increase strawberry yields, and improve plant resistance to stress such as drought and disease (Martinez-De la Cruz et al., 2022).

Furthermore, foliar spraying is a technique that involves applying specific solutions directly to the plant leaves, the maximizing crop yields and nutritional quality (Krishnasree et al., 2021). Seaweed-based solutions have gained recognition for their beneficial effects on plant growth (Azeez and Taha, 2022). Overall, seaweed extracts are used as organic fertilizers and soil conditioners in agriculture. They can improve soil structure, increase nutrient availability, and enhance plant growth and strawberry yields (Rana et al., 2023).

Potassium silicate, or potassium metasilicate, is a chemical compound comprising potassium (K), silicon (Si), and oxygen (O). Its distinctive characteristics and advantages make it a common choice for agricultural purposes (El-Sherpiny et al., 2022). It serves as a dual source of potassium (K) and silicon (Si) for plants, its silicate form, being a crucial nutrient for fostering strawberry growth (Shafiei et al., 2022). This nutrient reinforces cell walls, bolsters resistance against pests and diseases, and contributes to the overall well-being of plants. Additionally, potassium, another essential nutrient, supports the development of flowers and fruits while enhancing the overall vitality of plants (Hussain et al., 2022).

The foliar application of organic carbon refers to the process of applying organic carbon-based solutions directly to the leaves and stems of plants. This practice is a part of modern agricultural and horticultural techniques aimed at improving plant health and overall crop production. Organic carbon solutions used for foliar application are typically derived from organic matter and can include substances like humic acid, fulvic acid, and other natural organic materials. Organic carbon sprays can enhance the absorption of essential nutrients by plants, promoting better growth and development. Foliar applications of organic carbon can help plants become more resistant to environmental stresses, such as drought, heat, and disease, by strengthening their natural defense mechanisms. The application of organic carbon through foliar spraying is a valuable tool in modern agriculture, providing a means to address nutrient deficiencies, enhance plant vigor, and ultimately increase crop yields and quality of strawberry (Al-Karawi and Al-Rawi, 2016).

Therefore, the overarching aim of this study, conducted over two strawberry growing seasons, was to investigate the potential impacts of soil amendments, such as biochar and fulvic acid, and foliar applications, including organic carbon, seaweed, and potassium silicate, on strawberry cultivation in Egypt. The study sought to assess how these practices influence various plant parameters and fruit characteristics, ultimately aiming to enhance strawberry production, improve its quality, and contribute to Egypt's continued leadership in global strawberry cultivation and export.

## MATERIALS AND METHODS

### 1. Experimental site and soil sampling

During the two seasons of 2021/2022 and 2022/2023, a field experiment was carried out at the Agricultural Research Center's (ARC) Experimental farm in Paramon village, Mansoura city, Egypt. The soil's physical and chemical characteristics at the experimental site are detailed in **Table (1),** based on soil samples collected (from a depth of 0-30 cm) prior to the experiment. These samples were analyzed using established methods as outlined by Buurman et al. (1996).

**Table (1). Characters of the initial soil (average of both seasons).**

| Particle size distribution, % | | | | | Soil moisture constants,% | | | Available element, mg kg $^{-1}$ | | | Chemical properties | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **C. sand** | **F. sand** | **Silt** | **Clay** | **Textural class is Clay** | ***FC** | ****S** | *****WP** | **N** | **P** | **K** | **EC, dSm $^{-1}$** | **pH** | **O.M,%** |
| 5.30 | 10.23 | 35.78 | 48.69 | | 44.5 | 89.0 | 22.3 | 46.5 | 7.03 | 215.3 | 2.25 | 7.9 | 1.22 |

***FC**= Field capacity
****S**= Saturation percentage
*****WP**= Wilting point

## 2. Studied substances

**Biochar:** The process of characterizing biochar followed the methodology described. Plant residues, including rice, barley, wheat, and maize straw, were sourced from private farms and transported to the ARC. The pyrolysis of these plant residues was conducted in an oxygen-free environment at temperatures ranging from 400 to 500 °C for a period of two hours. The resulting biochar exhibited the following properties: a nitrogen content (N) of 1.39 %, an organic carbon content (OC) of 45.10%, a pH value of 8.8, an electrical conductivity (EC) value of 5.1 dSm $^{-1}$, and a cation exchange capacity (CEC) value of 64.0 cmol kg $^{-1}$.

**Fulvic acid (FA):** It was obtained from the Egyptian commercial market then the studied rate was prepared. The FA product consisted of trace minerals, such as iron, zinc, copper, and others. These minerals are chelated or bound to the fulvic acid molecules, which can enhance their availability to plants as mentioned in its brochure. Also, it contains phenolic compounds, organic acids, and polyphenols.

**Seaweed**: It was obtained from Eco Agro Company in Egypt then the studied rate was prepared. The seaweed product consisted of 20% algae extract, 1.5% alginic acid, and 0.5% mannitol in its composition.

**Potassium silicate ($K_2SiO_3$, 60.0 %K) and organic carbon:** They were purchased from Egyptian commercial market, and then the required application rates were prepared for the study.

## 3. Strawberry transplants

Fresh transplant of the Festival variety were acquired from ARC then transplanted on 20th October during both seasons. Before the transplanting process, all transplants were meticulously selected, with particular attention given to their crown diameter, ensuring that each seedling had a crown diameter of more than 0.5 cm.

## 4. Experimental set up:

A field experiment using a split-plot design to investigate the impact of soil amendments as the main plots, including biochar at a rate of 5.0 $m^3$ fed $^{-1}$ and fulvic acid at a rate of 10 kg fed $^{-1}$. The study also aimed to assess the benefits of foliar applications, with sub-main plots involving organic carbon (1.0 cmL $^{-1}$), seaweed (1.0 cmL $^{-1}$), and potassium silicate (2.0 cmL $^{-1}$). Control groups were established for each factor. Biochar and fulvic acid were applied at the beginning of the experiment. The foliar treatments were administered three times, specifically on days 70, 85, and 100 after the transplanting of the seedlings. Calcium superphosphate fertilizer with a phosphorus content of 15% ($P_2O_5$) was applied at a rate of 150 kg per feddan. After plowing and disking of the soil, planting lines were established, surveyed, and divided into terraces, each measuring 120 cm in width. The experimental unit covered an area of 14.4 $m^2$, comprising three beds, each 1.6 m wide and 3.0 m long. Within each bed, four rows of transplants were accommodated, totaling 140 plants per plot. For irrigation purposes, each bed was equipped with two dripper lines spaced 25 cm apart, delivering water at a rate of 4 l/h. Before planting, the fresh strawberry transplants were immersed in a disinfectant solution (Rhizolex solution) at a concentration of 3.0 g per liter for 30 minutes. After disinfection, the transplants were immediately planted, maintaining a 25 cm spacing between them on both sides of the dripper lines.

After 35 days from the transplanting date, the beds were mulched with brown-silvery plastic mulch measuring 60 microns in thickness. During the vegetative growth phase, every cubic meter of irrigation water was supplemented with 500 $cm^3$ of compound fertilizer containing 10% nitrogen (N), 2% phosphorus (P), 6% potassium (K), and microelements. In the flowering stage, the same amount of compound fertilizer, comprising 10% nitrogen (N), 4% phosphorus (P), 8% potassium (K), and microelements, was added to each cubic meter of irrigation water. During the fruiting stage, 500 $cm^3$ of compound fertilizer with 8% nitrogen (N), 2% phosphorus (P), 10% potassium (K), and microelements was incorporated into every cubic meter of irrigation water.

**5. Measurements**

Growth characteristics and leaf chemical constituents were evaluated by collecting samples from the central three rows of each experimental plot after 60 days of transplanting in both seasons. These samples were used to assess the following parameters;

- Foliage fresh and dry weights (g $plant^{-1}$)
- No. of branches $plant^{-1}$
- Leaf area ($cm^2$ $plant^{-1}$) according to Watson (1952)
- No. of secondary crown $plant^{-1}$
- Leaves content of chlorophyll (a and b mg $g^{-1}$)
- Percentage of nitrogen, phosphorus and potassium

Chlorophyll content (a and b) was assessed following the procedure described by Johan et al. (2014). Leaf samples were extracted using 80% acetone and the absorbance at wavelengths 663 nm and 645 nm was measured using a spectrophotometer. The digestion of strawberry leaves was carried out using a mixture of sulfuric acid ($H_2SO_4$) and perchloric acid ($HClO_4$), following the method described by Gotteni et al. (1982). The determination of total nitrogen (N), phosphorus (P), and potassium (K) percentages was performed using a Micro Kjeldahl apparatus, a spectrophotometer and a flame photometer, respectively, as outlined by Jones et al. (1991).

Strawberry fruits were harvested when they reached a size suitable for the market. They were then weighed and counted to determine

1-the average fruit weight (g)
2-fruit dry matter (%)
3- No. of fruits $plant^{-1}$
4- Yield (marketable and unmarketable, metric ton $ha^{-1}$)
5-The early yield was determined as the cumulative yield from December to March, while the total yield was assessed by recording the weights of all harvested fruits from each plot until the 3rd of June. At the first week of April, the quality traits of fruits *i.e.,* Total soluble solids (TSS, %), total sugars (%),fruit firmness (g $cm^2$), vitamin C (VC, mg 100 ml $juice^{-1}$) were determined according to AOAC (2000). In addition, anthocyanin pigment [mg 100 ml $juice^{-1}$, as described by Crecente-Campo et al., (2012)] was determined.

**6. Statistical analysis**

Statistical analysis was conducted following the approach outlined by Gomez and Gomez (1984). To assess the significance of treatment means, they were compared against the least significant differences test (L.S.D.) at a 5%

significance level. This analysis was performed using CoStat version 6.303 (1998-2004).

## RESULT AND DISCUSSION

### 1- Growth criteria, photosynthetic pigments and leaf chemical constituents

**Tables (2 and 3)** provide a comprehensive presentation of how soil amendments, such as biochar and fulvic acid, as well as foliar applications, including organic carbon, seaweed and potassium silicate, influence the performance of strawberry plants after 60 days of transplanting. The data includes both of the individual effects of both soil and foliar applications and all interactions between them on vegetative growth characteristics of strawberries, including foliage fresh and dry weights (g plant$^{-1}$), no. of branches plant$^{-1}$, leaf area (cm$^{2}$ plant$^{-1}$), no. of secondary crown plant$^{-1}$ and leaves content of chlorophyll (a and b mg g$^{-1}$) , as well as the percentage of nitrogen, phosphorus, and potassium in the leaves during seasons of (2021/202), (2022/2023). Results showed that the most favorable outcomes were obtained in plants grown in soil treated with fulvic acid, followed by biochar, while the control group had the lowest effective results. In terms of foliar applications, potassium silicate demonstrated the best performance, followed by seaweed then organic carbon and lately control treatments. Generally, it can be noticed that the maximum values of all aforementioned traits were achieved with the combined treatment of fulvic acid and potassium silicate. The same trend was found for both studied seasons.

The findings reveal that the soil amendments (biochar and fulvic acid) and foliar applications (organic carbon, seaweed, and potassium silicate) have a substantial impact on the development and performance of the strawberry plants.

The observed superior performance of strawberry plants in soil treated with fulvic acid can be attributed to several scientific reasons. Fulvic acid, a component of humic substances, is known to enhance nutrient availability and uptake by plants. It chelates essential minerals, making them more accessible to the plant roots. This results in improved plant nutrition, which, in turn, fosters robust vegetative growth. Additionally, fulvic acid promotes the development of a favorable soil environment for microbial activity, enhancing nutrient cycling and further benefiting plant health. The results are consistent with the findings reported by Ukalska-Jaruga et al. (2018 and 2022).

Biochar, while also exhibiting positive effects, might have been slightly less effective in this study due to its slower nutrient release characteristics. Biochar is recognized for its long-term impact on soil fertility, carbon sequestration, and microbial activity. Biochar is rich in carbon, and when incorporated into the soil, it acts as a stable organic matter that can retain and release nutrients over an extended period. This enhances the soil's nutrient-holding capacity, making essential elements like nitrogen, phosphorus, and potassium more available to plants. It also reduces nutrient leaching, preventing environmental pollution. Moreover, it helps enhance soil structure by increasing its porosity and water-holding capacity. This improved soil structure allows for better root penetration, aeration, and water infiltration. Also, it enhances the soil's CEC, which is its ability to retain and exchange cations (positively charged ions). This contributes to improved nutrient retention and availability for plants. Finally, its application can lead to improved soil health, thus strawberry performance. The findings are in harmony with those of Das et al. (2020) and Sanchez-Reinoso et al. (2020).

**Table (2). Impact of biochar and fulvic acid and foliar applications, with organic carbon, seaweed, and potassium silicate, on the vegetative growth characteristics of strawberry plants during 2021/2022 and 2022/2023 seasons.**

| Treatments | | Foliage fresh weight (g plant$^{-1}$) | | Foliage dry weight (g plant$^{-1}$) | | Secondary crowns | | Leaf area ( cm$^2$ plant$^{-1}$) | | No. of secondary crown plant$^{-1}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season |
| **Main factor: Soil additions** | | | | | | | | | | | |
| **Control: Without** | | 57.92c | 59.74c | 11.21c | 11.54c | 10.17c | 10.50c | 425.67c | 444.00c | 3.33b | 4.75c |
| **Biochar** | | 62.20b | 64.09b | 13.06b | 13.44b | 12.25b | 13.58b | 467.75b | 487.08b | 4.00b | 5.67b |
| **Fulvic acid** | | 65.82a | 67.89a | 14.84a | 15.33a | 17.00a | 18.75a | 503.00a | 522.75a | 4.92a | 6.67a |
| **LSD at 5%** | | **0.14** | **0.63** | **0.54** | **0.05** | **0.30** | **0.30** | **4.10** | **4.29** | **0.73** | **0.75** |
| **Sub main factor: Foliar applications** | | | | | | | | | | | |
| **Control: top water** | | 60.44c | 62.23d | 12.38d | 12.77c | 12.00c | 12.78c | 451.33d | 469.22d | 3.78a | 5.33a |
| **Organic carbon** | | 61.46bc | 63.36c | 12.86c | 13.26b | 13.00b | 13.89b | 461.22c | 480.67c | 4.00a | 5.67a |
| **Seaweed** | | 62.55ab | 64.54b | 13.26b | 13.64b | 13.67ab | 15.00a | 469.11b | 488.56b | 4.11a | 5.78a |
| **Potassium silicate** | | 63.47a | 65.50a | 13.66a | 14.08a | 13.89a | 15.44a | 480.22a | 500.00a | 4.44a | 6.00a |
| **LSD at 5%** | | **1.96** | **0.93** | **0.35** | **0.42** | **0.81** | **0.85** | **6.87** | **7.35** | ***N.S** | ***N.S** |
| **Interaction** | | | | | | | | | | | |
| **Control** | **Control** | 56.00 | 57.86 | 10.51 | 10.84 | 10.00 | 10.00 | 407.67 | 424.67 | 3.00 | 4.33 |
| | **Organic carbon** | 57.34 | 59.12 | 11.04 | 11.36 | 10.00 | 10.00 | 422.67 | 441.33 | 3.33 | 4.67 |
| | **Seaweed** | 58.53 | 60.34 | 11.45 | 11.76 | 10.00 | 11.00 | 431.67 | 450.33 | 3.33 | 5.00 |
| | **Potassium silicate** | 59.81 | 61.63 | 11.82 | 12.21 | 10.67 | 11.00 | 440.67 | 459.67 | 3.67 | 5.00 |
| **Biochar** | **Control** | 60.87 | 62.58 | 12.42 | 12.80 | 11.00 | 11.00 | 453.67 | 471.33 | 3.67 | 5.33 |
| | **Organic carbon** | 61.66 | 63.69 | 12.88 | 13.24 | 12.00 | 13.00 | 462.33 | 483.33 | 4.00 | 5.67 |
| | **Seaweed** | 62.92 | 64.83 | 13.29 | 13.67 | 13.00 | 15.00 | 470.33 | 490.00 | 4.00 | 5.67 |
| | **Potassium silicate** | 63.35 | 65.27 | 13.67 | 14.07 | 13.00 | 15.33 | 484.67 | 503.67 | 4.33 | 6.00 |
| **Fulvic acid** | **Control** | 64.45 | 66.25 | 14.20 | 14.67 | 15.00 | 17.33 | 492.67 | 511.67 | 4.67 | 6.33 |
| | **Organic carbon** | 65.37 | 67.27 | 14.66 | 15.19 | 17.00 | 18.67 | 498.67 | 517.33 | 4.67 | 6.67 |
| | **Seaweed** | 66.20 | 68.46 | 15.03 | 15.48 | 18.00 | 19.00 | 505.33 | 525.33 | 5.00 | 6.67 |
| | **Potassium silicate** | 67.25 | 69.59 | 15.48 | 15.97 | 18.00 | 20.00 | 515.33 | 536.67 | 5.33 | 7.00 |
| **LSD at 5%** | | **3.39** | **1.61** | **0.61** | **0.73** | **1.40** | **1.48** | **11.91** | **12.72** | **1.78** | **1.72** |

Means within the same column followed by a different letter (s) are statistically different at a 0.05 level.*N.S= Non-significant.

**Table (3). Impact of biochar and fulvic acid and foliar applications, with organic carbon, seaweed and potassium silicate, on both the photosynthetic pigments and chemical constituents in leaves of strawberry plants during 2021/2022 and 2022/2023 seasons.**

| Treatments | | Chlorophyll a | | Chlorophyll b | | Leaves nitrogen | | Leaves phosphorus | | Leaves potassium | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (mg $g^{-1}$) | | | | ( %) | | | | | |
| | | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season |
| **Main factor: Soil additions** | | | | | | | | | | | |
| **Control: Without** | | 0.807c | 0.842c | 0.631c | 0.657c | 2.85c | 2.99c | 0.401c | 0.407c | 2.50c | 2.62c |
| **Biochar** | | 0.870b | 0.906b | 0.660b | 0.687b | 3.09b | 3.25b | 0.431b | 0.438b | 2.79b | 2.93b |
| **Fulvic acid** | | 0.930a | 0.967a | 0.691a | 0.720a | 3.31a | 3.47a | 0.456a | 0.462a | 3.03a | 3.18a |
| **LSD at 5%** | | **0.021** | **0.022** | **0.014** | **0.021** | **0.03** | **0.05** | **0.003** | **0.003** | **0.03** | **0.04** |
| **Sub main factor: Foliar applications** | | | | | | | | | | | |
| **Control: Top water** | | 0.848d | 0.881d | 0.649c | 0.676c | 3.01c | 3.16c | 0.420c | 0.427c | 2.69d | 2.82d |
| **Organic carbon** | | 0.863c | 0.899c | 0.659b | 0.687b | 3.07b | 3.22b | 0.428b | 0.435b | 2.75c | 2.88c |
| **Seaweed** | | 0.877b | 0.913b | 0.665ab | 0.692ab | 3.11ab | 3.25b | 0.433ab | 0.439ab | 2.79b | 2.94b |
| **Potassium silicate** | | 0.889a | 0.926a | 0.671a | 0.698a | 3.14a | 3.31a | 0.437a | 0.443a | 2.86a | 3.01a |
| **LSD at 5%** | | **0.009** | **0.009** | **0.007** | **0.005** | **0.05** | **0.04** | **0.007** | **0.006** | **0.04** | **0.03** |
| **Interaction** | | | | | | | | | | | |
| **Control** | **Control** | 0.785 | 0.817 | 0.616 | 0.644 | 2.77 | 2.92 | 0.390 | 0.396 | 2.43 | 2.55 |
| | **Organic carbon** | 0.798 | 0.833 | 0.631 | 0.658 | 2.84 | 2.98 | 0.400 | 0.406 | 2.46 | 2.58 |
| | **Seaweed** | 0.815 | 0.850 | 0.636 | 0.661 | 2.87 | 3.01 | 0.405 | 0.411 | 2.50 | 2.62 |
| | **Potassium silicate** | 0.832 | 0.867 | 0.643 | 0.667 | 2.91 | 3.05 | 0.409 | 0.416 | 2.61 | 2.74 |
| **Biochar** | **Control** | 0.851 | 0.885 | 0.651 | 0.677 | 3.02 | 3.17 | 0.421 | 0.429 | 2.70 | 2.84 |
| | **Organic carbon** | 0.866 | 0.906 | 0.659 | 0.685 | 3.08 | 3.24 | 0.429 | 0.438 | 2.78 | 2.91 |
| | **Seaweed** | 0.876 | 0.913 | 0.662 | 0.690 | 3.11 | 3.26 | 0.436 | 0.442 | 2.81 | 2.96 |
| | **Potassium silicate** | 0.886 | 0.921 | 0.668 | 0.696 | 3.15 | 3.32 | 0.440 | 0.445 | 2.86 | 3.01 |
| **Fulvic acid** | **Control** | 0.907 | 0.942 | 0.680 | 0.708 | 3.23 | 3.40 | 0.449 | 0.456 | 2.93 | 3.08 |
| | **Organic carbon** | 0.924 | 0.959 | 0.689 | 0.718 | 3.29 | 3.45 | 0.455 | 0.461 | 3.01 | 3.15 |
| | **Seaweed** | 0.938 | 0.975 | 0.696 | 0.725 | 3.34 | 3.49 | 0.458 | 0.463 | 3.07 | 3.23 |
| | **Potassium silicate** | 0.951 | 0.990 | 0.701 | 0.730 | 3.37 | 3.55 | 0.462 | 0.469 | 3.11 | 3.27 |
| **LSD at 5%** | | **0.016** | **0.016** | **0.012** | **0.010** | **0.08** | **0.06** | **0.011** | **0.011** | **0.07** | **0.05** |

Means within the same column followed by a different letter (s) are statistically different at a 0.05 level

Potassium silicate's strong performance in promoting vegetative growth can be attributed to its role in enhancing plant strength and resistance to various stress factors. It contributes to the development of thicker cell walls, which can deter pests and diseases, and promotes stress tolerance, a crucial factor for plant health. Additionally, potassium silicate can improve photosynthesis efficiency, thus boosting overall plant growth. The findings are in agreement with those of Shafiei et al. (2022).

Seaweed applications, while also proving effective, may be associated with the presence of plant growth-promoting compounds, such as auxins and cytokinins, which stimulate plant development and enhance the efficiency of photosynthesis. Organic carbon sprays likely have a more indirect impact, primarily by improving nutrient uptake and stress tolerance, as well as supporting microbial activity in the soil. The results of this study align with the conclusions reached by Rana et al. (2023).

The most notable observation in the study is the consistent success of the combined treatment of fulvic acid and potassium silicate. The scientific rationale behind this synergistic effect lies in the complementary roles of these substances. Fulvic acid enhances nutrient availability and uptake, while potassium silicate strengthens plant structures and provides stress resistance. The combination of these two treatments appears to create an optimal environment for strawberry plants to thrive, resulting in the highest values for all growth characteristics.

**2- Fruit yield and quality**

**Tables (4, 5 and 6)** present the effect of various treatments involving biochar, fulvic acid, organic carbon, seaweed, and potassium silicate, either individually or in combinations on the yield and physical characteristics of strawberries, including average fruit weight (g), fruit dry matter (%), No. of fruits plant$^{-1}$ (**Table 4**), early and total yield (marketable and unmarketable, metric ton ha$^{-1}$) (**Table 5**) and quality traits of fruits *i.e.*, TSS (%), total sugars (%),fruit firmness (g cm$^{2}$), vitamin C (VC ) and anthocyanin pigments (mg 100 ml juice$^{-1}$) (**Table 6**). When examining the individual effects of soil additions, as indicated in both Tables 4 and 5, a clear pattern emerges. The treatment that consistently outperforms the others in terms of achieving the highest values for all the mentioned characteristics is the fulvic acid treatment. It consistently ranks as the top-performing treatment. On the other hand, the biochar treatment demonstrates a positive effect, albeit to a somewhat lesser degree compared to fulvic acid. It consistently performs better than the control treatment, which consistently ranks as the least effective treatment for enhancing the evaluated characteristics.

**Table (4). Impact of biochar and fulvic acid, and foliar applications organic carbon, seaweed, and potassium silicate, on the physical characteristics of strawberry fruits during 2021/2022 and 2022/2023 seasons.**

| Treatments | | Average fruit weight (g) | | Fruit dry matter (%) | | No. of fruits plant$^{-1}$ | |
|---|---|---|---|---|---|---|---|
| | | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season |
| **Main factor: Soil additions** | | | | | | | |
| **Control: Without addition** | | 20.45c | 20.79c | 7.90c | 8.06c | 28.50b | 29.08c |
| **Biochar** | | 21.21b | 21.62b | 8.31b | 8.48b | 29.75b | 30.67b |
| **Fulvic acid** | | 22.08a | 22.47a | 8.69a | 8.86a | 31.58a | 32.50a |
| **LSD at 5%** | | **0.016** | **0.24** | **0.02** | **0.16** | **1.32** | **0.86** |
| **Sub main factor: Foliar applications** | | | | | | | |
| **Control: Top water** | | 20.98c | 21.35c | 8.15c | 8.30c | 29.44a | 30.11a |
| **Organic carbon** | | 21.15bc | 21.53bc | 8.28bc | 8.42bc | 29.78a | 30.56a |
| **Seaweed** | | 21.35ab | 21.73ab | 8.34ab | 8.52ab | 30.11a | 31.00a |
| **Potassium silicate** | | 21.52a | 21.91a | 8.43a | 8.61a | 30.44a | 31.33a |
| **LSD at 5%** | | **0.32** | **0.28** | **0.13** | **0.14** | ***N.S** | ***N.S** |
| **Interaction** | | | | | | | |
| **Control** | **Control** | 20.21 | 20.52 | 7.71 | 7.86 | 28.00 | 28.33 |
| | **Organic carbon** | 20.36 | 20.75 | 7.91 | 8.02 | 28.33 | 29.00 |
| | **Seaweed** | 20.54 | 20.87 | 7.96 | 8.12 | 28.67 | 29.33 |
| | **Potassium silicate** | 20.69 | 21.03 | 8.03 | 8.21 | 29.00 | 29.67 |
| **Biochar** | **Control** | 20.92 | 21.32 | 8.17 | 8.32 | 29.00 | 30.00 |
| | **Organic carbon** | 21.12 | 21.50 | 8.27 | 8.44 | 29.67 | 30.33 |
| | **Seaweed** | 21.32 | 21.75 | 8.35 | 8.53 | 30.00 | 31.00 |
| | **Potassium silicate** | 21.49 | 21.91 | 8.43 | 8.61 | 30.33 | 31.33 |
| **Fulvic acid** | **Control** | 21.81 | 22.20 | 8.56 | 8.72 | 31.33 | 32.00 |
| | **Organic carbon** | 21.96 | 22.34 | 8.65 | 8.81 | 31.33 | 32.33 |
| | **Seaweed** | 22.18 | 22.56 | 8.72 | 8.91 | 31.67 | 32.67 |
| | **Potassium silicate** | 22.37 | 22.79 | 8.82 | 9.01 | 32.00 | 33.00 |
| **LSD at 5%** | | **0.56** | **0.48** | **0.23** | **0.25** | **2.23** | **2.38** |

Means within the same column followed by a different letter (s) are statistically different at a 0.05 level*N.S= Non-significant

**Table (5). Impact of biochar and fulvic acid, and foliar applications, including organic carbon, seaweed, and potassium silicate, on strawberry yield and it`s components.**

| Treatments | | Early yield, metric ton ha$^{-1}$ | | | | | | Total yield, metric ton ha$^{-1}$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Marketable | | Unmarketabl | | Total | | Marketable | | Unmarketabl | | Total | |
| | | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season | 1st seaso | 2nd season | 1st season | 2nd season |
| **Main factor: Soil additions** | | | | | | | | | | | | | |
| **Control: Without** | | 6.56 | 6.69 | 0.51 | 0.52 | 7.07 | 7.21 | 27.47 | 27.98 | 1.62 | 1.64 | 29.10 | 29.62 |
| **Biochar** | | 7.76 | 7.92 | 0.42 | 0.43 | 8.18 | 8.34 | 30.08 | 30.59 | 1.49 | 1.57 | 31.57 | 32.16 |
| **Fulvic acid** | | 8.96 | 9.16 | 0.30 | 0.30 | 9.25 | 9.45 | 32.52 | 33.07 | 1.31 | 1.35 | 33.83 | 34.43 |
| **LSD at 5%** | | **0.20** | **0.12** | **0.12** | **0.07** | **0.21** | **0.13** | **0.67** | **0.19** | ***N.S** | **0.18** | **0.77** | **0.09** |
| **Sub main factor: Foliar applications** | | | | | | | | | | | | | |
| **Control: Top water** | | 7.30 | 7.45 | 0.44 | 0.43 | 7.74 | 7.88 | 29.08 | 29.60 | 1.52 | 1.53 | 30.60 | 31.14 |
| **Organic carbon** | | 7.61 | 7.78 | 0.42 | 0.43 | 8.04 | 8.21 | 29.78 | 30.33 | 1.50 | 1.55 | 31.28 | 31.88 |
| **Seaweed** | | 7.90 | 8.06 | 0.41 | 0.43 | 8.31 | 8.49 | 30.35 | 30.86 | 1.47 | 1.55 | 31.82 | 32.41 |
| **Potassium silicate** | | 8.22 | 8.39 | 0.36 | 0.37 | 8.58 | 8.76 | 30.89 | 31.40 | 1.40 | 1.44 | 32.30 | 32.84 |
| **LSD at 5%** | | **0.09** | **0.10** | ***N.S** | ***N.S** | **0.09** | **0.09** | **0.35** | **0.41** | ***N.S** | ***N.S** | **0.37** | **0.14** |
| **Interaction** | | | | | | | | | | | | | |
| **Control** | **Control** | 6.04 | 6.18 | 0.53 | 0.51 | 6.58 | 6.69 | 26.35 | 26.82 | 1.65 | 1.63 | 28.00 | 28.45 |
| | **Organic carbon** | 6.44 | 6.56 | 0.51 | 0.54 | 6.95 | 7.11 | 27.29 | 27.78 | 1.63 | 1.67 | 28.93 | 29.45 |
| | **Seaweed** | 6.70 | 6.82 | 0.52 | 0.55 | 7.23 | 7.38 | 27.89 | 28.39 | 1.63 | 1.65 | 29.51 | 30.04 |
| | **Potassium** | 7.05 | 7.20 | 0.48 | 0.47 | 7.53 | 7.68 | 28.37 | 28.93 | 1.57 | 1.60 | 29.94 | 30.53 |
| **Biochar** | **Control** | 7.35 | 7.50 | 0.45 | 0.45 | 7.80 | 7.95 | 29.16 | 29.71 | 1.55 | 1.60 | 30.72 | 31.31 |
| | **Organic carbon** | 7.58 | 7.75 | 0.45 | 0.44 | 8.03 | 8.18 | 29.82 | 30.34 | 1.50 | 1.63 | 31.32 | 31.97 |
| | **Seaweed** | 7.87 | 8.03 | 0.42 | 0.44 | 8.29 | 8.47 | 30.41 | 30.84 | 1.47 | 1.65 | 31.88 | 32.50 |
| | **Potassium** | 8.23 | 8.39 | 0.36 | 0.37 | 8.59 | 8.76 | 30.93 | 31.48 | 1.43 | 1.39 | 32.36 | 32.87 |
| **Fulvic acid** | **Control** | 8.50 | 8.68 | 0.35 | 0.34 | 8.85 | 9.02 | 31.71 | 32.28 | 1.37 | 1.37 | 33.09 | 33.66 |
| | **Organic carbon** | 8.82 | 9.03 | 0.31 | 0.30 | 9.13 | 9.33 | 32.24 | 32.87 | 1.35 | 1.36 | 33.59 | 34.24 |
| | **Seaweed** | 9.11 | 9.33 | 0.29 | 0.29 | 9.40 | 9.62 | 32.77 | 33.36 | 1.30 | 1.34 | 34.06 | 34.69 |
| | **Potassium** | 9.39 | 9.59 | 0.24 | 0.26 | 9.63 | 9.85 | 33.38 | 33.78 | 1.21 | 1.35 | 34.59 | 35.12 |
| **LSD at 5%** | | **0.16** | **0.17** | **N.S** | **0.17** | **0.16** | **0.15** | **0.72** | **0.62** | ***N.S** | ***N.S** | **0.64** | **0.24** |

Means within the same column followed by a different letter (s) are statistically different at a 0.05 level *N.S= Non-significant

This pattern in the results suggests that fulvic acid has a notable and positive impact on both the yield and quality traits of strawberries, while biochar's effects, although were beneficial, and somewhat less pronounced. The control treatment, without any soil additives, yields were the least favorable outcomes. These findings emphasize the significance of soil amendments, particularly the application of fulvic acid, in enhancing the growth and quality of strawberry plants. The reasons for improved productivity with fulvic acid treatment were discussed previously, as well as the role of biochar in improving soil and plant health. Finally, it can be noticed `that the `effect of the studied treatments on growth indicators was reflected in accordance with the crop characteristics of strawberry plants. Conversely, the control treatment, which lacks any soil additives, consistently yields the least favorable results. This underscores the importance of incorporating soil amendments to optimize strawberry growth and quality.

**Table (6). Impact of biochar and fulvic acid and foliar applications, including organic carbon, seaweed, and potassium silicate, on chemical fruit quality characteristics of strawberry plants.**

| Treatments | | Total soluble solid (%) | | Total sugars (%) | | Fruit firmness (g cm²) | | Vitamin C (mg 100 ml juice⁻¹) | | Anthocyanin (mg 100 ml juice⁻¹) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season |
| **Main factor: Soil additions** | | | | | | | | | | | |
| **Control:** | | 7.47c | 7.69c | 6.00c | 6.11c | 338.67b | 353.17b | 54.41b | 55.12b | 56.62b | 57.69b |
| **Biochar** | | 7.97b | 8.20b | 6.32b | 6.45b | 336.08b | 349.33c | 54.26c | 54.97c | 56.36b | 57.49b |
| **Fulvic acid** | | 8.53a | 8.79a | 6.56a | 6.70a | 364.83a | 379.42a | 57.04a | 57.75a | 59.48a | 60.66a |
| **LSD at 5%** | | **0.17** | **0.01** | **0.15** | **0.12** | **2.87** | **3.68** | **0.07** | **0.03** | **1.32** | **1.41** |
| **Sub main factor: Foliar applications** | | | | | | | | | | | |
| **Control:** | | 7.79d | 8.03b | 6.18c | 6.31c | 332.22c | 346.33c | 54.00c | 54.65d | 56.25c | 57.30c |
| **Organic carbon** | | 7.94c | 8.19ab | 6.25b | 6.37bc | 345.56b | 359.33b | 55.04b | 55.80c | 57.27b | 58.41b |
| **Seaweed** | | 8.05b | 8.27ab | 6.34a | 6.46ab | 348.33b | 362.22b | 55.34b | 56.10b | 57.72b | 58.85b |
| **Potassium** | | 8.17a | 8.42a | 6.41a | 6.54a | 360.00a | 374.67a | 56.55a | 57.23a | 58.73a | 59.89a |
| **LSD at 5%** | | **0.09** | **0.25** | **0.07** | **0.11** | **5.21** | **5.36** | **0.90** | **0.25** | **0.66** | **0.74** |
| **Interaction** | | | | | | | | | | | |
| **Control** | **Control** | 7.22 | 7.43 | 5.83 | 5.94 | 315.67 | 329.67 | 52.50 | 53.04 | 54.64 | 55.50 |
| | **Organic** | 7.42 | 7.63 | 5.94 | 6.06 | 342.00 | 355.67 | 54.74 | 55.41 | 56.81 | 57.97 |
| | **Seaweed** | 7.54 | 7.74 | 6.07 | 6.17 | 345.33 | 359.67 | 54.99 | 55.81 | 57.31 | 58.50 |
| | **Potassium** | 7.69 | 7.94 | 6.16 | 6.28 | 351.67 | 367.67 | 55.42 | 56.21 | 57.73 | 58.78 |
| **Biochar** | **Control** | 7.80 | 8.03 | 6.22 | 6.34 | 324.33 | 338.67 | 53.22 | 53.95 | 55.35 | 56.34 |
| | **Organic** | 7.92 | 8.15 | 6.28 | 6.41 | 331.67 | 344.67 | 53.68 | 54.41 | 55.79 | 56.85 |
| | **Seaweed** | 8.03 | 8.27 | 6.37 | 6.49 | 334.67 | 347.33 | 54.03 | 54.80 | 56.31 | 57.40 |
| | **Potassium** | 8.13 | 8.36 | 6.41 | 6.55 | 353.67 | 366.67 | 56.10 | 56.73 | 57.99 | 59.39 |
| **Fulvic acid** | **Control** | 8.34 | 8.61 | 6.48 | 6.64 | 356.67 | 370.67 | 56.28 | 56.96 | 58.75 | 60.06 |
| | **Organic** | 8.48 | 8.78 | 6.53 | 6.65 | 363.00 | 377.67 | 56.72 | 57.57 | 59.19 | 60.42 |
| | **Seaweed** | 8.58 | 8.81 | 6.60 | 6.73 | 365.00 | 379.67 | 57.01 | 57.71 | 59.53 | 60.66 |
| | **Potassium** | 8.70 | 8.97 | 6.65 | 6.79 | 374.67 | 389.67 | 58.15 | 58.75 | 60.46 | 61.49 |
| **LSD at 5%** | | **0.16** | **0.47** | **0.12** | **0.19** | **9.02** | **9.30** | **1.56** | **0.43** | **1.14** | **1.28** |

Means within the same column followed by a different letter (s) are statistically different at a 0.05 level

In terms of the individual effect of foliar application, it can be noticed, from both Tables, that the superior treatment for obtaining the maximum values of all aforementioned traits was potassium silicate treatment, while the seaweed treatment came in the second order followed by organic carbon treatment and lately the control treatment, which came in the last order. The findings also reveal distinct outcomes based on the individual effects of foliar applications. Notably, the potassium silicate treatment stands out as the top-performing treatment, consistently achieving the highest values for the assessed characteristics. This outcome can be attributed to the known benefits of potassium silicate. It serves as a dual source of potassium (K) and silicon (Si) for plants, with silicon, in its silicate form, being a crucial nutrient for fostering plant growth (Shafiei et al., 2022). This nutrient reinforces cell walls, bolsters resistance against pests and diseases, and contributes to the overall well-being of plants. Additionally, potassium, another essential nutrient, supports the development of flowers and fruits while enhancing the overall vitality of plants (Hussain et al., 2023). In the second position is the seaweed treatment, which demonstrates a positive effect, albeit slightly less pronounced than potassium silicate. Seaweed-based solutions might enhance strawberry crop yields due to their content of growth-promoting compounds, such as auxins and cytokinins (Rana et al., 2023).The control treatment, without any foliar applications, consistently ranks as the least effective option for enhancing the evaluated characteristics Regarding the interaction effect, a compelling trend is evident. The data shows that the highest values for all the previously mentioned characteristics are consistently observed when utilizing the combined treatment of fulvic acid and potassium silicate. Remarkably, this trend is consistent across both of the studied seasons.

## CONCLUSION

The obtained results have provided valuable insights into the impact of soil amendments and foliar applications on strawberry cultivation in Dakahlia Governorate. The results indicate that soil treated with fulvic acid and biochar yielded the most favorable outcomes, significantly improving various plant parameters and fruit characteristics. Among the foliar applications, potassium silicate proved to be the most effective, followed by seaweed and organic carbon. These findings highlight the potential for enhancing strawberry production through the strategic use of soil amendments and foliar applications. Under clay soil conditions the combination of fulvic acid and potassium silicate appears particularly promising for achieving optimal results.

**Recommendations:**

1. Encourage strawberry farmers to consider the use of soil amendments such as biochar and fulvic acid. This can enhance soil quality and promote healthier plant growth, ultimately leading to better fruit yields under clay soil condition.
2. Promote the adoption of effective foliar application methods, especially the use of potassium silicate. Providing training and guidance to farmers on the correct application techniques is crucial to maximize its benefits in clay soil.
3. Continue research in this field to explore additional combinations of soil amendments and foliar applications. Investigate the long-term effects and sustainability of these practices to ensure consistent benefits.

By implementing these recommendations and building on the research findings, Egypt can further solidify its position as a leading global producer and exporter of strawberries, contributing to the growth of its agricultural sector and economy.

## REFERENCES

Abd-El-Kareem, F., Elshahawy, I. E. and Abd-Elgawad, M. M. (2022). Native bacteria for field biocontrol of black root rot in Egyptian strawberry. Bulletin of the National Research Centre, 46(1): 82.

Al-Karawi, H.N.R. and Al-Rawi, W.A. (2016). Effect of foliar application of organic extract and humic acid application on strawberry production. Iraqi Journal of Agricultural Sciences, 47 (3).

AOAC (2000). Official Methods of Analysis. 18th Ed. Association of Official Analytical Chemists, Inc., Gaithersburg, MD, Method 04.

Azeez, K.S. and Taha, S.M. (2023). Response two strawberry cultivars (Fragaria× ananassa Duch.) for foliar application of algae and iron chelate fertilizers. Kirkuk University Journal for Agricultural Sciences, 98-112.

Buurman, P., Van Lagen, B. and Velthorst, E.J. (1996). Manual for Soil and Water Analysis. Backhuys.

Crecente-Campo, J., Nunes-Damaceno, M., A Romero-Rodríguez, M. and Vázquez-Odériz, M.L. (2012). Color, anthocyanin pigment, ascorbic acid and total phenolic compound determination in organic versus conventional strawberries

(*Fragaria* × *ananassa* Duch, cv Selva). Journal of Food Composition and Analysis, 28(1): 23-30.

Das, S.K., Ghosh, G.K. and Avasthe, R. (2020). Application of biochar in agriculture and environment, and its safety issues. Biomass Conversion and Biorefinery, 1-11.

Elsherpiny, M. A. (2023). Role of compost, biochar and sugar alcohols in raising the maize tolerance to water deficit conditions. Egyptian Journal of Soil Science, 63(1): 67-81.

El-Sherpiny, M. A., Kany, M. A., and Ibrahim, N. R. (2022). Improvement of performance and yield quality of potato plant via foliar application of different boron rates and different potassium sources. Asian Journal of Plant and Soil Sciences, 294-304.

Gomez, K.A. and Gomez, A.A. (1984). “Statistical procedures for agricultural research”. John Wiley and Sons, Inc., New York.pp:680.

Gotteni, A. L., Verloo, L.G., and G. Camerlynch, (1982)."Chemical Analysis of Soil Lap of Analytical and Agro Chemistry", state Univ., Ghent, Belgium.

Hussain, Z.Z., Al-Dahwi, S.S.J. and Lelo,H.M. (2023). Effect of Foliar Fertilization with Potassium Silicate on some Morphological Characters of Strawberry Leaves Reducing Sucking Insects. In IOP Conference Series: Earth and Environmental Science, 1225(1): 012085). IOP Publishing.

Johan, F., Jafri, M.Z., Lim, H.S. and Maznah, W.W. (2014). Laboratory measurement: Chlorophyll-a concentration measurement with acetone method using spectrophotometer. In 2014 IEEE International Conference on Industrial Engineering and Engineering Management (pp. 744-748). IEEE.

Jones, J., Wolf, B.J.B. and Mills, H.A. (1991). "Plant analysis Handbook: A Practical Sampling, Preparation, Analysis and Interpretative Guide". Micro-Macro Publishing, Athens, Ga.

Krishnasree, R.K., Raj, S.K. and Chacko, S. R. (2021). Foliar nutrition in vegetables: A review. Journal of Pharmacognosy and Phytochemistry, 10 (1): 2393-2398.

Liu, X., Yang, J., Tao, J. and Yao, R. (2022). Integrated application of inorganic fertilizer with fulvic acid for improving soil nutrient supply and nutrient use efficiency of winter wheat in a salt-affected soil. Applied Soil Ecology, 170: 104255.

Martinez-De la Cruz, S., Gonzalez-Fuentes, J.A., Robledo-Olivo, A., R., Mendoza-Villarreal, A., Hernandez-Perez, M.D., Davila-Medina, A. and Alvarado-Camarillo, D. (2022). Humic substances and rhizobacteria enhance the yield, physiology and quality of strawberries. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 50(1):12578-12578.

Rana, V.S., Lingwal, K., Sharma, S., Rana, N., Pawar, R., Kumar, V. and Sharma, U. (2023). Enhancement in growth, yield and nutritive characteristics of strawberry (*Fragaria* × *ananassa* Duch.) by the application of biostimulant: seaweed extract. Acta Physiologiae Plantarum, 45 (10):122.

Sanchez-Reinoso, A.D., Ávila-Pedraza, E.A. and Restrepo-Díaz, H. (2020). Use of biochar in agriculture. Acta Biológica Colombiana, 25(2): 327-338.

Shafiei, A., Hadadinejad, M., Eshghi, S. and Ghasemi, K. (2022). The effect of mycorrhiza and potassium silicate application on photosynthetic and fluorescence parameters of strawberry under heat stress. Journal of Crops Improvement, 24(2): 585-599.

Ukalska-Jaruga, A., Debaene, G. and Smreczak, B. (2018). Particle and structure characterization of fulvic acids from agricultural soils. Journal of Soils and Sediments, 18: 2833-2843.

Ukalska-Jaruga, A., Bejger, R., Debaene, G. and Smreczak, B. (2021). Characterization of soil organic matter individual fractions (fulvic acids, humic acids, and humins) by spectroscopic and electrochemical techniques in agricultural soils. Agronomy, 11(6): 1067.

Watson, D.J. (1952). The physiological basis of variation in yield. In Advances in agronomy, (4): 101-145.

Weber, K. and Quicker, P. (2018). Properties of biochar. Fuel, 217: 240-261.

## الملخص العربي

## تأثير الرش الورقي ببعض المحفزات النباتيه على نمو وجودة محصول الفراولة تحت المعامله بالبيوشار وحمض الفولفيك

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تعتبر الفراولة أحدًا من أهم المحاصيل الاستراتيجية لصادرات مصر، حيث تحتل مصر مكانة مرموقة في زراعة وتصدير الفراولة على مستوى العالم، وهي المسألة التي تقضي بضرورة النظر إلى أهم التحديات التي تواجه المزارعين، لمحاولة التغلب عليها والحفاظ على الريادة المصرية في هذا المجال. لذلك، تمت إجراء تجربة حقلية على مدى موسمي زراعة للفراولة (2022/2021) و (2023/2022) باستخدام تصميم القطع المنشقة لاستقصاء تأثير بعض محسنات التربة كقطع رئيسية، كالبيوشار بمعدل 5.0 م$^3$ للفدان وحمض الفولفيك بمعدل 10 كجم للفدان. كما هدفت الدراسة إلى تقييم فوائد بعض الاضافات الورقية، كقطع منشقة تشمل الكربون العضوي (1.0 سم$^3$/لتر)، ومستخلص الطحالب البحرية (1.0 سم$^3$/لتر)، وسيليكات البوتاسيوم (2.0 سم$^3$/لتر). بالإضافة لمعاملات الكنترول لكل عامل. شملت الدراسة قياس مدلولات متنوعة، مثل أوزان الأوراق الطازجة (جرام/نبات)، وعدد الأفرع/نبات، والمساحة الورقية (سم$^2$/نبات)، ومحتوى الكلوروفيل (أ و ب ملليجرام/جرام)، بالإضافة إلى نسبة النيتروجين والفوسفور والبوتاسيوم في الأوراق. أيضا، شمل البحث تقييم صفات الثمار، مثل متوسط وزنها (جرام)، ونسبة المادة الجافة في الثمار، وعدد الثمار/ نبات، والمحصول المبكر والكلي وصلابة الثمار، المواد الصلبة الذائبة الكلية، ونسبة السكر الكلي (%)، وكذلك محتوى فيتامين C وصبغة الأنثوسيانين (ملليجرام /100 مللي من عصير الفراولة).

أظهرت النتائج أن أفضل النتائج تم الحصول عليها مع النباتات التي تم زراعتها في التربة التي تمت معاملتها بحمض الفولفيك، تلتها تلك النامية بتربه تم معاملتها بالبيوشار، بينما كانت مجموعة الكنترول لديها أقل النتائج. بالنسبة للمعاملات الورقية، أظهرت سيليكات البوتاسيوم أفضل أداء، تلتها الطحالب البحرية، ثم الكربون العضوي وأخيرًا مجموعة الكنترول، تسلط هذه النتائج الضوء على إمكانية تعزيز إنتاج الفراولة في مصر من خلال الاستخدام الاستراتيجي لمحسنات التربة والاضافات الورقية. أخيرا يبدو أن الدمج بين حمض الفولفيك وسيليكات البوتاسيوم واعد لتحقيق نتائج مثلى لمحصول وجوده ثمار الفراوله.