Effect of Spraying with Licorice Root Extract and Green Tea on the Vegetative Growth Traits of Strawberry Seedlings (*Fragaria* x *ananassa* Duch.) Cultivar (Festival)

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Abstract

This research was carried out in the greenhouse of the College of Agriculture, Al-Qasim Green Fields. The duration of the study was one complete growing season during 2025–2026. The objective was to assess the influence of foliar applications of extracts from licorice (*Glycyrrhiza glabra* L.) root and green tea on the vegetative growth performance of strawberry seedlings that were being raised in 3-kg plastic bags. The experiment was laid out in a factorial arrangement within a randomized complete block design. The treatments consisted of two sets of factors: the first factor was licorice root extract at 0, 3, and 5 g L^{-1}, and the second factor was green tea extract at 0, 4, and 6 g L^{-1}. Growth responses included parameters such as plant height, stem diameter, number of branches, number of leaves, number of runners, and chlorophyll content of leaves. Data obtained for all parameters indicated that foliar spray of both organic extracts enhanced the vegetative growth characteristics in comparison with the control. The highest values for all traits were generally obtained from plants treated with 5 g L^{-1} of licorice extract and 6 g L^{-1} of green tea extract, indicating the positive role of these biostimulants in promoting growth and vigor of strawberry seedlings under greenhouse conditions.

Keywords: Strawberry, Licorice Root Extract, Green Tea Extract, Foliar Application, Vegetative Growth, , Biostimulants.

Introduction

Strawberries are evergreen fruits belonging to Rosaceae family. They are among the most widely cultivated and consumed crops in the world. They are of great economic and commercial importance, with global production being double that of other fruit varieties. Strawberry production ranks fourth among the most consumed fruits after apples, oranges, and bananas. Strawberries are distinguished by their high nutritional value due to their content of important nutrients [5]. The absorption of nutrients in leaves occurs in two ways: either through cytoplasmic

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bridges located beneath the cuticle to the epidermal cells and then to the cytoplasm via symplasm, or through stomata and intercellular spaces in the leaf tissues to the phloem via apoplasm. One of the most important conditions for foliar fertilization is that the spraying should be carried out in the morning or evening, ensuring the leaves are completely wet. It is also crucial to water seedlings one day before spraying to increase the plants' efficiency in absorbing the sprayed substance. Moisture helps in the swelling of guard cells and the opening of stomata. Furthermore, watering before spraying reduces the concentration of solutes in the leaf cells, increasing the penetration of ions in the spray solution. Adding Tween 20 as a surfactant reduces the surface tension of water [3]. The use of plant extracts has become widespread in recent years, in line with the requirements for achieving clean agriculture, which has become the preferred and sought-after approach in countries worldwide to avoid the risks associated with some agricultural methods. Traditional methods aim to provide healthy plants and food free from pollutants and pesticide residues, and to put an end to water and soil pollution [1]. Plant growth and development result from the interaction between environmental conditions and agronomic practices, nutrient management being one of the most important factors. Licorice extract is one of the most commonly used examples of natural plant extracts promoting growth. The efficacy of this substance is due to the presence of several bioactive compounds, including mevalonic acid, a precursor involved in the biosynthesis of gibberellins that regulate processes related to growth in plants. For over thousands of years, licorice has been known as a very valuable medicinal plant and has been used extensively in traditional remedies. The roots of this plant have particularly high contents of glycyrrhizin- a sweet triterpenoid compound which occurs naturally and which is responsible for many biological properties of the plant. Its content varies depending on the age and environmental conditions of the plant as well as the characteristics of the roots; generally, it is found in relatively high amounts within the tissues of the roots [11]. Licorice extract is one of the most widely used plant extracts today. Licorice (*Glycyrrhiza glabra*) belongs to the legume family (Leguminoseae). It is a perennial herbaceous plant used in pharmaceuticals and medicine. Its rhizomes have been studied in many agricultural experiments due to its effect on plant growth because it contains many antioxidants, natural growth regulators, nutrients and vitamins [2]. Former researches proposed that foliar application of licorice extract can positively influence the growth and physiological performance of strawberries. Improved growth parameters were observed at suitable concentrations of the extract, including increased leaf chlorophyll content. This reflects enhanced photosynthetic activity and vigor in the plant [7].

Green tea extract is known to be a rich source of biologically active

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compounds, more particularly phenolics and flavonoids. These compounds have powerful antioxidant properties that protect plant tissues from oxidative stress. In addition to this, the extract of green tea has been reported to exhibit antimicrobial activity, which helps suppress some plant pathogens and, therefore, keeps the health of the plant in general [4]. Green tea leaves contain: 11.0 g of carbohydrates, 0.4 g of fats, 0.3 g of flavonoids, 2.9 g of tannins, 20.0 mg of protein, 1.19 g of nitrogen, 1 g of phosphorus, 0.5 g of potassium, 41 mg of magnesium, 51 mg of zinc, 60 mg of iron, 0.7 g of manganese, 110 mg of conisine, 90 mg of thiamin, 88 mg of vitamin A, 74.1 mg of vitamin B, 120 mg of vitamin C, and 315 mg of caffeic acid per kilogram of dry weight of green leaves [8]. [10] found that foliar spraying of strawberry seedlings with green tea extract significantly increased the number of branches, leaves, and runners.The above study aimed to demonstrate the effect of using spraying with natural, medicinal, and environmentally friendly materials on improving the vegetative growth of strawberry seedlings.

Materials and Methods

The study was conducted in greenhouse of College of Agriculture, Al-Qasim University, from December 1, 2025, to April 1, 2026. The effect of spraying with licorice and green tea extracts on strawberry seedlings was investigated. The seedlings were selected based on the degree of uniformity in growth vigor. Maintenance practices, including weeding and aphid control, were carried out. The seedlings were marked with numerical labels indicating the treatment used, with three replicates. Each treatment included two seedlings, resulting in a total of 54 seedlings. The seedlings were randomly distributed in a completely randomized block design. The arithmetic means were compared at the level of The probability was 0.05, as the experiment was a factorial with two factors: the first factor was licorice extract, which included three levels (5, 3, 0 g .L $^{-1}$. seedling), and the second factor was spraying with green tea, which included three levels (6, 4, 0 g .L $^{-1}$. seedling). The method for preparing the licorice and green tea extract was as follows: Powdered licorice and green tea were obtained from local markets. The required weight was soaked in one liter of distilled water for 24 hours. The extract was then filtered through a cotton cloth and sprayed onto the plants. Spraying was done using a hand sprayer in the early morning, with the addition of a brightening agent to create a foam that prevents or reduces evaporation of the fertilizer. The interval between spraying the licorice and green tea extracts was one full day, totaling four sprays, as follows: First spray: 1/12/2025 --- Second spray: 2/1/2026 ----- Third spray: 1/2/2026 ----- Fourth spray: 1/3/2026

Growth indicators studied:

Results were taken from the plants one month after the last spray, with the season ending on 1/4/2026, to study the following:

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to study the average increase of seedling height (cm). The seedling height measurement used a metric tape from the soil surface to the top of the seedling stem, with the average extracted for each experimental unit. The average increase in stem diameter of the seedlings (mm), as measured, utilized a Vernier caliper at 5 cm above the soil surface taking the average for each treatment. The mean increase of branch)the total number of branches plant-1) of lateral branches on the main stem of each seedling underwent calculation before getting the average. The total number of leaves (leaf plant-1) average increase for each seedling sustained estimation before averaging the number of leaves for each experimental unit.Number of Runners (runner plant^{-1}) Runner formation was evaluated by counting the runners developed by each plant for the duration of the study. The average number of runners per plant for each treatment was then calculated Measuring the total chlorophyll content of leaves (SPAD) employed an electronic device called SPAD

Results and Discussion

Effect of Irrigation Methods with Licorice Extract and Green Tea Extracts and Their Interactions on Vegetative Growth Traits of Strawberry Seedlings:

1- Seedling Height (cm): The results in Table (1) indicated that there were significant differences between the average plant height of strawberries sprayed with licorice extract. The 5 g.L^{-1} concentration of the spray irrigation method gave the highest average seedling height, which was recorded as 19.58 cm, in comparison with the control treatment. The results also showed that the treatments of foliar application had a very significant effect on plant height. The tallest mean plant height was recorded by those plants treated with the highest concentration of licorice root extract and the shortest was that of the untreated plants. Green tea extract also significantly boosted this trait, with the concentration of 6 g L^{-1} eliciting greater plant height compared to the control treatment. The interaction between licorice root extract and green tea was statistically significant. The highest plant height of 21.03 cm was obtained with the combined application of 5 g L^{-1} licorice extract and 6 g L^{-1} green tea extract; the least value of 15.14 cm was recorded in the control combination. These results indicate that the combined use of both natural extracts can effectively stimulate vegetative growth and improve plant development.

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Table (1): Effect of spray methods using licorice root extract and green tea, and their interactions, on the height of strawberry seedlings

Licorice extract g.L-1	**Green tea ($g.L^{-1}$)**			**Licorice root average extract**
	0	**4**	**6**	
0	15.14	15.70	16.32	15.16
3	16. 72	17.81	17.89	17.45
5	18.40	19.33	21.03	19.58
Green tea average	16.75	17.61	18.44	
LSD **(0.05)**	**interaction Green tea Licorice extract** **0.35 0.28 0.11**			

2- Stem Diameter (mm): The results in Table (2) showed significant differences in the average plant diameter after spraying with licorice extract. The 5 $g.L^{-1}$ concentration was was excelled the sprinkler irrigation method, giving the highest average seedling diameter of 25.85 mm, compared to the control treatment which gave the lowest average of 21.88 mm. Data indicated that diameter of stem was significantly affected by green tea extract, the highest mean diameter (24.97 mm) being recorded for plants given 6 g L^{-1}, while the least mean value (22.19 mm) was noted for untreated plants. A significant interaction was also recorded between licorice root extract and green tea treatments. The maximum stem diameter of 26.79 mm was recorded for the combination treatments of 5 g L^{-1} licorice extract and 6 g L^{-1} green tea extract, while the control combination gave the minimum value of 20.45 mm. These results reveal that application of both extracts can promote thickening of the stem and improve vegetative growth of strawberry plants.

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Table (2): Effect of spray method with licorice and green tea extract and their interactions on the stem diameter of strawberry seedlings

Licorice extract g.L^{-1}	Green tea g.L^{-1}			Licorice root average extract
	0	4	6	
0	20.45	22. 31	22.90	21.88
3	23.15	24. 03	24.70	23.96
5	25.14	25.63	26.79	25.85
Green tea average	22.19	23.09	24.97	
LSD **(0.05)**	**interaction Green tea Licorice extract 0.40 0.39 0.36**			

3. Total number of branches (branch plant^{-1}): The results presented inTable 3 shows the results of the branch production of strawberry plants due to foliar application of licorice extract. The mean highest number of branches (5.52 branches plant^{-1}) was recorded for plants treated with 5 g L^{-1} of licorice extract, while the control treatment had the lowest value (4.35 branches plant^{-1}). Green tea extract also contributed to the increase in branch formation, where the treatment of 6 g L^{-1} had the highest average number of branches (5.19 branches plant^{-1}) and the check treatment had the lowest average (4.96 branches plant^{-1}). A significant interaction effect between the two factors was observed. The highest branch number of 5.77 branches plant^{-1} was recorded with the combined treatment of 5 g L^{-1} licorice extract and 6 g L^{-1} green tea extract, while the control combination produced the lowest value of 4.10 branches plant^{-1}. These results indicate that branching and vegetative growth in strawberry plants can be improved by the combined use of licorice and green tea extracts.

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Table (3): Effect of spray methods using licorice root extract and green tea, and their interactions, on the number of branches in strawberry seedlings

Licorice extract g.L^{-1}	Green tea g.L^{-1}			Licorice root average extract
	0	4	6	
0	4.10	4.22	4.73	4.35
3	4.76	4.88	5.09	4.91
5	5.21	5.60	5.77	5.52
Green tea average	4.96	4.09	5.19	
LSD **(0.05)**	**interaction 0.26**		**Green tea 0.22**	**Licorice extract 0.15**

4- Total number of leaves (leaf.plant^{-1}): The results in Table (4) showed significant differences in the average leaf count of strawberries sprayed with licorice extract. Results obtained indicate that licorice root extract significantly enhanced leaf production in strawberry plants. The application of 5 g L^{-1} licorice extract gave the highest number of leaves with a mean value of 44.95 leaves plant^{-1}, while the untreated plants had the lowest mean value of 24.96 leaves plant^{-1}. A similar trend was seen with green tea extract; the 6 g L^{-1} treatment had the highest mean leaf number (31.91 leaves plant^{-1}) and the control treatment had the lowest value (29.02 leaves plant^{-1}). The interaction between the licorice and green tea treatments was statistically significant. The highest leaf number was recorded when 5 g L^{-1} of licorice extract was combined with 6 g L^{-1} of green tea extract, which was 37.11 leaves plant^{-1}. The lowest average, on the other hand, was observed in the untreated control combination, which was 24.11 leaves plant^{-1}. These mean that both extracts can stimulate the development of leaves to enhance vegetative growth, especially when they are used together.

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Table (4): Effect of spray method with licorice root and green tea extracts and their interactions on the number of leaves in strawberry seedlings

Licorice extract g.L^{-1}	Green tea g.L^{-1}			Licorice root average extract
	0	**4**	**6**	
0	24.11	25.80	25.99	24.96
3	28.73	30.18	32.65	30.52
5	34.23	36.51	37.11	44.95
Green tea average	29.02	30.83	31.91	
LSD **(0.05)**	**interaction**	**Green tea extract**		**Licorice**
	0.70	**0.45**	**0.26**	

5- Number of runners (runner.plant^{-1}): The results in Table (4) showed significant differences in the average number of runners of strawberries sprayed with licorice extract. Results showed that application of licorice root extract significantly increased runner production in strawberry plants. The highest mean number of runners (5.37 runners plant^{-1}) was recorded in plants treated with 5 g L^{-1} licorice extract and the lowest value in the control treatment (3.44 runners plant^{-1}). Positive effects of green tea extract were also observed for this trait. The 6 g L^{-1} concentration of green tea resulted in the highest average number of runners (4.80 runners plant^{-1}) while the untreated plants showed the lowest average (4.12 runners plant^{-1}). A significant interaction between the licorice and green tea treatments was noted. The combined application of 5 g L^{-1} licorice extract and 6 g L^{-1} green tea extract resulted in the highest runner production, at 5.70 runners plant^{-1} compared to 3.02 runners plant^{-1} in the control treatment.

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Table (5): Effect of spray method with licorice root and green tea extracts and their interactions on Number of runners in strawberry seedlings

Licorice extract g.L^{-1}	**Green tea g.L^{-1}**			**Licorice root average extract**
	0	**4**	**6**	
0	3.02	3.46	3.85	3.44
3	4.26	4.71	4.86	4.60
5	5.10	5.31	5.70	5.37
Green tea average	4.12	4.49	4.80	
LSD **(0.05)**	**interaction Green tea Licorice extract** **0.26 0.22 0.15**			

6- Leaf Total Chlorophyll Content (Spad): The results in Table (6) and Table (4) showed significant differences in the average chlorophyll content of strawberries sprayed with licorice extract. The results demonstrated that chlorophyll content was significantly affected by foliar application of licorice extract. Plants treated with 5 g L^{-1} licorice extract exhibited the highest chlorophyll reading, reaching 17.60 SPAD units, whereas the control treatment recorded the lowest value of 14.28 SPAD units. Green tea extract also enhanced chlorophyll accumulation, with the 6 g L^{-1} concentration producing the highest mean value (16.60 SPAD units), while untreated plants showed the lowest chlorophyll content (15.04 SPAD units). A significant interaction was detected between the two factors. The combined treatment of 5 g L^{-1} licorice extract and 6 g L^{-1} green tea extract resulted in the greatest chlorophyll content, reaching 18.80 SPAD units, whereas the control combination produced the lowest value of 14.11 SPAD units.

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Table (6): Effect of spray method with licorice root and green tea extracts and their interactions on Leaf Total Chlorophyll Content (Spad)

Licorice extract g.L^{-1}	**Green tea g.L^{-1}**			**Licorice root average extract**
	0	**4**	**6**	
0	14.11	14.23	14.51	14.28
3	16.02	16.44	16.51	16.32
5	16.91	17.11	18.80	17.60
Green tea average	15.04	15.92	16.60	
LSD **(0.05)**	**interaction Green tea Licorice extract** **0.18 0.16 0.15**			

The increase in the studied vegetative growth traits in the experiment in Tables (1-2-3-4-5-6), represented by (plant height, stem diameter, number of branches, number of leaves, number of runners, and leaf chlorophyll content), is due to the use of spraying methods with licorice root extract and green tea, which leads to the maximum benefit from the plant, thus increasing growth and uniformity as much as possible. Licorice contains more than 100 different compounds. The most important of these compounds are glycyrrhizin and phenolic compounds. In addition, it contains several minerals such as potassium and phosphorus, as well as sugars

that are absorbed by the leaves during spraying, thus increasing growth activity and playing an important role in increasing vegetative growth such as plant height and number of branches. It also contains magnesium, which has significant effects on increasing leaf cell division, thereby increasing chlorophyll content and some biological activities of the plant [6]. This increase in vegetative growth could be linked to better nutrient availability, along with bioactive compounds that facilitate different physiological and biochemical processes within the plant. These compounds play a role in metabolic activities concerning the use of energy, synthesis of structural cellular components, and formation of nucleic acids needed for the development and multiplication of cells [9]. Therefore, due to higher growth and vigor expressed by plant tissues, the performance of the vegetative parts improved as well. Similar results were obtained in previous studies on

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strawberry plants, regarding positive effects of natural growth-promoting substances on vegetative growth characteristics [7,10].

Conclusions and Recommendations

Results of this study showed that foliar application of licorice root extract and green tea extract significantly enhanced the vegetative growth of strawberry seedlings under greenhouse conditions. The best concentrations tested, 5 g L^{-1} of licorice extract and 6 g L^{-1} of green tea extract, gave better values for plant height, stem diameter, number of branches, leaves, runners, and chlorophyll content than the control treatment. The dual application of both extracts was more potent than their independent applications, which indicates a synergistic effect on plant growth and development. Findings imply that licorice and green tea extracts could be used as environmentally safe and cheap biostimulants for strawberry production. Hence, their application is suggested to boost seedling vigor and enhance vegetative growth.

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