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EFFECT OF FOLIAR SPRAY WITH SILICON, BORON, AND GIBBERELLIC ACID ON THE NUTRITIONAL ELEMENTS CONTENT IN LEAVES OF STRAWBERRY (*FRAGARIA X ANANASSA* DUCH.) CV. ALBION

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ABSTRACT

The effect of foliar spraying with silicon at three concentrations (0, 2 and 3 mmol Si L-1) using potassium silicate (18%) and with boron at three concentrations (0, 25 and 50 mg B L-1) using boric acid (17% boron) And gibberellic acid at two concentrations of 0 and 75 mg GA3 L-1 to study the effect of foliar spraying on the content of leaves of strawberry plants (Fragaria x ananassa Duch.) cv. Albion for some nutrients grown in the nurseries of the Department of Horticulture and Landscape Design /College of Agriculture and Forestry/University of Mosul during the 2022-2023 growing season, it was sprayed three times with each of silicon and boron and once with gibberellic acid during the cultivation period. The study was applied using an RCBD design with three replicates and nine plants for each experimental unit. The results showed that foliar spraying with silicon, boron, and gibberellic acid separately, as well as all interactions between them, especially the treatment (3 ml mol Si L-1, 50 mg B L-1, and 75 mg GA3 L-1), led to a significant increase in the following characteristics: nitrogen, phosphorus, potassium, and boron in plant leaves for each experimental unit compared to the control treatment.

INTRODUCTION

The strawberry is one of the small-fruited fruits that are widespread in the world and is a perennial herbaceous plant (1). The strawberry plant belongs to the Rosaceae family, within the genus Fragaria and the species Fragaria X ananassa Duch. (2), and most of the strawberry varieties are propagated by propagation, which is the most common, or by division of the plant crown, to become a herbaceous plant whose height does not exceed 30 cm. It is a perennial plant in hot regions and an annual crop in subtropical regions (3). Strawberry is a fruit with small, multi-shaped fruits, Its fruits are also distinguished by their high nutritional value, as they contain a high percentage of antioxidant compounds, phenolic substances, vitamins, and beta-carotene, which is the initiator of the formation of vitamin A. Despite its low concentrations, its presence enhances the antioxidant substances. Strawberry fruits are characterized by ease of digestion and contain abundant amounts of various organic acids and digestive enzymes (4). Strawberry follows the fruit and ranks fourth globally after apples, oranges, and bananas in terms of consumption and consumer preference. China is one of the largest producing countries, as its production in 2021 reached about 3,389,620.19 tons and the cultivated area was 129,046. ha, where it comes after China in productivity of strawberries. The United States of America, where production reached about 1,211,090 tons and the cultivated area was 19,992 hectares, comes after the United States of America in terms of strawberry productivity. Egypt, where production reached about 470,913.1 tons and the cultivated area was 12,579 hectares (5), and for the purpose of improving the growth and production of strawberry plants, some beneficial elements, including silicon, as silicon (Si) constitutes about 27.7% of the Earth's crust, and is one of the beneficial elements for plants that improves plant growth, development, and production, and increases the percentage of nitrogen in the plant (6). It is also the second most abundant element in terms of quantity present in the Earth's crust. Adding silicon to plants has positive effects on them, as it stimulates plants to develop and gives the plant resistance or tolerance to various stress conditions, whether abiotic or abiotic stress. Or biological stress (7), as (8) mentioned, silicon is one of the beneficial elements and that there is a possibility of using it as an alternative in solutions deficient in any of the nutrients necessary for plants, and that the amount of addition The successive application of silicon to plants has many beneficial effects on the growth and yield of a number of plant species, including improving resistance to diseases and harsh environmental conditions such as drought (Pilon-Smits et al., 2009). it positively affects the growth and development of plants under different stress conditions (9), as (10) found that potassium silicate (K2SiO3) helps the plant resist toxicity from some elements such as cadmium and aluminum. The silicon element is transferred from the root system to the vegetative branches through the bark or in the wood (11). The basis for the mechanism of action of the silicon element in resisting various stresses is the encouragement of antioxidant systems in plants. It works to form several complexes of heavy elements that bind with silicon and inhibit the movement of heavy elements in the growth environment of plants as well as their absorption by the plant. It has direct or indirect effects. Directly in the process of absorption of some elements in plants (12).

There are a number of researchers who have shown that foliar spraying of strawberry plants with silicon increases the content of the leaves of strawberry plants, including nutrients. (13) When foliar spraying of plants of the cv. Elsanta with 1 mmol Si L-1 , (14) When foliar spraying of plants of the cv. Paros with 3 mmol Si L-1 (15) When foliar spraying of plants of the cv. Camarosa with 10 mmol Si L-1 (16) when foliar spraying of plants of the cv. Fortuna with 1.5 mmol Si L-1.

As for the boron element, it is considered very important in plant nutrition. It is worth noting that boron accumulates in the leaves and reproductive organs and is found to a lesser extent in the roots and fruits (17), as its deficiency leads to the accumulation of nitrates in the plant and the lack of the formation of proteins and amino acids. (18). It is present in soil in small quantities, ranging from 7 to 80 mg kg-1, and boron is dissolved in the soil solution or on the surfaces of its colloids. Boron dissolved in the soil solution represents the most ready form of boron for absorption by the plant. It is one of the smallest nutrients necessary for all plants, and the plant needs it in very small quantities. It is an immobile element within the plant (19). It contributes to regulating osmotic potential and water balance in the cell by increasing the plant's efficiency in increasing potassium absorption, and it has an effect on manufacturing gibberellic acid in seeds, which helps in their germination (20,21). Boron availability decreases under dry soil conditions due to the inability of plants to absorb boron from the soil due to a lack of moisture in the root zone (22). Therefore, symptoms of its deficiency appear first on the upper parts and new growths (23). Boron works as a regulator of vital processes within the plant. (24) showed that boron regulates the activity of the enzyme 6-Phosphogluconate dehydrogenase.

There are a number of researchers who have shown that foliar spraying of strawberry plants with boron increases the content of nutrients in the leaves of strawberry plants, including (25) when foliar spraying of plants of the Selva variety with 5.5 kg ha-1. (26), when foliar spraying of plants of the variety Selva. Camarosa with 100 mg B L-1, (27) when foliar spraying plants of the variety Fortona with 4 mg B L-1, and (28) when foliar spraying plants of the varieties Red Merlin (029), Eyana, and Fortuna (116) with 75 mg B L-1.

Gibberellins are one of the main groups of growth regulators. They are naturally produced in plants and have aroused the interest of horticulturalists because of their broad effects on plants. It was first discovered by Elichi Kurosawa in 1926 in Japan, and its name is derived from the fungus Gibberella fujikurio. It has several effects on the physiological processes taking place in plants, including cell elongation, encouraging the growth of young tissue, elongating internodes and stems, producing seedless fruits, increasing cambium activity, compensating Biennial plants and long-day plants need cold in order to flower, stimulating enzymes that break down complex nutrients into simpler substances, and increasing the formation of protein and RNA (29). One of the most important gibberellins used for agricultural purposes is gibberellic acid, which is a simple gibberellin that promotes cell growth and elongation and is called gibberellin A3, which is abbreviated as gibberellic acid GA or GA3. The gibberellins move from the place of their construction (Source) to the place of their effect and benefit from them (Sink), and the gibberellins move in all directions and do not show the characteristic of polar transfer, meaning that they move from top to bottom and from bottom to top, meaning the movement of gibberellins is free within the plant and without hindrance, as well as It was found that it moves laterally from the phloem to the xylem and vice versa. Therefore, gibberellins are systemic growth regulators, and their transfer is linked to the speed of the transfer of juice in the plant until it reaches the site of its impact (30,31).

There are a number of researchers who have shown that foliar spraying of strawberry plants with gibberellic acid increases the content of the leaves of strawberry plants of nutrients, including (32) when foliar spraying of plants of the cv. Chandler with 25 mg GA3 L-1, and (33) when foliar spraying plants of Tudla, Camarosa, Festival, Gaviota, and Sweet Charlie with 50 mg GA3 L-1.

Therefore, this study aims to improve the nutritional element content of the leaves of the cv. Albion and to determine the appropriate concentrations of silicon, boron, and gibberellic acid that should be sprayed on the plants of this cultivar in order to achieve this. Due to the lack of studies similar to this one on this cultivar in the city of Mosul, a study was conducted. this study.

METHODOLOGY

This study was conducted in one of the greenhouses affiliated with the Department of Horticulture and Landscape Design/College of Agriculture and Forestry, University of Mosul (35 m long and 5 m wide).and an area of 170 m2 during the growing season 2022-2023. Some physical and chemical characteristics of the soil were taken before planting, as shown in Table No. (1).

Table 1. Some physical and chemical characteristics of greenhouse soil. The soil was analyzed in the central laboratory of the College of Agriculture and Forestry.

Pararmeter	*Unit*	*Value*
EC	(dsm. m^{-1})	3.40
pH	--------	7.04
Organic mater	gm kg^{-1}	1.20
Sand	gm kg^{-1}	530.5
Clay	gm kg^{-1}	179.5
Silt	gm kg^{-1}	290.0
Soil texture	------	Clay Loam
Available N	%	0.0088

Available P	mg kg^{-1}	12.9
Available K	mg kg^{-1}	75
$CaCO_3$	%	26.8

Albion seedlings were selected from one of the nurseries affiliated with the College of Agriculture and Forestry/Unified University of Mosul. They grew roughly. To implement this experiment, a randomized complete block design (RCBD) was used. They were fertilized with neutral NPK fertilizer (18:18:18). The fertilizer was spread on the upper surface of the terraces and mixed. It was well mixed with the soil, then the soil was irrigated directly, and then the terraces were covered with black polyethylene, with holes made for planting plants at the top of the terrace. The distance between one line and another was 25 cm. The distance between one plant and another was 25 x 25 cm. For planting plants in the first week of December, planting was done. The plants were planted with three lines, and three lines were extended for drip irrigation. The plants were sprayed with silicone in three concentrations (0, 2, and 3 mmol L^{-1}) and twice during the study period, with 30 days between one spraying and another, where the first spraying was on 2/4/2023, and with boron in the form of boric acid (17% B) and in three concentrations (0, 25 and 50 mg GA_3 L^{-1}), which was sprayed twice during the study period with an interval of 30 days between one spraying and the next. The first spraying was one day after spraying with silicone on 2/5/2023, and spraying with gibberellic acid at two concentrations (0 and 75 mg GA_3 L^{-1}) and one spray. One spraying was done during the study period, and the spraying was done one day after spraying with boron on 2/6/2023. The characteristics of the concentration of nutrients in the leaves of the strawberry plants were estimated. Leaf samples were collected from the plants for each experimental unit separately on June 1, 2023. Fully-grown leaves were taken (6 leaves per experimental unit), then washed, cut into small pieces, and dried in an electric oven at a temperature of 70 °C until the weight was constant (72 hours), and then ground using an electric grinder. 200 mg were then taken for each experimental unit and digested in Pyrex flasks by soaking them in 5 ml of concentrated sulfuric acid for 24 hours according to the method proposed by (34), after which 1 ml of concentrated perchloric acid heated the digestion flask and raised the vapors until a clear, transparent solution was obtained. Then the solution was cooled, and the volume was reduced to 50 ml with distilled water. The solution was then filtered, and some nutrients were estimated in the filtrate. Boron silicon and gibberellic acid were sprayed in the morning until the wetness stage. lbion seedlings were selected from one of the nurseries affiliated with the College of Agriculture and Forestry/Unified University of Mosul. They grew roughly. 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In implementing this study, a randomized complete block design (RCBD) was used. The experimental unit contained nine plants and three replicates. Each replicate had 18 experimental units. Thus, the number of plants for the three replicates was 486. at the end of the experiment, the following characteristics were estimated according to the established estimation methods, as follows:

The percentage of nitrogen in the leaves (%) was determined using the Micro-Kieldahl device and according to the method mentioned by (35).

1. The percentage of phosphorus (%) was estimated using the colorimetric method and reading the absorption of light at a wavelength of 882 nm using a spectrophotometer (Type 303-PD - APPL) according to the method of (36).

2. The percentage of potassium (%) in the leaves was estimated using a flame-photometer according to the method mentioned by (37).

3. Leaves' boron content, mg B liter-1, using an atomic absorption spectrophotometer and according to the method (38).

The results were analyzed according to a computer-aided design using the SAS program (SAS, 2001), and the means were compared using the Duncan multinomial test at a probability level of error of 0.05.

RESULTS AND DISCUSSION

Silicone effect: The results shown in Tables (2-5) confirmed that foliar spraying with silicon, especially at a concentration of 3 mmol L^{-1}, led to a significant increase in all the studied traits, which included the percentage of nitrogen (1.41%), the percentage of phosphorus (0.139%), and the percentage of potassium (1.61%). The concentration of boron (46.81 mg L^{-1}) in the leaves of the strawberry plant of the Albion variety compared to the control treatment gave the lowest values for these characteristics, which amounted, respectively, to 1.27%, 0.120%, 1.44%, and 39.83 mg L^{-1}. Foliar spraying with silicon, especially the concentration of 3 mmol Si L^{-1}, led to an increase in the concentration of the elements nitrogen, phosphorus, potassium, and boron, and this may likely lead to an increase in the depth and spread of roots in the soil when sprayed with silicon (39), In addition, treating plants with silicon may directly or indirectly affect the process of absorption of some elements in the plant (12). (8) also mentioned that silicon is one of the beneficial elements and that there is a possibility of using it as an alternative in deficient solutions of any of the nutrients necessary for plants, as silicon acts as a biostimulant and shows good results, and the use of silicon fertilizers increases the strength of plants and raises the percentage of nitrogen in the plant, which paves the way for increasing crop productivity (6), This is consistent with everything that everyone mentioned: (13,14,15).

Table 2. Effect of foliar spray with silicon, boron, and gibberellic acid and their interactions in the concentration nitrogen (%) in leaves plants of Strawberry plants cv. Albion.

Si Conc. (mmol Si L^{-1})	*B Conc. (mg B L^{-1})*	*GA_3 Conc. (mg GA_3 L^{-1})*		*Average effect of Si*	*Average effect of B*
		0	***75***		

0	*0*	0.97 j	1.50 d e	*0*	1.27 c	*0*	1.38 b
	25	1.107 i	1.50 d e				
	50	1.104 i j	*1.50* d e				
2	*0*	1.30 f g	1.53 c d	*2*	1.41 b	*25*	1.43 a
	25	1.23 g h	1.62 c				
	50	1.20 g h	1.59 c d				
3	*0*	1.40 e f	1.59 c d	*3*	1.54 a	*50*	1.41a b
	25	1.40 e f	1.72 b				
	50	1.33 f	1.82 a				
Si Conc. (mmol Si L^{-1})	B Conc. (mg B L^{-1})			Average effect of GA_3			
	0	25	50	*0*		*75*	
0	1.23 d	1.30 d	1.27 d				
2	1.41 c	1.43 c	1.39 c	1.22 b		1.60 a	
3	1.49 b	1.56 a	1.58 a				
Si Conc. (mmol Si L^{-1})	GA_3 Conc. (mg GA_3 L^{-1})		B Conc. (mg B L^{-1})	GA_3 Conc. (mg GA_3 L^{-1})			
	0	75		*0*		*75*	
0	1.04 f	1.50 c	*0*	1.22 c		1.54 b	
2	1.24 e	1.58 b	*25*	1.24 c		1.61 a	
3	1.38 d	1.71 a	*50*	1.19 c		1.64 a	

*The averages of each factor alone and the interactions between the studied factors individually followed by different letters indicate the presence of significant differences between them at the error probability level of 0.05 according to Duncan's multinomial test.

Table 3. Effect of foliar spray with silicon, boron, and gibberellic acid and their interactions in the concentration Phosphorus (%) in leaves plants of Strawberry plants cv. Albion.

Si Conc. (mmol Si L^{-1})	*B Conc. (mg B L^{-1})*	*GA_3 Conc. (mg GA_3 L^{-1})*		*Average effect of Si*		*Average effect of B*	
		0	**75**				
0	**0**	0.107 g	**0.130** c -f	**0**	**0.120** c	**0**	0.126 a
	25	0.117 e f g	0.127 c -g				
	50	0.117 e f g	0.123 d -g				
2	**0**	0.123 d -g	0.133 c -f	**2**	**0.130** b	**25**	0.129 a
	25	0.117 e f g	0.147 b c				
	50	0.117 e f g	0.143 b c d				
3	**0**	0.123 d -g	0.137 b -e	**3**	0.139 a	**50**	0.134 a
	25	0.117 e f g	0.153 b				
	50	0.123 d -g	**0.180** a				
Si Conc. (mmol Si L^{-1})	B Conc. (mg B L^{-1})			Average effect of GA_3			
	0	25	50	**0**		**75**	
0	0.118 c	0.122 c	0.120 c				
2	0.128 b c	0.132 b c	0.131 b c	0.118 b		0.141 a	
3	0.130 b c	0.135 a b	0.152 a				
Si Conc. (mmol Si L^{-1})	GA_3 Conc. (mg GA_3 L^{-1})		B Conc. (mg B L^{-1})	GA_3 Conc. (mg GA_3 L^{-1})			
	0	75		**0**		**75**	
0	0.113 d	0.127 c	**0**	0.118 c		0.133 b	
2	0.119 c d	0.141 b	**25**	0.117 c		0.142 a b	
3	0.121 c	0.157 a	**50**	0.119 c		0.149 a	

*The averages of each factor alone and the interactions between the studied factors individually followed by different letters indicate the presence of significant differences between them at the error probability level of 0.05 according to the Duncan multinomial test.

Table 4. Effect of foliar spray with silicon, boron, and gibberellic acid and their interactions in the concentration Potassium (%) in leaves plants of Strawberry plants cv. Albion.

Si Conc. (mmol Si L^{-1})	*B Conc. (mg B L^{-1})*	*GA_3 Conc. (mg GA_3 L^{-1})*		*Average effect of Si*		*Average effect of B*	
		0	**75**				
0	**0**	1.28 k	1.58 c -g	**0**	1.44 c	**0**	1.52 a
	25	1.38 i j k	1.57 c -g				
	50	1.33 j k	1.53 d -h				
2	**0**	1.47 g h i	1.61 b - f	**2**	1.54 b	**25**	1.55 a
	25	1.44 g h i	1.67 a b c				
	50	1.43 h i j	1.65 a -d				
3	**0**	1.52 e -h	1.64 b -e	**3**	1.61 a	**50**	1.53 a
	25	1.50 f -i	1.72 a b				
	50	1.49 e -i	1.76 a				

Si Conc. (mmol Si L^{-1})	B Conc. (mg B L^{-1})			Average effect of GA_3	
	0	25	50	**0**	**75**
0	1.43 d	1.47 c d	1.43 d		
2	1.54 b c	1.55 a b c	1.54 b c	1.43 b	1.64 a
3	1.58 a b	1.61 a b	1.63 a		

Si Conc. (mmol Si L^{-1})	GA_3 Conc. (mg GA_3 L^{-1})		B Conc. (mg B L^{-1})	GA_3 Conc. (mg GA_3 L^{-1})	
	0	75		**0**	**75**
0	1.33 e	1.56 c	**0**	1.42 b	1.61 a
2	1.45 d	1.64 b	**25**	1.44 b	1.65 a
3	1.50 c d	1.71 a	**50**	1.42 b	1.65 a

*The averages of each factor alone and the interactions between the studied factors individually followed by different letters indicate the presence of significant differences between them at the error probability level of 0.05 according to the Duncan multinomial test.

Table 5. Effect of foliar spray with silicon, boron, and gibberellic acid and their interactions in the concentration of boron (mg B L^{-1}) in leaves plants of Strawberry plants cv. Albion.

Si Conc. (mmol Si L^{-1})	*B Conc. (mg B L^{-1})*	*GA_3 Conc. (mg GA_3 L^{-1})*		*Average effect of Si*		*Average effect of B*	
		0	**75**				
0	**0**	22.23 i	25.76 i	**0**	39.83 b	**0**	25.23 c
	25	31.46 g h i	41.53 f g h				
	50	049.7 e f	**68.30**b c				
2	**0**	**22.60** i	**26.80**i	**2**	43.02 a b	**25**	38.93 b
	25	33.13 g h i	**42.90** f g				
	50	56.03 d e	**76.70** a b				
3	**0**	23.33 i	**30.70**h i	**3**	46.81 a	**50**	**65.50** a
	25	39.43 f g h	45.16 f				
	50	**62.80**c d	79.46 a				

Si Conc. (mmol Si L^{-1})	B Conc. (mg B L^{-1})			Average effect of GA_3	
	0	25	50	**0**	**75**
0	24.00 d	36.50 c	59.00 b		

2	24.70 d	38.01 c	66.36 a	37.85 b	48.59 a
3	27.01 d	42.30 c	71.13 a		
Si Conc. (mmol Si L^{-1})	GA_3 Conc. (mg GA_3 L^{-1})		B Conc. (mg B L^{-1})	GA_3 Conc. (mg GA_3 L^{-1})	
	0	75		**0**	**75**
0	34.46 e	45.20 b c	**0**	22.72 e	27.75 e
2	37.25 d e	48.80 a b	**25**	34.67 d	**43.20** c
3	41.85 c d	51.77 a	**50**	56.17 b	74.82 a

*The averages of each factor alone and the interactions between the studied factors individually followed by different letters indicate the presence of significant differences between them at the error probability level of 0.05 according to the Duncan multinomial test

Boron effect: The results shown in Tables (2-5) confirmed that foliar spraying with boron at a concentration of 50 mg B L^{-1} led to a significant increase in boron concentration (65.50 mg L^{-1}) and was significantly superior in this characteristic to the spray treatment with 25 mg B L^{-1}. The control treatment that gave the lowest value for this trait amounted to 25.23 mg B L^{-1}, while the 25 mg B L^{-1} treatment gave the highest values for the nitrogen percentage in the leaves (1.43%) and was significantly superior in this trait to the spraying treatment with a concentration of 50. mg B liter-1, which did not differ significantly from the control treatment, which gave the lowest values for this trait and amounted to 1.38%, while the percentage of phosphorus and potassium in the leaves of strawberry plants were not significantly affected by foliar spraying with boron. The significant increase in the elements nitrogen and boron in the leaves likely indicates an increase in the root growth of plants, which may lead to an increase in the absorption of nutrients from the soil, as the element boron has a very great importance in plant nutrition, and the importance and necessity of this element for high-end plants have been proven since the year 1910. (17), as it contributes to regulating the osmotic potential and water balance in the cell by increasing the plant's efficiency in increasing the absorption of some nutrients, as the adsorption sites on the surface of the roots increase when the root growth of plants increases. In addition, the increase in boron concentration in the leaves may be attributed to the leaves absorbing a proportion of the boron present in the spray solution, and as expected, with an increase in its concentration in the spray solution, Then, due to the role of boron in stimulating the plant to absorb various mineral elements from the soil solution by encouraging an increase in the number and length of roots (40), foliar spraying with microelements stimulates the plant to absorb the same elements from the soil **(41),** This is what the researchers agreed with: (25, 26), 44, 45all argue that increasing the concentration of boron in the spray solution may increase its uptake by the sprayed plants. **ron effect:** The results shown in Tables (2-5) confirmed that foliar spraying with boron at a concentration of 50 mg B L^{-1} led to a significant increase in boron concentration (65.50 mg L^{-1}) and was significantly superior in this characteristic to the spray treatment with 25 mg B L^{-1}. The control treatment that gave the lowest value for this trait amounted to 25.23 mg B L^{-1}, while the 25 mg B L^{-1} treatment gave the highest values for the nitrogen percentage in the leaves (1.43%) and was significantly superior in this trait to the spraying treatment with a concentration of 50. mg B liter-1, which did not differ significantly from the control treatment, which gave the lowest values for this trait and amounted to 1.38%, while the percentage of phosphorus and potassium in the leaves of strawberry plants were not significantly affected by foliar spraying with boron. The significant increase in the elements nitrogen and boron in the leaves likely indicates an increase in the root growth of plants, which may lead to an increase in the absorption of nutrients from the soil, as the element boron has a very great importance in plant nutrition, and the importance and necessity of this element for high-end plants have been proven since the year 1910. (17), as it contributes to regulating the osmotic potential and water balance in the cell by increasing the plant's efficiency in increasing the absorption of some nutrients, as the adsorption sites on the surface of the roots increase when the root growth of plants increases. In addition, the increase in boron concentration in the leaves may be attributed to the leaves absorbing a proportion of the

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Effect of gibberellic acid: The results shown in Tables (2-5) confirmed that foliar spraying with gibberellic acid at a concentration of 75 mg L^{-1} led to a significant increase in all the studied traits, which included the percentage of nitrogen (1.60%), the percentage of phosphorus (0.141%), the percentage of potassium (1.64%), and the concentration of boron (48.59 mg L^{-1}) in the leaves of the strawberry plant of the Albion variety compared to the control treatment that gave the lowest values for these characteristics, which amounted, respectively, to 1.22%, 0.118%, 1.43%, and 37.85 mg L^{-1}. Foliar spraying with gibberellic acid at a concentration of 75 mg GA_3 L^{-1} may increase the root growth of plants, which may lead to increased absorption of nutrients from the soil, as gibberellic acid may increase the size and breadth of cells through its role in the flexibility and pliability of the wall. cell wall and increased cell expansion (50), Adsorption sites on the surface of the roots also increase when the root growth of plants increases or through the role of auxin induced by spraying gibberellic acid, which has a role in cell growth and its importance in stimulating and modifying gene duplication processes and then translation processes and stimulating acid synthesis. Nuclear RNA and protein. On the other hand, auxins induced by gibberellin play an important role in the plasticity of cell walls, by breaking the bonds of the cell walls and rearranging them in new locations under inflationary pressure, which contributes to increasing the size and breadth of the cell. or auxins may affect enzymes, especially the cellulase enzyme. Which weakens fiber systems and causes degradation of cell wall components by activating proton pumping (Hydrogen ion) and reducing the acidity of the cell, which causes a change in the acidity of the cell wall and changes the bonds and then increases the plasticity of the cell wall, as it changes the water relations of the plant, especially the turgor and osmotic pressure of the cell, which causes the flow of water and nutrients into the cell and increases its expansion (44,45), and gibberellic acid increases the permeability of cell walls and makes them a strong magnet for nutrients as well as nutrients (51). Gibberellic acid also helps in building the alpha-amylase enzyme, which converts starch into reducing sugars, which in turn works to raise the negativity of the osmotic potential in plant cells and then increase the entry of water and nutrients into the cell, causing it to swell and increase in size, and these results are consistent with what was mentioned by (38) when foliar spraying of strawberry plants with gibberellic acid.

The effect of interactions among the studied factors: The results (Tables 2-5) indicate that all the binary interactions and the triple interactions among silicon, boron, and gibberellic acid had a significant effect on all the studied traits, as the highest concentrations of them (3 mmol Si L-1, 50 mg B L^{-1}, and 75 mg GA_3 L^{-1}) gave the highest values for all the studied traits, especially the triple interaction, in which the percentage of nitrogen in the leaves reached (1.82%), the percentage of phosphorus in the leaves (0.180%), and the percentage of potassium in the leaves (1.76%) The concentration of boron in the leaves was (79.46 mg B L^{-1}) compared to the control treatment that gave the lowest values for these characteristics, which amounted to 0.97%, 0.107%, 1.28%, and 22.23 mg B L^{-1}, respectively. This is due to the cooperative effect of silicon, boron, and gibberellic acid, increasing the growth and spread of roots in the soil, which increases their absorption of nutrients and increases their concentration in the leaves of the strawberry plant, for the same reasons that were mentioned when explaining the effect of each of them individually.

CONCLUSION

We conclude from the study that foliar spraying of strawberry plants cv. albion with high levels of silicon at a concentration of 3 mmol Si L-1, boron 50 mg B L-1, and gibberellic acid 75 mg GA3 L-1 individually or when mixed together led to an increase in absorption and leaf content. Strawberry is one of the beneficial nutrients for plants.

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