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RESEARCH ARTICLE

Effect of foliar spray with silicon, boron, and gibberellic acid on the Characteristics of vegetative and root growth of Strawberry plants (Fragaria x ananassa Duch.) cv. Albion

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ABSTRACT

This study was conducted in one of the unheated greenhouses of the Department of Horticulture and Landscape Design Department/College of Agriculture and Forestry/University of Mosul to find out the effects of foliar spray by using three concentrations of silicon (0 and 2 and 3 mmol Si L-1) using potassium silicate (18%) Si) and boron in three concentrations also (0, 25 and 50 mg B L-1) by using boric acid (17% B) and two concentrations of gibberellic acid in two concentrations. They 0 and 75 mg GA3 L-1 in some characteristics of vegetative growth of plants Strawberry (strawberry) (Fragaria x ananassa Duch.) cv. Albion For the period from 12/1/2022 until 6/1/2023 Except the description of the number of runners, which was taken on 9/15/2023 , the plants were sprayed three times with each of silicon and boron and once with gibberellic acid during the study period. The study was applied using a design RCBD. Three and nine replicate plants for each experimental unit. The results showed foliar spraying with silicon, boron, and gibberellic acid separately, as well as all interactions between them. Especially at concentrations of 3 mmol Si L-1 and 50 mg B L-1 with 75 mg GA3 L-1, it led to a significant increase in the following characteristics: total chlorophyll in leaves, plant leaves area, crown diameter, dry weight of the shoot and root system of the plants, and the number of runners for each plant. Compared to the control treatment.

INTRODUCTION

Prepare Strawberry (*Fragaria x ananassa* Duch). Of fruit plants, it follows The Rosary family Rosaceae includes 45 species, and it is of high economic importance due to its wide spread in different regions of the world, the large number of its varieties, and their ability to adapt and grow in varying environmental conditions. And the nutritional value of its fruits it appears in the markets early in the spring, and the plant is distinguished by its production of filamentous purls that form in the axils of the leaves and have the ability to root, forming new plants (Zhao, 2007), It is believed that the original home of the strawberry is North America. it is also grown in Europe, Asia, Africa, and America (Habib and Pharaoh, 2013), and some strawberry varieties have the ability to grow from the subtropical region until the 70˚ north line. Leveling But it is spread out in a way big between linear the offer (15˚-55˚) (Ceausescu et al., 1982), and estimated cultivated area for Schleck in the world around 389665 hectares and production of 9175384 tons (FAO, 2023) For the purpose of improving the growth and production of strawberry plants, it may be treated with some useful elements, including silicon, and necessary nutrients, including boron. silicone work to improve plant growth, development, and production, and add silicon to plants Through soil or foliar spray it leads to the healthy growth of

plants, directly or indirectly. Especially when plants are exposed to various stresses, silicone acts as a bio stimulant and shows good results. We Provide hardness to the plant. And more than the percentage of nitrogen in the plant, which paves the way for increasing crop productivity (Parimala and Singh, 2022), It has been observed that adding silicon to plants leads to a positive effect on them. As it stimulates plants to develop and gives the plant resistance or tolerance to various stress conditions, whether abiotic or biotic stress (Matichenkov et al., 2000), Jarosz (2014) mentioned, that silicon is the only element that does not harm plants when given to them in large quantities (Guntzer et al., 2012). In addition, silicon acts as a physiological barrier, especially in various parts of the plant, such as leaves and stems, and works to protect plant cells from the flow of harmful ions into the plant in quantities that reach toxicity (Kardoni et al., 2013). And to him, it is important to increase the efficiency of the photosynthesis process and the synthesis of important organelles in plant cells (Shu and Liu, 2001).

There are a number of researchers who have shown that foliar spraying strawberry plants with silicon improves their vegetative growth, including: Dehghanipoodeh (2018) when foliar spraying of plants of the cv. Camarosa with 10 mmol Si L^{-1} and Li et al., (2020) when foliar spraying of plants of the cv. Seolhyang with 75 mmol Si L^{-1} and Felipo-Peris (2020) when foliar spraying of plants of the cv. Fortuna with 1.5 mmol Si L^{-1} and Mohammed and Majeed (2023) when foliar spraying of plants of the cv. Festival with 2.5 mmol Si L^{-1}.

As for the boron element, it is one of the micro nutrients necessary for all plants, and the plant needs it in very small quantities. It is an immobile element within the plant (immobile), as it is found in most soils in small quantities ranging between 7 and 80 mg kg^{-1}, and boron is dissolved in the soil solution or on the surfaces of its colloids, and the boron dissolved in the soil solution represents the form of boron most ready for absorption by the plant (Gupta, 1993). This element has many benefits for the plant, as it increases...The efficiency of the plant in resisting fungal and insect diseases, And it has a role in the formation of pectin and lignin, as 50% of boron is found in the cell walls. It has an effect on the production of gibberellic acid in seeds, which helps in their germination (Abu Dahi and Al-Younis, 1988; Al-Mamouri, 1997). And it helps in a The products of the photosynthesis process are transferred from the leaves to the active areas, and this helps in building the growing shoots and reducing the fall of flowers, thus increasing the yield. Feeding the plant with boron, sprayed on the shoots at an appropriate concentration, stimulates the physiological processes in the flowering stage by increasing the growth of the pollen tube. It also increases the level of carbohydrates transferred to the active areas during the reproductive stage, which leads to an increase in the number of flowers and inflorescences and a decrease in the percentage of aborted flowers in the plants. (Abu Dahi and Al-Younes, 1988, and Al-Sahhaf, 1989), he mentioned (2010) Meena: Foliar spraying of strawberry plants with boron reduces the period required for flowering and fruit set and improves the vegetative growth of the plants. This is due to the physiological roles of this element, which include protein metabolism, building pectin, maintaining the water balance within the plant, building ATP, and transferring sugars to the flowers and fruits during their development stages. Boron is important in the process of plant cell division and specialization. it activates a number of enzymes, including peroxidase, catalase, saccharase, amylase, and some oxidation enzymes, in addition to its role in the process of protein formation.

There are a number of researchers who have shown that foliar spraying of strawberry plants with boron improves their vegetative growth, including: Ahmed et al., (2020) When foliar spraying of plants of the cv. Liberation D'Orleans with 60 mg B L^{-1} Mohamed et al., (2021): When foliar spraying of plants of the cv. Fortona With 4 mg B L^{-1}, Rozbiany and Ibrahim (2022) When foliar spraying of plants of the cv. Ruby Gem with 20 mg B L^{-1} and Bashari et al., (2023) when foliar spraying of plants of the cv. Festival with 5 mg B L^{-1}.

Gibberellins are growth-stimulating plant hormones. One of the most important of them is its use in agriculture. GA_3 is produced naturally within the various plant tissues of organisms in the plant kingdom, whether they are higher plants (gymnosperms or angiosperms) or primitive non-higher plants such as algae, fungi, bacteria, and ferns (Hedden and Thomas, 2006; Sponsel and Hedden, 2010). The physiological effect is attributed to For gibberellic acid it controls enzymatic activity and activates metabolic processes, such as increasing dissolved carbohydrates by activating an enzyme. α-amylase and the production of the carboxylase enzyme several hours after the addition. it also activates the formation of nucleic acids, and treatment with gibberellins contributes to the transfer of processed food materials to a greater extent towards the growth site (Idris, 2004; Younis et al., 2008; Al-Wahsh, 2008), and gibberellins play an important role. It stimulates many physiological responses in many plants, as it accelerates vegetative growth by increasing cell division and elongation and leads to increasing plant height through two different physiological processes, the first represented by cell division and the other by the elongation cells tissue of plant (Abu Zaid, 2000). And Idris, 2004 and Korkutal et al., 2008), and that the mission of gibberellin is that it is a supplement to auxin in the balanced growth and development of plants., since it helps in increasing the auxin that stimulates growth within the plant, especially the circulating auxin (diffusible auxin) (Wasfi, 1998; Toushan et al., 2000; Jandiyeh, 2003).

There are a number of researchers who have shown that foliar spraying of strawberry plants with gibberellic acid improves their vegetative growth, including: Al-Handel and Ghanim (2021), when foliar spraying of plants of the cv. Ruby Gem with 100 mg GA_3 L^{-1} and Aditee And Ankush (2020). When foliar spraying of plants of the cv. Camarosa with 10 mg GA_3 L^{-1} and Abbas et al., (2021) When foliar spraying of plants of the cv. Chandler With 100 mg GA_3 L^{-1} and Aziz Allah et al., (2023), When foliar spraying of plants of the cv. Chandler with 200 mg GA_3 L^{-1}.

Therefore, this study aims to improve the vegetative growth of Strawberry plant cv. Albion. And to determine the appropriate concentrations of silicon, boron, and gibberellic acid that should be sprayed on the plants of this cv. to achieve this. Due to the lack of studies similar to this study on this cv. in the city of Mosul, this study was conducted.

MATERIALS AND METHODS

This study was conducted in a greenhouse affiliated with the Department of Horticulture and Landscape Design /College of Agriculture and Forestry, University of Mosul, with an area of 175 m2. For the period from 12/1/2022 to 6/15/2023 On the plants of the strawberry cv. Albion it was estimated that some physical and chemical characteristics of the soil existed before planting, as explained in the table (1).

Table (1): Some physical and chemical characteristics of greenhouse soil.

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

* The soil was analyzed in the central laboratory of the College of Agriculture and Forestry.

The strawberry seedlings, cv. Albion, were selected from The nurseries affiliated with the College of Agriculture and Forestry/University of Mosul had almost homogeneous growth, as they were uprooted directly from the soil, and then the wounded roots and large leaves were removed, while keeping two new leaves. Add compound fertilizer. Before planting, according to fertilizer recommendations Posted fertilizer on the upper surface of the terrace and mixed it well with the soil, then irrigated it directly, then covered all the terraces with black polyethylene, making holes at the top of the terrace at a distance of 25 cm between one hole and another for planting plants. And that is done. The first of December For the year 2023 Plants were planted in three lines, the distance between one line and another is 25 cm, and the distance between one plant and another is 25 cm. Spraying treatments were carried out with silicone at three concentrations (0, 2, and 3 mmol Si L^{-1} (and twice during the study period. Duration: 30 days between one spraying and the next, as the first spraying was on 2/4/2023, and spraying with boron in the form of boric acid (17%B) at three concentrations (0, 25, and 50 mg B L^{-1}) And twice during the study period, with an interval of 30 days between one spray and another, The first spraying was on 2/5/2023, and with gibberellic acid at two concentrations (0 and 75 mg GA_3 L^{-1}) and one spray during the study period on 2/6/2023, silicon boron and gibberellic acid were sprayed early in the morning until completely wet, with material Tween 20 as a diffuser to reduce the surface tension of water when foliar spraying on leaves.

In implementing the study, a completely randomized block design (RCBD) was used with three factors, three replicates, 9 plants for each experimental unit. And so the number of plants used in the study is 486. At the end of the experiment, the following characteristics were evaluated:

1. Total chlorophyll in leaves, according to Mackinney (1941) and Arnon (1949).
2. Leaves area of plant (cm^2 $plant^{-1}$) According to the method he mentioned, Saieed (1990).
3. Crown diameter using the foot, Vernier.
4. The dry weight of the shoot and root system of the plant (gm plant $^{-1}$), by taking two plants from each experimental unit, and the shoots were separated from the roots. Then dry each of them separately in an electric oven at a temperature of 70 degrees Celsius until the weight is stable, and divide the result of each by 2 to extract the dry weight of one plant.
5. The number of runners for each plant, was chosen 6 be six for every experimental unit. The average number of incubators per plant was found by dividing the total number of incubators for each experimental unit. on six.

The results were analyzed according to the computer-aided design. using the program SAS (2001), averages were compared using Duncan's multinomial test at the polynomial at an error probability level 0.05.

RESULTS AND DISCUSSION

Silicon effect: The results shown in (Tables 2 -7) Foliar spraying with silicon, especially the concentration of 3 mmol L^{-1}, led to a significant increase in all the studied traits, which included total chlorophyll in leaves (3.34 mg g^{-1} fresh weight), plant leaves area (4067.55 cm^2 $plant^{-1}$), and crown diameter (13.78) mm, the dry weight of the shoot (35.45 gm $plant^{-1}$), the dry weight of the root system (8.37 gm $plant^{-1}$), and the number of runners for each plant (18.96 $runner^{-1}$ plant) compared to the control treatment that gave the lowest values for these characteristics, which amounted to 2.70 mg, respectively. gm^{-1} fresh weight, 3182.02 cm^2 $plant^{-1}$, 12.66 mm, 21.90 gm $plant^{-1}$, 5.66 gm $plant^{-1}$, and 15.53 $runner^{-1}$ plant . Since foliar spraying with silicone, especially concentrated at 3 mmol Si L^{-1}, this may be due to the increased material of food manufactured in A Waraq, which are carbohydrates, as a result of increasing the amount of chlorophyll in the leaves as well as the plant leaves area (Tables 2 and 3) some of which may be used in the growth of various plants. in addition, the silicon element is important in increasing the effectiveness of many enzymes and the concentration of soluble substances in the bark as a result of reducing the movement of ions that are harmful to plants. Silicon is also important in increasing the efficiency of the photosynthesis process and the synthesis of important organelles in plant cells (Shu and Liu, 2001), it has a positive effect on the growth and development of plants under different stress conditions (Ma And Yamaji (2008), and the basis is in the mechanics of the work of the element. Silicon's resistance to various stresses is due to the encouraging antioxidant systems in plants. Silicon also inhibits ethylene production and thus delays plant aging (Liang et al., 2007). The results of this study are consistent with what was mentioned by Liu et al., (2021), Mohammed and Majeed (2023), and Mohammed and Majeed (2024) showed that foliar spraying with silicon leads to increased vegetative growth of strawberry plants.

Table (2): Effect of foliar spray with silicone, boron, and gibberellic acid and their interactions on total chlorophyll (mg g^{-1} fresh weight) content in leaves 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	1.83 j	3.35 a b c	0	2.71 c	0	3.01 b
	25	2.52 h i	3.12 d e				
	50	2.44 i	3.02 e f				
2	0	2.85 e f g	3.43 b c	2	3.17 b	25	3.14 a
	25	2.77 f g h	3.68 a b				
	50	2.68 g h i	3.62 a b c				
3	0	3.00 e f g	3.57 a b c	3	3.34 a	50	3.08 a b

	25	2.96 e f g	3.80 a				
	50	2.88 e f g	3.85 a				
Si Conc. (mmol Si L^{-1})	B Conc. (mg B L^{-1})			Average effect of GA_3			
	0	25	50	0		75	
0	2.59 d	2.82 c	2.73 c d				
2	3.14 b	3.23 a b	3.15 b	2.663 b		3.499 a	
3	3.29 a b	3.38 a	3.37 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	2.26 f	3.17 c	0	2.56 c		3.45 a	
2	2.77 e	3.58 b	25	2.75 b		3.53 a	
3	2.95 d	3.74 a	50	2.67 b c		3.50 a	

*The means of each factor and the interactions between them separately, 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 (3): Effect of foliar spray with silicon, boron, and gibberellic acid and their interactions in plant leaves area (cm^2 $leaves^{-1}$) of strawberry plants of 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	2432.98 m	3726.86 e f	0	3182.02 c	0	3476.50 b
	25	2868.84 k l	3694.87 e f				
	50	2775.46 l	3593.10 f g				
2	0	3166.70 i j	3880.07 e	2	3699.18 b	25	3732.91 a
	25	3069.00 j k	4597.26 b c				
	50	3035.84 j k l	4446.22 c				
3	0	3464.15 f g h	4188.23 d	3	4067.55 a	50	3739.34 a

	25	3414.38 g h i	4753.13 b				
	50	3276.96 h i j	5308.47 a				

Si Conc. (mmol Si L^{-1})	B Conc. (mg B L^{-1})			Average effect of GA_3	
	0	25	50	0	75
0	3079.92 f	3281.86 e	3184.28 e f		
2	3523.39 d	3833.13 c	3741.03 c	3056.03 b	4243.14 a
3	3826.19 c	4083.76 b	4292.71 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	2692.43 f	3671.61 c	0	3021.28 c	3931.72 b
2	3090.51 e	4307.85 b	25	3117.41 c	4348.42 a
3	3385.16 d	4749.95 a	50	3029.42 c	4449.26 a

*The means of each factor and the interactions between them separately, 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 crown diameter (mm) 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	11.53 j	13.42 c -f	0	12.66 c	0	13.00 b
	25	12.42 h i	13.36 d e f				
	50	11.91 i j	13.32 d -g				
2	0	12.84 f g h	13.48 c -f	2	13.27 b	25	13.36 a
	25	12.77 f g h	14.08 b c				
	50	12.62 g h	13.84 b c d				
3	0	13.16 d -g	13.59 c d e	3	13.78 a	50	13.35 a
	25	13.03 e -h	14.49 c -f				

	50	13.00 e -g	15.41 a				
Si Conc. (mmol Si L^{-1})	B Conc. (mg B L^{-1})			Average effect of GA_3			
	0	25	50	0		75	
0	12.47 e	12.89 d e	12.62 e				
2	13.16 c d	13.42 b c	13.22 c d	12.58 b		13.88 a	
3	13.37 b c d	13.76 a b	14.20 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	11.95 e	13.36 c	0	12.51 c		13.49 b	
2	12.74 d	13.80 b	25	12.74 c		13.97 a	
3	13.06 c d	14.49 a	50	12.51 c		14.19 a	

*The means of each factor and the interactions between them separately, 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 dry weight of the shoot (g $Plant^{-1}$) 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	11.97 j	14.24 i j	0	21.90 c	0	17.22 c
	25	23.45 f g	23.29 f g				
	50	25.65 f	32.78 d				
2	0	17.27 h i	19.6 h i	2	30.86 b	25	31.41 b
	25	27.11 e f	40.21 c				
	50	31.52 d	49.42 b				
3	0	19.16 g h	21.01 h i	3	35.45 a	50	39.58 a
	25	30.71 d e	43.68 c				

	50	39.99 c	58.15 a				
Si Conc. (mmol Si L^{-1})	B Conc. (mg B L^{-1})			Average effect of GA_3			
	0	25	50	0		75	
0	13.11 h	23.37 f	29.21 e				
2	18.46 g	33.66 d	40.47 b	25.20 b		33.60 a	
3	20.08 g	37.20 c	49.07 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	20.35 e	23.44 d	0	16.13 e		18.30 e	
2	25.30 d	36.43 b	25	27.09 d		35.73 b	
3	29.95 c	40.94 a	50	32.39 c		46.78 a	

*The means of each factor and the interactions between them separately, 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 (6): Effect of foliar spray with silicon, boron, and gibberellic acid and their interactions in dry weight of the root system (g $Plant^{-1}$) 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	3.40 k	3.80 k	0	5.66 c	0	4.41 c
	25	6.06 h i	5.93 h i				
	50	6.20 g h i	8.61 d e				
2	0	3.96 k	5.10 i j	2	7.50 b	25	7.71 b
	25	6.86 g h	9.66 c d				
	50	8.17 e f	11.26 b				
3	0	4.51 j k	5.73 h i	3	8.37 a	50	9.42 a
	25	7.26 f g	10.48 b c				
	50	8.98 d e	13.28 a				

Si Conc. (mmol Si L^{-1})	B Conc. (mg B L^{-1})			Average effect of GA_3	
	0	25	50	0	75
0	3.60g	6.00e	7.40 d		
2	4.534 f	8.26 c	9.72 b	6.15 b	8.20 a
3	5.12 f	8.87 c	11.13 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	5.22 e	6.11 d	0	3.96 f	4.87 e
2	6.33 c d	8.67 b	25	6.73 d	8.69 b
3	6.92 c	9.83 a	50	7.78 c	11.05 a

*The means of each factor and the interactions between them separately, 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 (7): Effect of foliar spray with silicon, boron, and gibberellic acid and their interactions in number of runners (runner $plant^{-1}$) formed on 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}) 0	75	Average effect of Si		Average effect of B	
	0	11.90 m	19.14 d e				
0	25	12.95 l	18.62 e f	0	15.53 c	0	17.08 a
	50	12.57 l m	17.99 g				
	0	14.61 i j	19.57 d e				
2	25	14.04 j k	21.04 b c	2	17.22 b	25	17.46 a
	50	13.42 k l	20.61 c				
3	0	17.23 g	20.05 c d	3	18.96 a	50	17.15 a

	25	16.23 h	21.90 b
	50	15.38 h i	22.95 a

Si Conc.	B Conc. (mg B L^{-1})			Average effect of GA_3	
(mmol Si L^{-1})	0	25	50	0	75
0	15.52 c	15.78 c	15.28 c		
2	17.09 b	17.54 b	17.02 b		
				14.26 b	20.21 a
3	18.64 a	19.07 a	19.16 a		

Si Conc.	GA_3 Conc. (mg GA_3 L^{-1})		B Conc.	GA_3 Conc. (mg GA_3 L^{-1})	
(mmol Si L^{-1})	0	75	(mg B L^{-1})	0	75
0	12.47 f	18.58 c	0	14.58 c	19.58 b
2	14.03 e	20.41 b	25	14.41 c	20.52 a
3	16.28 d	21.63 a	50	13.79 d	20.52 a

*The means of each factor and the interactions between them separately, 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 mentioned in (Tables 2-7) Foliar spraying with boron at a concentration of 50 mg B L-1 led to a significant increase in the characteristics of the plant leaves area (3739.34 cm2 $plant^{-1}$), the dry weight of the shoot (39.50 gm $plant^{-1}$), and the dry weight of the root system (9.42 gm $plant^{-1}$), while treatment with 25 mg B L^{-1} gave the highest values for the two characteristics of total chlorophyll in the leaves (3.14 mg g^{-1} fresh weight) and crown diameter (13.36 mm). it was significantly superior in these two characteristics to the control treatment only, which gave the lowest values for these characteristics, which amounted to 3.01 mg g^{-1} fresh weight, respectively. And 3476.50 cm^2 $plant^{-1}$, 13.00 mm, 17.22 g $plant^{-1}$, and 4.41 g $plant^{-1}$, while the number of runners was not significantly affected by foliar spraying with boron. This may be due to the increased concentration of chlorophyll in the leaves when sprayed with boron as a result of the increased concentration of nitrogen and boron in the leaves when sprayed with boron, as nitrogen is involved in building this pigment, and boron also contributes indirectly to building this pigment (Havlin et al., 2005), as well as increasing the plant leaves area (Table 3), and this may be It leads to an increase in the substances manufactured in the leaves. it hydrates and is used in vegetative growth processes, and the radical is different, In addition, boron acts as a regulator of vital processes within the plant. Boron also affects the construction of cell walls, pectin, and lignin, and is necessary for the transport of carbohydrates within the plant (Vasil, 1964). These results are consistent with what was

mentioned by: Arunkumar et al., (2022) , Romano and Fisher (2022) , Rozbiany and Ibrahim (2022), and Bashari et al., (2023) when foliar spraying of strawberry plants with boron.

Effect of gibberellic acid: it is noted from the results shown in Tables (2-7) 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 total chlorophyll in leaves (3.49 mg g^{-1} fresh weight), plant leaves area (4243.14 cm^2 $plant^{-1}$), and crown diameter (13.88 mm). and the dry weight of the shoot (33.60 gm $plant^{-1}$), the dry weight of the root system (8.20 gm $plant^{-1}$), and the number of runners for each plant (20.21 $runner^{-1}$ $plant^{-1}$) compared to the control treatment that gave the lowest values for these characteristics, which amounted, respectively, to 2.66 mg gm^{-1} fresh weight, 3056.03 cm^2 $plant^{-1}$, 12.58 mm, 25.20 g $plant^{-1}$, 8.37 g $plant^{-1}$, and 14.26 runner $plant^{-1}$.This may indicate an increase in the concentration of nitrogen, phosphorus, potassium, and boron in the leaves when sprayed with gibberellic acid, as these elements have great benefits within the plant, especially building chlorophyll, as increasing the chlorophyll and plant leaves area may have led to an increase in the synthetic substances in the leaves, which are carbohydrates, which are used in different growth processes. Gibberellic acid works to stimulate cell elongation, increase the effectiveness of many enzymes that are important in plant growth and development, and increase the speed of biological and physiological processes by increasing the construction of nucleic acids and proteins. Mohammed (1985) and Al-Asadi and Al-Khikani (2019), the significant increase in all studied vegetative growth traits of the strawberry plant in this study upon foliar spraying with gibberellic acid it is consistent with what many researchers have obtained, including: Aditee And Ankush (2020), Abbas et al., (2021), and Aziz Allah et al., (2023).

The effect of interactions among the studied factors: The results (Tables 2-7) 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} it gave the highest values for all the traits studied, especially the triple interaction, in which the values of total chlorophyll in the leaves reached (3.85 mg g^{-1} fresh weight), the plant leaves area (5308.47 cm^2 $plant^{-1}$), the crown diameter (15.41 mm), the dry weight of the shoot (58.15 gm $plant^{-1}$), the dry weight of the root system (13.28 gm $plant^{-1}$), and the number of runners for each plant (22.95 runner $plant^{-1}$) compared to the control treatment that gave the lowest values for these characteristics, which amounted, respectively, to 1.83 mg g^{-1} fresh weight and 2432.98 cm^2 $plant^{-1}$, 11.53 mm, 11.97 gm $plant^{-1}$, 3.40 gm $plant^{-1}$, and 11.90 runners $plant^{-1}$. This is due to the cooperative effect of silicon, boron, and gibberellic acid in increasing the characteristics of vegetative and root growth, and 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 plants with Strawberry cv. Albion and high levels of silicon boron and gibberellic acid (3 mmol Si L^{-1}, 50 mg B L^{-1} and 75 mg GA_3 L^{-1}) greatly improves the vegetative and root growth of plants, which may positively affect the yield of plants.

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