Response Two Strawberry Cultivars (*Fragaria × ananassa Duch.)* for foliar Application of Algae and Iron chelate Fertilizers

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Abstract

The beginning of this study in the seasons of 2021-2022 from the orchard at agricultural training center in Erbil /Ministry of Agriculture / Kurdistan Region/ Iraq, The experiment examines the impact of Algae and Iron Chelate at three doses on growth, blooming, and yield as a foliar spray and their interactions on growth, chemical composition, production, and quality of strawberry at two strawberry cultivars (*Fragaria x ananassa Duch.*). Festival and Sabrina, using the six spraying while doing the experiment in the morning start in November 10 2021 to January 1 2022. The results showed The effect of fertilizer (Algae and Iron chelate) were significantly effect on leaf area, the value was (9.94) were obtained from Sabrina cultivar by using (6gm.L^{-1} algae and 2ml.L^{-1} iron chelate). and significantly Effect on fruit size, the value of fruit size is registered with Festival, (6 gm.L^{-1} algae) and (2 ml.L^{-1} iron chelate) which are (12.37). Also by spring (6gm.L^{-1} algae and 2ml.L^{-1} iron chelate), recorded the anthocyanin's value significant value (16.71 mg.100g-1 F.W.). Additionally, the relationship between (Cultivars + Fertilizers + Concentration) was significantly affected on leaf area, the value recorded in (sabrina + 6 gm.L^{-1} algae + 2ml.L^{-1} iron chelate) (14.46 cm^2). Also was significantly affected on fruit size, the value was recorded in (sabrina + 6 gm.L^{-1} algae + 2 ml.L^{-1} iron chelate) (13.04) in comparison with untreated strawberry cultivars, on the interaction among (Sabrina + 6gm.L^{-1} Algae + 2ml.L^{-1} Iron chelate) obtained the value (10.06 mg.$100g^{-1}$ F.W.), which obtained from the (sabrina + 0.0 algae+ 0.0 iron chelate).

Key words: Strawberry, *Fragaria x ananassa Duch.*, Festival, Sabrina , Algae, Iron Chelate.
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Introduction

Strawberry *(Fragaria x ananassa Duch.)* is a member of the Rosaceae family. the genus Fragaria, can produce fruit with a beautiful shape, delectable flavor, and high nutritional content. An great source of anthocyanins, ellagic acid, and vitamin C is strawberries. which is also a powerful natural antioxidant. Rich in the B-complex family of vitamins, they also contain modest levels of the health-promoting flavonoids zea-xanthin, lutein, and beta-carotene.. They provide a good quantity of fiber and folic acid, as well as a good number of minerals including potassium, manganese, fluorine, copper, iron, and iodine. Strawberries are bright red because of the huge amounts of phytonutrients and flavanoids they contain Around the world, strawberries may be produced in a range of conditions. [1]

Around the world, strawberries may be produced in a range of conditions,Because of its fragrant, sweet, aromatic qualities, and lovely look, it is a berry-like fruit that everyone consumes. Strawberries come in a variety of varieties and are mostly grown in temperate areas across the world. the strawberry plant, one of the most significant berry crops, is planted all over the world and is a significant part of our natural environment. The plants are produced as commercial crops in a variety of climates, including cool and warm temperate zones, cool and warm subtropical zones, and Mediterranean climatic zones.[2]

The production of strawberries, which were originally cultivated in backyard gardens, has expanded to become one of the more popular and coveted crops.. Its rapid expansion is what sets it apart [3]. The majority of the currently dispersed types in the would, including the Sabrina and Festival cultivars, are short-day, European and American plants [4]. The strawberry plant bears fruit early because the first fresh harvest is available for purchase in the spring, and its fruits are a rich source of substances that are effective powerful regulators of vascular, cardiovascular, and malignant illnesses [5]. In addition to being used in a variety of food industries, such as the production of jams, ice cream, and pastries, many foodstuffs, such as proteins, carbohydrates, fats, calcium, magnesium, phosphorus, potassium, copper, and zinc, as well as vitamin C, thiamine, and riboflavin, and its fruits, have medical and therapeutic benefits in the removal of various bacteria and the treatment of numerous diseases [6]. One of the most essential components of producing organic strawberries is selecting the proper cultivar since picking the wrong cultivar sometimes leads to problems [7]. Compared to 'Sweet Charlie' and 'Oso Grande,' the strawberry cultivar 'Earlibrite' much surpassed its fruit fresh weight. Over the past 20 years, there has been a noticeable rise in the usage of commercial seaweed products in horticulture and agriculture [8]. It is possible to dilute an organic fertiliser that contains a lot of algae and apply it to both delicate seedlings and transplants as well as larger plants [9] Nonetheless, Algae may contain enough trace elements, as has been confirmed, to repair peripheral deficiencies by Furthermore ,there is a strong possibility that the nutrients and trace elements will mix with other seaweed extract ingredients to generate a yield response [10]

[11] In a research, the effects of misting three seaweed extracts—Algren, Soluamine, and Mannarine—on two kinds of strawberries are (Hapil and Kaiser's samling). It is determined that spraying extracts of Soluamine has increased flower in each plant more than negative controls, although spraying cv. Kaiser's sample with seaweed (Algren) promotes an increase in the total chlorophyll content, When employing Algren extract on the cv. Hapil, there was an improvement in the crown diameter and an increase in the dry weight of the shoots and leaf area.However, With the application of extract Soluamine, fresh weight of the shoots and dry weight of the root system both increased.

[12] reportedly enhanced the leaf chlorophyll content and vegetative development qualities of peach plants when

seaweed extract was used. Compared to other plants, algae are an excellent source of multiple nutrients such fiber, minerals, proteins, vitamins, and fatty acids, which play a significant role in nutrition. [13] reported that strawberries (cv. 'Albion') produced more fruit and had higher quality fruit when seaweed extracts (Alga 600) were applied at doses of 2 to 8 g/L. Additionally, elements obtained from macroalgae may be used as biostimulants to help plants survive biotic and abiotic stress. [14] The availability of a wide range of compounds in algae, such as auxins, cytokinins, and betaines, that encourage plant development. [15]

The microelectronics, including iron, have an effective and important role in plants' natural development, and the microelectronics are no less important than the encroachments, and numerous studies revealed the importance of these microelectronics in the growth of plants [16] The iron component has a stimulating effect for vegetative growth in plants through the active cycle in the formation and activation of its chlorophyll pigment by entering it into the compounds that make up chlorophyll. Iron is also included in the composition of many compounds, such as the cytochrome responsible for the respiration process in plants, chloroplasts and the formation of plant proteins .[17]Iron has several forms and the most used form is chelated iron. As these compounds (chelating) preserve the element in a soft form for absorption and transfer by the plant, in addition to that they do not dissolve in Fe-EDDHA soil and Fe-EDTA is one of the most common chelating compounds and the most used in many plants [18]

Iron (Fe), one of the micronutrients, is a cofactor for over 140 enzymes that catalyze particular metabolic events. [19] Iron deficiency or low iron activity in the plant results in insufficient production of chlorophyll and pale leaves.. Chlorophyll loss causes a drop in the plant food processor, which in turn reduces the yield. The first sign of an iron deficiency is a yellowish hue between leaf veins, especially in young leaves, which might lead to the necrosis of all of these leaves.[20]

The aim of this study was to assess how two strawberry cultivars, algae 600 and iron chelate, responded to these nutrients in terms of growth and yield: Festival and Sabrina. The study aimed to determine whether these fertilizers, applied as a foliar spray, and to identify the cultivar that would respond positively to each fertilizer to aid in plant management. The findings from this research could significantly contribute to reducing the use of fertilizers and promote the sustainable production of strawberries while enhancing the plant's quality and productivity.

2.Materials and Methods:

The duration of time for this research is the growing season of 2021–2022. in orchard at agriculture training Center in Erbil/Ministry of Agriculture/ Kurdistan Region / Iraq, This research was done to investigate the impact, spraying three Concentration of Algae (0,3 and 6 gm L^{-1}) and Iron chelate with concentration (0,1 and 2 ml.L^{-1}) on growth, flowering, Yield and qualitative properties of Two Strawberry CV. Festival and Sabrina, using the six spraying while doing the experiment in the morning because the morning's lower temperatures, foliar spring was completed. Three spraying of Algae during the experiment, first spraing will be after (20) day of the transplanting was done in Novamber 10 In addition second spraing in 26. The period between Spray (20) day 3 spraying of Iron in the first at month after transplanting, second and third application 20 days after the first time and 20 days after second time.

Strawberry cultivars, Sabrina and Festival, were got from landscape company in Erbil, To achieve a balance between roots and vegetative development, all transplants were trimmed by removing any extra or damaged leaves and the remaining three leaves from each plant, additionally treated the roots fungicide-stripped sterilized (Topsin Wp), The transplants were placed at 0.30m between plants and 0.40m between rows of culture. In October 24 2021 planting in greenhouse to May 1 2022, Drip irrigation system was used. blossoms were continuously taken from plants during the first mouth after transplanting. There were 18

treatments in the study. (three Algae concentration, three Iron chelate concentration, and two strawberry CV) with three replication. Applied as a factorial experiment by using Randomized Complete Block Design (RCBD), Five seedlings were chosen from each treatment and measurements were taken. Means were compared using the Duncan 0.5 Multiple Ranges test at the 5% level. Following that, plants were used as a factorial experiment (2*3*3) using a split plot design. The cultivars are main Plot, and postharvest strawberry fruit started February 27 until April 1, for the following properties:

- Leaf area (cm^2)
- Total Chlorophyll content (mg. $100g^{-1}$ fresh weight)
- Leaf nitrogen percentage %
- Leaf phosphorus percentage%
- Leaf Iron chelate content (ppm)
- Fruit weight (g)
- Fruit size (cm^3)
- Total yield per plant (g)
- Total Soluble Solids/ Total Treatable Acidity Ratio (TSS/TTA)
- Anthocyanin Content ($mg.100g^{-1}$ F.W.)

3: Results and Discussion:

1. Leaf area (cm^2):

Table (1) illustration that the cultivars, Algae fertilizer and Iron chelate were significantly increased leaf area, the maximum value (9.94, 9.34 and 8.35 cm2) were obtained from Sabrina cultivar, ($6ml.L^{-1}$ algae and $2ml.L^{-1}$ iron chelate). Concerning the interaction between Algae fertilizer and cultivars has significant effect which the highest value (6 $gm.L^{-1}$) recorded (12.34 cm^2) in Sabrina, and the lowest value recorded in control (3.5 cm^2) with Festival.

Relative to the effect of interaction between Algae and Iron chelate was significantly affected, the highest value recorded in (6 $gm.L^{-1}$ algae + 2 ml.L-1 iron chelate) was (10.75 cm^2) and the lowest (0.0 Algae + 0.0 Iron chelate) was ($4.5cm^2$). Regarding the effect of interaction between Iron chelate and cultivars, there was a significant effect on leaf area, that the concentration (2 mg. L^{-1}) recorded the highest value (8.35 cm^2) and the lowest value was (6.31 cm^2) in control. Concerning the interaction between (Cultivars + Fertilizers + Concentration) was significantly affected, the maximum value recorded in (sabrina + 6 $gm.L^{-1}$ algae + $2ml.L^{-1}$ iron chelate) (14.46 cm^2). And the minimum value recorded in (festival + 0.0 algae + 0.0 iron chelate) was (3.06 cm^2).

Table (1) Effect of Algae and Iron chelate on the leaf area (cm^2) of two strawberry cultivars.

Treatments	Algae (gm.L-1)	Iron chelate($ml.L^{-1}$)			Algae × cv	Mean cv
		0	1	2		
Festival	0	3.06 j	3.29 j	4.16 i	3.5 f	4.92 b
	3	4.68 hi	4.62 hi	5.43 gh	4.91 e	
	6	5.31 gh	6.68 ef	7.03 e	6.34 d	
Sabrina	0	5.94 fg	8.42 d	8.49 d	7.62 c	9.94 a
	3	8.63 d	10.39 c	10.54 c	9.85 b	
	6	10.2 c	12.35 b	14.46 a	12.34 a	
					Mean Algae concentration	
Algae × Iron chelate	0	4.5 f	5.86 e	6.33 de	5.56 c	
	3	6.66 d	7.51 c	7.98 c	7.38 b	
	6	7.76 c	9.51 b	10.75 a	9.34 a	
Iron chelate × cv	Festival	4.35 f	4.87 e	5.54 d		
	Sabrina	8.26 c	10.39 b	11.16 a		
Mean Iron chelate concentration		6.31 c	7.63 b	8.35 a		

Mean within a column, row and their interaction following with the same latter are not significantly different according to Duncan multiple range test at the probability of 0.05 level

2. Total Chlorophyll content (mg. 100g-1):

Results in table (2) illustrated that Cultivars had non-significant effect on the total chlorophyll content, however (3gm.L^{-1} algae) and (2 ml.L^{-1} iron chelate) recorded the total chlorophyll content highest significant value (43.63 and 42.34 mg. 100g^{-1}) respectively as compared with other treatment. Also the same table indicated that the interaction between (Cultivars +Algae) had significantly affected on the total chlorophyll content, the highest value (3 gm.L^{-1} algae) recorded (festival + 43.73 mg. 100g^{-1}), and the lowest value recorded (37.64 mg.100g^{-1}) in (sabrina + 0.0 algae). Furthermore interactions between Algae and Iron chelate was significantly affected, the highest value noted in (Iron chelate) and (+ 6 gm.L^{-1} algae + 2 ml.L^{-1} iron chelate) was (44.25 mg.100g^{-1}) and the lowest (0.0 Algae + 0.0 Iron chelate) was (36.00 mg.100g^{-1}). Also though the effect of (Iron chelate + Cultivars) had significantly result, in (2 ml.L^{-1} + sabrina) illustrious highest value was (42.34 mg.100g^{-1}). and lowest value (40.90) in (0.0 festival). In addition, the same table shows that the interactions between (Cultivars + Fertilizers + Concentration) significantly increased total chlorophyll content in leaves, the maximum value recorded in (festival + 3 gm.L^{-1} algae + 0.0 iron chelate) (45.40 mg.100^{-1}), but the minimum value recorded in (Festival + 6 mg.L^{-1} algae + 0.0 iron chelate) (38.13mg.100g^{-1}).

Table (2) Effect of Algae and Iron chelate on the total Chlorophyll content (mg. 100g^{-1}) of two strawberry cultivars.

Treatments	Algae (gm.L-1)	Iron chelate(ml.L^{-1})			Algae × cv	Mean cv
		0	1	2		
Festival	0	39.17 b-d	40.1 a-d	45.1 ab	41.46 b	42.3 a
	3	45.4 a	41.23 a-d	44.57 a-c	43.73 a	
	6	38.13 d	41.93 a-d	45.1 ab	41.7 b	
Sabrina	0	32.83 e	38.83 cd	41.27 a-d	37.64 c	39.91 a
	3	38.7 cd	40.23 a-d	42.37 a-d	40.43 b	
	6	39.57 a-d	42.03 a-d	43.4 a-d	41.67 b	
					Mean Algae concentration	
Algae × Iron chelate	0	36 d	39.47 b-d	43.18 ab	39.55 b	
	3	42.05 a-c	40.73 a-c	43.47 ab	42.08 a	
	6	38.85 cd	41.98 a-c	44.25 a	41.69 a	
Iron chelate × cv.	Festival	40.9 c	41.09 b	44.92 b		
	Sabrina	37.03 b	40.37 ab	42.34 a		
Mean Iron chelate concentration		38.97 b	40.73 b	43.63 a		

Mean within a column, row and their interaction following with the same latter are not significantly different according to Duncan multiple range test at the probability of 0.05 level

3.Leaf nitrogen percentage:

Table (3) displays that the Cultivars had non-significant effect on the nitrogen percentage in the leaves Same table. Illustrates that (6 gm.L^{-1} algae) and (2 ml.L^{-1} Iron chelate) recorded the highest significant value of leaf nitrogen (2.04 and 1.82%) respectively as compared with other treatment. However, the same table showed that the interaction between (Cultivars + Algae) had significantly affected on leaf nitrogen percentage, the maximum value (sabrina + 6gm.L^{-1} algae) recorded (2.17%), and the minimum value recorded in (festival +

0.0 algae). Moreover interactions between Algae and Iron chelate was significantly affected on leaf nitrogen percentage, the greatest value recorded in (6 gm.L^{-1} algae + 2 ml.L-1 iron chelate) was (2.54%) and the smallest recorded in (+ 3 gm.L^{-1} algae+1 ml.L^{-1} iron chelate) was (1.30%). While the effect of (Iron chelate + Cultivars) had significantly result, in (2ml.L^{-1} + sabrina) illustrious greatest value was (1.89) and smallest value (1.25) in (Control + Festival). Results of (Cultivars + Fertilizers + Concentration) that the interaction among (Sabrina + 6 gm.L^{-1} algae + 2ml.L^{-1} iron) was the most effective treatment because it produced the highest leaf nitrogen percentage (2.75%), but the smallest value recorded in (Festival + 0.0 algae + 0.0 iron chelate) (0.99%).

Table (3) Effect of Algae and Iron chelate on the leaf Nitrogen percentage of two strawberry cultivars.

Treatments	Algae (gm.L-1)	Iron chelate(ml.L^{-1})			Algae × cv.	Mean cv.
		0	1	2		
Festival	0	0.99 g	1.15 fg	1.17 fg	1.1 d	1.46 a
	3	1.19 fg	1.26 fg	1.71 d	1.39 d	
	6	1.58 de	1.8 cd	2.32 b	1.9 c	
Sabrina	0	1.04 fg	1.16 fg	1.16 fg	1.12 c	1.58 a
	3	1.2 fg	1.34 fe	1.77 d	1.44 b	
	6	1.7 d	2.06 bc	2.75 a	2.17 a	
					Mean Algae concentrations	
Algae × Iron chelate	0	1.01 de	1.16 de	1.17 de	1.11 c	
	3	1.2 d	1.3 e	1.74 bc	1.41 b	
	6	1.64 c	1.93 b	2.54 a	2.04 a	
Iron chelate × cv	Festival	1.25 d	1.4 d	1.74 cd		
	Sabrina	1.31 c	1.52 b	1.89 a		
Mean Iron chelate concentration		1.28 c	1.46 b	1.82 a		

Mean within a column, row and their interaction following with the same latter are not significantly different according to Duncan multiple range test at the probability of 0.05 level

4.Leaf phosphorus percentage:

Table (4) illustrate that the Cultivars had non-significant effect in the leaves phosphorus Percentage. Same table clearly shows that there was a significant difference in leaf phosphorus concentration, and (6gm.L^{-1} algae) and (2 ml.L^{-1} iron chelate) gave the highest significant value (0.32 and 0.28%) respectively, as compared with control treatment. The interaction between (Cultivars +Algae) showed that there was a significant influence on leaf phosphorus percentage, which the highest value in (sabrina + 6gm.L^{-1} algae) recorded (0.31%), and the lowest value recorded (0.21%) in (festival + 0.0 algae). While foliar application of Iron chelates on strawberry cultivars gave the significant value in interaction as compared with control treatment, and the maximum value was obtained from (sabrina + 2ml.L^{-1} iron chelate) and (festival + 2ml.L^{-1} iron chelate) which gave (0.28 and 0.29%) respectively. Moreover interactions between fertilizers was significantly affected, the highest value recorded in (6 gm.L^{-1} algae + 2ml.L^{-1} iron chelate) was (0.36%) as compared to other interaction. The interaction between (Cultivars + Fertilizers + Concentration) was significantly affected, the maximum value recorded in (Festival + 6 gm.L^{-1} algae + 2 ml.L^{-1} iron chelate) (0.37%), the minimum value recorded in (sabrina + 0.0 algae + 0.0 iron chelate) was (0.20%).

Table (4) Effect of Algae and Iron chelate on the leaf phosphorus percentage of two strawberry cultivars.

Treatments	Algae (gm.L-1)	Iron chelate(ml.L^{-1})			Algae × cv	Mean cv
		0	1	2		
Festival	0	0.2 h	0.2 h	0.22 gh	0.21 d	0.27 a
	3	0.24 e-h	0.28 c-f	0.28 c-f	0.26 c	
	6	0.29 cd	0.32 cb	0.37 a	0.33 b	
Sabrina	0	0.2 h	0.22 gh	0.23 f-h	0.22 d	0.26 a
	3	0.25 d-g	0.28 c-f	0.27 d-f	0.27 c	
	6	0.28 c-e	0.29 cd	0.34 ab	0.31 a	
					Mean Algae concentration	
Algae × Iron chelate	0	0.2 f	0.21 f	0.22 fe	0.21 c	
	3	0.25 de	0.28 cd	0.27 c	0.27 b	
	6	0.29 bc	0.31 b	0.36 a	0.32 a	
Iron chelate × cv	Festival	0.24 b	0.27 ab	0.29 a		
	Sabrina	0.25 b	0.27 ab	0.28 a		
Mean Iron chelate concentration		0.24 c	0.27 b	0.28 a		

Mean within a column, row and their interaction following with the same latter are not significantly different according to Duncan multiple range test at the probability of 0.05 level

5. Leaf Iron chelate content (ppm):

Results in table (5) illustrated that Sabrina cultivar, 6 gm.L^{-1} Algae and 2 ml.L-1 Iron chelate recorded the leaf Iron chelate content (ppm) highest significant value (152.31, 206.56 and 177.13 ppm) respectively as compared with other treatment. Relative to the effect of interaction between (Cultivars + Algae) there was a significantly effect on leaf Iron chelate content (ppm) the maximum value (102.26 ppm) at 6 gm.L^{-1} Algae. Also interactions between fertilizers was significantly affected, the highest value recorded in (6 gm.L^{-1} algae + 2 ml.L^{-1} iron chelate) was (246.72 ppm) and the lowest (0.0 Algae + 0.0 Iron chelate) was (100.62ppm). Moreover the same table indicated that the interaction between (Cultivars + Iron chelate) had significantly result, in (sabrina + 2 ml.L^{-1} iron chelate) noted highest value was (179.81ppm) and lowest value (116.22ppm) in (festival + 0.0 iron chelate).The interaction between (Cultivars + Fertilizers + Concentration) was significantly affected, the maximum value recorded in (sabrina + 6 gm.L^{-1} algae + 2 ml.L^{-1} iron chelate) (248.67 ppm). And the minimum value recorded in (festival + 0.0 algae, 0.0 iron chelate) (99.58 ppm).

Table (5) Effect of Algae and Iron chelate on the leaf Iron chelate content (ppm) of two strawberry cultivars.

Treatments	Algae (gm.L-1)	Iron chelate(ml.L^{-1})				Mean cv
		0	1	2	Algae × cv	
Festival	0	101.67 j	101.64 j	103.48 ij	102.26 d	145.9 b
	3	107.39 ij	120.81 gh	175.11 d	134.44 c	
	6	139.6 f	218.62 c	244.77 a	201 b	
Sabrina	0	99.58 j	109.9 ij	114.47 hi	107.98 d	152.31 a
	3	104 ij	130.2 fg	176.3 d	136.83 c	
	6	157.93 e	229.77 b	248.67 a	212.12 a	
					Mean Algae concentration	
Algae × Iron chelate	0	100.62 g	105.77 fg	108.97 f	105.12 c	
	3	105.7 fg	125.51 e	175.71 c	135.64 b	
	6	148.77 d	224.2 b	246.72 a	206.56 a	
Iron chelate × cv	Festival	116.22 d	147.02 c	174.46 a		
	Sabrina	120.5 d	156.62 b	179.81 a		
Mean Iron chelate concentration		118.36 c	151.82 b	177.13 a		

Mean within a column, row and their interaction following with the same latter are not significantly different according to Duncan multiple range test at the probability of 0.05 level

6. Fruit weight (g):

The table (6) explains that the effect of organic fertilizer in fruit weight has non-significant effect. Data reported in same table, the effect of Algae and Iron chelate fertilizers there was a significantly affected on fruit weight which the highest value in (6 gm.$L^{-1}$and 2 ml.L^{-1}) recorded (14.54 and 13.66g) respectability compared with other treatments. Moreover the same table indicated that the interaction between (Algae + Cultivars), significantly increased fruit weight which recorded the highest value of fruit weight (14.75 and 14.34g) with (Sabrina + 6 gm.L^{-1} algae) and (festival + 2gm.L^{-1} algae)compared with control, respectively. Likewise interactions between fertilizers was significantly affected, the highest value recorded in (6gm.L^{-1} algae + 2 gm.L^{-1} + iron chelate) comparted with control. the interaction between (Iron Chelate + Cultivars), significantly increased fruit weight which recorded the highest value of fruit weight (13.9) in (festival + 2ml.L^{-1} iron chelate) and the minimum value (9.54) in (Sabrina + 0.0 iron chelate). The interaction between (Cultivars + Fertilizers + Concentrations) was significantly affected on fruit weight, the highest value recorded in (sabrina + 6gm.L^{-1} algae + 2 gm.L^{-1} iron chelate) (18.12g) comparted with other interaction treatments, and the minimum value recorded in control (6.81g) in Sabrina.

Table (6) Effect of Algae and Iron chelate on the Fruit weight (g) of two strawberry cultivars.

Treatments	Algae (gm.L-1)	Iron chelate(ml.L^{-1})			Algae × cv	Mean cv
		0	1	2		
Festival	0	9.78 e-g	11.64 c-e	12.06 b-e	11.16 b	12.55 a
	3	11.83 b-e	11.64 c-e	13 b-d	12.15 b	
	6	12.49 b-d	13.89 bc	16.63 a	14.34 a	
Sabrina	0	6.81 h	8.9 g	9.21 fg	8.3 c	11.49 a
	3	9.89 e-g	11.41 d-f	12.97 b-d	11.42 b	
	6	11.92 b-e	14.21 b	18.12 a	14.75 a	
					Mean Algae concentration	
Algae × Iron chelate	0	8.29 f	10.27 e	10.64 de	9.73 c	
	3	10.86 de	11.52 c-e	12.98 bc	11.79 b	
	6	12.21 cd	14.05 b	17.37 a	14.54 a	
Iron chelate × cv	Festival	11.37 de	12.39 b	13.9 a		
	Sabrina	9.54 d	11.51 c	13.43 a		
Mean Iron chelate concentration		10.45c	11.95 b	13.66 a		

Mean within a column, row and their interaction following with the same latter are not significantly different according to Duncan multiple range test at the probability of 0.05 level

7. Fruit size (cm^3):

Table (7) pointed out that there a difference between the treatments, significantly increased fruit size, the highest value of fruit size is registered with Festival, (6 gm.L^{-1} algae) and (2 ml.L^{-1} iron chelate) which are (11.12, 12.37 and 11.11cm3) respectively comparted to other treatments. Similarly the same table indicated that the interaction between (Algae + Cultivars) had significantly affected on the fruit size, the highest value (6 gm.L^{-1} algae + sabrina) recorded (12.45cm3) comparted to other treatments. Also interactions between (Algae and Iron chelate) was significantly affected, the highest value noted in (Iron chelate) and (6 ml.L^{-1} algae+2 ml.L^{-1} iron chelate) was (12.80cm3). Even though the effect interaction of (Iron chelate + Cultivars) had significantly differed, in (2 ml.L^{-1} iron chelate + festival) illustrious highest value was (11.69 cm3) comparted to other treatments. The interaction between (Cultivars + Fertilizers + Concentration)

was significantly affected, the maximum value recorded in (sabrina + 6 gm.L^{-1} algae + 2 ml.L^{-1} iron chelate) (13.04) in comparison with untreated strawberry cultivars.

Table (7) Effect of Algae and Iron chelate on the fruit size (cm^3) of two strawberry cultivars.

Treatments	Algae (gm.L-1)	Iron chelate(ml.L^{-1})			Algae × cv	Mean cv
		0	1	2		
Festival	0	8.66 ef	9.47 d-f	10.34 b-e	9.49 b	11.12 a
	3	11.12 b-d	11.45 a-d	12.17 ab	11.58 a	
	6	11.85 bc	12.44 ab	12.57 ab	12.29 a	
Sabrina	0	7.37 f	7.76 f	8.33 ef	7.82 c	9.93 b
	3	8.73 ef	9.61 c-f	10.24 b-e	9.53 b	
	6	11.7 a-d	12.6 ab	13.04 a	12.45 a	
					Mean Algae concentration	
Algae × Iron chelate	0	8.01 g	8.62 fg	9.34 e-g	8.66 c	
	3	9.93 d-f	10.53 c-e	11.2 b-d	10.55 b	
	6	11.78 a-c	12.52 ab	12.8 a	12.37 a	
Iron chelate × cv	Festival	10.54 ab	11.12 a	11.69 a		
	Sabrina	9.27 c	9.99 bc	10.54 ab		
Mean Iron chelate concentration		9.91 b	10.55 ab	11.11 a		

Mean within a column, row and their interaction following with the same latter are not significantly different according to Duncan multiple range test at the probability of 0.05 level

8. Total yield per plant (g):

According to the table (8) Cultivars has non-significant on yield per plant in two strawberry cultivars. Then, the effect of Algae and Iron chelate has significant effect which the greatest value in (6 gm.L^{-1} algae and 2ml.L^{-1} iron chelate) recorded (293.41g and 235.89g), and the smallest value recorded in control (119.85g and 145.41g) respectively. However the same table showed that the interaction between (Algae + Cultivars) had significantly affected on the yield per plant (311.47and 93.55 g) that was recorded with (6 gm.L^{-1} algae + festival) and (0.0 algae +Sabrina). While the interaction between (Algae + Iron chelate) the highest value (365.51g) was obtained at (6 gm.L^{-1} algae + 2ml.L^{-1} iron chelate) and the minimum value obtained at control. Although the effect of (Iron chelate + Cultivars) had significantly affect, in (2 ml.L^{-1} iron chelate + Sabrina) illustrious greatest value was (248.48g) and smallest value (113.19g) in (Control + Sabrina). Also interactions between (Algae and Iron chelate) was significantly affected, the greatest value recorded in (2 ml.L^{-1} Iron chelate 6gm.L^{-1} algae) was (365.51g) and the smallest (0.0 algae + 0.0 iron chelate) was (83.83g). In respect with the interaction between (Cultivars + Fertilizers + Concentration) was significantly affected, the greatest value recorded in (Sabrina + 6 gm.L^{-1} algae + 2ml.L^{-1} iron chelate) (372.61g), and the smallest value recorded in (Sabrina + 0.0 Algae + 0.0 Iron chelate) (50.05g).

Table (8) Effect of Algae and Iron chelate on the total yield per plant (g/plant) of two strawberry cultivars.

Treatments	Algae (gm.L-1)	Iron chelate(ml.L^{-1}) 0	1	2	Algae × cv	Mean cv
Festival	0	117.6 d-f	187.34 c-f	133.51 d-f	146.15 bc	216.45 a
	3	171.28 c-f	225.92 b-e	177.98 c-f	191.73 b	
	6	244.01 a-d	332 ab	358.41 ab	311.47 a	
Sabrina	0	50.05 f	98.36 ef	132.25 d-f	93.55 c	182.41 a
	3	130.9 d-f	163.49 c-f	240.57a-d	178.32 b	
	6	158.63 c-f	294.8 a-c	372.61 a	275.35 a	
					Mean Algae concentration	
Algae × Iron chelate	0	83.83 c	142.85 bc	132.88 bc	119.85 c	
	3	151.09 bc	194.7 b	209.28 b	185.02 b	
	6	201.32 b	313.4 a	365.51 a	293.41 a	
Iron chelate × cv	Festival	177.63 ab	248.42 a	223.3 a		
	Sabrina	113.19 c	185.55 b	248.48 a		
Mean Iron chelate concentration		145.41 b	216.98 a	235.89 a		

Mean within a column, row and their interaction following with the same latter are not significantly different according to Duncan multiple range test at the probability of 0.05 level

9. Total Soluble Solids/ Total Treatable Acidity Ratio (TSS/TTA):

Results in table (9) illustrated that Festival cultivar, 6 gm.L^{-1} Algae and 2 ml.L-1 Iron chelate recorded the (TSS\TTA) highest significant value (13.81, 15.64 and 13.73) respectively as compared with other treatment. Relative to the effect of interaction between (Cultivars + Algae) there was a significantly effect on (TSS\TTA) the maximum value (15.63) at 3 gm.L^{-1} Algae. Also interactions between fertilizers was significantly affected, the highest value recorded in (3 gm.L^{-1} algae + 2 ml.L^{-1} iron chelate) was (16.94%) and the lowest (0.0 Algae + 0.0 Iron chelate) was (9.32%). Moreover the same table indicated that the interaction between (Cultivars + Iron chelate) had significantly result, in (festival + 2 ml.L^{-1} iron chelate) noted highest value was (15.32%) and lowest value (11.53%) in (sabrina + 0.0 iron chelate).The interaction between (Cultivars + Fertilizers + Concentration) was significantly affected, the maximum value recorded (festival + 6 gm.L^{-1} algae + 2 ml.L^{-1} iron chelate) (19.52%). And the minimum value recorded in (sabrina + 0.0 algae, 0.0 iron chelate) (902%).

Table (9) Effect of Algae and Iron chelate on the TSS/TTA of two strawberry cultivars.

Treatments	Algae (gm.L-1)	Iron chelate(ml.L^{-1}) 0	1	2	Algae × cv	Mean cv
Festival	0	9.5 fg	13.38 cd	11.66 e	11.25 c	13.81 a
	3	12.97 de	17.91 b	15.84 c	15.63 a	
	6	14.47 d	12.43 de	19.52 a	15.18 a	
Sabrina	0	9.02 h	10.23 f	10.12 f	9.78 d	13.72 b
	3	14.56 d	15.44 cd	18.22 b	15.90 a	
	6	11.86 e	14.44 d	11.59 e	12.49 b	
					Mean Algae concentration	
Algae × Iron chelate	0	9.32 f	11.34 cd	10.86 e	10.38 c	
	3	13.88 b	16.68 a	16.94 a	15.64 a	
	6	13.03 d	13.47 bc	14.60 b	13.72 b	
Iron chelate × cv	Festival	11.96 d	14.24 b	15.32 a		
	Sabrina	11.53 d	12.87 c	12.45 c		
Mean Iron chelate concentration		11.67 b	13.56 a	13.73 a		

Mean within a column, row and their interaction following with the same latter are not significantly different according to Duncan multiple range test at the probability of 0.05 level

10. Anthocyanin Content (mg.100g^{-1} F.W.):

According to the table (10) Festival cultivar, (6gm.L^{-1} algae and 2ml.L^{-1} iron chelate), recorded the anthocyanin's highest significant value (15.66, 16.71 and 16.52 mg.100g-1 F.W.) respectively as compared with other treatment. Concerning to the effect of interaction between as to the effect of interaction between (Algae + Cultivars), (Algae + Iron chelate) and (Iron chelate + Cultivars) there was a significantly affected on anthocyanin content the maximum value(17.34, 18.21 and 16.73 mg.100g-1 F.W.) was obtained from interaction (6gm.L^{-1} + Festival), (6gm.L^{-1} algae + 2ml.L^{-1} iron chelate). In addition, the mentioned table illustrates that the combination of studied factors significantly increased anthocyanin content in strawberry fruits, the maximum value (18.25). (mg.100g^{-1}F.W.) obtained from the interaction among (Sabrina + 6gm.L^{-1} Algae + 2ml.L^{-1} Iron chelate) compared to the minimum value (10.06 mg.100g^{-1} F.W.), which obtained from the (sabrina + 0.0 algae+ 0.0 iron chelate)

Table (10) Effect of Algae and Iron chelate on the Anthocyanin content (mg.100g^{-1} F.W.) of two strawberry cultivars.

Treatments	Algae (gm.L-1)	Iron chelate(ml.L^{-1})			Algae × cv	Mean cv
		0	1	2		
Festival	0	11.96 ij	12.46 h-j	14.99 a-f	13.14 c	15.66 a
	3	16.33 a-e	16.07 a-f	17.04 a-d	16.48 a	
	6	16.53 a-e	17.43 a-c	18.16 ab	17.37 a	
Sabrina	0	10.06 j	12.81 hi	13.43 f-i	12.1 c	14.31 b
	3	13.43 f-i	13.75 e-i	17.24 a-d	14.81 b	
	6	14.49 d-i	15.37 b-g	18.25 a	16.04 ab	
					Mean Algae concentration	
Algae × Iron chelate	0	11.01 f	12.64 ef	14.21 de	12.62 c	
	3	14.88 cd	14.91 cd	17.14 ab	15.64 b	
	6	15.51 b-d	16.4 a-c	18.21 a	16.71 a	
Iron chelate × cv	Festival	14.94 bc	15.32 a-c	16.73 a		
	Sabrina	12.66 d	13.98 cd	16.31 ab		
Mean Iron chelate concentration		13.8 b	14.65 b	16.52 a		

Mean within a column, row and their interaction following with the same latter are not significantly different according to Duncan multiple range test at the probability of 0.05 level

The results show that the cultivar Sabrina was significantly excelled on the cultivar Festival in recorded the higher in leaf area (cm2) and leaf Iron chelate content, while, the cultivar Festival significantly superior on the cultivar Sabrina in fruit size (cm3), TSS/TTA and Anthocyanin content (mg.100g-1 F.W.). The reason is due the genetic difference between the two cultivars. The tables show that clearly. (1 - 10) The majority of the growth qualities were greatly improved by spraying the strawberry plant with three doses of algae and iron chelate, Leaf area (cm2), Total Chlorophyll content (mg. 100g-1), leaf Nitrogen percentage, leaf phosphorus percentage, the leaf Iron chelate content (ppm), fruit size (cm3), yield per plant (g/plant), (TSS/TTA) and Anthocyanin content (mg.100g-1 F.W). These results are the same found by [21] and [13]

The present results regarding the effect of foliar spray with three concentrations of Algae 600 on vegetative growth properties of two strawberry cultivars (Festival and Sabrina), might be related to the effect of Algae 600 application which had a positive effect on internal plant metabolism, due to presence of major

and minor elements, and organic substances that include plant growth regulators such as cytokines, auxins and gibberellins which improved vegetative growth, leaf area and nutritional status of leaves, as a result, increased total yield, as well as improved some physical and chemical properties of strawberry. Also, foliar spray of Algae 600 could supply sufficient amounts of growth promoting substances that increase cell division, cell-enlargement, eventually produces a higher yield. These findings agree with those obtained [22] by Data presented in tables (1-10) obviously shows that the foliar application with three concentrations significantly increased Leaf area (cm2), Total Chlorophyll content (mg. 100g-1), leaf Nitrogen percentage, leaf phosphorus percentage, the leaf Iron chelate content (ppm), fruit size (cm3), yield per plant (g/plant), (TSS/TTA) and Anthocyanin content (mg.100g-1 F.W).These results are the same found; [23] and [24] and[17]

The iron component has a stimulating effect for vegetative growth in plants through the active cycle in the formation and activation of its chlorophyll pigment by entering it into the compounds that make up chlorophyll [25],Iron is also included in the composition of many compounds, such as the cytochrome responsible for the respiration process in plants, chloroplasts and the formation of plant proteins [26]. Iron has several forms and the most used form is chelated iron. As these compounds (chelating) preserve the element in a soft form for absorption and transfer by the plant, in addition too that they do not dissolve in Fe-EDDHA soil and Fe-EDTA is one of the most common chelating compounds and the most used in many plants [18]

As well, tables (1-10) shows that foliar application by Iron chelate on two strawberry cultivars significantly improved most of vegetative growth and fruit properties be related with an increase in leaf content of nutrients including leaf nitrogen percentage and Iron content, which leads to an increase in extra protein, hence increasing the leaf area, which greatly improved the quality of the fruit and its role in stimulating enzyme action. which favorably boosted the photosynthesis process in the leaf. This in turn led to an increase in the nutrients produced by the plant and transported to the fruit. vitality biosynthesis processes and plant cell osmosis [11] and [12] and [13] and [14] .

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استجابة صنفين من الشليك (*Fragaria × ananassa Duch.*) لرش الورقي بالطحالب وحديد المخلبي

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- تاريخ استلام البحث 20/06/2023 وتاريخ قبوله 26/07/2023
- البحث مستل من رسالة ماجستير للباحث الاول .

المستخلص

نفذت هذه الدراسة خلال المواسم 2021–2022، من الحقل التجريبي في مركز التدريب الزراعي في اربيل تابع لوزارة الزراعة / اقليم كوردستان / العراق. لدراسة تأثير الرش بالطحالب وحديد المخلبي في نمو وحاصل لصنفين من الفراولة (*Fragaria x ananassa Duch.*)و ابتداء من 10 نوفمبر 2021 إلى 1 يناير 2022 في الصباح باستخدام الرش ست مرات أثناء إجراء التجربة بثلاثة مستويات للطحالب (0 و 3 و 6) غم.لتر$^{-1}$ و ثلاثة مستويات للحديد المخلبي (0 ، 1 و 2) مل.لتر$^{-1}$ لصنفين من الفراولة (صابرينا وفيستيفال) وتأثير التداخلات بين العوامل المدروسة في صفات النمو والتزهير والحاصل. نفذت التجربة وفقاً لتصميم القطاعات العشوائية الكاملة (R.C.B.D.) للتجارب العاملية و بثلاث مكررات و بواقع ست شتلات لكل وحدة تجريبية. وحللت النتائج احصائياً باستخدام برنامج (SAS V9.0) الجاهز وقورنت المتوسطات وفق اختبار دنكن متعدد الحدود عند مستوى احتمال (0.05). أظهرت النتائج تأثير الرش الورقي (الطحالب ومخلب الحديد) معنويا على مساحة الورقة، حيث بلغت القيمة (9.94) من صابرينا باستخدام (6 غم/ لتر$^{-1}$ طحالب و 2 مل/ لتر$^{-1}$ حديد المخلبي). وكذلك لديهم تأثير معنوي على حجم الثمار ، سجلت قيمة حجم الثمرة وهي (12.37) باستخدام (6 غم/ لتر$^{-1}$ طحالب و 2 مل/ لتر$^{-1}$ حديد المخلبي). وأيضا باستخدام (6 غم/ لتر$^{-1}$ طحالب و 2 مل/ لتر$^{-1}$ حديد المخلبي) تاثيرها معنوية على الأنثوسيانين وسجلت قيمة (16.71). بالإضافة إلى ذلك، فإن العلاقة بين (الصنف + الأسمدة + التركيز) تأثرت معنويا على مساحة الورقة، حيث سجلت القيمة في صابرينا (14.46) سم^2 من خلال استخدام (6 غم/ لتر$^{-1}$ طحالب و 2 مل/ لتر$^{-1}$ حديد المخلبي). كما تأثرت معنويا على حجم الثمار وسجلت القيمة (13.04) في صابرينا ايضا من خلال استخدام (6 غم/ لتر$^{-1}$ طحالب و 2 مل/ لتر$^{-1}$ حديد المخلبي). ولديها تاثير معنوي من خلال استخدام (0.0 غم/ لتر$^{-1}$ طحالب و 0.0 مل/ لتر$^{-1}$ حديد المخلبي) في صابرينا حصل على القيمة (10.06).

الكلمات المفتاحية: الفراولة، فيستفال، صابرينا، الطحالب، الحديد المخلبي.