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RESPONSE OF "RUBYGEM AND SWEET CHARLIE" STRAWBERRY TO FOLIAR APPLICATIONS CHELATED CALCIUM AND ZINC SULFATE

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Abstract:
The present study was conducted at the Agricultural Research Station, College of Agriculture, University of Kirkuk, in the Al-Sayada zone in Kirkuk governorate. This is to study the effect of spraying (0, 2.5, and 5) g L^{-1} of Ca and (0, 1.5, and 3) g L^{-1} of Zn sulfate on some vegetative properties and element concentrations in the leaves and fruits of two (Rubygem and Sweet Charlie) Strawberry cultivars. The plants were sprayed three times 1, 2, and 3/10/2018 until full wetness by using a little liquid soap as a surfactant. The experiment was carried out according to the randomized complete block design (RCBD) with three blocks. The results showed that spraying Ca at a levels of 2.5 and 5 g L^{-1} had a significant in the increasing leaf area, leaf chlorophyll content, Ca and Zn contents in the leaves, and Ca content in the fruits compared to the control. But the fruit dry matter significantly decreased compared to the control. And also, fruits treated with 1.5 and 3 g L^{-1} Zn sulfate were significantly increased leaf chlorophyll content, dry matter (%) in plant and fruit, and Ca content in the fruits compared to the control. However, leaf area significantly decreased when it compared to the control. The leaf chlorophyll content, and dry matter (%) in the plant was higher in Sweet Charlie cultivar than Rubygem, while a non-significant difference was found in all other properties.

Keywords: Calcium, Zinc Sulphate, Sweet Charlie, Rubygem.* Part of MSc. dissertation of the 1st author.

1. INTRODUCTION

Strawberry (*Fragaria* X *ananassa* Duchesne) belongs to the Rosaceae family. Strawberry fruit is an important part of the human diet. It is commercially important **(Prasanna et al., 2007).** The consumption of strawberry fruit by humans is also mainly due to their sensory and chemical properties. It plays a vital role in human nutrition by providing growth factors which are essential to maintaining normal health. It is also known as protective food because it is containing high amounts of vitamins such as A, B complex and C, and minerals Ca, Fe and P to maintain human health in good condition. The fruit is easily edible and contains sufficient amounts of various organic acids and digestive enzymes (Kriti 2016).

Strawberry is one of those plants that need a high level of fertilization because it provides high amount of yield in relation to its small size. Therefore, the importance of foliar fertilization appears support the plant against the deficiency of some basic nutrients. Fruit qualities affected by application of calcium before and after harvest, delayed fruit deterioration and aging, increased fruit Ca content, and enhanced the physiological characteristics of fruit and vegetables (Kazemi, Aran et al. 2011, AL-Jabary and Fadil 2017). The fruit production, which is a result of photosynthetic activity affected by the application of Ca fertilizer application. These chemical agents are associated to hormone metabolism, which promotes the primary synthesis of auxin, a crucial component of fruit growth (Seydi, Faryabi et al. 2016).

Foliar supplying of nutrients play an important role in strawberry quality and production (Sturm, Koron et al. 2003). Performing the spraying process at the appropriate stage improves the strawberry's qualitative and quantitative characteristics. Foliar application of essential element such as Zn is important for plant growth, development, and production of tryptophan amino acid. It is also micronutrient that plays an important role in promoting vegetative growth, flowering, yield, and fruit quality (Supriya, Langthasa et al. 1993, EI-Sherif, Saeed et al. 2000, Chaturvedi, Singh et al. 2005, Rashid, Khurshid et al. 2019). It is a component of auxins, dehydrogenases, and carbonic anhydrase, which encourages plant elongation and results in an increase in the dry and fresh weight of fruit (Seydi, Faryabi et al. 2016).

Therefore, the current study aims to determine (i) the effect of spraying with Ca chelate and Zn sulfate on some vegetative traits and (ii) its role in the Ca and Zn content of leaves and fruits of two cultivars of Rubygem and Sweet Charlie.

2. MATERIALS AND METHODS

The current study was carried out at the Kirkuk Governorate's Al-Sayada Zone Agricultural Research Station, Horticulture and Landscape Design Department, College of Agriculture. To investigate the impact of spraying with (0, 2.5, and 5) g L^{-1} chelated calcium and (0, 1.5, and 3) g L^{-1} zinc sulfate to study some vegetative parameters and elements content of the fruits of two (Rubygem and Sweet Charlie) strawberry cultivars. The plants were sprayed with chelated Ca and Zn sulfate till full wetness at the days of 10/1/2018, 10/2/2018, and 10/3/2018. The seedlings of uniform size were obtained from a private nursery. After preparing and levelling the soil, the experimental land was divided into three parts, each of them had a size of 30 m length, 1.0 m width, and 0.25 m hight. The drip system is used to irrigation plants in all parts. Each parts were covered with black polyethylene, and the distance between plants was (30 cm). The seedlings were planted on November 1st, 2017, and all the recommended agricultural operations during the experimental period were carried out such as weeding and fertilization.

2.1. Studied properties

Leaf area in (cm^2), was determined by taking two leaves (fully grown) from the middle leaves of each plant in the experimental unit after the last harvest on 4/25/2018 according the procedure described by (Saieed 1990). While the leaf chlorophyll content was estimated by using a SPAD-502 meter device according to the procedure reported by (Karhu, Puranen et al. 2007). The percentage of dry matter was calculated from the average fresh fruit weights of five plants from each experimental unit at the last harvest and then placed in paper bags of known weight in an electric oven at a temperature of (105) °C for 48 h until the constant weight according to (Aljabary, 2018).

2.2. Digestion of plant samples

The leaves and fruits were dried after placing them in perforated paper bags, and they were placed in an electric oven at a temperature of 72 °C or until the constant weight. The leaves and fruits were grounded and then about 0.5 g of dry samples were taken and digested using concentrated H_2SO_4 and $HClO_4$ at a ratio of (10:2) respectively according the procedure reported by (Johnson and Ulrich 1959). The Zn and Ca elements were estimated as follows: Calcium content (%) was measured using flame photometry (ELICO CL 378). Whilst, Atomic Absorption Spectrophotometry was used to measure zinc content (mg L^{-1})

2.3. Statistical Analysis

This experiment was carried out according to the randomized complete block design (RCBD) in three blocks. Each experimental unit included 10 plants. The data were analyzed statistically and according to the ANOVA table using SAS software and the averages were compared using Duncan's Multiple Range Test at 0.05 (Roger Mead and Hasted 2003).

3. RESULTS AND DISCUSSION

3.1. Leaf area (cm^2):

The results in (Table 1) show a significant difference in the leaf area between the cultivars. The lowest leaf area 41.64 cm^2 was recorded for Sweet Charlie and the highest 54.72 cm^2 was recorded for Rubygem. These results are consistent with the findings of (Özdemir et al., 2001; Hokanson et al., 2004). This is attributed to the nature of the growth and the genetic factor between cultivars, and the difference in the strength of vegetative and root growth of the plant in different varieties (Al-Saeedi 2000). As the vegetative growth characteristics of the strawberry plants differs according to the variety cultivated (Kirnak, Kaya et al. 2003).

The results appeared that spraying the seedlings with 2.5 and 5 g L^{-1} chelated calcium had a significant deference over the control, it reached to 51.934 and 47.485cm^2, respectively. These results can be supported by the results found by (Bakshi, Jasrotia et al. 2013). This may be attributed to the fact that calcium is necessary for the process of cell division and cell elongation, as well as Calcium is necessary for maintaining the permeability of cellular membranes (Abdul 1988) (Al-Qutb, Hamed et al. 2011) mentioned that calcium is found in large quantities in leaves, and is included in the composition of tissues of various parts, and this element contributes to the regulation of respiration processes, and calcium is important for the continuation of growth and division processes.

It was also noted that spraying with zinc sulfate caused a significant decrease in this characteristic, as the best results were found in plants unsprayed with zinc sulfate (49.163 cm^2), while the lowest leaf area was in plants treated with a concentration of 1.5 g l^{-1} (47.244 cm^2). This may be due to the toxic effect of the high concentration of this elements (Sharma and Sharma 2004) **(Sharma and Sharma, 2004)** or This may be due to the fact that spraying with high concentration reduced the number of leaves (data not shown), and the chlorophyll content in leaves, as shown in Tables (2), and thus reduced the leaf area.

The dual interaction between calcium concentrations and the cultivars contributed significantly when spraying calcium with 2.5 g.l^{-1} in the cultivar Rubygem, as it reached 58.653 cm^2 and was distinguished from the rest of the treatments, while the lowest leaf area was recorded in the Sweet Charlie cultivar which unsprayed with calcium. The results of the same table that there was a significant superiority of the Rubygem cultivar treated with 1.5 gm.l^{-1} of zinc sulfate compared to the other treatments, while the Sweet Charlie cultivar treated with the same concentration gave the lowest rate of leaf area. As for the interaction between the levels of calcium and zinc sulfate, a significant effect was observed at the concentration of 2.5 g.l^{-1} of calcium with untreated with zinc sulfate, which gave the largest leaf area of 57.376 cm^2 and was significantly superior to the rest of the other treatments.

Table 1: Effect of chelated calcium and zinc sulfate spraying on the leaf area (cm^2) and their interactions on "Rubygem and Sweet Charlie" cultivars.

Calcium (g.L^{-1})	Zinc Sulfate (g.L^{-1})	Cultivars: Rubygem	Cultivars: Sweet Charlie	Calcium × Zinc Sulfate	Calcium Mean
0	0	50.901 g	36.403 l	43.652 g	45.125 c
	1.5	62.337 b	32.441 n	47.389 d	
	3	48.674 h	39.996 k	44.335 f	
2.5	0	53.967 e	60.786 c	57.376 a	51.934 a
	1.5	68.923 a	33.563 m	51.243 c	
	3	53.069 f	41.297 j	47.183 d	
5	0	53.480 ef	39.443 k	46.461 e	47.485 b
	1.5	46.274 i	39.928 k	43.101 h	
	3	54.881 d	50.906 g	52.894 b	
Calcium × Cultivars	0	53.970 b	36.280 f	Zinc Sulfate Mean	
	2.5	58.653 a	45.215 d		
	5	51.545 c	43.426 e		
Zinc Sulfate × Cultivars	0	52.783 b	45.544 d	49.163 a	
	1.5	59.178 a	35.311 f	47.244 c	
	3	52.208 c	44.066 e	48.137 b	
Cultivars Mean		54.723 a	41.640 b		

Values with different letters within each factor and their interactions are statistically different at 0.05

Related to the triple interaction between calcium and zinc sulfate and the cultivars in the leaf area, the Rubygem cultivar, treated with the concentrations of calcium and zinc sulfate (2.5 and 1.5) g.l^{-1}, respectively, achieved a significant increase in the leaf area, which amounted to 68.923 cm^2 compared to all other overlap coefficients. At the same time, the lowest leaf area was 32.441 cm^2 in the Sweet Charlie cultivar, overlapping with 0 g.l^{-1} of calcium and 1.5 g.l^{-1} of zinc sulfate.

3.2. Leaf chlorophyll content (SPAD):

The results of Table 5 showed that the Sweet Charlie was significantly superior to the Rubygem in this trait. **Rutha (2019) (Rutha 2019)** explained during his study of two cultivars of strawberry that the Sweet Charlie cultivar was superior to the Rubygem, and explained the reason for this is due to the difference in growth between the two cultivars. Also, the results in the same table appeared that the use of different calcium concentrations had a significant effect on the chlorophyll content in the leaves compared to the comparison treatment. The highest leaves content was 36.546 when spraying with 2.5 g.l^{-1} and the lowest content was in the comparison treatment. This may come back to the role of calcium in the synthesis of chlorophyll and the level of activation of some enzymatic systems in the plant, as well as at the level of its relationship to nitrogen absorption and its representation, Amino Glycine is directly involved in the formation of the compound S-aminolevulinic acid, and this compound is the raw material for the synthesis of the chlorophyll molecule (Gibson, Laver et al. 1958) **(Gibson et al., 1958).**

As well, it was found in the results that the leaves chlorophyll content decreased with increasing the concentration of zinc sulfate. The highest content was recorded in the plants of the comparison treatment and non-significantly differ from 1.5 g.l^{-1} concentration. While the lowest content was found when spraying with a high concentration of zinc sulfate. This decrease may be due to the role of this concentration in reducing the leaf area as in Tables (1), and the leaves number (data not shown), which caused a decrease in the leaves chlorophyll content, or it may be due to the toxic effect of the high concentration of this element (Sharma and Sharma 2004) **(Sharma and Sharma, 2004**).

The interaction between calcium and the cultivars had a significant effect on this trait. The superiority of the Sweet Charlie cultivar that sprayed with the second level (2.5g.L^{-1}) of calcium, which reached the highest content of 40.378 compared to all other interaction treatments, but the lowest content was 31.428 recorded in the Rubygem cultivar when unsprayed with calcium.

As for the interaction between zinc sulfate and the cultivars, the Sweet Charlie cultivar overlapping with all concentrations was significantly superior to the cultivar Rubygem overlapping with all concentrations.

With regard to the effect of the interaction between calcium and zinc sulfate, the interaction contributed to increasing the significant differences between the treatments, so that the highest chlorophyll content reached 38.889 in the interaction treatment between 2.5 g.l^{-1} of calcium and 1.5 g.l^{-1} of zinc sulfate, which differed significantly from the rest of the treatments, while the lowest content (33.634) was shown in the treatment unsprayed with calcium and

3 g.l^{-1} of zinc sulfate (Table 2).

As for the triple overlap, the results in the same table show that the Sweet Charlie overlapping with 2.5 g.l^{-1} of calcium and 1.5 g.l^{-1} of zinc sulfate, and it was significantly superior to the rest of the interaction treatments. While the lowest content was 29.500 recorded in the Rubygem cultivar overlapping with the treatment unsprayed with calcium and 3 g.l^{-1} zinc sulfate.

Table 2: Effect of chelated calcium and zinc sulfate spraying on the leaf chlorophyll content (SPAD) and their interactions on "Rubygem and Sweet Charlie" cultivars.

Calcium (g.L^{-1})	Zinc Sulfate (g.L^{-1})	Cultivars		Calcium × Zinc Sulfate	Calcium Mean
		Rubygem	Sweet Charlie		
0	0	31.894 hij	38.654 cd	35.274 c	34.358 c
	1.5	32.889 h	35.442 f	34.166 de	
	3	29.500 k	37.768 de	33.634 e	
2.5	0	31.558 ij	39.110 c	35.334 c	36.546 a
	1.5	33.932 g	43.846 a	38.889 a	
	3	32.651 h	38.178 cde	35.414 c	
5	0	33.938 g	41.767 b	37.852 b	35.678 b
	1.5	32.158 hi	37.520 e	34.839 cd	
	3	30.944 j	37.743 de	34.344 de	
Calcium × Cultivars	0	31.428 e	37.288 c	Zinc Sulfate Mean	
	2.5	32.714 d	40.378 a		
	5	32.346 d	39.010 b		
Zinc Sulfate × Cultivars	0	32.463 d	39.844 a	36.154 a	
	1.5	32.993 d	38.936 b	35.964 a	
	3	31.032 e	37.896 c	34.464 b	
Cultivars Mean		32.163 b	38.892 a		

Values with different letters within each factor and their interactions are statistically different at 0.05

3.3. Dry matter in the plant (%)

The results in Table 3 confirm the differences between plants of the two cultivars in the dry matter (%). Sweet Charlie plants (36.048%) were significantly superior to Rubygem plants, because Sweet Charlie has a strong-growing plant, and this trait has a role in increasing dry matter in plants (Chandler and Sumler Jr 2002) **(Chandler and Sumler 2002).** Or maybe due to the increase in the leaf chlorophyll content (table 2), which in turn leads to an increase in photosynthesis and an increase in dry matter.

Spraying with calcium at 5 g.l^{-1} caused a significant increase in the dry matter plant percentage, which gave the highest percentage, which was significantly superior to other concentrations. These results agree with (Kazemi 2014) **Kazemi (2014)** in his study on the strawberry "Pajaro" cultivar, who stated that calcium leads to an increase in the plant dry weight. This could be attributed to the role of calcium is indirectly involved in the conversion of starch into sugar and vice versa, as well as in the food conversion of nitrogen compounds. Also, calcium encourages phosphorylation enzymes and some other enzymes to perform their functions, and for this reason, calcium encourages the growth of roots, thus calcium is important in root growth (Jundia 2003) **(Jundia, 2003).**

The results in the same table showed that zinc sulfate had an effective role in increasing the percentage of dry matter in plants, as the increase in the zinc sulfate concentration caused a significant increase in this characteristic, both concentrations (1.5 and 3) g.l^{-1} were significantly superior to the control treatment. This result is consistent with a previous study conducted by (**Kazemi, 2014**) (Kazemi 2014) who confirmed in their studies that an increase in zinc leads to an increase in the percentage of dry matter in plants. This may be attributed to the fact that the microelements play the role of enzyme conjugates in activating many enzymes and are involved in the process of photosynthesis, and this affects the increase in the accumulation of carbohydrates in the cells and is reflected in the growth of the plant (Mostafa, El-Haddad et al. 1997) **(Mostafa et al., 1996**) and thus The dry weight of the plant increases. As well as increasing the concentration of microelements in the plant by adding higher rates that improve root growth. Or maybe due to the role of zinc in the synthesis of the hormone indole acetic acid, which leads to the roots emergence and the division of cells and their large size, which causes the growth of roots (Hartmann, Kester et al. 2002) **(Hartman et al., 2002**).

It was noted from the same table that Sweet Charlie plants treated with a concentration of 5g.l^{-1} of calcium gave the best percentage of 37.321% of plant dry matter and significantly outperformed the rest of the interaction treatments.

As for the interaction between zinc sulfate and the cultivar, the highest percentage of dry matter was recorded at a high concentration of zinc sulfate when sprayed on the Sweet Charlie plants, which was significantly superior to other treatments, whilst the lowest percentage noted in Rubygem and unsprayed with zinc sulfate.

The interaction between the levels of calcium and zinc sulfate achieved a significant superiority in the interaction of the 5g.l^{-1} of calcium and the 1.5g.l^{-1} of zinc sulfate reaching the highest percentage of 36.920% compared to the other interactions.

The triple interaction between the factors of the study contributed to obtaining a significant superiority in the percentage of dry matter in Sweet Charlie plants overlapped with the 5g.l^{-1} of calcium and the 1.5g.l^{-1} of zinc sulfate, which recorded the highest percentage (39.019%) compared to the other interactions, while the lowest percentage was 28.144% recorded. In Rubygem plants were overlapped with 2.5 g.l^{-1} of calcium and unsprayed with zinc sulfate (Table 3).

Table 3: Effect of chelated calcium and zinc sulfate spraying on the dry matter (%) in the plant and their interactions on "Rubygem and Sweet Charlie" cultivars.

Calcium (g.L^{-1})	Zinc Sulfate (g.L^{-1})	Cultivars		Calcium × Zinc Sulfate	Calcium Mean
		Rubygem	Sweet Charlie		
0	0	31.926 e	35.426 d	33.676 c	33.620 b
	1.5	29.857 fg	35.472 d	32.665 d	
	3	32.344 e	36.696 c	34.520 b	
2.5	0	28.144 h	35.109 d	31.626 e	32.127 c
	1.5	29.624 fg	32.381 e	31.003 f	
	3	30.116 f	37.386 bc	33.751 c	
5	0	30.108 f	35.029 d	32.568 d	34.334 a
	1.5	34.820 d	39.019 a	36.920 a	
	3	29.114 g	37.914 b	33.514 c	
Calcium × Cultivars	0	31.375 d	35.865 b	Zinc Sulfate Mean	
	2.5	29.295 e	34.959 c		
	5	31.348 d	37.321 a		
Zinc Sulfate × Cultivars	0	30.059 f	35.188 c	32.624 c	
	1.5	31.434 d	35.624 b	33.529 b	
	3	30.525 e	37.332 a	33.928 a	
Cultivars Mean		30.673 b	36.048 a		

Values with different letters within each factor and their interactions are statistically different at 0.05

3.4. Calcium content in the leaves (%):

Table (4) shows that there are no significant differences between the two cultivars and also between the zinc sulfate concentrations, in addition to bilateral interaction between the zinc sulfate and the cultivars in the calcium content in the leaves.

As for the spraying with calcium, it had a significant effect on this characteristic, as spraying with both concentrations (2.5 and 5) g.l^{-1} of calcium was significantly superior to the comparison treatment which gave the lowest rate (2.601)%. This increase in the calcium content of the leaves may be attributed to the easy absorption of the calcium element by the leaves, which led to the continued supply of the plant with the calcium element, and this leads to an increase in the concentration of this element in the tissues of the plant.

The interaction between calcium and the cultivars had a significant effect on the calcium content in the leaves, as the highest rate (3.331)% was obtained in the Sweet Charlie treated with 2.5 g.l^{-1} of calcium compared to the lowest rate (2.523)% in the Sweet Charlie when unsprayed with calcium.

As for the interaction between the levels of calcium and zinc sulfate, it had a significant effect, as the highest rate (3.325)% was obtained when spraying with 2.5 g.l^{-1} of calcium and 1.5 g.l^{-1} of zinc sulfate, compared to the lowest rate (2.008)% in plants unsprayed with both calcium and zinc sulfate (Table 4).

With regard to the triple interaction between the study factors, it had a significant effect on this trait, as spraying with 2.5 g.l^{-1} of calcium and 1.5 g.l^{-1} of zinc sulfate in Sweet Charlie plants gave the highest calcium content in leaves (3.807)%, while the lowest content was 1.920% when unsprayed with both calcium and zinc sulfate in the Sweet Charlie plants.

Table 4: Effect of chelated calcium and zinc sulfate spraying on the calcium content in the leaves (%) and their interactions on "Rubygem and Sweet Charlie" cultivars.

Calcium (g.L^{-1})	Zinc Sulfate (g.L^{-1})	Cultivars		Calcium × Zinc Sulfate	Calcium Mean
		Rubygem	Sweet Charlie		
0	0	2.097 cd	1.920 d	2.008 c	2.601 b
	1.5	2.830 bcd	2.763 bcd	2.797 ab	
	3	3.110 ab	2.887	2.998 ab	

			abcd		
2.5	0	2.930 abc	3.147 ab	3.038 ab	3.098 a
	1.5	2.843 bcd	3.807 a	3.325 a	
	3	2.820 bcd	3.040 abc	2.930 ab	
5	0	3.087 ab	2.673 bcd	2.880 ab	2.697 a
	1.5	2.750 bcd	2.677 bcd	2.713 ab	
	3	2.193 bcd	2.803 bcd	2.498 bc	
Calcium × Cultivars	0	2.679 b	2.523 b	Zinc Sulfate Mean	
	2.5	2.864 ab	3.331 a		
	5	2.677 b	2.718 b		
Zinc Sulfate × Cultivars	0	2.704 a	2.580 a	2.642 a	
	1.5	2.808 a	3.082 a	2.945 a	
	3	2.708 a	2.910 a	2.809 a	
Cultivars Mean		2.740 a	2.857 a		

Values with different letters within each factor and their interactions are statistically different at 0.05

3.5. Zinc content in the leaves (mg.kg^{-1} DW):

The results are shown in Table (5) that the zinc content in the leaves was not affected significantly either in the individual effects or the bilateral or triple interactions among the studied factors, except for the effect of calcium and the interaction between calcium concentrations and cultivars.

Whereas, the sprayed with calcium was significantly increasing the zinc content in the leaves, as the highest rate (0.171) mg.kg^{-1} recorded in plant leaves sprayed with 2.5 g.l^{-1} of calcium, compared to the comparison treatment, which gave the lowest rate (0.105) mg.kg^{-1}. This may be attributed to the role of calcium in regulating the entry of nutrients into the plant, and the presence of calcium in the soil affects the absorption of other elements by the plant (Casero, Benavides et al. 2002) **(Casero et al., 2002)**, as well as its role in increasing the number of leaves, the leaf area, and the chlorophyll content of leaves when sprayed with the same concentration as in the tables. (3, and 5), which led to an increase in the absorption of water and nutrients, and thus caused an increase in the zinc content of the leaves.

It was found that the overlap between calcium and the cultivars had a significant effect on the zinc content of the leaves, as the Sweet Charlie plants sprayed with 2.5 g.l^{-1} gave the maximum rate (0.191) mg.kg^{-1} and the lowest rate (0.085) mg.kg^{-1} found in the Sweet Charlie which unsprayed with calcium.

Table 5: Effect of chelated calcium and zinc sulfate spraying on the zinc content in the leaves (mg.kg^{-1}) and their interactions on "Rubygem and Sweet Charlie" cultivars.

Calcium (g.L^{-1})	Zinc Sulfate (g.L^{-1})	Cultivars		Calcium × Zinc Sulfate	Calcium Mean
		Rubygem	Sweet Charlie		
0	0	0.095 a	0.062 a	0.078 a	0.105 b
	1.5	0.065 a	0.107 a	0.086 a	
	3	0.215 a	0.086 a	0.150 a	
2.5	0	0.182 a	0.142 a	0.162 a	0.171 a
	1.5	0.101 a	0.222 a	0.162 a	
	3	0.171 a	0.210 a	0.190 a	
5	0	0.188 a	0.078 a	0.133 a	0.114 ab
	1.5	0.097 a	0.136 a	0.117 a	
	3	0.077 a	0.106 a	0.091 a	
Calcium × Cultivars	0	0.125 ab	0.085 b	Zinc Sulfate Mean	
	2.5	0.151 ab	0.191 a		
	5	0.121 ab	0.107 ab		
Zinc Sulfate × Cultivars	0	0.155 a	0.094 a	0.124 a	
	1.5	0.088 a	0.155 a	0.121 a	
	3	0.154 a	0.134 a	0.144 a	
Cultivars Mean		0.132 a	0.128 a		

Values with different letters within each factor and their interactions are statistically different at 0.05

3.6. Calcium content in the fruits (%):

The results of Table (6) indicate that the cultivars did not have a significant effect on the calcium content in the fruits.

The spraying with calcium had a significant effect on the calcium content in the fruits, as the spraying with 2.5 g.l^{-1} calcium significantly exceeded compared to the control treatment in the fruits calcium content. This may be attributed to the fact that spraying with calcium led to an increase in the content of calcium in the leaves as shown in Table (4), which led to an increase in the transfer of calcium from the leaves to the fruits, thus increased the calcium percentage in the fruits.

Also spraying with zinc sulfate has a significant effect on increasing the calcium content of the fruits, as the spraying with both concentrations (1.5 and 3) g.l^{-1} of zinc sulfate distinguished significantly over the comparison treatment, and the reason for this may be attributed to its role in increasing the fruit content of the amino acid tryptophan, which in turn contributes to the synthesis (IAA), and works to attract nutrients to the fruits (Cakmak and Marschner 1993) **(Cakmak and Marschner, 1993**), and thus leads to an increase in Absorbing elements like Ca element and others.

The results in the same table indicate that the interaction between calcium and the cultivars had a significant effect on the calcium content in the fruits, as the highest rate (2.540)% was recorded in the Sweet Charlie when sprayed with 2.5 g.l^{-1} of calcium which superior on the unsprayed with calcium in the same cultivar.

The results in the same table indicate that the interaction between zinc sulfate and the cultivars had a significant effect on the calcium content in the fruits, as the best rate appeared in the Sweet Charlie when sprayed with 1.5 g.l^{-1} of zinc sulfate which was superior to the unsprayed with zinc sulfate in both cultivars.

Likewise, all triple interactions did not differ significantly between them, whereas all of them were significantly superior to the comparison treatment of the two cultivars.

Table 6: Effect of chelated calcium and zinc sulfate spraying on the calcium content in the fruits (%) and their interactions on "Rubygem and Sweet Charlie" cultivars.

Calcium (g.L^{-1})	Zinc Sulfate (g.L^{-1})	Cultivars		Calcium × Zinc Sulfate	Calcium Mean
		Rubygem	Sweet Charlie		
0	0	1.793 b	1.800 b	1.797 b	2.216 b
	1.5	2.467 a	2.533 a	2.500 a	
	3	2.500 a	2.203 ab	2.352 a	
2.5	0	2.383 a	2.533 a	2.458 a	2.457 a
	1.5	2.353 a	2.590 a	2.472 a	
	3	2.383 a	2.497 a	2.440 a	
5	0	2.250 a	2.347 a	2.298 a	2.344 ab
	1.5	2.417 a	2.530 a	2.473 a	
	3	2.343 a	2.180 ab	2.262 a	
Calcium × Cultivars	0	2.253 b	2.179 b	Zinc Sulfate Mean	
	2.5	2.373 ab	2.540 a		
	5	2.337 ab	2.352 ab		
Zinc Sulfate × Cultivars	0	2.142 c	2.227 cd	2.184 b	
	1.5	2.412 ab	2.551 a	2.482 a	
	3	2.409 ab	2.293 ab	2.351 a	
Cultivars Mean		2.321 a	2.357 a		

Values with different letters within each factor and their interactions are statistically different at 0.05

3.7. Dry matter in the fruit (%):

According to the results of the statistical analysis in Table (7), there was no significant effect between the two cultivars in the dry matter percentage in the fruit.

It was found that spraying with chelated calcium led to a significant decrease in the dry matter percentage in the fruit, as it reached the lowest percentage in the fruits of the treatment with a concentration of 2.5 g.l^{-1} calcium 7.794%, while the highest percentage was in the fruits of the comparison treatment. These results are consistent with what was found by (Al-Mayahi 2007) **(Al-Mayahi, 2007)**, who they stated that an increase in calcium concentration causes a decrease in the dry matter in the fruits due to the high water content when the fruits are ripening. Or may be due to the role of calcium in retaining moisture and reducing moisture loss in the fruits. By entering the middle layer of the cell wall in the form of calcium pectus. (Kazemi 2014) **(Kazemi, 2014)** stated that calcium had no significant change in dry weight.

Also found in the same table that the zinc sulfate concentrations used had a significant effect on this characteristic, the results indicated that spraying with 1.5 and 3 g.l^{-1} of zinc sulfate which were significantly superior to the comparison treatment. This may be due to the physiological role of the element zinc, which leads to an increase in the efficiency of the photosynthesis process, which improves the characteristics of vegetative growth and the transfer of the products of this process from leaves to fruits (Mengel and Kirkby 2004) (**Mengel and Kirkby, 2001**). As well as its role in increasing the percentage of dry matter in the plant, as in the results of the current study (Table 6), and thus increased the percentage of dry matter in the fruits.

In the table below, it was found that the fruits of both Rubygem and Sweet Charlie cultivars overlapped with 0 g.l^{-1} of calcium and were (8.550 and 8.708)% respectively significantly superior to most of the treatments, and the lowest was in the Rubygem fruits sprayed with 2.5 g.l^{-1} of calcium.

The interaction between zinc sulfate and the cultivars had a significant effect on this trait, as the Rubygem fruits treated with 3 g.l^{-1} of zinc sulfate were significantly superior to the other treatments. As for the effect of the interaction between calcium and zinc sulfate, the unsprayed with calcium overlapped with 1.5 g.l^{-1} of zinc sulfate was significantly superior to the rest of the treatments except for the treatment of spraying with calcium at 5 g.l^{-1} and 3 g.l^{-1} of zinc sulfate.

The triple interaction between the factors of the study had a significant effect on the percentage of dry matter in the fruit, where the Rubygem fruits treated with 5 g.l^{-1} of calcium and 3 g.l^{-1} of zinc sulfate were significantly superior to the other treatments, except for the Sweet Charlie fruits that untreated with calcium and treated with 1.5 g.l^{-1} of zinc sulfate (Table 7).

Table 7: Effect of chelated calcium and zinc sulfate spraying on the dry matter in the fruit (%) and their interactions on "Rubygem and Sweet Charlie" cultivars.

Calcium (g.L^{-1})	Zinc Sulfate (g.L^{-1})	Cultivars		Calcium × Zinc Sulfate	Calcium Mean
		Rubygem	Sweet Charlie		
0	0	8.447 bcd	8.285 bcd	8.366 bc	8.629 a
	1.5	8.625 b	9.850 a	9.237 a	
	3	8.577 bc	7.989 bcde	8.283 bc	
2.5	0	7.219 ef	8.053 bcde	7.636 d	7.794 b
	1.5	7.220 ef	7.899 bcde	7.560 d	
	3	8.249 bcd	8.125 bcde	8.187 bcd	
5	0	6.812 f	8.357 bcd	7.584 d	8.071 b
	1.5	8.233 bcd	7.625 cdef	7.929 cd	
	3	9.875 a	7.524 def	8.699 ab	
Calcium × Cultivars	0	8.550 a	8.708 a	Zinc Sulfate Mean	
	2.5	7.563 c	8.026 bc		
	5	8.306 ab	7.835 bc		
Zinc Sulfate × Cultivars	0	7.493 d	8.232 bc	7.862 b	
	1.5	8.026 bc	8.458 ab	8.242 a	
	3	8.900 a	7.879 cd	8.390 a	
Cultivars Mean		8.140 a	8.190 a		

Values with different letters within each factor and their interactions are statistically different at 0.05

4. CONCLUSION

According to the current results, we can conclude that the spraying with calcium at 2.5 and 5 g L^{-1} resulted in a significant increase in the leaf area, leaf chlorophyll content, Ca and Zn contents in the leaves, and Ca content in the fruits, but the dry matter in the fruit decreased significantly compared to the control. However, fruits treated with 1.5 and 3 g L^{-1} of Zn sulfate were significantly increased chlorophyll content in the leaf, dry matter (%) in the plant and fruit, and Ca content in the fruits, while caused a significant decrease in the leaf area compared to the control. Sweet Charlie cultivar had higher response than the Rubygem in leaf chlorophyll content, and dry matter (%) in the plant but on the contrary, in the leaf area property, while a non-significant difference was found in all other properties.

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