

## RESEARCH PAPER

# Influence of Calcium Foliar Application to Increase Growth and Yield of Two Strawberry Cultivars (*Fragaria x ananassa* Duch.)

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### ABSTRACT:

There are many studies about calcium effect on strawberry plants in the world, but few studies have been devoted to investigating its effects on strawberries in Kurdistan-Iraq. Strawberry, which has around twenty documented species, is native to Asia, Europe and South and North America. In the horticulture, it is considered the most important fruits. This research investigates the effect of spray of calcium on growth, flowering and yield of two strawberry cultivars (*Fragaria X ananassa* Duch.). Three different concentrations of Ca (0, 250 and 500 ppm) were applied by foliar method on two cultivars of strawberry (Festival and Albion). The results revealed a substantial increase in all the vegetative growth parameters at the level (500 ppm) of calcium for Albion cultivar. However, the highest number of daughter plants was recorded at the level (250 ppm). while all flowering parameters increased significantly at the level (500 ppm) of calcium for Festival cultivar, significant increases were observed in the fruit parameters such as dry weight (g), dry weight percentage and fruit length (cm) at the level (500 ppm) of calcium for Albion cultivar. Furthermore, it is monitored that fresh weight (g), fruit diameter (cm), fruit size (cm<sup>3</sup>), number of fruits, yield/plant (g) and yield/ha were increased significantly at the level (500 ppm) of calcium for Festival cultivar. Moreover, the highest value of fruit fall percentage was recorded at the control of Albion cultivar, conversely the lowest value was at control of Festival. The TSS and ascorbic acid were significantly elevated at the level (500 ppm) for Albion cultivar, however, acidity percentage and sugar percentage raised significantly at the level (500 ppm) calcium for Festival cultivar. The biggest amount of vitamin C was acquired after storage of Festival cultivar that treated with (500 ppm) calcium, whereas the smallest amount was from the control group of Festival cultivar.

KEY WORDS: Ca concentration, Foliar application, Festival, Albion, *Fragaria X ananassa* Duch.

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## 1.INTRODUCTION

Calcium plays a very important role in plant growth and nutrition, as well as in cell wall deposition. *Fragaria X ananassa* Duch is the periodic fruiting type of the strawberry and is a long-night plant. During this short time, limited vegetative growth happens. Consequently, according to (Asrey et al., 2004) and (Singh et al., 2007) the produced fruit has poor quality and minimum marketable yield. Thus,

it fetches less price in the market. Even though fresh strawberries contain high amount of vitamin C and phenolic compounds, their quality declines straight after harvest (Sturm, 2003 and Oszmianski, 2009). Testoni (2006) expressed that strawberries fruit is a highly rich source of bioactive composites comprising vitamin E, ascorbic acid,  $\beta$ -carotene and phenolic compounds (phenol acids, flavan-3-ols, flavones, and anthocyanin). In addition, to determine fruit quality in strawberry, total soluble solids (TSS), total acids (TA) and their proportion (TSS/TA) considered as vital parameters. Within the mitochondria, Ca play a vital role in the formation

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of protein and escalating the amount of protein. Because of mitochondria's role in aerobic respiration and absorbing nutrients, it can be stated that the amount of calcium directly related to nutrient uptake by plants. The uptake of calcium by the plant is utilized by the mass diffusion.

The quality and the firmness of fruit is closely associated to calcium (Ca) (Sams, 1999). Chéour (1991) demonstrated that the functions and structure of cell walls and membranes, and cell metabolism events might be impacted by the frequent application of Ca, it is considered a vital mineral element that strawberry fruit quantity. However, calcium may cause issues for the quality because of its slow movement. The transference of Ca to the plant and fruit might decrease physiological damage of fruit. The ripening process rises DE polymerization of pectin in the strawberry fruit. Kaya (2002) reported that one of the most important constituents in the plant cell wall is Ca which leads the solidity of cell wall. According to Hernandez- Muñoz *et al.* (2008) fruit nutrition value and fruit density are positively affected by the addition of calcium. Moreover, Levent Tuna *et al.* (2007) indicated that Ca supplementation has positive impact on the growth and crop yields. The results of Andriolo *et al.*, (2010) revealed that the calcium chloride ( $\text{CaCl}_2$ ) applications did not significantly impact plant growth, total soluble solids (TSS) and the TSS/TA proportion. The study also demonstrated that while  $\text{CaCl}_2$  addition rises the leaf area index, it reduces fruit production. In addition, each of Dunn and Able (2006) and Ramezani *et al.* (2009) stated that average size and fruit weight of strawberry fruits increased by the application of  $\text{CaCl}_2$ . However, the treatable acidity was not affected significantly. It was also reported that  $\text{CaCl}_2$  escalates the contents of ascorbic acid. In fruits, retaining ascorbic acid content was significantly affected by  $\text{CaCl}_2$  treatments. This could be related to calcium chloride concentration that suspend the quick oxidation of ascorbic acid (Ramezani *et al.* 2009).

The effect of supplementary calcium and potassium on fruit yield and quality of strawberry (*Fragaria X ananassa* Duch.) was investigated by Khayyat *et al.* (2007) who found that while the ratio of TSS/TA was bigger in  $\text{NaCl}+\text{K}_2\text{SO}_4$  treatment, the TA, TSS and vitamin C were higher in  $\text{NaCl}+\text{CaCl}_2$  treatment. It proposes that the

application of  $\text{CaSO}_4$  results in escalation in production and quality of strawberry in saline conditions. According to Hernandez-Muñoz *et al.* (2008), fruit nutrition value and fruit density are positively affected by the addition of calcium. Moreover, Levent Tuna *et al.* (2007) indicated that Ca supplementation has positive impact on the growth and crop yields. Calcium application caused the increased number of runner/plants significantly (Dastjerdy *et al.*, 2014). It exhibits that flower number, fruit harvest and the inflorescence affected by nitrogen. The post-harvest life is enhanced and increased by calcium. Using spraying technique for calcium application positively impacted plant growth. Nitrogen addition resulted in the increase in the amount of the total soluble solids. For improving fruit production, the ideal treatment was observed when the nitrogen concentration were 240 mg/l and calcium concentration was 300 mg/l. These concentrations of nitrogen and calcium were proposed to decline production costs and increase the post-harvest life (Motamedi *et al.*, 2010).

Kazemi (2013) examined the effect of salicylic acid and calcium chloride sprays on the production parameters of strawberry. It was demonstrated that vegetative and reproductive growth were significantly impacted by the foliar application of salicylic acid and calcium chloride either alone or in mixture. It was also displayed that quality and yield of strawberry plants was enhanced in low levels of calcium chloride and salicylic acid. The study concluded that for yield enhancement and preventing yield reduction, the application of calcium chloride and salicylic is advantageous. The most effective approach for escalating calcium content in fruit is direct application of calcium to the fruit (Conway *et al.*, 2002).

Wojcik and Lewandowski (2003) stated that applying calcium chloride by foliar technique delays ripening process and retards fungal growth on strawberries. Kazemi (2014) investigated the effect of foliar application of iron, calcium and zinc sulphate on reproductive growth, yield and several qualitative characteristics of strawberry plants. The study exposed that leaf area, dry weight, length of roots of strawberry increased by the application of calcium, iron and zinc sulphate. The number of flowers, weight of primary and secondary fruits were enhanced by spraying of calcium at 10 mM. Generally, to increase the

strawberry yield, spraying calcium at 10 mM concentration is suggested. The objective of this experiment is to show the effect of calcium on the growth, flowering and fruiting of strawberry plant in different concentrations by foliar application.

## 2. Materials and Methods

Two strawberry cultivars; Albion and Festival were planted in plastic house with ambient sunlight. Planting date was October 15, 2016. The plants were dormant from November, 2016 to March, 2017. The treatments were applied on the plants when they completely grown after three months. Different levels of calcium were applied. The experiment comprised of three treatment groups: a control group (0 ppm calcium), and the other two groups were either treated with (250 ppm) or (500 ppm) calcium. Spraying method was utilized for supplying Ca. Standard practices of fertilizer and pesticides were applied for improving the vegetative growth and controlling insects and diseases. The experiments were performed using Complete Randomized Design (CRD) with 6 replications and results were analyzed using Statistical Analysis System (SAS) software.

## 3. Results

Table 1 demonstrates that most of vegetative growth parameters as fresh weigh, dry weight, crown diameter, Number of stolons (runners) and chlorophyll pigment percentage had recorded the higher values in Albion cultivar in comparison to the Festival cultivar at the level

(500 ppm) of calcium. Nevertheless, the number of daughter plants recorded the higher value at the level (250 ppm) of calcium for Albion cultivar and this in agreement with (Levent Tuna *et al.*, 2007 and Kazemi, 2013).

In Table 2, it can be observed that there is a significant increase in all flowering parameters including number of flowers, fruit set% and available pollen grain at the level (500 ppm) calcium for Festival cultivar compared to the Albion cultivar at the same level. This result is in agreement with (Dastjerdy *et al.*, 2014).

Table 3 displays significant increases in the fruit parameters such as fresh weight, dry weight, fruit diameter, number of fruit, fruit size, yield/plant (g) and yield/ha (kg) at the level (500 ppm) of spray calcium for Festival. Nonetheless, fruit length at the level (500 ppm) calcium for Albion cultivar. However, the highest value of fruit fall percentage was recorded at the control treatment of Albion cultivar and the lowest value was at the control treatment of Festival. This in agreement with (Levent Tuna *et al.*, 2007; Kazemi, 2013 and 2014).

It is clearly shown in table (4) that TSS and ascorbic acid increased significantly at the level (500 ppm) calcium for Albion cultivar, while acidity percentage and sugar percentage increased significantly at the level (500 ppm) calcium for Festival cultivar (Andriolo *et al.*, 2010; Motamedi *et al.*, 2010 and Dastjerdy *et al.*, 2014) found similar results.

**Table 1.** Effect of foliar calcium application on the growth of some vegetative parameters of strawberry plants (Festival and Albion cultivar).

| Parameters          | Festival |         |         | Albion  |         |         |
|---------------------|----------|---------|---------|---------|---------|---------|
|                     | 0        | 250 ppm | 500 ppm | 0       | 250 ppm | 500 ppm |
| Fresh weigh (g)     | 59.01 f  | 82.79 d | 90.67 b | 60.67 e | 87.10 c | 92.11 a |
| Dry weight (g)      | 18.89 f  | 25.64 d | 36.41 b | 21.17 e | 30.21c  | 42.57 a |
| Crown diameter (cm) | 0.97 f   | 1.55 d  | 2.120 c | 1.070 e | 2.10 b  | 2.24 a  |

|                    |         |         |         |         |         |         |
|--------------------|---------|---------|---------|---------|---------|---------|
| No. runners        | 7.47 f  | 9.33 d  | 11.07 b | 8.020 e | 10.22 c | 11.92 a |
| No. daughter plant | 9.41 e  | 16.36 c | 20.66 b | 10.22 d | 21.62 a | 20.66 b |
| Chlorophyll %      | 11.33 e | 14.09 c | 15.69 a | 11.92 d | 15.24 b | 15.69 a |

**Table 2.** Effect of foliar calcium application on some flowering parameters of strawberry plants (Festival and Albion cultivar).

| Parameters              | Festival |         |         | Albion  |         |         |
|-------------------------|----------|---------|---------|---------|---------|---------|
|                         | 0        | 250 ppm | 500 ppm | 0       | 250 ppm | 500 ppm |
| No. flowers             | 11.18 e  | 20.80 c | 23.37 a | 10.33 f | 18.74 d | 21.52 b |
| Fruit set%              | 57.79 e  | 69.95 c | 83.06 a | 47.39 f | 65.66 d | 79.78 b |
| Available pollen grain% | 46.62 d  | 58.55 c | 71.80 a | 41.74 e | 59.32 c | 63.64 b |

**Table 3.** Effect of foliar calcium application on some parameters of the strawberry fruits (Festival and Albion cultivar).

| Parameters                    | Festival |          |          | Albion   |          |          |
|-------------------------------|----------|----------|----------|----------|----------|----------|
|                               | 0        | 250 ppm  | 500 ppm  | 0        | 250 ppm  | 500 ppm  |
| Fresh weight (g)              | 6.00 e   | 7.28 c   | 8.34 a   | 5.73 f   | 7.30 c   | 8.04 b   |
| Dry weight (g)                | 0.46 e   | 0.77 d   | 1.90 a   | 0.47 e   | 0.91 b   | 1.11 b   |
| Fruit diameter (cm)           | 1.00 e   | 1.37 b   | 1.63 a   | 1.01 e   | 1.17 d   | 1.33 c   |
| Fruit length (cm)             | 1.00 f   | 1.37 e   | 1.58 d   | 1.92 c   | 2.48 b   | 2.72 a   |
| Fruit size (cm <sup>3</sup> ) | 1.35 e   | 2.28 c   | 2.63 a   | 1.23 f   | 1.94 d   | 2.38 b   |
| No. fruits                    | 12.79 f  | 19.31 c  | 24.60 a  | 13.98 e  | 18.87 d  | 24.09 b  |
| Fruit fall%                   | 20.19 b  | 15.43 c  | 11.99 e  | 20.94 a  | 15.34 c  | 12.88 d  |
| Yield/plant (g)               | 67.94 e  | 84.52 b  | 87.03 a  | 59.78 f  | 70.59 d  | 75.79 c  |
| Yield/ha (kg)                 | 339.72 e | 422.63 b | 435.15 a | 293.85 f | 351.75 d | 374.05 c |

**Table 4.** Effect of foliar calcium application on some chemical substance in strawberry fruits (Festival and Albion cultivar).

| Parameters | Festival |         |         | Albion  |         |         |
|------------|----------|---------|---------|---------|---------|---------|
|            | 0        | 250 ppm | 500 ppm | 0       | 250 ppm | 500 ppm |
| TSS        | 5.49 e   | 6.05 c  | 6.78 a  | 4.97 f  | 5.75 d  | 6.23 b  |
| Vitamin C  | 24.75 e  | 26.24 c | 27.59 a | 24.91 f | 26.09 d | 26.81 b |
| Acidity%   | 0.79 d   | 0.79 d  | 0.84 b  | 0.81 c  | 0.79 d  | 0.87 a  |
| Sugar%     | 0.10 d   | 0.12 c  | 0.14 b  | 0.10 d  | 0.12 c  | 0.15 a  |

#### 4. Discussions

Calcium, in the form of calcium pectate, is responsible for holding together the cell walls of plants. Calcium is also used in activating certain enzymes and to send signals that coordinate certain cellular activities. It is a structural part of the cell walls, by forming cross-links within the pectin polysaccharide matrix. With rapid plant growth, the structural integrity of stems that hold flowers and fruit. It assists in movement of carbohydrates within the plant. Calcium insufficiency may impede plant growth and, as its function in root growth is so important, plants may suffer from other nutrient deficiencies as a result of calcium deficiency.

In strawberry cultivar Festival with foliar calcium at 500 ppm resulted in a remarkable increase of most of studied characteristics. While Albion cultivar showed less response to foliar calcium at the same level. Wójcik and Lewandowski, (2003) examined the effects of foliar applications of calcium (Ca) and boron (B) on yield and fruit quality of 'Elsanta' strawberries grown on a sandy loam. Results showed that fruit and leaves from Ca-treated plants had increased Ca concentrations.

#### 5. Conclusion

The results exposed that the application of calcium significantly affected vegetative and reproductive characteristics of strawberry. Furthermore, increasing the concentration of Ca increased the postharvest life. Moreover, the application of Ca by spraying method had positive

effects on the growth of the plant. Generally, spraying calcium at the level (500 ppm) had the highest impact on the growth, flowering and yield of strawberry plants.

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