The Effect of Spraying With Calcium, Boron and Benzyl Adenine on The Quantity and Quality of Yield for Strawberry Plants (Fragaria Ananassa Duch) CV. Rubygem

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Abstract

This experiment was conducted inside the plastic house of the Agricultural Research and Experiments Station in the Al-Sayada area of the College of Agriculture - University of Kirkuk / Iraq, during the growing season of 2020-2021, To study the effect of spraying with calcium and boron with four concentrations (0, 100 Calcium, 20 Boron and 100 Calcium + 20 Boron) mg.L⁻¹ and growth regulator benzyl adenine with three concentrations (0, 30, 60) mg.L⁻¹ on some quantitative and qualitative characteristics of the yield of strawberry plant Rubygem variety. The experiment was carried out in accordance with Randomized Complete Block Design (RCBD) for simple factorial tests with three replicates and one tree per experimental unit. The results were statistically analyzed using the ready-made (SAS V 9.0) program. The averages were compared according to Duncan’s Multiple Range Test at probability level (0.05). The results obtained can be summarized when spraying with a combination of calcium 100 mg.L⁻¹ and boron 20 mg.L⁻¹ led to a significant increase in the average number of flowers and fruits, set percentage and Average diameter of fruit. Whereas, spraying with calcium alone at a concentration of 100 mg.L⁻¹ resulted in a significant superiority in the characteristics (average length and size of the fruit, average fruit weight, average yield per plant and yield per unit area). Whereas, spraying with a concentration of 60 mg.L⁻¹ of growth regulator benzyl adenine led to a significant superiority in all the studied traits compared with the rest of the other treatments. The bilateral overlap between the levels of the factors included in the study had a clear significant effect in compared to the comparative treatment.

Keywords: Calcium, Boron, Benzyl adenine, Rubygem.

1. Introduction

The strawberry plant (Fragaria ananassa Duch.) belongs to the Rosaceae family, which includes about 100 genera and 2,500 species. It is one of the most important crops with small fruits after grapes widespread in different regions of the world due to its many varieties and its ability to grow and adapt to different environmental conditions [1,2]. Strawberries are grown in order to obtain fruits that are eaten fresh or canned, or are included in many food industries such as jams, juices, ice cream and pastries. The strawberry fruit is one of the aggregate fruits with an attractive external appearance and sweet taste that contains a slight acidity and its flavor is due to the presence of some aromatic compounds in the fruit such as Benzylacetate and Zimtsaeure methylester. It is of high nutritional value, as 100 grams of soft weight of strawberry contains 31.9 grams of calories, 0.66 grams of protein, 0.29 grams of fat and 7.95 grams of carbohydrates in addition to being rich in sugars, vitamins, organic acids and many mineral elements [3,4]. Calcium is one of the macronutrients important and influencing the growth and development of plants. It is one of the slow moving and moving elements between cells this problem can be overcome by spraying it on the shoots to reduce the symptoms of its deficiency and increase its concentration in the leaves and fruits according to the concentration and the number of times and times of spraying [5]. It is essential for growth and cell division, It plays a key role in the permeability of plasma membranes due to its role in transmitting signals within the plant, as well as increasing the plant's ability to represent carbon dioxide and absorb and utilize many nutrients, thus increasing the cells' tolerance to environmental, thermal and water stress and their resistance to fungal and insect infections, It also plays an important role in activating enzymes[6,7]. In studying [8] about spraying strawberry plants with calcium chloride at a rate of 2 kg.ha⁻¹ has significantly increased the yield of one plant compared to the rest of the treatments, reach 168.4 g, and in studying [9] when spraying strawberry plant Festival Cultivar with chelated calcium at a concentration of 100 mg.L⁻¹, they found a significant increase in the size and weight of the fruit, reaching (18.79 cm³, 12.11 g) respectively. While explained [10] in
studying the effect of spraying with calcium on the growth and yield of apricot trees, cultivar Royal, the average diameter, length, size and weight of fruits were significantly affected when spraying with a concentration of 1000 mg. L\(^{-1}\) of chelated calcium compared with spraying with a concentration of 500 mg. L\(^{-1}\) and the comparison treatment.

Boron is considered one of the important and necessary micronutrients in plant production and growth, and it is no less important than the major nutrients, it has many physiological functions in plants, as it has a role in the processes of differentiation and cellular morphology and in the fertilization process as it is necessary in the production of pollen, flowering and seed formation. It affects the formation of the cell wall and the formation of pectin and lignin, as it was found that 50% of the boron present in the plant is concentrated in the cell wall [11,12], it contributes to the transport of carbohydrates and sugars within the plant, participates in the formation of nucleic acids, DNA and RNA, and contributes to the process of water absorption and transpiration, as well as the formation of protein upon biosynthesis of atmospheric nitrogen [13,14]. In this regard, [15] found in his study the spraying of two varieties of strawberry Rubygem and Fortuna concentration of 20 mg. L\(^{-1}\) of boric acid, it significantly increased the rate of number of flowers and fruits, the percentage of set, the total yield of the plant, and the yield per unit area, and [16] found that the yield of one strawberry plant was significantly affected when spraying with boron at a concentration of 4 g. L\(^{-1}\), reaching 713.28 g. The study of [9] showed that spraying Festival strawberry plants with chelated calcium and boron, the interaction with a concentration of 100 mg. L\(^{-1}\) of chelated calcium and 20 mg. L\(^{-1}\) of boric acid increased the number of fruits, the size of the fruit, the yield of one plant and the yield. The unit area was significant compared to the comparison treatment, where it reached (6.33 fruit. plant\(^{-1}\), 23.51 cm\(^3\), 72.06 g, 1.44 ton.ha\(^{-1}\)) respectively.

And the growth regulator benzyl adenine 6-benzyl amino purine is one of the most important groups of synthetic cytokines, which are plant hormones naturally produced by plants, which are compounds derived from adenine its molecules contain a nitrogenous base (Purine) [17]. Among the most important physiological effects of cytokinins is to stimulate cell division and elongation and the growth of stems, roots and side shoots as they work to end the apical dominance induced by auxin and break the dormancy of seeds and buds [18]. Some studies have shown that one of the main factors determining the growth of fruits and reaching the final size is the production of compounds similar to cytokinins, as the addition of industrial cytokines increases the effectiveness of cytokinins-like compounds in plant tissues, which stimulates the growth of fruits in some plants [19,20]. And in this area explained [19] the fruit size and the total yield of pear trees were significantly affected when spraying with a concentration of 100 mg. L\(^{-1}\) of benzyl adenine. While [21] found that spraying apple trees with benzyl adenine at a concentration of (150 and 200) mg. L\(^{-1}\) led to an increase in the size of fruits and the number of flowers compared to the concentration of 100 mg. L\(^{-1}\) and the control treatment. The results are well shown [22] the percentage of set and total yield of orange tree increased significantly when spraying with a concentration of 45 mg. L\(^{-1}\) from benzyl adenine, reaching (27.09% and 42.57 kg. tree\(^{-1}\)), respectively, compared to spraying with a concentration of (15 and 30) mg. L\(^{-1}\) and comparison treatment. The study aims to improve the quantity and quality of yield for strawberry plants CV. Rubygem by spraying with calcium and boron and the growth regulator benzyl adenine.

2. Materials and Methods

This experiment was conducted inside the plastic house of the Agricultural Research and Experiments Station in the Al-Sayada area of the College of Agriculture - University of Kirkuk during the growing season 2020-2021, to study the effect of spraying with calcium and boron in four concentrations (0, 100 Ca, 20 B, 100 Ca+20 B) mg. L\(^{-1}\) symbolized as (A\(_0\), A\(_1\), A\(_2\), A\(_3\)) respectively and spraying with benzyl adenine in three concentrations (0, 30, 60) mg. L\(^{-1}\) denoted by (B\(_0\), B\(_1\), B\(_2\)) respectively, the seedlings were brought from Dana nursery in Sulaimani Governorate, of suitable and homogeneous sizes and ready for planting, the soil was prepared, smoothed and prepared for planting, and seedlings were planted on 2020/11/1 on ridge with a width of 60 cm and a height of 25 cm, and the distance between one plant and another is 30 cm. Seedlings are sprayed with chelated calcium (Ca-EDTA), which contains 14% calcium as a source of calcium, and boric acid (H\(_3\)BO\(_3\)) containing 17% boron as a source of the element boron, and the growth regulator benzyl adenine (6 – benzyl amino purine) after dissolving it with a little ethyl alcohol at a rate of three sprays and a difference of one month between the spray and the second during the growing season, where the first spray was on 2020/12/1, the second spray was a month after the first spray date, and the third spray was a month after the second spray. The spray was carried out until complete wetness and Tween-20 was used at a concentration of 0.1 mL L\(^{-1}\) as a diffuser to reduce surface tension. The experiment was carried out according to the RCBD design, with three replications, at a rate of 8 seedlings per one experimental unit. Thus, the number of seedlings per replicate was 96 seedlings and the number of seedlings of the total experiment was 288 seedlings. 5 random plants were taught from each experimental unit for the purpose of taking readings on them. The data were statistically analyzed according to the analysis of variance using the SAS system for the analysis of statistical experiments (SAS 2001, V 9.0) and the means were compared using Duncan’s polynomial test under the probability level of 0.05 [23]. The following traits were studied at the end of the experiment: Average number of flowers. plant\(^{-1}\), Average number of fruits. Plant\(^{-1}\), set percentage %, Average length and diameter of fruit (mm), Average fruit size (cm\(^3\)), Average fruit weight (g), Average yield per plant (g), Yield per area (ton. hectare\(^{-1}\)).
3. Results and Discussion

3.1. Effect of calcium and boron

The results shown in Table (1) the spray with calcium and boron significantly affected the increase average number of flowers, fruits and set percentage and Average length and diameter of fruit for strawberry plant where the transaction A3 significantly outperformed the rest of the transactions by an increase of (16.27, 24.32, 6.32, 5.43)\% respectively, compared with the comparative treatment. Whereas, spraying with calcium at a concentration of 100 mg.L\(^{-1}\) treatment (A2) significantly outperformed the rest of the treatments with respect to (average length and diameter of fruit, average fruit size and weight, average yield per plant, yield per area) an increase of (3.25, 14.57, 5.76, 25.99, 25.86)\% respectively, compared with the comparative treatment.

The reason for this is due to the role of calcium and boron in building cell walls in addition to their entry into the synthesis of cellular membranes and controlling their permeability [7], as calcium is a necessary element for the processes of growth and cell division and plays a key role in the permeability of the plasma membranes, which is directly reflected in the growth of the plant and the number of flowers, which leads to an increase in set percentage and the number of fruits, and thus an increase in the yield per area [6]. Boron also has a role in the fertilization process because it is necessary in the production of pollen, seed formation and pollen tube growth [11], these results are consistent with the findings of [8-10] .

Table 1. Effect of spraying with calcium and boron on the quantity and quality of yield for strawberry plants (Fragaria ananassa Duch) CV. Rubygem.

| Characteristics | Concentrations Calcium & boron | Average number of flowers/plant\(^1\) | Average number of fruits/plant\(^2\) | Set percentage \%(\()) | Average length fruit (mm) | Average diameter fruit (mm) |
|-----------------|---------------------------------|---------------------------------------|-------------------------------------|------------------------|---------------------------|---------------------------|
|                 | \(A_0\) 13.03 d                  | 11.35 d                               | 87.12 c                             | 38.14 d                | 28.72 d                   |
|                 | \(A_1\) 14.78 b                  | 12.98 b                               | 87.86 b                             | 38.39 c                | 29.41 c                   |
|                 | \(A_2\) 13.64 c                  | 11.86 c                               | 86.76 d                             | 39.38 a                | 30.05 b                   |
|                 | \(A_3\) 15.15 a                  | 14.11 a                               | 92.63 c                             | 38.77 b                | 30.28 a                   |

Means not sharing the same letter (s) within each column for each area significantly different at 0.05 level of probability.

3.2. Effect of benzyl adenine

The results in Table (2) show that spraying strawberry plants with the growth regulator benzyl adenine led to a significant and clear increase in the quantity and quality of the strawberry yield, where spraying with a concentration of 60 mg.L\(^{-1}\) treatment \((B_2)\) was significantly superior to all treatments in all studied traits of where the average number of flowers and total fruits and set percentage and average length, diameter and size of fruit and average fruit weight and average yield per plant and yield per area by an increase over the comparison comparative treatment to (40.72, 41.83, 1.07, 7.09, 4.26, 16.84, 20.22, 23.81, 23.03)% respectively to all attributes. The reason for this is that benzyl adenine treatment may stimulate the synthesis of nucleic acids and proteins and help transport nutrients and hormones, including auxins, to the treated area [24]. In addition to the role of cytokinin in stimulating division, cell elongation, growth of lateral buds, and breaking dormancy of buds, it is one of the main determinants of fruit growth and reaching the final size, as the addition of synthetic cytokinins increases the effectiveness of cytokinin-like compounds in plant tissues, which stimulates the growth of fruits in some plants [18,20]. These results are in consistent with [19-22].
Table 2. Effect of spraying with benzyl adenine on the quantity and quality of yield for strawberry plants (*Fragaria ananassa* Duch) CV. Rubygem.

| Characteristics | Concentrations benzyl adenine | Average number of flowers.plant⁻¹ | Average number of fruits.Plant⁻¹ | Set percentage % | Average length fruit (mm) | Average diameter fruit (mm) |
|----------------|-------------------------------|----------------------------------|----------------------------------|------------------|--------------------------|----------------------------|
|                 | B₀                            | 11.59 c                          | 10.40 c                          | 89.24 b          | 36.92 c                  | 28.84 c                    |
|                 | B₁                            | 14.55 b                          | 12.57 b                          | 86.33 c          | 39.33 b                  | 29.93 b                    |
|                 | B₂                            | 16.31 a                          | 14.75 a                          | 90.20 a          | 39.75 a                  | 30.07 a                    |

| Characteristics | Concentrations benzyl adenine | Average fruit size (cm³) | Average fruit weight (g) | Average yield per plant (g) | Yield per area (ton.ha⁻¹) |
|----------------|-------------------------------|-------------------------|-------------------------|-----------------------------|---------------------------|
|                 | B₀                            | 10.69 c                 | 9.79 c                  | 159.89 c                    | 1.78 c                    |
|                 | B₁                            | 11.38 b                 | 10.54 b                 | 174.01 b                    | 1.93 b                    |
|                 | B₂                            | 12.49 a                 | 11.77 a                 | 197.96 a                    | 2.19 a                    |

Means not sharing the same letter (s) within each column for each area significantly different at 0.05 level of probability.

3.3. Influence of interference

Shows the results shown in Table (3) the interference by spraying between levels of calcium, boron, and growth regulator benzyl adenine in the treatment of A₁B₂ led to a significant increase in (average number of fruits, set percentage, average fruit size, average yield per plant and yield per area) which amounted to (16.29 fruits.plant⁻¹, 95.19%, 14.25 cm³, 218.89 g, 2.43 ton.ha⁻¹) respectively, compared with the rest of the treatments, whereas, the interference treatment A₁B₁ with respect to the average length and average fruit weight, was significantly superior to the rest of the treatments, as it reached (41.32 mm, 12.62 g) respectively, the interference treatment A₁B₁ significantly superior the rest of the coefficients for the average number of total flowers, which reached 17.78 flowers.plant⁻¹, as for the average fruit diameter, treatment A₁B₁ significantly superior the rest of the treatments, reaching 31.62 mm.

Table 3. Effect spraying interference of with calcium, boron and benzyl adenine on the quantity and quality of yield for strawberry plants (*Fragaria ananassa* Duch) CV. Rubygem.

| Characteristics | Treatments | Average number of flowers.plant⁻¹ | Average number of fruits.Plant⁻¹ | Set percentage % | Average length fruit (mm) | Average diameter fruit (mm) |
|----------------|------------|----------------------------------|----------------------------------|------------------|--------------------------|----------------------------|
|                 | A₀         | B₀                               | 10.32 l                          | 9.10 l           | 87.53 h                  | 35.81 k                    |
|                 | A₀         | B₁                               | 14.87 f                          | 13.34 e          | 89.74 f                  | 38.68 g                    |
|                 | A₀         | B₂                               | 13.89 g                          | 11.61 h          | 84.08 i                  | 39.92 c                    |
|                 | A₁         | B₀                               | 10.63 k                          | 9.45 k           | 88.72 g                  | 36.58 j                    |
|                 | A₁         | B₁                               | 15.93 d                          | 13.23 f          | 83.32 j                  | 39.59 d                    |
|                 | A₁         | B₂                               | 17.78 a                          | 16.25 b          | 91.53 c                  | 38.98 e                    |
|                 | A₂         | B₀                               | 12.27 i                          | 11.02 i          | 89.75 f                  | 37.81 h                    |
|                 | A₂         | B₁                               | 12.13 j                          | 9.72 j           | 80.54 k                  | 39.03 e                    |
|                 | A₂         | B₂                               | 16.52 c                          | 14.84 c          | 90.00 e                  | 41.32 a                    |
|                 | A₃         | B₀                               | 13.17 h                          | 12.03 g          | 90.96 d                  | 37.49 i                    |
|                 | A₃         | B₁                               | 15.25 e                          | 14.00 d          | 91.73 b                  | 40.04 b                    |
|                 | A₃         | B₂                               | 17.04 b                          | 16.29 a          | 95.19 a                  | 38.79 f                    |

| Characteristics | Treatments | Average fruit size (cm³) | Average fruit weight (g) | Average yield per plant (g) | Yield per area (ton.hea⁻¹) |
|----------------|------------|-------------------------|-------------------------|-----------------------------|---------------------------|
|                 | A₀         | B₀                      | 10.75 i                 | 8.47 i                      | 104.54 l                  | 1.16 l                     |
|                 | A₀         | B₁                      | 10.32 k                 | 10.89 e                     | 157.44 j                  | 1.75 j                     |
Means not sharing the same letter(s) within each column for each area significantly different at 0.05 level of probability.

### Conclusion

It was concluded from this study that spraying strawberry plants CV. Rubygem with calcium at a concentration of 100 mg.L\(^{-1}\) and a combination between calcium and boron at a concentration (100 calcium + 20 boron) mg.L\(^{-1}\) and the growth regulator benzyl adenine at a concentration of 60 mg.L\(^{-1}\) led to improvement in the quantitative and qualitative characteristics of the yield of plants individually or overlapping with each other significantly.

### References

[1] Hassan, Ahmed Abd al manaem (2002). Strawberry production. Arab Publishing and Distribution House, Faculty of Agriculture, Cairo University.

[2] Zhao, Y. (2007). Berry Fruit. Printed in the United State of America on acide free Paper.

[3] Al-Sheikha, Abdul Rahman Mohammed Rashidi (2002). Fruit production theoretical part. Directorate of University Books and Publications-University of Aleppo, College of Agriculture.

[4] USDA.(2006).National Nutrient database for standard http://www.us.gov.

[5] Tomala, K. and A. Soska. (2004). Effects of calcium and/or phosphorus sprays with different preparations on preparation quality and storability of Sampin apples. Hor. Sci. 34, 12.

[6] Palta, J. P. (2010). Improving potato tuber quality and production by targeted calcium nutrition: the discovery of tuber roots leading to a new concept in potato nutrition. Potato research, 53(4), 267-275.

[7] Cakmak, I. (2014). Major functions of calcium and magnesium in crop plants. In: De Melo Benites V, editor. 16th World fertilizer congress of CIEC, Rio de Janeiro: CIEC, pp. 30–32.

[8] Singh, R., R.R. Sharma and S.K. Tyagi (2007). Pre-harvest foliar application of calcium and boron influences physiological disorders, fruit yield and quality of strawberry (Fragaria xananassa Duch.). Scientia horticulturae 112: 215-220.

[9] Azeec, D.R., R.A. Medan and S. A. Hussein (2017). Effect of foliar application of chelated calcium and boron on growth and yield of strawberry (Fragaria xananassa Duch.) CV. Festival. Kirkuk University Journal of Agricultural Sciences, folder extension(8):77-86.

[10] Medan, Raad Ahmed (2010). Effect of Foliar Application of Potassium and Calcium on Vegetative Growth, Yield and Fruit Quality of "ROYAL" Apricot Trees. Plant Cell Biotechnology and Molecular Biology 21(33&34):106-112.

[11] Abu Dahl, Y. M. and M.A. Al Younis. (1988). Guide to Plant Nutrition. Ministry of Higher Education and Scientific Research. Baghdad University.

[12] Hussein, S.A., J.M. Al-Ishaqui and O.I.Al-Zaidi Bagy (2016). Effect of Foliar Spray by Boron and Growth Regulator NAA on Some Active Materials in The Two Cultivars of Olives Seedlings (Olea europaeu L.). Tikrit University Journal of Agricultural Sciences, 2(16):106-115.

[13] Abdul Hafiz, Ahmed Abu Al-Yazid (2005). Modern techniques in fertilizing horticultural crops. The scientific office of the United Company for Agricultural Development(UAD), Cairo, Egyptian Arabic Republic.

[14] Taiz L. and Zeiger E. (2010). Plant physiology.5th ed. Sin Auer Associates Inc. Publisher Sunderland, Massachus - AHS. U.S.A.

[15] Lateef, Mohammed Abdul Aziz (2014). The effect of spraying with humic and boron on the growth and yield of two varieties of strawberry (Fragaria x ananassa Duch.). Master Thesis, College of Agriculture, University of Kirkuk.

[16] AL- Karawi, H. N. R. F. A. Salman, and A. J. J. Al-Mosawi, (2018). Effect of spraying with dry yeast (Saccharomyces cerevisiae) and boron on the growth and production of the strawberries plant cultivated under the conditions of protected agriculture. Euphrates Journal of Agriculture Science-01 (3): 60 – 68.

[17] Hanza OM and AL-Taei DKA.2020. A study on the effect of glutamic acid and benzyl adenine application up on growth and yield parameters and active components of two Broccoli hybrids. Int. J. Agricult. Stat. Sci., 16, Supplement 1: 1163-1167. DocID: https://connectjournals.com/03899.2020.16.1163.

[18] AL-Taei DKA and Majid ZZ. 2018. Study Effect of Kinetin, Bio-fertilizers and Organic Matter Application in Lettuce under Salt Stress. Journal of Global Pharma Technology,10(1):148-164

[19] Al-Taei DKA, Mijwel AK, and Al-Azaway SS. , 2018. Study efficiency of poultry litter and kinetin in reduced effects of saline water in Vicia faba. Research J. Pharm. and Tech. 2018; 11(1): 294-300.
[20] AL-Taey DKA, Saadoon AHS and ALAzawi SSM. 2021. STUDY OF KINETIN TREATMENT ON GROWTH AND ACTIVITY OF SOME ANTIOXIDANT ENZYMES OF SPINACH UNDER SALT STRESS. Current Trends in Natural Sciences, 10(19), 457-465. https://doi.org/10.47068/ctns.2021.v10i19.061

[21] Shakir, A.A., Salman, E.F., Shakir, A.J., Mohammed, M.A., Abdulridha, W.M., Almayahi, B.A. (2019). Optical properties of polyvinyl alcohol membrane with n-HAp for bio-medical applications, Prensa Medica Argentina, 105 (11), pp. 836-841.

[22] Al-Hamdani, K.A.S. and M.N.H. Al-Jubouri (2014). Effect of Benzyladenine, Urea, Iron, Boron and Nu film-17 Antitranspiration Spraying on Fruit Set, Dropping and Some Growth Characteristics of Vegetative in Orange (Citrus sinensis). Tikrit University Journal of Agricultural Sciences - a special issue of the proceedings of the third specialized conference-plant production:28-35.

[23] Roger Mead, R.N.C. and A.M. Hasted (2003). Statistical Methods in Agriculture and Experimental Biology Champan. 3ed Edi: Hall, CRC, A CRC Press Co., Washington, D. C.

[24] Wilkins, M. B. (1979). The physiology of plant growth and development. Mc Graw – Hill, London, p. 695.