

Effect of calcium chelate and carbonic powder on growth, yield and quality of Strawberry (*Fragaria x ananassa* Duch.)cv. Winter Dawn

Abstract

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The present investigation was carried out during 2023-24 at Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh to study the effect of calcium chelate and carbonic powder on growth, yield and quality of Strawberry (*Fragaria x ananassa* Duch.) cv. Winter Dawn under agro-climatic conditions of Prayagraj. The experiment was laid out in RBD, replicated 3 times with 16 treatments with different combinations i.e., T0: Control (RDF), T1: Calcium chelate (1g/L)+RDF (19:19:19), T2: Calcium chelate (3g/L)+RDF(19:19:19), T3: Calcium chelate (5g/L)+RDF(19:19:19), T4: Carbonic powder (1g/L)+RDF(19:19:19), T5: Carbonic powder (3g/L)+RDF(19:19:19), T6: Carbonic powder (5g/L)+RDF(19:19:19), T7: Calcium chelate (1g/L)+Carbonic powder (1g/L)+RDF(19:19:19), T8: Calcium chelate (1g/L)+Carbonic powder (3g/L)+RDF(19:19:19), T9: Calcium chelate (1g/L)+Carbonic powder (5g/L)+RDF(19:19:19), T10: Calcium chelate (3g/L)+Carbonic powder (1g/L)+RDF(19:19:19), T11: Calcium chelate (3g/L)+Carbonic powder (3g/L)+RDF(19:19:19), T12: Calcium chelate (3g/L)+Carbonic powder (5g/L)+RDF(19:19:19), T13: Calcium chelate (5g/L)+Carbonic powder (1g/L)+RDF(19:19:19), T14: Calcium chelate (5g/L)+Carbonic powder (3g/L)+RDF(19:19:19), T15: Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19). Among different treatments, T₁₅ performed best in terms of growth, yield, and quality parameters of strawberry.

Comment [IA2]: This complete treatment should be provided in Material and methods section

INTRODUCTION

Strawberry (*Fragaria X ananassa* Duch.) belongs to the Rosaceae family. Strawberry is considered one of the early fruits in production, because it appears in the markets in the spring, and its fruits have a distinctive taste and aroma, and their nutritional value is high (Al-Saidi, 2000). It is believed that the original habitat of the Strawberry is the temperate regions in the northern hemisphere (Europe and North America), as the strawberry was found growing wild in those areas (Hassan, 2002). Strawberry cultivation is widespread in some Arab countries, Japan, and some Mediterranean countries, and the United States of America ranks first in production, Spain ranks second, and Morocco ranks third in terms of production sequence (Franco, 2009). Calcium is one of the important elements that affect the quality of the fruits. Increasing the calcium content of the fruits is of great importance in delaying ripening and ripening in the fruits (Tomala and Fallahi 1997, et al. 1997). Calcium is very important in prolonging the storage life of fruits, and its concentration increases at the

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beginning of the growth and development of fruits, as it supports the cell wall, reduces the respiration processes that occur in fruit cells, delays the ripening process of fruits, increases their hardness and their content of vitamins, and reduces the possibility of biological injury when storing and handling. It tolerates transport and reduces fruit loss (Al-Shammari, 2016). Favaro et al. (2007) reported that the calcium ions (Ca) play an important role in many biochemical processes, i.e., delaying senescence and controlling physiological disorders in fruits and vegetables. Asfanani et al., (2008) indicated that the calcium chelate and inhibitor of calcium channels inhibited flower bending caused by heaviness in some flower stems. Abou El-Yazied (2011) indicated that the foliar application of 250 or 500 ppm chelated calcium increased leaf number and leaf area in the two tested seasons compared to the control treatment. On the other hand, Chauhadry et al., (2012) studied the effect of different concentration of calcium chloride (0.1, 0.2, 0.3, 0.4 and 0.5 m), showed that the highest fruit set was obtained with 0.5m calcium chloride with maximum number of compound leaves per plant and fruit weight per plant. . In another study conducted by **AbdEl-Gawad et al., (2013)** showed that **then** addition of 750 ppm of chelate calcium mixed with ammonium nitrate increase numbers of leaves, leaf area, dry matter and the chlorophyll index compared to the control treatment. Iron is an essential element for plants but due to its low solubility, iron availability to plants is very low specially in arid regions(**Eskandari, 2011**).According to **Beiparsya et al., (2023)**, application of calcium chloride and carbon dioxide successfully inhibited fungal growth, maintained firmness, minimized weight loss, and extended the shelf life compared to the control group. These findings have significant implications for the apple industry, as they provide a means to improve fruit quality and increase the shelf life in fruits.

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MATERIALS AND METHODS

A Field experiment was carried out at the Department of Horticulture, SHUATS, Prayagraj, U.P. in the months of October 2023 to February, 2024. The experiment was conducted on strawberry cv. Witner dawn in Randomized Block Design with three replications using 16 treatment combinations. Treatment combinations are mentioned below:

Comment [IA7]: please provide a more adequate information to ensure that this method is reproduceable, e.g. when the seed was sown, transplanted and when the treatment was applied, etc.

T0: Control (RDF), T1: Calcium chelate (1g/L)+RDF (19:19:19), T2: Calcium chelate (3g/L)+RDF(19:19:19), T3: Calcium chelate (5g/L)+RDF(19:19:19), T4: Carbonic powder (1g/L)+RDF(19:19:19), T5: Carbonic powder (3g/L)+RDF(19:19:19), T6: Carbonic powder (5g/L)+RDF(19:19:19), T7: Calcium chelate (1g/L)+Carbonic powder (1g/L)+RDF(19:19:19), T8: Calcium chelate (1g/L)+Carbonic powder (3g/L)+RDF(19:19:19), T9: Calcium chelate (1g/L)+Carbonic powder (5g/L)+RDF(19:19:19), T10: Calcium chelate (3g/L)+Carbonic powder (1g/L)+RDF(19:19:19), T11: Calcium chelate (3g/L)+Carbonic powder (3g/L)+RDF(19:19:19), T12: Calcium chelate (3g/L)+Carbonic powder (5g/L)+RDF(19:19:19), T13: Calcium chelate (5g/L)+Carbonic powder (1g/L)+RDF(19:19:19), T14: Calcium chelate (5g/L)+Carbonic powder (3g/L)+RDF(19:19:19), T15: Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19).

STATISTICAL ANALYSIS

Data were subjected to analysis of variance (ANOVA) using OPISTAT Software version 9.3.

RESULTS AND DISCUSSION

The maximum plant height (cm) (33.74) was recorded in T15: Calcium chelate (5g/L) + Carbonic powder (5g/L) + RDF (19:19:19). Whereas the minimum plant height (cm) (20.39) was found recorded in T₀ Control. In this trial maximum plant height is seen in the T₁₅ treatment, this might be due to calcium, it plays a vital role for cell wall structure and strength in plants, including strawberries. Calcium chelate is a form of calcium that is more easily absorbed by plants. Adequate calcium levels can promote stronger stems and overall plant vigor, potentially leading to increased plant height. Carbonic powder, or calcium carbonate, can influence plant growth by adjusting soil pH. It can raise the pH of acidic soils, making essential nutrients more available to plants. However, excessive amounts can lead to alkaline conditions, which may affect nutrient uptake negatively. It may indirectly affect plant height by improving overall plant health and nutrient availability. Similar results were also found by **Abdulhadiet al., (2022)**.

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The maximum plant spread (cm) (41.18) was recorded in T15: Calcium chelate (5g/L) +Carbonic powder (5g/L) +RDF (19:19:19). Whereas the minimum plant spread (cm) (26.95) was found recorded in T₀Control. In this trail treatment T16 shows the best result with respect to plant spread ,this is due to Calcium is essential for plant growth and development. Chelated forms of calcium can improve nutrient uptake, strengthen cell walls, and promote overall plant health. In strawberries, adequate calcium levels can lead to stronger stems, healthier roots, and improved fruit quality. This can indirectly support better spread as healthier plants are more vigorous and can produce more runners, allowing for better coverage and spread. Carbonic powder, often derived from sources like crushed limestone or dolomite, can help to adjust soil pH. It provides calcium and magnesium to the soil, which are essential nutrients for plant growth. By maintaining proper pH levels, carbonic powder can enhance nutrient availability to plants, improve soil structure, and encourage microbial activity, all of which contribute to healthier strawberry plants. Healthier plants Aare more likely to spread vigorously through runners, leading to increased plant coverage. Similar results were also found by **Naïem *et al.*, (2019)**.

The maximum Petiole length (cm) (14.96) was recorded in T15: Calcium chelate (5g/L) +Carbonic powder (5g/L) +RDF (19:19:19). Whereas the minimum Petiole length (cm) (9.44) was found in T₀Control respectively. The minimum days to first flowering (40.18) was found in treatment T15: Calcium chelate (5g/L) +Carbonic powder (5g/L) +RDF (19:19:19) and maximum days to first flowering (53.37) was found in treatment T₀ Control. In this experiment, maximum petiole length is seen in T16 treatment is due to Calcium chelate can improve calcium availability to the plant, resulting in stronger cell walls and potentially shorter petioles. Shorter petioles often indicate sturdier plants with better support for leaves and fruit, as they are less likely to bend or break under their weight. Carbonic powder, by adjusting soil pH and providing essential nutrients like calcium and magnesium, can contribute to overall plant health and vigor. This can indirectly affect petiole length by supporting robust growth and development. Additionally, proper soil pH can optimize nutrient uptake, which may lead to balanced growth and, potentially, shorter petioles. Similar results were found by **Naïem *et al.*, (2019)**, **Kumar *et al.*, (2017)**.

The minimum days to first fruiting (48.57) was found in treatment T15: Calcium chelate (5g/L) +Carbonic powder (5g/L) +RDF(19:19:19) and maximum days to first fruiting (61.31) was found in treatment T₀ Control. In this trial maximum fruitsetis seen in the T₁₆ this might be due to adequate calcium levels are crucial for proper fruit development and can help

prevent disorders such as blossom end rot. Calcium chelate provides a readily available form of calcium to the plant, which promotes strong cell wall formation in flowers and fruits. This can lead to improved pollination and fruit set, especially during the critical period of first fruit development. Carbonic powder, which likely contains carbonates or other carbon-containing compounds, can help improve soil structure and microbial activity. Healthy soil microbial populations support nutrient availability and uptake, which is essential for fruit set. Additionally, carbonic powder can aid in maintaining proper soil pH, creating optimal conditions for nutrient absorption and utilization by the plants. This can contribute to healthier plants with improved flowering and fruiting, including during the first fruit set in strawberries. Same results were observed by **Eman *et al.*, (2020)**

The maximum number of flower per plant (20.62) was found in treatment T15: Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19) and minimum number of flowers per plant (10.77) was found in treatment T0 Control. In this trial maximum flower per plant is seen in the T₁₆ this might be due to calcium is essential for cell division and growth, including in flower development. Adequate calcium levels can promote the formation of healthy flower buds, which may lead to an increased number of flowers per plant. Calcium chelate provides a readily available source of calcium, ensuring that the plant has access to this vital nutrient during critical growth stages. This can result in more robust flower production and potentially higher yields. Carbonic powder, by improving soil structure and fertility, can indirectly affect the number of flowers per plant. Healthy soil conditions supported by carbonic powder promote strong root development and nutrient uptake, which are essential for optimal flower formation. These factors combined can contribute to increased flower production and a higher number of flowers per plant. Same results was observed by **Kumar *et al.*, (2017)**.

The maximum Number of fruit per plant (16.30) was found in treatment T15: Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19). Whereas the minimum Number of fruit per plant (7.34) was found in treatment T0 Control. In this trial maximum fruits per plant is seen in the T₁₆ this might be due to adequate calcium levels are crucial for fruit development, as calcium plays a significant role in cell division and structure. Calcium chelate provides a readily available source of calcium to the plant, ensuring that it has what it needs during critical growth stages. This can lead to stronger fruit set and development, potentially resulting in a higher number of fruits per plant. Carbonic Powder: Carbonic powder can improve soil structure, microbial activity, and nutrient availability. Healthy soil conditions supported by carbonic powder promote strong root development and nutrient

uptake, which are essential for optimal fruit formation. Additionally, carbonic powder can enhance soil pH, creating favorable conditions for nutrient absorption and utilization by the plants. These factors combined can contribute to increased fruit production and a higher number of fruits per plant. Same results observed by **Kumar et al., (2017)**.

The maximum Fruit weight (gm) (40.78) was found in treatment T15: Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19) where as the minimum Fruit weight (gm) (40.78) was found in treatment T0 Control. In this trial maximum fruit weight is seen in the T₁₆ this might be due to adequate calcium levels are crucial for proper fruit development and cell wall formation. Calcium chelate provides a readily available source of calcium to the plant, ensuring that it has sufficient amounts during critical growth stages. This can result in stronger, thicker cell walls in the fruits, leading to increased fruit weight. Additionally, proper calcium levels can help prevent disorders like blossom end rot, which can affect fruit development and weight negatively. Carbonic powder improves soil health and fertility, which indirectly influences fruit weight. It promotes better root development, nutrient uptake, and microbial activity in the soil. These factors contribute to healthier plants with improved nutrient availability, which can lead to larger and heavier fruits. Additionally, carbonic powder can help maintain optimal soil pH, which is essential for nutrient absorption and utilization, further enhancing fruit weight. Same results was observed by **Arabloo et al., (2017)**.

The maximum Fruit per plant (g) (664.77) was found in treatment T15: Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19). Where as the minimum Fruit per plant (g) (196.47) was found in treatment T0 Control. In this trial maximum fruit per plant is seen in the T₁₆ this might be due to adequate calcium levels are crucial for fruit development and can impact the number of fruits per plant. Calcium chelate provides a readily available source of calcium to the plant, promoting proper cell division and fruit development. This can lead to increased fruit set and a higher number of fruits per plant. Carbonic powder improves soil health and fertility, indirectly affecting fruit production. By enhancing soil structure, microbial activity, and nutrient availability, carbonic powder supports overall plant health and vigor. Healthy plants are more likely to produce a higher number of flowers, leading to increased fruit set and ultimately more fruits per plant. Same results was observed by **Kumar et al., (2017)**.

The maximum fruit per plot (kg) (2.66) was found in treatment T15: Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19). Where as the minimum fruit per plot (kg) (0.79) was found in treatment T0 Control.

The maximum Fruit yield $t\ ha^{-1}$ (26.59) was found in treatment T15: Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19). Where as the minimum Fruit yield $t\ ha^{-1}$ (7.86) was found in treatment T0 Control. In this trial maximum fruit yield is seen in the T₁₆ this might be due to calcium is essential for fruit development, as it helps strengthen cell walls and prevent disorders like blossom end rot. Calcium chelate provides a readily available source of calcium, ensuring that the plants have what they need for optimal fruit development. By preventing calcium deficiencies and related issues, calcium chelate can contribute to higher fruit yield. Carbonic powder, such as calcium carbonate, influences soil pH. It can raise pH levels in acidic soils, making essential nutrients more available to plants. This can indirectly promote fruit yield by improving overall plant health and nutrient uptake. However, excessive use of carbonic powder can lead to alkaline conditions, which may negatively affect nutrient availability and, consequently, fruit yield. Same results was found by **Naiem *et al.*, (2019)**.

The maximum Fruit length (cm) (4.12) was found in treatment T15: Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19). Where as the minimum Fruit length (cm) (1.77) was found in treatment T0 Control. In this trial maximum fruit length is seen in the T₁₆ this might be due to calcium is essential for cell wall development and structural integrity in plants, including strawberries. Adequate calcium levels, provided through calcium chelate, can promote stronger cell walls, which may result in longer fruit. Additionally, calcium helps prevent disorders like fruit cracking, which can indirectly contribute to longer, healthier fruit. Carbonic powder, such as calcium carbonate, affects soil pH. It can raise pH levels in acidic soils, making essential nutrients more available to plants. While carbonic powder itself may not directly influence fruit length, the improved nutrient availability resulting from balanced soil pH can lead to healthier plants with potentially longer fruits. Same results was observed by **Kumar *et al.*, (2017)**.

The maximum Fruit width (cm) (3.76) was found in treatment T15: Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19). Where as the minimum Fruit width (cm) (1.56) was found in treatment T0 Control. In this trial maximum fruit width is seen in the T₁₆ this might be due to Calcium is essential for plant cell wall development and structure.

Calcium chelate is a form of calcium that is more readily absorbed by plants. When applied to strawberries, it can help in strengthening the cell walls, which potentially results in larger and firmer fruits. Carbonic powder, which could be a form of powdered carbonate like calcium carbonate or similar, is often used to adjust soil pH. Strawberries prefer slightly acidic to neutral soil (pH 5.5 to 6.5), and maintaining this pH can optimize nutrient availability, thus potentially enhancing fruit size and quality. Same results was observed by **Kumar *et al.*, (2017)**.

The maximum TSS ⁰Brix (10.45) was found in treatment T15: Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19). Where as the minimum TSS ⁰Brix (7.31) was found in treatment T0 Control. In this trial maximum TSS is seen in the T₁₆ this might be due to calcium is essential for cell wall stability and fruit firmness in strawberries. Calcium chelate can help improve calcium uptake by the plant, leading to firmer fruit with higher TSS. Adequate calcium levels can also reduce disorders like blossom-end rot, which can negatively affect TSS. Carbonic powder typically refers to a form of calcium carbonate, which can act as a pH buffer in the soil. Proper soil pH is crucial for nutrient uptake by the plants, including calcium. By maintaining optimal pH levels, carbonic powder can indirectly influence TSS by ensuring the availability of essential nutrients. Same results was observed by **Arabloo *et al.*, (2017)**.

The maximum Acidity (%) (1.02) was found in treatment T15: Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19). Where as the minimum Acidity (%) (0.59) was found in treatment T0 Control. In this trial maximum acidity is seen in the T₁₆ this might be due to calcium chelate enhances the uptake of calcium by the plant. Calcium itself doesn't directly alter the acidity (pH) of the fruit but can influence how other nutrients are absorbed. For instance, an adequate calcium level can help maintain a balanced uptake of potassium and magnesium, which are involved in the synthesis of organic acids and overall plant health. Carbonic powder" we mean a carbonate compound (like calcium carbonate), its primary effect on soil is to raise the pH, making the soil less acidic. This adjustment can influence the availability of micronutrients such as iron, manganese, and zinc, which are more soluble in acidic conditions. Higher soil pH can lead to decreased availability of these nutrients, potentially affecting fruit acidity. For strawberries, which thrive in slightly acidic soils, too much carbonate might lead to nutrient imbalances that could alter fruit taste and acidity. The increased soil pH from carbonic powder could reduce the solubility and

uptake of certain nutrients that are critical for the production of organic acids, potentially leading to fruits with lower acidity. Same results was observed by **Arabloo et al., (2017)**.

The maximum Ascorbic acid (mg/100g) (58.47) was found in treatment T15: Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19). Where as the minimum Ascorbic acid (mg/100g) (50.63) was found in treatment T0 Control. In this trial maximum ascorbic acid is seen in the T₁₆ this might be due to adequate calcium levels in the plant can enhance its overall health and metabolism. This may result in increased production of ascorbic acid, as vitamin C synthesis is influenced by various metabolic pathways. Additionally, calcium can help regulate enzyme activity involved in ascorbic acid synthesis, potentially leading to higher levels of vitamin C in strawberries. Carbonic powder, particularly if it contains calcium carbonate, can help maintain proper soil pH. An optimal pH level is essential for nutrient uptake, including the uptake of micronutrients involved in vitamin C synthesis. By ensuring the availability of these nutrients, carbonic powder can indirectly contribute to higher levels of ascorbic acid in strawberries. Same results is observed by **Basit et al., (2023)**.

The maximum Specific gravity (1.45) was found in treatment T15: Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19). Where as the minimum Specific gravity (1.02) was found in treatment T0 Control. In this trial maximum specific gravity is seen in the T₁₆ this might be due to calcium is essential for cell wall formation and fruit firmness. Adequate calcium levels, facilitated by calcium chelate, can promote firmer fruit with higher specific gravity. This is because calcium strengthens cell walls, reducing water loss and maintaining fruit integrity, which contributes to higher density and specific gravity. Carbonic powder, especially if it contains calcium carbonate, can help maintain optimal soil pH. Proper pH levels are crucial for nutrient availability, including calcium, which is essential for fruit quality. By ensuring the availability of calcium and other nutrients, carbonic powder can indirectly influence specific gravity by promoting the development of denser, firmer fruit. Same results was observed by **Ansari et al.,(2020)**.

The maximum juice content (%) (94.58) was found in treatment T15: Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19). Where as the minimum juice content (%) (81.64) was found in treatment T0 Control. In this trial maximum juice content is seen in the T₁₆ this might be due to calcium is crucial for cell wall integrity and fruit firmness. Adequate calcium levels, facilitated by calcium chelate, can lead to firmer strawberries with less susceptibility to mechanical damage and water loss. As a result, strawberries treated with

calcium chelate may have higher juice content because their firmer texture helps retain more juice during handling and storage. Carbonic powder, especially if it contains calcium carbonate, can help maintain optimal soil pH, which is important for nutrient uptake by plants. Proper nutrient uptake, including calcium, can contribute to healthier plants and improved fruit quality. However, excessive calcium carbonate can lead to higher pH levels, potentially affecting fruit quality negatively. So, it's essential to apply it judiciously. Same results are found by *Arabloo et al., (2017)*, *Naiem et al., (2019)*, *Ansari et al., (2020)*.

The maximum pH (3.89) was found in treatment T0 Control and the minimum pH (3.17) was found in treatment T15: Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19). In this trial maximum pH is seen in the T₁₆ this might be due to calcium chelate primarily affects the pH of the soil rather than the fruit itself. However, by improving calcium availability to the plant, it can indirectly influence fruit pH. Calcium plays a role in cell wall formation and overall fruit quality. Adequate calcium levels can lead to firmer fruit, which may have a slightly lower pH due to reduced water uptake. This can result in slightly more acidic strawberries. Carbonic powder, such as calcium carbonate, directly affects soil pH. Calcium carbonate is a common pH buffer that can help raise soil pH, making it less acidic. However, excessive application of carbonic powder can lead to overly alkaline conditions, which may negatively impact plant health and fruit quality. Similar results were found by *Arabloo et al., (2017)*.

Application of calcium chelate enhances the cell structure, firmness, quality and yield of fruits. Application of carbonic powder increases the ability of soil to absorb essential nutrients and yield of the strawberry.

Table 1. List of Treatment Combinations for plant height, plant spread and fruit per plant

Symbols	Treatment Combination	Plant height (120DAT)	Plant spread 120 DAT	Number of flower per plant	Number of fruit per plant
T ₀	Control (RDF)	20.39	26.95	10.77	7.34
T ₁	Calcium chelate (1g/L)+RDF (19:19:19)	27.47	34.13	15.10	12.29
T ₂	Calcium chelate (3g/L)+RDF(19:19:19)	28.01	31.18	16.96	12.76
T ₃	Calcium chelate (5g/L)+RDF(19:19:19)	28.08	31.81	17.71	12.58

Comment [IA10]: Delete. Plant height....., days after the application of calcium chelate and carbonic powder.

T ₄	Carbonic powder (1g/L)+RDF(19:19:19)	29.96	36.58	16.31	11.32
T ₅	Carbonic powder (3g/L)+RDF(19:19:19)	29.13	32.15	15.37	11.65
T ₆	Carbonic powder (5g/L)+RDF(19:19:19)	27.87	34.47	15.62	11.96
T ₇	Calcium chelate (1g/L)+Carbonic powder (1g/L)+RDF(19:19:19)	28.02	31.66	14.69	12.04
T ₈	Calcium chelate (1g/L)+Carbonic powder (3g/L)+RDF(19:19:19)	31.72	36.96	14.87	12.10
T ₉	Calcium chelate (1g/L)+Carbonic powder (5g/L)+RDF(19:19:19)	29.91	32.68	17.15	12.68
T ₁₀	Calcium chelate (3g/L)+Carbonic powder 3(1g/L)+RDF(19:19:19)	28.46	33.83	16.13	13.62
T ₁₁	Calcium chelate (3g/L)+Carbonic powder (3g/L)+RDF(19:19:19)	31.04	37.53	16.20	12.77
T ₁₂	Calcium chelate (3g/L)+Carbonic powder (5g/L)+RDF(19:19:19)	31.26	37.30	15.00	11.93
T ₁₃	Calcium chelate (5g/L)+Carbonic powder (1g/L)+RDF(19:19:19)	31.74	37.92	18.63	15.75
T ₁₄	Calcium chelate (5g/L)+Carbonic powder (3g/L)+RDF(19:19:19)	31.97	39.10	19.11	16.01
T ₁₅	Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19)	33.74	41.18	20.62	16.30
	F-Test	S	S	S	S
	S.Ed.	0.963	0.743	1.487	0.574
	CD at 0.5%	1.966	1.517	3.037	1.172
	CV	4.024	2.621	5.191	5.536

Table 2. List of Treatment Combinations for TSS, pH, juice content and fruit yield

Comment [IA11]: Delete. TSS....(see revision for title in table 1)

UNDER PEER REVIEW

Symbols	Treatment Combination	TSS 0Brix	pH	Juice content (%)	Fruit weight (g)	Fruit yield t ha ⁻¹
T ₀	Control (RDF)	7.31	3.89	81.64	26.63	7.86
T ₁	Calcium chelate (1g/L)+RDF (19:19:19)	8.26	3.63	88.74	34.64	17.03
T ₂	Calcium chelate (3g/L)+RDF(19:19:19)	8.57	3.57	87.94	35.43	18.10
T ₃	Calcium chelate (5g/L)+RDF(19:19:19)	8.88	3.74	91.74	31.80	16.04
T ₄	Carbonic powder (1g/L)+RDF(19:19:19)	9.48	3.70	92.11	34.30	15.57
T ₅	Carbonic powder (3g/L)+RDF(19:19:19)	8.94	3.65	90.98	36.14	16.85
T ₆	Carbonic powder (5g/L)+RDF(19:19:19)	8.64	3.62	90.77	33.78	16.16
T ₇	Calcium chelate (1g/L)+Carbonic powder (1g/L)+RDF(19:19:19)	8.64	3.72	91.83	34.96	16.83
T ₈	Calcium chelate (1g/L)+Carbonic powder (3g/L)+RDF(19:19:19)	9.07	3.68	92.84	35.77	17.25
T ₉	Calcium chelate (1g/L)+Carbonic powder (5g/L)+RDF(19:19:19)	9.02	3.70	93.47	37.27	18.90
T ₁₀	Calcium chelate (3g/L)+Carbonic powder 3(1g/L)+RDF(19:19:19)	9.18	3.73	91.80	35.15	19.14
T ₁₁	Calcium chelate (3g/L)+Carbonic powder (3g/L)+RDF(19:19:19)	8.53	3.59	91.67	34.61	17.63
T ₁₂	Calcium chelate (3g/L)+Carbonic powder (5g/L)+RDF(19:19:19)	9.08	3.70	91.92	34.17	16.31
T ₁₃	Calcium chelate (5g/L)+Carbonic powder (1g/L)+RDF(19:19:19)	10.06	3.47	91.88	37.57	23.68
T ₁₄	Calcium chelate (5g/L)+Carbonic powder (3g/L)+RDF(19:19:19)	10.17	3.29	92.83	38.27	24.49
T ₁₅	Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19)	10.45	3.17	94.58	40.78	26.59
	F-Test	S	S	S	S	
	S.Ed.	0.172	0.064	1.147	1.487	
	CD at 0.5%	0.350	0.130	2.342	3.037	
	CV	2.330	2.152	1.542	5.191	

Table 3. List of Treatment Combinations for cost cultivation and net return

Comment [IA12]: Delete (see title revision for table 1.

Symbols	Treatment Combination	Total cost of cultivation	Gross return (Rs. ha-1)	Net return (Rs. ha-1)	B:C Ratio
T ₀	Control (RDF)	491514.1	943032.16	451518.03	0.92
T ₁	Calcium chelate (1g/L)+RDF (19:19:19)	494393.4	2043976.928	1549583.548	3.13
T ₂	Calcium chelate (3g/L)+RDF(19:19:19)	500151.9	2171858.4	1671706.52	3.34
T ₃	Calcium chelate (5g/L)+RDF(19:19:19)	505910.4	1924974.496	1419064.116	2.80
T ₄	Carbonic powder (1g/L)+RDF(19:19:19)	492103.2	1868053.6	1375950.42	2.80
T ₅	Carbonic powder (3g/L)+RDF(19:19:19)	493281.3	2022057.6	1528776.32	3.10
T ₆	Carbonic powder (5g/L)+RDF(19:19:19)	494459.4	1939775.68	1445316.3	2.92
T ₇	Calcium chelate (1g/L)+Carbonic powder (1g/L)+RDF(19:19:19)	494982.4	2019086.56	1524104.13	3.08
T ₈	Calcium chelate (1g/L)+Carbonic powder (3g/L)+RDF(19:19:19)	496160.5	2070002.4	1573841.87	3.17
T ₉	Calcium chelate (1g/L)+Carbonic powder (5g/L)+RDF(19:19:19)	497338.6	2268176	1770837.37	3.56
T ₁₀	Calcium chelate (3g/L)+Carbonic powder 3(1g/L)+RDF(19:19:19)	500740.9	2296454.4	1795713.47	3.59
T ₁₁	Calcium chelate (3g/L)+Carbonic powder (3g/L)+RDF(19:19:19)	501919	2115698.4	1613779.37	3.22
T ₁₂	Calcium chelate (3g/L)+Carbonic powder (5g/L)+RDF(19:19:19)	503097.1	1957580	1454482.87	2.89
T ₁₃	Calcium chelate (5g/L)+Carbonic powder (1g/L)+RDF(19:19:19)	506499.4	2841777.6	2335278.17	4.61
T ₁₄	Calcium chelate (5g/L)+Carbonic powder (3g/L)+RDF(19:19:19)	507677.5	2939160.64	2431483.11	4.79
T ₁₅	Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF(19:19:19)	508855.6	3190914.4	2682058.77	5.27

CONCLUSION

From the present investigation, it is concluded that treatment combination T15: Calcium chelate (5g/L)+Carbonic powder (5g/L)+RDF (19:19:19) is the best treatment for growth, yield and fruit quality viz, plant height (cm) (33.74), plant spread (cm) (41.18), number of leaves per plant (44.01) , petiole length (cm) (14.96) , days to first flowering (40.18) , days to first fruiting (48.57), number of flower per plant (20.62), number of fruit per plant (16.30), fruit weight (gm) (40.78),fruit per plant (g) (664.77) , fruit yield t ha⁻¹ (26.59) , TSS⁰brix (10.45), juice content (%) (94.58) and pH(3.17) of strawberry.

The highest benefit cost ratio was also found in the same treatment with 5.27.

REFERENCES

- Abd El-Gawad, H.G., S.E. Elminiawy and L.M. Gebrel. 2013. Effect of Different Nitrogen Sources and Chelated Calcium on Productivity and Quality of Common Bean Seeds. *Res. J. Agric. & Biol. Sci.*,**9**(5): 241-247.
- Abdulahadi, M. D., Saeed, A. K. A. J. M., & Haraz, M. T. (2022). Effect of chelated calcium and iron foliar spraying on growth and flowering of snapdragon (*Antirrhinum majus* L.).*International Journal of Health Sciences*,**6**(S3), 10329–10336.
- Abou El-Yazied, A., 2011. Foliar application of glycinebetaine and chelated Calcium improves seed production and quality of common bean (*Phaseolus vulgaris* L.) under water stress conditions. *Research Journal of Agriculture and Biological Sciences*, **7**(4): 357-370.
- Al-Saeedi, Ibrahim Hassan (2000). Small fruit production. The second part . Dar Al-Kutub for printing and publishing. University of Al Mosul. Iraq.
- Al-Shammari, Ghalib Nasser (2016). Care and storage of horticultural crops. The Republic of Iraq. Ministry of Higher Education and Scientific Research. Diyala University. faculty of Agriculture.
- Ansari Naiem, Sevan Das Khunte and Prasad, V.M. (2020). Effect of Bio fertilizers with Different Levels of N, P and K on physico-chemical Properties of Strawberry

Comment [IA13]: The references should be listed in the order that they appear in the text

(*Fragaria x ananassa* Duch.) cv. Chandler. *Int.J.Curr.Microbiol.App.Sci.* 9(01): 727-732.

Arabloo M., Taheri M., Yazdani H., Shahmoradi M. (2017). Effect of foliar application of amino acid and calcium chelate on some quality and quantity of golden delicious and granny smith apples. *Trakia Journal of Sciences*, No 1, pp 14-19, 2017

Asfanani, M., G.H. Davarynejad and A. Tehranifar, 2008. Effects of pre-harvest calcium fertilization on vase life of rose cut flowers cv. Alexander. *Acta Hort.*, 804: 217-221.

Basit Ali, Muhammad Babar, Riffat Nasim Fatima, Arshad Mahmood, Ali Sher, Tehmina Siddique, Muhammad Shoab Aslam, Sher Afzal, Muhammad Luqman, Khuram Shahzad, Talha Murad, Muhammad Shaiban, Muhammad Zahid Aslam, Shahab Ali (2023).Effect of Different Doses of NPK at Different Time Intervals on Growth, Yield and Quality of Strawberry CV. Chandler (*Fragaria ananassa*).*Journal of Survey in Fisheries Sciences*. Vol. 10 No. 2S (2023): Special Issue 2

Beiparsya A, Samir Topno, Annjoe V Joseph., (2023). Effect of calcium chloride(CaCl₂) and Carbon Dioxide(CO₂) on Post Harvest Quality of Apple Fruit (*Malus domestica*) cv. Gala. *Inetrnational Journal of Plant & Soil Science*. Vol 35i83283

Chauhadry, M.A., A.P. Muhammad, R.S. Muhammad, I.A. Muhammad, W.H. Muhammad, H. Shabbir and M. Nasir, 2012. Assessment of various growth and yield attributes of tomato in responseto pre-harvest applications of calcium chloride. *Pak. j. life soc. Sci.*, **10**(2): 102-105.

Eman S. El-Hady, Mohamed A. Merwad, Mohamed F. M. Shahin & Laila F. Hagagg (2020) Influence of foliar spray with some calcium sources on flowering, fruit set, yield and fruit quality of olive Kalmata and Manzanillo cultivars under salt stress. *Bulletin of the National Research Centre* volume 44, Article number: 197.

Favaro, S.P.B., J.A. Takahashi, H.W. Miglioranza and E. Ida, 2007. Rates of calcium, yield and quality of snap bean. *Scientia Agricola*, **64**(6): 616-620. (c.a. CAB Abstract.2007- 2008).

Franco , S , U.S. Agency for International development (USAID). (2009).The Production of Strawberries in Iraq P 1-10 .

Hassan, Ahmed Abdel Moneim (2002). Strawberry production. Faculty of Agriculture, Cairo

University. The Arab House for Publishing and Distribution. First Edition 2002.

Kumar Jayant Maurya, Jagendra Pratap Singh, Saurabh Tomar and Rajeev Kumar. 2017. Optimization of NPK Fertilizers for Higher Yield and Quality of Strawberry (Fragaria x Ananassa Duch.) Fruits. *Int.J.Curr.Microbiol.App.Sci.* 6(9): 1534-1538.

Naiem Ansari, Sevan Das Khunte and Prasad, V. M. (2019). Economics Studies of Bio fertilizers and N, P, K Treated Strawberry (Fragaria x ananassa Duch.) cv. Chandler in Allahabad Region. *Int.J.Curr.Microbiol.App.Sci.* 8(12): 1130-1135.

Tomala, K. (1997). Orchard factors affecting fruit storage quality and prediction of harvest date of apples. *Acta Hort.*, 485: 373–383.

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