Research Article

Influence of Calcium chloride and Gibberellic acid levels on the growth, yield and quality of tomato in the agro-climatic conditions of Mardan-Pakistan

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Abstract
Tomato is an important vegetable commercialized in Pakistan, and the use of Gibberellic acid (GA₃) to cultivate it in the Peshawar valley may promote the production of high quality tomato. Therefore, A field experiment was conducted at the Agriculture Farm of Abdul Wali Khan University Mardan during summer 2017, to study the influence of calcium chloride and gibberellic acid levels on the growth yield and quality of tomato. (Cv. Ontario). There were four concentrations of calcium chloride i.e, 0, 3, 6, and 9% and four levels of GA₃ i.e, 0, 50, 75 and 90 ppm ha⁻¹. The experiment was laid out in randomized complete block design (RCBD) having three replication. Applications of calcium chloride and gibberellic acid levels have significant effect on the growth, yield and quality of tomato. The maximum number of branches plant⁻¹ (8.18), number of flower cluster plant⁻¹ (10), number of flower plant⁻¹ (45), number of fruit cluster plant⁻¹ (6), number of fruit plant⁻¹ (27), yield plant⁻¹ (2.0 kg), yield ha⁻¹ (2.2 tons), weight of individual fruit (80.3 g), vitamin C content (69.63 mg 100 g⁻¹), fruit firmness (14 N) and cost benefit ratio (1.8) was observed at 75 ppm of GA₃, while the maximum plant height (88.93 cm) was found at 90 ppm of GA₃. In case of calcium chloride the maximum number of branches plant⁻¹ (7.19), plant height (87.58 cm), number of flower cluster plant⁻¹ (10), number of flower plant⁻¹ (43), number of fruit cluster plant⁻¹ (5), number of fruit plant⁻¹ (23), yield plant⁻¹ (1.6 kg), yield plant⁻¹ (6.8 kg) yield ha⁻¹ (18.8 tons), weight of individual fruit (74 g), Vitamin C content (70 mg 100 g⁻¹) and cost benefit ratio (2.3) was found at 9 % of CaCl₂, while the maximum fruit firmness (14.19 N) and minimum blossom end rot (4.82 %) was noted at 6 % of CaCl₂. It was concluded that CaCl₂ at the rate of 9% and GA₃ at the rate of 75 ppm has significant effect on enhancing growth and quality attributes of tomato. Therefore it is recommended that CaCl₂ at the rate of 9% and GA₃ at the rate of 75 ppm should be used for maximum growth, yield and quality of tomato in the agro-climatic conditions of District Mardan.

Keywords: Calcium chloride; Gibberellic acid; Mardan; Quality; Yield

Introduction
Tomato (Lycopersicon esculentum) belongs to family Solanaceae and is locally called as Tamater. It is one of the most important and commonly cultivated vegetable crops in the world. Tomato ranks 3rd position in the world in vegetables and is on the first place as processing crop in
vegetables tropical America is considered as its origin [1]. However, China, Iran, Egypt, Turkey, India, USA, Brazil, Italy, Indonesia and Mexico are the leading tomato producing parts of the world [2]. The major tomato crop is grown in summer; flowers and fruits during the months of May and July, when the temperature could be as high as 45°C. It grows well at the temperature ranged 25-30°C during the day and 21°C at night [3]. High temperature also inactivates Rubisco, the major photosynthetic enzyme that decreases the rate of photosynthesis [3]. The high summer temperature is also accompanied by extended high light intensity, which may aggravate other stresses [6]. In tomato plant, the optimum light duration is about 12 hours [7] and excessive light (17 hours) may cause leaf chlorosis [8].

The agro climate conditions of Pakistan are suitable for the cultivation of tomato. In Pakistan tomato has a great demand throughout the year due to its variety of uses in Pakistani dishes both traditional as well as modern foods. It is very nutritious vegetable which can be used in salads, soups, ketchup, curry, sauce, juice and chutney etc. Tomato is highly nutritious because it contains calories energy (23), Protein (2 g), water (94%), Mg (7 mg), Ca (1 g), Vitamin “C” (31 mg), Vitamin “A” (1000 IU), Riboflavin (0.03 mg), Thiamin (0.1 mg), Niacin (0.8 mg).100 g^{-1} of edible portion [9].

In Pakistan, the area and production of tomato in the year 2013-14 was 52300 ha^{-1} with 530,000 tones, respectively. Whereas, the average yield of tomato was about 10 tones ha^{-1}. However, in Khyber Pakhtunkhwa this crop was grown on 12.6 ha and produced 113.2 tons tomatoes. The average yield ha^{-1} in Kpk is 8.98 tons [10]. GA3 are growth promoter and can play a major role to improve plant growth, and development of vegetable crop. GA3 is one of the most important growth stimulating substance which help in cell division, and cell elongation, thus it can improve the plant growth and development of many crop [11]. [12] Reported that gibberellic acid (GA3) can promote the fruit growth and development in pollinated ovaries which become dormant because of high temperature. It is also important for the better yield of tomato. Calcium is an important secondary macro nutrient and can play a role in defense singling [13]. Calcium plays a major role in many physiological activity and plant development of bulbous flower [14] (Pan and Dong 1995). Direct applying of Calcium is the most effective method to increase the Calcium content in fruit [15]. Calcium increase vitamin C content as well as improves the quality of fruit and vegetable and also retains fruit firmness [16]. Calcium is an important nutrient for the growth development, quality and shelf life of tomato. Calcium application to the soil improves the growth of tomato, while applying as a foliar application during fruit growth period it can improve the quality of fruit [17]. Calcium deficiency can reduce the fruit quality and the disease like Blossom end rot and many other physiological disorders [18]. Calcium can play a major role in the cell membrane and cell wall stabilization [19].

In view of the above findings, it can be concluded that GA3 and Calcium are the important sources for the improvement of yield and quality of fruit. Therefore, an experiment was designed to study the influence of Calcium and Gibberellic acid levels on the growth, yield and quality of tomato in the climatic conditions of Mardan; with the following Objective to investigate the optimum level of Calcium chloride for better growth, yield and quality of tomato. To explore the optimum level of GA3 for growth, yield and quality of tomato. To determine the suitable interaction of Calcium chloride and GA3 for the higher growth and yield of tomato.
Materials and methods
An experiment “Influence of Calcium chloride and Gibberellic acid levels on the growth, yield and quality of tomato in the climatic conditions of Mardan” was conducted at the Agriculture farm of Abdul Wali Khan University Mardan. The seedling of tomato was acquired from reliable source and was transplanted in the first week of April, 2017 with 50cm plant to plant distance and 60cm row to row distance. All the management activities were practiced according to the general recommendations.

Different concentration of Calcium chloride i.e., 0, 3, 6, 9% and GA₃ solution with concentration 0, 50, 75, 90 ppm was prepared and sprayed after 30 days of transplantation. The experiment was laid out as two factors RCBD experiment.

Study parameters
The following parameters were studied.

Number of branches plant⁻¹
Number of branches were counted from the selected plants from the ground level to the top of the stem and means value were calculated.

Plant height (cm)
Plant height was measured from the selected plants from the ground surface to the top of the stem and means value was calculated.

Number of flower clusters plant⁻¹
The numbers of flower clusters were counted from the selected plants and the average numbers of flower clusters produced plant⁻¹ were calculated.

Number of flowers plant⁻¹
The total numbers of flower were counted from the selected plants. Each time the recorded clusters were marked with permanent marker and the average number of flower produced plant⁻¹ were calculated.

Number of fruit clusters plant⁻¹
The numbers of fruit cluster plant⁻¹ were counted from the selected plants and the average number of fruit clusters produced plant⁻¹ was recorded.

Number of fruits plant⁻¹
The total numbers of fruit were counted from the selected plants and the average numbers of fruit produced per plant were recorded.

Weight of individual fruit (g)
The weights of Ten (10) randomly selected fruits were taken in each treatment and mean was calculated.

Fruit yield plant⁻¹(kg)
The weight of fruit plant⁻¹ was measured by using weighing balance. It was determined by totalling of fruit yield from each plant during the period from first to final harvest and mean were calculated.

Fruit yield plot⁻¹ (kg)
The weights of fruit plot⁻¹ were measured by using weighing balance. It was determined by totaling of fruit yield from each plot during the period from first to final harvest and mean were calculated.

Fruit yield hectare⁻¹ (tons)
It was measured by the following formula:
Fruit yield per hectare (ton) = Fruit yield plot⁻¹ kg x10000 m²/ Area of plot (m²) x 1000 kg

Vitamin C (mg 100g⁻¹)
Vitamin C content of 10 randomly selected fruits was determined by analysing their sample in a lab. The average mean was calculated.

Procedure
10 ml of juice was taken from the extracted juice of tomato with the help of pipette. It was then poured into the graduated cylinder and after that the volume was raised to 100 ml with the help of 0.1N oxalic acid solution to make 10% solution. From that 10% solution, 10 ml was taken with help of pipette and poured into beaker, then it was titrated against the dye solution (2-6 dichloro phenol indo phenol + baking soda) from the burette and when the pink colour was attained titration was stopped and the reading was noted. Vitamin C contents was calculated using the following formula.

\[
\text{Vitamin C contents (mg 100 ml}^{-1}) = F \times T \times \frac{100}{D} \times \frac{S}{100}
\]

Where \( F \) = factor of standardization (ml of ascorbic acid used) / (ml of dye used)
T=ml of dye used for sample – ml of dye used for blank
D = ml of sample taken for titration
S = ml of dilute sample taken for titration

**Fruit firmness (N)**
The firmness of 10 randomly selected fruit were measure by using penetrometer. The mean was calculated.

**Blossom end rot (%)**
The blossom end rot was calculated as follow:

\[
BER \(\%\) = \frac{\text{No of ber fruit}}{\text{Total No of fruit}} \times 100
\]

**Cost benefit ratio**
The benefit cost ratio was calculated as follow:

\[
\text{Cost benefit ratio} = \frac{\text{Gross return ha}^{-1}}{\text{Total cost of production}}
\]

**Statistical analysis of data**
The data was statistically analyzed to determine the statistical significance. The means for all the treatments was calculated and the analysis of variance for all the characters was performed by “F” (variance ratio) test. The significance of the difference among the means was evaluated by Least Significance Difference (LSD) according to[20]Steel and Torrie, (1980) for interpretation of the result at 5% level of probability.

**Results and discussion**
This chapter includes the presentation and discussion of the results obtained from the influence of CaCl\(_2\) and GA\(_3\) on the growth yield and quality of tomato. The influence of different concentration of CaCl\(_2\) and GA\(_3\) and their interaction on the growth yield and quality of tomato contributing attributes. Yield and quality have been presented in (Table 1 to 14). The results of each parameter in the experiment have been studied and discussed under below.

**Number of Branches plant\(^{-1}\)**
The mean data regarding number of branches plant\(^{-1}\) is shown in (Table 1) shows that the influence of Calcium chloride and Gibberellic acid was significant, while their interaction was found non-significant. The mean data showed that the highest number of branches plant\(^{-1}\) (8.18) was observed at 75ppm of GA\(_3\), followed by (7.277) at G\(_4\) (90ppm), while the lowest number of branches plant\(^{-1}\) (5.77) was recorded in control. In case of Calcium chloride the maximum number of branches plant\(^{-1}\) (8.08) were observed at C\(_4\) (9%), followed by (7.19) at C\(_3\) (6%), while minimum number of branches plant\(^{-1}\) (5.84) were recorded in control.

The increase in number of branches may be due to the fact that GA\(_3\) rapidly increases the cell division and cell elongation in meristematic region, this result was supported by[21, 22]. Similar results were found by[23] who reported that GA\(_3\) significantly increased the number of branches plant\(^{-1}\) as compare to control, [24] also reported the same result.

In case of calcium Increase in number of branches may be due to its key role in cell division, mitosis and carbohydrates metabolism [25]. Same result were shown by[26], who reported that Ca have a significant effect on the number of branches plant\(^{-1}\), he reported that maximum number of branches plant\(^{-1}\) (7) were recorded at 15 Mm CaCl\(_2\) as compare to control. [27] also found similar results in Okra.

| Table 1. Number of branches plant\(^{-1}\) as affected by GA\(_3\) and CaCl\(_2\) in tomato |
|-----------------|-------|-------|-------|-------|-------|
| CaCl\(_2\) (%) | 0 | 50 | 75 | 90 | Mean |
| 0 | 3.74 | 5.42 | 7.03 | 7.17 | 5.84c |
| 3 | 5.60 | 7.50 | 8.12 | 6.48 | 6.93b |
| 6 | 6.95 | 6.65 | 8.58 | 6.57 | 7.19b |
| 9 | 6.78 | 7.67 | 9.00 | 8.85 | 8.08a |
| Mean | 5.77c | 6.81b | 8.18a | 7.27b |
Plant height (cm)
The mean data regarding plant height is shown in (Table 2) shows that GA$_3$, CaCl$_2$ and their interaction significantly affected plant height.

The mean value shows that the maximum plant height (88.39 cm) were recorded at 90 ppm GA$_3$, followed by (83.53 cm) at G$_3$ (75 ppm) level, while the minimum plant height (80.20 cm) were recorded in control. In case of Calcium chloride the maximum plant height (87.58 cm) were recorded at C$_4$ (9%), followed by (84.50 cm) at C$_3$ (6%), while minimum plant height (78.38 cm) were observed at control. In case of interaction the maximum plant height (95.27 cm) were observed at C$_4$ (9%) and G$_4$ (90 ppm), Followed by (93.33 cm) at G$_4$ (90 ppm) and C$_3$ (6%), while the lowest plant height (77.37 cm) were observed at C$_1$G$_1$ (control).

The increase in plant height due to GA$_3$ application may be due to the reason that, GA$_3$ stimulate cell division, cell elongation and cell enlargement and ultimately lead to better plant growth, [28]. Same result was found by [29] they reported that GA$_3$ have positive effect on the plant height during vegetative growth [22, 30] also found the same results. Calcium applications significantly affect the plant height by activating enzyme for mitosis cell division and cell elongation and thus increase the plant height [31]. Same result was found by [32] they reported that maximum plant height (84.10 cm) was observed at 6% Calcium. [26] Also found the similar results.

| CaCl$_2$ (%) | GA$_3$ ppm | 0   | 50  | 75  | 90  | Mean   |
|--------------|-------------|-----|-----|-----|-----|--------|
| 0            | 77.37       | 78.30 | 81.53 | 78.33 | 78.88c |
| 3            | 79.97       | 80.50 | 81.53 | 93.33 | 83.83b |
| 6            | 84.57       | 83.10 | 81.70 | 88.63 | 84.50b |
| 9            | 78.90       | 86.80 | 89.97 | 95.27 | 87.58a |
| Mean         | 80.20c      | 82.18bc | 83.53b | 88.39a |

Number of flower cluster plant$^{-1}$
The mean data regarding number of flower cluster plant$^{-1}$ as affected by CaCl$_2$ and GA$_3$ are given in (Table 3) shows that CaCl$_2$ and GA$_3$ significantly affected number of flower cluster plant$^{-1}$ while their interaction was found non-significant. The mean value shows that the maximum number of flower cluster plant$^{-1}$ (10.21) was found at G$_3$ (75 ppm), Followed by (9.03) at G$_4$ (90 ppm), while the minimum number of flower cluster plant$^{-1}$ (7.25) was found at control. In case of Calcium chloride, the highest number of flower cluster plant$^{-1}$ (10.17) was found at C$_4$ (9%), followed by (9.05) at C$_3$ (6%), which was statistically similar to C$_4$ (9%), while the lowest number of flower cluster plant$^{-1}$ (7.64) was observed in control.

The number of flower cluster plant$^{-1}$ mainly depends on number of branches plant$^{-1}$. As the GA$_3$ resulted in maximum number of branches per plant therefore number of flower cluster$^{-1}$ was also increased this result was confirmed by [21]. Same result was found by [22], who reported that GA$_3$ at 70 ppm can significantly increase number of flower cluster plant$^{-1}$ as compare to control. [33] Also found the similar result. Calcium has a vital role in photosynthesis, enzyme activation and carbohydrates metabolism, which will help to produce more flower cluster [34], same result was found by [35] they reported that the Calcium can significantly increase flower cluster, this result was confirmed by [36].
Table 3. Number flower cluster plant\(^1\) as affected by GA\(_3\) and CaCl\(_2\) in tomato

| CaCl\(_2\) (%) | 0  | 50 | 75 | 90 | Mean |
|--------------|----|----|----|----|-----|
| 0            | 3.88 | 8.17 | 9.50 | 9.00 | 7.64c |
| 3            | 7.17 | 8.58 | 10.57 | 7.53 | 8.51bc |
| 6            | 8.87 | 8.67 | 9.83 | 8.83 | 9.05ab |
| 9            | 9.08 | 10.08 | 10.75 | 10.75 | 10.17a |
| Mean         | 7.25c | 8.88b | 10.21a | 9.03b |       |

**Number of flower plant\(^1\)**

The mean data regarding number of flower plant\(^1\)is shown in (Table 4) shows GA\(_3\) and CaCl\(_2\) have significant effect on the number of flower plant\(^1\), while their interaction was found non-significant. The mean value shows that the maximum number of flower plant\(^1\) (45.10) was noted at G\(_3\) (75ppm), followed by (41.57) at G\(_4\) (90ppm), while the minimum number of flower plant\(^1\) (37.73) was observed in control. In case of Calcium chloride the maximum number of flowers plant\(^1\) (43.57) was found at C\(_4\) (9%), followed by (42.10) at C\(_3\) (6%). While the minimum number of flower plant\(^1\) (38.75) were recorded in control.

Increase in number of flower may be due to the fact that GA\(_3\) increase the levels of endogenous Gibberellin and can play an important role in breaking the dormancy [57]. Same result was found by [29] who reported that GA\(_3\) have significantly affected on number of flower plant\(^1\); they found the maximum number of flower plant\(^1\) (24.58) was noted at 50ppm of GA\(_3\).

Swami (2013) also found the same result in strawberry. Calcium play a vital role in chlorophyll component cell wall and membrane integrity enhance pollen germination and growth, and activator of enzyme which help to increase number of flowers [38, 53]. Same result was found by [35] who stated that Calcium can significantly increase the number of flower as compare to control. [26] Also found the similar result.

Table 4. Number of flower plant\(^1\) as affected by GA\(_3\) and CaCl\(_2\) in tomato

| CaCl\(_2\) (%) | 0  | 50 | 75 | 90 | Mean |
|--------------|----|----|----|----|-----|
| 0            | 31.25 | 36.82 | 44.80 | 42.12 | 38.75c |
| 3            | 38.77 | 38.48 | 43.42 | 38.67 | 39.83bc |
| 6            | 40.01 | 42.28 | 44.70 | 41.42 | 42.10ab |
| 9            | 40.90 | 41.82 | 47.47 | 44.09 | 43.57a |
| Mean         | 37.73c | 39.85bc | 45.10a | 41.57b |       |

**Number of fruit cluster plant\(^1\)**

In (Table 5) shows the mean value regarding number of fruits cluster plant\(^1\) and 4.5a shows GA\(_3\) and Calcium chloride significantly affected number of fruit cluster plant\(^1\), while their interaction was found non-significant. The mean value shows that the maximum number of fruit cluster per plant (6.27) was observed at G\(_3\) (75ppm), Followed by (5.35) at G\(_4\) (90ppm), while the minimum number of fruit cluster plant\(^1\) (4.87) at control. In case of Calcium chloride the more number of fruit cluster plant\(^1\) (5.91) was noted at C\(_4\) (9%), followed by (5.67) at C\(_4\) (6%) and C\(_3\) (6%) level. While the less number of fruit cluster plant\(^1\) (4.74) was found at C\(_1\) (control) level.

More number of fruit cluster per plant is due the maximum number of flower cluster. GA\(_3\) help to increase number of flower cluster and fruit-set plant\(^1\) [30, 12] Also found the similar results i.e., GA\(_3\) increased number of fruit cluster, fruit set percentage as compare to control. Calcium reduces the abscission of flowers and fruit which results
increased number of fruit cluster [39] same result was found by [35] who reported that the Calcium can significantly increase the number of fruit cluster plant$^{-1}$ as compare to control.

Table 5. Number of fruit cluster plant$^{-1}$ as affected by GA$_3$ and CaCl$_2$ in tomato

| CaCl$_2$ (%) | 0  | 50 | 75 | 90 | Mean  |
|--------------|----|----|----|----|-------|
| 0            | 4.13 | 4.77 | 5.29 | 4.75 | 4.74c  |
| 3            | 4.63 | 5.48 | 6.46 | 4.88 | 5.37b  |
| 6            | 5.53 | 4.98 | 6.60 | 5.55 | 5.67ab |
| 9            | 5.17 | 5.50 | 6.74 | 6.23 | 5.91a  |
| Mean         | 4.87c | 5.18bc | 6.27a | 5.35b |       |

Number of fruit plant$^{-1}$

The mean data regarding number of fruits plant$^{-1}$ is shown in (Table 6) shows that the influence of GA$_3$ and CaCl$_2$ on number of fruit plant$^{-1}$ were significant, while their interaction was found non-significant. The mean value shows that the maximum number of fruit plant$^{-1}$(27.13) was found at G$_3$ (75ppm), Followed by (21.88) at G$_4$ (90ppm), while the lowest number of fruit plant$^{-1}$(16.83) was observed at control. In case of CaCl$_2$ the maximum number of fruit plant$^{-1}$(23.76) was found at C$_4$ (9%), Followed by (21.98) at C$_3$ (6%). While the minimum number of fruit plant$^{-1}$(19.53) was observed at control.

Table 6. Number of fruit plant$^{-1}$ as affected by GA$_3$ and CaCl$_2$ in tomato

| CaCl$_2$ (%) | 0  | 50 | 75 | 90 | Mean  |
|--------------|----|----|----|----|-------|
| 0            | 14.90 | 20.48 | 24.50 | 18.25 | 19.53c  |
| 3            | 16.47 | 19.40 | 27.23 | 20.97 | 21.02b  |
| 6            | 17.17 | 20.10 | 28.50 | 22.17 | 21.98b  |
| 9            | 18.80 | 21.80 | 28.30 | 26.13 | 23.76a  |
| Mean         | 16.83d | 20.45c | 27.13a | 21.88b |       |

Weight of individual fruit (g)

The mean data regarding weight of individual fruit is shown in (Table 7) shows that the influence of CaCl$_2$ and GA$_3$ on weight of individual fruit was significant, while their interaction was found non-significant. The mean value shown that the maximum weight of individual fruit (80.3g) was found at G$_3$ (75ppm), followed by (71.1g) at G$_4$ (90ppm). While the minimum individual fruit weight (59.3 gm) was observed at control. In case of CaCl$_2$ the maximum individual fruit weight (74.5 g) was found at C$_4$ (9%), followed by (72.23 g) at C$_3$ (6%). While the minimum individual fruit weight (63.8 g) was found at control.

The maximum individual fruit weight may be due to the fact that GA$_3$ increase the photosynthetic material and its efficient mobilization in plant giving rise to increased stimulation of fruit growth and
eventually lead to maximize the fruit weight [11, 43]. Same result was found by [29] who reported that GA3 can significantly increase the fruit weight as compare to control. Calcium applications significantly maximize the plant by activating enzyme for cell mitosis, carbohydrates metabolism and nutrient uptake increase the fruit weight [31]. Same result was found by [32]. They stated that the Calcium have positive effect on fruit weight. [62] Also reported that Calcium can increase the fruit weight as compare to control.

Table 7. Weight of individual fruit (g) as affected by GA3 and CaCl2 in tomato

| CaCl2 (%) | GA3 ppm | Mean |
|-----------|---------|------|
| 0         | 0       | 58.17 |
| 3         | 0       | 60.30 |
| 6         | 0       | 59.47 |
| 9         | 0       | 59.53 |
| Mean      | 59.37c  | 58.17 |

Yield plant\(^1\)(kg)
The mean data regarding yield plant\(^1\) is shown in (Table 8) revealed that CaCl2 and GA3 significantly affected yield plant\(^1\), while their interaction was found non-significant. The mean data shown that the highest yield plant\(^1\)(2.09kg) was observed at G3 (75ppm), followed by (1.3kg) at G4 (90ppm). While the minimum yield/plant (0.99 kg) was noted at control. In case of CaCl2 the maximum yield plant\(^1\)(1.68kg) was found at C4 (9%), Followed by (1.39 kg) at C3 (6%). While the minimum yield plant\(^1\) (1.18 kg) was observed at control. The maximum yield plant\(^1\) is due to increased number of fruit and fruit weight by GA3. GA3 are growth stimulating substance which help to improve the plant growth and development and also increase the fruit set in tomato [41], same result was found by [52] they reported that the application of GA3 can significantly increase the yield plant\(^1\).[54] also reported that GA3 can increase yield plant\(^1\) as compare to control. Calcium is important elements for the growth and yield of plant and act as an activator of enzyme[33], yield plant\(^1\) depend on nutrient uptake, and fruit weight, calcium increase these parameters and ultimately increases yield plant\(^1\) [67] same result was found by[26, 69] they reported that Calcium can significantly increase yield plant\(^1\) as compare to control.

Table 8. Yield plant\(^1\)(kg) as affected by GA3 and CaCl2 in tomato

| CaCl2 (%) | GA3 ppm | Mean |
|-----------|---------|------|
| 0         | 0       | 0.89 |
| 3         | 0       | 0.81 |
| 6         | 0       | 0.97 |
| 9         | 0       | 1.29 |
| Mean      | 0.99c   | 1.23b|

Yield plot\(^1\)(kg)
The data regarding yield plot\(^1\) is shown in (Table 9) showed that the influence of GA3 and CaCl2 on yield plot\(^1\) was significant, while their interactive effect was found non-significant. The mean value shows that the more yield plot\(^1\)(8.01kg) was found at G3 (75ppm), followed by (5.62kg) at G4 (90ppm). While the minimum yield plot\(^1\)(3.95kg) was observed at control. In case of CaCl2 the highest yield plot\(^1\)(6.88kg) was observed at C4 (9%), followed by
(5.94 kg) at C3 (6%) level. While the minimum yield plot-1 (4.16 kg) was found at control.

GA3 are growth motivating substance which improve the plant growth and development and also increase the fruit set in tomato as well as improve yield weight plant-1 which ultimately increases yield plot-1, [41]. Same result was found by [54] they stated that GA3 have a significant impact on yield/plant as compare to control. [56] Also found the similar result in mandarin. Increase in yield plot-1 due to calcium application might be due to the fact that Calcium not only increase number of fruits but it also reduce fruit drop and increase fruit retention [42], same result was found by [35] they examined that Ca can increase the yield plant-1 as compare to control. This result was supported by [6, 48].

Table 9. Yield plot-1 (kg) as affected by GA3 and CaCl2 in tomato

| CaCl2 (%) | 0     | 50    | 75    | 90    | Mean   |
|-----------|-------|-------|-------|-------|--------|
| 0         | 1.83  | 3.22  | 7.10  | 4.50  | 4.16c  |
| 3         | 3.70  | 4.52  | 8.03  | 5.70  | 5.49b  |
| 6         | 5.23  | 5.17  | 8.13  | 5.23  | 5.94b  |
| 9         | 5.03  | 6.67  | 8.77  | 7.04  | 6.88a  |
| Mean      | 3.95d | 4.89bc| 8.01a | 5.62b |        |

Yield hac-1 (tons)
The data regarding yield ha-1 was affected by CaCl2 and GA3 is given in (Table 10) showed that the effect of CaCl2 and GA3 was significant, while their interaction effect were found non-significant. The mean value showed that the highest yield ha-1 (22 tons) was found at G3 (75ppm) followed by (16.36 tons) at G4 (90ppm). While the lowest yield ha-1 (10.5 tons) was observed at G1 control level. In case of CaCl2 the maximum yield ha-1 (18.83 tons) was obtained at C4 (9%), followed by (16.97 tons) at C3 (6%) level. While the minimum yield ha-1 (11 tons) was found at control level.

Table 10. Yield ha-1 (tons) as affected by GA3 and CaCl2 in tomato

| CaCl2 (%) | 0     | 50    | 75    | 90    | Mean   |
|-----------|-------|-------|-------|-------|--------|
| 0         | 6.43  | 10.80 | 14.87 | 12.17 | 11.07c |
| 3         | 11.50 | 10.83 | 22.77 | 18.17 | 15.82b |
| 6         | 11.83 | 15.23 | 24.50 | 16.30 | 16.97b |
| 9         | 12.40 | 18.13 | 25.90 | 18.80 | 18.83a |
| Mean      | 10.56d| 13.75c| 22.01a| 16.36b|        |

Vitamin C content (mg 100 g-1)
The data regarding vitamin C content is shown in (Table 11). The effect of Calcium chloride and Gibberellic acid was significant, while their interactive effect was found non-significant. The mean value showed that the highest vitamin C content (69.63 mg 100g-1) was observed at G3(75ppm), Followed by
(65.48 mg 100 g⁻¹) at G₄ (90 ppm). While the lowest vitamin C content (57.69 mg 100 g⁻¹) was observed at control. In case of CaCl₂ the maximum Vitamin C content (70.15 mg 100 g⁻¹) was found at C₄ (9%), followed by (63.37 mg 100 g⁻¹) at C₃ (6%), while the lowest Vitamin C content (59.53 mg 100 g⁻¹) was found at control. The increase in vitamin C content may be due to the fact that GA₃ increase the mobilization of nutrient, carbohydrates and photosynthetic material which improve the fruit quality [11, 43, 51] Found the similar result in strawberry. Who reported that GA₃ at 90 ppm increased Vitamin C content as compare to control. [49] Also found the similar result in apple. Calcium can increase the Calcium content in fruit [15] increase vitamin C content as well as improves the quality of fruits [16], same result was found by [26] who reported that Ca at 10mM can increased vitamin C content as compare to control. [35] Also found the similar results.

Table 11. Vitamin C content (mg 100 g⁻¹) as affected by GA₃ and CaCl₂ in Tomato

| CaCl₂ (%) | GA₃ ppm | Mean |
|-----------|---------|------|
| 0         | 0       | 50.57 |
| 3         | 0       | 57.23 |
| 6         | 0       | 68.58 |
| 9         | 0       | 67.63 |
| Mean      |         | 57.69c|

Fruit firmness (N)
Fruit firmness is affected by different levels of CaCl₂ and GA₃, (Table 12) shown the mean value shows that the effects of CaCl₂ and GA₃ were significant, while their interaction was found non-significant. The mean value shows that the maximum fruit firmness (14.01 N) was found at G₃ (75 ppm), followed by (11.97 N) at G₄ (90 ppm), while the minimum fruit firmness (9.87 N) was observed at untreated control level. In case of CaCl₂ the maximum fruit firmness (14.19 N) was observed at C₃ (6%), Followed by (12.86 N) at C₄ (9%).

Table 12. Fruit firmness (N) as affected by GA₃ and CaCl₂ in tomato

| CaCl₂ (%) | GA₃ ppm | Mean |
|-----------|---------|------|
| 0         | 0       | 7.57 |
| 3         | 0       | 8.83 |
| 6         | 0       | 12.50|
| 9         | 0       | 10.57|
| Mean      |         | 9.87c|

Blossom-end-rot (%)
The data regarding Blossom end rot is given in (Table 13) showed that the influence of CaCl₂ was significant, while the effect of GA₃ as well as their interaction was found non-significant. The mean value showed...
that the maximum blossom end rot fruit (11.68%) was observed at control. Followed by (10.68%) at C2 (3%) which was statistically similar to C1 (control) While the minimum blossom end rot fruit (4.8 %) was found at C3 (6%). Calcium can play a significant role in the stabilization of membrane system and the formation of Calcium-pectates which increase the rigidity of the cell wall and middle portion of the fruit [45, 46]. Calcium inhibit the degradation of the middle portion and cell wall [47].And also play a role in defense singling, and reduce the Blossom end rot [13], same result was found by [38] they reported that Ca reduce the Blossom end rot up to 8% as compare to control. [26] Also reported that Calcium reduce blossom end-rot up to 4 % as compare to control.

| Table 13. Blossom end rot (%) as affected by GA3 and CaCl2 in tomato |
|---------------------------|----------------|----------------|----------------|----------------|
| CaCl2 (%) | GA3 ppm | Mean | |
| 0 | 11.57 | 11.67 | 12.47 | 11.00 | 11.68a |
| 3 | 8.97 | 9.87 | 10.67 | 13.20 | 10.68a |
| 6 | 5.13 | 4.97 | 4.57 | 4.60 | 4.82c |
| 9 | 6.00 | 5.50 | 7.90 | 6.93 | 6.58b |
| Mean | 7.92 | 8.00 | 8.90 | 8.93 | |

**Economic analysis**

Input cost for land preparation, seed cost, fertilizer and manure cost and man power required for all the operations from transplanting of seedling to harvesting of tomato were recorded for unit plot and converted into cost per hectare. Prices of tomato were considered in market rate basis. The economic analysis was carried out to find the gross and net return and the benefit cost ratio in the current research work and presented under following headings.

**Gross return**

CaCl2 showed different gross return under the trial. The maximum gross return (Rs 187900 ha⁻¹) was obtained from C4 (9%), and the minimum gross return (Rs 11000 ha⁻¹) was calculated from C1 (0 % Ca) in case of GA3 the maximum gross return (Rs 220000 ha⁻¹) was obtained from G3 (75ppm), while the minimum Gross return (Rs 105000 ha⁻¹) at control level.

**Net return**

In case of net return, CaCl2 showed different results. The highest net return (Rs107300 ha⁻¹) were obtained from C4 (9%), while the lowest net return (Rs 45500 ha⁻¹) was obtained from C1 (control). GA3 showed the highest net return (Rs 100000 ha⁻¹) were obtained from G3 (75ppm) level, while the lowest net return (Rs 31000 ha⁻¹) was obtained from control level.

**Cost benefit ratio (CBR)**

Highest cost benefit ratio (2.3) was obtained from C4 (9%) and the lowest cost benefit ratio (1.8) was obtained from C1 (control). In case of GA3 the highest cost benefit ratio (1.8) was obtained from G3 (75ppm), whereas the lowest (1.2) was found at G4 (90 ppm). From the economic point of view, it is apparent that CaCl2 at (9%) and GA3 (75ppm) was the most profitable than rest of the treatments under the study (Table 14).
Table 14. Cost and return of tomato cultivation as influenced by GA3 and CaCl2

| Treatments | Cost of production ha⁻¹ (Rs/ha) | Yield of tomato (t/ha) | Gross return (Rs/ha) | Net return (Rs./ha) | Benefit cost ratio |
|------------|---------------------------------|------------------------|----------------------|--------------------|-------------------|
| C1 (Control) | 64500                           | 11                     | 110000               | 45500              | 1.8               |
| C2         | 69900                           | 15.82                  | 158200               | 88300              | 2.2               |
| C3         | 75300                           | 16.9                   | 169000               | 93700              | 2.2               |
| C4         | 80700                           | 18.8                   | 187900               | 107300             | 2.3               |
| G1 (CONTROL) | 64500                          | 10.5                   | 105000               | 40500              | 1.6               |
| G2         | 102000                          | 13.75                  | 137500               | 35500              | 1.3               |
| G3         | 120000                          | 22                     | 220000               | 100000             | 1.8               |
| G4         | 132000                          | 16.36                  | 163000               | 31000              | 1.2               |

Cost of tomato@Rs. 10000/ton
1 gm of GA3 @Rs. 3000/gm

Conclusion
The overall results obtained from the study facilitated to draw the following conclusions; GA3 at a rate 75ppm was produced the maximum number of branches plant⁻¹, number of flower cluster plant⁻¹, number of flower plant⁻¹, number of fruit cluster plant⁻¹ number of fruit plant⁻¹, weight of individual fruit, yield plant⁻¹, yield plot⁻¹, yield ha⁻¹, vitamin C content, and also increase cost benefit ratio. CaCl2 at rate of 9% was found best as it increase the number of branches, plant height, number of flower cluster plant⁻¹, number of flower plant⁻¹, number of fruit cluster plant⁻¹, number of fruit plant⁻¹, weight of individual fruit, yield plant⁻¹, yield plot⁻¹, yield ha⁻¹, Vitamin C content, as well as cost benefit ratio, whereas 6% of CaCl2 was consider best for increasing the fruit firmness and reduce blossom end rot. Therefore it is recommended that GA3 at 75ppm and CaCl2 9% was most effective for the better growth yield and quality of tomato.

Authors’ contributions
Conceived and designed the experiments: MN Khan & M Ilyas, Performed the experiments: W Muhammad, Analyzed the data: W Muhammad, Contributed materials/analysis/tools: M Hissam, W Khan, B Ali & M Hilal, Wrote the paper: M Ilyas.

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