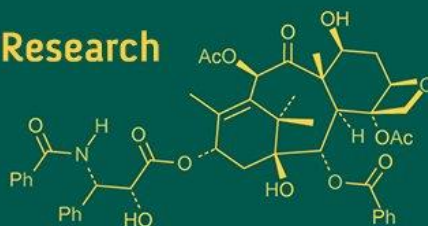


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Zode Ayushi Laxmikant
M.Sc. Scholar, Department of
Vegetable Science, Post
Graduate Institute, Dr.
PDKV, Akola, Maharashtra,
India

AP Wagh
Professor Department of
Vegetable Science, Dr. PDKV,
Akola, Maharashtra, India

AM Sonkamble
Professor and Head of the
Department of Vegetable
Science, Dr. PDKV, Akola,
Maharashtra, India

VS Kale
Professor Department of
Vegetable Science, Dr. PDKV,
Akola, Maharashtra, India

SD Jadhao
Professor and Head of the
Department of Soil Science,
Dr. PDKV, Akola,
Maharashtra, India

Corresponding Author:
Zode Ayushi Laxmikant
M.Sc. Scholar, Department of
Vegetable Science, Post
Graduate Institute, Dr.
PDKV, Akola, Maharashtra,
India

Effect of silicon fertilizers and silicic acid on growth, yield and quality of tomato

Zode Ayushi Laxmikant, AP Wagh, AM Sonkamble, VS Kale and SD Jadhao

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Abstract

A field experiment entitled “Effect of silicon fertilizers and silicic on growth, yield and quality of tomato.” was carried out during summer season of year 2025 at Instructional farm, Department of Vegetable Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M. S.) with the objectives to study the effect of different silicon fertilizers and silicic acid on growth, yield and quality of tomato and to find out the suitable concentration of silicon fertilizers and silicic acid for better growth, yield and quality of tomato. The experiment was laid out in Randomized Block Design (RBD) with three replications and eight treatments viz., T₁ (Foliar spray of calcium silicate-0.5%), T₂ (Foliar spray of calcium silicate-1%), T₃ (Foliar spray of potassium silicate-0.5%), T₄ (Foliar spray of potassium silicate-1%), T₅ (Foliar spray of amorphous silica-0.2%), T₆ (Foliar spray of amorphous silica-0.4%), T₇ (Foliar spray of silicic acid-0.5%), T₈ (Foliar spray of silicic acid-1%), T₉ (Control-water spray). The various observations in respect of plant growth, yield and quality of tomato were recorded periodically. The silicon fertilizers and its concentration showed significantly varied growth and yield parameters. From the present findings, it was observed that the growth parameters in respect of plant height (127.42 cm), number of branches plant⁻¹ (12.80), stem diameter (20.46 mm) were found maximum in treatment T₅ with foliar application of amorphous silica-0.2%, leaf area (44.58 cm²) was found maximum in treatment T₈ (Foliar spray of silicic acid-1%) and root length and root biomass were found to be maximum in treatment T₂ (Foliar spray of calcium silicate-1%). As regards to yield and yield attributing parameters treatment T₅ (Foliar spray of amorphous silica-0.2%) was found superior in respect of viz., fruit diameter (58.79 mm), average fruit weight (85.98 g), number of fruits plant⁻¹ (27.87), minimum days to first fruit harvest (66.27), yield plant⁻¹ (2.40 kg), yield plot⁻¹ (59.88 kg), and yield hectare⁻¹ (739.70 q). In respect of quality parameter treatment T₈ (Foliar spray of silicic acid-1%) recorded maximum TSS (5.83°B), chlorophyll index (57.34 SPAD) and T₃ (Foliar spray of potassium silicate-0.5%) was recorded maximum shelf life (24.00 days). Considering the cost of economics, the highest gross, net monetary return and benefit cost ratio were obtained with treatment T₅ (Foliar spray of amorphous silica-0.2%).

Keywords: Tomato, silicon fertilizers, calcium silicate, potassium silicate, amorphous silica, silicic acid, growth, yield, quality

Introduction

Tomato (*Solanum lycopersicum* L.) is an edible berry that is commonly grown and consumed as a vegetable. It belongs to the family Solanaceae and has a chromosome number of 2n = 24. The crop originated in the Andean region of South America (Peralta and Spooner, 2007)^[12]. Owing to its high nutritional value, wide adaptability, and economic importance, tomato is one of the most extensively cultivated vegetable crops in the world.

Tomato is a highly nutritious vegetable crop, valued for its rich content of vitamins, minerals, and antioxidants that contribute significantly to human health. It serves as an important source of carbohydrates, mainly in the form of natural sugars and starches, and contains both soluble and insoluble dietary fiber. Tomato is an important ingredient in many cuisines and is valued as a rich source of vitamins A and C, along with natural antioxidants (Dorais *et al.*, 2008)^[6].

Tomato is one of the most widely cultivated and consumed vegetable crops worldwide and is an important source of income for millions of farmers. India ranks second in global tomato production, with an area of about 8.55 lakh ha and a production of approximately 206 lakh tonnes.

Madhya Pradesh is the leading tomato-producing state, followed by Andhra Pradesh, Karnataka, Gujarat, Uttar Pradesh, Odisha, West Bengal, Chhattisgarh, Maharashtra, and Bihar (Anonymous, 2024) [3].

Tomato is a warm-season crop that grows well under a wide range of climatic conditions, with optimum growth and fruit development occurring at 21-27 °C. High temperatures during flowering can reduce pollen viability, increase flower drop, and impair fruit set, leading to lower yields (Abdel-Zaher *et al.*, 2023) [1]. The rising demand for tomato and the challenges of climate change highlight the need for sustainable production practices. Silicon application can enhance plant growth, improve tolerance to abiotic and biotic stresses, and increase fruit yield and quality. Therefore, evaluating silicon-based fertilizers is important for developing sustainable and resilient tomato production systems.

Materials and Methods

The experiment was conducted at the instructional farm of the Department of Vegetable Science, Dr. PDKV Akola, during the *summer* season of 2025-26.

Planting Materials: The seeds of tomato were obtained from private sector which was hybrid and planted at 60 × 45 cm. Broad bed furrow method was used for transplanting of seedling. Seedlings were transplanted in the month of February in open-field condition.

The experiment was laid out in Randomized Block Design (RBD) with three replications and eight treatments viz., T₁ (foliar application of calcium silicate-1%), T₂ (foliar application of calcium silicate-1%), T₃ (foliar spray of potassium silicate-0.5%), T₄ (foliar spray of potassium silicate-1%), T₅ (foliar application of amorphous silica-0.2%), T₆ (foliar application of amorphous silica-0.4%), T₇ (foliar spray of silicic acid-0.5%), T₈ (foliar spray of silicic acid-1%), T₉ (Control-water spray).

The selected data were statistically analyzed by Panse and Sukhatme (1967). The standard error and critical difference at a 5% significance level were computed to evaluate the differences between treatment means.

Results and Discussion

Growth parameters

Height of plant (cm)

The data regarding plant height as influenced by foliar application of silicon fertilizer and silicic acid were recorded and presented in table 1. Among the treatments the foliar application of amorphous silica-0.2% (T₅) resulted in the maximum plant height, recording a height (127.42 cm). It was found at par with treatment T₈ (foliar spray of silicic acid-1%) and T₄ (foliar spray of potassium silicate-1%). In contrast, the control treatment (T₉) exhibited the minimum plant height, with a recorded value of 125.20 cm. The increased plant height may be attributed to the higher availability, which promotes cell division and elongation, enhances photosynthetic activity, and improves nutrient absorption. Similar finding was reported by Alsaeedi *et al.* (2019) [2] and Prasad *et al.* (2022) [14].

Number of branches plant⁻¹

The data presented in Table 1 indicates that the foliar application of silicon fertilizers and silicic acid significantly

influenced the number of branches plant⁻¹. Among the treatments, the highest number of branches (12.80) was recorded in plants treated with foliar application of amorphous silica-0.2% (T₅), whereas the control treatment (T₉) exhibited the lowest number of branches (9.67). This improvement may be attributed to the higher availability of silicon, which improved plant vigor by strengthening tissues and reducing stress, thereby promoting the development of lateral branches. The present results are in conformity with Prasad *et al.* (2022) [14] and Kumari *et al.* (2025) [10].

Stem diameter (mm)

The foliar application of silicon fertilizers and silicic acid had a significant effect on the stem diameter were recorded and presented in table 1. Among the treatments the foliar application of amorphous silica-0.2% (T₅) resulted in the maximum stem diameter, recording a diameter (20.46 mm) and it was found at par with treatment T₈ (foliar spray of silicic acid-1%) and T₄ (foliar spray of potassium silicate-1%). In contrast, the control treatment (T₉) exhibited the minimum stem diameter, with a recorded value of 15.47 mm. This improvement may be due to the better availability of silicon from the amorphous form, which supports stem growth by promoting cell division and strengthening cell walls leading to sturdier stems. These results are in line with the findings of Lob *et al.* (2023) [11].

Leaf area (cm²)

The data in respect of leaf area influenced by foliar application of silicon fertilizers and silicic acid were recorded and presented in table 1. Among the treatments the foliar application of silicic acid-1% (T₈) resulted in the maximum leaf area, recording a leaf area of (44.58 cm²) it was found at par with treatment T₅ (foliar spray of amorphous silica-0.2%), T₄ (foliar spray of potassium silicate-1%) and T₇ (foliar application of silicic acid-0.5%). In contrast, the control treatment (T₉) exhibited the minimum leaf area, with a recorded value of 31.45 cm². The superior leaf development observed may be due to the easy availability of silicon supports chlorophyll formation, enhances photosynthetic activity, resulting in broader and healthier leaves. The similar results were obtained in Jesal *et al.* (2020) [8].

Root length (cm)

The data in respect of root length influenced by foliar application of silicon fertilizers and silicic acid were recorded and presented in table 1. Among the treatments the foliar application of calcium silicate-1% (T₂) resulted in the maximum root length, recording a root length of (32.47 cm) it was found at par with treatment T₅ (foliar spray of amorphous silica-0.2%) and T₄ (foliar spray of potassium silicate-1%). In contrast, the control treatment (T₉) exhibited the minimum root length, with a recorded value of 20.13 cm. The enhanced root growth may be attributed to the combined effects of silicon and calcium, which improved root development and increased the efficiency of water and nutrient uptake, resulting in a stronger root system. The result of present investigation are in agreement with the findings of Jiang *et al.* (2021) [9] and Dobaria *et al.* (2023) [5].

Table 1: Effect of plant growth regulators on height (cm), number of branches plant⁻¹, stem diameter (mm), leaf area (cm²), root length (cm) and root biomass (g)

Treatments	Plant height (cm)	Number of branches plant ⁻¹	Stem diameter (mm)	Leaf area (cm ²)	Root length (cm)	Root biomass (g)
T ₁ (foliar spray of calcium silicate-0.5%)	107.93	11.20	16.61	34.96	24.60	12.15
T ₂ (foliar spray of calcium silicate-1%)	112.60	10.87	18.54	38.56	32.47	16.27
T ₃ (foliar spray of potassium silicate-0.5%)	110.53	11.53	19.01	35.93	26.93	13.09
T ₄ (foliar spray of potassium silicate-1%)	123.13	12.13	19.52	41.42	29.87	15.68
T ₅ (foliar spray of amorphous silica-0.2%)	127.42	12.80	20.46	43.73	31.13	14.96
T ₆ (foliar spray of amorphous silica-0.4%)	120.47	11.87	17.27	37.13	21.93	11.88
T ₇ (foliar spray of silicic acid-0.5%)	116.67	10.53	17.73	40.57	23.27	11.03
T ₈ (foliar spray of silicic acid-0.1%)	125.20	12.40	20.03	44.58	28.73	14.36
T ₉ (Control-water spray)	103.80	9.67	15.47	31.45	20.13	9.40
F test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m)±	1.86	0.49	0.82	0.51	1.11	0.64
CD at 5%	5.58	1.48	2.46	4.54	3.34	1.92

Root biomass (g)

The data in respect of root biomass influenced by foliar application of silicon fertilizers and silicic acid were recorded and presented in table 1. Among the treatments the foliar application of calcium silicate-1% (T₂) resulted in the maximum root biomass, recording a root biomass of (16.27 g) it was found at par with treatment T₄ (foliar spray of potassium silicate-1%), T₅ (foliar spray of amorphous silica-0.2%) and T₈ (foliar spray of silicic acid-1%). In contrast, the control treatment (T₉) exhibited the minimum root biomass, with a recorded value of (9.40 g). This improvement may be due to the positive effects of silicon and calcium on root development, which enhanced water and nutrient uptake, leading to a larger root system and increased biomass production. The close review found in González-Moscóso *et al.* (2022) [7].

Yield and yield attributing parameters**Fruit diameter (cm)**

The data regarding average fruit diameter as influenced by foliar application silicon fertilizers and silicic acid were recorded and presented in table 2. The data depicted in Table 2 clearly indicated that, maximum fruit diameter (58.79 mm) was recorded in the foliar spray of amorphous silica-0.2% (T₅), which was found statistically at par with treatment T₈ (foliar spray of silicic acid-1%), T₆ (foliar application of amorphous silica-0.4%) and T₄ (foliar spray of potassium silicate-1%) respectively. While, the minimum fruit diameter (43.85 mm) was observed in the control treatment (T₉). This improvement may be due to the availability of silicon, which promotes cell division and enlargement, resulting in fruits with greater diameter. These results are in line with the findings of Prasad *et al.* (2022) [14].

Average fruit weight (g)

The data regarding average fruit weight as influenced by foliar application of silicon fertilizers and silicic acid were recorded and presented in table 2. The data depicted in Table 2 clearly indicated that, the maximum fruit weight (85.98 g) was recorded in treatment T₅ with foliar spray of amorphous silica-0.2%, which was found statistically at par with treatment T₈ (foliar spray of silicic acid-1%), T₇ (foliar spray of silicic acid-0.5%), T₄ (foliar spray of potassium silicate-1%), T₂ (foliar spray of calcium silicate-1%) and T₃ (foliar spray of potassium silicate-0.5%) respectively. The minimum average fruit weight (75.31 g) was recorded in

treatment T₉ (Control-Water spray). This improvement may be due to the positive effect of silicon on photosynthesis and nutrient uptake, which enhanced the supply of assimilates to developing fruits, resulting in higher fruit weight. The similar results in this regard were concluded by Pinedo-Guerrero *et al.* (2020) [13] and Kumari *et al.* (2025) [10].

Number of fruits plant⁻¹

The data regarding number of fruits vine⁻¹ as influenced by foliar application of silicon fertilizers and silicic acid were recorded and presented in table 2. The data depicted in Table 2 clearly indicated that, the highest number of fruits plant⁻¹ (27.87) was recorded in treatment T₅ with foliar spray of amorphous silica-0.2%, which was found statistically at par with treatment T₈ (foliar spray of silicic acid-1%), T₄ (foliar spray of potassium silicate-1%), T₇ (foliar spray of silicic acid-0.5%), T₂ (foliar spray of calcium silicate-1%) and T₆ (foliar spray of amorphous silica-0.4%) respectively. Whereas, the lowest (21.40) was observed in the control (T₉). This response may be attributed to the positive effect of silicon on photosynthesis, which enhanced assimilate production and translocation to reproductive organs, resulting in improved flower retention, better fruit set, reduced flower and fruit drop, and higher fruit number. The above results are in conformity with findings of Prasad *et al.* (2022) [14].

Days to first fruit harvest

The data regarding the days to first fruit harvest as influenced by foliar application of silicon fertilizers and silicic acid were recorded and presented in table 2. The data depicted in Table 2 clearly indicated that, the minimum days to first fruit harvest (66.27) was recorded in treatment T₅ with foliar spray of amorphous silica-0.2%, followed by treatment T₈ (foliar spray of silicic acid-1%). Whereas, maximum days required to first fruit harvest (77.53) was recorded in treatment T₉ (Control-Water spray). This early harvesting may be due to the beneficial effect of silicon on plant growth and reproductive development, which promoted timely flowering, faster fruit growth, and earlier fruit maturity. The similar results were recorded in Kumari *et al.* (2025) [10].

Yield plant⁻¹ (kg)

The data regarding the yield vine⁻¹ as influenced by foliar application of silicon fertilizers and silicic acid were recorded and presented in table 2. Statistically, maximum

yield plant⁻¹ (2.40 kg) was recorded in in treatment T₅ (foliar spray of amorphous silica-0.2%), which was found statistically at par with treatment T₈ (foliar spray of silicic acid-1%), T₄ (foliar spray of potassium silicate-1%) and T₇ (foliar spray of silicic acid-0.5%), respectively. However, minimum yield plant⁻¹ (1.61 kg) was recorded in treatment T₉ (Control-Water spray). The highest fruit yield plant⁻¹ may be attributed to improved photosynthetic efficiency, nutrient uptake, and assimilate translocation, which enhanced fruit set, fruit development, and overall plant productivity. Corroborative results have also been reported by, Zhang *et al.* (2024) ^[19].

Yield hectare⁻¹ (q)

The data regarding the yield hectare⁻¹ as influenced by foliar application of silicon fertilizers and silicic acid were recorded and presented in table 2. The maximum yield hectare⁻¹ (739.70 q) was recorded in treatment T₅ with foliar spray of amorphous silica-0.2%, which was found statistically at par with treatment T₈ (foliar spray of silicic acid-1%), T₄ (foliar spray of potassium silicate-1%) and T₇ (foliar spray of silicic acid-0.5%), respectively. Whereas, minimum yield hectare⁻¹ (497.93 q) was recorded in treatment T₉ (Control-Water spray). These results are in line with the findings of Prasad *et al.* (2022) ^[14], Bocharnikova *et al.* (2023) ^[4].

Table 2: Effect of plant growth regulators on fruit diameter (mm), average fruit weight, number of fruits plant⁻¹, days to first fruit harvest, yield plant⁻¹ (kg) and yield hectare⁻¹ (q)

Treatments	Fruit diameter (mm)	Average fruit weight (g)	Number of fruits plant ⁻¹	Days to first fruit harvest	Yield plant ⁻¹ (kg)	Yield hectare ⁻¹ (q)
T ₁ (foliar spray of calcium silicate-0.5%)	46.78	77.18	23.27	74.13	1.79	551.43
T ₂ (foliar spray of calcium silicate-1%)	47.69	81.27	25.13	73.60	2.01	620.36
T ₃ (foliar spray of potassium silicate-0.5%)	49.76	80.81	23.87	71.40	1.94	597.73
T ₄ (foliar spray of potassium silicate-1%)	51.61	82.21	26.87	69.80	2.21	682.09
T ₅ (foliar spray of amorphous silica-0.2%)	58.79	85.98	27.87	66.27	2.40	739.70
T ₆ (foliar spray of amorphous silica-0.4%)	54.96	79.76	24.73	73.27	1.97	609.04
T ₇ (foliar spray of silicic acid-0.5%)	53.42	83.65	26.13	70.20	2.19	673.86
T ₈ (foliar spray of silicic acid-0.1%)	56.56	84.57	27.27	67.93	2.31	712.95
T ₉ (Control-water spray)	43.85	75.31	21.40	77.53	1.61	497.93
F test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m)±	1.88	1.98	1.11	1.54	0.11	33.37
CD at 5%	5.65	5.94	3.33	4.61	0.32	100.05

Quality Parameter

TSS (°B)

The data regarding the TSS of tomato as influenced by foliar application of silicon fertilizers and silicic acid were recorded and presented in table 3. The maximum TSS (5.83 °B) was recorded in in treatment T₈ with foliar spray of silicic acid-1% which was found statistically at par with treatment T₄ (foliar spray of potassium silicate-1%) and T₇ (foliar spray of silicic acid-0.5%) respectively. However, Minimum TSS (4.10°B) was recorded in treatment T₉ (Control-Water spray). This increase in TSS may be attributed to the positive influence of readily available silicon on photosynthetic activity and fruit metabolism, which favoured the accumulation of soluble sugars in the fruits. This agrees with results of Thimmappa *et al.*, (2021) ^[18].

Chlorophyll index (SPAD)

The data regarding the chlorophyll index of tomato leaves as influenced by foliar application of silicon fertilizers and silicic acid were recorded and presented in table 3. The maximum chlorophyll index of tomato leaves (57.34) was recorded in in treatment T₈ with foliar spray of silicic acid-1% which was found statistically at par with treatment T₄

(foliar spray of potassium silicate-1%) and T₇ (foliar spray of silicic acid-0.5%) respectively. However, Minimum chlorophyll index of tomato leaves (38.03) was recorded in treatment T₉ (Control-Water spray). The higher chlorophyll index may be attributed to the beneficial effect of readily available silicon on chlorophyll formation and maintenance of healthy leaf tissue. Our results are in accordance with the findings of Salim *et al.* (2021) ^[16].

Shelf life (days)

The data regarding the shelf life of tomato as influenced by foliar application of silicon fertilizers and silicic acid were recorded and presented in table 3. The maximum shelf life of tomato (24.00 days) was recorded in in treatment T₃ with foliar spray of potassium silicate-0.5% which was found statistically at par with treatment T₄ (foliar spray of potassium silicate-1%). However, Minimum shelf life of tomato (15.13 days) was recorded in treatment T₉ (Control-Water spray). The extended shelf life may be attributed to the role of silicon in maintaining fruit firmness and delaying the processes associated with ripening, softening and preserving fruit quality for a longer period. Corroborative results have also been reported by Shehata *et al.* (2018) ^[17].

Table 3: Effect of silicon fertilizers and silicic acid on TSS, chlorophyll index and shelf life

Treatments	TSS (°B)	Chlorophyll index	Shelf life (days)
T ₁ (foliar spray of calcium silicate-0.5%)	4.37	43.48	20.87
T ₂ (foliar spray of calcium silicate-1%)	4.51	44.45	19.67
T ₃ (foliar spray of potassium silicate-0.5%)	4.90	49.57	24.00
T ₄ (foliar spray of potassium silicate-1%)	5.63	55.75	23.13
T ₅ (foliar spray of amorphous silica-0.2%)	5.13	50.96	16.47
T ₆ (foliar spray of amorphous silica-0.4%)	4.70	47.06	18.53
T ₇ (foliar spray of silicic acid-0.5%)	5.30	53.44	21.80
T ₈ (foliar spray of silicic acid-1%)	5.83	57.34	17.40
T ₉ (Control-water spray)	4.10	38.03	15.13
F test	Sig	Sig	Sig
SE(m)±	0.18	1.73	0.69
CD at 5%	0.54	5.18	2.07

Economics

Benefit: Cost ratio

The data regarding the benefit cost ratio as influenced by foliar application of silicon fertilizers and silicic acid were recorded and presented in table 5. The data presented in Table 4 revealed that highest net monetary return (913650 Rs ha⁻¹) was obtained from treatment T₅ with foliar spray of amorphous silica-0.2% with highest benefit: cost ratio (3.65)

followed by treatment T₈ (foliar spray of silicic acid-1%) with net monetary return (858780 Rs ha⁻¹) and benefit: cost ratio (3.43). While, lowest net monetary return (515166 Rs ha⁻¹) from the treatment T₉ (Control-Water spray) with benefit: cost ratio (2.55).

Overall, it revealed that the treatments with foliar spray of amorphous silica-0.2% concentration are comparatively economical.

Table 5: Effect of plant growth substances on Benefit: Cost ratio

Treatments	Yield (q ha ⁻¹)	Cost of Cultivation	GMR (Rs ha ⁻¹)	NMR (Rs ha ⁻¹)	B:C ratio
T ₁ (foliar spray of calcium silicate-0.5%)	551.43	338535	937431	598896	2.76
T ₂ (foliar spray of calcium silicate-1%)	620.36	346035	1054612	708577	3.04
T ₃ (foliar spray of potassium silicate-0.5%)	597.73	340035	1016141	676106	2.98
T ₄ (foliar spray of potassium silicate-1%)	682.09	349035	1159553	810518	3.32
T ₅ (foliar spray of amorphous silica-0.2%)	739.70	343840	1257490	913650	3.65
T ₆ (foliar spray of amorphous silica-0.4%)	609.04	346912	1035368	688456	2.98
T ₇ (foliar spray of silicic acid-0.5%)	673.86	342135	1145562	803427	3.34
T ₈ (foliar spray of silicic acid-0.1%)	712.95	353235	1212015	858780	3.43
T ₉ (Control-water spray)	497.93	331315	846481	515166	2.55

Future scope

Future research should focus on optimizing the source, concentration, and application schedule of silicon fertilizers and silicic acid in tomato. Studies are needed to evaluate their influence on growth, yield, fruit quality, and shelf life across different tomato hybrids. Further investigation on silicon-mediated resistance against biotic and abiotic stresses is warranted. Research on the physiological and biochemical mechanisms involved in silicon uptake and utilization will enhance understanding of its role in crop improvement. Economic analyses and multi-location trials are also essential for developing location-specific recommendations for sustainable tomato production.

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Conclusion

From the above result it can be concluded that, the growth parameter viz., plant height, number of branches plant⁻¹, stem diameter were found significantly maximum in foliar spray of amorphous silica-0.2%, leaf area was found maximum in foliar spray of silicic acid-1% and root length (cm) and root biomass (g) were found maximum in foliar

spray of calcium silicate-1%.

Yield parameter viz., fruit diameter (mm), average fruit weight (g), number of fruits plant⁻¹, minimum days to first fruit harvest, yield plant⁻¹ (kg), yield hectare⁻¹ (q) was found maximum in foliar spray of amorphous silica-0.2%.

The quality parameter viz., TSS (°Brix), chlorophyll index (40 and 70 DAT) were recorded significantly maximum in foliar spray of silicic acid-1% and shelf life (days) was found maximum in foliar spray of potassium silicate-0.5%.

Considering, the economics of cultivation the highest gross monetary return, net monetary return and benefit cost ratio was obtained in foliar spray of amorphous silica-0.2%.

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