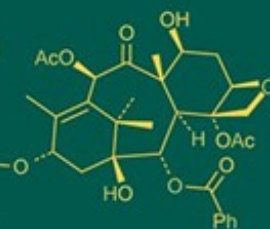
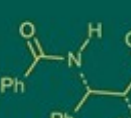
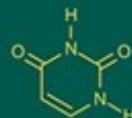


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Mahesh Bhosle

M.Sc. Scholar, Department of Vegetable Science, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India.

R. S. Wankhade

Assistant Professor (Horticulture), Agriculture Research Station, Achalpur Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India.

V. S. Kale

Professor, Department of Vegetable Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India.

P. A. Sonkamble

Professor, Department of Botany, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India.

D. S. Kankal

Assistant Professor, Department of Soil Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India.

Effect of foliar application of silicon on growth, yield, quality and economics of onion bulb

Mahesh Bhosle¹, R. S. Wankhade², V. S. Kale³, P. A. Sonkamble⁴, D. S. Kankal⁵

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ABSTRACT

A field investigation was carried out during the Rabi season of 2024–2025 at the Main Garden, Department of Vegetable Science, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, to assess the response of onion cv. Akola Safed to foliar application of silicon. The study was undertaken to evaluate the influence of different silicon concentrations supplied through calcium silicate and potassium silicate and to identify the most effective concentration for enhancing growth, productivity and bulb quality. The experiment comprised nine treatments, including an untreated control, and was conducted in a Randomized Block Design with three replications. Calcium silicate and potassium silicate were applied as foliar sprays at 0.4, 0.6, 0.8 and 1.0 per cent concentrations at 20, 40 and 60 days after transplanting.

Application of silicon resulted in considerable improvement in several growth and yield attributes of onion. At 90 days after transplanting, calcium silicate at 1.0 per cent produced the tallest plants (62.10 cm), closely followed by potassium silicate at 1.0 per cent (62.08 cm), while the control recorded 52.73 cm. The highest number of leaves per plant was observed under potassium silicate at 1.0 per cent (11.95), followed by potassium silicate at 0.8 per cent (11.93) and calcium silicate at 1.0 per cent (11.53). Potassium silicate at 1.0 per cent also promoted earlier maturity, with bulbs attaining maturity in 113.66 days compared with 123.23 days in the untreated control.

Yield performance was markedly improved by silicon application. The maximum fresh bulb production was obtained with calcium silicate at 1.0 per cent (28.30 t ha⁻¹), followed by calcium silicate at 0.8 per cent (27.49 t ha⁻¹) and potassium silicate at 1.0 per cent (27.14 t ha⁻¹). Similarly, the highest cured bulb yield (27.25 t ha⁻¹) was recorded with calcium silicate at 1.0 per cent. Potassium silicate at 1.0 per cent resulted in the greatest average bulb weight (166.67 g). The maximum polar diameter (54.59 mm) was obtained with calcium silicate at 1.0 per cent, whereas potassium silicate at 1.0 per cent produced the largest equatorial diameter (65.52 mm). The highest total soluble solids content (12.83 °Brix) was recorded with calcium silicate at 1.0 per cent.

The economic evaluation further demonstrated the superiority of calcium silicate at 1.0 per cent, which recorded the highest gross monetary returns of ₹3,27,000 ha⁻¹, net monetary returns of ₹1,85,621 ha⁻¹ and a cost benefit ratio of 2.31. On the basis of the overall performance, foliar application of calcium silicate and potassium silicate at 1.0 per cent proved to be the most effective treatment for enhancing growth, yield, bulb quality and economic profitability of onion cv. Akola Safed under the agro-climatic conditions of Akola.

Keywords: Onion, *Allium cepa*, Silicon, Calcium silicate, Potassium silicate, Growth, Yield, Quality, Akola Safed

1. Introduction

Onion (*Allium cepa* L.) is one of the most important bulbous vegetable crops cultivated throughout the world and belongs to the family Alliaceae. It is widely used as a vegetable, condiment and flavouring ingredient. Onion is also valued for its nutritional and medicinal properties. The quality and market value of onion bulbs depend mainly on bulb size, shape, colour, pungency, total soluble solids and storage quality. The India is one of the major onion-producing country with Maharashtra being an important onion-producing state.

Silicon is one of the most abundant elements in the earth's crust. Although it is generally not considered an essential element for higher plants, it has been associated with improved plant growth, structural strength, stress tolerance and productivity. Plants generally absorb silicon in the form of monosilicic acid. Silicon can accumulate in plant tissues and contribute to strengthening plant structures.

The application of silicon has received considerable attention in crop production because of its potential role in improving plant growth, physiological performance and resistance to environmental stresses. Previous studies have reported beneficial effects of silicon application in cereals and horticultural crops. In onion, however, comparatively limited information is available regarding the foliar response to different silicon

Corresponding Author: Mahesh Bhosle

M.Sc. Scholar, Department of Vegetable Science, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India.

sources and concentrations. The present investigation was therefore undertaken to evaluate the effect of calcium and potassium silicate as foliar sources of silicon on onion cv. Akola Safed on growth, yield and quality.

2. Materials and methods

The experiment was conducted during the Rabi season of 2024–2025 at the Main Garden, Department of Vegetable Science, PGI, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experimental field had medium black soil with moderate fertility and good drainage. Onion cv. Akola Safed was used for the experiment.

The experiment was laid out in a Randomized Block Design (RBD) with three replications. The layout was broad bed and furrow (BBF), with nine treatments. The plot size was 3 × 1 m with a spacing of 15 × 10 cm and the recommended fertilizer dose was 100:50:50:30 kg NPKS ha⁻¹. Silicon was applied as foliar spray at 20, 40 and 60 days after transplanting.

Treatment details

Treatment	Treatment description
T ₁	Control
T ₂	Calcium silicate @ 0.4%
T ₃	Calcium silicate @ 0.6%
T ₄	Calcium silicate @ 0.8%
T ₅	Calcium silicate @ 1.0%
T ₆	Potassium silicate @ 0.4%
T ₇	Potassium silicate @ 0.6%
T ₈	Potassium silicate @ 0.8%
T ₉	Potassium silicate @ 1.0%

Observations were recorded for plant height, number of leaves per plant, neck thickness, bolting, days to maturity, fresh and cured bulb yield, average bulb weight, polar and equatorial bulb diameter, shape index, TSS and split bulbs.

3. Results and discussion

3.1 Plant height

At 90 DAT, significant variation in plant height was observed among the different silicon treatments. The maximum plant height was recorded in T₅ (calcium silicate @ 1.0%), with a value of 62.10 cm. It was closely followed by T₉ (potassium silicate @ 1.0%) and T₄ (calcium silicate @ 0.8%), which recorded plant heights of 62.08 and 61.00 cm, respectively. Treatment T₈ (potassium silicate @ 0.8%) also recorded a comparatively higher plant height of 59.77 cm. These treatments were statistically at par with each other. In contrast, the minimum plant height of 52.73 cm was recorded in T₁ (control).

The improvement in plant height due to silicon application may be associated with its beneficial influence on cellular development, particularly cell division and elongation, thereby promoting vegetative growth (Jaleel *et al.*, 2009) [1]. Amany *et al.* (2019) [2] also reported that foliar application of potassium silicate at 4000 ppm resulted in greater plant height in garlic at 120 days after planting compared with the untreated control. According to Yoshida *et al.* (1969) [3], silicon deposition in the cell walls contributes to greater rigidity and erectness of leaves and stems. This improved plant architecture can reduce mutual shading among plants, enhance light interception and consequently favour photosynthetic activity and vegetative growth. The present results are in conformity with the findings of Durgude *et al.* (2014) [4] in onion.

3.2 Number of leaves per plant

At 90 DAT, significant variation in the number of leaves per plant was observed among the different silicon treatments. The maximum number of leaves per plant was recorded in T₉ (potassium silicate @ 1.0%), with 11.95 leaves, followed by T₈ (potassium silicate @ 0.8%) with 11.93 leaves, T₅ (calcium silicate @ 1.0%) with 11.53 leaves and T₄ (calcium silicate @ 0.8%) with 11.40 leaves per plant. The differences among these treatments were statistically non-significant, indicating that they were at par with each other. In comparison, the minimum number of leaves per plant was recorded in T₁ (control), with 9.00 leaves. The increased leaf production in silicon-treated plants may be attributed to improved vegetative growth, enhanced nutrient uptake and more efficient physiological activity, which collectively promoted leaf initiation and development. Similar observations were reported by Amany *et al.* (2019) [2] in garlic, where the application of potassium silicate favourably influenced vegetative growth and leaf production.

Table 1. Effect of foliar application of silicon on growth parameters

Treatments	Plant height(cm)at 90 DAT	No. of leaves at 90 DAT	Neck thickness(mm) at 90 DAT	Bolting (%)	Days to maturity
T ₁ - Control	52.73	9.00	10.32	1.19	123.23
T ₂ - Foliar spray of Calcium silicate @ 0.4%,	56.57	9.93	11.21	0.95	122.16
T ₃ - Foliar spray of Calcium silicate @ 0.6%	57.10	10.00	11.32	0.95	120.73
T ₄ - Foliar spray of Calcium silicate @ 0.8 %	61.00	11.40	11.40	0.71	119.66
T ₅ - Foliar spray of Calcium silicate @ 1.00 %	62.10	11.53	11.54	0.47	119.33
T ₆ - Foliar spray of Potassium Silicate @ 0.4 %	56.07	10.00	11.34	0.95	116.40
T ₇ - Foliar spray of Potassium Silicate @ 0.6%	56.27	10.50	11.36	0.71	115.13
T ₈ - Foliar spray of Potassium Silicate @ 0.8 %	59.77	11.93	11.41	0.71	115.20
T ₉ - Foliar spray of Potassium Silicate @ 1.00 %	62.08	11.95	11.56	0.23	113.66
'F' test	Sig	Sig	Sig	NS	Sig
SE (m) ±	1.09	0.33	0.22	0.10	1.71
CD at 5%	3.23	0.97	0.65	-	5.18

3.3 Neck thickness

At 90 DAT, significant variation in neck thickness was observed among the different silicon treatments. The highest neck thickness was recorded in T₉ (potassium silicate @ 1.0%), measuring 11.56 mm, which was closely followed by T₅ (calcium silicate @ 1.0%) with 11.54 mm. Treatments T₈ (potassium silicate @ 0.8%) and T₄ (calcium silicate @ 0.8%) recorded neck thickness values of 11.41 and 11.40 mm, respectively. In contrast, the lowest neck thickness was observed in T₁ (control), with 10.32 mm. Statistically, treatments T₂ to T₉ were found to be at par with one another. The present findings are in agreement with those reported by Durgude *et al.* (2014) [4] and Bhangare *et al.* (2020) [5], who also observed a favourable influence of different sources and levels of silicon application on neck thickness in onion.

3.4 Bolting

The results indicated that the differences among the treatments were non-significant. The bolting percentage ranged from 0.23 to 1.19 per cent.

3.5 Days to maturity

The application of different silicon treatments significantly influenced the number of days required for maturity of onion. Among all the treatments, T₉ (foliar application of potassium silicate @ 1.00%) exhibited the earliest maturity, requiring only 113.66 days, followed by T₇ (potassium silicate @ 0.6%) with 115.13 days and T₈ (potassium silicate @ 0.8%) with 115.20 days. In the calcium silicate treatments, T₅ (calcium silicate @ 1.00%) recorded the lowest number of days to maturity (119.33 days), followed by T₄ (119.66 days), T₃ (120.73 days) and T₂ (122.16 days). In contrast, the control treatment T₁ required the maximum period of 123.23 days to attain maturity. The reduction in maturity period with potassium silicate application, partic-

ularly at 1.00 per cent, could be attributed to the complementary role of potassium and silicon in enhancing carbohydrate movement, regulating enzymatic processes, maintaining plant water balance and promoting overall physiological development, thereby facilitating earlier crop maturity.

3.6 Fresh bulb yield

The application of silicon significantly affected the fresh bulb yield of onion. Among the treatments, calcium silicate applied at 1.0 per cent (T₅) produced the maximum fresh bulb yield of 28.30 t ha⁻¹. This was followed by calcium silicate at 0.8 per cent, which recorded 27.49 t ha⁻¹, and potassium silicate at 1.0 per cent (T₉), with a yield of 27.14 t ha⁻¹. In comparison, the untreated control (T₁) recorded the minimum fresh bulb yield of 24.23 t ha⁻¹. The enhanced bulb yield obtained with silicon application could be attributed to better plant growth, increased photosynthetic efficiency, improved nutrient absorption and utilization, and greater movement of assimilates towards bulb development. The beneficial influence of silicon on yield enhancement is in accordance with the findings of Durgude *et al.* (2014) [4], Bhangare *et al.* (2020) [5], Amany *et al.* (2019) [2] and Oliveira *et al.* (2024) [6].

3.7 Cured bulb yield

Cured bulb yield was significantly affected by the foliar application of silicon. Among the treatments, calcium silicate @ 1.0 per cent (T₅) recorded the highest cured bulb yield of 27.25 t ha⁻¹, followed by calcium silicate @ 0.8 per cent (T₄) with 26.43 t ha⁻¹ and potassium silicate @ 1.0 per cent (T₉) with 26.30 t ha⁻¹. In comparison, the lowest cured bulb yield of 23.51 t ha⁻¹ was obtained in the control (T₁). The treatments T₅, T₄ and T₉ were found to be statistically at par with each other. Therefore, foliar application of calcium silicate @ 1.0 per cent (T₅) was found to be the most effective treatment for improving cured bulb yield under the conditions of the present investigation.

Table 2. Effect of foliar application of silicon on yield and yield attributes

Treatments	Fresh bulb yield (t/ha)	Cured bulb yield (t/ha)	Average bulb weight (g)
T_1 - Control	24.23	23.51	110.07
T_2 - Foliar spray of Calcium silicate @ 0.4%,	24.98	24.15	130.67
T_3 - Foliar spray of Calcium silicate @ 0.6%	25.66	24.90	140.27
T_4 - Foliar spray of Calcium silicate @ 0.8 %	27.49	26.43	155.73
T_5 - Foliar spray of Calcium silicate @ 1.00 %	28.30	27.25	160.40
T_6 - Foliar spray of Potassium Silicate @ 0.4 %	24.24	23.49	125.27
T_7 - Foliar spray of Potassium Silicate @ 0.6%	25.36	24.47	130.27
T_8 - Foliar spray of Potassium Silicate @ 0.8 %	26.41	25.48	160.53
T_9 - Foliar spray of Potassium Silicate @ 1.00 %	27.14	26.30	166.67
'F' test	Sig	Sig	Sig
SE (m) $\pm$	0.38	0.35	2.61
CD at 5%	1.16	1.05	7.81

3.8 Average bulb weight

The average bulb weight was significantly influenced by the foliar application of silicon and varied from 110.07 to 166.67 g. The highest average bulb weight (166.67 g) was obtained with potassium silicate @ 1.0 per cent (T_9), followed by potassium silicate @ 0.8 per cent (T_8) with 160.53 g and calcium silicate @ 1.0 per cent (T_5) with 160.40 g. In contrast, the minimum average bulb weight of 110.07 g was recorded in the control treatment (T_1). The enhancement in bulb weight with potassium silicate application may be attributed to the synergistic role of potassium and silicon in improving photosynthetic activity, carbohydrate production and their translocation towards the

developing bulb, thereby promoting better bulb enlargement. The present results are in conformity with the findings of Durgude *et al.* (2014) [4] and Bhangare *et al.* (2020) [5], who also reported improved bulb development and yield-related attributes in onion with silicon application.

3.9 Polar diameter

The maximum polar diameter was recorded with calcium silicate @ 1.0 per cent (T_5), measuring 54.59 mm, followed by potassium silicate @ 1.0 per cent (54.13 mm). The control recorded the minimum polar diameter of 43.69 mm. Similar matters of finding were also reported by Durgude *et al.* (2014) [4].

3.10 Equatorial diameter

Potassium silicate @ 1.0 per cent (T_9) recorded the maximum equatorial diameter of 65.52 mm, followed by calcium silicate @ 1.0 per cent (65.50 mm). The control recorded 55.53 mm. The increase in bulb diameter may be associated with enhanced vegetative growth, photosynthetic activity and translocation of assimilates towards the developing bulb. The present findings are in agreement with the observations of Bhangare *et al.* (2020) [5], who reported that silicon application significantly improved bulb diameter and other yield-contributing characters in onion.

3.11 Shape index

The shape index of onion bulbs was influenced by the different foliar applications of silicon. Treatments T_3 (calcium silicate @ 0.6%), T_4 (calcium silicate @ 0.8%) and T_5 (calcium silicate @ 1.0%) recorded comparatively higher shape indices of 0.81, 0.83 and 0.83, respectively. Treatment T_9 (potassium silicate @ 1.0%) also registered a shape index of 0.83 and remained statistically at par with T_3 , T_4 , T_5 and T_8 . In contrast, the lowest shape index of 0.79 was observed in T_1 (control), T_2 (calcium silicate @ 0.4%), T_6 (potassium silicate @ 0.4%) and T_7 (potassium silicate @ 0.6%).

3.12 Total soluble solids

Total soluble solids (TSS) content was influenced by the application of silicon. Among the treatments, T_5 (foliar application of calcium silicate @ 1.00%) recorded the highest TSS content of 12.83 per cent, followed by T_4 (calcium silicate @ 0.8%) with 12.60 per cent and T_9 (potassium silicate @ 1.00%) with 12.56 per cent. The minimum TSS content of 11.40 per cent was observed in T_1 (control).

The higher TSS content under increased levels of silicon application may be associated with enhanced photosynthetic efficiency and greater movement and accumulation of soluble carbohydrates in the developing bulbs. Silicon application may also improve nutrient uptake and utilization, along with promoting various physiological processes involved in bulb development, consequently enhancing the accumulation of soluble solids. Similar results were reported by Pharanade *et al.* (2014) [7].

Table 3. Effect of foliar application of silicon on quality

Treatments	Polar diameter of bulb (mm)	Equatorial diameter of bulb (mm)	Shape index (%)	Total soluble solid (TSS)	Split bulb
T ₁ - Control	43.69	55.53	0.79	11.40	0.95
T ₂ - Foliar spray of Calcium silicate @ 0.4%,	47.97	60.67	0.79	11.90	0.71
T ₃ - Foliar spray of Calcium silicate @ 0.6%	48.82	60.70	0.81	12.10	0.71
T ₄ - Foliar spray of Calcium silicate @ 0.8 %	52.43	63.20	0.83	12.60	0.23
T ₅ - Foliar spray of Calcium silicate @ 1.00 %	54.59	65.50	0.83	12.83	0.00
T ₆ - Foliar spray of Potassium Silicate @ 0.4 %	48.73	61.33	0.79	11.55	0.95
T ₇ - Foliar spray of Potassium Silicate @ 0.6%	49.02	61.87	0.79	11.90	0.47
T ₈ - Foliar spray of Potassium Silicate @ 0.8 %	52.20	64.50	0.81	11.80	0.23
T ₉ - Foliar spray of Potassium Silicate @ 1.00 %	54.13	65.52	0.83	12.56	0.00
'F' test	Sig	Sig	Sig	Sig.	NS
SE (m) ±	0.79	0.98	0.01	0.16	0.12
CD at 5%	2.39	2.89	0.03	0.49	-

3.13 Split bulbs

The data pertaining to the percentage of split bulbs as affected by foliar application of silicon are presented in Table 3. Statistical analysis revealed that the treatments did not produce any significant variation in the incidence of split bulbs. The percentage of split bulbs varied from 0.00 to 0.95 per cent among the different treatments.

3.14 Economics

The economic analysis revealed that calcium silicate @ 1.0 per cent (T₅) was the most profitable treatment. It recorded gross monetary returns of ₹3,27,000 ha⁻¹, net monetary returns of ₹1,85,621 ha⁻¹ and a

B:C ratio of 2.31. Calcium silicate @ 0.8 per cent and potassium silicate @ 1.0 per cent recorded B:C ratios of 2.26 and 2.24, respectively. The higher profitability under T₅ (calcium silicate @ 1.00 per cent) was mainly associated with its higher cured bulb yield and consequently greater monetary returns. Maximum B:C ratio was obtained due to increased yield and yield attributes because of beneficial effects of silicon. The economics of onion agreed with Joseph *et al.* (2003) [8] in pumpkin, Priya *et al.* (2015) [9] in potato, Nessreen *et al.* (2011) [10] and Amira *et al.* (2015) [11] in faba bean.

Table 4. Effect of foliar application of silicon on economics of onion at harvest

Treatments	Yield (t/ha)	Cost of cultivation	GMR (Rs/ha)	NMR (Rs/ha)	B:C ratio
T ₁ - Control	23.51	1,35,055	2,82,120	1,47,065	2.09
T ₂ - Foliar spray of Calcium silicate @ 0.4%,	24.15	1,37,585	2,89,800	1,52,215	2.11
T ₃ - Foliar spray of Calcium silicate @ 0.6%	24.90	1,38,849	2,98,800	1,59,951	2.15
T ₄ - Foliar spray of Calcium silicate @ 0.8 %	26.43	1,40,114	3,17,160	1,77,046	2.26
T ₅ - Foliar spray of Calcium silicate @ 1.00 %	27.25	1,41,379	3,27,000	1,85,621	2.31
T ₆ - Foliar spray of Potassium Silicate @ 0.4 %	23.49	1,37,465	2,81,880	1,44,415	2.05
T ₇ - Foliar spray of Potassium Silicate @ 0.6%	24.47	1,38,669	2,93,640	1,54,971	2.12
T ₈ - Foliar spray of Potassium Silicate @ 0.8 %	25.48	1,39,874	3,05,760	1,65,886	2.19
T ₉ - Foliar spray of Potassium Silicate @ 1.00 %	26.30	1,41,079	3,15,600	1,74,521	2.24

4. Conclusion

The present investigation demonstrated that foliar application of silicon through calcium silicate and potassium silicate had a positive influence on growth, yield and quality attributes of onion cv. Akola Safed. Among the treatments, calcium silicate @ 1.0 per cent (T₅) emerged as the most promising treatment followed by potassium silicate @ 1.0 per cent (T₉) for overall crop performance. Calcium silicate @ 1.0 per cent (T₅) recorded the maximum plant height at 90 DAT, highest fresh bulb yield (28.30 t ha⁻¹), highest cured bulb yield (27.25 t ha⁻¹), maximum polar bulb diameter (54.59 mm), highest

TSS (12.83 °Brix), minimum split bulbs (0.00%) and maximum gross monetary returns, net monetary returns and B:C ratio (2.31). Potassium silicate @ 1.0 per cent (T₉) also performed very well, particularly for number of leaves per plant, neck thickness, average bulb weight (166.67 g), equatorial bulb diameter (65.52 mm) and early maturity (113.66 days). Therefore, under the agro-climatic and experimental conditions of the present investigation, foliar application of calcium or potassium silicate @ 1.0 per cent at 20, 40 and 60 DAT is recommended as the most promising treatment for improving growth, yield, quality and economic returns of onion cv. Akola Safed as they are at par with each other.

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