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Impact of Silicon on Vegetative Growth and Flower Production in Jasmine (*Jasminum sambac* L.)

[1]Ahsan Akram, [2]Sabahat, [1]Adnan Younis, [2]Muhammad Shahbaz, [1]Abdullah Ma 'Arij, [3]Ghazal Rahim

[1]Institute of Horticultural Sciences, University of Agriculture, Faisalabad, 38040, Pakistan
[2]Department of Botany, University of Agriculture, Faisalabad, 38040, Pakistan
[3]Directorate of Floriculture (T&R), Lahore, Punjab, Pakistan

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Corresponding author:
Sabahat,
Department of Botany University of Agriculture, Faisalabad,38040, Pakistan

ABSTRACT

Background and Objective: Jasmine (*Jasminum sambac* L.) is an economically important ornamental crop valued for its highly fragrant flowers. Although silicon (Si) is not considered an essential plant nutrient, it has been reported to enhance growth, stress tolerance and yield in several horticultural crops. However, information on the specific effects of silicon on jasmine growth and yield is limited. This study aimed to evaluate the influence of different silicon concentrations on the vegetative growth and flower yield of jasmine plants.

Materials and Methods: A field experiment was conducted using one-year-old jasmine plants with heights ranging from 35 to 90 cm. Six silicon treatments (25, 50, 75, 100, 125 and 150 mg L^{-1}), along with an untreated control, were evaluated. Silicon was applied three times at 15-day intervals. The experiment was laid out in a Randomized Complete Block Design (RCBD) with five replicates per treatment and each block consisted of 35 plants. Vegetative growth parameters, including plant height, number of leaves, number of branches and stem diameter, were recorded during the vegetative growth stage. Data were subjected to statistical analysis using Statistix 8.1.

Results: All measured growth attributes exhibited highly significant responses to silicon application. Silicon-treated plants showed marked improvements in vegetative growth parameters compared with the control. In addition, flower yield was significantly enhanced by silicon application, indicating a positive dose-dependent response within the tested range.

Conclusion: The findings demonstrate that silicon application significantly improves vegetative growth and flower yield in jasmine. Although silicon is not an essential nutrient, its supplementation proved beneficial for the growth and yield development of *Jasminum sambac*, suggesting its potential use as an effective growth-enhancing input in jasmine cultivation.

INTRODUCTION

The floriculture industry, encompassing the production and distribution of ornamental plants, plays a vital role in fulfilling aesthetic needs and enhancing the visual appeal of residences, gardens, parks and public spaces. Beyond their decorative value, ornamental plants contribute to human well-being by promoting psychological comfort and emotional satisfaction. Sevik et al.[1] reported that ornamental species such as roses, orchids and ferns create pleasant and engaging environments while positively influencing mood, creativity and mental clarity. Proximity to green spaces and natural habitats has been shown to exert a beneficial effect on mental health by reducing stress and improving overall well-being [2].

In Pakistan, the floriculture sector offers a rich diversity of colors, fragrances and textures that appeal to the senses. A wide range of flowers, including vibrant tulips, radiant marigolds, delicate orchids and fragrant jasmine, are cultivated across the country. These flowers are widely used in bouquets, floral arrangements and decorative displays, thereby enhancing the aesthetic value of weddings, social events and ceremonial occasions and creating visually enchanting environments[3].

Jasmine (*Jasminum sambac* L.) is among the oldest and most highly valued fragrant flowers and is often referred to as the "King of Oils." It is renowned for its elegant blossoms and captivating aroma, with a single plant capable of perfuming an entire space. The term "jasmine" is derived from the Arabic word *Yasmin*, meaning fragrance, an apt description of this aromatic species. Jasmine has long held cultural and spiritual significance, particularly in India, which is recognized as one of its major centers of origin. The genus *Jasminum*, belonging to the family Oleaceae, comprises approximately 200 species distributed worldwide, of which nearly 40 species are reported to occur in India[3].

Jasmine is a highly cherished ornamental plant cultivated for household gardens as well as for commercial purposes. Its flowers and buds are extensively used in garlands, bouquets and religious offerings, while the vines are traditionally worn as hair adornments. Jasmine flowers are also valued for the extraction of perfumed hair oils and attars. The essential oil of jasmine, characterized by its sweet floral fragrance, is highly esteemed globally and blends harmoniously with other floral extracts, making it a key ingredient in high-quality perfumes used in the soap, cosmetic and mouthwash industries[4].

The leaves of jasmine serve as the primary photosynthetic organs, capturing solar energy to sustain plant growth and development. During the flowering season, the plant produces clusters of pure white blossoms set against lush green foliage, contributing to its ornamental appeal. The characteristic fragrance of jasmine flowers attracts pollinators such as bees but terflies and nocturnal moths, thereby supporting ecological interactions within the surrounding environment[5].

Beyond its ornamental value, jasmine is economically important due to its fragrant flowers, which yield a small but highly valuable quantity of essential oil known as "otto" or "attar of jasmine." This oil has been prized for centuries for its distinctive aroma and therapeutic properties. Jasmine oil is a complex mixture of more than a thousand compounds, with major constituents including benzyl acetate, linalool, benzyl alcohol, indole, benzyl benzoate, cis-jasmone, geraniol and methyl anthranilate, along with trace amounts of isophytol and phytol[6].

The export of flowers from Pakistan has increased steadily in recent years, contributing to employment generation and economic growth. Both fresh and dried Pakistani florals are experiencing rising demand in international markets[7]. The economic importance of jasmine is further reflected in its widespread use in horticulture, where it is cultivated by nurserymen for its aesthetic value and its ability to mask unattractive structures in landscapes[8].

Silicon (Si) has been reported to strengthen cell walls, improve water and nutrient uptake and enhance overall plant structural stability, leading to healthier and more productive plants. Its role in mitigating environmental stresses, including drought and soil salinity, has demonstrated promising results in several plant species, including jasmine[9]. Silicon-mediated regulation of physiological processes, particularly under unfavorable conditions, may reduce reliance on synthetic growth enhancers and contribute to more sustainable flower production systems[10]. Studies on ornamental plants suggest that Si application can improve flower size, petal number and postharvest longevity, likely through enhanced nutrient-use efficiency, improved water relations and increased tissue strength[11].

Although, silicon is not classified as an essential plant element, it is widely recognized as beneficial for the growth and development of many horticultural and agricultural crops[12]. Previous research has shown that Si fertilization can influence plant growth both directly and indirectly by reinforcing cell walls, reducing lodging and enhancing tolerance to abiotic and biotic stresses[13]. In this context, the present study aimed to investigate the influence of silicon on jasmine growth, flowering performance and overall yield improvement under varying environmental conditions. Optimizing jasmine flowering is essential for improving both yield and quality, thereby supporting sustainable ornamental crop production.

MATERIALS AND METHODS

The experiment was conducted during 2025 at the Floriculture Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad. Uniform, one-year-old *Jasminum sambac* L. plants were selected and arranged under seven fertilizer treatments following a Randomized Complete Block Design (RCBD), with five replications per treatment to ensure statistical precision and reliability.

The treatments comprised the following silicon (Si) concentrations applied as foliar sprays:

- T_0: Control (distilled water spray)
- T_1: 25 mg L ^{1} silicon
- T_2: 50 mg L ^{1} silicon
- T_3: 75 mg L ^{1} silicon
- T_4: 100 mg L ^{1} silicon
- T_5: 125 mg L ^{1} silicon
- T_6: 150 mg L ^{1} silicon

Foliar application was adopted to promote rapid and efficient absorption of silicon by the plants. The treatments were applied three times at 15-day intervals to ensure uniform and sustained nutrient availability throughout the experimental period. Data were recorded for key vegetative growth parameters following the application of the respective treatment combinations.

Morphological parameters: Morphological parameters represent measurable traits describing the external form, structure and physical dimensions of plants. The following observations were recorded to assess the effect of treatments on plant growth and development.

Plant height (cm): Plant height was measured at the completion of the experiment as the vertical distance from the soil surface at the stem base to the apical tip, using a calibrated measuring rod.

Shoot length (cm): Shoot length was determined by measuring the distance from the point of shoot emergence on the main stem to the shoot apex with a measuring rod.

Stem diameter (mm): Stem diameter was measured using a digital Vernier caliper. All measurements were taken at a uniform reference height above the soil surface to ensure consistency.

Leaf area (cm²): Leaf area was estimated by placing individual leaves flat on a smooth surface. Leaf length was measured from the base to the tip, while width was recorded at the widest point using a ruler. Leaf area was then calculated by multiplying leaf length by leaf width.

Number of branches per plant: The total number of branches produced per plant was counted and the mean value was calculated.

Number of leaves per plant: The total number of leaves per plant was counted and the average was computed.

Bud diameter (mm): The diameter of flower buds was measured in millimeters using a Vernier caliper.

Flower diameter (mm): Flower diameter was measured in millimeters using a Vernier caliper and mean values were calculated.

Number of nodes per plant: The total number of nodes per plant was counted and the average was determined.

Number of primary shoots: The number of primary shoots emerging from the ground, excluding the main stem, was recorded for each plant.

Number of flower buds per plant: The total number of flower buds produced per plant was counted and the average was calculated.

Statistical analysis: Data were analyzed using the statistical software Statistix 8.1. One-way Analysis of variance (ANOVA) was performed to evaluate the significance of treatment effects. Treatment means were compared using the least significant difference (LSD) test at the 5% probability level[14].

RESULT AND DISCUSSION

Plant height (cm): Plant height was measured and the data were subjected to analysis of variance (ANOVA), with the results also illustrated in Fig. 1. Highly significant differences were observed among all treatments with respect to plant height. Among the evaluated treatments, T_6 produced the maximum mean plant height (44.356 cm), whereas the minimum value (32.873 cm) was recorded in the control treatment (T_0). Notably, even relatively small differences in silicon concentrations resulted in statistically significant variations in plant height, indicating a strong treatment response.

The observed enhancement in plant height is consistent with previous findings. Sivanesan et al.[15,16] reported that sub-irrigational application of K_2SiO_3 and foliar spraying of Na_2SiO_3 significantly increased plant height, whereas sub-irrigational supply of $CaSiO_3$ reduced plant height compared with the control. The overall increase in plant height observed in the present study may be attributed to improved nutrient availability and enhanced physiological efficiency resulting from silicon application. Similar responses to silicon supplementation have been reported in other ornamental crops; Swaroop et al.[17] documented a significant increase in plant height in gladiolus following silicon and micronutrient application and observed comparable improvements in marigold and rose.

Stem diameter (mm): Analysis of variance (ANOVA) revealed a statistically significant effect of the treatments on stem diameter. The results, which are also presented in Fig. 2, indicated clear differences among treatments, demonstrating that the applied silicon concentrations did not exert uniform effects. Among all treatments, T_6 recorded the highest mean stem diameter (1.6033 mm), whereas the control treatment (T_0) exhibited the lowest mean value (1.1193 mm), indicating comparatively poor performance.

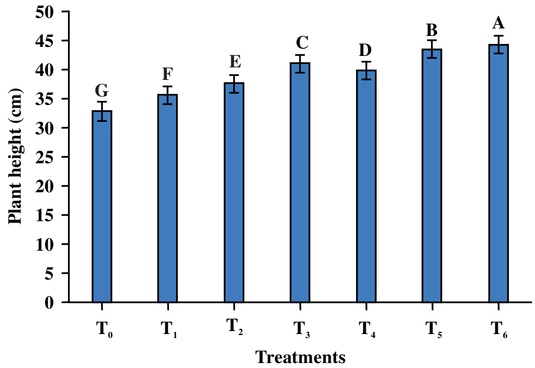

Fig. 1: Effect of silicon on plant height (cm) of *Jasminum sambac* L

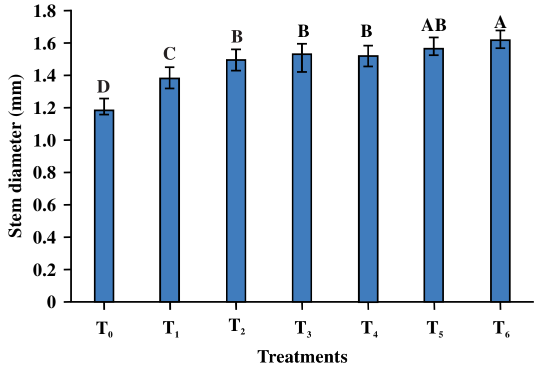

Fig. 2: Effect of Silicon on stem diameter (mm) of *Jasminum sambac* L

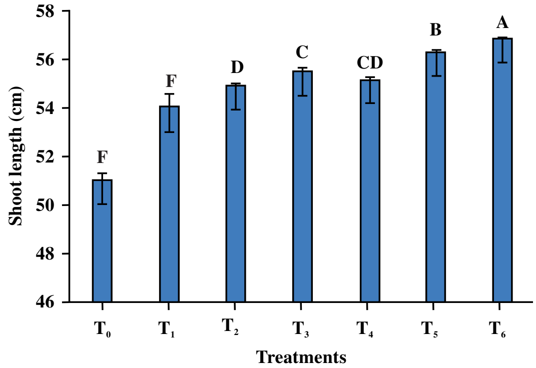

Fig. 3: Effect of silicon on shoot length (cm) of *Jasminum sambac* L

In agreement with the current results, Sivanesan et al.[15,16] showed that silicon application could either increase or decrease stem diameter relative to the control, depending on the source and method of application. Specifically, sub-irrigational application of K_2SiO_3 increased stem diameter, while both foliar and sub-irrigational applications of Na_2SiO_3 also resulted in significant increases. Similar positive effects of silicon on stem diameter have been reported in several ornamental crops, including carnation and chrysanthemum[16], gerbera[17], marigold[18] and rose[19].

Shoot length (cm): Shoot length data were subjected to statistical analysis and are also presented in Fig. 3. Among the treatments, T recorded the highest mean shoot length (56.91 cm), whereas the control treatment (T_6) exhibited the lowest mean value (51.04 cm). These results indicate a positive response of shoot elongation to silicon application. The present findings are in agreement with those of Karimian et al.[21], who reported a significant increase in shoot length in tuberose following foliar application of silicon and silicon nanoparticles (SiNPs). In contrast, Greger et al.[22] observed that silicon application reduced potassium accumulation in the shoots of species with low

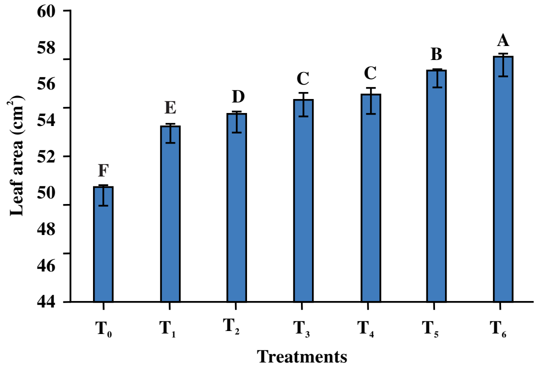

Fig. 4: Effect of Silicon on leaf area (cm^2) of *Jasminum sambac* L

silicon-accumulating capacity, such as lettuce, carrot and pea, suggesting species-specific responses to silicon. Furthermore, Saeedeh et al.[19] reported that marigold plants treated with silicon and silica exhibited significant reductions in plant height, shoot length, shoot fresh weight and flower diameter, highlighting variability in silicon responses among ornamental species. Overall, the results of the present study are consistent with those of Karimian et al.[21], confirming that silicon application can enhance shoot length and flower stem development in ornamental plants.

Leaf area (cm^2): The experiment was conducted to evaluate the effect of different treatments on leaf area using a Randomized Complete Block Design (RCBD). The results, which are also illustrated in Fig. 4, revealed significant variation in leaf area among the treatments. Among all treatments, T_6 recorded the maximum leaf area (57.51 cm^2), indicating a pronounced improvement compared with the other treatments, whereas the control treatment (T_0) exhibited the minimum leaf area (50.32 cm²).

Results of the present study indicated that silicon application significantly increased both leaf number and leaf area of African marigold. Khan et al.[23] also documented a significant increase in plant spread and leaf area in chrysanthemum and marigold, supporting the positive influence of silicon on vegetative growth attributes in ornamental crops.

Number of branches per plant: The results for the number of branches per plant were subjected to statistical analysis and are also presented in Fig. 5. Among the treatments, T_6 produced the highest mean number of branches (52.67), followed by T_3 and T_5, which recorded comparable values slightly below 51. Treatment T_4 showed a moderate response, whereas T_2, T_1 and the control treatment exhibited progressively lower numbers of branches, with the minimum value (40.40) observed in the control.

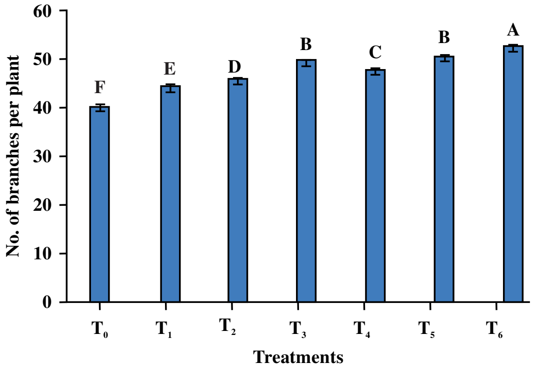

Fig. 5: Effect of Silicon on number of branches per plant of *Jasminum sambac* L

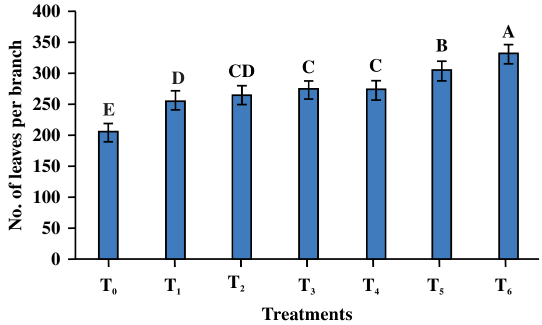

Fig. 6: Effect of Silicon on the number of leaves per branch of *Jasminum samba* L

Results of the current study indicated that silicon application enhances branching and overall plant architecture in ornamental species. Karimian et al.[21] reported a significant increase in the number of branches in chrysanthemum, marigold and rose following silicon application, supporting the positive influence of silicon on shoot proliferation and structural development.

Number of leaves per branch: The results for the number of leaves per plant were analyzed statistically and are also presented in Fig. 6. Among all treatments, T_6 was the most effective, recording the highest mean number of leaves (330.13), whereas the control treatment (T_0) produced the lowest mean value (203.60), indicating a comparatively weaker response.

The present findings are supported by previous studies demonstrating the beneficial effects of silicon on leaf production. Karimian et al.[21] reported a significant increase in leaf number in tuberose following foliar application of silicon. In contrast, Shahzad et al.[24] reported a reduction in leaf number and leaf area in tuberose under certain conditions, suggesting that plant response to silicon may vary depending on species, growth stage and application method. Farooq et al.[25] observed that foliar sprays of silicon in combination with potassium significantly increased leaf number in gladiolus, African marigold and chrysanthemum.

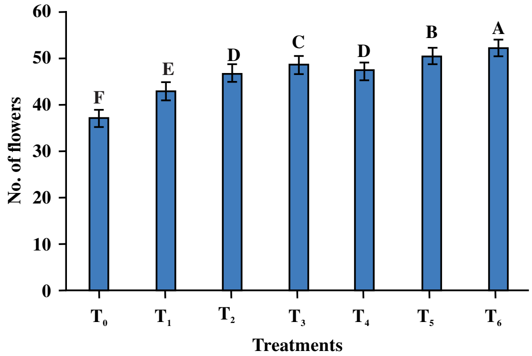

Fig. 7: Effect of Silicon on the number of flowers per plant of *Jasminum sambac* L

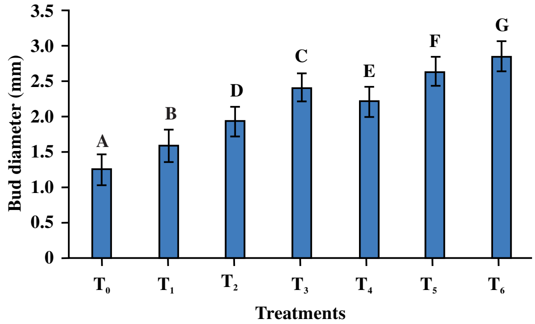

Fig. 8: Effect of Silicon on bud diameter (mm) of *Jasminum sambac* L

Number of flowers per plant: The results for the number of flowers per plant were analyzed statistically and are also presented in Fig. 7. Among all treatments, T_6 exhibited the highest mean number of flowers (52.467), followed by T_0 (50.600) and T_3 (48.800). The control treatment (T_0) produced the lowest mean value (37.400), indicating a comparatively poor flowering response.

These findings are consistent with previous reports demonstrating the positive effects of silicon on floral development. Both the source of silicon and the cultivar were found to significantly influence flower number in chrysanthemum. Sub-irrigational and foliar applications of K_2SiO_3 and Na_2SiO_3 markedly increased flower production compared with the control. Notably, K_2SiO_3 applied via appropriate methods has been shown to enhance flower yield in chrysanthemum[26].

Bud diameter (mm): The results for bud diameter were statistically analyzed and are also presented in Fig. 8. Among all treatments, T_6 produced the highest mean bud diameter (2.8600 mm), followed by T_5 (2.6600 mm) and T_3 (2.4267 mm). The control treatment (T_0) exhibited the smallest bud diameter (1.3200 mm), indicating minimal effect on bud development. These results demonstrate that T_6 was the most effective treatment in promoting bud growth, whereas T_0 had the least influence.

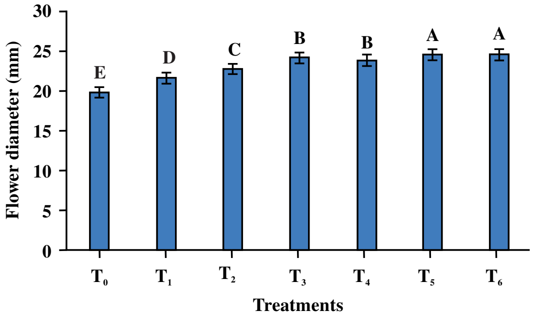

Fig. 9: Effect of Silicon on flower diameter (mm) of *Jasminum sambac* L

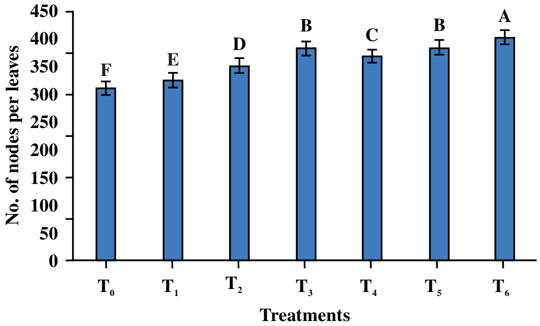

Fig. 10: Effect of Silicon on number of nodes per leaves of *Jasminum sambac* L

These findings are in agreement with previous study conducted by Zaheer et al.[27] who reported a significant increase in bud diameter in African marigold and gladiolus following silicon application. Similarly, Khan et al.[23] observed significant enhancements in plant spread, leaf area and bud diameter in chrysanthemum and marigold, supporting the positive role of silicon in improving vegetative and floral development in ornamental crops.

Flower diameter (mm): The results for flower diameter were statistically analyzed and are also presented in Fig. 9. Among all treatments, T_6 (24.65 mm) and T_5 (24.53 mm) were the most effective, showing significantly higher flower diameters compared with the other treatments. The control treatment (T_0) exhibited the lowest mean flower diameter (19.95 mm), indicating minimal effect on flower expansion.

These findings are supported by Mattson and Leatherwood[26], who reported a significant increase in flower diameter in chrysanthemum following foliar application of Na_2SiO_3. Sivanesan et al.[15,16] observed that chrysanthemum plants treated with silicon exhibited variable effects, including reductions in plant height, stem dry weight, flower diameter, fresh flower weight and dry flower weight, depending on the silicon source and method of application. In contrast, our results align with Sivanesan et al.[15,16] regarding the beneficial effects of $CaSiO_3$, which was

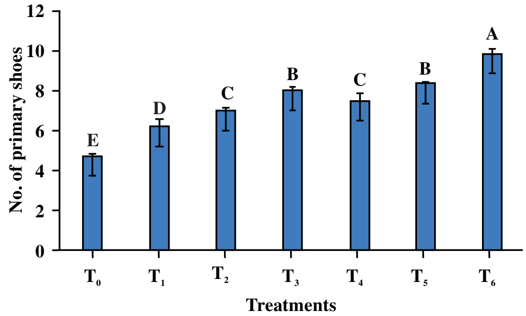

Fig. 11: Effect of Silicon on the number of primary shoots of *Jasminum sambac* L.

reported to increase stem diameter and flower size, supporting the positive influence of silicon on floral development.

Number of Node per leaves: The results for the number of nodes per plant were statistically analyzed and are also presented in Fig. 10. Among all treatments, T_6 was the most effective, producing the highest mean number of nodes (403.53), whereas the control treatment (T_0) recorded the lowest mean value (312.00), indicating minimal influence on nodal development.

Foliar application of silicon, micronutrients and growth enhancers promoted a higher number of nodes per primary shoot in marigold. Enhanced nodal development is particularly important, as it contributes to improved shoot growth and flowering potential, likely due to increased carbohydrate accumulation and overall physiological activity. Similar responses have been reported by Zahid et al.[28] in jasmine, rose and chrysanthemum, highlighting the positive role of silicon and related treatments in enhancing vegetative growth and reproductive capacity.

Number of primary shoots: The results for the number of primary shoots per plant were statistically analyzed and are also presented in Fig. 11. Among all treatments, T_6 exhibited the highest mean number of primary shoots (9.73), followed by T_5 (8.27) and T_3 (7.93). Moderate responses were observed in T_4 (7.40) and T_2 (6.93), while T_1 (6.13) showed a comparatively lower effect. The control treatment (T_0) recorded the minimum mean value (4.67), indicating limited influence on primary shoot development.

These findings are consistent with previous studies. Zaheer et al.[27] reported a significant increase in the number of primary shoots in African marigold and gladiolus following silicon application. Similarly, Khan et al.[23] observed significant enhancements in plant spread, leaf area, flower size, bud diameter and the number of primary shoots in chrysanthemum, supporting the positive role of silicon in promoting vegetative growth and shoot proliferation in ornamental crops.

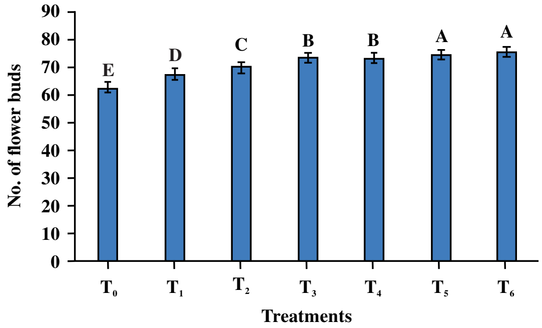

Fig. 12: Effect of Silicon on no of flower buds of *Jasminum sambac* L

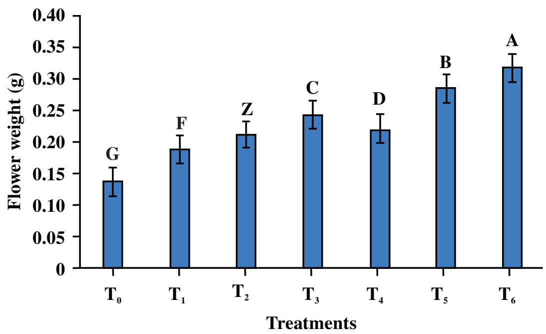

Fig. 13: Effect of silicon on flower weight(g) of *Jasminum sambac* L

Number of flowers buds: The results for the number of flower buds per plant were statistically analyzed and are also presented in Fig. 12. Among all treatments, T_6 exhibited the highest mean number of flower buds (74.93), followed closely by T_5 (74.07). Treatments T_3 (73.00) and T_4 (72.73) also showed satisfactory performance, whereas T_2 (69.47) and T_1 (67.00) demonstrated moderate improvement. The control treatment (T_0) recorded the lowest mean value (62.07), indicating minimal effect on flower bud production. These findings are supported by previous study conducted by Abdel Sadek et al.[30] who reported a significant increase in the number of flower buds in chrysanthemum following foliar application of potassium silicate. In contrast, Sadique et al.[30] observed that marigold plants treated with potassium silicate in combination with zinc and salicylic acid exhibited significant reductions in plant height, inflorescence stalk length, flower diameter, fresh flower weight and dry flower weight, highlighting that the response to silicon-based treatments may vary depending on species, treatment combinations and application methods.

Flower weight(g): The results for flower weight were statistically analyzed and are also presented in Fig. 13. Among all treatments, T produced the highest mean flower weight (0.316 g), followed by T (0.284 g) and T (0.242 g). The control treatment (T_6) exhibited the lowest mean flower weight (0.136 g), indicating minimal contribution to floral biomass.

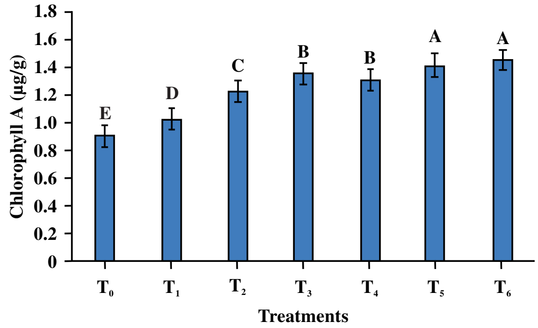

Fig. 14: Effect of Silicon on Chlorophyll A (µg/g) of *Jasminum sambac* L

In agreement with the findings of the present study, Abdel Sadek et al.[29] reported a significant increase in flower weight in chrysanthemum following foliar application of potassium silicate. In contrast, Sadique et al.[30] observed that marigold plants treated with potassium silicate in combination with zinc and salicylic acid showed significant reductions in plant height, inflorescence stalk length, flower diameter, fresh flower weight and dry flower weight. Similarly, Mahant et al.[31] documented significant increases in flower weight, bud diameter and flower diameter in African marigold. Khan et al.[23] also reported notable improvements in plant spread, leaf area, bud diameter and flower weight in chrysanthemum and marigold, supporting the beneficial role of silicon-based treatments in enhancing floral development and biomass accumulation in ornamental crops.

Biochemical attributes

Chlorophyll A: The results for chlorophyll A content were statistically analyzed and are also presented in Fig. 14. The overall average (grand mean) across treatments was 1.2467, with a coefficient of variation (CV) of 5.70%, indicating consistent and reliable measurements. Among the treatments, T_6 exhibited the highest chlorophyll A content (1.4600), followed by T_5 (1.4200), whereas the control treatment (T_0) recorded the lowest mean value (0.9067).

These findings are supported by previous studies reporting that silicon application significantly enhances chlorophyll A content in ornamental species such as tuberose and chrysanthemum, with values ranging from 16.43 to 25.88 mg g^{-1}, compared to 10.72 mg g^{-1} in untreated controls. The observed improvement is likely attributable to silicon's role in enhancing nutrient uptake and stabilizing chloroplast structure, thereby improving photosynthetic efficiency[32].

Chlorophyll B (µg/g): The results for chlorophyll B content were statistically analyzed and are also presented in Fig. 15. Treatments were grouped into seven homogeneous

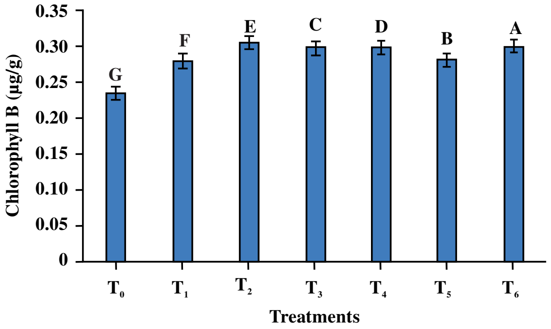

Fig. 15: Effect of Silicon on Chlorophyll B (µg/g) of *Jasminum sambac* L

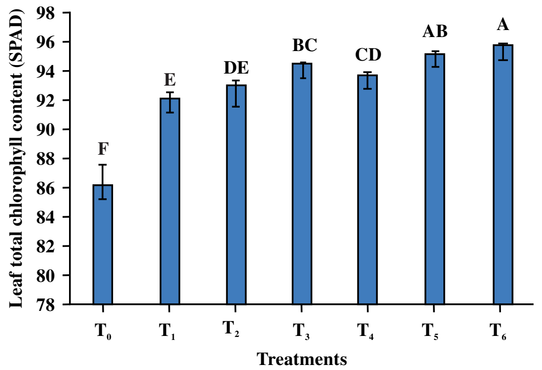

Fig. 16: Effect of Silicon on total leaf Chlorophyll content (SPAD) of *Jasminum sambac* L.

categories (A-G), each representing statistically distinct performance levels. T_6 exhibited the highest mean chlorophyll B content (0.5800) and was classified in group A, indicating the best performance. This was followed by T_5 (0.5400) in group B and T_3 (0.4400) in group C. Subsequent treatments showed progressively lower values: T_4 (0.3600) in group D, T_2 (0.3200) in group E, T_1 (0.2400) in group F and T_0 (0.1218) in group G, representing the lowest performance.

Chlorophyll B content increased with silicon application, ranging from 8.35 to 14.67 mg g^{-1}, compared with 5.12 mg g^{-1} in the control. The elevated chlorophyll B levels indicate enhanced pigment formation and light-harvesting capacity, which likely contributed to improved plant growth and flowering[32]. These results are consistent with Harizanova and Koleva Valkova[33], who reported significant increases in chlorophyll A, chlorophyll B and total chlorophyll in plants following silicon application.

Total leaf chlorophyll content (SPAD): The results for total leaf chlorophyll content were statistically analyzed and are also presented in Fig. 16. Among the treatments, T_6 exhibited the highest mean value (95.699) and was classified in group A, representing the best-performing treatment. T_5 (95.188) and T (94.431) also showed high performance,

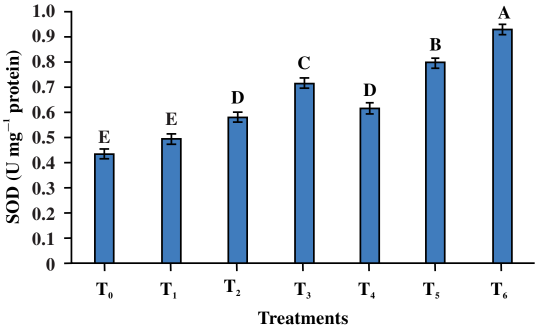

Fig. 17: Effect of Silicon on Superoxide dismutase activity of *Jasminum sambac* L.

falling into groups AB and BC, respectively. Treatments T_4 (93.754) and T_2 (92.999) demonstrated moderate performance, while T recorded a comparatively lower value (92.007). The control treatment (T_0) exhibited the lowest mean (86.148), representing the least effective treatment.

Silicon significantly increased chlorophyll accumulation in jasmine and chrysanthemum compared with the control. Eghlima et al.[34] reported that silicon and other foliar applications positively influenced chlorophyll content in marigold. Similarly, previous studies on chrysanthemum (*Dendranthema grandiflorum*)[15,16] also demonstrated increased chlorophyll levels following silicon supplementation, supporting the role of silicon in enhancing photosynthetic pigment accumulation.

Enzymes activity

Superoxide dismutase activity (U mg^{-1} protein): The results for superoxide dismutase (SOD) activity (U mg^{-1} protein) were statistically analyzed and are also presented in Fig. 17. Among the treatments, T_6 recorded the highest mean SOD activity (0.9200), followed by T_5 (0.7867) and T_3 (0.7067), whereas the control treatment (T_0) exhibited the lowest mean value (0.4267), comparable to T_1 (0.4867). These results indicate significant treatment effects and demonstrate the effectiveness of the Randomized Complete Block Design (RCBD) in minimizing experimental error.

Shahzad et al.[24] observed significantly lower activities of ascorbate peroxidase (APX) and SOD in tuberose, while silicon application increased the activities of both enzymes. In marigold, reductions in APX and SOD activity were noted under control conditions, whereas silicon treatment enhanced their activities. Conversely, catalase (CAT) activity showed negligible reductions across all treatments. Overall, SOD exhibited the highest physiological activity among the antioxidant enzymes, showing significantly greater activity compared to the control and other experimental conditions. These results suggest that foliar application of silicon can effectively enhance the activity of antioxidant enzymes, contributing to improved plant stress tolerance.

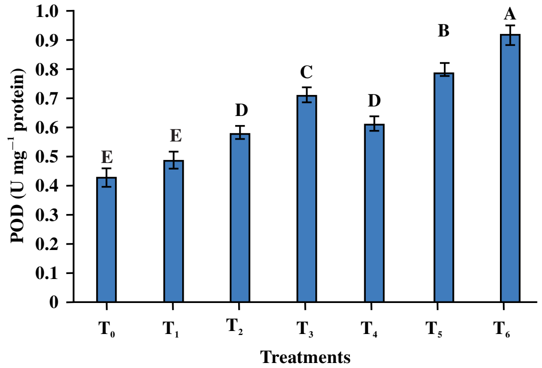

Fig. 18: Effect of silicon on peroxide activity of *Jasminum sambac* L.

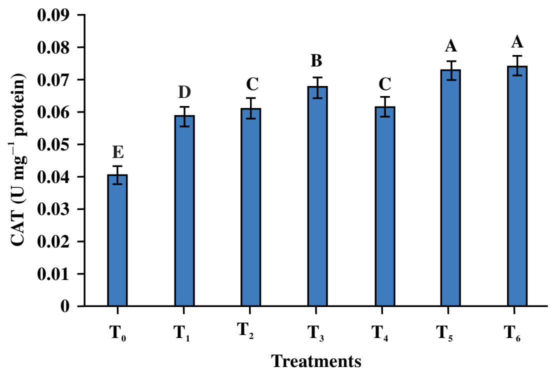

Fig. 19: Effect of silicon on catalase activity of *Jasminum sambac* L

Peroxide activity (U mg^{-1} protein): The results for peroxidase (POD) activity (U mg^{-1} protein) were statistically analyzed and are also presented in Fig. 18. Among all treatments, T exhibited the highest mean POD activity (0.9200), followed by T_5 (0.7867) and T_3 (0.7067). The lowest mean value (0.4267) was observed in the control treatment (T_0), with T_1 showing a comparable, slightly higher value (0.4867). These results indicate that T was the most effective treatment, whereas T_0 showed minimal performance, highlighting the significant impact of silicon application on POD activity.

Silicon treatment has been shown to enhance peroxidase activity, contributing to the mitigation of oxidative stress in plants. Similarly, previous studies reported increased POD activity in sunflower following silicon supplementation[35]. These observations suggest that silicon strengthens the antioxidant defense system by enhancing POD and related enzyme activities. In addition, the present study demonstrated increased enzyme activity in the apical tips of sunflower leaves during silicon application, further supporting its role in improving plant physiological resilience.

Catalase activity (U mg^{-} Protein): The results for catalase (CAT) activity (U mg^{-1} protein) were statistically analyzed and are also presented in Fig. 19. The treatment means showed clear and statistically significant differences. T_6 (0.0744) and T_5 (0.0726) recorded the highest CAT activity, indicating that these treatments were most effective in enhancing the studied parameter. T (0.0680) also exhibited strong performance, though slightly lower than T_6 and T_5. Moderate effects were observed in T_4 (0.0616) and T_2 (0.0612), which performed better than the lower-ranked treatments but did not match the top three. T_1 (0.0590) showed a relatively weaker effect, while the control treatment (T_0, 0.0404) exhibited the lowest mean value, indicating minimal effectiveness.

Silicon application significantly enhances CAT activity in plants, including chrysanthemum, which plays a crucial role in detoxifying hydrogen peroxide ($H_2 O_2$) into water and oxygen. This increase may be attributed to silicon's influence on the CAT biosynthesis pathway within peroxisomes. Enhanced CAT activity also supports the activation of other antioxidant enzymes, such as ascorbate peroxidase (APX) and guaiacol peroxidase (GPX). Similarly, previous studies have reported that silicon boosts CAT activity in various crops and ornamental flowers, including wheat, marigold and tuberose[36].

CONCLUSION

All measured parameters exhibited significant responses to silicon application. The study concludes that foliar application of silicon markedly enhanced the growth and flower yield of jasmine (*Jasminum sambac* L.) by improving plant height, number of branches, leaf area, stem diameter, number of flowers and flower size. Among all treatments, T_6 (150 mg L^{-1} silicon) was the most effective in promoting overall plant performance and floral productivity. These findings indicate that silicon can serve as a valuable supplement in jasmine cultivation to improve both growth and yield. Future research should investigate silicon's role in enhancing post-harvest quality and vase life of jasmine flowers. Additionally, studies should explore its potential application in organic jasmine farming systems. The development of digital decision-support tools could further assist growers in optimizing silicon use in real-time, thereby improving efficiency and crop performance.

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