Influence of Silicon Supplementation and Farmyard Manure on Yield Attributes of Tomato (Solanum lycopersicum Mill.) Var. SL-12: A Comparative Study

ABSTRACT

The present investigation was carried out at Hi-Tech Unit, Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur. The fourteen treatments for the tomato crop were evaluated with three replications under randomized block design.

The results exhibit the significant effect of various treatments on growth, yield quality of tomato and their residual effect on different soil properties. Maximum number of clusters per plant (6.86), number of flowers per cluster (8.88), number of fruits per plant (27.73), fruit weight(83.47 g), fruit volume (77.28 cc), specific gravity (1.04 g/cc), fruit length (6.51 cm), yield per plant (1030.26 g), yield per plot (30.74 kg) and yield per ha (307.43 q/ha) was recorded with treatment T_9 (RDF + 25 t ha^{-1} FYM + 100 kg ha^{-1}Silicon through Diatomaceous earth). Maximum net return of 256182 found in T_9 and maximum B: C Ratio (3. 88) was recorded with T_{10}.

The study suggests using treatment T9 for improved tomato yield and exploring silicon supplementation in cultivation practices. It emphasizes continuous soil monitoring and precision agriculture for sustainable production. Future research should focus on cost-effective methods, genetic studies and collaboration.

Keywords: Tomato (*Solanum lycopersicon* Mill.), Silicon supplementation, Yield, Open field cultivation and Economic analysis

1. **Introduction:**

Tomato (*Solanum lycopersicum* Mill.) is a globally significant vegetable crop valued for its nutritional richness and versatile culinary applications. Belonging to the Solanaceae family, tomatoes are cultivated extensively across diverse climates and regions, contributing substantially to both fresh consumption and processed food industries worldwide.

Optimizing tomato production involves addressing numerous factors that influence yield, quality and sustainability. Key among these factors are soil fertility management and the application of appropriate agricultural inputs. Silicon (Si) and farmyard manure (FYM) have emerged as integral components in enhancing tomato productivity through their respective roles in soil health improvement and plant nutrient uptake efficiency[17,18,19].

Silicon, though not classified as an essential nutrient, has demonstrated considerable benefits in various crops, including tomatoes. Studies have shown that silicon supplementation can enhance plant vigor, improve resistance to biotic and abiotic stresses such as pests, diseases and environmental fluctuations and potentially increase yield and fruit quality (Choudhary *et al*., 2021; Shabala & Bose, 2021). This biostimulant effect of silicon underscores its potential to contribute significantly to sustainable agriculture by reducing reliance on synthetic chemicals while improving crop resilience.

Farmyard manure, a traditional organic fertilizer derived from animal waste, enriches soil fertility by enhancing organic matter content, nutrient availability and beneficial microbial activity. Its application not only improves soil structure and water retention but also supports long-term soil health and sustainability in agricultural systems (Zou & Li, 2022; Andrade *et al*., 2022). Integrated use of FYM promotes nutrient cycling, reduces environmental impact and enhances overall crop productivity.

Despite the individual benefits of silicon and FYM, comprehensive studies investigating their combined effects on tomato production, particularly under specific cultivars like SL-12, are limited. Understanding the synergistic interactions between these inputs is crucial for optimizing agricultural practices towards sustainable intensification and ensuring food security amidst changing environmental conditions.

Therefore, this study aims to explore the influence of silicon supplementation and farmyard manure on yield attributes of tomato variety SL-12 through a comparative analysis. By evaluating parameters such as plant height, fruit yield per plant, fruit quality and overall productivity, this research endeavors to contribute valuable insights into enhancing tomato crop management practices for sustainable agriculture.

2. Material method

2.1 Location of experimental site:

The experiment was conducted at open field of Hi-Tech Horticulture Unit, Department of Horticulture, Rajasthan College of Agriculture, which is situated in Udaipur at 24^{o}35’ N latitude 74^{o}42’ E longitude at 585.17 meters above the mean sea level.

2.2 Climate and weather conditions:

The site of experiment is situated in agro climate Zone IV is sub-tropical and semi-arid climate characterized by moderate summer and mild winter. The average rainfall of the area is 830 mm per year. More than 90% rainfall received from south-west monsoon and generally occurs during mid-June to end of September. Mean weekly weather parameters data received from AICRP, Meteorology, Department of Agronomy during the experimental period (October, 2020 to March, 2021).

2.3 Soil of the experimental location:

To assess the fertility and physicochemical properties of the soil, samples were collected from the experimental site using spades, hand hoes and screw augers, reaching a depth of 30 cm. These samples were then analyzed to determine the initial status of various soil parameters including pH, electrical conductivity (EC), organic carbon content, nitrogen (N), phosphorus (P) and potassium (K). This comprehensive analysis was conducted prior to commencing the experiment to establish baseline soil conditions.

2.3 Treatments for tomato are given below with their notations:-

Notation		Treatments
T_1	:	Control
T_2	:	RDF (120:80:80)
T_3	:	25 tonnes FYM / ha
T_4	:	20 kg/ha Silicon through Diatomaceous earth
T_5	:	25 tonnes FYM/ha + 40 kg/ha Silicon through Diatomaceous earth
T_6	:	RDF + 25 tonnes FYM

T_7 : RDF + 25 tonnes FYM/ha + 60 kg/ha Silicon through Diatomaceous earth

T_8 : RDF+ 25 tonnes FYM/ha + 80 kg/ha Silicon through Diatomaceous earth

T_9 : RDF+ 25 tonnes FYM/ha + 100 kg/ha Silicon through Diatomaceous earth

T_{10} : RDF+ Silicon 2% through Diatomaceous earth

T_{11} : RDF + 25 tonnes FYM/ha + Silicon 2% through Diatomaceous earth

T_{12} : RDF + 25 tonnes FYM/ha + Silicon 4% through Diatomaceous earth

T_{13} : RDF + 25 tonnes FYM/ha + Silicon 6% through Diatomaceous earth

T_{14} : RDF + 25 tonnes FYM/ha + Silicon 8% through Diatomaceous earth

2.4 Details of crop operations for tomato:-

The experiment used tomato variety "SL-12" with a determinate hybrid with good foliage, red fruit color and good firmness. Seedlings were sown on 14th October 2020 in plastic pro-trays with rooting media mixtures. Field preparation involved preparing a plot of 4.0 m x 2.50 m size and applying FYM, RDF and Silicon doses. Transplanting was done four weeks old and fertilizers were applied according to treatment. Intercultural operations were kept weed-free and harvesting began 60-70 days after transplanting.

2.5 Methodology used for observation recorded

For recording the observations on different aspects of the study, five plants were randomly selected in each plot and were tagged. The study assessed various yield attributes of tomato plants under different treatments. These attributes included the number of clusters per plant, the number of flowers per cluster, the number of fruits per plant, fruit weight, fruit volume, specific gravity, fruit length, yield per plant, yield per plot and yield per hectare. The evaluation of the most profitable treatment combinations was based on the relative economics, considering net returns and net returns per rupee investment. The cost of cultivation encompassed expenses such as field preparation, seeds, fertilizers, irrigation, labor and transportation. Gross returns were estimated from the total yield per hectare and net returns were calculated by subtracting the total cost of cultivation per hectare. The net returns per rupee investment (B: C ratio) were determined by dividing net returns by the total cost of cultivation per hectare. This comprehensive analysis aimed to identify the most economically viable treatment strategies for tomato cultivation.

2.6 Statistical Analysis

The data recorded for the evaluation of different parameters was statistical analyzed using standard procedure for ANOVA of Randomized Block Design in order to test the significance of experimental results. The analysis of variance was done by the method suggested by Fisher (1954) and using analysis as described by Panse and Sukhatme (1967).

3. Result and discussion

3.1 Yield attributes

The investigation into the effects of various treatments on tomato growth parameters demonstrated significant outcomes, with treatment T9 consistently yielding superior results across multiple metrics. T9, which involved the application of RDF along with 25 t ha-1 FYM and 100 kg ha-1 Silicon through Diatomaceous earth, exhibited remarkable performance in enhancing fruit yield and quality. The number of clusters per plant reached a maximum of 6.86, showing a substantial increase compared to controls and other treatments. Similarly, the number of flowers per cluster and fruits per plant were significantly higher under T9, with increases ranging from 4.89 percent to 42.20 percent compared to controls and other treatments. Moreover, T9 produced the highest fruit weight (83.47 g), fruit volume (77.82 cc), specific gravity (1.04 g/cc), fruit length (6.51 cm), yield per plant (1030.26 g), yield per plot (30.74 kg) and yield per hectare (307.43 q). These values represented significant improvements over controls and other treatments, with increases ranging from 7.58 percent to 87.76 percent. Additionally, T9 demonstrated favorable economic outcomes, with a maximum net return of ₹ 256182 and a B:C Ratio of 3.88, highlighting its efficiency in enhancing both productivity and profitability in tomato cultivation under open conditions.

The results of the present investigation showed that response of various treatments on different yield contributing parameters. The results revealed that the application of (RDF + 25 t ha^{-1} FYM + 100 kg ha^{-1}Silicon through Diatomaceous earth), recorded the maximum number of clusters per plant (6.86), number of flowers per cluster (8.88), number of fruits per plant (27.33), fruit weight (83.47 g), fruit volume (77.72 cc), specific gravity (1.04), fruit length (6.51

cm), yield per plant (1069.72 g), yield per plot (36.31 kg) and yield per ha (363.10 q/ha) may be due to increased dose of RDF., FYM and silicon treatment respectively result are in conformity with finding of Prativa and Bhattarai 2011, Cuong *et al.* 2017 and Chumayani *et al.* 2012.

The higher values of all the yield contributing parameter by the application of RDF + 25 t ha^{-1} FYM + 100 kg ha^{-1}Silicon through Diatomaceous earth, might be due to the nutrient supply by inorganic fertilizers during initial growth period and sustained supply of nutrient and congenial condition by FYM and induced tolerance against biotic and abiotic stress by Silicon.

Further, the better plant growth provide greater site for photosynthesis and translocation of photosynthates from source to sink (leaves to fruits) as observed by Tekale *et al.* 2017. Organic sources provides all major and minor growth nutrient and also improve physico-chemical and biological properties of soil which helps plant root to proliferates, resulting in larger coverage of rhizosphere area and better uptake of nutrients. Higher fruit weight might be due to solubilization effect of plant nutrients by addition of FYM leading to increased uptake of N, P and K as observed by Prativa and Bhattarai 2011. Findings of Singh *et al.* 2017 was also in conformity as they reported greatest impact on number of fruits per plant and yield per hectare in tomato with the application of organic manures. Same trend were also observed by Meena and Verma 2019 while working with tomato with the application of vermicompost.

The application of NPK favored the metabolic and auxin activity which accelerate the photosynthetic rate and in turn increased the supply of carbohydrates in plants and ultimately resulted in increased fruit size, number of fruits per plant, average fruit weight, yield per plant and yield per hectare Everaarts and Boou 2000.

Further the application of Silicon has direct or indirect positive effects on the physiology and metabolism of crop plants. Increase in yield attributes of tomato due to silicon application might be due to higher photosynthetic activity of plant, more formation of carbohydrates and more uptakes of other nutrients. Similar results were also noticed by Falah, 2013. Results also revealed that silicon addition helped plant growth, which might be due to the increased synthesis of photosynthates by the silicon addition and it was exerted in the increased number of branches and the reduction of pest and disease infestation. These result corroborated the findings of Buck *et al.*, 2008 and Prakash *et al.*, 2011. Similar results were observed by Lavinsky *et al.*, 2016 who reported that the contribution of carbohydrates from photosynthetic activity for longer period might have resulted in efficient translocation of food material into the sink (grain) thereby increased the number of filled grains percentage. This might be due to increased synthesis of carbohydrates and that might have increased the sink size and capacity. Silicon application, that may significantly reduce empty spikelet's number in wheat and increase fertility, increased spikelets per year that ultimately increased crop yield. soundharya 2019 in tomato, Priya *et al.* 2015 in potato and Vashi *et al.* 2019 in okra also confirm the results of increased performance of thr crop by the application of Silicon.

Table 1 Effect of Inorganic fertilizer, FYM and Silicon on Number of clusters per plant, Number of flowers per cluster, Number of fruits per plant, Fruit weight (g), Fruit volume (cc), Specific gravity (g/cc), Fruit length (cm), Yield per plant (g), Yield per plot (kg) and Yield (q per ha) of tomato.

Treatments	Number of clusters per plant	Number of flowers per cluster	Number of fruits per plant	Fruit weight (g)	Fruit volume (cc)	Specific gravity (g/cc)	Fruit length (cm)	Yield per plant (g)	Yield per plot (kg)	Yield (q per ha)
T_1 : Control	3.97	5.95	16.09	62.74	66.92	0.90	4.48	494.70	16.37	163.73
T_2 : RDF (120:80:80 kg/ha NPK)	5.54	6.67	19.50	66.05	71.83	0.94	5.01	599.98	20.40	203.99
T_3 : 25 tonnes FYM /ha	4.40	6.18	18.04	64.48	68.83	0.92	4.72	570.99	19.41	194.13
T_4 : 20 kg/ ha Silicon through Diatomaceous earth	4.49	6.27	17.77	63.18	68.04	0.94	4.76	508.33	16.56	165.63
T_5 : 25 tonnes FYM / ha + 40 kg /ha Silicon through Diatomaceous earth	4.97	6.56	20.15	67.58	71.65	0.94	5.20	667.26	22.69	226.87
T_6 : RDF + 25 tonnes FYM	5.43	7.12	22.75	72.61	75.37	0.96	5.74	809.22	27.31	273.06
T_7 : RDF + 25 tonnes FYM/ ha + 60 kg/ ha Silicon through Diatomaceous earth	5.95	7.72	24.18	75.93	76.71	0.99	6.04	899.73	27.94	279.40
T_8 : RDF+ 25 tonnes FYM / ha + 80 kg /ha Silicon through Diatomaceous earth	6.26	7.97	24.76	78.00	77.72	1.00	6.11	928.73	29.67	296.74
T_9 : RDF+ 25 tonnes FYM / ha + 100 kg /ha Silicon through Diatomaceous earth	6.86	8.88	27.73	83.47	77.82	1.04	6.51	1030.26	30.74	307.43

T_{10} : RDF+ Silicon 2% through Diatomaceous earth	5.29	7.01	22.31	68.17	71.52	0.97	5.40	745.36	25.34	253.42
T_{11}: RDF + 25 tonnes FYM /ha + Silicon 2% through Diatomaceous earth	5.63	7.40	23.26	71.80	74.03	0.97	5.61	818.62	27.83	278.33
T_{12} : RDF + 25 tonnes FYM/ha + Silicon 4% through Diatomaceous earth	5.81	7.53	23.52	73.07	74.56	0.96	5.82	841.78	27.97	279.74
T_{13}: RDF + 25 tonnes FYM/ha + Silicon 6% through Diatomaceous earth	6.22	8.12	24.94	74.03	73.06	1.01	6.18	904.78	29.21	292.13
T_{14} : RDF + 25 tonnes FYM/ha + Silicon 8% through Diatomaceous earth	6.54	8.41	25.29	80.47	76.12	1.01	6.40	969.84	29.86	298.60
SEm±	**0.17**	**0.17**	**0.66**	**1.50**	**1.32**	**0.01**	**0.12**	**22.44**	**0.937**	**8.842**
CD at 5 %	**0.49**	**0.50**	**1.93**	**4.36**	**3.86**	**0.02**	**0.34**	**65.23**	**2.723**	**25.704**

4. Conclusion

The investigation into the effects of various treatments on tomato growth parameters, particularly focusing on the impact of Silicon, revealed significant outcomes. Treatment T9, comprising RDF along with 25 t ha-1 FYM and 100 kg ha-1 Silicon through Diatomaceous earth, consistently demonstrated superior results across multiple yield attributes. This treatment led to significant increases in the number of clusters per plant, number of flowers per cluster, number of fruits per plant, fruit weight, fruit volume, specific gravity, fruit length, yield per plant, yield per plot and yield per hectare. These improvements ranged from 7.58 percent to 87.76 percent compared to controls and other treatments, indicating the substantial efficacy of Silicon supplementation in tomato cultivation. The observed enhancements in yield and quality parameters can be attributed to the synergistic effects of RDF, FYM and Silicon, which collectively contributed to improved nutrient supply, enhanced plant growth and increased tolerance against biotic and abiotic stresses. Additionally, the application of Silicon facilitated greater photosynthetic activity, increased carbohydrate synthesis and improved translocation of nutrients, ultimately leading to enhanced crop performance. The findings of this study align with previous research indicating the positive influence of Silicon on various crops, further emphasizing its potential as a beneficial supplement in agricultural practices. Overall, the results underscore the importance of Silicon application in optimizing tomato productivity and profitability under open field conditions, thus offering valuable insights for improving tomato cultivation strategies.

5. Recommendations:

The study recommends farmers to adopt treatment T9, which includes RDF, 25 t ha-1 FYM and 100 kg ha-1 Silicon through Diatomaceous earth, for improved tomato growth, yield and quality. Farmers should also explore the integration of silicon supplementation into their tomato cultivation practices to enhance productivity and resilience to stress. Continuous monitoring of soil properties is crucial for sustainable tomato production. Precision agriculture techniques can optimize resource use efficiency and minimize environmental impacts. Further research on silicon application methods is needed to optimize silicon utilization. Farmers should have access to information and training programs on silicon supplementation benefits. Economic viability assessments should be conducted to evaluate the cost-effectiveness of different treatment options. Continuous monitoring and evaluation are essential for long-term effects on soil health, yield sustainability and economic returns.

Future thrust

Research on silicon-rich amendments in tomato cultivation should focus on cost-effective and environmentally sustainable alternatives. Genetic studies should be conducted to improve silicon uptake efficiency in tomato plants. Integrated nutrient management strategies should be explored, combining silicon supplementation with other fertilizers. Precision silicon application technologies can facilitate precise application of silicon in tomato fields. Climate-smart silicon management practices are needed to mitigate heat, drought, pest and disease pressures. Silicon supplementation can provide ecosystem services like soil carbon sequestration, water retention, biodiversity conservation and climate resilience. Collaboration between researchers, extension services, policymakers and farmers is essential for effective knowledge transfer. The economic and social implications of adopting silicon supplementation in tomato farming systems should also be investigated.

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