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Performance of Tomato (*Solanum lycopersicum* L.) as influenced by silica and biochar in Polyhouse condition

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ABSTRACT

This study evaluated the effects of soil-applied biochar and silica, combined with foliar silica sprays, on the growth, yield, quality and economics of tomato (*Solanum lycopersicum* L.) under polyhouse conditions. Conducted from August, 2024 to February, 2025 at the Hi-Tech Horticulture Unit, Udaipur, the experiment employed a completely randomized design with fifteen treatments: biochar (@100 and @200 kg/acre), silica (@100 and @200 kg/acre), foliar silica (1% and 2%), and all possible combinations. Combined amendments significantly enhanced vegetative growth (plant height, branches number and leaf area), accelerated flowering, harvest and improved fruit attributes (size and weight). The highest performance was achieved by T_{11} (Biochar @200 kg/acre + 2% foliar silica), yielding 3.47 kg per plant and 12.83 kg per meter square. These findings demonstrate that integrating biochar and silica optimizes tomato productivity, fruit quality and profitability in protected cultivation.

KEYWORDS

Tomato, Silica, Biochar, Polyhouse

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Tomato (*Solanum lycopersicum* L.) ranks among the most widely cultivated and economically significant vegetable crops globally, second only to potato. Belonging to the Solanaceae family, tomato contributes substantially to human nutrition, offering a rich source of vitamins A and C, iron and antioxidants. Its versatile use in raw and cooked forms across salads, sauces, juices and pickles adds to its high demand and popularity. According to (Anonymous, 2022), global tomato production reached 186.82 million tons in 2020, with India contributing 11.01% (20.57 million tons), placing it second after China.

Despite its importance, tomato cultivation faces challenges from soil degradation nutrient deficiencies and the excessive use of chemical fertilizers that threaten long-term productivity and environmental health. To address these concerns, the application of sustainable soil amendments such as biochar and silica is gaining momentum. Biochar a carbon-rich byproduct from pyrolyzed agricultural waste improves soil structure, water retention, cation-exchange capacity and microbial activity, while contributing to carbon sequestration and nutrient conservation (Lehmann *et al.,* 2011). Similarly, silicon (Si), the second most abundant element in the Earth's crust, is recognized for its role in strengthening plant cell walls, enhancing stress resilience and optimizing nutrient uptake (Zhang *et al.,* 2021).

Studies have shown that biochar enhances tomato growth and branching, particularly under drought conditions, by improving moisture and nutrient availability (Afaf *et al.,* 2023). Silica applications, especially via foliar sprays, contribute to photosynthetic efficiency, reduction in transpiration and modulation of hormonal activity, which promotes branch outgrowth and enhances fruit set (Fryrear *et al.,* 2010). These amendments also booster plant resistance to both biotic and abiotic stressors, including salinity, temperature extremes and pathogen attacks. Recent research suggests that combining biochar and silica can produce synergistic benefits, resulting in improved crop yield, quality traits such as total soluble solids and fruit firmness and economic returns. The integration of these sustainable inputs holds promise for transforming protected cultivation systems like polyhouses, where controlled environments amplify the effectiveness of nutrient interventions.

Materials and Methods

The experiment was conducted in a naturally ventilated polyhouse from August 2024 to February 2025 at the Hi-Tech Horticulture Unit, Department of Horticulture, Rajasthan College of Agriculture, Udaipur, Rajasthan. Udaipur is situated at 24°35'N latitude and 74°42'E longitude, 585.5 meters above mean sea level and comes under the IV agro-climatic zone of Rajasthan, known as sub-humid southern plains and Aravali hills.

The experiment was laid out in a completely randomized design with three replications and fifteen treatments as per the recommended dose of fertilizer T_1- Control, T_2- Soil application of Biochar @100kg/acre, T_3- Soil application of Biochar @200kg/acre, T_4- Soil application of Silica @100kg/acre, T_5- Soil application of Silica @200kg/acre, T_6- Foliar application of Silica @1%, T_7- Foliar application of Silica @2%, T_8- Soil application of Biochar @100kg/acre + Foliar application of Silica @1%, T_9- Soil application of Biochar @100kg/acre) + Foliar application of Silica @2%, T_{10}- Soil application of Biochar @200kg/acre + Foliar application of Silica @1%, T_{11}- Soil application of Biochar @200kg/acre + Foliar application of Silica @2%, T_{12}- Soil application of Silica @100kg/acre + Foliar application of Silica @1%, T_{13}- Soil application of Silica @100kg/acre + Foliar application of Silica @2%, T_{14}- Soil application of Silica @200kg/acre + Foliar application of Silica @1%, T_{15}- Soil application of Silica @200kg/acre + Foliar application of Silica @2%. Silica and Biochar were applied before transplanting and foliar application was done at30 and 60DAT.

The tomato cv. Heem Sohna was used in this experiment. Date of raising the nursery of crop was 28 July, 2024 and transplanting of seedlings was done on the day of 30 August, 2024. Data were recorded for plant height at 30 DAT, 60 DAT and at final harvest (cm), number of branches per (at final harvest), leaf area (cm^2), days taken to first anthesis, days taken to first harvest, number of fruits per plant, fruit diameter (cm), fruit length (cm), fruit weight (g), fruit volume (cc), fruit yield per plant (kg) and yield per meter square (kg) from randomly selected five tagged plants of each treatment and were further analyzed.

Results and Discussion

Growth Parameters

Maximum plant height at 60 DAT, 90 DAT and final harvest (45.91 cm, 82.30 cm and 239.25 cm, respectively), number of branches per plant at final harvest (29.86), leaf area (249.85 cm^2) were recorded with treatment T_{11} while minimum days taken for first anthesis (42.66) and days taken for first harvest (81.92) were recorded with treatment T_{15}.

While, T1 recorded minimum plant height at 60 DAT, 90 DAT and at final harvest (30.49 cm, 64.92 cm and 215.55 cm, respectively), number of branches per plant (20.12), leaf area (201.2 cm^2), maximum days taken for first anthesis (45.55) and days taken for first harvest (92.62). This might be due to physico-chemical and biological properties of soil, availability of organic carbon for heterotrophic organisms, improved soil aggregation, an increased organic acid which acts as stimulant for crop nutrient supply. Organic amendments enhance physiological processes like leaf expansion and chlorophyll synthesis. A finding of (Tombeur *et al*., 2021, Afshari *et al*., 2021 and Satter *et al*., 2020) was in conformity with study.

Yield Parameters

Maximum number of fruits per plant (42.98), fruit diameter (5.15 cm), fruit length (4.50 cm), fruit weight (80.67 g), fruit volume (85.96 cc), fruit yield per plant (3.47 kg) and yield per meter square (12.83 kg) was obtained with treatment T_{11}. Whereas, minimum number of fruits per plant (2.23 kg), fruit diameter (4.15 cm), fruit length (4.05 cm), fruit weight (71.43 g), fruit volume (73.86 cc), fruit yield per plant (2.23 kg) and yield per meter square (8.26 kg) was observed in treatment T_1. This might be due to the cumulative effect of increased plant growth parameters like plant height, number of branches per plant and application of higher concentration of treatments which enables plant roots to proliferate, resulting in better soil coverage and uptake of nutrients by plant. The better plant growth provides greater sites and surface area for photosynthesis and translocation of photosynthates from source to sink (fruits). The present findings over yield and its associated traits closely matched with the observations of (Zhai *et al.,* 2016, Agbna *et al.,* 2017 and Surve *et al.,* 2021).

Table 1. Effect of silica and biochar on various growth parameters of tomato

S. N.	Plant Height (cm)			Number of Braches at Final Harvest	Leaf Area (cm^2)	Days to First Anthesis	Days to First Harvest
	60 DAT	90 DAT	at Final Harvest				
T1	30.49	64.92	215.55	31.25	201.02	45.55	92.62
T2	31.42	69.27	220.92	32.92	210.29	45.25	91.98
T3	33.37	74.65	224.62	33.68	216.12	44.99	91.16
T4	31.03	65.33	218.41	32.09	212.51	44.86	90.82
T5	33.76	74.99	228.44	34.11	216.82	44.50	89.48
T6	32.29	73.43	220.92	32.18	211.75	43.89	88.86
T7	36.83	75.03	229.01	34.91	219.78	43.56	87.68
T8	39.71	76.29	230.41	36.89	218.36	42.90	87.16
T9	40.84	77.23	232.71	35.51	230.65	42.82	86.78
T10	42.17	78.32	233.09	41.46	239.11	42.46	86.26
T11	45.91	82.30	239.25	42.98	249.85	41.75	84.38
T12	43.42	78.86	234.35	37.15	231.13	41.12	83.65
T13	44.49	80.38	237.19	35.38	234.49	40.92	82.76
T_{14}	43.49	79.69	234.39	41.21	240.06	40.25	82.16
T_{15}	44.83	81.61	237.19	42.06	249.35	39.91	81.92
SEm±	1.674	2.060	2.15	0.573	2.307	0.694	1.243
CD (P=0.05)	5.084	6.258	6.52	1.656	6.662	2.004	3.589

Conclusion

This study conclusively suggests that treatment T_{11} was most effective in increasing both growth and yield attributes in tomato under polyhouse conditions.

This finding explains the potential for enhancing agricultural output and maintains a long-term sustainability.

Table 2. Effect of silica and biochar on various yield parameters of tomato

S. N.	Number of Fruits per Plant	Fruit Length (cm)	Fruit Weight (gm)	Fruit Diameter (cm)	Fruit Volume (cc)	Fruit Yield per Plant (kg)	Yield per Meter Square (kg)
T1	31.25	4.05	71.43	4.15	73.86	2.23	8.26
T2	32.92	4.10	71.65	4.23	73.95	2.36	8.73
T3	33.68	4.12	72.16	4.29	74.15	2.43	8.99
T4	32.09	4.16	72.45	4.34	74.56	2.33	8.61
T5	34.11	4.17	73.37	4.37	75.69	2.50	9.26
T6	32.18	4.18	73.67	4.43	76.56	2.37	8.77
T7	34.91	4.19	74.86	4.62	77.07	2.61	9.67
T8	36.89	4.27	73.95	4.74	78.12	2.73	10.10
T9	35.51	4.31	75.66	4.81	78.43	2.69	9.94
T10	41.46	4.35	75.91	4.87	79.47	3.15	11.64
T11	42.98	4.50	80.67	5.15	85.96	3.47	12.83
T12	37.15	4.36	76.21	4.91	80.37	2.83	10.48
T13	35.38	4.37	78.35	4.99	81.44	2.77	10.25
T_{14}	41.21	4.39	79.45	5.01	82.66	3.27	12.12
T_{15}	42.06	4.44	80.55	5.04	85.93	3.39	12.54
SEm±	0.573	0.081	1.175	0.083	0.989	0.065	0.242
CD (P=0.05)	1.656	0.234	3.394	0.240	2.855	0.189	0.698

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