

Original Research Paper

Effect of bio-fertilizers and bio-stimulants on quality parameters of strawberry

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ABSTRACT

Strawberry (*Fragaria x ananassa* Duch.) is a highly valuable fruit crop known for its flavor, nutritional profile, and antioxidant properties. This study investigated various biofertilizers and organic formulations impacted on the fruit quality and post-harvest shelf life of strawberries. Utilizing 12-month-old runners grown in raised beds, the experiment evaluated 10 treatment combinations alongside a control group, testing *Amrit Pani*, *Jivamrit*, *Panchagavya*, *Azotobacter*, and phosphorus-solubilising bacteria (PSB) either alone or combined. The results demonstrated substantial differences in fruit quality across the treatments. Notably, the combined application of *Jivamrit*, PSB, and *Azotobacter* yielded the best performance, achieving the highest total soluble solids (12.34 °Brix), juice content (58.79%), and ascorbic acid concentration (57.02 mg/100 g). This specific combination also minimised titratable acidity (1.04%), maximized the TSS-to-acidity ratio (12.07) and significantly extended shelf life to 2.78 days (compared to just 1.22 days in the control). While the control group retained the highest pulp content (51.02%), the *Jivamrit* + PSB + *Azotobacter* matrix stands out as a highly effective and sustainable nutrient management strategy for strawberry production.

Keywords: Biofertilizer, biostimulant, quality, strawberry, sustainability

INTRODUCTION

Strawberry is an economically important fruit crop belonging to the family Rosaceae. It is a rich source of vitamin C, minerals, phenolics, flavonoids and other antioxidants, which contribute to its nutritional and health benefits (Charoenwoodhipong et al., 2025; Bezerra et al., 2024). Its adaptability to diverse climatic conditions and the development of varieties suited to subtropical regions have expanded its cultivation beyond traditional growing areas (Verma et al., 2018). Increasing consumer demand for high-quality fruits has encouraged intensive production practices involving synthetic fertilizers and pesticides. However, their excessive use raises concerns regarding soil health, environmental sustainability and pesticide residues in fresh fruits (Bhanti & Taneja, 2007; Handique & Roy, 2020). Therefore, sustainable nutrient management practices are essential to maintain fruit quality while reducing dependence on synthetic inputs.

Azotobacter contributes to biological nitrogen fixation, whereas phosphorus-solubilising bacteria (PSB) enhance phosphorus availability and uptake, thereby supporting plant growth and productivity

(Kumar et al., 2019). Similarly, organic bio-enhancers such as *Amrit Pani*, *Jivamrita* and *Panchagavya* promote soil microbial activity, nutrient availability and plant growth. Their application has also been associated with improvements in fruit quality attributes, including total soluble solids (TSS), acidity and sugar content. However, limited information is available on the integrated application of these bio-enhancers and biofertilizers in strawberry, particularly in cv. Chandler. Therefore, the present investigation was undertaken to evaluate the effects of biofertilizers and organic bio-enhancers, applied individually and in combination, on the fruit quality attributes and shelf life of strawberry cv. Chandler, with the objective of identifying suitable combinations for sustainable strawberry production.

MATERIALS AND METHODS

Twelve-month-old runners of strawberry cv. Chandler was planted on 8-10 cm raised beds of 60 cm x 90 cm dimension at the spacing of 45 cm x 20 cm, accommodating six plants in each plot in Department of Horticulture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, India during 2022 to 2024. The experimental soil was sandy loam,



slightly alkaline, pH 7.50, organic carbon content (0.44%), available nitrogen (211.64 kg ha⁻¹), available phosphorus (12.84 kg ha⁻¹) and available potassium (153.82 kg ha⁻¹). Ten treatment combinations, along with one control, were replicated thrice in a randomised block design. The ten treatment consisting of T₁-control (FYM-5 kg/bed), T₂-Amritpani (20%) + *Azotobacter* (50 g/bed), T₃-Panchagavya (3%) + *Azotobacter* (50 g/bed), T₄-Jivamrit (20%) + *Azotobacter* (50 g/bed), T₅-Amritpani (20%) + *PSB* (50 g/bed), T₆-Panchagavya (3%) + *PSB* (50 g/bed), T₇-Jivamrit (20%) + *PSB* (50 g/bed), T₈-Amritpani (20%) + *PSB* (50 g/bed) + *Azotobacter* (50 g/bed), T₉-Panchagavya (3%) + *PSB* (50 g/bed) + *Azotobacter* (50 g/bed) and T₁₀-Jivamrit (20%) + *PSB* (50 g/bed) + *Azotobacter* (50 g/bed). The data recorded on different parameters during both years of experimentation, were analysed. Observations were recorded on plant height (cm), plant spread (cm), number of leaves per plant, leaf area (cm²), number of crowns and runners per plant, days taken to produce first flower, number of flower per fruit, duration of flowering, number of days to fruit set, number of fruit set/plant, duration of harvesting, fruit length (cm), fruit weight (g), fruit diameter (cm), fruit volume (cc), specific gravity (g/cc), yield per plant (g) and yield per plot (kg). The number of flowers and fruits per plant was counted at five-day intervals during the whole season. Data on berry weight and yield per plant were recorded at each picking. The length and width of ten berries were measured with a vernier calliper. The biochemical parameters were also estimated using standard analytical procedures as described by the association of official analytical chemists (AOAC, 2012).

Statistical analysis

The data recorded during the investigation were subjected to statistical analysis following the methods described by Panse & Sukhatme (1985). Analysis of variance (ANOVA) was performed to test the significance of treatment effects. The significance of treatment effects was assessed using the F-test at the 5% level of significance, and differences among treatment means were tested using duncan's multiple range test (DMRT) at $p \leq 0.05$. Correlation analysis was performed using the *corrplot* package, while principal component analysis (PCA) was carried out using the *FactoMineR* package in R. All statistical analyses were performed using RStudio software.

RESULTS AND DISCUSSION

Effect on quality parameters

The present experimental findings exhibited significant variation in TSS due to the application of different bio-fertilisers and bio stimulants in strawberry (Table 1). Pooled data showed that the maximum TSS (12.34 °Brix) was recorded in fruits from plants treated with T₁₀-Jivamrit (20%) + *PSB* (50 g/bed) + *Azotobacter* (50 g/bed), whereas, the minimum TSS (9.85 °Brix) was observed in untreated plants (T₁). The higher TSS under T₁₀ may be associated with improved rhizosphere activity and nutrient availability resulting from the combined action of *Jivamrit*, *PSB* and *Azotobacter*. Improved nitrogen and phosphorus availability could enhance photosynthetic activity and assimilate production, while better root activity may facilitate the translocation of carbohydrates to developing fruits. During ripening, these assimilates are converted into soluble sugars and other soluble

Table 1 : Influence of bio-stimulants and bio-fertilizers on quality parameters of strawberry (*Fragaria x Ananassa* Dutch) cv. Chandler

Treat-ment	TSS (°Brix)	Juice (%)	Ascorbic acid (mg/100 g)	Titrateable acidity (%)	Pulp content (%)	TSS: acid	Juice pulp ratio	Fruit pH	Shelf life	Sugar content
T ₁	9.85±0.05 e	48.98±0.48 e	49.50±0.64 c	1.21±0.02 a	51.02±0.04 a	8.24±0.19 g	0.96±0.01 e	3.62±0.08 f	1.22±0.01 h	5.21±0.13 d
T ₂	9.86±0.22 e	50.76±0.63 e	50.00±0.73 c	1.19±0.03 a	49.24±0.33 b	8.38±0.03 g	1.03±0.01 e	3.69±0.05 ef	1.25±0.03 h	5.31±0.02 cd
T ₃	10.24±0.18 d	53.23±1.25 d	49.85±0.98 c	1.17±0.03 ab	46.77±0.03 c	8.86±0.15 f	1.14±0.02 d	3.69±0.06 ef	1.39±0.03 g	5.45±0.03 bc
T ₄	10.32±0.13 d	53.37±0.64 d	50.54±0.45 c	1.17±0.00 ab	46.63±0.37 cd	8.94±0.08 f	1.14±0.01 d	3.73±0.08 def	1.54±0.01 f	5.53±0.09 bc
T ₅	11.33±0.06 c	54.84±0.11 cd	51.10±0.29 c	1.13±0.02 bc	45.16±0.42 cde	10.17±0.00 e	1.21±0.01 c	3.90±0.04 cde	1.63±0.04 e	5.54±0.02 bc
T ₆	11.54±0.04 bc	55.03±1.29 cd	53.86±1.04 b	1.10±0.02 cd	44.97±0.70 de	10.65±0.11 d	1.22±0.02 c	3.96±0.04 cd	1.82±0.04 d	5.54±0.11 bc
T ₇	11.64±0.04 bc	56.01±0.47 bc	53.86±0.67 b	1.09±0.02 cde	43.99±0.96 e	10.84±0.26 cd	1.27±0.01 b	4.04±0.02 c	2.33±0.01 c	5.62±0.05 b
T ₈	11.73±0.04 b	56.16±0.20 bc	54.38±0.43 ab	1.06±0.01 de	43.84±0.84 e	11.24±0.22 bc	1.29±0.01 b	4.05±0.09 c	2.33±0.02 c	5.64±0.10 b
T ₉	11.85±0.07 b	58.35±0.27 ab	56.08±1.31 ab	1.05±0.01 de	41.65±0.17 f	11.48±0.05 b	1.40±0.00 a	4.38±0.07 b	2.67±0.02 b	6.11±0.06 a
T ₁₀	12.34±0.19 a	58.79±1.01 a	57.02±1.10 a	1.04±0.00 e	41.21±0.49 f	12.07±0.22 a	1.43±0.03 a	4.62±0.12 a	2.78±0.01 a	6.25±0.05 a

compounds, resulting in greater accumulation of TSS. Thus, the higher TSS under T_{10} may reflect improved nutrient acquisition, photosynthetic assimilate production and source-sink partitioning during fruit development. Negi et al. (2021) also reported highest TSS (10.47 °B) with 50% FYM + 50% vermicompost + *Azotobacter* + *Pseudomonas*, in strawberry.

Significant effects of different treatments were observed for juice percentage (Table 1). The pooled data showed the highest juice percentage (58.79%) in T_{10} -*Jivamrit* (20%) + PSB (50 g/bed) + *Azotobacter* (50 g/bed), whereas the minimum (48.98%) was recorded in untreated plants (T_1). The higher juice percentage under T_{10} may be associated with improved nutrient and water uptake and greater cell division and expansion during fruit development. The present findings are supported by Datta et al. (2024), who reported that combined application of *Azotobacter* and PSB with inorganic fertilizers improved juice content in aonla.

Ascorbic acid content was significantly influenced by the application of different bio-fertilisers and bio stimulants (Table 1). The pooled data showed that the highest ascorbic acid content (57.02 mg/100 g) was recorded in fruits from plants treated with T_{10} -*Jivamrit* (20%) + PSB (50 g/bed) + *Azotobacter* (50 g/bed), whereas the minimum content (49.50 mg/100 g) was observed in untreated plants (T_1). The higher ascorbic acid accumulation under T_{10} may be associated with the complementary effects of the microbial inoculants and *Jivamrit* on nutrient availability and plant physiological activity. Sahu & Joseph (2024) also recorded the highest vitamin C content (58.94 mg/100 g) under T_{11} (poultry manure 20 t/ha + bio-capsule 150% of optimum). Tripathi et al. (2015) in strawberry and Bhadauria & Tripathi (2023a) in mango reported beneficial influence of integrated organic and microbial nutrient inputs on fruit ascorbic acid accumulation. The minimum titratable acidity (1.04%) was recorded in T_{10} -*Jivamrit* (20%) + PSB (50 g/bed) + *Azotobacter* (50 g/bed), whereas the untreated control (T_1) exhibited the maximum acidity (1.21%). Improved nutrient availability and assimilate production under the combined application of *Jivamrit*, PSB and *Azotobacter* may promote greater accumulation of carbohydrates, while organic acids can be progressively utilized as respiratory substrates during fruit development. Consequently, the relative proportion of sugars may increase while titratable

acidity declines, contributing to a more favourable sweetness-acidity balance. The present findings are in close conformity with the results of Negi et al. (2021) in strawberry and Bhadauria & Tripathi (2023b) in mango. Similarly, Patel et al. (2023) reported the lowest titratable acidity (0.46%) under bio-fertiliser + organic manure treatment in strawberry, supporting the beneficial influence of integrated organic and microbial nutrient management on fruit acidity. The maximum pulp content (51.02%) was recorded in T_1 (control), whereas the minimum (41.21%) was observed in T_{10} -*Jivamrit* (20%) + PSB (50 g/bed) + *Azotobacter* (50 g/bed). Improved nutrient and water uptake under T_{10} may have promoted greater fruit expansion and accumulation of juice and soluble constituents, thereby reducing the relative proportion of pulp. Conversely, the higher pulp percentage in the control may reflect a greater relative contribution of pulp tissues in the absence of the enhanced fruit development and juice accumulation observed under T_{10} . Thus, pulp percentage should be interpreted together with juice percentage and juice:pulp ratio rather than as an independent indicator of superior fruit quality.

TSS: acid ratio (12.07) was highest in T_{10} -*Jivamrit* (20%) + PSB (50 g/bed) + *Azotobacter* (50 g/bed), indicating better sweetness and flavour balance. This is possibly due to the optimal balance of nutrients, leading to enhanced sugar synthesis and lower acid accumulation. The higher TSS: acid ratio under T_{10} , together with the higher TSS and lower titratable acidity observed in the same treatment, suggests a more favourable balance between soluble sugars and organic acids during fruit development and ripening. This response may be associated with improved nutrient availability and assimilate production under the combined application of *Jivamrit*, PSB and *Azotobacter*. Kaur & Kaur (2017) reported that poultry manure+*Azotobacter*+wood ash+phosphorus solubilising bacteria+mustard oil cake recorded maximum TSS:acid ratio (11.12) in strawberry. Similarly, Pesakovic et al. (2023) recorded higher TSS : acid ratio with biofertilizer application.

T_{10} -*Jivamrit* (20%) + PSB (50 g/bed) + *Azotobacter* (50 g/bed) recorded the highest juice pulp ratio (1.43), whereas the lowest ratio (0.96) was observed in untreated plants (T_1). The higher ratio under T_{10} , consistent with its greater juice percentage and lower pulp proportion, suggests a favourable shift in the relative distribution of fruit components towards the

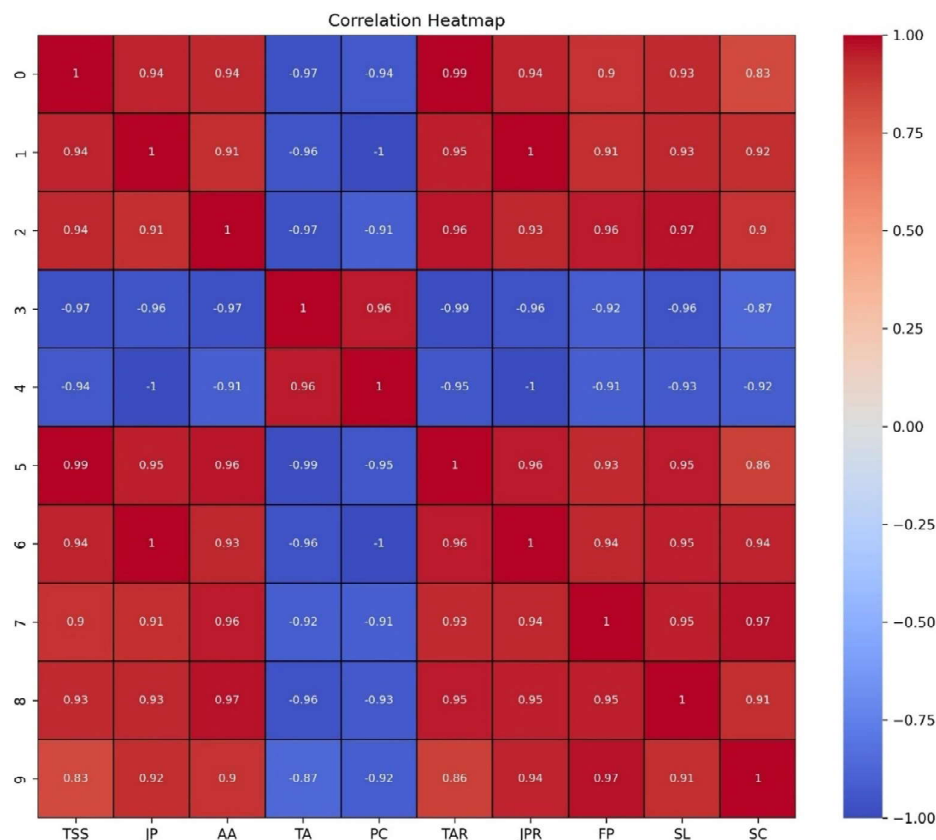


Fig. 1 : Correlation analysis of quality attributes of strawberry cv. Chandler

(0: TSS, 9: SC), TSS ($^{\circ}$ Brix), JP: juice percentage, AA: ascorbic acid (mg/100 g), TA: titratable acidity (%), PC: pulp content (%), TAR: TSS: acidity ratio, JPR: juice pulp ratio, FP: fruit pH, SL: shelf life and SC: sugar content

juice fraction. Fruit pH was also significantly influenced by the treatments (Table 1), with the highest pH (4.62) recorded under T_{10} and the lowest (3.62) in T_1 . This may be associated with changes in organic-acid metabolism and fruit maturation under improved nutritional conditions. Kilic (2023) also reported highest fruit juice pH (4.01) under Biofarm + Botanica + Rizofil. Kumar et al. (2020) also reported a higher pH (4.23) in Chandler strawberry with biofertilizer application and indicated that fruit pH can vary with cultivar, environmental conditions and treatment effects.

Significant differences were observed among treatments, with T_{10} -Jivamrit (20%) + PSB (50 g/bed) + Azatobacter (50 g/bed) recording the longest shelf life (2.78 days), while the shortest (1.22 days) was observed in the control (T_1). The longer shelf life under T_{10} may be associated with improved fruit nutritional status and tissue integrity resulting from better nutrient acquisition and fruit development.

The highest total sugar content (6.25%) was recorded under T_{10} , whereas the lowest (5.21%) occurred in T_1 . It may be associated with improved nutrient availability, photosynthetic assimilate production and carbohydrate partitioning towards developing fruits. Similarly, Yashasvi et al. (2021) and Nazir et al. (2015) reported improved total sugar accumulation in strawberry under integrated nutrient management involving PSB and vermicompost.

Character association for quality attributes

Pearson's correlation coefficient analysis was performed to assess the relationships among strawberry fruit quality attributes under different biofertilizer and bio-enhancer treatments using pooled data (Fig. 1). Total soluble solids (TSS) exhibited significant positive correlations with TSS-to-acidity ratio, juice-to-pulp ratio, juice percentage, ascorbic acid content, shelf life, fruit pH and sugar content. Conversely, TSS was negatively correlated with titratable acidity and pulp content. Juice percentage

showed significant positive correlations with juice-to-pulp ratio, TSS-to-acidity ratio, shelf life, sugar content, ascorbic acid content and fruit pH, but negative correlations with pulp content and titratable acidity. Similarly, ascorbic acid content was positively correlated with shelf life, TSS-to-acidity ratio, fruit pH, juice-to-pulp ratio and sugar content, while, showing negative correlations with titratable acidity and pulp content. Titratable acidity exhibited significant positive correlation with pulp content but negative correlations with TSS-to-acidity ratio, ascorbic acid content, juice-to-pulp ratio, shelf life, juice percentage, fruit pH and sugar content. Juice-to-pulp ratio was positively correlated with TSS-to-acidity ratio, shelf life, sugar content and fruit pH, but negatively correlated with pulp content. Fruit pH showed positive correlations with sugar content and shelf life. Shelf life was also positively correlated with TSS-to-acidity ratio and sugar content, whereas, sugar content showed a negative correlation with pulp content.

Principal component analysis

Principal component analysis (PCA) was performed using ten fruit quality traits through singular value

decomposition. Of the ten principal components, only PC1 had an eigen value greater than 1, explaining 94.66% of the total variation, with an eigen value of 3.08 (Table 2).

The PCA biplot (Fig. 2) revealed that T_9 (Panchagavya + PSB + *Azotobacter*) and T_{10} (*Jivamrit* + PSB + *Azotobacter*) were closely associated with higher TSS, sugar content, shelf life and TSS-to-acidity ratio, indicating favourable responses in these traits. In contrast, treatments involving individual or fewer inputs, such as T_2 (Amrit Pani + *Azotobacter*) and T_4 (*Jivamrit* + *Azotobacter*), showed comparatively weaker associations with these traits. T_5 and T_6 also exhibited favourable responses but were less closely associated with the desirable quality attributes. The biplot further indicated positive correlations among total soluble solids, TSS-to-acidity ratio, sugar content and shelf life, suggesting their interrelated contribution to fruit quality. Conversely, titratable acidity and fruit pH showed negative associations with these traits. The close association of T_9 and T_{10} with desirable quality attributes suggests that integrating organic bio-enhancers with beneficial microorganisms may improve multiple fruit quality parameters simultaneously.

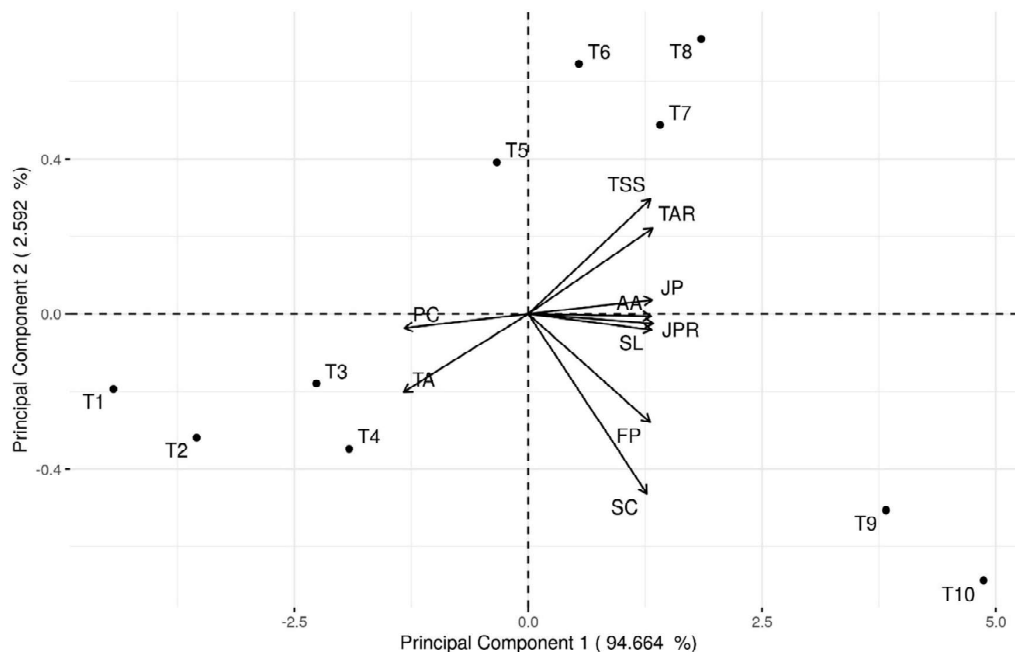


Fig. 2 : Principal component analysis of different treatments, on quality attributes of strawberry cv. Chandler

TSS (°Brix), JP: juice percentage, AA: ascorbic acid (mg/100g), TA: titratable acidity (%), PC: pulp content (%), TAR: TSS-to-acidity ratio, JPR: juice-to-pulp ratio, FP: fruit pH, SL: shelf life, and SC: sugar content

Table 2 : Extracted Eigen values and correlation values for growth and yield attributes of Strawberry (*Fragaria × ananassa* Dutch.) cv. Chandler

Principal component	Eigen value	Percentage of variance	cumulative % of variance
PC1	3.0768	94.664	94.664
PC2	0.5092	2.592	97.257
PC3	0.4293	1.843	99.1
PC4	0.2385	0.569	99.669
PC5	0.148	0.219	99.888
PC6	0.0888	0.079	99.967
PC7	0.0559	0.031	99.998
PC8	0.0138	0.002	100
PC9	0.0035	0.002	100
PC10	0.0025	0.002	100
Variable	PC1	PC2	PC3
TSS (°Brix)	0.314	0.4309	0.0676
Juice percentage	0.3181	0.0522	-0.4675
Ascorbic acid (mg/100g)	0.316	-0.0084	0.4785
Titrateable acidity (%)	-0.3197	-0.2921	-0.1136
Pulp content (%)	-0.3181	-0.0522	0.4676
TSS-to-acidity ratio	0.3195	0.3209	0.1421
Juice-to-pulp ratio	0.3215	-0.0355	-0.333
Fruit pH	0.3131	-0.4056	0.3114
Shelf life	0.3173	-0.0592	0.2749
Sugar content	0.3046	-0.6717	-0.1126

CONCLUSION

The findings of this study confirm that bio-fertilizers and bio-stimulants significantly influence the quality metrics of strawberry cv. Chandler. Specifically, the integration of *Jivamrit* (20%) + PSB (50 g/bed) + *Azotobacter* (50 g/bed) optimized the majority of the analyzed parameters, yielding peak values for total soluble solids (12.34 °Brix), juice content (58.79%), ascorbic acid (57.02 mg/100 g), TSS : acid ratio (12.07), juice : pulp ratio (1.43), fruit pH (4.62), total sugars (6.25%), and post-harvest shelf life (2.78 days). Conversely, this group exhibited the lowest titrateable acidity (1.04%) and pulp content (41.21%). Correlation analysis revealed strong, positive relationships among these key quality traits, whereas titrateable acidity and pulp content displayed negative correlations with the majority of the variables. Principal component analysis (PCA) isolated treatments T9 and T10 as the most effective, with PC1 accounting for 94.66% of the total variance. Consequently, combining bio-stimulants with PSB and *Azotobacter*—particularly the T₁₀ T₁₀-*Jivamrit* (20%) + PSB (50 g/bed) + *Azotobacter* (50 g/bed), holds strong potential as a sustainable nutrient management framework to enhance the market quality of Chandler strawberries.

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REFERENCES

- AOAC. (2012). Official methods of analysis of AOAC International. 19th ed. Washington, DC: Association of Official Analytical Chemists. p. 121-130.
- Bezerra, M., Ribeiro, M., Cosme, F., & Nunes, F. M. (2024). Overview of the distinctive characteristics of strawberry, raspberry, and blueberry in berries, berry wines, and berry spirits. *Comprehensive Reviews in Food Science and Food Safety*, 23(3), e13354. <https://doi.org/10.1111/1541-4337.13354>
- Bhadauria, A. S., & Tripathi, V. K. (2023a). Effect of bio-enhancers and bio-fertilizers on growth and quality of mango cv. Amrapali under sub-tropical plains of central Uttar Pradesh, India. *International Journal of Plant & Soil Science*, 35(19), 1260-1267. <https://doi.org/10.9734/ijpps/2023/v35i>

- Bhadauria, A. S., & Tripathi, V. K. (2023b). Fruit characteristics and yield of mango cv. Amrapali as influenced by bio-enhancers and bio-fertilizers. *International Journal of Environment and Climate Change*, 13(10), 1973-1981. <https://doi.org/10.9734/ijecc/2023/v13i102855>
- Bhanti, M., & Taneja, A. (2007). Contamination of vegetables of different seasons with organophosphorous pesticides and related health risk assessment in northern India. *Chemosphere*, 69(1), 63-68. <https://doi.org/10.1016/j.chemosphere.2007.04.071>
- Charoenwoodhipong, P., Zuelch, M. L., Keen, C. L., Hackman, R. M., & Holt, R. R. (2025). Strawberry (*Fragaria* × *ananassa*) intake on human health and disease outcomes: A comprehensive literature review. *Critical Reviews in Food Science and Nutrition*, 65(25), 4884-4914. doi: 10.1080/10408398.2024.2398634
- Datta, S., Roy, S., Mandal, K. K., Hasan, M. A., & Bauri, F. K. (2024). Effect of organic and inorganic nutrients on growth, yield and quality of aonla (*Emblica officinalis* Gaertn.) cv. NA-7 in the red and laterite zones of West Bengal. *International Journal of Minor Fruits, Medicinal and Aromatic Plants*, 10(1), 97-101. doi: 10.53552/ijmfmap.10.1.2024.97-101
- Handique, G., & Roy, S. (2020). Nonchemical pest management approaches in tea ecosystem: Evading the pesticide trap. In A. K. Chakravarthy (Ed.), *Innovative pest management approaches for the 21st century: Harnessing automated unmanned technologies* (pp. 255-272). Springer Singapore. https://doi.org/10.1007/978-981-15-0794-6_13
- Kaur, H., & Kaur, G. (2017). Effect of inorganic and organic fertilizers on fruit quality and yield attributes in guava cv. Sardar. *International Journal of Advanced Research*, 5(12), 1346-1351. <http://dx.doi.org/10.21474/IJAR01/6093>
- Kilic, N. (2023). Synergistic effect of organic and bio fertilisers on strawberry cultivation. *Sustainability*, 15(10), 8206. <https://doi.org/10.3390/su15108206>
- Kumar, P., Sharma, N., Sharma, S., & Gupta, R. (2020). Rhizosphere stoichiometry, fruit yield, quality attributes and growth response to PGPR transplant amendments in strawberry (*Fragaria* × *ananassa* Duch.) growing on solarised soils. *Scientia Horticulturae*, 265, 109215. <https://doi.org/10.1016/j.scienta.2020.109215>
- Kumar, S., Kundu, M., Das, A., Rakshit, R., Siddiqui, M. W., & Rani, R. (2019). Substitution of mineral fertilizers with biofertilizer: An alternate to improve the growth, yield and functional biochemical properties of strawberry (*Fragaria* × *ananassa* Duch.) cv. Camarosa. *Journal of Plant Nutrition*, 42(15), 1818-1837. <https://doi.org/10.1080/01904167.2019.1643363>
- Nazir, N., Kumar, A., Khalil, A., & Bandey, S. A. (2015). Effect of integrated organic nutrient management on fruit yield and quality of strawberry cv. Senga Sengana. *International Journal of Farm Sciences*, 5(2), 83-89.
- Negi, Y. K., Sajwan, P., Uniyal, S., & Mishra, A. C. (2021). Enhancement in yield and nutritive qualities of strawberry fruits by the application of organic manures and biofertilizers. *Scientia Horticulturae*, 283, 110038. <https://doi.org/10.1016/j.scienta.2021.110038>
- Panse, V. G., & Sukhatme, P. V. (1985). *Statistical methods for agricultural workers*. Indian Council of Agricultural Research (ICAR), New Delhi, India.
- Patel, H., Taghavi, T., & Samtani, J. B. (2023). Fruit quality of several strawberry cultivars during the harvest season under high tunnel and open field environments. *Horticulturae*, 9(10), 1084. <https://doi.org/10.3390/horticulturae9101084>
- Pesakovic, M., Tomić, J., Cerović, R., Stampar, F., Jakopič, J., Karaklajić Stajić, Ž., Milenković, S., & Mikulic-Petkovsek, M. (2023). Evaluating effects of a new liquid vermicompost-based product on fruit quality in organic strawberries (*Fragaria* × *ananassa* Duch.). *Biological Agriculture & Horticulture*, 39(4), 269-282. <https://doi.org/10.1080/01448765.2023.2217156>
- Sahu, A., & Joseph, A. V. (2024). Effect of organic manures and biocapsules on growth, yield and quality of strawberry (*Fragaria* × *ananassa* cv. Winter Dawn). *Journal of Advances in Biology & Biotechnology*, 27(8), 1307-1315. <https://doi.org/10.9734/jabb/2024/v27i81254>
- Tripathi, V. K., Kumar, S., & Gupta, A. K. (2015). Influence of *Azotobacter* and vermicompost on growth, flowering, yield and quality of strawberry cv. Chandler. *Indian Journal of Horticulture*, 72(2), 201-205. <https://doi.org/10.5958/0974-0112.2015.00039.0>
- Verma, S., Osorio, L. F., Lee, S., Bassil, N. V., & Whitaker, V. M. (2018). Genome-assisted breeding in the octoploid strawberry. In T. Hytönen, J. Graham, & R. Harrison (Eds.), *The genomes of rosaceous berries and their wild relatives* (pp. 161-184). Springer, Cham. doi: 10.1007/978-3-319-76020-9_12.
- Yashasvi, G. N., Tripathi, V. K., Awasthi, V., & Anushi. (2021). Impact of PSB and vermicompost on growth, yield and quality of strawberry. *Biological Forum -An International Journal*, 13(3a), 314-318. <https://doi.org/10.2139/ssrn.4189980>

