Original Research Article

Impact of biofertilizer combinations on quality, yield, and economic returns of strawberry in central region of Punjab

ABSTRACT

Strawberries are a globally cherished fruit, celebrated for their sweet flavor, vibrant color, and rich nutritional profile. The use of biofertilizers in strawberry cultivation is gaining importance in India due to their eco-friendly and sustainable nature. Biofertilizers enhance soil fertility by promoting beneficial microbial activity, which improves nutrient availability and uptake by strawberry plants. This leads to healthier crops with better yields and quality, while also reducing using artificial fertilisers, thus benefiting both the environment and farmers' long-term productivity. The current inquiry was conducted at experimental farm, Mata Gujri College, Shri Fatehgarh Sahib, Kharora (Punjab), India during 2023-24. In this research, there are eight bio-fertilizer treatments combination and three replications were laid out in RBD. Among them T_8 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant) significantly increased the plant height (16.82cm), plant spread (32.78cm), berry length (45.88mm), berry breadth (38.96mm), berry weight (12.76g), TSS (9.42°Brix), anthocyanin content (26.14mg/100g) and yield attributes *i.e.*, yield plant^{-1} (238.88g) and yield hectare^{-1} (13.14t/ha). It also concluded that plants treated with T_8 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant) gives us maximal leaf nutritional content, namely, nitrogen (3.09 %), phosphorus (1.37 %), potassium (3.39 %), calcium (2.37 %) and magnesium (0.39 %) and also gives highest net return *i.e.*, 16,61,790 Rs/ha and highest B:C ratio *i.e.*, 3.77 as economics point of view T_8 found to be more suitable.

Keywords: leaf nutrient, fruit quality, net returns, nutrient, microbial activity

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INRODUCTION

Strawberry (*Fragaria* × *ananassa* Duch.) is a perennial herbaceous plant in the Rosaceae family that is octaploid by nature, possessing chromosomal number 2n=8x=56 (Hossain *et al*., 2019). *F. chiloensis* Duch. and *F. virginiana* Duch., two native American species, are

hybridised to create it and botanically it is an aggregate fruit which is highly perishable in nature. There are about sixteen wild strawberry species worldwide, but only four have been identified in India i.e., F. Vesca, *F. Chiloensis, F. Daltoniana* and *F. Nilgerrernsis.* Strawberry is one of India's most prominent tropical fruits that may reach heights over 12,000 feet above mean sea level in both arid and wet climate regions. Fruits, also a great source of endogenous metabolites, phenols, carotenoids, vitamins, and flavonoids, among other natural antioxidants. (Jideani *et al.*, 2021). In strawberries, indiscriminate and prolonged use of inorganic chemical fertilisers and pesticides raises production costs while contaminating the environment, water, and soil by volatilisation, runoff, leaching, and denitrification. It negatively affects the fertility, vegetation, and fauna of the soil. Beneficial microorganisms found in bio-fertilizers include *Azospirillum*, *Azotobactor*, *Pseudomonas*, *Bacillus*, *Mycorrhizae fungi*, *Aspergillus, and Penicillium*, can boost nutrient availability, absorption, and biological activity in the rhizosphere to affect plant growth and health. According to (Reddy *et al.*, 2020) fixing nitrogen from the atmosphere, solubilising phosphorus, and mobilising iron, zinc, and phosphorus to different degrees through the synthesis of secondary metabolites, phytohormones, and antibiotics that help host plants withstand abiotic stress conditions and disease. Bio-fertilizers are living microorganisms (useful bacteria and fungi) which, by nitrogen-fixing, significantly contribute to enhancing soil fertility, solubilise insoluble soil phosphates, potassium removable and improving plant production (Nosheen *et al*., 2021). They contribute significantly to crop productivity and are environmentally beneficial. According to Mishra and Barolia (2020), bio-fertilizers or microbial inoculants, are carrier-based preparations contain advantageous microbes that increase biological activity in the rhizosphere with the goal of enhancing soil fertility and facilitating plant growth. In other words, biofertilizers depend on renewable energy sources, which are more eco-friendly than commercial fertilizers (Kaur and Purewal, 2019).

Commented [T2]: Strawberry is a well-known fruit in the world, you can introduce it in two lines. Spend a large part of the introduction stating the necessity of conducting this study in the Punjab region.

Commented [T3]: You can use previous studies on the positive (or negative) effects of the use of microorganisms on the quality and growth of strawberries. At the end of the introduction, state your purpose of conducting this study.

MATERIALS AND METHODS

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The current inquiry was executed at experimental farm, Mata Gujri College, Shri Fatehgarh Sahib, Kharora (Punjab), India during 2023-24. This study examined the influence of several bio-fertilizers *viz.*, T_1 (Control), T_2 (RDF + *Azotobacter*@2g/plant), T_3 (RDF + PSB@2g/plant), T_4 (RDF + *Azospirillum*@2g/plant), T_5 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant), T_6 (RDF + *Azotobacter*@2g/plant + *Azospirillum*@2g/plant), T_7 (RDF + PSB@2g/plant + *Azospirillum*@2g/plant) and T_8 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant). The experiment was divided into 24 sub-plots with

Commented [T5]: Which strawberry cultivar did you study?

Commented [T6]: You must mention the following:
- How to prepare and grow plants
- Soil physicochemical analysis (such as pH, EC, organic matter, etc.)
- Plant nutrition conditions during the vegetative and reproductive period of the plant
- Weather conditions (such as average day and night temperature and relative humidity)

Commented [T7]: What is RDF and PSP? be mentioned in full. State how the treatments were applied and at what stage of plant growth.

dimensions of 15 m × 1 m. Every plot had three replications and eight treatments set up in an RBD. The significance of variation among treatments was determined using the ANOVA and critical difference (C.D) tests at the 5% probability level.

Commented [T8]: Randomized block **design** (**RBD**)

Commented [T9]: ($p<0.05$)

VEGETATIVE GROWTH ATTRIBUTES OF PLANT

Plant height: A metre scale was used to measure the plant's elevation from the primary leaf apex to the crown and the findings stated in terms of centimetres (cm). The final number was determined based on the average plant height.

Plant spread: Using a metre scale, the plant spread was measured in centimetres (cm) from East to West and North to South. The average of five plants in each direction was then computed to represent the mean value.

Commented [T10]: meter

Commented [T11]: centimeters

Leaf area: A leaf area meter was used to measure five leaves from each plant. To calculate the overall leaf area of a single plant and the outcome should be expressed in cm and calculated by multiplying the average area of each leaf by the number of leaves.

Commented [T12]: What device was used (device model and country of manufacture)?

FLOWERING CHARACTERS OF PLANT

Days taken to first flower: The interval (10%) between the first flower opening date and the planting date has been noted in order to calculate the number of days required to generate the first flower.

Number of flowers per plant: The overall quantity of flowers was noted at 10-day intervals, and the average quantity of flowers per plant was calculated to ascertain the quantity of flowers per plant.

QUALITY PARAMETER OF PLANT

Berry length: A digital vernier calliper was used to measure the length of the fruit, and the mean of the observations was computed and expressed in millimetres.

Berry breadth: The fruit diameter was measured using Digital Vernier Callipers on the same fruits used to measure length, and the mean was given in millimetres.

Berry weight: After weighing the ten fruits on the above list, the total weight of the fruits was calculated and expressed in grammes.

Total soluble solids: The strained juice of the fruits was analysed for TSS using a 'Erma-hand refractometer' (0 to 32 ºBrix). The refractometer was calibrated with distilled water prior to use and measure the TSS, a few juice drops were put on the prism. A temperature correction was performed when it was above or below 20ºC (AOAC, 2002). To accurately estimate TSS, an average of three readings per treatment were recorded and expressed as ˚Brix.

Acidity (Titrable acidity) **:** The level of acidity was evaluated by diluting a known weight of dry material (which was weighted and pulverised thoroughly with a pestle and mortar) and titrating it against standard 0.1 NaOH, using phenolphthalein as an indicator. Pale pink appears to indicate the final value. The acidity is determined using the following formula and represented in percentages.

$$\text{Acidity (\%)} = \frac{1 \times \text{Eq. Wt of acid} \times \text{Normality of NaOH} \times \text{Titre}}{10 \times \text{Weight of sample}} \times 100$$

Anthocyanin content: Harborne's (1973) approach was used to determine the anthocyanin pigments in berries. One gram of berry pulp was immersed in a known volume of methanol containing 1 percent hydrochloric acid. The goods were permitted to remain overnight. Sub-zero temperatures in a deep freezer were used, and using a Spectronic-20 colorimeter, the absorbance of the resultant red solution was determined at 530 nm. The intensity of color was measured and represented in absorbance units per gram of fresh fruit.

Commented [T13]: 0.1N NaOH

Commented [T14]: Write a reference.

Commented [T15]: Write a reference

Leaf analysis

Collection and preparation of leaf samples

A composite sample of hundred leaves for each orchard/cropping system were taken during the month of january from the plant with a total of 20 leaves from each treatment. From the plants that were marked, leaves, including petioles from the mid-terminal shoots of the growth for this season, were gathered. The leaf samples were carried directly to the laboratory and properly cleaned with tap water before being treated with 0.1N HCl and distilled water to eliminate dust particles, as described by Chapman (1964). For surface drying, the washed leaf samples were placed on sheets of filter paper. After that, they were put in paper bags and left for 48 hours at 65 ± 5˚C to dry in a hot air oven. The dehydrated samples were finely pulverized and homogeneous. The ground samples were subsequently stored in butter paper bags and kept in cold and shady spot to estimate nutritional

components. Sampling and the preparation for leaf chemical analysis was carried out using standard procedure.

Digestion of leaf samples

Leaf samples (1g) were processed in intense H_2SO_4 with a mixture of K_2SO_4 (400parts), $CuSO_4$ (20parts), $HgSO_4$ (3parts), and Se (1part) for total nitrogen measurement. The samples were kept boiling until they turned a pale blue tint. Following cooling, the samples were diluted with 100 millilitres of distilled water. The appearance of a slight crimson tint marked the conclusion. To compute P, K, Ca, and Mg, 0.5g of sample was digested in a di-acid mixture of HNO_3 and $HCLO_4$ in a 4:1 ratio, adopting all appropriate precautions as recommended by Piper (1966).

Nitrogen: The total N was calculated using Micro-Kjeldhal's method (Jackson, 1967), and the outcomes were represented as percent nitrogen on a dry weight basis.

Phosphorus: The Vanado-molybdate Phosphoric Yellow Colour Method (Jackson 1967) was used to measure total phosphorus. Pipette 10ml of digested aliquot into a 25ml volumetric flask, then add 5ml of vanado molybdate reagent. After adding purified water to dilute the solution to 25 ml, it was left to develop colour for 30 minutes. Following colour development, the concentration of phosphorus in the solution was measured using a 470 nm wavelength Nukes UV-VIS spectrophotometer, with a blank run in parallel to adjust zero absorption. The leaf P was represented in percent on a dry weight basis.

Potassium, Calcium, Magnesium: Total potassium content was assessed utilising the Agilent 5110 ICP-OES as suggested by Jackson (1973) and the results were expressed in (%). Using an Analyst 400 Atomic Absorption Spectrometer, total calcium and magnesium were measured. The outcomes were displayed as dry weight percentages.

Results and discussion

Vegetative growth attributes

The data collected for the various growth attributes are displayed in Table.1, which stated that the highest plant height (16.82cm), plant spread (32.78cm), number of leaves plant^{-1} (20.00), leaf area (121.53cm^2) were increased significantly and recorded highest with T_8 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant). However, the application of T1 (control) resulted the smallest plant height (10.66cm), plant spread

(22.90cm), number of leaves plant^{-1} (11.87), and leaf area (101.02cm^2). According to Beer *et al.* (2017), The capacity of a biofertilizer to produce antibacterial and antifungal compounds is linked to its growth-promoting properties, in addition to its N-fixing capabilities, growth regulators, and siderophores, resulting in increased vegetative development of strawberries. The use of biofertilizers such as PSB and *Azospirillum* improves biological N_2 fixation and phosphorus availability, both are essential for vigorous vegetative growth (Kumar *et al.*, 2015). These findings are consistent with those of Gupta and Tripathi (2012), Lata *et al.* (2013), and Negi *et al.* (2021).

Commented [T16]: Link the results to your findings in the leaf elements and soil physicochemical analysis section. Explain what growth problems there were in the soil used, which treatments improved growth compared to the control.

Physico-chemical attributes of berry

According to the present analysis, there was a considerable rise in fruit length, berry width, and berry weight. The highest berry length (45.88mm), berry breadth (38.96mm), berry weight (12.76g), total soluble solid (9.42°Brix), total sugar (7.58%), reducing sugar (4.38%) and anthocyanin content of berries (26.14mg/100g) were recorded in treatment T_8 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant). However, lowest berry length (34.31mm), berry breadth (31.43mm), berry weight (8.38g), Total soluble solid (6.90°Brix), total sugar (5.68%), reducing sugar (3.73%) and anthocyanin content of berries (16.39mg/100g) was resulted in treatment T_1 (control). The appropriate supply of macro and micronutrients may have contributed to the improved fruit physical quality., as well as hormones that promote growth that are generated by different biofertilizers used in varied combinations with RDF treatments. This may be related to more fruit filling from a more balanced food intake, which may have enhanced the plant's metabolic processes and increased the synthesis of proteins and carbohydrates (Nazir *et al.*, 2015). The release of growth-promoting compounds, the increased availability of P and the improved ability of microbial inoculants to fix atmospheric N that quicken physiological processes like carbohydrate synthesis could all be responsible for greater ascorbic acid content (Beer *et al.*, 2017). Rise in anthocyanin pigment following the administration of nitrogen and *Azotobacter* is consistent with the results of (Rana *et al.*, 2003), who noticed strawberry's increased red pigment cv. Chandler following the simultaneous treatment of nitrogen and bio-fertilizers. The given results are consistent comparing said by Singh *et al.* (2018) and Jain *et al.* (2017).

Commented [T17]: These parameters were not mentioned in the materials and methods section.

Commented [T18]: Fresh Weight (FW)

Commented [T19]: What were the characteristics of the microorganisms you used? Do you have data related to the amount of auxin production, solubility of phosphorus, potassium, nitrogen fixation, etc. to relate your results to it.

Flowering characteristics

The outcome demonstrated from Table 2 showed the plants need a minimum of 58.99 days to generate their first blooming which were treated with T_8 (RDF +

Azotobacter@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant). However, maximum number of days taken to produce first flowering (70.55days) was noted in T_1 (control). The highest number of flowers plant^{-1} (24.13) was recorded in T_8 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant) and lowest number of flowers plant^{-1} (14.60) were recorded in T_1 (control). According to (Bashandy *et al.*, 2019), *Azotobacter* and *Azospirillum* reduced the number of days for the first flower to bloom compared to the control in both years. It's feasible that using bio-fertilizers makes nitrogen more available to plants, forcing them to transition from the vegetative to reproductive phase earlier. Strawberry plants infected with biofertilizers took the fewest days to produce their first blossom, according to research by Tripathi *et al.* (2016). Similar outcomes have been documented by Singh *et al.* (2015), Kushwah *et al.* (2018), and Jaiswal *et al.* (2023).

Yield characteristics

Table 3 represented the combination of biofertilizers showed a notable variance in the quantity of fruits, yield plant^{-1}, and yield hectare^{-1}, where highest number of fruits plant^{-1} (18.73), yield plant^{-1} (238.88g) and yield hectare^{-1} (13.14t/ha) was found in the plants that received application treatment of T_8 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant). However lowest number of fruits plant^{-1} (10.87), yield plant^{-1} (91.04g) and yield hectare^{-1} (5.01t/ha) was noted in the plant treated with T_1 (control). Increased production could also be attributed to improved nutrient absorption and utilisation due to the combined use of inorganic and organic fertilisers, as well as bio-fertilizers. The biofertilizer's positive effect on harvesting duration and fruit yield could be attributed due to advantageous effects on vegetative development and flowering, which probably gave the inoculated plants access to more photosynthates for a longer amount of time, boosting fruit yield and lengthening the harvesting season, Gupta and Tripathi (2012). Similar outcomes were presented by Jain *et al.* (2017), Singh *et al.* (2015), and Reddy and Goyal (2020).

Leaf nutrient content

The results demonstrated that the maximal leaf nutritional content, namely, nitrogen (3.09 %), phosphorus (1.37 %), potassium (3.39 %), calcium (2.37 %) and magnesium (0.39 %) was recorded in T_8 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant) and minimum nitrogen (2.21 %), phosphorus (0.94 %), potassium (2.15 %), calcium (1.70 %) and magnesium (0.11 %) was recorded in T_1 (control) (Table 4). The intake of any nutrient from the soil has a significant impact on how much of it

accumulates in the leaves. Weinbaum *et al.* (1978) discovered the presence of leaves was necessary for nitrate uptake in prune trees, and they addressed this phenomenon in terms of the supply of leaf carbohydrates. In a similar vein, adding FYM and vermicompost that had been enhanced with *Pseudomonas* and *Azotobacter* increased the phosphorus levels in strawberry leaves. (Negi *et al.*, 2021). Yadav (2010) found that increased nitrogen application led to an increase in nitrogen and phosphorus content in peaches. Furthermore, Azotobacter and PSB boosted leaf phosphorus content, indicating that biofertilizers may have produced a specific microbial community in the roof rhizosphere zone to improve phosphorus absorption. Singh *et al.* (2012) and Verma and Rao (2013) found that organic manures and biofertilizers had a similar favourable effect on the NPK content of strawberry leaves. These findings unequivocally demonstrate that bacterial strains would have facilitated the correct uptake of soil nutrients and that the nutritional condition of leaves was positively correlated with increased availability of soil nutrients.

Soil health attributes

In light of the current study's findings, the application of bio-fertilizers in combination with RDF had a substantial effect on soil electrical conductivity, organic carbon, and soil pH. Lowest soil pH (7.13) and soil electrical conductivity (0.36dS/m) were measured after applying T_8 (RDF + Azotobacter@2g/plant + PSB@2g/plant + Azospirillum@2g/plant). However, maximum soil pH (7.70), soil electrical conductivity (0.65dS/m) was resulted in treatment T_1 (control). On the other side highest organic carbon (0.64%), available nitrogen (349.93kg/ha), phosphorus (59.17kg/ha) and potassium content (150.77 kg/ha) is recorded in T_8 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant) and minimum organic carbon (0.41%), available nitrogen (271.57kg/ha), phosphorus (36.70kg/ha) and potassium content (127.97kg/ha) is observed in T_1 (control) (Table 5). Bio-fertilizers may have boosted biological nitrogen fixation and phosphate solubilisation, resulting in an increase in available N and P content. Singh *et al.* (2012) also indicated that bio-fertilizers improved plant growth and had a direct impact on N_2-fixation and phosphorous mobilisation in strawberry plants. Addition of phosphate-solubilizing microorganisms to inorganic fertilisers also had a considerable impact on the accumulation of accessible phosphorous in the soil. These results align with Singh *et al.* (2010) and Sau *et al.* (2017).

Economic attributes

Commented [T20]: In this amount of soil pH, how did absorption increase?
Please state clearly how and by what mechanism the increase in the availability of elements happened?

Commented [T21]: What method was used for calculation? Explain in the materials and methods section.

Economics of strawberry influenced by different treatments of bio-fertilizers. The cost of cultivation of strawberry cv. Winter Dawn computed, in open field circumstances, treatment-wise, for a single season on a hectare of land. The result indicated that net return was higher in treatment T_8 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant). Data pertaining to economics of different treatments shows that maximum gross income (21,02,150 ₹/ha), net return per hectare (16,61,790 ₹/ha) and B:C ratio (3.77) was observed for strawberry production with the application of RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant. Whereas, the minimum net return per hectare (3,98,969 ₹/ha), gross income (8,01,128 ₹/ha) and B:C ratio (0.99) were observed with treatment T_1 (control) (Table 6). The increased yield of high-quality fruits may account for the rise in benefit-to-cost ratio (Kumar *et al*. 2018). These results concur with Hazarika *et al*. (2016), Pardeep and Saravanam (2017) and Jaiswal *et al*. (2023) which support the result obtained in the present investigation.

Conclusion

From overall study, we obtained that bio-fertilizers are more essential for cultivation of strawberry. The overall results, gave treatment T_8 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant) best in all attributes. The treatment significantly increased the vegetative growth (plant height, plant spread, number of leaves, leaf area), flowering attributes (days taken for first flowering and no. of flowers per plant) in strawberry plant. In case of physico-chemical attributes, soil attributes and yield attributes the maximum result was also found with T_8 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant) as compared to all other treatment combination and also gave us maximum net return (₹ 16,61,790) and highest B:C ratio.

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Table 1: Effect of biofertiizer on vegetative growth attributes of strawberry cv. Winter Dawn

Treatment	Plant height (cm)	Plant spread (cm)	Number of leaves per plant	Leaf area (cm^2)
T_1	10.66^{e}	22.90^{h}	11.87^{f}	101.02^{h}
T_2	13.59^{c}	27.93^{e}	14.73^{d}	113.45^{d}
T_3	12.22^{d}	27.22^{f}	13.60^{e}	110.37^{f}
T_4	11.69^{d}	26.57^{g}	13.13^{e}	106.76^{g}
T_5	15.01^{b}	31.48^{b}	18.73^{b}	119.10^{b}
T_6	14.89^{b}	29.98^{c}	17.07^{c}	116.53^{c}
T_7	13.9^{c}	29.18^{d}	15.27^{d}	112.02^{e}
T_8	16.82^{a}	32.78^{a}	20.00^{a}	121.53^{a}
$C.D._{(0.05)}$	0.70	0.62	0.65	0.62
SE(m)	0.23	0.20	0.21	0.20
SE(d)	0.32	0.29	0.30	0.28

Such as: T_1(Control), T_2(RDF + *Azotobacter*@2g/plant), T_3(RDF+PSB@2g/plant), T_4(RDF+ *Azospirillum*@2g/plant), T_5 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant), T_6 (RDF + *Azotobacter*@2g/plant + *Azospirillum*@2g/plant), T_7(RDF +PSB@2g/plant + *Azospirillum*@2g/plant), T_8(RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant)

Table 2: Effect of biofertiizer on flowering and yield characteristics of strawberry cv. Winter Dawn

Treatment	Days taken to first flowering	Numbers of flower per plant	Number of fruits per plant	Yield per plant (g)	Yield per hectare (t/ha)
T_1	70.55^{a}	14.60^{g}	10.87^{g}	91.04^{g}	5.01^{g}
T_2	63.33^{d}	19.53^{d}	14.87^{e}	165.41^{d}	9.09^{d}
T_3	67.77^{bc}	17.80^{e}	14.40^{e}	153.41^{e}	8.44^{e}
T_4	68.55^{b}	16.73^{f}	13.53^{f}	132.86^{f}	7.31^{f}

T_5	60.77^{e}	23.00^{b}	17.73^{b}	198.57^{b}	10.92^{b}
T_6	62.55^{d}	21.60^{c}	16.80^{c}	187.57^{c}	10.32^{c}
T_7	66.66^{c}	20.73^{c}	15.80^{d}	165.10^{d}	9.08^{d}
T_8	58.99^{e}	24.13^{a}	18.73^{a}	238.88^{a}	13.14^{a}
C.D.$_{(0.05)}$	1.75	0.92	0.74	7.76	0.43
SE(m)	0.57	0.30	0.24	2.54	0.14
SE(d)	0.85	0.43	0.34	3.59	0.19

Such as: T_1(Control), T_2(RDF + *Azotobacter*@2g/plant), T_3(RDF+PSB@2g/plant), T_4(RDF+ *Azospirillum*@2g/plant), T_5 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant), T_6 (RDF + *Azotobacter*@2g/plant + *Azospirillum*@2g/plant), T_7(RDF +PSB@2g/plant + *Azospirillum*@2g/plant), T_8(RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant)

Table 3: Effect of biofertiizer on physico-chemical attributes of strawberry cv. Winter Dawn

Treatment	Berry length (mm)	Berry breadth (mm)	Berry weight (g)	TSS ($^{\circ}$Brix)	Total sugar (%)	Reducing sugar (%)	Anthocyanin content (mg/100g)
T_1	34.31^{e}	31.43^{e}	8.38^{e}	6.90^{c}	5.68^{d}	3.73^{d}	16.39^{d}
T_2	40.42^{c}	35.77^{b}	11.13^{b}	8.13^{b}	6.12^{d}	4.04^{b}	20.29^{c}
T_3	39.71^{c}	34.11^{c}	10.65^{c}	8.17^{b}	6.76^{bc}	4.08^{b}	17.65^{d}
T_4	35.18^{e}	33.03^{cd}	9.82^{d}	8.37^{b}	6.63^{c}	3.82^{cd}	17.92^{d}
T_5	42.27^{b}	36.74^{b}	11.20^{b}	8.95^{ab}	7.18^{b}	4.29^{a}	22.57^{b}
T_6	39.11^{cd}	36.08^{b}	11.16^{b}	8.53^{b}	7.01^{bc}	4.05^{b}	23.93^{ab}
T_7	37.52^{d}	32.79^{d}	10.45^{c}	8.15^{b}	6.98^{bc}	3.96^{bc}	18.74^{cd}
T_8	45.88^{a}	38.96^{a}	12.76^{a}	9.42^{a}	7.58^{a}	4.38^{a}	26.14^{a}
C.D.$_{(0.05)}$	1.74	1.21	0.36	0.81	0.40	0.15	2.28
SE(m)	0.57	0.39	0.12	0.26	0.13	0.05	0.74
SE(d)	0.80	0.56	0.16	0.37	0.19	0.07	1.05

Such as: T_1(Control), T_2(RDF + *Azotobacter*@2g/plant), T_3(RDF+PSB@2g/plant), T_4(RDF+ *Azospirillum*@2g/plant), T_5 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant), T_6 (RDF + *Azotobacter*@2g/plant + *Azospirillum*@2g/plant), T_7(RDF +PSB@2g/plant + *Azospirillum*@2g/plant), T_8(RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant)

Table 4: Effect of biofertiizer on leaf nutrient content of strawberry cv. Winter Dawn

Treatment	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Calcium (%)	Magnesium (%)
T_1	2.21^{h}	0.94^{f}	2.15^{h}	1.70^{g}	0.11^{f}
T_2	2.63^{e}	1.18^{cd}	2.76^{e}	2.02^{d}	0.20^{de}
T_3	2.53^{f}	1.14^{de}	2.54^{f}	1.92^{e}	0.14^{f}
T_4	2.47^{g}	1.09^{e}	2.30^{g}	1.86^{f}	0.17^{ef}
T_5	2.93^{b}	1.28^{b}	3.21^{b}	2.21^{b}	0.31^{b}
T_6	2.82^{c}	1.21^{c}	3.11^{c}	2.13^{c}	0.27^{bc}
T_7	2.71^{d}	1.23^{bc}	2.99^{d}	2.03^{d}	0.24^{cd}
T_8	3.09^{a}	1.37^{a}	3.39^{a}	2.37^{a}	0.39^{a}
C.D.$_{(0.05)}$	0.04	0.04	0.04	0.05	0.02
SE(m)	0.014	0.013	0.015	0.015	0.007
SE(d)	0.02	0.02	0.02	0.02	0.01

Such as: T_1(Control), T_2(RDF + *Azotobacter*@2g/plant), T_3(RDF+PSB@2g/plant), T_4(RDF+ *Azospirillum*@2g/plant), T_5 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant), T_6 (RDF + *Azotobacter*@2g/plant + *Azospirillum*@2g/plant), T_7(RDF +PSB@2g/plant + *Azospirillum*@2g/plant), T_8(RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant)

Table 5: Effect of biofertiizer on soil health attributes of strawberry cv. Winter Dawn

Treatment	Soil pH	Soil EC (dS/m)	Organic carbon (%)	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)
T_1	7.70^{a}	0.65^{a}	0.41^{d}	271.57^{g}	36.70^{g}	127.97^{h}
T_2	7.40^{bc}	0.51^{bc}	0.53^{bc}	333.40^{c}	44.83^{f}	137.80^{d}
T_3	7.43^{b}	0.55^{b}	0.50^{bc}	323.37^{e}	51.07^{d}	133.83^{f}
T_4	7.43^{b}	0.54^{bc}	0.47^{c}	296.83^{f}	46.23^{e}	132.53^{g}
T_5	7.20^{cd}	0.42^{d}	0.56^{b}	344.53^{b}	57.43^{b}	147.10^{b}
T_6	7.30^{bcd}	0.49^{c}	0.54^{b}	342.57^{b}	47.53^{e}	143.50^{c}
T_7	7.47^{b}	0.55^{b}	0.49^{bc}	326.83^{d}	53.50^{c}	135.87^{e}
T_8	7.13^{d}	0.36^{d}	0.64^{a}	349.93^{a}	59.17^{a}	150.77^{a}
C.D.$_{(0.05)}$	0.20	0.06	0.02	2.08	1.31	1.29
SE(m)	0.06	0.02	0.01	0.68	0.43	0.42
SE(d)	0.09	0.03	0.01	0.96	0.61	0.59

Such as: T_1(Control), T_2(RDF + *Azotobacter*@2g/plant), T_3(RDF+PSB@2g/plant), T_4(RDF+ *Azospirillum*@2g/plant), T_5 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant), T_6 (RDF + *Azotobacter*@2g/plant

+ *Azospirillum*@2g/plant), T_7(RDF +PSB@2g/plant + *Azospirillum*@2g/plant), T_8(RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant)

Table 6: Effect of biofertiizer on economic attributes of strawberry cv. Winter Dawn

Treatment	Gross income	Net Return	B:C
T_1	8,01,128.5	3,98,969	0.99
T_2	14,55,643	10,18,583	2.33
T_3	13,50,020	9,12,960	2.09
T_4	11,69,127	7,30,967	1.67
T_5	17,47,398	13,09,238	2.99
T_6	16,50,587	12,11,327	2.76
T_7	14,52,886	10,13,626	2.31
T_8	21,02,150	16,61,790	3.77

Such as: T_1(Control), T_2(RDF + *Azotobacter*@2g/plant), T_3(RDF+PSB@2g/plant), T_4(RDF+ *Azospirillum*@2g/plant), T_5 (RDF + *Azotobacter*@2g/plant + PSB@2g/plant), T_6 (RDF + *Azotobacter*@2g/plant + *Azospirillum*@2g/plant), T_7(RDF +PSB@2g/plant + *Azospirillum*@2g/plant), T_8(RDF + *Azotobacter*@2g/plant + PSB@2g/plant + *Azospirillum*@2g/plant)