RESEARCH ARTICLE

Enrichment in Growth, Yield and Quality Attributes of Strawberry (*Fragaria* × *ananassa* Duch.) Cv. Camarosa, through the INM

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Abstract

An experiment was conducted in the Farm Unit 02, Department of Agriculture, IIAST, Integral University, Lucknow, during the two subsequent years i.e. 2020-21 and 2021-22 to study the Effect of Integrated Nutrient Management (INM) on growth, yield and quality of strawberry (*Fragaria* × *ananassa*.Duch) cv. Camarosa. All doses of biofertilizers viz, *Azotobacter, Azospirillium* and PSB were applied as root treatment when transplantation was done in the plots according to treatments. The experiment's two year's worth of data were combined and examined. During research, height of the plant increased to (15.60 cm), the number of leaves was counted (19.68), spread of plant (13.81 cm). Those plants treated with T7 were recorded to be greater than other treatments. While the lowest result was the plant height (9.93 cm), the of leaves number was counted (13.94), the spread of the plant was recorded (9.90 cm) in the T0 (control), on the other hand berry length (5.57 cm), width of berry (4.25 cm), weight of berry (22.84 g), counted berries per plant (22.83), yield of the berry per plant (508.98 gm), berry yield/block (10.17 Kg) and berry harvest quintals/ha-1 (272.08 q/ha) were recorded in T7. The maximum TSS (14.40 Brix), total sugars (7.71%), TSS acid ratio (23.43), and minimum acidity (0.60%) were recorded in T_7 while maximum acidity was found at T0.

Keywords: Strawberry, Biofertilizer, Integrated nutrient management, growth and quality.

Highlights

- INM help in reducing contamination of water body.
- Biofertilizers improve the soil texture and increase the yield of plants by 25% to 30%.
- Biofertilizers protect the environment from pollutants since they are natural fertilizers.
- Strawberry crops are ready to harvest within 4 to 5 months.
- Strawberries' contain high levels of vitamin C and antioxidants which help reduce the risk of serious health problems.

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Introduction

Strawberry (*Fragaria* × *ananassa* Duch.) is a popular testy, nutritious and tiny fruit that requires many ingredients to grow well. Singh *et al.,* (2023). Strawberries belongs to the Rosaceae family. It includes species of *Fragaria,* with n = 7 basic chromosomes. Serce *et al.,* (2010) and Vijayan *et al.,* (2008). The strawberry fruit plant It is a hybrid of mainly two dioecious species, octoploid in nature. When female *Fragaria chiloensis* plants from Chile were planted alongside male *Fragaria* plants from North America in the early 17th century, it is believed that *Fragaria chiloensis* and *Fragaria virginiana* spontaneously hybridized in Europe. G. Chandramohan Reddy *et al.,* (2020). The strawberry plant has short days and rapid growth (Gallette and Bringhurst, 1990). The strawberry fruit plant's nature is herbaceous and the growth of this fruit plant is prostrate in habit that acts as a perennial in cold climates and an annual in subtropical climates. In the open field, strawberries grow freely. Although strawberries are a temperate fruit crop, certain varieties can be grown in subtropical climates with ease Grappelli *et al.,* (1987). In India, it is planted in the plains and sub-mountainous areas of Uttar Pradesh, Uttarakhand, Karnataka, Maharashtra, Himachal Pradesh, Punjab, Haryana and Madhya Pradesh, wherever irrigation facilities are available. Strawberry production is growing rapidly in northern India due to its high profitability rates. Because crop produces high yield and production after transplanting to last harvesting, its area and production have multiplied many times in recent decades Zargar, *et al.,* (2008). However, strawberry plants' sensitivity to nutritional balance, their root system is shallow, and their maximum productivity. Albregts *et al.,* (1985). Fresh, ripe strawberries are a fantastic source of nutrients and vitamins. Vitamin C (30–120 mg/100 g of fruit pulp) and vitamin A (60 IU) are two fairly important sources of vitamins. Strawberries also contain a lot of calcium

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pectate, a type of pectin perfect for making gelatin. Mitra *at al.,* (1991). Biofertilizers are organic materials created by plant roots or cultivated soil that occur naturally and do not negatively impact the environment, soil or plants in any way. In addition to their functions in fixing atmospheric nitrogen and solubilizing phosphorus, they also help in increasing growth hormones. Biofertilizers fix nitrogen from the atmosphere. Beneficial microorganisms present in biofertilizers influence plant growth and health, enhancing nutrient availability, uptake and biological activity in the rhizosphere. G. Chandramohan Reddy *et al.,* (2020). while PSB solubilizes phosphates that is present in the soil but are insoluble, increasing soil fertility and promoting biological activity. Living microorganisms are used to create biofertilizers, which can fix nitrogen from the atmosphere and change into soluble phosphorus into soluble phosphorus that plants can absorb (Walid *et al.,* 2014). These biofertilizers are intended to be applied to soil or seeds and function as carriers of advantageous microorganisms in a viable state. In addition to improving soil fertility, they promote the growth of plants by enhancing the quantity and biological activity of beneficial microorganisms in the root zone. Gabr *et al.* (2001). From a sustainability point of view, there are strong arguments of nutrient recycling within the society, which means more use of organic nutrient sources within agriculture and horticulture. Karl-Johan Bergstrand (2022)

The integrated nutrient management method (IMN) plans to use chemical fertilizers with organic fertilizers, green fertilizers and biofertilizers. The availability of nutrients from both organic and inorganic sources is crucial for crop production and quality. INM helps restore and increase crop yields and soil fertility. It may also be helpful to check for increasing deficiencies of nutrients other than N, P, and K. Selim (2020)

The current study aimed to identify the most effective nutrient ratios to encourage commercial strawberry development while maximizing the use of biofertilizers. Therefore, the current experiment was to use bio fertilizers to remedy eco-friendly and agriculturally beneficial fertilizers. To determine the appropriate proportions of treatments in strawberries, we conducted a randomized block design (RBD) experiment to investigate impact of different proportions of treatments on vegetative characters, fruits quality and yield.

Materials And Methods

The research unit, sample and location: In the agronomic region of the central humid subtropical zone, India, the field experiment was carried out at the Farm Unit -02, Department of Agriculture, IIAST, Integral University, Lucknow, U.P. for two following years i.e. 2020-21 and 2021-22. The site of the experiment is situated at latitude 26.950 N and longitude 80.990 E, at an altitude of 49 meter overhead level of the sea. Experiment was done with simple RBD design by three repetitions in a clay soil with well-drained (58.07% sand, 32.75% silt, 9.18% clay), isohyperthermal, typical ustipsamments pH range 6 to 7 soil to solution ratio (1.0 MKCl) of 1:15, electrical conductivity of 0.25 dS/m, organic carbon of 0.54%, available nitrogen of 254.0 kg/ha, available phosphorus of 23 kg/ha and available potash of 342.0 kg/ha. During the growing period, the mean heist temperature 38 to 40°C. However, the mean least temperature was 5 to 10°C during the growing time. In the research region, there is 670 mm of precipitation annually. The above data was clearly written in (Table 1). The strawberry runners used for the current study 'Camarosa' were transported from Dr. Yashwant Singh Parmar University of Horticulture and Forestry, H. P. India. The runner was set aside for one to three days before being transplanted in the field in plots. That was randomly distributed in according to the layout plant. Standard cultural practices were adhered to during the trial time to maintain performance and quality.

Table 1: The site of experimental conditions and mean of weather performance at Department of Agriculture, IIAST, Integral University, Lucknow, India

Parameters	*Units*	*Cropping season*	*Maximum temp. (^{0}C)*	*Minimum temp. (^{0}C)*	*Humidity (%)*	*Sunshine (in hours)*
Altitude	49 m above sea level	Agro climatic parameters during October 2020 to April 2021 (First year)				
Longitudes	80.99^0 E	October	31.2	21.4	53	7.26
Latitudes	26.95^0 N	November	24.24	12.52	51.86	6.63
Climate	Humid Sub- tropical	December	18.52	8.70	59.62	4.5
Average annual rainfall	670 mm	January	16.69	8.48	63.27	3.5
Soil	Loamy soil	February	23.10	11.83	57	7.32
Sand	58.07%	March	31.01	17.79	42.43	7.46
Silt	32.75%	April	35.46	20.32	42.53	8.41
Clay	9.18%	Agro-climatic parameters during October 2021 to April 2022 (Second year)				
Ph	6.5 to 7.5	October	33.4	21.4	55.32	8.16
Soils to solution ratio	1.15	November	23.17	12.52	50.16	6.23
EC	0.25 ds/m	December	19.71	8.70	60.62	4.57
Organic carbon	0.54%	January	17.69	8.48	61.34	4.1
Available nitrogen	254 kg/ha	February	25.32	11.83	59.61	7.62
Available phosphorus	23 kg/ha	March	33.16	17.79	40.33	7.96
Exchangeable K	342 kg/ha	April	37.52	20.32	44.13	8.61

Treatment and experimental details

The experiment was set up with three replicates and an individual plot size of 2.0 m (width) and 1.0 m (length). The total number of treatments is nine with absolute control. About 25 plants were planted in each plot. The nine treatments were the following: T_0 Control, T_1-100% RDF, T_2-100% RDF + 2kg/ha *Azotobacter*, T_3-100% RDF + 2kg *Azospirillium*, T_4-100% RDF + 2kg PSB, T_5-50% RDF + *Azotobacter* 2kg + 50% P and K fertilizer, T_6-50% RDF + 2 kg/ha *Azospirillium* + 50% P and K fertilizer, T_7-50% RDF + *Azotobacter* + PSB + 50% P and K and T_8 -50% RDF + *Azospirillium* + PSB + 50% K. During the investigation in both years, RDF—120: 80: 100 Kg/ha was applied nitrogen phosphorus, and potash were applied via urea (46%), SSP containing 16% phosphorus, another is murate of potassium-containing 60% potash. All planting materials were kept under a similar program throughout the research. Vegetative characteristics of strawberry plants were recorded during the growth period. After harvesting of fruits, a biochemical analysis of fruits was carried out and again physiochemical parameter was recorded during the harvesting period of the fruits. The soil was collected as a sample before transplanting of runners in the main experimental plots of different physicochemical analysis. Previously transplanting the runner, 0 to 15 and 15 to 30 cm depth samples of the soil were collected for soil nutrient analysis from the investigated field to estimate the soil's baseline properties. The samples of the collected soil were dried in the air and after drying, the soil was crushed through a wooden roller and passed through a 2 mm sieve before chemical analysis. Cation exchange capacity was estimated by using sodium acetate ($C_2H_3NaO_2$) (buffered to pH 8.2) and ammonium acetate (CH_3COONH_4) (buffered to pH 7.0) according to Sumner and Miller (1996). Soil organic carbon estimated through. Walkley and Black (1934). Ammonium acetate (CH_3COONH_4) buffered at pH 7. Thomas (1982) was used to determine exchangeable cations. To estimate available nitrogen by Kjeldahl method. Subbia *et al.,* (1956). Plant-available phosphorus was estimated by the using of spectrophotometer Olsen *et al.,* (1954). Soil micronutrients were determined by diethylenetriaminepentaacetic acid ($C_{14}H_{23}N_3O_{10}$) (DTPA) extraction method Lindsay *et al.,* (1978). pH of the soil was estimated in 1:2 method. (Jackson,1973) Extracts and calcium carbonate ($CaCO_3$) concentrations were estimated according to McLean (1982). The biofertilizer was purchased online from Indian Farmers Fertilizer Cooperative Limited (IFFCO).

Preparation methods of working solution of biofertilizer

On planting day, working solutions of biofertilizers were made early in the morning using several buckets filled with water and biofertilizer powder and dissolved thoroughly. Before planting in the main field, root of the runner was dipped in a working solution in approximately 30 minutes. However, nitrogen, phosphorus, and potassium fertilizer were applied according to the treatments.

Method of planting

Runners were planted on bund in the evening time plant spacing was kept 45 x 45 cm. After transplanting, initial irrigation was given in the evening and morning by watering cans for 20 days, and then the plant was irrigated by an electric motor through a pipe. Manual weeding is carried out 35 days after planting and additional weeding is carried out when required.

Mulch martials

Paddy straw was used as mulch because it was easily available to farmers, and paddy straw mulch protected the fruits from rotting, checked weed growth, regulated soil temperature, and improved soil moisture. After the final harvest of fruits, this mulch is mixed in the same field because rotted paddy straw enhances soil fertility. It also reduces the cost of cultivation.

Data collection and traits

The twelve most profitable traits of the experiment: Height of plant (cm), spread of plant (cm) and number of leaves plant^{-1} are recorded after transplanting at intervals of 15, 30, 45, 60, and 75 DAP. Berry length (cm), berry width (cm), berry weight (g) berry per plant, berry yield q./ha^{-1}, TSS (^{0}Brix), total sugars (%), TSS acid ratio and titratable acidity (%) were measured morphometrically at the time of harvest. Initially, more than 30 days are needed after transplanting strawberry runners to establish strawberry plants.

Plant growth and yield analysis

Vegetative parameters and yield parameters were noted following standard procedure. Berry sample in every treatment were collected at harvesting time and their physicochemical properties were analysed according to standard methods. A digital Vernier caliper was used to measure the berries' length and breadth. Ten randomly chosen fruits each plot had their weights assessed, and an average was determined. Each plant's berry at ripening was harvested, weighed, and expressed in kilos to determine the yield per plant.

Fruit quality analysis

Total sugars (%) were calculated according to the formula given below.

$$\text{Total sugar (\%)} = \frac{\text{mg of invert sugar x Dilution x 100}}{\text{Titrate value x volume of sample x 10000}}$$

The berry's acidity was estimated using the process assumed by Ranganna (1997). To estimate the acidity of fruits, 10 g of sample was taken and the volume was brought to 100 ml. It was titrated against 0.1 N NaOH by using a phenolphthalein indicator. The endpoint showed in light pink colour.

$$\text{Acidity (\%)} = \frac{\text{Titrate x Normality of alkali x made vol. x equivalent wt. of acid x 100}}{\text{Volume of aliquot taken x volume of sample x 10000}}$$

TSS acid ratio was intended by separating the total soluble solids by the acidity. TSS: Total soluble solids (TSS) were measure by using of an ERMA manual refractometer. The recorded data were express in the °Brix unit. Statistical Analysis: The pooled data of the two years were analysed using Microsoft Excel, SPSS software available in version 1.0. Statistical analysis was performed according to the experimental design recommended by Panse *et al.,* (1987) and Ranganna (1995). Clarification of the result is based on *'F'* test.

Result And Discussion

Growth Parameters

Plant height (cm), Plant spread (cm), and leaves per plant

The height characteristics of cv. Camarosa has been meaningfully prejudiced by the immunization of biofertilizer in the root area

Table 2: Influence of integrated nutrient management (INM) on vegetive characters of Strawberry (*Fragaria* × *ananassa* Duch.)

Treatment	*Pant height (cm)*					*Plant spread (cm)*					*Leaves per plant*				
	15 DAP	*30 DAP*	*45 DAP*	*60 DAP*	*75 DAP*	*15 DAP*	*30 DAP*	*45 DAP*	*60 DAP*	*75 DAP*	*15 DAP*	*30 DAP*	*45 DAP*	*60 DAP*	*75 DAP*
T_0	2.52	3.16	5.38	6.68	9.93	4.61	5.61	6.98	8.11	9.90	3.33	5.24	7.56	10.39	13.94
T_1	3.04	3.72	5.57	6.99	10.62	4.49	6.61	8.12	9.24	10.32	3.63	5.45	8.20	10.65	14.83
T_2	3.06	3.74	5.53	7.54	11.04	4.20	6.51	8.07	9.29	11.28	3.69	5.69	8.19	11.54	15.73
T_3	2.69	3.73	5.59	7.89	11.37	5.19	6.74	8.26	9.52	11.16	4.23	6.44	8.39	11.93	16.21
T_4	2.74	3.75	5.98	8.21	12.07	5.10	7.24	8.46	9.60	11.50	4.59	7.48	9.16	12.63	17.19
T_5	2.77	3.62	6.26	8.56	12.49	5.31	7.47	8.85	10.03	12.35	4.60	8.28	9.32	13.57	18.07
T_6	2.79	3.82	6.67	9.25	14.52	5.24	7.67	9.11	10.49	12.80	4.70	8.12	9.94	14.59	18.58
T_7	3.47	4.62	7.49	10.37	15.60	5.98	8.77	9.82	11.31	13.81	5.81	8.87	11.20	16.34	19.68
T_8	2.62	3.97	6.84	8.62	14.43	5.13	7.48	9.29	10.82	13.09	5.13	8.22	11.15	15.11	19.35
SEm±	0.19	0.27	0.33	0.59	0.47	0.35	0.46	0.42	0.63	0.51	0.32	0.50	0.64	0.71	0.74
CD (P=0.05)	0.57	0.82	1.00	1.77	1.43	1.05	1.38	1.28	1.89	1.55	0.97	1.51	1.92	2.15	2.22

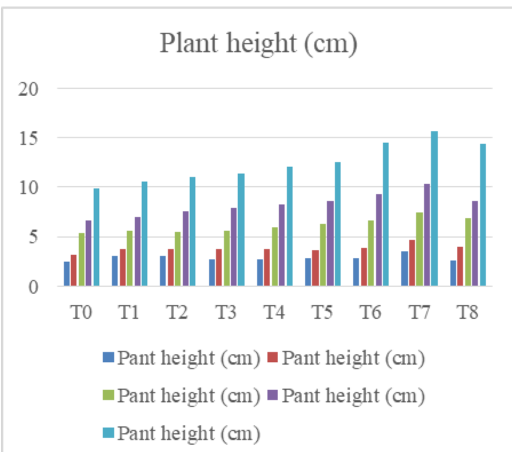


Fig. 1: Plant height

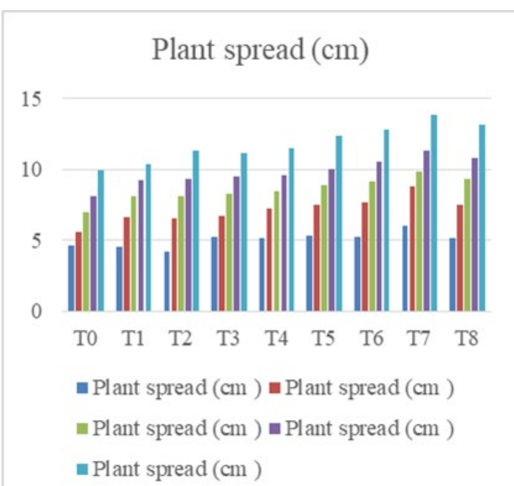
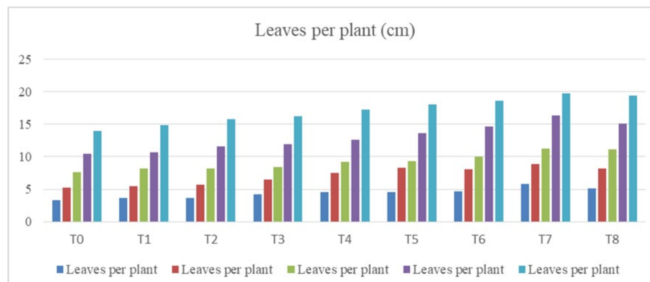


Fig. 2. Plant Spread



Average of three replications, each replication consisting of 180 plants. Each plot consisting 20 plants innumber; **least significant difference at 5% probability level; DAP= Day after planting.

The data presented is the average of two successive cropping seasons (2020–21 and 2021–22). Mean values in the table represented with different letters are significantly different (p <0.05)

Fig. 3: Leaves per Plant

of the plants and the application of chemical fertilizers in (Table 2). Plant height (cm) plant^{-1} has got a good result in all biofertilizer-treated plants compared to the T_0. The heist plant height (15.60 cm) was recorded at 75 DAS in T_7 followed by T_6 (14.52 cm). However, the minimum plant height (9.93 cm) will be recorded in the control (T_0). Which is graphically illustrated in (Fig. 1). Maximum plant spread (13.81 cm) was recorded during data observations at T_7 followed by T_8 (13.09 cm); However, minimum plant spread (9.90cm) will be observed in untreated plants during the investigation. Which is graphically illustrated in (Fig. 2). The heist leaf per plant (19.68) was found under the T_7 followed by T_8 (19.35 cm). However, the last leaf per plant (13.94) was counted in the control (T_0) at the time of investigation, which is graphically illustrated in (Fig. 3).

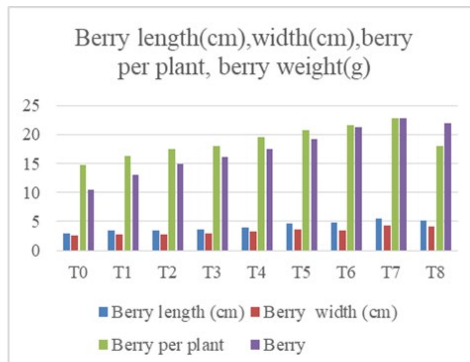
Discussion

Biofertilization works so well regarding vegetative traits because it helps plants obtain nutrients by adding microorganisms to the soil, which are beneficial in supporting plant nutrition and stimulating root growth. It also changes the pH of the soil, which helps plants absorb nutrients and grow more quickly by making nutrients already present in the soil more soluble or available to plants. Howeidi *et al.,* (2021) and Kumar (2018) reported a similar result in strawberries. Inoculation of nitrogen fixers may

Table 3: Influence of integrated nutrient management (INM) Fruit parameter and Yield of Strawberry (*Fragaria* x *ananassa* Duch)

Treatments	*Berry length (cm)*	*Berry width (cm)*	*Berry per plant*	*Berry Weight(g)*	*Berry yield per plant (g)*	*Berry yield per plot (kg)*	*Berry yield q ha^{-1}*
T_0	2.92	2.55	14.70	10.42	178.33	3.56	94.75
T_1	3.38	2.72	16.22	13.01	214.12	4.28	114.22
T_2	3.50	2.75	17.45	14.95	245.97	4.91	131.02
T_3	3.67	2.92	18.08	16.17	292.96	5.82	155.24
T_4	4.02	3.29	19.62	17.57	347.77	6.94	185.28
T_5	4.56	3.56	20.80	19.25	399.24	7.98	212.84
T_6	4.73	3.51	21.68	21.22	451.33	9.02	240.62
T_7	5.57	4.25	22.83	22.84	508.98	10.17	272.08
T_8	5.21	4.17	18.03	21.88	471.90	9.43	251.50
SEm±	0.25	0.23	2.64	5.49	19.04	0.38	10.13
CD (P=0.05)	0.76	0.71	7.94	16.49	57.12	1.14	30.39

have increased the amount of chlorophyll in the plant, causing an increase in both the height of the plant and the number of leaves per plant. The additional cause of increased vegetative growth could be rhizosphere bacteria that produce plant growth regulators that are absorbed by the roots. Therefore, greater biological nitrogen fixation may be responsible for greater vegetative growth. Mohandas (1987). The highest number of leaves was counted in those treatments treated with *Azospirillium* + PSB. These findings were reported by Hazarika *et al.,* (2015). This may also be the result of the application of biofertilizer and organic fertilizer. These organic fertilizers replenish the physical condition of the soil and provide all the necessary nutrients, especially in light-textured soils. Singh *et al.,* (2021). Tripathi *et al.,* (2010) also recorded similar results with respect to vegetative characters. Naggar *et al.,* (2015) and Chawla *et al.,* (2020).



**Least significant difference at 5% probability level;

The data presented is the average of two successive cropping seasons (2020–21 and 2021–22). Mean values in the table represented with different letters are significantly different (*p* <0.05

Fig. 4: Berry length, Berry width, Berry per plant Berry Weight

Berry growth and yield

Berry length (cm), berry width (cm), berry/plant, berry weight (g**),** berry yield/ plant (g), berry yield/plot (kg) and berry yield (q ha^{-1}) As of the data in (Table 3) it is clearly understood that the maximum berry length (5.57 cm) was measured in T_7-treated plants, followed by (5.21 cm) in T_8 and (4.73 cm) in T6. However, the minimum berry length was recorded in the (T_0). Maximum berry width (4.25 cm) was measured at T_7 followed by T_8 (4.17 cm), which is the second holdup value (3.56 cm) at T_5; however, the minimum berry width (2.55 cm) was observed in the control. The maximum berries per plant were counted during an investigation at T_7 (22.83), followed by T_6 and T_5 (21.68 and 20.80), respectively. However, the minimum number of berry plants^{-1} was counted in the control (T_0). In the case of berry weight, the maximum berry weight (22.84 g) was observed at T_7 followed by (21.88 g) in T_8. However, the minimum berry weight was recorded at T_0 (control). The above parameters were clearly showed in (Fig. 4). The maximum berry yield/plant (g) was observed during the investigation (508.98 g) at T_7 however, the least berry yield per plant was recorded in the T_0 control. On the other hand, the maximum berry yield per plot (kg) was recorded in T_7, which was (10.17 kg), followed by T_8 (9.43 kg); However, the minimum berry yield per plot (3.56 kg) was recorded under control (T_0) on the other hand, the maximum berry yield was recorded in T_7 (272.08) quintals/ha^{-1} followed by T_8 (251.50q. per ha^{-1}); However, minimum berry yield in quintal per hectare was calculated at T_0 (control) which is 94.75 (q/ha^{-1}). Above yield attributes were clearly shown in (Fig. 5).

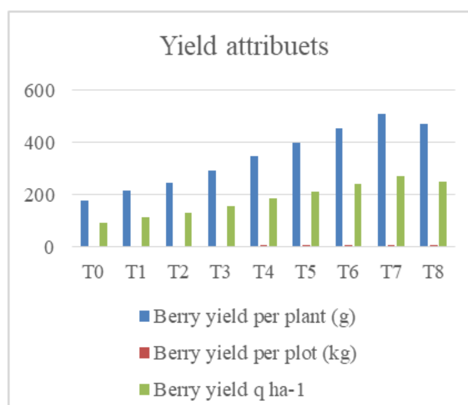
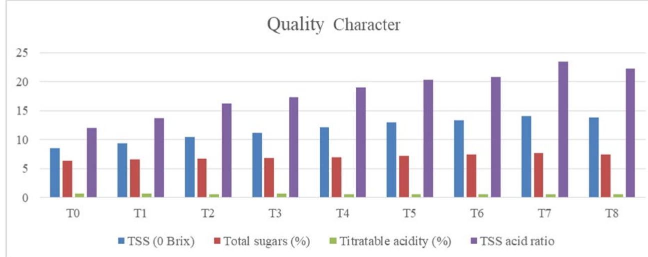


Fig. 5: Berry yield per plant, Berry yield per plot, Berry yield

Table 4: Influence of integrated nutrient management (INM) on quality parameter of Strawberry (*Fragaria* x *ananassa* Duch)

Treatment	TSS (^{0} Brix)	Total sugars (%)	Titratable acidity (%)	TSS acid ratio
T_0	8.50	6.40	0.70	12.03
T_1	9.36	6.60	0.68	13.75
T_2	10.49	6.77	0.64	16.20
T_3	11.23	6.86	0.65	17.36
T_4	12.15	7.02	0.64	18.97
T_5	13.00	7.15	0.64	20.30
T_6	13.37	7.40	0.64	20.79
T_7	14.04	7.71	0.60	23.43
T_8	13.84	7.48	0.62	22.23
SEm$\pm$	0.52	0.68	0.01	0.93
CD ($p = 0.05$)	1.56	2.04	0.05	2.80



LSD = least significant difference; P: probability level.

The data presented is the average of two sequential cropping seasons (2020–21 and 2021–22). Values in the table signified with different letters are significantly dissimilar ($p < 0.05$)

Fig. 6: Quality Character

The nitrogen fixation capacity of vermicompost and the phosphorus solubilization capacity of biofertilizers can increase the availability of phosphorus and nitrogen to plants and their translocation, helping to increase fruit weight and overall fruit production. Chattopadhyay *et al.,* (2022). Fruit characteristics such as length, width and weight may be related to better fruit fillings due to more balanced absorption of nutrients, which has improved metabolic activities and increased carbohydrate and protein synthesis. Nayyer *et al.,* (2014). The results of finding similar with Singh *et al.*, (2022), Kumar *et al.,*(2012), Khunte *et al.,* (2020) and Kumar *et al.,*(2019) and Nazir *et al.,* (2015) and Shukla *et al.,*(2009) and Macit *et al.,*(2007).

Berry quality

TSS (^{0}Brix), Total sugars (%), Titratable acidity (%) and TSS acid ratio.

As of the data in (Table 4) it is clearly understood the highest Total Soluble Solids content (^{0}Brix) was observed in the fruits which was harvested in T_7 (14.04 0Brix) followed by T_8. Although a minimum TSS was recorded in the $T_{0.}$ as of the data obtainable in (Table 4), it is predicted that the total sugar content increased in those treatments treated with *Azotobacter* + PSB compared to the control. Maximum was estimated at T_7 (7.71%) followed by T_8 (7.48%). However, minimum was recorded in control (6.40%). Minimum acidity (0.60%) was recorded during the investigation in the T_7, while a maximum acidity (0.70%) was recorded in the T_0, this is clearly indicated in (Table 4) A close examination of the data on the TSS acid ratio indicate noteworthy differences between the dissimilar treatment. (Table 4) clearly showed that TSS acid ratio augmented significantly in all treatments treated to biofertilizers, with the highest data in the treatment composed of T_7 (23.43) followed by T_8 (22.23). However, the minimum was recorded in control (12.03). The above parameters was also clearly showed in (Fig. 6).

A gradual supply of nutrients throughout the growing period may cause the increase in total sugars and TSS in berries due to the inoculation of biofertilizers with organic fertilizers, thus increasing the metabolites in the berry. Singh *et sal.,* (2006). and Starch and pectin undergo quick metabolic changes to become soluble molecules, and sugars move quickly from leaves to growing fruits. However, the maximum titratable acidity was significantly higher than that of any other treatment. It was found that the inoculation of biofertilizers alone or in combination significantly decreased the sourness of the fruits. Their change into sugar can explain the decreased sourness of the fruit through reactions that involve the reversal of the glycolytic pathway. Biofertilizers can also increase the amount of total sugar and TSS content. The application could be explained by the rapid metabolic change of complex polysaccharides into simple sugar, the quick translocation of sugar from leaves to emerging fruits, and rapid metabolic transformation of starch and pectin into soluble compounds. These results are in similar to Negi *et al.,* (2021) in strawberries and Athani *et al.,* (2009) in guava.

Conclusion

After conducting various tests, it has been concluded that the best treatment for cultivating the Camarosa variety of strawberry plants is T7-50% RDF + *Azotobacter* + PSB + 50% P and K dressing. This treatment promotes good growth and development, higher yields, and better quality of strawberries. Moreover, it enhances soil quality without hampering soil fertility, making it an ideal substitute for chemical fertilizers. This treatment promotes sustainable agricultural practices, benefiting soil and human health. Therefore, we can say that the T7 treatment is the most effective for strawberry cultivation as it improves the quality of the product with marketable fruits. After conducting various tests, it has been concluded that the best treatment for cultivating the Camarosa variety of strawberry plants is $T_{7.}$ This treatment promotes good growth and development, higher yields, and better quality of strawberries. Using this treatment promotes sustainable agricultural practices, which is beneficial for soil and human health. Therefore, we can say that the T7 treatment is the most effective for strawberry cultivation as it improves the quality of the product with marketable fruits.

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Author's Contribution

AS: Planning of the study, review and editing of MS. MAN: Conceptualization of idea, administration and supervision of the study. SS: correction as per suggestion from reviewer and editor. AKS: Review and editing of MS and correction as per suggestion from reviewer and editor. AK: Conceptualization of idea and writing original draft of manuscript. SP: collection of review literature and compilation.

Conflict of Interest

The authors have no conflict of interest.

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