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Effect of bio-fertilizer on growth, yield and quality of strawberry (*Fragaria × ananassa*Duch.) cv. Camarosa

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ABSTRACT
To search the alternative route to combat the harmful effect of excessive use of mineral fertilizers, an experiment was conducted to substitute the mineral fertilizer with biofertilizer in the field of strawberry cv. Camarosa. The experimental finding revealed that the sole inoculation of Azospirillium and Azotobacter and in combination with PSB significantly influenced the plant height and leaf size compared to control and 100% RDF treatment. Through the application of biofertilizer, duration of fruiting and the yield per hector area has increased significantly over control. Harvesting span was observed maximum in 75% RDF + Azospirillium @ 2g/plant + PSB @ 2g/plant + topdressing of 25% K (70 days) with at par result in 75% RDF + Azotobacter @ 2g/plant + PSB @ 2g/plant + topdressing of 25% K treatment. Fruit yield as calculated in one hector area was also increased significantly under these two treatments (19.87 and 17.41 t/ha, respectively). In addition, fruit size in respect to fruit length, width and volume was also measured maximum (40.99 mm, 31.78 mm and 25.50 cc, respectively) in the treatment consist of 75% RDF + Azospirillium @ 2g/plant + PSB @ 2g/plant + topdressing of 25% K. Further, fruit quality attributes viz. TSS:Acid ratio and reducing sugar content was estimated maximum in 75% RDF + Azospirillium @ 2g/plant + PSB @ 2g/plant + topdressing of 25% K treatment with par results in 75% RDF + Azotobacter @ 2g/plant + PSB @ 2g/plant + topdressing of 25% K treatment(10.97 and 4.92%, respectively). Therefore, from the experiment, it can be concluded that 75% RDF + Azospirillium @ 2g/plant + PSB @ 2g/plant + topdressing of 25% K treatment and 75% RDF + Azotobacter @ 2g/plant + PSB @ 2g/plant + topdressing of 25% K treatment can be used as the best alternative against conventional mineral fertilization application to increase the yield of strawberry cv. Camarosa without hampering the soil fertility status particularly under subtropical region of the country.
Key words: *Bio-fertilizer, Fruit quality, Harvest Span, Strawberry, Yield*

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INTRODUCTION

Strawberry (*Fragaria × ananassa*Duch.), an aggregate fruit of Rosaceae family, occupies a significant place in fruit industry, since it is cultivated both in plains as well as in hills.It is an herbaceous crop with prostate growth habit, which behaves as an annual in sub-tropical region and perennial in temperature region and has gained the status of being one of the most important soft fruit of the world after grape. Being rich in vitamin A (60 IU/100g), vitamin C (30-120 mg/100g), fiber, iron, pectin (0.55%) and ellagic acid, strawberry is mainly consumed as fresh fruit. However, it also contain very good amount of phenols, flavonoids, dietary glutathionine that too exhibit a high level of antioxidant capacity against free radicals.
Due to very high return per unit area and production of berries within few months of planting, the crop has gained economic importance throughout the world [27] which ultimately increases the area and production of the crop to many folds over the past decades. However, due to shallow root system, large number of fruit production per unit area and sensitivity of the plants to nutritional balance [2], strawberry needs extensive use of mineral fertilizersas these mineral fertilizers play the fundamental role in determining growth, yield and quality of the fruit. But the inorganic forms of fertilizer are short in

supply and very expensive too which ultimately increases the production cost up to 30% [11]. In addition, even though chemical fertilizers are beneficial in increasing the crop yield but at the same time their regular, excessive and imbalance use may leads to health and ecological hazards, depletion of physico-chemical properties of the soil water. Moreover, the production of these chemical fertilizers is an energy intensive process, require energy resources. Further, import of these fertilizers creates pressure on foreign exchange reserves to a great extent.

Hence, there is an urgent need to think about the use of alternative source of safe fertilizers which may enhance sustainably of crop yield without having any adverse effect on soil properties and environmental hazards and also to reduce cost of cultivation. Biofertilizers are considered as economically attractive and ecologically sound route for reducing external inputs augmenting nutrient supply and to improve the quality and quantity of internal resources with maximum outputs. These biofertilizers act as carriers containing beneficial micro-organisms in a viable state, intended for seed or soil application, designed to improve soil fertility status and also helps in plant growth by increasing the number and biological activity of desired microorganisms in root environment [9].Further, they are able to fix atmospheric nitrogen in the range of 20-200 kg N/ha/year; solubilize P in the range of 30-50 kg P_2O_5/ha/year; mobilize P, Zn, Fe, Mo to varying extent. So far considerable number of bacterial species mostly associated with the plant rhizosphere has been tested and found to be beneficial for plant growth, yield and fruit quality. These includes *Azospirillum*, *Azotobacter*, *Pseudomonas* [8] etc. De Silva *et al.*[5],Sudhakar *et al*.[25],Esitken *et al.*[7],Aslantas *et al.*[3],Karlıdag *et al*.[15], Kumar *et al*. [16] also reported that these bacteria colonize in the root of the plant and stimulate the growth and increase the yield of different fruit crops such as apple, apricot, blueberry, citrus, cherry, peach, mulberry, strawberry. Hence, the possible solution to lower the risk of accumulation of inorganic source of fertilizer is to combine chemical fertilizers with biofertilizers[1]. However, there is scanty information available regarding the potentially of biofertilizer to substitute the amount of inorganic fertilizers for improving the growth, yield and quality of strawberry. Keeping these views in mind, the present investigation was carried out to study the effect of bio-fertilizer on growth, yield and quality of strawberry (*Fragaria* × *ananassa* Duch.) cv. Camarosa.

MATERIAL AND METHODS

Materials

Strawberry (*Fragaria* × *ananassa*Duch.) cv. Camarosa was used for the present study. The experimental plants were inoculated with three different biofertilizers, consisting eight different treatment combination *viz.*Control, 100% RDF(N:P:K @6:10:6 g/plant), 100% RDF + Azotobacter @ 2g/plant, 100% RDF + Azospirillum @ 2g/plant, 75% RDF + Azotobacter @ 2g/plant + topdressing of 25% each of P and K, 75% RDF + Azospirillum @ 2g/plant + topdressing of 25% each of P and K, 75% RDF + Azotobacter @ 2g/plant + PSB @2g/plant + topdressing of 25% K and 75% RDF + Azospirillum @ 2g/plant + PSB @2g/plant + topdressing of 25% K. All the plants were maintained under uniform cultural schedule during the entire course of investigation.

Preparation of working solution of biofertilizers

Bihar Azoto, Bihar Azospi and Bihar Phosphorous were used as the source of *Azotobacter*, *Azospirillum* and Phosphate Solubilising Bacteria (PSB) stains respectively. On the day of planting, working solution of *Azotobacter*, *Azospirillum* and PSB were prepared in the morning by dissolving 200 gmeachbiofertilizer powder in separate buckets containing 8 lit of water each.

Treatment to experimental plants

After preparation of working solution, the root system of experimental strawberry plants were dipped in to those solutions according to the treatment for about 30 min before planting them in to the main field. However, top dressing of phosphorous and potassic fertilizer was done to the plants on 15 days after planting (DAP) according to the treatment.

Observations recorded

Growth

Plant height was measured by erecting the measuring scale from the bottom to the maximum height of the plant for three different plants under each replication and average plant height for each replication was calculated thereafter. Similarly leaf length and breadth was also measured using measuring scale, while total number of runner produced per plant in each replication was calculated by counting the number of runner produced in each plant. However, duration of harvesting span was calculated by counting the total number of days taken by the plant in each replication under each treatment from harvesting of 1^{st} fruit to last fruit and expressed in days.

Yield

All the fruits from an individual plant were picked manually in each harvesting and weighted them on digital weighing balance. At the end of last harvesting, yield/plant was calculated by adding the value of fruit weight in each harvesting. Thereafter, yield per hector area was calculated by using following formula and expressed in tonnes/ha.

$$\text{Yield/ha} = \text{Yield/plant} \times \text{No. of plants accomodated in one hector (55555)}$$

Fruit quality

Fruit length was measured with the help of digital vernier caliper. It was measured from the base of the fruit stalk to the calyx end and expressed in millimeter (mm). Similarly, fruit breadth was also measured with the help of digital vernier caliper at the point where it was observed maximum and expressed in millimeter (mm). On the other hand, fruit volume was measured by water displacement method and was expressed in cubic centimeter (cc). However, total number of achiens/$cm^2$of fruit surface was calculated during the ripening of the fruit in each treatment by using graph paper.

Total soluble solids present in the fruits were recorded at room temperature for ten individual fruits under each replication using hand refractometer according to the method described by Rangana[22]. Similarly, titratable acidity was determined for the same ten fruits separately under each replication by using titration method [22]. Thereafter, TSS/Acid ratio was calculated by dividing the TSS with total acidity for those ten fruits separately under each replication and average value was calculated thereafter.

On the other hand, reducing sugar content in the fruit was determined by Lane and Eynone[17] method. For this 10 gm of fruit sample was grinded using pestle and mortar and transfer to a 250ml volumetric flask. Therefore, 100 ml distilled water and 2ml lead acetate solution was added to it. Then, 1.9 ml potassium oxalate solution was added to it and made the volume up to 250ml with distilled water and filtered the sample through filter paper. For estimating reducing sugar, took the filtrate in burette and Fehling's solution A and B was taken in a conical flask @ 5ml each and 50 ml distilled water was added in it. Therefore, boiling of the solution was done until it becomes colourless. Therefore, 2 drops of methylene blue indicator was added to it and titrate it with filtrate solution until brick red end point came. The per cent of reducing sugar present in the sample was calculated using following formula-

$$\text{Reducing sugar \%} = \frac{\text{Factor x Dilution}}{\text{Titrate Value x Weight of sample}} \times 100$$

For estimation of total sugar solution, 50 ml of filtrate solution was taken in a 100ml volumetric flask and 5ml concentrated HCl was added to it and kept it for 24 hr. Thereafter, 2 drops of phenolphthalein indicator was added to it and 40% NaOH solution was poured into it until pink colour appear. After that 0.1 N HClwas added to it drop by drop until pink colour disappear. Then made the volume with distilled water and took this solution in burette and follow the procedure same as for reducing sugars. The per cent of total sugar present in the sample was calculated using following formula-

$$\text{Total sugar \%} = \frac{\text{Factor} \times \text{Dilution} \times 100}{50 \times \text{Titrate Value} \times \text{Weight of sample}} \times 100$$

Thereafter non-reducing sugar content in the fruit was estimated using following formula -

$$\text{Non reducing sugar} = (\text{Total sugar \%} - \text{Reducing sugar \%}) \times 0.95$$

Statistical analysis

The experiment was laid out in randomized block design (RBD) with three replications.The observations were statistical analyzed through statistical analysis software (SAS 9.3; SAS Institute, Cary, NC, USA).Mean difference were tested by 'F' test at five per cent level of significance (LOS) and the means were compared using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Growth

The results on the response of biofertilizer on plant height of strawberry cv. Camarosa indicate a significant variation among the treatment (Table 1). Among different treatment maximum plant height was observed in the treatment consist of 75% RDF + Azotobacter @ 2g/plant + PSB @ 2g/plant + topdressing of 25% K (16.14 cm) followed by the treatment of 75% RDF + Azospirillium @ 2g/plant + PSB @ 2g/plant + topdressing of 25% K (14.39 cm) and 75% RDF + Azospirillium @ 2g/plant + topdressing of 25% each of P & K (14.03 cm). However, the control plant having least plant height (11.41 cm) which was statistically at par with the treatment of 100% RDF (11.70), 100% RDF + Azotobacter @ 2g/plant (11.81 cm), 75% RDF + Azotobacter @ 2g/plant + topdressing of 25% each of P & K (12.30 cm) and 100% RDF + Azospirillium @ 2g/plant treatment (12.54 cm).

A perusal of data pertaining to leaf size indicated that the leaf length and breadth differed significantly due to the effect of various treatments of biofertilizers (Table 1). As compared to control, leaf length has increased in each and every treatment and it was observed maximum in the treatment consist of 75% RDF + Azospirillium @ 2g/plant + PSB @ 2g/plant + topdressing of 25% K (8.55 cm) which was 54.33% higher than control (5.54 cm). Similarly, as compared to control, leaf breadth was also increased significantly in all the plants treated with different combination of biofertilizers and it was also measured maximum in the plants treated with 75% RDF + Azospirillium @ 2g/plant + PSB @ 2g/plant + topdressing of 25% K (11.59 cm) followed by 75% RDF + Azotobacter @ 2g/plant + PSB @ 2g/plant + topdressing of 25% K (10.83 cm) which was 18.51% and 10.74% higher than the control (9.78 cm).

The maximum increase of growth attributes viz. tree height, leaf length and bread thunder the treatment consist of 75% RDF + Azospirillium @ 2g/plant + PSB @2g/plant + topdressing of 25% K and 75% RDF + Azotobacter @ 2g/plant + PSB @2g/plant + topdressing of 25% K is mainly due to the enhancing effects of the non-symbiotic N_2-fixing bacteria on the morphology and/or physiology of root system; which promoted the growth of the plant. Jagnow *et al.*[14] and Noel *et al.*[19] indicated that the non-symbiotic N_2-fixing bacteria such as Azospirillum and Azotobacter strains produced adequate amounts of IAA and cytokinins which increased the surface area per unit root length and enhanced root hair branching with an eventual increase in the uptake of nutrients from the soil. Moreover, Pandey and Kumar [20] pointed out that the promoting effects of a biofertilizer on growth, not only related to their N-fixing proficiency but also to their ability to produce antibacterial and antifungal compounds, growth regulators and siderophores, resulting higher vegetative growth of strawberry cv. Camarosa in various biofertilizer treatment over control. Results of the present study were in general agreements with those obtained by Kumar *et al.* [16] on strawberry, Gabr*et al.*[9] on pepper, and El-Zeiny*et al.*[6] on tomato, who clarified that the biofertilization improved number of leaves, leaf area, plant height, and top fresh and dry weights plant^{-1}. Furthermore, Carletti *et al*. [4] demonstrated that the inoculated plants with Azospirillum displayed higher increase in total root length by 150% compared to the uninoculated control which is the probable reason for higher growth of strawberry cv. Camarosa by75% RDF + Azospirillium @ 2g/plant + PSB @2g/plant + topdressing of 25% K treatment as compared to75% RDF + Azotobacter @ 2g/plant + PSB @2g/plant + topdressing of 25% K treatment.

The influence of biofertilizer on runner production per plants was observed statistically non-significant among all the treatment (Table 2). Number of runner per plant was recorded maximum in 100% RDF treatment (3.33) and the treatment consist of 75% RDF + Azotobacter @ 2g/plant + PSB @2g/plant + topdressing of 25% K (3.00) which was 0.67 and 0.5 times higher than the control (2.00), respectively. On the other hand, the plants treated with 75% RDF + Azospirillium @ 2g/plant + PSB @2g/plant + topdressing of 25% K, 75% RDF + Azotobacter @ 2g/plant + topdressing of 25% each of P & K and 100% RDF + Azospirillium @ 2g/plant produced similar number of runner per plant as of control (2.00); however, it was recorded minimum in 100% RDF + Azotobacter @ 2g/plant treatment (1.67).The production of higher number of runner per plant in 100% RDF treatment might be associated with the lower reproductive growth by 100% RDF treatment resulting accumulation of more energy followed by production of more number of runner while the increased runner production under Azotobacter treated plots might be due to secretion of growth-promoting substances, especially cytokinin by Azotobacter which increased the runner production [18].

Harvest span and Yield

It is envisaged from the data presented in table 2 that the duration of harvesting span of strawberry cv. Camarosa extended significantly over control in all the bio-fertilizer treatments. Longest harvesting duration was observed in 75% RDF + Azospirillium @ 2g/plant + PSB @2g/plant + topdressing of 25% K treatment (70.00 days) which was statistically at par with 75% RDF + Azotobacter @ 2g/plant + PSB @ 2g/plant + topdressing of 25% K treatment (68.51 days), 100% RDF + Azospirillium @2g/plant treatment (67.32 days) and 75% RDF + Azospirillium @ 2g/plant + topdressing of 25% each of P & K treatment (66.37 days). Further, the duration of harvesting was also significantly increased in the treatment consist of 100% RDF + Azotobacter @2g/plant (62.08 days) and 75% RDF + Azotobacter @ 2g/plant + topdressing of 25% each of P & K (61.19 days). However, the harvesting span of ripped strawberry fruit of cv. Camarosa was recorded minimum in control (55.33 days) with at par value in 100% RDF treatment (57.67 days).

A perusal of data on total fruit yield of strawberry cv. Camarosa showed significant variations among different treatments (Fig. 1). Fruit yield was recorded maximum in 75% RDF + Azospirillium @ 2g/plant + PSB @2g/plant + topdressing of 25% K treatment (19.87 t/ha) followed by 75% RDF + Azotobacter @ 2g/plant + PSB @2g/plant + topdressing of 25% K treatment (17.41 t/ha) which was 1.60 and 1.40 times of the control (12.40t/ha). In addition, yield of strawberry cv. Camarosa was also increased significantly in the plants treated with 100% RDF + Azospirillium @2g/plant (1.25 times of the control), 75% RDF + Azospirillium @ 2g/plant + topdressing of 25% each of P & K (1.15 times of the control), 100% RDF +

Azotobacter @2g/plant (1.14 times of the control), 75% RDF + Azotobacter @ 2g/plant + topdressing of 25% each of P & K (1.10 times of the control) and 100% RDF (1.07 times of the control).

The positive effect of the biofertilizer on duration of harvesting as well as fruit yield might be related to its beneficial effect on vegetative growth and flowering [16] which probably supplied more photosynthates for longer period of time to the inoculated plants and hence, increase the fruit yield and also the duration of harvesting. These results are in agreement with the earlier findings of Hassan [12], Verma and Rao [26], Gupta and Tripathi [10] in strawberry.

Fruit quality

A significant variation in fruit size with respect to fruit length, width and volume was observed as a result of different types and combination of biofertilizer application in strawberry cv. Camarosa (Table 3). Maximum fruit length was obtained in 75% RDF + Azospirillium @ 2g/plant + PSB @2g/plant + topdressing of 25% K treated plants (40.99 mm) which was statistically at par with the treatment consist of 75% RDF + Azotobacter @ 2g/plant + PSB @2g/plant + topdressing of 25% K (40.07 mm), 100% RDF + Azospirillium @2g/plant (37.00 mm) and 75% RDF + Azospirillium @ 2g/plant + topdressing of 25% each of P & K (36.81). Apart from these, as compared to control, fruit length was also increased significantly in the plants treated with 100% RDF + Azotobacter @ 2g/plant (36.35 mm) and 75% RDF + Azotobacter @ 2g/plant + topdressing of 25% each of P & K (35.01 mm). However, it was recorded minimum in control (30.21 mm) with at par value in 100% RDF treatment (33.01 mm). Similar trend was also observed for fruit width and volume of strawberry cv. Camarosa as influenced by different types and combination of biofertilizer application (Table 3) with maximum value in 75% RDF + Azospirillium @ 2g/plant + PSB @2g/plant + topdressing of 25% K treated plants (31.78 mm and 25.50 cc, respectively) and 75% RDF + Azotobacter @ 2g/plant + PSB @2g/plant + topdressing of 25% K (31.40 mm and 25.05 cc, respectively). Similar to fruit length, fruit width and volume was also obtained minimum in control (25.01 mm and 16.17 cc, respectively) with at par value in 100% RDF treatment (26.76 mm and 16.55 cc, respectively). The better berry size with multi-inoculation might be due to increased availability of N and P through enhanced biological N-fixation in strawberry by N-fixing bacteria and P availability through phosphate solubilizing bacteria (PSB) [21]. Synergism among Azospirillum along with PSB and Azotobacter with PSB might have resulted in better berry size as against single inoculation [23].

The number of achiens/cm^2 fruit surface of strawberry cv. Camarosa was varied significantly in different types and combination of biofertilizer treatment (Table 3). It was estimated maximum in control (16.35) with at par number in 100% RDF treatment (15.00) and 100% RDF + Azotobacter @ 2g/plant treatment (12.66). however, in the treatment of 75% RDF + Azospirillium @ 2g/plant + PSB @2g/plant + topdressing of 25% K, the number of achiens/cm^2 fruit surface was recorded minimum (44.22% lower than the control) which was at par with 75% RDF + Azotobacter @ 2g/plant + PSB @2g/plant + topdressing of 25% K treatment (41.41% lower than the control), 100% RDF + Azospirillium @2g/plant treatment (37.98% lower than the control), 75% RDF + Azospirillium @ 2g/plant + topdressing of 25% each of P & K treatment (31.25% lower than the control) and 75% RDF + Azotobacter @ 2g/plant + topdressing of 25% each of P & K treatment (29.24% lower than the control).

The effect of biofertilizers on the TSS: Acid ratio of strawberry cv.Camarosa varied significantly among different treatments (Table 4). The TSS:Acid ratio was recorded maximum in 75% RDF + Azospirillium @ 2g/plant + PSB @2g/plant + topdressing of 25% K treatment (10.97) with at par value in 75% RDF + Azotobacter @ 2g/plant + PSB @2g/plant + topdressing of 25% K treatment (10.53) which was 55.60% and 49.36% higher than the control (7.05). In addition, TSS:Acid ratio of strawberry cv Camarosa was also increased significantly in the treatment consist of 100% RDF + Azospirillium @ 2g/plant (22.26% higher than the control), 75% RDF + Azospirillium @ 2g/plant + topdressing of 25% each of P & K (20.85% higher than the control), 100% RDF + Azotobacter @ 2g/plant (17.87% higher than the control) and 75% RDF + Azotobacter @ 2g/plant + topdressing of 25% each of P & K (13.62% higher than the control). However, it was recorded minimum in control (7.05) which was statistically non-significant with 100% RDF treatment (7.62).

It is envisaged from the data presented in table 4 that the reducing sugar content was increased significantly in biofertilizer treated plants as compared to control; however, non-reducing content decreased in all the treatment as compared to control. Reducing sugar content was recorded maximum in the treatment consist of 75% RDF + Azospirillium @ 2g/plant + PSB @2g/plant + topdressing of 25% K (4.92%) with at par value in 100% RDF + Azospirillium @ 2g/plant (4.87%), 75% RDF + Azotobacter @ 2g/plant + PSB @2g/plant + topdressing of 25% K (4.83%), 75% RDF Azospirillium @ 2g/plant + topdressing of 25% each of P & K (4.80%), 75% RDF + Azotobacter @ 2g/plant + topdressing of 25% each of P & K (4.79%) and 100% RDF + Azotobacter @ 2g/plant (4.76%); however, it was estimated minimum in control (4.32%) followed by 100% RDF treatment (4.65%).On the other hand, non-reducing sugar content was estimated maximum in control (1.88%) with minimum in 75% RDF + Azotobacter @ 2g/plant + topdressing of 25% each of P & K treatment (1.67%) which was statistically at par with the treatment consist of 100% RDF + Azotobacter @ 2g/plant (1.70%), 100% RDF + Azospirillium @ 2g/plant (1.71%), 75% RDF + Azospirillium @ 2g/plant + topdressing of 25% each of P & K (1.75%), 100% RDF (1.76%), 75% RDF + Azospirillium @ 2g/plant + PSB @2g/plant + topdressing of 25% K (1.77%) and 75% RDF + Azotobacter @ 2g/plant + PSB @2g/plant + topdressing of 25% K (1.78%).

Increased TSS: Acid ratio and reducing sugars in strawberry fruits of cultivar Camarosaby inoculation of free-living nitrogen-fixing bacteria either sole or co-inoculation might be due to steady supply of nutrients by the bio-inoculants throughout the growth period. This increased the vigour of strawberry plants with higher synthesis of assimilates due to enhanced rate of photosynthesis. Such effects might be attributed to increased rate of mobility of photosynthetic products from leaves to developing fruits, thereby increasing TSS and total sugars in ripe fruit [24]. However, decline in TSS: Acid ratio under control and 100% RDF treatment might be due to the fact that most of the metabolites were consumed by excessive vegetative growth, whereas a little amount were left for storage in the berries [13].

Table 1: Effect of biofertilizer on plant height and leaf size of strawberry (*Fragaria* × *ananassa*Duch.) cv. Camarosa

Treatment	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)
Control	11.41^{d}	5.54^{c}	9.78^{c}
100% RDF	11.70^{d}	5.62^{c}	9.87^{c}
100% RDF + Azoto@ 2g/plant	11.81^{d}	5.66^{c}	9.88^{c}
100% RDF + Azospi @ 2g/plant	12.54^{cd}	6.37^{b}	10.33^{bc}
75% RDF + Azoto @ 2g/plant + topdressing of 25% each of P & K	12.30^{d}	5.77^{c}	10.05^{c}
75% RDF + Azospi @ 2g/plant + topdressing of 25% each of P & K	14.03^{bc}	6.66^{b}	10.29^{bc}
75% RDF + Azoto @ 2g/plant + PSB @ 2g/plant + topdressing of 25% K	16.14^{a}	6.71^{b}	10.83^{b}
75% RDF + Azospi @ 2g/plant + PSB @ 2g/plant + topdressing of 25% K	14.39^{b}	8.55^{a}	11.59^{a}

Value indicates mean of three replicates. Different letters in the same column indicate significant differences at P ≤ 0.05 (Duncan's Multiple Range Test).

Table 2: Effect of biofertilizer on harvesting span and runner production of strawberry (*Fragaria* × *ananassa* Duch.) cv. Camarosa

Treatment	Duration of harvesting (Days)	Runner no/plant
Control	55.33^{d}	2.00^{a}
100% RDF	57.67^{cd}	3.33^{a}
100% RDF + Azoto@2g/plant	62.08^{bc}	1.67^{a}
100% RDF + Azospi @2g/plant	67.32^{a}	2.00^{a}
75% RDF + Azoto @ 2g/plant + topdressing of 25% each of P & K	61.19^{c}	2.00^{a}
75% RDF + Azospi @ 2g/plant + topdressing of 25% each of P & K	66.37^{ab}	2.33^{a}
75% RDF + Azoto @ 2g/plant + PSB @2g/plant + topdressing of 25% K	68.51^{a}	3.00^{a}
75% RDF + Azospi @ 2g/plant + PSB @2g/plant + topdressing of 25% K	70.00^{a}	2.00^{a}

Value indicates mean of three replicates. Different letters in the same column indicate significant differences at P ≤ 0.05 (Duncan's Multiple Range Test).

Table 3: Effect of biofertilizer on fruit size and achiens number on strawberry (*Fragaria* × *ananassa*Duch.) cv. Camarosa

Treatment	Fruit size			No. of achiens per cm²of fruit
	Length (mm)	Width (mm)	volume (cc)	
Control	30.21[d]	25.01[c]	16.17[d]	16.35[a]
100% RDF	33.01[cd]	26.76[c]	16.55[d]	15.00[ab]
100% RDF + Azoto@ 2g/plant	36.35[bc]	28.33[abc]	19.04[c]	12.66[abc]
100% RDF + Azospi @2g/plant	37.00[abc]	30.99[ab]	22.33[b]	10.14[c]
75% RDF + Azoto @ 2g/plant + topdressing of 25% each of P & K	35.01[c]	27.14[bc]	21.00[bc]	11.57[bc]
75% RDF + Azospi @ 2g/plant + topdressing of 25% each of P & K	36.81[abc]	30.85[ab]	21.28[bc]	11.24[bc]
75% RDF + Azoto @ 2g/plant + PSB @2g/plant + topdressing of 25% K	40.07[ab]	31.40[a]	25.05[a]	9.58[c]
75% RDF + Azospi @ 2g/plant + PSB @2g/plant + topdressing of 25% K	40.99[a]	31.78[a]	25.50[a]	9.12[c]

Value indicates mean of three replicates. Different letters in the same column indicate significant differences at P ≤ 0.05 (Duncan's Multiple Range Test).

Table 4: Effect of biofertilizer on fruit quality attributes of strawberry (*Fragaria* × *ananassa*Duch.) cv. Camarosa

Treatment	TSS : Acid ratio	Reducing sugar (%)	Non- reducing sugar (%)
Control	7.05[c]	4.32[c]	1.88[a]
100% RDF	7.62[bc]	4.65[b]	1.76[bc]
100% RDF + Azoto@2g/plant	8.31[b]	4.76[ab]	1.70[bc]
100% RDF + Azospi @2g/plant	8.62[b]	4.87[a]	1.71[bc]
75% RDF + Azoto @ 2g/plant + topdressing of 25% each of P & K	8.01[bc]	4.79[ab]	1.67[c]
75% RDF + Azospi @ 2g/plant + topdressing of 25% each of P & K	8.52[b]	4.80[ab]	1.75[bc]
75% RDF + Azoto @ 2g/plant + PSB @2g/plant + topdressing of 25% K	10.53[a]	4.83[ab]	1.78[b]
75% RDF + Azospi @ 2g/plant + PSB @2g/plant + topdressing of 25% K	10.97[a]	4.92[a]	1.77[bc]

Value indicates mean of three replicates. Different letters in the same column indicate significant differences at P ≤ 0.05 (Duncan's Multiple Range Test).

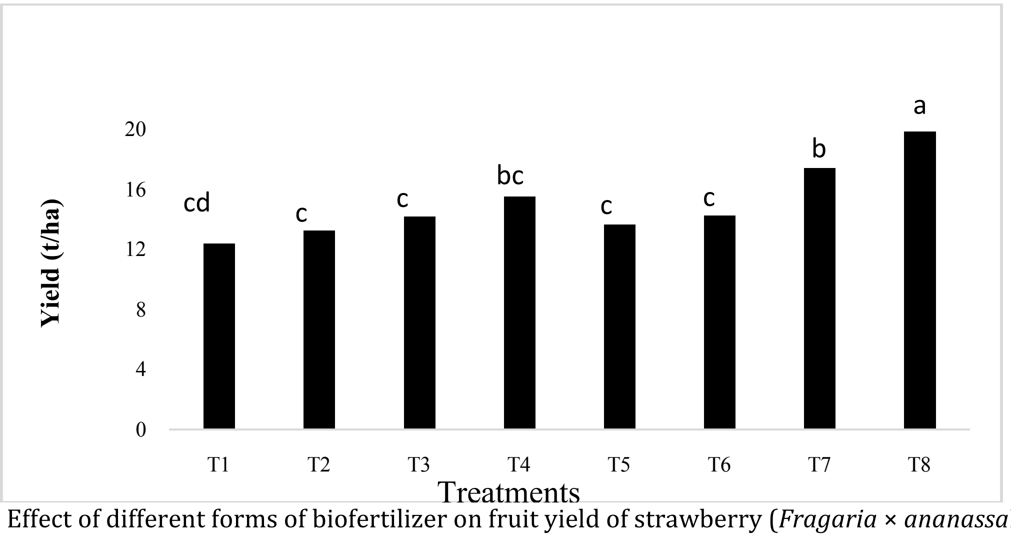

Figure 1: Effect of different forms of biofertilizer on fruit yield of strawberry (*Fragaria* × *ananassa*Duch.) cv. Camarosa.

Vertical bar indicate the mean value of fruit yield (t/ha). Different letters on the vertical bars indicate significant differences at P ≤ 0.05 (Duncan's Multiple Range Test).

T1: Control (treated with distilled water); T2: 100% RDF (N:P:K @6:10:6 g plant^{-1}); T3: 100%RDF + Azotobacter @ 2g plant^{-1}; T4: 100% RDF + Azospirillum @ 2g plant^{-1}; T5: 75% RDF + Azotobacter @ 2g plant^{-1}+ top dressing of 25% each of P and K; T6: 75% RDF + Azospirillum @ 2g plant^{-1}+ topdressing of 25% each of P and K; T7: 75%RDF + Azotobacter @ 2g plant^{-1}+ PSB @2g plant^{-1}+ topdressing of 25% K; and T8: 75% RDF + Azospirillum @ 2g plant^{-1}+ PSB @ 2g plant^{-1}+ topdressing of 25% K.

CONCLUSION

The result of this experiment indicates that among different treatments, 75% RDF + Azospirillium @ 2g/plant + PSB @ 2g/plant + topdressing of 25% K treatment and 75% RDF + Azotobacter @ 2g/plant + PSB @ 2g/plant + topdressing of 25% K treatment are highly effective for enlarging the harvest span with highest yield of best quality fruits in strawberry cv. Camarosa. Hence, these two treatments can be used as the potential substitute or best alternative against conventional mineral fertilization to increase the quality yield of strawberry cv. Camarosa without hampering the soil fertility status.

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