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Effect of Bio-fertilizers on Growth, Yield and Quality of Strawberry (*Fragaria x ananassa* Duch.) CV. Winter Dawn in Prayagraj (U.P.) Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was carried out at Research Field of Horticulture Research Farm, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) India, during Rabi Season 2023-2024 to investigate twelve treatments *viz.,* T_0 (RDN (Control), T_1 (RDN + Azosprillum@7 kg/ha), T_2 (RDN + Phosphate Solubilizing Bacteria @6kg/ha), T_3 (RDN + VAM @10kg/ha), T_4 (RDN + Azotobacter@7kg/ha), T_5 (RDN + Azospirillum@7kg/ha + PSB@ 6kg/ha), T_6 (RDN + Azospirillum@7kg/ha + VAM@10kg/ha), T_7 (RDN + PSB@6kg/ha + VAM@ 10kg/ha) and T_8 (RDN + PSB@6kg/ha + Azotobacter@7kg/ha), T_9 (RDN + Azotobacter@7kg/ha + VAM@10kg/ha) , T_{10} , (RDN+Azotobacter@7kg/ha+ PSB@6kg/ha + VAM@10kg/ha) and T_{11} (RDN

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+ Azospirillum@7kg/ha + PSB@6kg/ha + VAM@10kg/ha)along with their combinations, replicated thrice in a Randomized Block Design. In strawberry use the application of bio-fertilizer like *Azotobacter* and *Azospirillum* hasten early flowering along with the expanded duration of blossoming, harvesting by increasing the growth, yield and quality of strawberry. The integrated nutrient management maximized plant height (cm), number of leaves per plant, plant spread (E-W, N-S) (cm), number of flowers per plant, number of fruit per plant, fruit weight (g), fruit length (cm), fruit diameter (cm), fruit yield (q/ha), total soluble solids, ascorbic acid (mg/100g). From the above experimental finding it may concluded that, the production of strawberry by the bio fertilizer application of T11 (RDN + Azospirillum@7kg/ha + PSB@6kg/ha + VAM@10kg/ha) was found to best in terms of growth, yield and quality. In the investigation improves vegetative growth of flowering and improve yield by the help of bio fertilizer such. The highest net return was also found in the T11 and highest B:C ratio was found in T10 with 3.64.

Keywords: Strawberry (Fragaria × ananassa Duch.); azotobacter and azospirillum; phosphate solubilizing bacteria; vesicular arbuscular mycorrhiza.

1. INTRODUCTION

"Strawberry is an herbaceous perennial plant and is adapted to different climates, and can even be grown from tropical and subtropical to temperate regions of high altitudes up to 3000 meter above mean sea level with assured irrigation facility. It is the most widely distributed fruit-crop due to its genotypic diversity, highly heterozygous nature and broad range of environmental adaptations" [1,2]. Due to the constant efforts of strawberry breeders, the worldwide interest for strawberry cultivation has boosted its production tremendously, which has resulted in widespread popularity of strawberry in the last 50 years.

"The modern cultivated strawberry is one of the most delicious, refreshing and soft fruits of the world. It is the most important soft fruit in the world after grape and is being preferred by the people around the world due to its attractive colors and pleasant flavor and aroma" [3]. "The fresh- ripe fruits of strawberry are the rich source of vitamins and minerals" [4]. Among vitamins it is a fairly good source of vitamin A (60 IU/100g of edible portion) and vitamin C (30-120 mg/100g of edible portion).

"In India, during the last decade; it has become favourite fruit among growers because of its remunerative prices and higher profitability" [5,6]. "Strawberry can be grown on a wide range of soil ranging from heavy clay to light sand. The plant has fibrous root system and most of its roots are confined to the top 15-20 cm layer of the soil, and it grows best in the light porous soil that is rich in humus" [7,8,9]. The plant is a surface feeder; therefore fertility, moisture, drainage and microbial status of the upper layer of soil have a great impact on growth, development, fruit, quality and production of runners.

The application of synthetic fertilizers has improved yield per unit area manifold but these fertilizers are expensive and hamper the ecological balance of the soil. Imbalance and inadequate fertilizer application gradually reduces their response efficiency.

Organic manures like vermicompost, FYM, compost, bio fertilizers etc. have been utilized in agriculture as a significant source of organic manure. These manures help not only in bridging the existing wide gap between the nutrient removal and supply but also in ensuring balanced nutrient proportion, by enhancing response efficiency, and maximizing crop productivity of desired quality.

2. MATERIALS AND METHODS

2.1 Geographical Location of the Experimental Site

The experimental site is located at a latitude of 25°41' North and longitude of 81°84 'East, with an altitude of 98 meters above the mean sea level (MSL).

2.2 Climatic Conditions of the Experimental Area

The area of Prayagraj comes under humid subtropical climate, which experiences warm humid monsoon, hot dry summer and cold dry winter. The annual mean temperature is 26.1ºC while monthly mean temperatures are 18-29ºC. The daily average maximum temperature is

about 22ºC and the minimum temperature is 9ºC. The average annual rainfall received is 1042.2 mm. At this location, the temperature reaches upto 46ºC-48ºC and the minimum temperature recorded is 4ºC-5ºC. The relative humidity ranges in this location ranges between 20-94%.

Table 1. Treatment Combinations

Notations	Treatments
T0	RDN (Control)
T1	RDN + Azosprillum@7 kg/ha
T2	RDN + Phosphate Solubilizing Bacteria @6kg/ha
T3	RDN + VAM @10kg/ha
T4	RDN + Azotobacter@7kg/ha
T5	RDN + Azospirillum@7kg/ha + PSB@6kg/ha
T6	RDN + Azospirillum@7kg/ha + VAM@10kg/ha
T7	RDN + PSB@6kg/ha + VAM@10kg/ha
T8	RDN + PSB@6kg/ha + Azotobacter@7kg/ha
T9	RDN + Azotobacter@7kg/ha + VAM@10kg/ha
T10	RDN+Azotobacter@7kg/ha+ PSB@6kg/ha + VAM@10kg/ha
T11	RDN + Azospirillum@7kg/ha + PSB@6kg/ha + VAM@10kg/ha

3. RESULTS AND DISCUSSION

3.1 Vegetative Growth, Flowering Parameter and Fruit Parameter

The data revealed that different treatments of soil application of bio-fertilizer the on different parameter such maximum plant height (29.83 cm), Plant spread (17.89 cm), Number of leaves (37.18), Number of flower per plant (38.78), Fruit diameter (3.85 cm) and Fruit length (5.74 cm) were observed under T_{11} (RDN + Azospirillum @7kg/ha + PSB@6kg/ha + VAM@ 10kg/ha) respectively, while the minimum plant height (22.61 cm), Plant spread (12.22 cm), Number of leaves (28.84), Number of flower per plant (27.89), Fruit diameter (2.69 cm) and Fruit length (3.91 cm) were recorded under the treatment RDF + Control (T_0) respectively.

“The increased plant height of strawberry may be due to the increased nitrogen fixation, organic nitrogen utilization, development of root system” [10]. “Due to application of inorganic fertilizers & bio-fertilizers increased the available NPK status, organic C & microbial biomass & dehydrogenase activity & hence they help in increasing plant height” [11]. “Similar results were also reported” by Tripathi et al. [7] in strawberry.

Beer et al., [10], “reported increase in plant spread might be due to increased growth of plant in the form of height, which accumulated more photosynthesis & thereby increases leaf area per plant”. These findings are corroborates with the finding of Umar et al. (2009).

Higher number of leaves & leaf area might be due to higher cell division caused by cytokinins & also due to higher supply of assimilate mediated by biofertilizers application. Increased number of leaves might have increased the photosynthetic activity resulting in higher accumulation of carbohydrates. Relatively higher amount of carbohydrate could have promoted the growth rate & in turn increased the berry weight. The findings are in close agreement with the findings of Dwivedi et al. (1999) in strawberry.

“This might be due to the effect of bio-fertilizers as soluble phosphorus obtained from bio-fertilizers increases the cell elongation and division. Soluble phosphorus increases photosynthetic activities of leaves, which leads to development of primary flowers, production of viable flowers. Similar results were also obtained” by Neetu & Sharma et al. [12] Tripathi et al. [7] and Singh et al. (2015) in strawberry.

“The increase in fruit diameter might be due to the effect of bio-fertilizers as it plays a vital role to promote starch formation and activity involved in transportation of carbohydrates in plants. Similar results were also obtained” by Yadav et al. [4] and Khalid et al. [2] in strawberry.

“The increased fruit length attributed to better fillings of fruits may be due to more balanced uptake of nutrients which may have led to better metabolic activities in the plant which ultimately led to high protein and carbohydrate synthesis. Similar observations have been reported” by Yadav et al., [4], Khalid et al., [2] in strawberry.

3.2 Fruit Parameter, yield Parameter and Quality Parameter

The data revealed that different treatments of soil application of bio-fertilizer the on different parameter such maximum Number of fruits per plant (35.65), Fruit weight (30.75 g), Fruit Yield

Table 2. Effect of Bio-fertilizer on vegetative growth, Number of flowers per plant, Fruit length (cm) and Fruit diameter (cm) of Strawberry

Treatment	Plant Height (cm)	Number of leaves per plant	Plant spread (E-W, N-S) (cm)	Fruit diameter (cm)	Number of flowers per plant	Fruit length (cm)
T0	22.61	28.84	12.22	2.69	27.89	3.91
T1	23.05	29.29	13.00	2.71	28.11	4.31
T2	24.83	30.29	13.00	2.96	28.78	4.47
T3	25.27	30.51	13.22	3.36	30.56	4.65
T4	25.39	31.62	13.78	3.01	32.56	4.85
T5	26.27	31.62	13.89	3.22	32.89	5.18
T6	26.83	31.73	15.00	3.57	33.22	5.42
T7	26.83	32.07	15.44	3.79	33.89	5.49
T8	27.72	33.62	16.56	3.56	35.45	5.54
T9	28.23	34.56	16.76	3.6	36.56	5.67
T10	28.89	35.35	17.34	3.82	37.87	5.72
T11	29.83	37.18	17.89	3.85	38.78	5.74
F test	S	S	S	**S**	S	S
S. Ed. ±	1.23	0.23	0.45	0.38	0.88	1.02
CD at 5 %	1.89	0.39	0.27	0.19	0.53	1.89
CV	5.67	4.58	10.59	3.52	9.21	2.67

Table 3. Effect of Bio-fertilizer on Fruit parameter, Yield parameter and Fruit quality of Strawberry

Treatment	Fruit weight (g)	Fruit yield (q/ha)	Number of fruits per plant	TSS (°B)	Tit. Acidity (%)	Juice (%)	Vitamin C (mg/100g)
T0	22.67	30.15	27.52	4.67	4.62	70.92	49.52
T1	25.12	32.43	28.11	6.00	5.95	71.14	50.44
T2	26.56	31.82	28.56	6.33	6.28	71.81	50.81
T3	26.79	33.16	29.67	6.00	5.95	73.59	51.61
T4	27.90	36.77	29.90	6.00	5.95	75.59	52.08
T5	28.23	39.04	30.23	4.00	3.95	75.92	51.35
T6	28.23	40.09	30.23	4.33	4.28	76.25	50.23
T7	29.01	40.89	31.01	6.33	6.28	76.92	50.77
T8	29.56	42.27	31.56	5.33	5.28	79.48	50.28
T9	29.75	45.56	32.73	5.00	4.95	80.23	50.56
T10	30.56	45.85	34.67	5.67	5.48	82.69	50.23
T11	30.75	53.42	35.65	5.67	5.88	85.81	50.35
F test	S	S	S	S	S	S	S
S. Ed. ±	0.89	3.12	0.41	0.25	0.25	0.95	0.22
CD at 5 %	1.37	4.23	1.08	0.15	0.15	0.57	0.13
CV	7.32	6.56	4.14	15.72	15.87	4.28	1.47

Table 4. Economics of treatments of Strawberry cultivation

Treatments	Fruit yield (q/ha)	Selling rate (Rs./ q)	Gross return (Rs.)	Cost of cultivation	Net return (Rs.)	B/C ratio
T0	30.15	21000	633150	211700	421450	1.99
T1	32.43	21000	681030	214700	466330	2.17
T2	31.82	21000	668220	206700	461520	2.23
T3	33.16	21000	696360	213700	482660	2.26
T4	36.77	21000	772170	225200	546970	2.43
T5	39.04	21000	819840	207700	612140	2.95
T6	40.09	21000	841890	209700	632190	3.01
T7	40.89	21000	858690	219200	639490	2.92
T8	42.27	21000	887670	221200	666470	3.01
T9	45.56	21000	956760	225200	731560	3.25
T10	45.85	21000	962850	207700	755150	3.64
T11	53.42	21000	1121820	249700	872120	3.49

(53.42 q per ha) and Juice (%) (85.81) were observed under T_{11} (RDN + Azospirillum @7kg/ha + PSB@6kg/ha + VAM@ 10kg/ha) respectively, while the Number of fruits per plant (27.52), Fruit weight (22.67 g), Fruit Yield (30.15 q per ha), and Juice (%) (70.92) were recorded under the treatment RDF + Control (T_0) respectively.

The data presented in the revealed the acidity percentage of fruit was significantly influenced by different treatments. Minimum acidity percentage of fruit was recorded with T_0 with 0.62 closely followed by T_1 (0.65). Maximum acidity percentage of fruit was recorded in T_9 (0.79). The data presented in the revealed the TSS of fruit was significantly influenced by different treatments. Maximum TSS of fruit was recorded with T_7 6.33 closely followed by T_2 (6.33). Minimum TSS of fruit was recorded in T_5 (4.00). The data presented in the revealed the ascorbic acid of fruit was significantly influenced by different treatments. Maximum ascorbic acid of fruit was recorded with T_{11} 56.40, closely followed by T_{10} (55.99). Minimum ascorbic acid of fruit was recorded in T_0 control (49.70).

"The increased number of berries/plant and ultimately yield might also be due to the fact that the enhanced level of nutrients and auxins due to Azospirillum from the integration of nutrients could have diverted photo assimilates to the developing flower buds & helped in the conversion of lowers to more femaleness to produce higher number of fruits which in turn also increased the berry weight & yield. This is in agreement with findings" of Tripathi, [7].

"The increased fruit weight attributed to better fillings of fruits may be nitrogen filling abilities of the microbial inoculants, the capacity to release phyto- hormones especially, GA_3 should be released, which maximize the fruit size" Khalid et al*.* [2] & [13]. "Similar observations have been also reported" by Yadav et al*.* [4] in strawberries.

"The reduction in titratable acidity may be attributed to conversion of organic acids and photosynthesis into sugar during fruit ripening by applying bio fertilizers" (Esitken et al*.,* 2010). "The reduction in titratable acidity may also be due to utilization of acids as a substrate for respiration during the ripening and neutralization of organic acids due to potassium in tissues [14-19]. These findings are in close conformity with the results" of Singh and Singh, (2009), Umar et al*.* (2009) and Khalid et al*.* [2] in strawberry.

"The increase in TSS content with combined use with NPK, organic manures and bio-fertilizer might be due to accumulation of sugars and other soluble components from hydrolysis of protein and oxidation of ascorbic acid. This finding corroborates with the findings" of Singh and Singh et al*.,* (2009).

The respective increase in ascorbic acid content might be due to the increased efficiency of microbial inoculants to fix atmospheric nitrogen, increase in availability of phosphorus and secretion of growth promoting substances, which accelerates the physiological process like carbohydrates synthesis. Beer et al., [10] reported that bio-fertilizers application maximize the amount of ascorbic acid content. Similar results were also reported by Tripathi et al*.* [7] in strawberry.

3.3 Economics of Strawberry Cultivation

The maximum net return of strawberry production was obtained Rs. 872120 with T_{11} (RDN + Azospirillum@7kg/ha + PSB@6kg/ha + VAM@10kg/ha) and maximum cost benefit ratio was recorded 3.64 with T_{10}. However, the minimum cost benefit ratio was recorded 1.99 with T_0 (control). This might be attributed towards higher yield. Several workers also reported higher net return and cost benefit ratio viz. Ahmadi et al., 2017 in strawberry, Yadav et al., [4], Verma and Rao, 2013 in strawberry.

4. CONCLUSION

This study concludes that the from the above experimental finding it may concluded that, the production of strawberry by the bio fertilizer application of T11 (RDN + Azospirillum@7kg/ha + PSB@6kg/ha + VAM@10kg/ha) was found to best in terms of growth, yield and quality. The investigation improves vegetative growth of flowering and improves yield by the help of bio fertilizer such. The highest net return was found in the T11 but highest B:C ratio was found in T10 with 3.64.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Larson KD. Strawberry (In): Handbook of environmental physiology of fruit crops 1: Temperate crops Schaffer, B and Anderson, P.C. (Eds). CRC, Press. Inc. 1994;271- 297.
2. Khalid S, Qureshi KM, Hafiz IA, Khan KS, Qureshi US. Effect of organic amendments on vegetative growth, fruit yield and quality of strawberry. Pakistan J. Agric. Res. 2013;26(2):104-112.
3. Sharma RR. Growing strawberries. International Book Distributing Co. Lucknow; 2002.
4. Yadav A, Pratap B, Shivam AK, Patro A. Assess the effect of micronutrients and plant growth regulators on quality parameters of strawberry cv. Chandler. The Pharma Innovation J. 2018;7(1):303-305.
5. Sharma RM, Yamdagni R. Modern strawberry cultivation. Ludhiana, India, Kalyani Pub. 2000;37(1):163-165
6. Singh R, Sharma VP. Prospects of growing strawberries under plains. Ind. Hort. 1970;15(3):13-15.
7. Tripathi V, Kumar Sanjeev, Gupta, Alok. Influence of azotobacter and vermicompost on growth, flowering, yield and quality of strawberry cv. Chandler. Indian Journal of Horticulture. 2015;72:201.
8. Singh D, Kumar S, Verma RS, Shukla A, Kumar R. Effect of organic manure and bio-fertilizers on growth and yield parameters of Strawberry (*Fragaria x ananassa* Duch.) cv. Chandler Int. J. Curr. Microbiol. App. Sci. 2019;8(5):960-964 960.
9. Verma, Neelendra Singh, Kv, Ramana, Rao, Rajwade, Yogesh, Yadav, Deepika, Trivedi, Ayushi, Rao, Ramana. Growth and yield of strawberry (*Fragaria x ananassa* Duch) under different mulches in vertices of Madhya Pradesh. The Pharma Innovation. 2023;12:1324-1327.
10. Beer K, Kumar S, Gupta AK, Syamal MM. Effect of organic, inorganic and bio-fertilizers on growth, flowering, yield and quality of Strawberry (*Fragaria* × *ananassa* Duch.) cv. Chandler. Int. J. Curr. Microbiol. App. Sci. 2017;6(5):2932-2939.
11. Hazarika TK, Ralte, Zothankima, Nautiyal BP, Shukla AC. Influence of bio-fertilizers and bio-regulators on growth, yield and quality of strawberry (*Fragaria x ananassa* Duch.). Indian Journal of Agricultural Sciences. 2015;85(9):1201–1205.
12. Neetu and Sharma SP. Evaluation of strawberry cultivars for growth and yield characteristics in the plain region of Chhattisgarh, India. Int. J. Curr. Microbiol. App. Sci. 2018;7(2):2835-2840.
13. Mahmood M, Ahmed F. Effect of media culture, nano and normal micronutrients on some flowers and yield traits of Strawberry. AIP Conference Proceedings. 2022; 2394.
14. Awasthi RP, Godara RK, Kaith NS. Interaction effect of VA- mycorrhizae and Azotobacter inoculation on micro-nutrient uptake by peach seedlings. Journal of Horticulture. 1998;11:1–5.
15. Childers NF, Morris JR, Sibbett GS. Modern Fruit Science Horticulture Publication Grains YiLLE, Florida, U.S.A; 1995.
16. Pathak RK, Singh R. Effect of some external factors on growth and fruiting of strawberry II. Effect of GA3, growth retardants and colchicine on flowering and yield. Progressive Horticulture. 1971;3:53-63.
17. Sharma VP. Effect of certain plant regulating substances and photoperiod on the growth behaviour and fruiting of strawberries. Ph.D. Thesis, Kanpur University, Kanpur, India; 1975.
18. Sharma RR, Singh SK. Strawberry Cultivation a highly

remunerative farming enterprise. Agro. India. 1999;3:20- 22.

19. Ombita SN, Mwendwa SM, Mureithi SM. Influence of organic fertilization on growth and yield of strawberry (*Fragaria× ananassa*) in Kabete and Mbooni areas, Kenya. Heliyon. 2024;10(3).

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