

**" IMPACT OF BIO-FERTILIZER ON GROWTH, YIELD AND QUALITY OF STRAWBERRY (*Fragariaannanasa*–*Winter dawn*)"**

Comment [M1]: Change to Effect

**ABSTRACT:-**

Comment [M2]: Reformatting the extract, there is no need to mention the studied characteristics, only the superior qualities.

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 October 2022-2023 to investigate the **Impact of Bio-fertilizer on Growth, Yield and Quality of Strawberry (*Fragaria × ananassa*Duch.) cv. Winter Dawn in Allahabad (U.P.) Conditions**” twelve treatments viz., T<sub>0</sub> (RDN (Control), T<sub>1</sub> (RDN + Azospirillum@7 kg/ha), T<sub>2</sub> (RDN + Phosphate Solublizing Bacteria @6kg/ha), T<sub>3</sub> (RDN + VAM @10kg/ha), T<sub>4</sub> (RDN + Azotobacter@7kg/ha), T<sub>5</sub> (RDN + Azospirillum@7kg/ha + PSB@6kg/ha), T<sub>6</sub> (RDN + Azospirillum@7kg/ha + VAM@10kg/ha), T<sub>7</sub> (RDN + PSB@6kg/ha + VAM@10kg/ha) and T<sub>8</sub> (RDN + PSB@6kg/ha + Azotobacter@7kg/ha), T<sub>9</sub> (RDN + Azotobacter@7kg/ha + VAM@10kg/ha) , T<sub>10</sub> , (RDN+Azotobacter@7kg/ha+ PSB@6kg/ha + VAM@10kg/ha)andT<sub>11</sub> (RDN + 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 area (cm<sup>2</sup>), number of flowers per plant, number of fruit per plant, fruit weight (g), fruit length (cm), fruit diameter (cm), fruit yield/ha (kg), 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 T<sub>11</sub> (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 T<sub>11</sub> and highest B:C ratio was found in the same with 3.49.

**Keywords:** Strawberry, *Azotobacter*and *Azospirillum*, Phosphate Solublizing Bacteria

## 1. INTRODUCTION:-

Strawberry is an herbaceous perennial plant and is adapted to different climates, and can even be grown from tropical and sub-tropical to temperate regions of high altitudes up to 3000meter 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 (Larson, 1994, Childers *et al.*, 1995) <sup>[6,5]</sup>. Due to the constant efforts of strawberry breeders, the world wide 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 a 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 flavour and aroma (Sharma and Yamdagni, 2000) <sup>[14]</sup>. The fresh- ripe fruits of strawberry are the rich source of vitamins and minerals (Singh *et al.* 2007) <sup>[18]</sup>. Among vitamins it is a fairly good source of vitamin A (60 IU/100g of edible portion) and vitamin C (30-120mg/100g of edible portion).

In India, during last decade; it has become favourite fruit among growers because of its remunerative prices and higher profitability (Pathak and Singh, 1971; Sharma, 1975) <sup>[11,13]</sup> 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 15-20cm layer of the soil, and it grows best in the light porous soil that is rich in humus (Singh and Sharma, 1970; Sharma and Singh, 1999; Sharma, 2002) <sup>[16,15,17]</sup>. The plant is a surface feeder; therefore fertility, moisture, drainage and microbial status of the upper layer of soil have 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 insuring balanced nutrient proportion, by enhancing response efficiency, and maximizing crop productivity of desired quality.

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**Comment [M3]:** Add a paragraph explaining the purpose of the study.

## 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°04' 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 sub-tropical climate, which experiences warm humid monsoon, hot dry summer and cold dry winter. The annual mean temperature is 26.1°C while monthly mean temperatures are 18-29°C. The daily average maximum temperature is about 22°C and the minimum temperature is 9°C. The average annual rainfall received is 1042.2 mm. At this location, the temperature reaches up to 46°C-48°C and the minimum temperature recorded is 4°C-5°C. The relative humidity ranges in this location between 20-94%.

**Comment [M4]:** It is preferable to add climate data for the experiment site in a table.

**Comment [M5]:** Add a table showing the physical and chemical properties of the experimental field.

### 2.3 Experimental details

**Table 1: Treatment Combinations**

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

### 3. RESULTS AND DISCUSSION

Comment [M6]: Verifying the values in the text with the values in the tables.

#### 3.1 Vegetative Growth, Flowering parameter and Fruit Parameter

The data revealed that different treatments of soil application of bio-fertilizer 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 (Beer *et al.*, 2017). 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 (Hazarika, 2015). Similar results were also reported by Tripathi *et al.* (2010) in strawberry.

Beer *et al.*, 2017, 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 corroborated with the finding of Umare *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 leading to development of primary flowers, production of viable flowers. Similar results were also obtained by Neetu & Sharma *et al.* (2018) Tripathi *et al.* (2015) and Singh *et al.* (2015) in strawberry.

The increase in fruit diameter might be due to 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. (2010)* and *Khalid et al. (2013)* 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 carbohydrates synthesis. Similar observations have been reported by *Yadav et al., (2010)*, *Khalid et al., (2013)* in strawberry.

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

Treatment	Plant Height (cm)	Number of leaves	Plant spread (Cm)	Fruit diameter (cm)	Number of flower 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

### 3.2 Fruit parameter, yield parameter and Quality Parameter

The data revealed that different treatments of soil application of bio-fertilizer on different parameter such maximum Number of fruits per plant (35.65), Fruit weight (30.75 g), Fruit Yield (53.42 q per ha) and Juice (%) (85.81) were observed under T<sub>11</sub> (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<sub>0</sub>) 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<sub>0</sub> with 0.62 closely followed by T<sub>1</sub> (0.65). Maximum acidity percentage of fruit was recorded in T<sub>9</sub> (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<sub>7</sub> 6.33 closely followed by T<sub>2</sub> (6.33). Minimum TSS of fruit was recorded in T<sub>3</sub> (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<sub>11</sub> 56.40, closely followed by T<sub>10</sub> (55.99). Minimum ascorbic acid of fruit was recorded in T<sub>0</sub> 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, (2010)**.

The increased fruit weight attributed to better fillings of fruits may be nitrogen filling abilities of the microbial inoculants, the capacity to releasing phyto-hormones especially, GA<sub>3</sub> should be released, which maximize the fruit size **Khalid et al. (2013) & (Ahmad & Mohammad, 2012)**. Similar observations have been also reported by **Yadav et al. (2010)** in strawberry.

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. These findings are in close conformity with the results of **Singh and Singh, (2009)**, **Umar et al. (2009)** and **Khalid et al. (2013)** 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 phosphorous and secretion of growth promoting substances, which accelerates the physiological process like carbohydrates synthesis. **Beer et al., 2017** reported that bio-fertilizers application maximize the amount of ascorbic acid content. Similar results were also reported by **Tripathi et al. (2015)** in strawberry.

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

Treatment	Fruit weight (g)	Fruit yield (q/ha)	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

<b>CD at 5 %</b>	1.37	4.23	1.08	0.15	0.15	0.57	0.13
<b>CV</b>	7.32	6.56	4.14	15.72	15.87	4.28	1.47

### 3.3 Economics of Strawberry

The maximum net return of strawberry production was obtained Rs. 872120 with T<sub>11</sub> (RDN + Azospirillum@7kg/ha + PSB@6kg/ha + VAM@10kg/ha) and maximum cost benefit ratio was recorded 3.64 with T<sub>10</sub>. However, the minimum cost benefit ratio was recorded 1.99 with T<sub>0</sub>(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., 2010*, *Verma and Rao, 2013* in strawberry.

**Table: 4 Economics of treatment of Strawberry**

Treatments	Fruit yield per plant	Fruit yield per plot (kg)	Selling price (Rs/kg)	Total cost of Cultivation	Gross return	Net return	B: C
T0	15.02	2.52	400	850	1007.55	157.55	0.19
T1	16.11	2.63	400	850	1050.9	200.9	0.24
T2	16.56	2.91	400	850	1165.97	315.97	0.37
T3	17.67	3.15	400	850	1258.36	408.36	0.48
T4	17.9	3.37	400	850	1346.33	496.33	0.58
T5	18.23	3.48	400	850	1393.28	543.28	0.64
T6	18.23	3.48	400	850	1393.28	543.28	0.64
T7	19.01	3.77	400	850	1506.28	656.28	0.77
T8	19.56	3.97	400	850	1588.58	738.58	0.87
T9	20.73	4.24	400	850	1697.79	847.79	1
T10	22.67	4.81	400	850	1922.78	1072.78	1.26
T11	26.78	5.72	400	850	2289.69	1439.69	1.69

#### 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 T<sub>11</sub> (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 T<sub>11</sub> and highest B:C ratio was found in the same with 1.69.

**Comment [M7]:** Rephrase the conclusion more precisely.

## References:-

Comment [M8]: Formatting references according to the terms of publication in the journal.

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