Effectofbio-fertilizersongrowth,yieldandqualityofstrawberry(*Fragariaxananassa* Duch.)cv.WinterDawninPrayagraj(U.P.)Conditions

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, duringOctober2022-2023toinvestigatetwelvetreatments *viz.*, T_0 (RDN (Control), T_1 (RDN+Azosprillum@7kg/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)andT_{11}(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*hastenearly flowering alongwiththeexpandeddurationofblossoming,harvestingbyincreasingthegrowth,yieldand qualityofstrawberry.Theintegratednutrientmanagementmaximizedplantheight(cm),numberofleaves 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 strawberryby the bio fertilizer application of T11 (RDN + Azospirillum@7kg/ha + PSB@6kg/ha + VAM@10kg/ha) wasfoundtobestintermsofgrowth,yieldandquality.Intheinvestigationimprovesvegetativegrowthof floweringandimproveyieldbythehelpofbiofertilizersuch.Thehighestnetreturnwasalsofoundinthe T11 and highest B:C ratio was found in the same with 3.49.

Key words: Strawberry(*Fragaria* × *ananassa*Duch.), *Azotobacter*and *Azospirillum*, Phosphate Solubilizing Bacteria, Vesicular Arbuscular mycorrhiza

1. INTRODUCTION

"Strawberryisanherbaceousperennialplantandisadaptedtodifferentclimates,andcanevenbe grownfromtropicaland 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 genotypicdiversity,highlyheterozygousnatureandbroadrangeofenvironmentaladaptations"(**Larson, 1994, Childers *et al.*, 1995**) [6,5]. 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" (Sharma and Yamdagni, 2000) [14]. "The fresh- ripe fruits of strawberry are the rich source of vitamins and minerals" (Singh*etal.* 2007) [18]. 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". (**Pathak and Singh, 1971; Sharma, 1975**) [11,13]."Strawberry can be grown on a wide range of soil ranging from heavy claytolightsand.Theplanthas fibrous root systemandmostofitsrootsareconfinedtothetop15-20cmlayerofthesoil,anditgrows bestinthe light porous soil that is rich in humus" (**Singh and Sharma, 1970; Sharma and Singh, 1999; Sharma, 2002**) [16,15,17]. The plant is a surfacefeeder;thereforefertility,moisture,drainageand microbialstatusoftheupperlayerof 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 inadequatefertilizer 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. MATERIALSANDMETHODS

2.1 Geographicallocationoftheexperimentalsite

Theexperimental site is located at a latitude of $25^0$41' North and longitude of $81^0$84 'East, with an altitude of 98 meters above the mean sea level (MSL).

2.2 Climaticconditionsoftheexperimentalarea

The area of Prayagrajcomesunderhumidsubtropicalclimate,whichexperienceswarmhumid monsoon, hot dry summer and cold dry winter. The annual mean temperature is 26.1ºC while monthly meantemperaturesare18-29ºC.Thedailyaveragemaximumtemperatureisabout22ºCandtheminimum temperature is 9ºC. The average annual rainfall received is 1042.2 mm. At this location,thetemperature reaches upto 46ºC-48ºC and the minimum temperaturerecordedis4ºC-5ºC.Therelativehumidityranges in this location ranges between 20-94%.

Table1:TreatmentCombinations

Notations	Treatments
T0	RDN(Control)
T1	RDN+Azosprillum@7kg/ha
T2	RDN+PhosphateSolubilizingBacteria@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. RESULTSANDDISCUSSION

3.1 VegetativeGrowth,FloweringparameterandFruitParameter

The data revealed that different treatments of soil application of bio-fertilizer the ondifferent 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(12.22cm),Numberofleaves(28.84),Numberofflower per plant (27.89), Fruit diameter (2.69 cm) and Fruit length (3.91cm)wererecordedunderthetreatment 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 growthofplantin 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 mightbeduetohighercelldivisioncausedbycytokinins& also due to higher supply of assimilatemediatedbybiofertilizersapplication.Increasednumberofleaves 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 berryweight.Thefindings are in close agreement with the findings of **Dwivedi*et al.* (1999)** in strawberry.

"Thismightbeduetotheeffectofbio-fertilizersassolublephosphorusobtainedfrom bio-fertilizers increases the cell elongation and division. Soluble phosphorus increases photosynthetic activities of leaves, which leadstodevelopmentofprimaryflowers,productionofviableflowers.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 totheeffectofbio-fertilizersasitplaysavitalroleto promote starch formation and activity involved in transportation of carbohydrates in plants. Similarresults were also obtained" by **Yadav *et al.* (2010) and Khalid *et al.* (2013)** in strawberry.

"Theincreasedfruitlengthattributedtobetterfillingsoffruitsmaybeduetomorebalanced

uptake of nutrients which may have led to better metabolic activities in the plantwhichultimatelyledto high protein and carbohydrate 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 flowers per plant, Fruitlength (cm) and Fruit diameter (cm) of Strawberry

Treatment	Plant Height (cm)	Numberof leaves per plant	Plantspread (E-W, N-S) (cm)	Fruit diameter (cm)	Number of flowersper 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
Ftest	S	S	S	**S**	S	S
S.Ed.±	1.23	0.23	0.45	0.38	0.88	1.02
CDat5%	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 Fruitparameter,yieldparameterandQualityParameter

The data revealed that different treatments of soil application of bio-fertilizer the ondifferent parameter such maximum Number of fruits perplant(35.65),Fruitweight(30.75g),FruitYield(53.42q 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 influencedby different treatments. Minimum acidity percentage of fruit was recorded with T_0 with 0.62 closelyfollowed by T_1(0.65).Maximumacidity percentageoffruitwasrecordedinT_9(0.79).Thedatapresented 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). MinimumTSSoffruitwasrecordedinT_5 (4.00). The data presented in the revealed the ascorbic acid of fruit was significantly influenced by different treatments.MaximumascorbicacidoffruitwasrecordedwithT_{11}56.40,closelyfollowedbyT_{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 producehighernumberoffruitswhichinturnalsoincreasedtheberryweight&yield.This is in agreement with findings" of **Tripathi, (2010).**

"The increased fruit weight attributed to better fillings offruitsmaybenitrogenfillingabilitiesof the microbial inoculants, the capacity to release phyto- hormones especially, GA_3 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 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 respirationduring 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)andKhalid*etal.*(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 phosphorus 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)	Fruityield (q/ha)	Number of fruits perplant	TSS (°B)	Tit. Acidity (%)	Juice (%)	VitaminC (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
Ftest	S	S	S	S	S	S	S
S.Ed.±	0.89	3.12	0.41	0.25	0.25	0.95	0.22
CDat5%	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

3.3 EconomicsofStrawberrycultivation

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). Thismight 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:4EconomicsoftreatmentsofStrawberrycultivation.

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

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 also found in the T11andhighestB:Cratiowasfoundinthesamewith 1.69.

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1. CHAT-GPT version 3.5

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