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Influence of fertigation and liquid plant growth promoting rhizo-microbial consortia on fruit quality of strawberry (*Fragaria* x *ananassa* Duch.) under naturally ventilated poly house

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Abstract
The present study was carried out to evaluate the effect of fertigation and liquid plant growth promoting rhizo-microbial consortia on quality of strawberry (*Fragaria* x *ananassa* Duch.) under naturally ventilated poly house during 2017-18 on strawberry *cv.* Sabrina. The experiment was laid out in Completely Randomized Design with eleven treatments replicated thrice. Significant differences were observed among treatments tested for quality parameters. The results revealed that application of 75% RDF (112.5: 75: 90 Kg NPK/ha) through fertigation along with liquid consortia of *Azotobacter,* phosphate solubilising bacteria and potassium solubilising bacteria recorded highest total soluble solids (12.20 ^{0}B), reducing sugar (6.19%), non reducing sugar (2.01%), total sugar (8.20%), ascorbic acid content (68.83 mg/100g), sugar:acid ratio (12.00), shelf life (2.81 days) and high yield of 387.67 g/plant.

Keywords: *Azotobacter,* fertigation, phosphate solubilising bacteria, potassium solubilising bacteria, strawberry

Introduction
Strawberry (*Fragaria x ananassa* Duch.) is one of the most delicious fruit of the world, attained a prime position in the world market not only as fresh fruit but also in the processing industries (Sharma and Sharma, 2003) [14]. All the cultivated varieties of strawberry are octaploid (2n=56) in nature and belongs to the family Rosaceae. The fruits are delicious and attractive, having pleasant aroma with a delicate flavour. In India, the crop finds its cultivation mostly in poly houses with utmost care and gains a good market.

A profitable crop production is based on achieving maximum yields under suitable agro-ecological conditions and timely marketing of the goods produced. Under poly house conditions, commercially important crops are grown with keen care. Under such care, nutrient and water management coupled with plant protection measures play a dominant role to exploit crops potentiality. Developing a suitable method of application of fertilizer is one such measure from the point of quality assurance along with maximum quantity. Fertigation is the application of water soluble solid or liquid fertilizer formulations through drip irrigation system and very effective method of fertilization in modern intensive agriculture systems. Fertigation enhances use efficiency of fertilizers due to minimum losses of nitrogen due to leaching, control of nutrient concentration in soil solution and saving in application cost.

In recent years, the use of chemical fertilizers has increased tremendously as it is an essential part of the crop production for getting higher yields despite its higher cost and not eco-friendly. Efforts are always concentrated on alternative nutrient sources that are cheap and eco-friendly so that farmers can reduce the investment made on fertilizers leading to ecologically sustainable farming. In this regard, the use of microbial consortia has a better perspective since they are cheaper and eco-friendly. A microbial consortium is nothing but bio-fertilizer containing carrier based micro-organisms which help to enhance the productivity through fixation, solubilization and mobilisation, makes it available for plants. Liquid microbial consortia are the microbial preparations containing specific beneficial microorganisms which are capable of having above characteristics for plant nutrients by their biological activity (Sharma *et al*., 2010) [13]. It facilitates the long survival of the organism than carrier-based bio-fertilizers by providing the suitable medium which is sufficient for the entire crop cycle.

Azotobacter is free living bacteria capable of performing several metabolic activities, including atmospheric nitrogen fixation by conversion to ammonia and serves as potential bio-fertilizer for all non-leguminous plants. Similarly, phosphate solubilising bacteria have the ability to solubilize chemically fixed soil phosphorus and rock phosphate.

They can also mineralize organic phosphorous compounds present in the organic manures and soil (Rodrigues and Fraga, 1999) [12]. Potash solubilizing bacteria have the ability to solubilize the potassium which can be easily absorbed by plants. Thereby, it also enhances the efficiency of chemical fertilizer (Patel, 2011) [6].

Preferential care of plants under poly house situations paves way for testing many scientific facts and adopting the same taking consideration of cost of production. In the present study, judicious application of inorganics through irrigation along with plant growth promoting rhizo-consortia as organics was taken up to find out the best combination for getting higher quality in strawberry.

Material & Methods

The present investigation was conducted during 2017-18 in naturally ventilated poly house belongs to Department of Fruit Science, College of Horticulture, Mudigere, Karnataka, India. The experiment was laid out in a Completely Randomized Design with three replications and eleven treatments *viz.*, T_1 - 75% recommended dose of fertilizers (RDF) through fertigation, T_2-100% RDF through fertigation, T_3-100% RDF through soil application, T_4-75% RDF through soil application, T_5 - 75% RDF through fertigation + *Azotobacter*, T_6 - 75% RDF through fertigation + phosphorus solubilising bacteria (PSB), T_7-75% RDF through fertigation + potassium solubilising bacteria (KSB), T_8-75% RDF through fertigation + *Azotobacter* + PSB ,T_9 -75% RDF through fertigation + *Azotobacter* + KSB, T_{10}-75% RDF through fertigation + PSB + KSB, T_{11}-75% RDF through fertigation + *Azotobacter* + PSB + KSB. The test variety was Sabrina. Fertilizers were applied through drip irrigation method by using the ventury system. The source of nutrients used to meet the demand were urea, di ammonium phosphate, muriate of potash, potassium nitrate and 19:19:19. Fertigation schedule includes six times started from 15 days after planting and was continued up to 90 days at 15 days interval. The crop was provided recommended dose 150: 100: 120 kg/ha of NPK and liquid microbial consortia which is mixed with FYM and then applied to the soil 15 days before planting at 250 ml/acre. The phosphorus and potassium solubilizers used in the study are *Bacillus megaterium* and *Bacillus mucilaginosus*. The observations on quality parameters include, total soluble salts, reducing sugar, non reducing sugar, total sugar, ascorbic acid, titratable acidity, sugar: acid ratio and shelf life were recorded and the data was subjected to statistical analysis to draw the meaningful inferences.

Total Soluble Solid (TSS) of the juice was determined with digital refractometer at room temperature by putting a few drops of juice on the prism and expressed as degree brix (ºBrix). The reducing sugar content of the fruit was estimated through anthrone reagent method by following standard procedure involving glucose as standard solution measured at 630 nm. The sugar content was calculated through standard glucose curve.

$$\text{Reducing sugars (\%)} = \frac{\text{Glucose (mg) in sample from standard curve}}{\text{Aliquot taken for test (ml)}} \times \frac{\text{Vol. made (ml) after alcohol evaporation}}{\text{Vol. taken for alcohol evaporation (ml)}} \times \frac{\text{Vol. made (ml) after sample extraction}}{\text{Sample taken for extraction (mg)}} \times 100$$

The percentage of non-reducing sugars was obtained by subtracting the percentage of reducing sugars from the total sugars.

Non-reducing sugar (%) = Total sugar – Reducing sugar

The total sugar content of the fruit was estimated by following the method of Ranganna (1986) [9] and expressed in percentage. The total sugar content of the fruit can be calculated by using the below formula,

$$\text{Total sugars (\%)} = \frac{\text{Glucose (mg) in sample from standard curve}}{\text{Aliquot taken for test (ml)}} \times \frac{\text{Vol. made (ml) after hydrolysis (ml)}}{\text{Vol. taken for alcohol hydrolysis (ml)}} \times \frac{\text{Vol. made after alcohol evaporation (ml)}}{\text{Volume taken for evaporation (mg)}} \times \frac{\text{Vol. made (ml) after sample extraction (ml)}}{\text{Sample taken for extraction (mg)}} \times 100$$

Ascorbic acid was estimated by using 2, 6-dichlorophenol indophenol titration method involving oxalic acid and calculated as follows.

$$\text{Ascorbic acid (mg / 100g)} = \frac{\text{Titre value} \times \text{dye factor} \times \text{vol. made up}}{\text{Aliquot taken for estimation} \times \text{vol. of sample taken}} \times 100$$

Titratable acidity was estimated with available standard methodology involving N/10 NaOH solution using phenolphthalein as an indicator and was expressed in terms of citric acid percentage on fresh fruit weight basis

$$\text{Titratable acidity (\%)} = \frac{\text{Titrate} \times \text{Normality of Alkali} \times \text{Volume made up} \times \text{Equivalent wt. of acid}}{\text{Vol. of sample taken} \times \text{Vol. of aliquot taken} \times 1000} \times 100$$

The sugar to acid ratio was calculated by dividing the total sugar content by the titratable acidity. Shelf life of fruits was decided based on the appearance and marketability of the fruits. When the fruits crossed edible ripe stage were considered the end of their shelf life (Turner, 1997) [16] and is expressed in days.

Results & Discussion

The analysis of data showed significant difference among different treatments for quality parameters (Table 1 & 2). Total soluble salts ranged from 9.13 to 12.2 ^{0}B while that of reducing and non reducing sugars were 4.77 to 6.19 and 1.33 to 2.01 per cent respectively. Among the different treatments, application of 75% RDF through fertigation + *Azotobacter* + PSB + KSB recorded maximum total soluble solid content (12.20 ºB), reducing sugars (6.19%), non-reducing sugars (2.01%), total sugars (8.20%) and sugars to acid ratio (12.00). The increase in these parameters may be attributed to even supply of required nutrients to crop plants due to combined effect of microbial consortium and optimum supply of NPK through fertigation. Further, nutrients from different sources reflected in increasing the vigour of strawberry plants including increased leaf area resulting higher synthesis of assimilates due to enhanced rate of photosynthesis. Such effects have been attributed to increased rate of translocation of photosynthetic products from source to developing fruits there helped to increase sugar content (Magge, 1963) [5] and due to increase in total sugars, sugar to acid ratio was found to be maximum. The current findings are in line with the findings of Ahmad and Mohammad (2012) [1], Umar *et al*. (2009) [17], Pesakovic *et al*. (2013) [7] and Rayees *et al*. (2015) [11] in strawberry.

The highest ascorbic acid content (68.83 mg/100 g) was recorded in plots treated with 75% RDF through fertigation + *Azotobacter* + PSB + KSB while the minimum was recorded in 75% RDF through soil application (54.17 mg/100 g). The higher ascorbic acid content may also be due to influence of liquid microbial consortia which might increase the rate of biosynthesis of ascorbic acid from its precursor glucose 6-phosphate which may enhance the ascorbic acid content. The organic fertilizers are hydrophilic in nature and absorb moisture and nutrients which persist longer thus improving the soil structure and indirectly enhancing fruit quality and ascorbic acid contents (Ali *et al.* 2003) [2]. Higher ascorbic acid content in strawberry fruits may also be due to nitrogen supply through fertigation and as well *Azotobacter* that help to sustain or increase the synthesis and catalytic activity of several enzymes and co-enzymes that are instrumental in ascorbic acid synthesis (Bora *et al*. 2000) [3].

The maximum titratable acidity was recorded in 75% RDF through soil application (0.91%) which was on par with 100% RDF through soil application (0.88%), while the minimum titratable acidity (0.68%) was observed in plots receiving 75 per cent RDF through fertigation + *Azotobacter* + PSB + KSB. The reduction in titratable acidity may be attributed to the conversion of the organic acids and photosynthates into sugar during fruit ripening by applying biofertilizers (Esitken *et al*., 2010) [4].

The results depicted that the higher shelf life was observed in treatment which received 75% RDF through fertigation + *Azotobacter* + PSB + KSB (2. 81 days) which was on par with 75% RDF through fertigation + *Azotobacter* + KSB (2.77 days) and 75% RDF through fertigation + PSB + KSB (2.75 days) where as the minimum (1.90 days) was observed in 75% RDF through soil application. The possible reason for reduction in weight loss and spoilage by microbial consortium might be due to rapid chemical changes by them within fruits, so that the fruits could retain more water against the force of evaporation and possibly they might have also altered some of the proteinaceous constituents (Singh *et al*., 1995) [15].

Among the different treatments, plots which received 75% RDF through fertigation + *Azotobacter* + PSB + KSB recorded highest yield (387.67 g/plant) where as minimum yield (209.33 g/plant) was observed in 75% RDF through soil application. With respect to yield per plot, 75% RDF through fertigation + Azotobacter + PSB + KSB recorded maximum fruit yield per plot (4.73 kg) and the minimum fruit yield per plot of 2.60 kg was observed in plots which received 75 per cent RDF through soil application. The higher might be due to sustained nutrient availability due to fertigation schedule. The combined effect of inorganic fertilizers along with microbial consortia enhanced the macronutrient availability in the soil that might have coincided with plant need. The yield attributes or the sink capacity of the crop is determined by its vegetative growth throughout the life cycle of the plant as nitrogen fixers and phosphorous solubilizers increased the availability of nitrogen and phosphorous in the rhizosphere that helped in more translocation from root to flower through plant foliage. These results are in line with the findings of Rana and Chandel (2003) [8], Zargar *et al.* (2008) [19] and Yadav *et al.* (2016) [18] in strawberry.

Table 1: Effect of fertigation and liquid plant growth promoting rhizo-microbial consortia on fruit quality of strawberry cv. Sabrina

Treatments	Total soluble solids (0B)	Reducing sugar (%)	Non Reducing sugar (%)	Total sugar (%)	Yield/plant (g)	Yield /plot (Kg)
T_1	9.13	5.51	1.59	7.10	260.67	3.07
T_2	9.27	5.53	1.64	7.17	278.00	3.13
T_3	8.69	4.97	1.39	6.37	234.33	2.84
T_4	8.33	4.77	1.33	6.10	209.33	2.60
T_5	10.67	5.68	1.85	7.53	325.67	3.57
T_6	10.80	5.57	1.80	7.37	317.67	3.33
T_7	10.86	5.55	1.78	7.33	311.00	3.23
T_8	11.63	5.97	1.97	7.93	370.33	4.23
T_9	11.73	5.82	1.91	7.73	361.73	4.00
T_{10}	11.33	5.81	1.91	7.72	351.67	3.87

T_{11}	12.20	6.19	2.01	8.20	387.67	4.73
S. Em ±	0.13	0.05	0.04	0.05	1.16	0.07
C. D. (P = 0.05)	0.39	0.16	0.12	0.15	3.36	0.21

Legend:

T_1 -75% recommended dose of fertilizers (RDF) through fertigation	T_7-75% RDF through fertigation + potassium solubilising bacteris (KSB)
T_2-100% RDF through fertigation	T_8-75% RDF through fertigation + *Azotobacter* + PSB
T_3-100% RDF through soil application	T_9 -75% RDF through fertigation + *Azotobacte*r + KSB
T_4-75% RDF through soil application	T_{10}-75% RDF through fertigation + PSB + KSB
T_5 - 75% RDF through fertigation + *Azotobacter*	T_{11}-75% RDF through fertigation + *Azotobacter* + PSB + KSB
T_6 - 75% RDF through fertigation + phosphorus solubilising bacteris (PSB)	

Table 2: Effect of fertigation and liquid plant growth promoting rhizo-microbial consortia on fruit quality of strawberry cv. Sabrina

Treatments	Ascorbic acid (mg/100gm)	Titratable acidity (%)	Sugar :acid ratio	Shelf life (days)
T_1	60.83	0.85	8.35	2.43
T_2	63.03	0.84	8051	2.47
T_3	56.00	0.88	7.26	2.03
T_4	54.17	0.91	6.68	1.90
T_5	64.67	0.83	9.23	2.27
T_6	63.67	0.84	8.84	2.33
T_7	62.33	0.82	9.1	2.47
T_8	66.83	0.79	9.77	2.63
T_9	67.70	0.73	10.86	2.77
T_{10}	66.30	0.76	10.18	2.75
T_{11}	68.83	0.68	12.00	2.81
S. Em ±	0.31	0.01	0.10	0.05
C. D. (P = 0.05)	0.91	0.03	0.30	0.14

Legend:

T_1 -75% recommended dose of fertilizers (RDF) through fertigation	T_7-75% RDF through fertigation + potassium solubilising bacteris (KSB)
T_2-100% RDF through fertigation	T_8-75% RDF through fertigation + *Azotobacter* + PSB
T_3-100% RDF through soil application	T_9 -75% RDF through fertigation + *Azotobacte*r + KSB
T_4-75% RDF through soil application	T_{10}-75% RDF through fertigation + PSB + KSB
T_5 - 75% RDF through fertigation + *Azotobacter*	T_{11}-75% RDF through fertigation + *Azotobacter* + PSB + KSB
T_6 - 75% RDF through fertigation + phosphorus solubilising bacteris (PSB)	

Conclusion

On the basis of results obtained from the present study, it can be concluded that application of 75% RDF (112.5: 75: 90 Kg NPK/ha) through fertigation along with *Azotobacter*, PSB (*Bacillus megaterium*) and KSB (*Bacillus mucilaginosus*) in liquid form performed well for achieving higher yield with good quality fruits in strawberry crop.

References

1. Ahmad D, Mohammad J. Impact of integrated organic nutrient combinations on fruit yields and quality of strawberry cv. Kurdistan in Iran. J Orn. Hort. 2012; 2(4):251-256.
2. Ali Y, Masood I, Shah S, Ahmad MJ. Effect of different combinations of nitrogen, phosphorus and farmyard manure on yield and quality of strawberry. Sarhad. J Agric. 2003; 19:185-188.
3. Bora SS, Singh AP, Kumar N. Biofertilizers: Natural cheap source of nutrients. Indian Farmers Digest. 2002; 53-56.
4. Esitken A, Yildiz HE, Ercisli S, Donmez MF, Turan M, Gunes A. Effects of plant growth promoting bacteria (PGPB) on yield, growth and nutrient contents of organically grown strawberry. Sci. Hort. 2010; 124: 62-66.
5. Magge, DH. The reduction in growth in apple trees brought about by fruiting. J Hort. Sci. 1963; 338:119-125.
6. Patel, BC. Advance method of preparation of bacterial formulation using potash mobilizing bacteria that mobilize potash and make it available to crop plant. WIPO Patent Application WO/2011/154961; 2011.
7. Pesakovic M, Stajic ZK, Milenkovic S, Mitrovic O. Biofertilizer affecting yield related characteristics of strawberry (*Fragaria x ananassa* Duch.) and soil microorganisms. Sci. Hort. 2013; 150:238-243.
8. Rana RK, Chandel JS. Effect of bio-fertilizer and nitrogen on growth, yield and fruit quality of strawberry. Progressive Hort. 2003; 35(1):23-30.
9. Ranganna S. Handbook of Analysis and Quality Control for Fruit and Vegetable Products, Tata Mc Graw Hill, New Delhi, 1986, 190-210.
10. Ranganna S. Manual of analysis of fruits and vegetable products. Tata Mcg*row* Hill Pub. Co. Ltd. New Delhi. 1977, 255.
11. Rayees A, Hakeem SA, Sabiya B, Seerat G, Mohammad NM, Prasad VM. Impact of integrated nutrient management on growth, yield and quality of strawberry (*Fragaria x ananassa* Duch.) cultivation in India. J. Nat. and Sci. 2015; 13(1):39-44.
12. Rodríguez H, Fraga R. Phosphate solubilizing bacteria and their role in plant growth promotion. Biotechnol Adv. 1999; 17:319-339.
13. Sharma MP, Sharma SK. Dwivedi A. Liquid biofertilizer application in soybean and regulatory mechanisms. Agric. Today. 2010; 44:25-28.
14. Sharma VP, Sharma RR. The Strawberry. Indian Council of Agricultural Research, New Delhi, 2003, 166.

15. Singh S, Kumar P, Brahmchari VS, Singh DN. Effect of pre harvest spray of GA_3 and Ethanol on storage life of mango cv. Amrapali. The Orissa J Hort. 1995; 23:112-115.
16. Turner DW, Post harvest Physiology and Storage of Tropical and Sub-tropical Fruits, Mitra, S.K. (Ed.), CAB International, New York, 1997, 47-77.
17. Umar I, Wali VK, Kher R, Jamwal M, Effect of FYM, urea and Azotobacter on growth, yield and quality of strawberry cv. Chandler. Not. Bot. Hort. Agrobot. Cluj. 2009; 37(1):139-143.
18. Yadav SK, Khokhar UU, Kumar P. Response of strawberry to organic versus inorganic fertilizers. J. Pl. Nutr. 2016; 39(2):60-66.
19. Zargar MY, Baba ZA, Sofi PA. Effect of N, P and biofertilizers on yield and physiochemical attributes of strawberry (*Fragaria x ananassa* Duch.). Agro Thesis. 2008; 6(1):3-8.