

Original Research Article

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## Influence of Fertigation and Liquid Plant Growth Promoting Rhizo Microbial Consortia on Yield of Strawberry (*Fragaria x ananassa* Duch.) under Naturally Ventilated Polyhouse

G. Nisarga<sup>1\*</sup>, D. Madaiah<sup>2</sup>, M. Dinesh Kumar<sup>3</sup> and H.S. Yogananda<sup>4</sup>

<sup>1</sup>Department of Fruit Science, <sup>2</sup>Department of Postharvest Technology, College of Horticulture, Mudigere, Karnataka, India

<sup>3</sup>Department of Agronomy, College of Agriculture, Shivamogga, Karnataka, India

<sup>4</sup>Division of Vegetable Science, Indian Agricultural Research Institute, New Delhi, India

\*Corresponding author

### ABSTRACT

#### Keywords

*Azotobacter*,  
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The present study was carried out under naturally ventilated polyhouse during 2017-18 with an objective to evaluate the effect of fertigation and liquid plant growth promoting rhizo-microbial consortia on yield of strawberry (*Fragaria x ananassa* Duch.). The experiment was laid out in Completely Randomized Design with eleven treatments replicated thrice. Among the different treatments tested, application of 75% RDF (112.5: 75: 90 kg NPK/ha) through fertigation + *Azotobacter* + Phosphate solubilising bacteria (PSB) + Potassium solubilising bacteria (KSB) in liquid form recorded highest number of flowers per plant (24.21), fruits per plant (21.00), fruit weight (20.90 g), fruit volume (21.67 cc), fruit length (4.78 cm) fruit diameter (3.90 cm) resulting high yield of 387.67 g/plant followed by application of 75% RDF (112.5: 75: 90 kg NPK/ha) through fertigation + *Azotobacter* + Phosphate solubilising bacteria (PSB) in liquid form that yielded 370.33 g/plant.

### Introduction

Strawberry (*Fragaria x ananassa* Duch.) of Rosaceae family is one of the most delicious and refreshing soft fruits of the world and cultivated varieties are octaploid (2n=56) in nature. The cultivated strawberry (*Fragaria x*

*ananassa*), is a hybrid of *Fragaria chiloensis* and *Fragaria virginiana* native American species but first developed in France during the seventeenth century. The fruits are widely acclaimed for pleasant flavour, conspicuous colour and varied blend of taste. Earlier the strawberry was a commercial fruit of

temperate region but with the development of day neutral varieties, its cultivation is being extended to tropical and subtropical climate also. Strawberry is a low creeping perennial herb offers quicker returns on capital investment.

Sustainable production is based entirely on adaption of suitable packages to exploit the potentiality of crop under varied agro ecological conditions. Basically, irrigation and nutrient management hold the key for the purpose in a given system of production. Development of a suitable method of fertilizer application is a focal aspect both for yield realization and also for economy apart from soil health aspects. By and large, drip method of irrigation is a proven technique for economy of water and also achieving higher yields in many situations of crop growing. On the other hand, compared to traditional applications, fertigation is an upcoming technology based on drip for many commercial crops. 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. It also gives advantages such as minimum losses of applied nutrients due to leaching, control of nutrient concentration in soil solution and saving in application cost.

In recent years, with evolution and adoption of high yielding varieties and hybrids, chemical fertilizers has become an essential component of the crop production for getting higher yields. To that extent usage and dependency on chemical fertilizers has risen in spite they are not eco-friendly and their prices high. There is need to seek 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-fertilizers containing carrier based micro-organisms which help to enhance the productivity through biological nitrogen fixation, solubilization of insoluble phosphate and mobilising potassium and makes it available for plants. Liquid microbial consortia are the microbial preparations containing specific beneficial microorganisms which are capable of fixing or solubilizing or mobilizing plant nutrients by their biological activity (Sharma *et al.*, 2010). 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 biofertilizer 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). Potash solubilizing bacteria has the ability to solubilize the potassium which can be easily absorbed by plants. It offers to the plant multifaceted benefits in terms of growth by mobilizing potash and making it available to crops. Thereby, it also enhances the efficiency of chemical fertilizer (Patel, 2011).

Many sources of organic options are available for sustenance of yield but obtaining high yields is a hard reality from the sole application of organic manures or biological products. Therefore, a judicious combined application of inorganic and organic fertilizers or bio-fertilizers may be helpful in enhancing the fruit production of strawberry. Hence the

present study was taken up to find out the best combination of different microbial consortia for higher yield in strawberry.

## **Materials and Methods**

The experiment was carried out in a low cost polyhouse belongs to Department of Fruit Science, College of Horticulture, Mudigere situated in the Western Ghats and represents the typical hilly zone (Zone-9 and Region-V) of Karnataka, India. It is located at 13<sup>0</sup> 25' North latitude and 75<sup>0</sup> 25' East longitude with an altitude of 982 m above mean sea level. The experiment was laid out in a Completely Randomized Design with three replications and eleven treatments viz., T<sub>1</sub> -75% recommended dose of fertilizers (RDF) through fertigation, T<sub>2</sub>-100 % RDF through fertigation, T<sub>3</sub>-100% RDF through soil application, T<sub>4</sub>-75 % RDF through soil application, T<sub>5</sub> - 75% RDF through fertigation + *Azotobacter*, T<sub>6</sub> - 75% RDF through fertigation + PSB , T<sub>7</sub>-75% RDF through fertigation + KSB, T<sub>8</sub>-75% RDF through fertigation + *Azotobacter* + PSB ,T<sub>9</sub> -75% RDF through fertigation + *Azotobacter* + KSB, T<sub>10</sub>-75% RDF through fertigation + PSB + KSB, T<sub>11</sub>-75% RDF through fertigation + *Azotobacter* + PSB + KSB. Tissue cultured plants of Sabrina variety of strawberry was planted at a spacing of 30 cm x 30 cm on raised beds with 12 plants per plot viz., 6 plants of 2 rows. The crop was raised with the recommended dose 150: 100: 120 kg/ha of NPK and liquid microbial consortia @ 250 ml/acre is mixed with FYM and then applied to the soil 15 days before planting. The phosphorus and potassium solubilizers used in the study are *Bacillus megaterium* and *Bacillus mucilaginosus*. Fertilizers were applied through drip irrigation method by using the ventury system. The source of nutrients used to meet the demand of N, P and K were urea, di ammonium phosphate, muriate of potash, potassium nitrate and

19:19:19. At different intervals, fertilizer solution was prepared by mixing the required quantity of fertilizers and water in the plastic container which was connected with suction device of the ventury system. Fertigation schedule was started from 15 days after planting and was continued up to 90 days at 15 days interval. Different growth and yield parameters were recorded and the data was subjected to statistical analysis for meaningful conclusions.

## **Results and Discussion**

The analysis of data showed significant difference among different treatments for yield parameters (Table 1 and 2). All the yield parameters were relatively higher in fertigation and consortia applied plots. In that, two microbial consortia combinations caused the betterment of crop growth and yield components. Per plant yield data of 100 per cent RDF application through fertigation (278g) was found statistically better than soil application (234.33 g) but found on par to that of 75 per cent RDF application through fertigation (260.67 g). Further, the yield components obtained with application of 75 per cent RDF through fertigation and consortia of single microbe (T<sub>5</sub> to T<sub>7</sub>) improved and resulted in average yields of per plant to 311-325 g conferring statistical significance over plots receiving 100 per cent RDF though fertigation. It clears envisages the role of microbes in enhancing the fixation or solubilisation individually and might have met the demand of crop at right time. The variations in the above treatments might be due to sustained nutrient availability facilitated by microbial consortia. Further, the plots with microbes combination of two along with 75 per cent RDF through fertigation T<sub>8</sub> to T<sub>10</sub>) boosted the combined nutrient availability further and helped the crop to express potentially better as per recorded components of yield and per plant yield (351-

370 g). These results are in line with the findings of Rana and Chandel (2003). 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 or potassium solubilizers increased the availability of nutrients 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), Zargar *et al.*, (2008) and Mishra and Tripathi (2011) in strawberry.

In the study, maximum number of flowers (24.21) and berries (21.00) per plant was recorded in plots receiving 75 per cent RDF through fertigation + *Azotobacter* + PSB + KSB whereas, minimum number of flowers

(17.83) and berries (15.03) per plant was observed in plants which received 75 per cent RDF through soil application. The increased number of flowers might be due to supply of optimum level of nutrients as N, P and K and hormones provided by microbial consortium played a significant role in increasing gibberlic acid in roots thus breaking bud dormancy and increased flowering buds and fruiting sites (Tagliavini *et al.*, 2005). Further, increased phosphorus availability through phosphorous solubilizing bacteria and IAA from *Azotobacter* might have increased various endogenous hormonal levels in plant tissue responsible for enhanced pollen germination and pollen tube formation which might have ultimately led to increased fruit set and number of fruits per plant.

**Table.1** Effect of liquid plant growth promoting rhizo-microbial consortia on yield of strawberry (cv. Sabrina)

Treatments	Number of flowers/plant	Number of berries/plant	Berry weight (g)	Yield/plant (g)	Yield /plot (kg)
T <sub>1</sub>	20.17	16.45	16.67	260.67	3.07
T <sub>2</sub>	21.50	16.87	17.08	278.00	3.13
T <sub>3</sub>	19.33	16.03	15.33	234.33	2.84
T <sub>4</sub>	17.83	15.03	14.80	209.33	2.60
T <sub>5</sub>	22.00	18.07	18.43	325.67	3.57
T <sub>6</sub>	21.83	17.97	18.17	317.67	3.33
T <sub>7</sub>	21.73	17.75	17.83	311.00	3.23
T <sub>8</sub>	23.74	20.17	20.13	370.33	4.23
T <sub>9</sub>	22.60	19.33	19.55	361.73	4.00
T <sub>10</sub>	22.75	18.83	19.17	351.67	3.87
T <sub>11</sub>	24.21	21.00	20.90	387.67	4.73
S. Em ±	0.19	0.15	0.22	1.16	0.07
C.D. (P=0.05)	0.56	0.44	0.65	3.36	0.21

**Legend:**

- T<sub>1</sub> -75% recommended dose of fertilizers (RDF) through fertigation
- T<sub>2</sub>-100 % RDF through fertigation
- T<sub>3</sub>-100% RDF through soil application
- T<sub>4</sub>-75 % RDF through soil application
- T<sub>5</sub> - 75% RDF through fertigation + *Azotobacter*
- T<sub>6</sub> - 75% RDF through fertigation + phosphorus solubilising bacteria (PSB)
- T<sub>7</sub>-75% RDF through fertigation + potassium solubilising bacteria (KSB)
- T<sub>8</sub>-75% RDF through fertigation + *Azotobacter* + PSB
- T<sub>9</sub> -75% RDF through fertigation + *Azotobacter* + KSB
- T<sub>10</sub>-75% RDF through fertigation + PSB + KSB
- T<sub>11</sub>-75% RDF through fertigation + *Azotobacter* + PSB + KSB

**Table.2** Effect of liquid plant growth promoting rhizo microbial consortia fruit length, diameter and volume of strawberry (cv. Sabrina)

Treatments	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (cc)
T <sub>1</sub>	3.93	3.15	17.87
T <sub>2</sub>	3.98	3.20	18.03
T <sub>3</sub>	3.70	2.73	16.50
T <sub>4</sub>	3.45	2.57	15.97
T <sub>5</sub>	4.23	3.27	19.81
T <sub>6</sub>	4.12	3.23	19.30
T <sub>7</sub>	4.08	3.15	19.17
T <sub>8</sub>	4.56	3.73	21.23
T <sub>9</sub>	4.42	3.70	21.17
T <sub>10</sub>	4.30	3.52	20.75
T <sub>11</sub>	4.78	3.90	21.67
S. Em ±	0.11	0.07	0.17
C.D. (P=0.05)	0.31	0.21	0.51

**Legend:**T<sub>1</sub> -75% recommended dose of fertilizers (RDF) through fertigationT<sub>2</sub>-100 % RDF through fertigationT<sub>3</sub>-100% RDF through soil applicationT<sub>4</sub>-75 % RDF through soil applicationT<sub>5</sub> - 75% RDF through fertigation + *Azotobacter*T<sub>6</sub> - 75% RDF through fertigation + phosphorus solubilising bacteria (PSB)T<sub>7</sub>-75% RDF through fertigation + potassium solubilising bacteria (KSB)T<sub>8</sub>-75% RDF through fertigation + *Azotobacter* + PSBT<sub>9</sub> -75% RDF through fertigation + *Azotobacter* + KSBT<sub>10</sub>-75% RDF through fertigation + PSB + KSBT<sub>11</sub>-75% RDF through fertigation + *Azotobacter* + PSB + KSB

These results are in accordance with the earlier findings of Yadav *et al.*, (2010), Macit *et al.*, (2007), Khalid *et al.*, (2013) in strawberry. Further, the berry weight was significantly differed with fertigation and liquid PGPR treatments of strawberry plants. The maximum berry weight (20.90 g) was recorded in 75 per cent RDF through fertigation + *Azotobacter* + PSB + KSB due to cumulative effect of increased population of bacteria at balanced dose of NPK which in turn increased biological fixation, production of growth regulators and solubilisation of available nutrients which resulted in producing maximum photosynthates in terms of high biomass and translocation of assimilates to the developing sink results in higher fruit weight (Patil and Shinde, 2013). These results are in line with the findings of

Sahoo and Singh (2005) in strawberry.

The fruit characteristics such as length, diameter and volume showed significant difference among the different treatments. The maximum fruit length (4.78 cm), diameter (3.90 cm) and volume (21.67 cc) was recorded in 75 per cent RDF through fertigation + *Azotobacter* + PSB + KSB while, that of minimum fruit length (3.45 cm), diameter (2.57 cm) and volume (15.97 cc) was recorded in 75% RDF through soil application. The increase in fruit length, width and volume might be attributed to better fillings of fruits due to balanced uptake of nutrients with better metabolic activities in the plant ultimately led to high protein and carbohydrate synthesis (Ahmad and Mohammad, 2012), improved cell elongation,

cell thickening and fruit development (Ghaderi and Talaie, 2008). These results are in conformity with the findings of Yadav *et al.*, (2010), Khalid *et al.*, (2013), Nazir *et al.*, (2006), Rana and Chandel, (2003) and Umar *et al.*, (2009) in strawberry.

The results of the study revealed that significant variations for yield in plants subjected to different fertigation treatments. The plants which received 75 per cent RDF through fertigation + *Azotobacter* + PSB + KSB recorded maximum fruit yield per plant (387.67 g) and fruit yield per plot (4.73 kg) while, the minimum fruit yield per plant (209.33 g) and fruit yield per plot (2.60 kg) was recorded in plots which received 75 per cent RDF through soil application. The increase in yield is due to increased flowering, more fruit set per plant, berry size, higher fruit characteristics as indicated and explained earlier. The combined effect of inorganic fertilizers along with microbial consortia enhanced the macronutrient availability in the soil that might have coincided with plant need. These results are in line with the findings of Verma and Rao (2013) and Yadav *et al.*, (2016) in strawberry.

On the basis of results obtained from the present investigation, it can be concluded that application of 75 per cent RDF (112.5: 75: 90 Kg NPK/ha) through fertigation along with *Azotobacter*, PSB (*Bacillus megaterium*) and KSB (*Bacillus mucilaginosus*) in liquid form showed promising results, there by saved 25 per cent of fertilizers.

## References

Ahmad, D. and Mohammad, J., 2012, Impact of integrated organic nutrient combinations on fruit yields and quality of strawberry cv. Kurdistan in Iran. *J. Orn. Hort.* 2(4): 251-256.  
Ghaderi, N. and Talaie, A. R., 2008, Influence

of manure and urea on yield and some other fruit characteristics in strawberry cv. Kurdistan. *Iranian J. Hort. Sci.* 39(1): 99-107.

- Khalid, S., Qureshi, K. M., Hafiz, I. A., Khan, K. S. and Qureshi, U. S., 2013, Effect of organic amendments on vegetative growth, fruit yield and quality of strawberry. *Pakistan J. Agric. Res.* 26(2): 104-112.
- Macit, I., Koc, A., Guler, S. and Deligoz, I., 2007, Yield, quality and nutritional status of organically and conventionally grown strawberry cultivars. *Asian J. Plant Sci.* 6(7): 1131-1136.
- Mishra, A.N and Tripathi, V.K., 2011, Influence of different levels of *Azotobacter*, PSB alone and in combination on vegetative growth, flowering, yield and quality of strawberry cv. Chandler. *Int. J. Applied Agri., Res.* 6 (3): 203-210.
- Nazir, N., Singh, S. R., Aroosa, K., Masarat, J. and Shabeena, M., 2006, Yield and growth of strawberry cv. Senga Sengana as influenced by integrated organic nutrient management system. *Environ.and Ecol.* 243(3): 651-654.
- Patel, B.C., 2011, 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.
- Patil, V. K. and Shinde, B. N., 2013, Studies on integrated nutrient management on growth and yield of banana cv. Ardhapuri (Musa AAA). *J. Hort and Forestry.* 5(9): 130-138.
- Rana, R. K. and Chandel, J. S., 2003, Effect of bio-fertilizer and nitrogen on growth, yield and fruit quality of strawberry. *Progressive Hort.* 35(1): 23-30.
- Rodríguez, H. and Fraga, R., 1999, Phosphate solubilizing bacteria and their role in plant growth promotion. *Biotechnol*

- Adv. 17: 319-339.
- Sahoo, S. K. and Singh, D. B., 2005, Effect of different level of biofertilizer on growth, yield and quality of strawberry. Orissa J. Hort. 2: 82-85.
- Sharma, M. P., Sharma, S.K. and Dwivedi, A, 2010, Liquid biofertilizer application in soybean and regulatory mechanisms. Agric. Today. 44: 25-28
- Tagliavini, M. E., Baldi, E., Lucchi, P., Antonelli, M., Sorrenti, G., Baruzzi, G. and Faedi, W., 2005, Dynamics of nutrient uptake by strawberry plants (*Fragaria x ananassa* Duch.) grown in soil and soilless culture. Eur. J. Agro. 23: 15-25.
- Umar, I., Wali, V. K., Kher, R. and Jamwal, M., 2009, Effect of FYM, urea and Azotobacter on growth, yield and quality of strawberry cv. Chandler. Not. Bot. Hort. Agrobot. Cluj. 37(1): 139-143.
- Verma, J. and Rao, V. K., 2013, Impact of integrated nutrient management on soil properties, plant growth and yield parameters of strawberry cv. Chandler. J. Hill Agric. 4(2): 61-67.
- Yadav, S. K., Khokhar, U. U. and Kumar, P., 2016, Response of strawberry to organic versus inorganic fertilizers. J. Pl. Nutr. 39 (2): 60-66.
- Yadav, S. K., Khokhar, U. U. and Yadav, R. P., 2010, Integrated nutrient management for strawberry cultivation. Indian J. Hort., 67(4): 445-449.
- Zargar, M. Y., Baba, Z. A. and Sofi, P. A., 2008, Effect of N, P and biofertilizers on yield and physiochemical attributes of strawberry (*Fragaria x ananassa* Duch.). Agro Thesis. 6(1): 3-8.

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