International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(1): 807-810

Received: 01-11-2017
Accepted: 02-12-2017

K Vanilarasu
Ph.D. Scholar, Department of Fruit Crops, HC&RI, TNAU, Coimbatore, Tamil Nadu, India

J Suresh
Professor Hort, and Deputy Registrar Administration, TNAU, Coimbatore, Tamil Nadu, India

K Soorianathasundaram
Professor Hort, Department of Fruit Crops, HC&RI, TNAU, Coimbatore, Tamil Nadu, India

T Raguchander
Professor Plant Pathology, Department of Plant Pathology, SRS, TNAU, Cuddalore, Tamil Nadu, India

K Devrajan
Professor Nematology, Department of Nematology, AC&RI, TNAU, Madurai, Tamil Nadu, India

K Kumar
Professor Retd, Agricultural Microbiology, TNAU, Coimbatore, Tamil Nadu, India

Correspondence
K Vanilarasu
Ph.D. Scholar, Department of Fruit Crops, HC&RI, TNAU, Coimbatore, Tamil Nadu, India

Impact of biofertigation on growth and yield of banana *cv*. Ney poovan

K Vanilarasu, J Suresh, K Soorianathasundaram, T Raguchander, K Devrajan and K Kumar

Abstract
Banana requires large amounts of chemical fertilizers which are costly and can be hazardous to the environments when used excessively. Application of bioinoculants along with commercially available fertilizers in crop production can play a vital role in biological nitrogen fixation, synthesis of phytohormones, mineralization and release of nutrients when crop required at appropriate growth stages, nutrient use efficiency and minimum deleterious effects on soil fertility. A field experiment was conducted to gain information on the efficacy of bioinoculants along with commercial fertilizers on growth and yield of banana cv. Ney Poovan. The results revealed that among the different treatments, 100 % RDF along with *Azospirillun* and *Pseudomonas fluorescens* through fertigation followed by the treatment received 100 % RDF along with *Azospirillun* and *Bacillus subtilis* through fertigation recorded better values for growth and yield characteristics. Hence, the application of required nutrients through split application (weekly interval) along with PGPR (*Pseudomonas fluorescens* and *Bacillus subtilis*) at 3rd, 5th and 7th MAP registered better values in terms of growth and yield attributes rather than soil application of nutrients.

Keywords: Banana, fertigation, PGPR, growth, yield

Introduction
Banana is a highly exhaustive crop which requires large quantities of mineral nutrients for rapid growth and development, thus it readily responds to applied nutrients. Major nutrients like nitrogen, phosphorus and potassium play an important role in the vegetative and reproductive phases of crop growth. Ney Poovan is the choicest diploid (AB) cultivar, which is under commercial cultivation on a large scale especially in Karnataka and Tamil Nadu. In general, the input use efficiency of various nutrients used for crop growth and development is currently very low leading to problems of decreased productivity, degradation of soil health and increased environmental pollution apart from the wastage of substantial quantity of costly and scarce inputs. Increasing the efficiency of water and fertilizer can itself go a long way in realizing the growing demand for food and other plant products. Though farmers spend huge amount on fertilizers, only 50 % of potential yield is realized due to poor fertilizer use efficiency.

Banana is a heavy feeder of nutrients and nearly 25 to 30% of cost of inputs goes for fertilizers and manures. It is estimated that a crop of 50 t of banana in 1 ha removes 320 kg of N, 32 kg of P_2O_5 and 325 kg of K_2O every year (Lahav and Turner, 1983) [7]. Hence, it is of importance to maintain high degree of soil fertility by timely and judicious application of NPK to achieve fruit yield and quality of banana. However, increased use of chemical fertilizers for production of banana has resulted in several undesirable consequences, in the fragile soil eco-system leading to gradual decline in productivity (Prabhuram, 1992) [15]. Those multiple requirements led to adoption of fertigation, which very much improves the nutrient uptake efficiency to an extent of 30-40 per cent, prevents soil degradation, and reduces the cost of fertilizer and application besides improving the productivity and quality of the produce and minimizes the pollution of ground water by preventing losses through run off and leaching.

Fertigation improves the productivity and quality of banana studied by many investigators (Srinivas, 1997 [20], Mahalakshmi *et al.*, 2001 [11] and Pandey *et al.*, 2001) [14]. Nanda (2010) [12] obtained 60 to 70 per cent higher yield through drip fertigation in banana as compared to soil application of conventional fertilizers. Hence, there is a burgeoning interest to develop and standardize eco-friendly approaches for sustainable production of crops and in this context,

plant growth promoting rhizobacteria (PGPR) play a major role. PGPR's like *Pseudomonas fluorescens, Bacillus subtilis,* Azospirillum along with AM fungi can partly replace the nutrient requirement of the crops by enhancing the availability of nutrients in rhizosphere for the usage of crop plants. Selvaraj *et al*., (2014) [17] reported that application of *Pseudomonas fluorescens* @ 4 lit/ ha at 60, 120, 180 and 240 days after planting through drip irrigation system improved the growth and yield of banana. Therefore, the present investigation was carried out to study the influence of fertigation with bioinoculants application on growth and yield attributes of banana cv. Ney Poovan.

Material and methods

Plant Growth Promoting Rhizobacteria and AM fungi

Liquid and talc based formulation of *Pseudomonas fluorescens* and *Bacillus subtilis* were obtained from the Department of Plant Pathology and Azospirillum and AM fungi were obtained from the Department of Agricultural Microbiology, Tamil Nadu Agricultural University, Coimbatore.

Field Experiment

The present investigation was carried out at Horticultural College and Research Institute, TNAU, Coimbatore, during the year 2014-2015 with banana (*Musa* sp.) cv. Ney Poovan. The experiment was laid out in a Randomized Block Design with nine treatments and three replications. Guard rows were provided on all sides of the plots. Observations were taken up from centrally located three plants. The recommended spacing of 1.8m x 1.8m was adopted for planting. Sword suckers of *cv*. Ney Poovan weighing around 1.5 $\pm$ 0.5 kg were planted in all the treatments. Before planting the suckers were pre-treated with *Pseudomonas fluorescens* and *Bacillus subtilis* as per the treatment and control treatment, suckers pared and pralinaged with Carbofuran @ 40g/ sucker and planted in the field. The present experiment of various treatments as follows T_1 (100 % RDF + *Bacillus subtilis* + *Azospirillum* + fertigation), T_2 (100 % RDF + *Pseudomonas fluorescens* + *Azospirillum* + fertigation), T_3 (100 % RDF + *Azospirillum* + fertigation), T_4 (75 % RDF + *Bacillus subtilis* + *Azospirillum* + fertigation), T_5 (75 % RDF + *Pseudomonas fluorescens* + *Azospirillum* + fertigation), T_6 (100 % RDF + *Azospirillum* + fertigation) T_7 (100 % RDF + *Bacillus subtilis* + *Azospirillum* + soil application), T_8 (100 % RDF + *Pseudomonas fluorescens* + *Azospirillum* + soil application), and T_9 (100 % RDF + *Azospirillum* + soil application).

The recommended dose of fertilizer (RDF) @ 110:35:330 g of NPK per plant was used as per the treatment schedule. Phosphorus was applied as soil application in single dose after third month of planting to all the treatments. Nitrogen and Potassium applied as weekly interval as per the treatment schedule of fertigation treatments and for rest of the treatments applied in three split doses in the third, fifth and seventh months after planting. The treatment of 100 % RDF as N in the form of urea, phosphorus in the form of single super phosphate and potash in the form of murite of potash. *Azospirillum* @ 5 ml / lit and AM fungi @ 10 g/plant were inoculated to irrespective of the treatments applied around the suckers by mixing with farmyard manure (FYM) as basal application.

Morphological attributes of banana

Observations on growth characters like pseudostem height (cm), girth (cm), number of leaves (Summerville, 1944) [22] and Leaf area index was measured by the non-destructive method (Leaf area of the plant/ground area occupied by the plant) by Watson (1952) [26] and crop duration was recorded by number of days taken from planting to shooting and also till harvest.

Yield and yield attributes of banana

Weight of the bunch was recorded including the peduncle measuring 20 cm above the first hand and expressed in kilograms (kg). Number of hands and total number of fingers per bunch were counted and expressed in numbers. Five middle fingers in the top and bottom rows of the second hand were selected as representative fingers (Gottreich *et al.*, 1964) [4] to record the average finger and pulp weight of fruits.

Results and Discussion

Effect of biofertigation on growth parameters of banana

Among the different treatments, the plants treated with 100 % RDF + bioinoculants through fertigation showed significant improvements for pseudostem height (256.23 cm), pseudostem girth (56.61 cm), number of leaves (15.94), leaf area index (2.39), phyllochron production (11.74 days), sucker production numbers (7.85 suckers) and minimum crop duration (341.50 days) when compared to the treatments received 75 % RDF + bioinoculants through fertigation and 100 % RDF + bioinoculants through soil application (Table 1). It is natural that higher nutrient availability as a result of higher doses can result in better vegetative growth. The increased growth promotion might have been due to the effect of chemical fertilizers that supply the nutrients in readily available form to the plants immediately after application (Upadhyay, 1988) [24] and more particularly with respect to nitrogen which helped in increasing the values of pseudostem height and girth. Improved number of leaves and leaf area index could be attributed to improved nutrient uptake and improved photosynthetic rate of plants (Balakrishna *et al.*, 2005) [2]. It is proven fact that adequate supply of nitrogen promotes vegetative growth and helps to retain leaves for a longer time (Tisdale *et al.*, 1995) [23]. Raina *et al.* (2011) [16] reported that increased number of successive leaf production might be better utilization, higher uptake of plant nutrients and excellent maintenance of soil, water and air continuum with higher oxygen concentration in the root zone adequate supply of fertilizers at appropriate growth stages through fertigation and also it enhances the better sprouting of lateral buds on the rhizome. The enhanced growth promotion might also be in addition to *Bacillus, Pseudomonas* and Azospirillum have direct role on the ability to produce various compounds including phtohormones, organic acids, siderophores, fixation of atmospheric nitrogen, phosphate solubilization, antibiotics and some other unidentified mechanisms Glick and Ibid (1995) [3]. The results are in line with the findings of Kavino *et al.* (2010) [6], Akila *et al.* (2011) [1] and Selvaraj *et al.* (2014) [17] in banana.

Effect of biofertigation on yield and yield attributes of banana

In any crop production practices the yield could be the result of various growth and yield attributing traits. Yield in banana is a function of bunch weight and number of plants per hectare. Figure1 showed that the bunch weight, number of hands per bunch, number of fingers per bunch, finger weight,

finger length and pulp weight were significantly affected by different treatments. It was due to the effect of continuous and immediate supply of N to banana crop which would have favored better differentiation of fruit bud with more number of hands and fingers. The highest bunch weight was recorded in treatment T_2 (13.75 kg/plant) which received 100 % RDF along with bioinoculants through fertigation followed by the treatment T_1 (13.59 kg/plant). The RDF might have first improved the internal nutritive condition of plant leading to increased growth and vigour associated with photosynthesis by which the applied nutrients accelerated mobility of photosynthates from source to sink as influenced by the growth hormones and finally translocation of assimilates into the fruits (Sharma *et al.*, 2013) [19].

The way in which increase in yield occurred might be due to greater plant height resulting in higher number of leaves per plant, leaf area, leaf area index and photosynthetic rate. The resultant higher accumulation of photosynthates may be responsible for greater yield because of more preferential influx of photosynthates to the sink. The current findings are in agreement with the earlier observation of Lalramthara (2001) [8] in turmeric. Further, increase in growth of bio inoculated plants leads to high potential for active photosynthesis. The high rate of photosynthesis by bio inoculated plants may be evoked by number of changes such as increase in plant hormones, stomatal opening, enhanced ion transport and regulation of chlorophyll level (Senthilkumar *et al.*, 2014) [17]. Further increased uptake of N, P, K, Cu, Mn, Fe and Zn might have been contributed to production of more number of leaves and more leaf area, thereby higher photosynthetic capacity during reproductive phase and translocation of carbohydrates from other plant parts to reproductive parts, which had resulted in increased yield and yield attributes. The results are in concordance with those obtained by Kavino *et al*. (2010) [6], Akila *et al.* (2011) [1] and Wang *et al* (2016) [25].

The highest number of hands and fingers per bunch were recorded in plots fertilized with 100 % RDF along with bioinoculants. It was due to the effect of continuous and immediate supply of N to banana crop which would have favored better differentiation of fruit bud with more number of hands and fingers. Similar to the results of present study, Suganthi (2002) [21] also reported that application of higher dose of nutrients resulted in more number of fingers per bunch due to the effect of nutrients especially N & K fed at an appropriate stages of growth of crop namely vegetative, flower initiation and differentiation phases favoring the development of more number of fingers per bunch and such view was also shared by Mahalakshmi (2002) [10], who indicated that differences in nutrient level did not influence the number of hands but affected the number of fingers produced.

A perusal of average finger and pulp weight revealed superior performance of the treatment T_1 followed by the treatment T_2. The increased weight of bunch with 100 % RDF along with bioinoculants might have first improved the internal nutritive condition of plant leading to increased growth and vigour associated with photosynthesis and finally translocation of assimilates into the fruits. Such assumption gains support from the findings of several workers like Magge (1963) [9] in apples and Hansen (1969) [5] in strawberry who reported increased rate of translocation of photosynthetic products from leaves to developing fruits increased fruit weight. The increase in fruit weight with the increasing nitrogen application was also reported by Neuweiler and Anuman (1996) [13] in strawberry and this also lends support to the findings of present study. It is well known that efficiency of bio-agents can be well exploited with the use of recommended dose of fertilizers which might have improved the yield parameters through better availability and uptake of nutrients from plant roots and enhancing the source sink relationship and thereby increasing the movement of carbohydrates from the leaves to the fruits.

Table 1: Effect of biofertigation on growth characters in banana cv. Ney Poovan

Treatments	Pseudostem height (cm)	Pseudostem girth (cm)	Number of leaves	Leaf area index	Phyllochron (days)	Sucker production (Numbers)	Crop duration (Days)
T_1	252.45	56.61	15.45	2.39	11.74	7.85	352.29
T_2	256.23	55.98	15.94	2.25	12.68	7.23	341.50
T_3	247.93	52.47	14.88	2.22	11.96	7.18	346.75
T_4	235.02	51.27	14.38	2.07	12.75	6.74	366.98
T_5	238.71	52.38	14.33	1.87	13.45	7.35	368.04
T_6	232.91	51.07	13.98	2.21	13.14	7.18	374.84
T_7	245.57	53.23	15.11	2.13	12.29	7.21	378.30
T_8	255.10	54.44	14.84	2.01	12.33	7.37	364.57
T_9	231.28	53.12	15.12	2.15	13.02	7.49	375.74
SEd	2.77	1.00	0.29	0.03	0.27	0.10	5.90
CD (0.05)	5.87	2.13	0.63	0.06	0.58	0.23	12.50

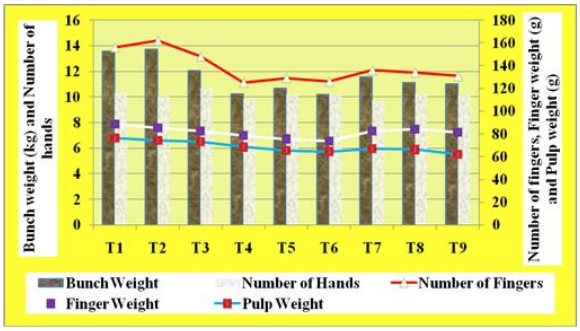

Fig 1: Effect of biofertigation on yield and yield attributes in banana *cv.* Ney Poovan

Conclusion

Most of banana growers are migrating from flood irrigation to fertigation to get maximum yield. This study demonstrated that use of liquid formulations of bioinoculants along with commercial fertilizers through fertigation enhanced the growth and yield of banana rather than soil application and reduced ill effects on soil fertility by the increased nutrient uptake from soil through the application of *Pseudomonas fluorescens, Bacillus subtilis, Azospirillum* and AM fungi.

Acknowledgement
The authors are highly grateful to Department of Fruit Crops, Horticulture College and Research Institute, Tamil Nadu Agricultural University, Coimbatore for providing the financial support and necessary facilities for conducting the experiments.

References

1. Akila R, Rajendran L, Harish S, Saveetha K, Raguchander T Samiyappan R. Combined application of botanical formulations and biocontrol agents for the management of *Fusarium oxysporum* f. sp. *cubense* (Foc) causing *Fusarium* wilt in banana. Biological Control. 2011; 57:175-183.
2. Balakrishna HT, Swamy GSK, Sabared AT, Patil PB, Patil CP, Athani SI. Response of *Glomus fasiculatum*, Vermiculture and *Trichoderma harzianum* for yield and yield attributes on banana ratoon crop. The Karnataka Journal of Horticulture. 2005; 1(4):63-70.
3. Glick B, Ibid R. Genotyping of antifungal compounds producing PGPR *Pseudomonas*. Canadian Journal of Microbiology. 1995; 41:107-109.
4. Gottreich M, Bradu D, Halovy Y. A simple method for determining average banana fruit weight. Ktavim. 1964; 14:161-162.
5. Hansen P, The influence of season of storage and mobilization of levelled compounds. Plant Physiology. 1969; 20:720-725.
6. Kavino M, Harish S, Kumar N, Saravanakumar D, Samiyappan R. Effect of chitinolytic PGPR on growth, yield and physiological attributes of banana (Musa spp.) under field conditions. Applied Soil Ecology. 2010; 45:71-77.
7. Lahav E, Turner DW. Banana nutrition. International Potash Institute Bulletin. 1983; 7:33.
8. Lalramthara C, Maiti S, Nakro T, Singh VB. Comparative studies of farmyard manure and pig manure under terrace condition of Nagaland of ginger cv. Nagaland local in respect to yield and quality. Journal of International Academicia. 2001; 5(2):176-179.
9. Magge DH. The reduction in growth in apple trees brought about by fruiting. Journal of Horticultural Sciences. 1952; 338:119- 125.
10. Mahalakshmi, M. Studies on standardization of optimum dose and time of potassium application in banana *cv.* Rasthali (AAB). M.Sc. (Hort.) Thesis, Tamil Nadu Agricultural University, Coimbatore, 2002.
11. Mahalakshmi M, Kumar N, Jayakumar P, Soorianathasundaram K. Fertigation studies in banana under normal system of planting. South Indian Horticulture. 2001; 49:80-85.
12. Nanda RS, Fertigation to enhance farm productivity. Indian Journal Fertilizers. 2010; 6(2):13-16.
13. Neuweiler RW, Anuman DT. New ways in fertigation and soil management of strawberries. Obst-ad Weinbau, 1996; 132(19):496-499.
14. Pandey SD, Jayabaskaran KJ, Laxman RH, Santhi VP, Panse VG, Mustaffa MM. Effect of irrigation, N fertigation and planting geometry on growth and yield of banana cv. Nendran. South Indian Horticulture. 2001; 49:76-79.
15. Prabhuram, R. Effect of organic manures and urea on the growth and development of banana *cv.* Rasthali and changes in the soil ecosystem. M.Sc. (Hort.) Thesis, Tamil Nadu Agricultural University, Coimbatore, 1992.
16. Raina JN, Sharma T, Suman S. Effect of drip fertigation with different fertilizers on nutrient distribution in soil, leaf nutrient content and yield of Apricot (*Prunus armeniaca* L.). Journal of Indian Society of Soil Science. 2011; 59:268-277.
17. Selvaraj S, Ganeshamoorthi P, Anand T, Raguchander T, Seenivasan N, Samiyappan R. Evaluation of a liquid formulation of *Pseudomonas fluorescens* against *Fusarium oxysporum* f. sp. *cubense* and *Helicotylenchus multicinctus* in banana plantation. Biocontrol, 2014; 59:345-355.
18. Senthilkumar M, Ganesh S, Srinivas K, Panneerselvam P. Influence of Fertigation and consortium of biofertilizer on photosynthesis, chlorophyll content, yield parameters and yield of banana cv. Robusta (AAA). Plant Archives, 2014; 14(1):387-391.
19. Sharma A, Wali VK, Bakshi P and A. Jasrotia A. Effect of organic and inorganic fertilizers on quality and shelf life of guava (*Psidium guajava* L.) cv. Sardar. Bioscan. 2013; 8(4):1247-1250.
20. Srinivas K. Growth, yield, and quality of banana in relation to N fertigation. Tropical Agriculture, 1997; 74(4):260-264.
21. Suganthi, L. Fertigation management studies in banana cv. Red Banana (AAA) under different planting densities M.Sc. (Hort.) Thesis. Tamil Nadu Agricultural University. Coimbatore, 2002.
22. Summerville, W.A.T. Studies on nutrition as qualified by development in *Musa Cavindishii* (L). Queensland Journal of Agricultural Sciences. 1994; 1:1-27.
23. Tisdale SL, Nelson WL, Beaton WL, Havlin JL. Soil fertility and fertilizers. 5, Prentice Hall of India Private Limited, New Delhi, 1995; 638.
24. Upadhyay. Effect of NP, K fertilizers on growth, yield and quality of banana (*Musa cavindish* L.) variety Harichal. Progressive Horticulture. 1988; 20:257-262.
25. Wang Beibei, Shen Zongzhuan, Zhang Fengge, Waseem Raza, Yuan Jun, Huang Rong *et al*. *Bacillus amyloliquefaciens* Strain W19 can Promote Growth and Yield and Suppress *Fusarium* Wilt in Banana Under Greenhouse and Field Conditions. Pedosphere. 2016; 26 (5):733-744.
26. Watson DJ. The physiological basis of variation in field. Advances in Agronomy. 1952; 4:101-14.