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INFLUENCE OF FERTIGATION AND CONSORTIUM OF BIOFERTILIZER ON PHOTOSYNTHESIS, CHLOROPHYLL CONTENT, YIELD PARAMETERS AND YIELD OF BANANA CV. ROBUSTA (AAA)

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Abstract

A study was undertaken to know the combined effects of fertigation and consortium of bio-fertilizers on photosynthetic rate, chlorophyll content, yield attributing characters and yield of banana cv Robusta (AAA) at Indian Institute of Horticultural Research, Bangalore in the year 2010. From the results, it was observed that the treatment of 100% recommended dose of fertilizers through fertigation (RDFTF) with 300 g of consortium of biofertilizers (CBF) recorded significantly higher photosynthesis rate, total chlorophyll content, yield attributing characters such as number of leaves, fruit length, circumference, fruit weight, bunch weight compared to 100% recommended dose of fertilizers applied through soil (RDFTS). The treatment of 100% RDFTF with 100,200 & 300 g of CBF have recorded 40 to 48% higher yield than the plants applied with 100% RDF through soil. Besides, the fertigation treatment of 75% RDF and CBF combinations yielded on par with 100 % RDFTF and CBF combinations and also 36 to 43% significantly higher yield than 100 %RDFTS. Similarly 50% RDFTF with CBF combinations have recorded 18 to 21 % increased yield than the soil application of 100% RDF.

Key words : Banana, drip irrigation, fertigation, PGPR, Biofertilizers, AM fungi.

Introduction

Banana (*Musa* spp) is one of the ancient fruits of the world and known as "Apple of the paradise". It is the cheapest and plentiful fruit. India is the largest producer of banana in the world contributing 27 per cent to the global production of banana, with a total production of 284 lakh tonnes from an area of 7.97 lakh ha (Anon, 2012). Among the desert bananas, Robusta (AAA) assumes much importance in the international trade. In general Banana, a nutrient lover, requires large quantity of nutrients for its growth and development. It requires large amount of nitrogen and potassium nutrients constituting a considerable part of input cost. In recent times bio-fertilizers have emerged as potential nutrient suppliers or mobilizers in various horticultural crops. Where as, to derive the maximum benefit of individual biofertilizers, the consortium of bio-fertilizers (combination of two or more biofertilizers) is being tried world wide. The beneficial effects of biofertilizers have been widely reported in banana (Tiwary *et al*., 1998 and Mohandas, 1996). However, exclusive studies on the beneficial effects of consortium of biofertilizers in banana when combined with fertigation are very meagre. Therefore, an experiment was conducted by combining consortium of biofertilizers with fertigation and the effects were studied on the photosynthetic activity, chlorophyll content, yield parameters and yield in banana cv Robusta (AAA).

Materials and Methods

The study was conducted at the Indian Institute of Horticultural Research; Bangalore, situated at 13° 58' N and 78°E at an altitude of 890 meters. The soil was acidic in reaction and free from excessive salts with organic carbon content of around 0.92%. It was having a total nitrogen of 160 kg ha^{-1} and the phosphorus, potassium contents were around of 22 and 232 kg ha^{-1} respectively. The soil was tested for the initial level of microbial population (*Azospirillum*-OAS to 0.22 x 10^4 cfu g^{-1} of soil, PSB-0.24 to 0.28 x 10^4 cfu g^{-1} of soil and AM fungi 4.3 to 5.2 spores g^{-1} of soil).

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The planting material of banana Musa AAA, Cavendish sub group cv Robusta consisted, of healthy suckers weighing about 0.80 to 1.0 kg each were planted during the first week of January-2010 at a spacing of 1.5 x 1.5 m (4444 plants ha^{-1}) and the ratoon crop was continued in the year 2011. Single super phosphate, as per the treatment was applied in the pit itself before planting as a single dose. After fifteen days, the consortium of biofertilizers having Azospirillum, phosphate solubilising bacteria and AM fungi in equal proportion was incorporated. Three levels of fertigation 100% Recommended Dose of Fertilizer (RDF) (200 g N, 110 g P and 200 g K $plant^{-1}crop^{-1}$), 75% RDF and 50% RDF and three levels (100, 200, 300 g $plant^{-1}$ $crop^{-1}$) of consortium of biofertilizers (CBF) were combined along with soil application of recommended dose of fertilizers, apart from one treatment with 15 kg of Farm Yard Manure and 300 g of consortium of biofertilizers $plant^{-1}$. These 12 treatment combinations were replicated thrice in a randomized block design. Nitrogen was applied in the form of calcium ammonium nitrate and Potassium as muriate of potash respectively. The fertigation was started from 60^{th} day of planting and given at weekly intervals up to 320 days. (Reddy *et al.*, 2002). Irrigation was given on daily basis replenishing 80% of evaporation losses (Hegde and Srinivas, 1991). Any rain, which fell, was deducted from the evaporation but rain in excess of evaporation was disregarded. Two emitters were placed for each plant at equal distance of 30 cm from the pseudo stem with a discharge rate of 8 litre of water/ hour. All the suckers were removed periodically until flowering and one sword sucker per plant was retained for the ratoon crop.

The total number of functional leaves produced at maturity was recorded and expressed in number. Finger length was measured from the base of the pedicle to the tip of the fruit along the convex side and expressed in centimetres. The circumference at mid position of the representative fingers was measured using a Vernier calipers and expressed in centimetres. Ten fruits selected randomly were weighed and the average fruit weight was recorded. Weight of the bunch was recorded including the peduncle measuring 20 cm from the first hand and expressed in kilograms. The total number of fingers per bunch were counted and expressed in number.

The photosynthetic rate of the plants was measured at six months after planting and at the time of active flowering stage using LICOR portable photosynthetic meter. In each plant the third functional leaf was chosen for measurements (Eckstein and Robinson, 1995). Fresh leaf sample was taken from each replication at 180 days after planting and at flowering and chlorophyll a and Chlorophyll b were estimated by following the method of Hiscox and Isrealstam (1979). The total chlorophyll content was arrived by adding the values of chlorophyll a and b. The data were analyzed using Web Agri Stat Package version WASP 1.0. The data were subjected to one way analysis of variance (ANOVA). Treatment difference was evaluated using least significant difference (LSD) at $p \geq 0.05$.

Results and Discussion

Photosynthesis

At 180 days after planting, the treatment of 100% recommended dose of fertilizers through fertigation (RDFTF) with 300 g of consortium of biofertilizers (CBF) recorded significantly higher photosynthetic rate (table 1) compared to 100% recommended dose of fertilizers through soil (RDFTS). At grand flowering stage also similar trend was observed. This indicates the active role of microbes in substituting the required nutrients to the plants there by the plants applied with consortium of biofertilizers with fertigation have differed significantly in fixation of Photosynthesis. This also showed that the applied N,P,K were utilized efficiently by the plants which resulted in producing maximum photosynthesis (Nalina *et al*., 2009) in the plants. The higher N incorporation by bacterial N_2 fixation of PGPR might also have apparently increased the formation of protein and enzyme for better physiological activities. The higher N also might have contributed to the formation of chlorophyll, which consequently, increased the photosynthetic activity (Mia *et al.*, 2005). Both at six month after planting and flowering stages, the plants treated with the farm yard manure (FYM) with 300 g of CBF recorded the lowest photosynthetic rates.

Chlorophyll content

In the present study, the chlorophyll a, b and total chlorophyll content estimated at six months after planting and shooting differed significantly among the treatments (table 1). The plants applied with 100% RDFTF and 300 g of CBF recorded significantly higher chlorophyll content compared to other treatments but on par with 75% RDF and CBF combinations. It was also observed that the treatments of 75% and 50% RDFTF with CBF combinations too have recorded significantly higher chlorophyll content at flowering than the 100% recommended dose of fertilizers through soil (RDFJS). Accumulation of more chlorophyll even at reduced rate of in organic fertilizers might me due to the synergetic effect of consortium which facilitated better uptake of

Table 1 : Effect of fertigation and consortium of biofertilizers on chlorophyll content and photosynthesis in Banana cv Robusta (AAA).

Treatment	Chlorophyll a (mg g^{-1})		Chlorophyll b (mg g^{-1})		Total Chlorophyll (mg g^{-1})		Photosynthetic rate (µ mol$CO_2m^{-2}s^{-1}$)	
	6MAP	Shooting	6MAP	Shooting	6 MAP	Shooting	6MAP	Shooting
T_1:FYM+ 300 g CBF	0.620	0.770	0.410	0.483	1.03	1.25	12.800	9.450
T_2:100 %RDFTF+100 g CBF	0.917	1.190	0.583	0.750	1.50	1.94	19.433	13.020
T_3:100%RDFTF+ 200 g CBF	0.887	1.217	0.593	0.743	1.48	1.96	19.520	13.390
T_4:100%RDFTF+ 300 g CBF	0.923	1.223	0.617	0.757	1.54	1.98	20.740	13.810
T_5:75%RDFTF+100 g CBF	0.870	1.123	0.540	0.737	1.41	1.86	17.460	12.100
T_6:75%RDFTF+ 200 g CBF	0.900	1.150	0.550	0.770	1.45	1.92	17.800	12.190
T_7:75%RDFTF+ 300 g CBF'	0.907	1,123	0.573	0.767	1.48	1.89	17.490	13.130
T_8:50%RDFTF+ 100 g CBF	0.767	0.897	0.490	0.613	1.26	1.51	14.190	10.340
T_9:50%RDFTF+ 200 g CBF	0.807	0.883	0.493	0.647	1.30	1.53	14.840	10.560
T_{10}:50%RDFTF+ 300 g CBF	0.830	0.933	0.480	0.647	1.31	1.58	14.650	10.630
T_{11}:l00°/oRDFTF	0.810	0.913	0.541	0.587	1.35	1.50	16.650	11.750
T_{12}:100% RDF(soil application)	0.700	0.823	0.411	0.507	1.11	1.33	15.270	10.450
S.Em.±	**0.04**	**0.05**	**0.03**	**0.03**	**0.07**	**0.08**	**0.82**	**0.58**
CD(p ≥ 0.05)	**0.12**	**0.15**	**0.07**	**0.10**	**0.19**	**0.24**	**2.40**	**1.70**

FYM-Farm yard manure, RDFTF-Recommended dose of fertilizer through fertigation, CBF-Consortium of biofertilizers, MAP-Months after planting.

N, P and K by the plant resulted in higher accumulation of chlorophyll content. Similar results were observed by Abo El-Ez and Hussein (2003) in banana in a nutrient trail involving VAM. This was in conformity with Mia et al. (2010) who observed that inoculation of PGPR bacteria significantly increased plant height (42-50%), leaf area (128-134%), leaf chlorophyll content (25- 33%) and total dry matter (TDM) (129-176%) in biofertilizer applied plants compared to un inoculated plants in banana. Sarig *et al*. (1988) further suggested that the incorporation of PGPR results in growth promoting effects mainly derived from morphological and physiological changes in roots and enhancement in water and plant nutrient uptake.

Yield parameters and yield

The yield attributing characters such as number of leaves, fruit length, circumference and fruit weight were significantly higher in plants treated with the combination of 100% RDFTF and 300 g of CBF compared to plants applied with 100% RDFTS. Similar trend was observed in the case of fruit length and girth. Where as, the number of fruits was observed to be high in plants treated with 100 % RDFTF and 100 g of CBF. Wange and Patil (1994) found that combined application of Azospirillum, Azotobacter and inorganic nitrogen fertilizer resulted in taller plants, number of leaves and girth, in bananas compared to un-inoculated control. Like wise, Kumar and Shanmugavelu (1988) reported that both soil and foliar application of nitrogen and in combination with Azotobacter increased the plant height, plant girth, number of hands, bunch and number of finger/ hands significantly in banana cv. Robusta. Dobbelarere *et al*., (1999) too suggested that secretions of plant growth promoting substances such as auxins, gibberellins and cytokinins by the bacteria seem to be responsible for these beneficial effects in plants inoculated with consortium of biofertilizers. The increased growth of PGPR inoculated plants might also be due to the higher N accumulation by bacterial N_2 fixation and better root growth, which in turn would have promoted the greater uptake of water and nutrients (Mia *et al*., 2005).

In general, the combined application of consortium of biofertilizer and inorganic fertilizers through fertigation has resulted around. 18 to 48 % increased yield than the 100% RDF applied through soil. Farm yard manure applied in combination with 300 g of CBF did not influence the yield increase of banana. Much scientific evidence indicated that AM fungi have significant importance owing to their ability to supplement requirement of fertilizers, phosphorus and nitrogen and improve crop productivity in many crop plants. Singh *et al.* (2003) reported that the combination of inorganic fertilizers with AM fungi showed yield optimization in banana, this finding also revealed

Table 2 : Effect of fertigation and consortium of biofertilizers on yield parameters and yield in Banana cv Robusta (AAA).

Treatments	Leaves at maturity (No.)	Average fruit length (cm)	Average fruit circumference (cm)	Average fruit weight (g)	Fruits bunch^{-1} (No.)	Average bunch weight (kg)	Yield ha^{-1} (MT)
T_1:FYM+ 300 g CBF	7.00	18.00	11.21	195.16	62.00	12.10	53.77
T_2:100 %RDFTF+100 g CBF	8.95	22.60	13.36	249.06	98.69	24.58	109.23
T_3:100%RDFTF+ 200 g CBF	8.95	24.25	13.75	250.89	97.54	24.93	110.92
T_4:100%RDFTF+ 300 g CBF	9.27	24.75	14.67	260.84	97.54	25.93	115.23
T_5:75%RDFTF+100 g CBF	8.09	22.52	13.64	249.00	95.92	23.87	106.08
T_6:75%RDFTF+ 200 g CBF	8.65	23.02	14.44	249.90	93.36	24.25	107.77
T_7:75%RDFTF+ 300 g CBF	8.83	23.21	14.50	257.75	94.63	24.86	111.89
T_8:50%RDFTF+ 100 g CBF	8.60	20.30	12.13	222.12	90.04	20.72	92.07
T_9:50%RDFTF+ 200 g CBF	8.96	20.88	12.40	227.27	91.40	21.15	93.99
T_{10}:50%RDFTF+ 300 g CBF	9.50	21.40	12.28	230.13	91.82	21.45	94.54
T_{11}:100%RDFTF	7.07	21.57	13.17	246.00	93.60	23.00	101.06
T_{12}:100% RDF(Soil application)	7.00	19.10	11.78	230.64	78.90	17.50	77.77
SEm±	**0.40**	**1.06**	**0.64**	**11.57**	**4.28**	**1.06**	**4.72**
CD($p \geq 0.05$)	**1.17**	**3.10**	**1.87**	**33.94**	**12.56**	**3.10**	**13.85**

FYM-Farm yard manure, RDFTF-Recommended dose of fertilizer through fertigation, CBF-Consortium of biofertilizers, MAP-Months after planting.

that optimum banana yield can be obtained with 50 % saving of phosphorus fertilizer.

Among the treatments, 100 % RDFTF with 300 g of CBF has resulted in significantly higher bunch weight and yield ha^{-1}. But the difference was not marked between the treatments of 75% and 100% RDFTF with CBF combinations. Similarly, the plants given 50% RDFTF and CBF yielded on par with plants applied 75% RDFTF and CBF. The yield obtained at 50% RDFTF with CBF was also significantly higher than the plants applied with 100% RDF through soil (table 2). This also demonstrates the effective role of consortium of biofertlizers in increasing the input use efficiency. Increased fertilizer use efficiency and compensation of nutrient requirement might also be due to the interactions of plant roots with microbes making the nutrients available, there by the requirement of nutrients is compensated at the level of half of the recommended dose. Present findings also supported the conclusions of Harinikumari and Bagyaraj (1998) that application of half of the recommended level of chemical fertilizers together with soil conditioners (organic matter) favoured the build up of native VAM population in subtropical soils. Therefore, their active association with roots might have afforded more uptake of moisture, increased percent of water and nutrients. Tiwary *et al*. (1998) also reported that inoculation of biofertilizers with various combinations of inorganic fertilizers had increased the yield of banana by 18-84 % over the control and the response was more pronounced when the dose of N was reduced to half.

Conclusion

The present findings have clearly revealed that the combined application of fertigation and consortium of biofertilizers significantly enhanced the photosynthesis rate, chlorophyll content, yield attributing characters and yield of banana in general compared to un-inoculated plants. Fertigation with 100% recommended dose of fertilizers along with consortium of biofertilizers recorded significantly higher yield compared to 100% RDF applied through soil. The yield differences was not marked between 100% and 75% recommended doses of fertilizers through fertigation combined with consortium of biofertilizers. Similarly 50% RDF through fertigation with CBF yielded significantly higher than the 100% RDF applied through soil, widening the scope of obtaining optimum yield in banana even at considerably reduced level of inorganic fertilizers through fertigation combined with consortium of biofertilizers in the near future.

References

Abo El-Ez, A. T. and A. M. Hussein (2003). Response of inoculated and un inoculated Williams banana (*Musa* sp.) cv. *in vitro* plants with endomycorrhizal to mineral nutrients II. Effects of different levels of nitrogen and potassium on chemical composition. *Assiut J. Agri. Sci.*, **34** : 49-66.

Anonymous (2012). Indian horticulture data base. Pub:National Horticulture Board, India.

Dobbelarere, S., A. Cronnenborgh, A. Thys, A. Vande Broek and J. Vanderleyden (1999). Phytostimulatory effects of *Azospirillum brasilense* wild type and mutant strains altered in IAA production on wheat. *Plant Soil.,* **212** : 155-164.

Eckstein, K. and J. C. Robinson (1995). Physiological response of Banana(Musa AAA) Cavendish sub group) in the the sub tropics.I Influence of internal plant factors on gas exchange of banana leaves. *J. Hort. Sci*.,**70** : 147-156.

Harinikumari, K. M. and D. J. Bagyaraj (1998). In : A Praksah (Ed) Fungi in biotechnology pp 65-70. New Delhi, India:CBS.

Hedge, D. M. and K. Srinivas (1991). Growth, yield, nutrient uptake and water use of banana crops under drip and basin irrigation with N and K fertilization. *Trop. Agric*., **68(4)** : 331-334.

Hiscox, J. D. and Isrealstam (1979). A method for the extraction of chlorophyll from leaf tissue without maceration. *Can. J. Bot*, **57** : 1332-1334.

Kumar Ashok, A. and K. G. Shanmugavelu (1988). *Banana Newsl*. **11** : 11-12.

Mia, M. A. B., Z. H. Shamsuddin, W. Zakaria and M. Marziah (2005). High-yieJding and quality banana production through plant growth promoting rhizobacterial inoculation. *Fruits*, **60** : 179-185.

Mia, M. A. B., Z. H. Shamsuddin, Z. Wahab and M. Marziah (2010). Effect of plant growth promoting rhizobacterial (PGPR) inoculation on growth and nitrogen incorporation of tissue-cultured Musa plantlets under nitrogen-free hydroponics condition. *Australian Journal of Crop Science*, **4(2)** : 85-90.

Mohandas, S. (1996). Biofetilizer in banana cultivation. abstracted in the "Conference of Banana production and utilization in 21st Century held at NRC on Banana, Trichy. Sept. 24-25, 1996 pp 33-38.

Nalina, L., N. Kumar, K. Soorianathasundharam and P. Jeyakumar (2009). Effect of different nutrient levels on growth and development of tissue cultured banana cv Robusta(AAA). *Indian J. Hort*., **66** : 169-174.

Reddy, B. M. C., K. Srinivas, P. Padma and H. B. Ragupathi (2002). Response of Robusta banana to N and K fertigation. *Indian J. Hort.,* **59** : 342-348.

Sarig, S., A. Blum and Y. Okon (1988). Improvement of water status and yield of field-grown grain sorghum (*Sorghum bicolor*) by inoculation with *Azospirillum brasilense*. *J. Agric Sci*., **110** : 271.

Singh, A., S. P. Singh and A. K. Yadav (2003). Use of 'VAM' Bio-fertilizer In Sustainable Banana Production. Extending the Benefits of Technology for All. 07-09 January 2003 Eds. Basavaprabhu Jirli Editor in Chief, Diapk De, K. Ghadei and Kendadmath, G.C., Department of Extension Education, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, (India).

Tiwary, D. K., Md. Abu Hasan and Chattopadhyay (1998). Studies on the effect of inoculation with azotobacter and azospirillum on growth, yield and quality of banana. *Indian Agric.*, **42(4)** : 235-240.

Wange, S. S. and P. I. Patil (1994). Effect of combined inoculation of Azotobacter, Azospirillum with chemical nitrogen on Basarai banana. *Madras Agric. J*., **81** : 163-165.