

Original Research Article

<https://doi.org/10.20546/ijcmas.2017.612.296>

Studies on Integrated Nutrient Management (INM) Practices on Soil Characteristics and Yield in Tissue Culture Banana cv. Grand Naine (AAA)

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ABSTRACT

A field study was undertaken at College of Horticulture, Anantharajupet during the years 2012 – 2013 to investigate the possible effects of different INM treatments on soil nutrient contents before planting and harvest, number of leaves emerged and yield and its attributes. The results revealed available nitrogen content in the experimental plots even before planting of the experiment was significantly differed and recorded higher available nitrogen content (215.39) in the plot allotted for 80 % RDF (inorganic) + 20 % RDN (FYM) along with *Azospirillum* + Phosphate solubilizing bacteria (PSB) + *Fratureuria aurantia* (FA). Before planting of the experiment, available phosphorus content in the soil was significantly altered and significantly higher available phosphorus content in the soil was registered in the plot allotted for 100 % RDF (inorganic). Available potassium content in the soil was significantly affected before planting of the experiment and significantly higher available potassium content in the soil was recorded in the plot allotted for 80 % RDF (inorganic) + 20 % RDN (FYM) + FA (450.83 kg ha⁻¹). Significantly higher available potassium content in the soil was registered in the 80 % RDF (inorganic) + 20 % RDN (VC) + *Azospirillum*, PSB and FA (276.51 kg ha⁻¹) treatment plot. At 5 MAP, plants supplied with 80 % RDF (inorganic) + 20 % RDN (FYM) along with *Azospirillum*, PSB and FA have put forth significantly maximum number of leaves (29.6). Application of 80 % RDF (inorganic) + 20 % RDN (FYM) along with *Azospirillum*, PSB and FA has resulted in production of maximum leaves at shooting (37.8). Significantly maximum number of hands bunch⁻¹ (10.75) was obtained with application of 80% RDF + 20% RDN through FYM + *Azospirillum*, PSB and FA and it was at par with application of 80% RDF + 20% RDN through VC + *Azospirillum*, PSB and FA and 80% RDF + 20% RDN through FYM + FA. Application of 80% RDF + 20% RDN through FYM + *Azospirillum*, PSB and FA has recorded significantly higher number of fruits bunch⁻¹ (156.50) and it was on a par with application of 80% RDF + 20% RDN through FYM and 80% RDF + 20% RDN through VC + *Azospirillum*, PSB and FA. Significantly highest bunch weight (24.53 kg) was recorded with application of 80% RDF + 20% RDN through FYM + *Azospirillum*, PSB and FA and it was on a par with application of 80% RDF + 20% RDN through VC + *Azospirillum*, PSB and FA and 80% RDF + 20% RDN through VC + FA

Keywords

INM, Tissue culture, Banana and Grand Naine.

Article Info

Accepted:

19 October 2017

Available Online:

10 December 2017

Introduction

By nature, banana is a heavy consumer of nutrients and requires large quantities of nutrients for its growth, development and yield (Hazarika and Ansari, 2010). The requirements of these nutrients are generally supplied by inorganic fertilizers. But this often results in extremes situations for the soil, crop and climate involved. The soil has lost its biological dynamic owing to repeated and indiscriminate use of chemical fertilizer.

Chemical fertilizers have some deleterious effects on fruit quality besides adverse effects on soil, water and environmental conditions (Dutta *et al.*, 2010). On the other hand, organic and microbial sources of nutrients have advantage of consistent and slow release of nutrients, maintaining ideal C: N ratio, improving water holding capacity and microbial biomass of soil profile, without any adverse residual effects (Yadav *et al.*, 2010). It is estimated that 50 tonnes of banana in one hectare removes 320kg N, 32kg P₂O₅ and 925kg K₂O every year (Lahav and Turner, 1983). Application of inorganic fertilizers though increases the yield substantially but could not able to sustain the fertility status of the soil (Bharadwaj and Omanwar, 1994) and have caused several undesirable consequences in the fragile eco-system, leading to gradual decline in productivity. Considering the present situation of soil quality and environmental security, it is necessary to go for an integrated nutrient management, involving various sources of organic manures and biofertilizers besides using chemical fertilizers in banana. Integrated nutrient management in banana are being practiced and experimented in various parts of India.

The utility of microbes in maintenance and built up of soil fertility, thereby, enhancing plant growth and yield is indispensable (Marathe *et al.*, 2011). Although chemical

fertilizers contribute a lot in fulfilling the nutrient requirement but their regular, excessive and unbalanced use may lead to health and ecological hazards, depletion of physico-chemical properties of the soil and ultimately poor crop yields (Singh and Singh, 2009). Hence, there is an urgent need to think of alternate source of safe fertilizers which may enhance crop yields without having adverse effects on soil properties. Thus, the use of biofertilizers seems to be array of hope in this direction. Biofertilizers have been considered cheap, eco-friendly way of improving soil fertility status. Biofertilizers like *Azospirillum* have also been found to promote synthesis of growth promoting substances like auxins, gibberellins, and cytokinins (Awasthi *et al.*, 1998). N – fixing bacteria possess unique potential of fixing atmospheric nitrogen either by living symbiotically or non – symbiotically or to transform native soil nutrients, from non – usable form to usable form through biological process (Marwaha, 1995).

The organic manures and biofertilizers help in better utilization of added inorganic fertilizers thus reduce its level of application as well as reduce the deleterious effect of harsh chemical residues that the inorganic fertilizers leave in the soil (Umar, 2007). A judicious use of organic manures and biofertilizers may be effective not only in sustaining crop productivity and in soil health, but also in supplementing chemical fertilizers of the crops (Jaipaul *et al.*, 2011). Integrated nutrient management (INM) found to be beneficial for maintenance of soil fertility and plant nutrient supply to an optimum level, for sustaining desired crop productivity through optimization of benefits from all possible sources of plant nutrients in an integrated manner. The basic principle of INM is the maintenance of soil fertility, sustainable agricultural productivity and improving farmers profitability through judicious and

efficient use of chemical fertilizers, organic manure and biofertilizers etc (Bhalerao *et al.*, 2009).

Materials and Methods

The present investigation was carried out during the years 2012 – 13 at College of Horticulture, Anantharajupet which is located at an altitude of 215 meters above mean sea level at 13. 98⁰ North latitude and 79.40⁰ East longitude, respectively. The maximum and minimum temperatures during the experiment were 39.03⁰C and 31.0⁰C and relative humidity during the period of crop growth ranged between 77.0 to 87.0 % respectively. The experiment consisted of eleven treatments which were replicated thrice and the statistical design used was Randomized Block Design (RBD).

The treatments included were T₁ – 100 % Recommended dose of fertilizers (RDF) 300:50:300 g NPK plant⁻¹ crop cycle⁻¹, T₂ – 80 % RDF 240:40:240 g NPK plant⁻¹ crop cycle⁻¹ through inorganic fertilizers + 20 % RDN through vermicompost (VC), T₃ – 80 % RDF through inorganic fertilizers + 20 % RDN through VC + *Azospirillum*, T₄ – 80 % RDF through inorganic fertilizers + 20 % RDN through VC + Phosphate solubilizing bacteria (PSB), T₅ – 80 % RDF through inorganic fertilizers + 20 % RDN through VC + *Frateuria aurantia* (FA), T₆ – 80 % RDF through inorganic fertilizers + 20 % RDN through VC + *Azospirillum* + PSB + FA, T₇ – 80 % RDF through inorganic fertilizers + 20 % RDN (Farmyard manure (FYM), T₈ – 80 % RDF through inorganic fertilizers + 20 % RDN (FYM) + *Azospirillum*, T₉ – 80 % RDF through inorganic fertilizers + 20 % RDN (FYM) + PSB, T₁₀ – 80 % RDF through inorganic fertilizers + 20 % RDN (FYM) + FA and T₁₁ – 80 % RDF through inorganic fertilizers + 20 % RDN (FYM) + *Azospirillum* + PSB + FA.

Calculated quantities of organic manures (Vermicompost @ 4.285 kg plant⁻¹ and Farmyard manure @ 5.309 kg plant⁻¹) along with biofertilizers *viz.*, *Azospirillum* (50 g), Phosphate solubilizing bacteria (50 g) and *Frateuria aurantia* (25 g) were applied directly to the pits prior to planting. Soil samples were collected before planting of banana seedlings and after the plant crop. Soil samples were analyzed for the physico-chemical characters. The data was analyzed as per the method of variance outlined by Panse and Sukhatme (1985). Statistical significance was tested by F value at 5% level of significance. Critical difference at 0.05 levels was worked out for the effects which were significant.

Results and Discussion

Soil nutrient (available) status (kg ha⁻¹)

Nitrogen

Available nitrogen content in the experimental plots even before planting of the experiment was significantly differed and recorded higher available nitrogen content (215.39) in the plot allotted for 80 % RDF (inorganic) + 20 % RDN (FYM) along with *Azospirillum* + PSB +FA (Table 3).

It was observed there is a gradual exhaustion of nutrients (nitrogen) in all the treatmental plots at harvest when compared to the initial fertility status of experimental plots. The depletion of nitrogen was less in the plots that received different INM treatments than the plots that received 100 % RDF through inorganic fertilizers alone. It has been reported that combined use of organic and inorganic nutrient sources may influence the forms and availability of nitrogen through the process of mineralization and also act as store house of nutrients. Similar results were in concurrence with Selvamani and Manivannan

(2009) and Hazarika *et al.*, (2011) in banana cv. Grand Naine.

Phosphorus

Before planting of the experiment, available phosphorus content in the soil was significantly altered and significantly higher available phosphorus content in the soil was registered in the plot allotted for 100 % RDF (inorganic). However, available phosphorus content in the soil did not differ significantly after harvest of the crop (Table 3).

The dynamic changes of available phosphorus in soil before and after the plant crop can be attributed to beneficial influence of inoculated PSB. The organic manures themselves might

have also contributed phosphorus to the nutrient pool. These results were in agreement with the findings of Srivastava (1998).

Potassium

It was conspicuous from Table 3 that available potassium content in the soil was significantly affected before planting of the experiment and significantly higher available potassium content in the soil was recorded in the plot allotted for 80 % RDF (inorganic) + 20 % RDN (FYM) + FA (450.83 kg ha⁻¹). Significantly higher available potassium content in the soil was registered in the 80 % RDF (inorganic) + 20 % RDN (VC) + *Azospirillum*, PSB and FA (276.51 kg ha⁻¹) treatment plot.

Table.1 Nutrient concentrations of organic manures and their quantities used in the investigation

Organic manure	Nurtient concentration (%)			Moisture (%)	Quantity applied (kg plant ⁻¹ crop cycle ⁻¹)
	N	P	K		
Vermicompost	1.40	0.33	0.90	37.2	4.285 kg plant ⁻¹
FYM	1.63	0.28	0.76	25.2	5.309 kg plant ⁻¹

Table.2 Physico – chemical properties of experimental site

A. Chemical composition

Properties	Characterization	Method of analysis
Soil pH	7.58	Glass electrode pH meter model 335 (Jackson, 1973)
Electrical conductivity (dSm ⁻¹)	0.232	Conductivity Bridge ELICO Model EM 88 (Jackson, 1973)
Available Nitrogen (Kg ha ⁻¹)	204.30	Alkaline permanganate method (Subbaiah and Asija, 1956)
Available Phosphorus (P ₂ O ₅) (Kg ha ⁻¹)	18.84	Olsen’s method (Olsen <i>et al.</i> , 1954)
Available potassium (K ₂ O) (Kg ha ⁻¹)	395.0	Neutral normal Ammonium Acetate method using Flame Photometer (Muhr, 1965)

B. Physical composition

Properties	Characterization	Method of analysis
Sand (%)	70	International pipette method (Piper, 1966)
Silt (%)	10	
Clay (%)	20	
Textural class	Sandy loam	

Table.3 Influence of different INM treatments on available soil nutrient status of Experimental plots

Treatments	Available N (Kg ha ⁻¹)		Available P (Kg ha ⁻¹)		Available K (Kg ha ⁻¹)	
	Before planting	After harvest	Before planting	After harvest	Before planting	After harvest
T₁ : 100 % RDF	204.04	166.23	28.35	15.60	369.17	239.36
T₂ : 80 % RDF + 20% RDN through VC	206.07	178.77	19.76	15.19	325.00	210.00
T₃ : T ₂ + <i>Azospirillum</i>	215.38	180.76	20.16	14.59	390.00	260.26
T₄ : T ₂ + PSB	199.88	174.04	23.52	15.98	323.33	260.96
T₅ : T ₂ + FA	209.13	179.34	18.92	15.00	417.50	269.17
T₆ : T ₂ + <i>Azospirillum</i> + PSB + FA	195.97	173.86	19.26	15.00	431.67	276.51
T₇ : 80 % RDF + 20% RDN through + FYM	214.04	181.10	19.59	15.10	379.17	224.32
T₈ : T ₇ + <i>Azospirillum</i>	203.55	182.72	16.46	16.00	390.00	234.08
T₉ : T ₇ + PSB	197.13	165.62	21.48	17.04	369.17	227.35
T₁₀ : T ₇ + FA	204.11	172.50	19.36	14.08	450.83	261.09
T₁₁ : T ₇ + <i>Azospirillum</i> + PSB + FA	198.10	197.74	24.19	16.54	367.50	271.36
Mean	204.30	177.51	21.00	15.46	383.03	248.58
S.Em. (±)	3.47	5.05	1.24	1.25	19.6	8.00
C.D. (P= 0.05)	10.32	15.01	3.70	N.S.	58.31	23.75

RDF: Recommended dose of fertilizers, RDN: Recommended dose of nitrogen, PSB: Phosphate solubilizing bacteria, FA: *Frateuria aurantia*

Table.4 Total number of leaves emerged plant⁻¹ at various stages of crop growth as influenced by different INM practices

Treatments	Total number of leaves emerged plant ⁻¹ crop cycle ⁻¹		
	3 MAP	5 MAP	Shooting
T₁ : 100 % RDF	17.9	26.7	34.7
T₂ : 80 % RDF + 20% RDN through VC	17.2	26.9	35.6
T₃ : T ₂ + <i>Azospirillum</i>	17.7	26.8	36.3
T₄ : T ₂ + PSB	17.8	27.2	34.3
T₅ : T ₂ + FA	18.8	27.6	36.7
T₆ : T ₂ + <i>Azospirillum</i> + PSB + FA	19.3	29.1	36.8
T₇ : 80 % RDF + 20% RDN through + FYM	16.2	26.7	34.1
T₈ : T ₇ + <i>Azospirillum</i>	17.7	28.0	33.8
T₉ : T ₇ + PSB	18.3	27.8	35.3
T₁₀ : T ₇ + FA	18.7	28.0	35.9
T₁₁ : T ₇ + <i>Azospirillum</i> + PSB + FA	20.2	29.6	37.8
Mean	18.16	25.12	35.57
S.Em. (±)	0.73	0.50	0.22
C.D. (P= 0.05)	N.S.	1.49	0.66

RDF: Recommended dose of fertilizers, RDN: Recommended dose of nitrogen, PSB: Phosphate solubilizing bacteria, FA: *Frateuria aurantia*

Table.5 Influence of different INM treatments on yield and its attributes in tissue culture banana cv. Grand Naine

Treatments	No. of hands bunch ⁻¹	No. of fruits bunch ⁻¹	Fruit length (cm)	Fruit girth (cm)	Bunch weight (kg)	Yield (t ha ⁻¹)
T₁ : 100 % RDF	8.91	136.58	21.73	13.16	19.35	53.65
T₂ : 80 % RDF + 20% RDN through VC	9.25	139.16	21.15	13.12	19.80	54.89
T₃ : T ₂ + <i>Azospirillum</i>	9.16	144.58	21.65	13.41	20.91	57.97
T₄ : T ₂ + PSB	9.41	145.41	22.50	13.25	22.00	60.99
T₅ : T ₂ + FA	9.50	144.33	22.25	12.94	23.50	65.15
T₆ : T ₂ + <i>Azospirillum</i> + PSB + FA	10.33	150.08	24.33	14.25	23.92	66.31
T₇ : 80 % RDF + 20% RDN through + FYM	9.16	150.25	23.39	13.87	21.50	59.61
T₈ : T ₇ + <i>Azospirillum</i>	9.25	137.00	22.20	13.34	20.40	56.57
T₉ : T ₇ + PSB	8.83	138.41	22.42	13.00	19.75	54.76
T₁₀ : T ₇ + FA	10.00	141.66	22.79	13.98	21.41	59.36
T₁₁ : T ₇ + <i>Azospirillum</i> + PSB + FA	10.75	156.50	23.12	14.37	24.53	68.02
Mean	9.50	143.99	22.50	13.51	21.55	59.75
S.Em. (±)	0.30	2.90	0.55	0.28	0.83	2.29
C.D. (P= 0.05)	0.91	8.62	1.62	0.84	2.46	6.81

RDF: Recommended dose of fertilizers, RDN: Recommended dose of nitrogen, PSB: Phosphate solubilizing bacteria, FA: *Frateuria aurantia*

There is a gradual decline of potassium levels in all the treatmental plots at harvest when compared to the plots allotted for treatment application prior to planting. Plots that received 80 % RDF (inorganic) along with supply of 20 % RDF either through vermicompost or FYM and *Frateuria aurantia* has exhibited less depletion of potassium over its initial status.

Santhy *et al.*, (1999) observed the role of organic manures associated with minimizing the losses from leaching by retaining K – ions on exchange sites. Further, *Frateuria aurantia* has a role of releasing potassium from clay minerals by shifting the equilibrium between soluble and insoluble forms (Alexander, 1985). This is a positive indication that inclusion of *Frateuria aurantia* as one of the

component in the INM package to obtain beneficial influence on soil potassium results.

Total number of leaves emerged plant⁻¹

Total number of leaves emerged plant⁻¹ was significantly influenced at each crop stage by different treatments except at 3 MAP (Table 4). At 5 MAP, plants supplied with 80 % RDF (inorganic) + 20 % RDN (FYM) along with *Azospirillum*, PSB and FA have put forth significantly maximum number of leaves (29.6). Application of 80 % RDF (inorganic) + 20 % RDN (FYM) along with *Azospirillum*, PSB and FA has resulted in production of maximum leaves at shooting (37.8).

The total number of leaves emerged in a plant crop are in a range of 35 to 46 as prescribed

by Stover, 1979 for Grand Naine banana in tropics and this can be explained by the role of biofertilizers (*Azospirillum*, PSB and *Frateuria aurantia*) and organic manures such as vermicompost and farmyard manure might have improved the soil physical condition required for plant growth and it also could be due to increased availability of nutrients especially nitrogen as it has a prominent role in leaf emission (Murray, 1960).

Yield characters

Data presented in Table 5 indicates that significant differences were observed with regard to yield and its attributes viz., number of hands bunch⁻¹, fruits bunch⁻¹, bunch weight and fruit yield due to different treatments.

Significantly maximum number of hands bunch⁻¹ (10.75) was obtained with application of 80% RDF + 20% RDN through FYM + *Azospirillum*, PSB and FA and it was at par with application of 80% RDF + 20% RDN through VC + *Azospirillum*, PSB and FA and 80% RDF + 20% RDN through FYM + FA.

Application of 80% RDF + 20% RDN through FYM + *Azospirillum*, PSB and FA has recorded significantly higher number of fruits bunch⁻¹ (156.50) and it was on a par with application of 80% RDF + 20% RDN through FYM and 80% RDF + 20% RDN through VC + *Azospirillum*, PSB and FA.

Significantly highest bunch weight (24.53 kg) was recorded with application of 80% RDF + 20% RDN through FYM + *Azospirillum*, PSB and FA and it was on a par with application of 80% RDF + 20% RDN through VC + *Azospirillum*, PSB and FA and 80% RDF + 20% RDN through VC + FA.

The increase in bunch weight was associated with corresponding increase in number of hands bunch⁻¹, fruits bunch⁻¹, fruit girth which

were found to be highest in treatment 80% RDF + 20% RDN through FYM + *Azospirillum*, PSB, FA plant¹ were in accordance with the findings of Tejinder and Dhaliwal (2009).

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How to cite this article:

Firoz Hussain, S., Lakshminarayana Reddy and Venkata Ramudu. 2017. Studies on Integrated Nutrient Management (INM) Practices on Soil Characteristics and Yield in Tissue Culture Banana cv. Grand Naine (AAA). *Int.J.Curr.Microbiol.App.Sci.* 6(12): 2557-2564.
doi: <https://doi.org/10.20546/ijcmas.2017.612.296>