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THE GROWTH, YIELD AND QUALITY PARAMETERS OF BANANA CULTIVAR GRAND NAINE (AAA) AS INFLUENCED BY DIFFERENT ORGANIC AMENDMENTS

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Abstract

An investigation was carried out at Horticultural College and Research Institute, Anantharajupet to standardize organic management protocol with organic manures like FYM and vermicompost supplemented with inorganic fertilizers in combination with biofertilizers. The results showed that application of 80% RDF + 20% RDN through vermicompost + biofertilizers *viz*., 50 g *Azospirillum*, 50 g Phosphate solubilising bacteria (PSB) and 25 g potassium mobilising bacteria (KMB) (*Frateuria aurantia*) plant^{-1} has resulted in the highest plant height at 3 MAP (129.67 cm) and 5 MAP (184.29 cm) and maximum pseudostem girth at 3 MAP (35.61 cm) and 5 MAP (49.74 cm) as well as highest fruit length (24.33 cm). Application of 80% RDF + 20% RDN through farmyard manure + biofertilizers *viz*., 50 g *Azospirillum*, 50 g PSB and 25 g KMB plant^{-1} has registered maximum retention of functional leaves at 3 MAP (10.58) and at shooting (15.75) and maximum leaf area (3.87 m^2) at 3 MAP along with maximum number of hands bunch^{-1} (10.75), fruits bunch^{-1} (156.50), fruit girth (14.37 cm), bunch weight (24.53 kg) and fruit yield (68.02 t ha^{-1}).

Key words : Banana, growth, *Azospirillum*, Phosphate solubilising bacteria (PSB), Potassium mobilising bacteria (KMB).

Introduction

Banana (*Musa* spp.) is the oldest fruit of tropical countries and regarded as Adams fig or fruit of heaven. To establish a crop yielding of 50 t ha^{-1} year^{-1}, banana removes about 189:29:778 kg ha^{-1} of NPK (Twyford and Walmsley, 1968). These nutrients have to be replenished in order to maintain soil fertility and to permit continuous production of high yields. This is achieved by applying organic manures and mineral fertilizers in combination with biofertilizers which supply nutrients in readily available form. Banana responds positively to organic manures which improve physical, chemical and biological properties of the soil but heavy organic manuring is required to equalize chemical fertilization in banana (Lahav, 1973). Chemical fertilizers have some deleterious effects on fruit quality besides adverse effects on soil, water and environmental conditions (Dutta *et al*., 2010). Grand Naine is a popular variety grown mostly in all export oriented countries of Asia, South America and Africa. This is a superior selection of Giant Cavendish, which was introduced to India in 1990's. Due to many desirable traits like excellent fruit quality, immunity to panama wilt etc, it has proved better variety (Singh and Chundawat, 2002). However, its requirement of nutrients through organic sources along with inorganic fertilizers is not well documented. Keeping these aspects in mind, the present investigation was undertaken to find out the suitable combination of organic, inorganic and biofertilizers for tissue cultured Grand Naine banana under Anantharajupet conditions.

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Materials and Methods

The present investigation was conducted at Horticultural College and Research Institute, Anantharajupet during *Kharif*, 2012-13. The experiment was laid out in randomized block design comprising of eleven treatments which were replicated thrice. The plants were spaced at 1.8 m × 1.8 m. Recommended doses of nitrogen (300 g N plant^{-1} crop cycle^{-1}) and potassium (300 g K plant^{-1} crop cycle^{-1}) in the form of inorganic fertilizers (Urea and MOP) were applied in twelve equal split doses at an interval of 15 days starting from 15 days after planting till shooting by pocketing method at 30 cm away from plant on either side of plant. The entire dose of phosphorus (50 g for 100% RDF and

40 g for 80% RDF) was applied at the time of planting. The biofertilizers *Azospirillum*, PSB and KMB were applied at 50 g, 50 g and 25 g plant^{-1} as a basal application. The treatments included were T_1- 100% RDF, T_2 - 80% RDF (240:40:240 g NPK plant^{-1} crop cycle^{-1}) + 20% RDN through vermicompost (VC), T_3- 80% RDF + 20% RDN through VC + *Azospirillum*, T_4- 80% RDF + 20% RDN VC + Phosphate solubilizing bacteria (PSB), T_5- 80% RDF + 20% RDN through VC + *Frateuria aurantia* (KMB), T_6- 80% RDF + 20% RDN through VC + *Azospirillum* + PSB + KMB, T_7- 80% RDF + 20% RDN Farm Yard Manure (FYM), T_8- 80% RDF + 20% RDN through FYM + *Azospirillum*, T_9 - 80% RDF + 20% RDN through FYM + PSB, T_{10} - 80% RDF + 20% RDN through FYM + KMB, T_{11}- 80% RDF + 20% RDN through FYM + *Azospirillum* + PSB + KMB. The nitrogen content in vermicompost was 1.40% (Ratan, 2006) whereas the same in FYM was taken as 1.63% (Ratan, 2006). Calculated quantities of organic manures (vermicompost @ 4.285 kg plant^{-1} and FYM @ 5.309 kg plant^{-1}) to supply 20 % RDN *i.e.* 60 g N plant^{-1} crop cycle^{-1}, were applied prior to planting to the respective treatment plots. Observations on growth attributes *viz*., plant height, pseudostem girth, functional leaves and leaf area were recorded at various stages of crop growth. The rest of observations on fruit parameters were recorded at eaten-ripe stage of the fruit.

Results and Discussion

Growth characters

Data presented in table 1 indicated that there were significant differences with respect to growth and its attributes *viz*., plant height, pseudostem girth, functional leaves and leaf area at various stages of crop growth. Application of 80% RDF (inorganic) + 20% RDN (VC) along with *Azospirillum*, PSB and KMB (T_6) has recorded significantly higher plant height (129.67 cm) at 3 MAP and it was on par with application of 80% RDF + 20% RDN through FYM + *Azospirillum*, PSB and KMB (T_{11}), 80% RDF + 20% RDN through VC + PSB (T_4), 80% RDF + 20% RDN through FYM + KMB (T_{10}) and 80% RDF + 20% RDN through VC + KMB (T_5). At 5 MAP, the plants applied with 80% RDF + 20% RDN through VC + *Azospirillum*, PSB and KMB (T_6) have shown significantly highest plant height (184.29 cm) and it was on a par with application of 80% RDF + 20% RDN through FYM + *Azospirillum*, PSB and KMB (T_{11}), 80% RDF + 20% RDN through FYM + *Azospirillum* (T_8), 80% RDF + 20% RDN through FYM + PSB (T_9), 80% RDF + 20% RDN through FYM + KMB (T_{10}) and 80% RDF + 20% RDN through FYM (T_7). No significant differences in plant height were observed at shooting stage due to different treatments. Application of 80% RDF + 20% RDN through VC + *Azospirillum*, PSB and KMB (T_6) has recorded significantly higher pseudostem girth at 3 MAP (35.61 cm) and 5 MAP (49.74 cm). Maximum number of functional leaves were recorded at 3 MAP (10.58) and shooting (15.75) with the application of 80% RDF + 20% RDN through FYM along with *Azospirillum*, PSB and KMB (T_{11}). At 3 MAP, highest leaf area (3.87 m^2) was registered with the application of 80% RDF + 20% RDN through FYM + *Azospirillum*, PSB and KMB (T_{11}).

Improvement in plant height and pseudostem girth with different INM treatments as that of inorganic treatments might be ascribed to the involvement of biofertilizers such as *Azospirillum*, PSB and KMB and organic amendments *viz.,* vermicompost and farmyard manure. Ramaswamy (1976) reported the role of phosphorus in improving the pseudostem height in banana. Retention of functional leaves in plants that received different INM treatments at 3 MAP and shooting can be explained by the involvement of inorganic nutrients which supply nutrients immediately in assimilable form and organic manures *viz*., vermicompost and farmyard manure and the biofertilizers might have released plant growth substances which might have delayed the senescence of leaves and ultimately resulted in retention of more functional leaves than the 100% RDF application. This result is in coincidence with the findings of Jeyabaskaran and Mustaffa (2010) in banana. Maintenance of highest leaf area at 3 MAP and 5 MAP in the plants that received different INM treatments could be attributed to the active role of biofertilizers which might have supplied the nutrients as per plant requirement particularly potassium solubilising bacteria *Frateuria aurantia* which might have solubilized unavailable potassium in to available form through the secretion of organic acids and enzymes. Potassium has a prominent role in the improvement of leaf area and dry matter production within the plant which ultimately resulted in leaf expansion. Similar results were in agreement with the findings of Kanamadi *et al*. (2004).

Yield characters

Data presented in table 2 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 KMB (T_{11}) and

Table 1 : Vegetative growth parameters of banana as influenced by different INM treatments.

Treatments	Plant height (cm)			Pseudostem girth (cm)			Leaf area (m^2)			Functional leaves		
	3 MAP	5 MAP	Shooting	3 MAP	5 MAP	Shooting	3 MAP	5 MAP	Shooting	3 MAP	5 MAP	Shooting
T_1 : 100% RDF	112.72	167.43	201.96	31.42	44.39	50.66	3.00	6.18	10.72	8.83	13.50	14.16
T_2 : 80% RDF + 20% RDN through VC	118.15	163.37	196.46	33.31	44.41	49.08	2.96	6.86	9.59	9.25	13.58	14.00
T_3 : T_2 + *Azospirillum*	117.68	166.78	198.62	32.62	44.57	50.83	2.95	6.34	8.82	9.08	13.33	14.00
T_4 : T_2 + PSB	124.01	173.29	204.50	33.66	45.48	53.12	2.76	7.24	10.19	8.58	13.66	13.88
T_5 : T_2 + KMB	121.30	172.77	200.67	32.81	44.91	51.66	3.24	7.47	10.64	10.08	14.00	14.66
T_6 : T_2 + *Azospirillum* + PSB + KMB	129.67	184.29	201.96	35.61	49.74	50.00	3.81	8.76	12.3	10.50	14.58	15.50
T_7 : 80% RDF + 20% RDN through FYM	118.99	172.13	203.04	32.29	48.27	50.33	2.96	6.90	10.38	9.16	13.83	13.75
T_8 : T_7 + *Azospirillum*	114.17	176.00	201.54	31.51	45.78	50.20	3.00	6.59	9.84	9.66	13.33	13.83
T_9 : T_7 + PSB	119.53	158.21	190.29	33.17	45.21	48.04	2.68	6.72	9.60	8.75	13.33	14.25
T_{10} : T_7 + KMB	121.37	167.37	206.42	32.62	44.85	51.62	3.13	7.55	10.88	9.66	13.50	14.00
T_{11} : T_7 + *Azospirillum* + PSB + KMB	125.26	178.75	197.04	35.24	48.93	50.95	3.87	7.55	11.52	10.58	14.08	15.75
Mean	**120.25**	**170.94**	**200.22**	**33.11**	**46.04**	**50.59**	**3.12**	**7.105**	**10.40**	**9.46**	**13.70**	**14.34**
S.Em.(±)	2.97	4.18	5.89	0.72	1.24	1.60	0.13	0.50	0.85	0.24	0.27	0.24
C.D. (P=0.05)	8.83	12.41	N.S	2.12	3.67	N.S	0.38	N.S	N.S	0.72	N.S	0.71

MAP- Months after planting, **RDF**: Recommended dose of fertilizers, **RDN**: Recommended dose of nitrogen, **PSB**: phosphate solubilizing bacteria, **KMB**: *Frateuria aurantia*.

it was at par with application of 80% RDF + 20% RDN through VC + *Azospirillum*, PSB and KMB (**T_6**) and 80% RDF + 20% RDN through FYM + KMB (**T_{10}**). Application of 80% RDF + 20% RDN through FYM + *Azospirillum*, PSB and KMB (**T_{11}**) 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 (**T_7**) and 80% RDF + 20% RDN through VC + *Azospirillum*, PSB and KMB (**T_6**). Significantly highest bunch weight (24.53 kg) was recorded with application of 80% RDF + 20% RDN through FYM + *Azospirillum*, PSB and KMB (**T_{11}**) and it was on a par with application of 80% RDF + 20% RDN through VC + *Azospirillum*, PSB and KMB (**T_6**) and 80% RDF + 20% RDN through VC + KMB (**T_5**). 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, KMB plant^{-1} were in accordance with the findings of Tejinder and Dhaliwal (2009).

Quality parameters

Significant differences were observed with respect to TSS content of fruits and maximum TSS (24.00°B) was observed with the application of 80% RDF + 20% RDN through VC + *Azospirillum*, PSB and KMB (**T_6**) and it was on a par with application of 80% RDF + 20% RDN through FYM + *Azospirillum*, PSB and KMB (**T_{11}**), 80% RDF + 20% RDN through VC + KMB (**T_5**). Improvement in fruit quality (TSS) could be due to the involvement of organic manures (FYM and vermicompost), which might have supplied nutrients especially micronutrients, since organic manures are the rich source of micronutrients. This beneficial influence can also be attributed to biofertilizers particularly

Table 2 : Yield and its attributes as influenced by different inorganic and organic sources of nutrients along with biofertilizers 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})
T_1 : 100% RDF	8.91	136.58	21.73	13.16	19.35	53.65
T_2 : 80% RDF + 20% RDN through VC	9.25	139.16	21.15	13.12	19.80	54.89
T_3 : T_2 + *Azospirillum*	9.16	144.58	21.65	13.41	20.91	57.97
T_4 : T_2 + PSB	9.41	145.41	22.50	13.25	22.00	60.99
T_5 : T_2 + KMB	9.50	144.33	22.25	12.94	23.50	65.15
T_6 : T_2 + *Azospirillum* + PSB + KMB	10.33	150.08	24.33	14.25	23.92	66.31
T_7 : 80% RDF + 20% RDN through FYM	9.16	150.25	23.39	13.87	21.50	59.61
T_8 : T_7 + *Azospirillum*	9.25	137.00	22.20	13.34	20.40	56.57
T_9 : T_7 + PSB	8.83	138.41	22.42	13.00	19.75	54.76
T_{10} : T_7 + KMB	10.00	141.66	22.79	13.98	21.41	59.36
T_{11} : T_7 + *Azospirillum* + PSB + KMB	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 fertilisers, **RDN**: Recommended dose of nitrogen, **PSB**: phosphate solubilizing bacteria, **KMB**: *Frateuria aurantia*.

Table 3 : Quality parameters as influenced by different inorganic and organic sources of nutrients along with biofertilizers in tissue culture banana *cv.* Grand Naine.

Treatments	TSS (^{0}Brix)	Acidity (%)	Reducing sugars (%)	Non reducing sugars (%)	Shelf life (Days)
T_1 : 100% RDF	20.25	0.91	3.57	4.01	9.08
T_2 : 80% RDF + 20% RDN through VC	21.25	1.09	3.50	4.33	12.58
T_3 : T_2 + *Azospirillum*	22.06	0.61	3.61	4.04	11.50
T_4 : T_2 + PSB	22.19	0.72	3.52	4.08	12.33
T_5 : T_2 + KMB	22.34	0.87	3.57	4.42	12.58
T_6 : T_2 + *Azospirillum* + PSB + KMB	24.00	0.62	3.22	4.77	14.16
T_7 : 80% RDF + 20% RDN through FYM	21.33	1.05	3.41	4.03	12.66
T_8 : T_7 + *Azospirillum*	21.55	0.70	3.51	4.07	12.50
T_9 : T_7 + PSB	22.19	1.15	3.49	4.62	12.33
T_{10} : T_7 + KMB	21.73	0.82	3.65	4.34	12.58
T_{11} : T_7 + *Azospirillum* + PSB + KMB	23.83	0.66	3.65	4.75	13.75
Mean	**22.06**	**0.83**	**3.51**	**4.31**	**12.36**
S.Em. (±)	0.59	0.20	0.11	0.25	0.31
C.D. (P=0.05)	1.76	N.S	N.S	N.S	0.93

RDF: Recommended dose of fertilisers, **RDN**: Recommended dose of nitrogen, **PSB**: phosphate solubilizing bacteria, **KMB**: *Frateuria aurantia*.

Azospirillum. Jeeva *et al*. (1988) recorded an improvement in the TSS content of the fruits in banana with *Azospirillum* inoculation. However, significant differences were not observed in acidity, reducing and non reducing sugars with the application of different INM treatments.

Shelf life of the fruits was significantly influenced by different treatments. Fruits obtained with the application of 80% RDF + 20% RDN through VC + *Azospirillum*, PSB and KMB ($\mathbf{T_6}$) have shown significantly higher shelf life (14.16 days) and it was at par with 80% RDF + 20% RDN through FYM + *Azospirillum*, PSB and KMB ($\mathbf{T_{11}}$) treatment. In general, polyamines play a role in extension of shelf life of fruits by affecting the permeability of cell membranes along with their opposing effects on the action of ethylene. In banana, extension of shelf life could be ascribed to the rate of degradation of polyamines and recorded a slower degradation of polyamines in fruits with longer shelf life (Bhagawan *et al*., 2000).

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