International Journal of Bio-resource and Stress Management 2016, 7(4):832-836 DOI: HTTPS://DOI.ORG/10.23910/IJBSM/2016.7.4.1551b

Full Research Article

Effect of Organic Manures and Bio-fertilizers on Yield and Fruit Quality of Banana cv. Grand Naine (AAA)

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Article History

Manuscript No. AR1551b
Received in 2nd March, 2016
Received in revised form 24th July, 2016
Accepted in final form 25th July, 2016

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Keywords

Banana, fruit quality, organic manures and bio-fertilizers

Abstract

An attempt was made to study the effect of certain organic manures (vermicompost, farmyard manure, poultry manure, ash and neem cake) and bio-fertilizers (*Azospirillum*, *T. harzanianum*, arbuscular mycorrhizal fungi and phosphate solubilizing bacteria) on yield and fruit quality of banana cv. Grand Naine in comparision with T_{11} (200 g N+50 g P+200 g K) and control (N_0+P_0+K_0). Yield characters viz., hands bunch^{-1}, fruit length, fruit girth, bunch weight, yield ha^{-1} were higher in treatment T_{11} and among organic treatments,T_4-FYM (15 kg)+NC (1.875 kg)+VC (7.5 kg)+Ash (9.94 kg) recorded higher yield attributes. Organic treatment T4 was recorded with highest fruit quality characters *viz.*, total soluble solids, reducing sugars, non reducing sugars, higher shelf life and recorded higher ratings in organoleptic evaluation among all the treatments. T_{11} was recorded with higher pulp to peel ratio followed by T_4. The utilization of organic manures and bio-fertilizers are considered as promising alternative for chemical fertilizers, especially for developing countries. Organic fertilization is another option for supplying nutrient elements to banana production. The organic materials improve soil structure and reduce soil temperature, resulting in better root growth and more efficient use of water and nutrients. Organic production of Grand Naine improves soil health, yield of crop, fruit quality viz. fruit taste, colour, keeping quality of the fruits than conventionally produced fruits. Higher profits were realized under organic banana production.

1. Introduction

Banana is the most important crop grown in the tropical and subtropical regions of the world. In India, an area of 0.83 mha is under the banana cultivation, with a production of about 29.78 mt and an average productivity of 35.90 t ha^{-1}. In India, A.P contributes about 9.3% of total production with an area of 0.079 mha and produces about 27.74 mt and an average productivity of 35.0 t ha^{-1} (NHB, 2011). It is cultivated in diverse agro-climatic conditions of the state for its generally assured income. Generally, banana plants need large amounts of fertilizers, especially nitrogen and potassium (Ganeshamurthy et al., 2011). Moreover, it draws nutrient elements from a very limited soil depth due to its shallow root system. Also, high water requirements cause a great leaching of most applied nutrients, particularly nitrogen besides volatilization and denitrification. The major problems faced by the banana growers are the high cost of inorganic fertilizers needed for banana plants. Beside this, chemical fertilizers are considered as air, soil and water polluting agents during their production and utilization. Consequently, it has drawn the attention of researchers and banana growers to use organic manures and bio-fertilizers which are safe for human, animals and environment.

Organic fertilization is another option for supplying nutrient elements to banana production. The organic materials improve soil structure and reduce soil temperature, resulting in better root growth and more efficient use of water and nutrients (Casale et al., 1995). Organic farming slashes cultivation and input costs due to the use of cheaper, natural products like manures instead of chemical fertilizers. 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 Fusarium wilt etc, it has proved as better variety (Singh and Chundawat, 2002).

2. Materials and Methods

The field experiment was conducted during 2011–2012 at Horticultural Research Station, Kovvur, West Godavari, Andhra Pradesh, India. The soil of experimental field was black alluvial with a pH of 7.5 and an EC of 0.48 dSm^{-1}. The experiment was laid out in randomized block design with three replications. Tissue cultured Grand Naine banana plants were planted at a spacing of 1.8×1.8 m^2. The treatment details are as follows: T_1: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (6.6 kg), T_2: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (14.20 kg), T_3: FYM (15 kg)+NC (1.875 kg)+VC (7.5 kg)+Ash (2.36 kg), T_4: FYM (15 kg)+NC (1.875 kg)+VC (7.5 kg)+Ash (9.94 kg), T_5: T_{12}+Triple green manuring with sunhemp+cowpea+cowpea as intercrop, T_6: AMF (25 g), *Azospirillum* (50 g), PSB (50 g) and *T. harzianum* (50 g), T_7: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (6.6 kg)+T_{12}+Triple green manuring with sunhemp+cowpea+cowpea as intercrop, T_8: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (6.6 kg)+AMF (25 g), *Azospirillum* (50 g), PSB (50 g) and *T. harzianum* (50 g), T_9: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (6.6 kg)+T_{12}+Triple green manuring with sunhemp+cowpea+cowpea as intercrop+AMF (25 g), *Azospirillum* (50 g), PSB (50 g) and *T. harzianum* (50 g), T_{10}: Poultry manure (10 kg)+Neem cake (1.875 kg), T_{11}: 200 g N+50 g P+200 g K, T_{12}: N_0+P_0+K_0.

Yield parameters like hands $bunch^{-1}$, finger length, finger girth, bunch weight and yield were recorded in the experiment. In the experiment fruit quality characters like pulp to peel ratio, peel thickness, total soluble solids, titrable acidity, reducing sugars, non reducing sugars, shelf life and organoleptic evaluation are determined with their respective procedures and mentioned below. B:C was also calculated to know the profitability of each treatment.

Pulp and peel of individual fruit was weighed individually and expressed as pulp to peel ratio. Thickness (mm) of the peel of individual fruit was measured with vernier calipers after separating the peel from the pulp by cutting transversely at midpoint of fruit. The total soluble solids were determined by using ERMA hand refractometer and expressed as per cent TSS (°Brix) (Ranganna, 1986). Titrable acidity was estimated by titration method (Ranganna, 1986). Reducing sugars and non reducing sugars in the fruit are determined by the method Lane and Eyon (AOAC, 1965).

The end of the shelf life was decided when more than 50% of the fruits started shrivelling which was judged by visual scoring. Sensory evaluation of the fruits obtained from different treatment plots was taken up with a panel of five judges and were asked to give the score (1–4) on characteristics like appearance, colour, flavour, taste and overall acceptability of the fruit (Peryam and Pilgrim, 1957). Organoleptic evaluation was done at eating ripe stage.

3. Results and Discussion

Highest bunch yield, bunch weight, hands $bunch^{-1}$, fruit length, fruit girth were recorded by the plants in the treatment applied with 100% RDF (Table 1). However, among organic treatments, application of T_4 registered maximum fruit yield (89.22 t ha^{-1}), bunch weight (36.13), hands $bunch^{-1}$ (9.39), fruit length (21.42) and fruit girth (12.91). Plants in the treatment T_{12} have recorded lowest yield characters among the treatments. Increase in yield in the treatments T_{11} and T_4 could be attributed to increase in morphological traits and also higher nitrogen uptake by the plants (Nalina et al., 2009). The maximum fruit size in the treatment 100% RDF followed by T_4 could be attributed to the adequate filling of the fruits due to the balanced levels of nutrients (Basagarahally, 1996).

In the experiment, bunch weight was dramatically influenced by the various treatments. In banana, early phases of growth were considered very critical for the subsequent development (Summerville, 1944). Further, low levels of nitrogen reduced the bunch weight through its effect on number of fingers and fruit weight (Arunachalam et al., 1976). Insufficient potassium supply reduces the total dry matter production and distribution within the plant and bunch is the most affected organ in the banana plant (Turner and Barkus, 1980). The effect of low potassium supply on dry matter production would be through reduction of photosynthesis due to reduced total leaf area of the plant (Summerville, 1944).

Krishnan and Shanmugavelu (1979) found that plants with thicker pseudo stem are desirable as they reflect on bunch size and other related characters. The higher fruit yield with application of treatment T_4 (FYM+NC+VC+Ash) might be due to slow and consistent release of nutrients throughout the crop period ultimately resulting in more number of fingers, finger length, breadth, hands $bunch^{-1}$ resulting in higher yield. Gowen (1995) reported that banana plantations on application with external organic matter improve nutrient availability to the plants and results in high yields. Esitken et al. (2010) reported that application of organic matter increased yield in fruit crops.

Reducing and non reducing sugars content in fruits was higher (9.40 and 9.00) in T_4 which make the fruits sweeter and acceptable (Table 2). Application of organic sources influenced on sugar content in the fruits. Potassium improves sugars in the fruits and improves quality (Bhargava and

Table 1: Effect of different organic manures and bio-fertilizers on yield and its attributes of banana cv. Grand Naine (AAA)

Treatments	Yield and its attributes				
	Hands bunch^{-1} (no.)	Fruit length (cm)	Fruit girth (cm)	Bunch weight (kg)	Yield (t ha^{-1})
T_1	7.63	17.31	11.65	23.96	59.16
T_2	8.08	19.53	11.81	28.88	71.31
T_3	7.67	18.50	11.83	24.70	61.00
T_4	9.39	21.42	12.91	36.13	89.22
T_5	7.10	16.17	10.64	16.03	39.57
T_6	7.15	16.22	10.94	16.08	39.70
T_7	7.70	19.80	11.97	25.42	62.76
T_8	7.22	18.59	11.69	25.06	61.88
T_9	8.19	19.67	11.66	29.55	72.97
T_{10}	8.70	20.59	12.03	30.03	74.16
T_{11}	10.13	24.05	14.48	37.31	92.12
T_{12}	6.17	14.43	9.85	14.43	35.64
SEm±	0.23	0.26	0.26	0.28	0.69
CD (p=0.05)	0.68	0.76	0.78	0.82	2.04

T_1: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (6.6 kg); T_2: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (14.20 kg); T_3: FYM (15 kg)+NC (1.875 kg)+VC (7.5 kg)+Ash (2.36 kg); T_4: FYM (15 kg)+NC (1.875 kg)+VC (7.5 kg)+Ash (9.94 kg); T_5: T_{12}+Triple green manuring with sunhemp+cowpea+cowpea as intercrop; T_6: AMF (25 g), *Azospirillum* (50 g), PSB (50 g) and *T. harzianum* (50 g); T_7: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (6.6 kg)+T_{12}+Triple green manuring with sunhemp+cowpea+cowpea as intercrop; T_8: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (6.6 kg)+AMF (25 g), *Azospirillum* (50 g), PSB (50 g) and *T. harzianum* (50 g); T_9: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (6.6 kg)+T_{12}+Triple green manuring with sunhemp+cowpea+cowpea as intercrop+AMF (25 g), *Azospirillum* (50 g), PSB (50 g) and *T. harzianum* (50 g); T_{10}: Poultry manure (10 kg)+Neem cake (1.875 kg); T_{11}: 200 g N+50 g P+200 g K; T_{12}: N_0+P_0+K_0

Table 2: Effect of different organic manures and bio-fertilizers on fruit quality of banana cv. Grand Naine (AAA)

Treat-ments	Redu-cing sugars (%)	Non-reducing sugars (%)	Shelf life (days)	TSS (°Brix)	Pulp to peel ratio	Organoleptic quality of the fruit			
						Appea-rance	Flavour	Taste	Over all acceptability
T_1	8.40	6.22	14.00	19.47	2.60	3.17	2.83	3.27	3.07
T_2	9.13	6.00	14.67	20.20	2.73	3.25	3.18	3.28	2.67
T_3	8.41	6.15	15.00	19.40	2.76	3.22	3.16	3.11	3.07
T_4	9.40	9.00	17.00	21.27	2.80	3.55	3.20	3.80	3.80
T_5	8.55	6.25	14.00	20.07	2.65	2.67	2.54	3.22	2.80
T_6	9.07	7.03	14.67	20.33	2.76	3.00	2.97	3.16	3.05
T_7	8.54	6.65	16.00	20.47	2.54	3.22	2.83	3.28	3.05
T_8	8.27	6.26	15.33	19.80	2.75	3.07	2.72	3.13	3.10
T_9	8.60	6.60	16.00	20.07	2.73	3.24	2.61	2.77	3.07
T_{10}	9.03	7.00	16.00	20.47	2.78	3.33	3.63	3.33	3.13
T_{11}	8.43	6.39	14.00	17.67	3.15	3.00	2.33	3.00	2.67
T_{12}	8.09	4.29	10.67	14.33	1.99	2.00	2.16	2.00	2.05
SEm±	0.28	0.64	0.36	0.21	0.10	0.05	0.13	0.12	0.19
CD (p=0.05)	NS	1.89	1.08	0.64	0.35	0.15	0.39	0.37	0.56

Chadha, 1993). Results from the experiment indicated that application of farmyard manure, vermicompost, neem cake and ash recorded higher TSS (21.27 °Brix) content. More the TSS more will be the sweetness in the fruits, application of organic sources to banana plants improved TSS content in the treatment T_4. Due to high accumulation in the fruit and plant tissue, K is considered as the most important plant nutrient in banana production. Singh et al., 2010 reported that vermicompost usage in fruit crops improved fruit quality.

Potassium does not play direct role in the plant cell structure, however, it is fundamental, because it catalyses important reactions such as respiration, photosynthesis, chlorophyll formation and water regulation. Potassium improves total soluble solids and sugars (Bhargava and Chadha, 1993). These results are in conformity with Chang et al., (2007), Fawzi et al., (2010), Ravishankar et al., (2010), Vazquez-Ovando et al., (2012).

Pulp to peel ratio was higher (3.15) in the treatment T_{11} and among organic it is T_4 (2.80). This may be due to application of nutrients to the plants in available form and in required quantities. Shelf life of the fruits was higher in the treatment T_4 and this may be attributed to adequate application of nutrients especially potassium. Fruits of organically grown plants have better shelf life than conventionally grown plants (Babu Ratan, 2006). In organoleptic evaluation, fruits obtained with application of T_4 have registered higher ratings for appearance, taste, flavor, overall acceptability. Von Uexkll (1985) reported that low potassium nutrition results in thin and fragile bunch with shorter shelf life.

Among all the treatments, highest benefit cost ratio (2.46) was obtained with application of T_4 (FYM+VC+NC+Ash) followed by T_6 (2.45) and T_{10} (2.45) (Table 3). However, in the domestic market organic fruits are having demand and getting higher price (1 kg @ ₹ 8/-) than the conventionally produced fruits (1 kg @ ₹ 5/-) as banana produced under organic practices is superior in fruit quality characters than conventionally produced fruits.

Table 3: Benefit cost ratio for treatment combinations

Treatment combinations	Cost of cultivation (₹ ha^{-1})	Yield (t ha^{-1})	Gross returns (₹ ha^{-1})	Benefit (₹ ha^{-1})	B:C ratio
T_1	228745.6	59.16	473284	244538.4	2.07
T_2	270971.2	71.31	570469.1	299497.9	2.11
T_3	247552.7	61.00	487967.1	240414.4	1.97
T_4	289667.1	89.22	713744.9	424077.8	2.46
T_5	133492	39.57	316576.1	183084.1	2.37
T_6	129571	39.70	317563.8	187992.8	2.45
T_7	254890.6	62.76	502057.6	247167	1.97
T_8	250969.2	61.88	495078.2	244109	1.97
T_9	277114.6	72.97	583769.5	306654.9	2.11
T_{10}	242246.7	74.16	593280	351033.3	2.45
T_{11}	250614	92.12	460576.1	209962.1	1.84
T_{12}	104947	35.64	178189.3	73242.3	1.70

4. Conclusion

Application of 100% RDF recorded better yield characters. The present study was conducted to evaluate organic manures and bio-fertilizers sources for the yield of tissue cultured banana cv. Grand Naine and it can be concluded that T_4-FYM (15 kg)+NC (1.875 kg)+VC (7.5 kg)+Ash (9.94 kg) recorded better yield characters, fruits with high TSS content, better shelf life and higher sugar content, highest B:C ratio among all the treatments due to its demand for fruit quality.

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