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Effect of Integrated Nutrient Management on Yield and Economics of Banana

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Abstract

Field experiment was conducted during 2010-11 and 2011-12 at Agricultural Research Station (Tamil Nadu Agricultural University), Bhavanisagar, Erode district of Tamil Nadu to study the effect of integrated nutrient management practices on yield and economics of banana under irrigated conditions. The results revealed that application of 100% recommended dose of fertilizer along with 40% *Wellgro soil* recorded the maximum number of hands (10.2 and 10.3), number of fingers (136.3 and 145.2), bunch weight (23.9 and 25.3 kg/plant) and total yield (72.8 and 77.1 t/ha) during 2010-11 and 2011-12,respectively. Similarly, net income and B: C ratio was also influenced by integrated nutrient management practices during both years of study. Hence, integrated nutrient management practices have been found to be an ideal option to improve yield and economics of banana under soil and climatic conditions of Western zone of Tamil Nadu.

Key words: Chemical fertilizers, *Wellgro soil*, *Wellgro grains*, Liquid organic manure, Farm Yard Manure (FYM).

Introduction

Banana '*Poor man's apple*' is the major staple food crop for millions of people in Central, East and West Africa, Latin America and the Caribbean. It is mainly produced in tropical and sub-tropical regions of the world and recognised as the fourth most important food in terms of gross value after paddy, wheat and milk products (FAO, 2006). Banana is a cheap source of energy like vitamins A, C, B_6 and other minerals with traces of fat. Banana production in India is 27.0 m tonnes from an area of 0.77 m ha and the productivity is 34.4 tonnes. The major banana growing states in India are Tamil Nadu, Maharashtra, Gujarat, Andhra Pradesh, Karnataka, Madhya Pradesh, Bihar and West Bengal (Anon., 2010).

Bananas owing to its large size and rapid growth rate require relatively large amount of nutrients for high yields of quality fruits. It is estimated that 50 tonnes of banana in one hectare removes 320kg N, 32kg P_2O_5 and 925kg K_2O 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 soil 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, organic cakes and bio-fertilizers besides using chemical fertilizers in banana. Integrated nutrient management in banana are being practiced and experimented in various parts of India. Bhalerao et al. (2009) observed that combined application of 100% recommended dose of NPK along with organic manures increased the pseudostem height and girth, minimize the days for flowering and total crop duration and increased yield attributes in banana. Similar trend was also reported by Hazarika and Ansari (2010); Badgujar et al. (2010) and Barakat et al. (2011). In today's cultivation many commercial organic manures are being used because of their application in lesser volume and also enriched with nutrients. One such commercial organic manure used in the study is *Wellgro*. *Wellgro* organic manure is a unique product with a blend of neem and non-timber forest produce and a rich source of nutrients and this organic based farm input addresses soil fertility and crop nutrition in line with the perception of Integrated Nutrient Management (INM). The experiment on effect of integrated nutrient management practices in banana with commercial formulations of organic products (*Wellgro*) is new under the soil and climatic conditions of Western zone of Tamil Nadu. Hence, this study was under taken to find out the influence of INM on yield and economics of banana.

Materials and Methods

The experiments were laid out at Northern Block Farm, Agricultural Research Station (Tamil Nadu Agricultural University), Bhavanisagar, Erode district of Tamil Nadu. The farm is geographically located at 11°29´ N latitude and 77°08´ E longitude at an altitude of 256 m above MSL.

The experiments were conducted under irrigated conditions. Throughout the experiment, the mean annual rainfall was 538.8 mm in 38 rainy days and 742.8 in 43 rainy days during first and second year, respectively. The mean maximum and minimum temperatures recorded were 33.8°C and 21.9°C in 2010-11 and 34°C and 21.1°C in 2011-12. Similarly, the mean maximum and minimum relative humidity was 87.8 and 50.2% during 2010-11 and 86.2 and 56.3% during 2011-12. Mean bright sunshine hours per day was 4.67 with a mean solar radiation of 453 cal cm^2 day^{-1}. The soil type was sandy loam in texture. The soils were neutral (pH 7.06 and 7.18) with low soluble salts (EC 0.263 and 0.254 dSm^{-1}), medium and low in organic carbon content (0.51 and 0.46%), low in available nitrogen (208 and 232 kg/ha), medium in available phosphorus (14.7 and 15.3 kg/ha) and high in available potassium (611 and 649 kg/ha) for 2010-11 and 2011-12, respectively. Similarly, soil bulk density was 1.35 and 1.28 g/cc, particle density was 2.27 and 2.31g/cc and porosity was 40.3 and 44.6% during 2010-11 and 2011-12, respectively.

The banana *cv.* Grand Naine (AAA) was used as a test crop during both the years of experimentation. The field was uniformly levelled and the pits were dug out to a dimension of 45x45x30 cm at 1.8m×1.8m spacing and plot size was 14.4m x 5.4m (77.76 m^2). The experiment was laid out in a Randomized Complete Block Design with thirteen treatments and replicated thrice as suggested by Gomez and Gomez (2010). The treatment comprises T_1- 100% recommended dose of fertilizer (control), T_2- 100% RDF + *Wellgro soil* @ 20% w/w of chemical fertilizers, T_3- 100% RDF + *Wellgro soil* @ 40% w/w of chemical fertilizers, T_4- 75% RDF + *Wellgro soil* @ 20% w/w of chemical fertilizers, T_5- 75% RDF + *Wellgro soil* @ 40% w/w of chemical fertilizers, T_6- 100% RDF + liquid organic manure spray (LOM) on bunches, T_7- 75% RDF + liquid organic manure spray (LOM) on bunches, T_8- 100% RDF + *Wellgro grains* @ 20% w/w of chemical fertilizers, T_9- 100% RDF + *Wellgro grains* @ 40% w/w of chemical fertilizers, T_{10}- 75% RDF + *Wellgro grains* @ 20% w/w of chemical fertilizers, T_{11}- 75% RDF + *Wellgro grains* @ 40% w/w of chemical fertilizers, T_{12}- 100% RDF + FYM @ 10kg/plant and T_{13}- 75% RDF + FYM @ 10kg/plant.

The following formula was used to calculate the quantity of *Wellgro soil* and *Wellgro grains* @ 20 and 40% w/w of chemical fertilizers.

$$\textit{Wellgro soil/grains}\ (\text{g plant}^{-1}\ \text{split}^{-1}) = \frac{\text{Urea+ super phosphate+ muriate of potash (g plant}^{-1}\ \text{split}^{-1})}{100} \times 20 \text{ or } 40\%$$

The experimental plots consisted of three rows with eight plants in each row. The plots were separated by buffer channels to minimize the movement of nutrients and water. At the time of planting, Furadon granules were applied @ 20g/pit. Applied *Azospirillum* and *Phosphobacteria* 20g each and Vasicular Arbuscular Mycorrhizae (VAM) @ 10kg/ha at planting and 5th month after planting preceding chemical fertilizer application uniformly to all the treatments.

The 100 and 75% recommended dose of fertilizers *i.e.*, 165-52.5-495 and 123.7-39.4-371.3g N-P-K/plant respectively were applied through urea, single super phosphate (SSP) and muriate of potash (MOP). Entire dose of phosphorus and FYM were applied during 2^{nd} month after planting to scheduled treatments. Remaining nitrogen and potash were applied along with *Wellgro* organic manure at 2^{nd}, 4^{th}, 6^{th} and 8^{th} MAP (two months interval). Fertilizers and organic manures were applied in a circular band around the base of the plants. Liquid organic manure @ 2% was sprayed twice (*i.e.*, at 15 and 30 days after last hand opening) uniformly on the foliage and developing bunches. Other cultural practices like weeding, irrigation, pest and disease management and special operations like desuckering, denavelling, pruning of leaves, earthing up and propping were followed uniformly for raising the crop as per the Crop Production Techniques of Horticultural crops (2004).

The following characters were estimated

Bunches were harvested at the green maturity stage. During harvest, the marketable bunch weight and number of hands and fingers per bunch was recorded. Individual bunch weight was converted in to hectare (3050 plants/ha) and expresses as total yield (t/ha).

Economic analysis

The cost of cultivation was worked out taking into account of various inputs used for cultivation during the entire experimental period. The following economic analyses were carried out during the study.

Total variable cost (TVC)

The cost incurred from field preparation to harvest was worked out for each treatment of the study and expressed as Rs. ha^{-1}.

Gross return

The crop yield was computed per hectare and the total income (Rs. ha^{-1}) was worked out based on the minimum market rate prevalent during the period of study.

Net return

Net return was obtained by subtracting TVC from gross return as detailed below and expressed as Rs. ha^{-1}.

Net return (Rs. ha^{-1}) = Gross return (Rs. ha^{-1}) – Total variable cost (Rs. ha^{-1}).

Benefit-Cost Ratio (BCR)

BCR was calculated based on gross return and variable cost of cultivation as given below.

$$BCR = \frac{\text{Gross return (Rs. ha}^{-1})}{\text{Total variable costs (Rs. ha}^{-1})}$$

The data were statistically analyzed by the analysis of variance method as suggested by Gomez and Gomez (2010). Wherever the treatment differences were found significant, critical differences were worked out at 5% probability level and the values are furnished. Non-significant treatment differences were denoted as NS.

Results and Discussion

Yield Parameters

Crop had significant effect on bunch traits due to integrated nutrient management practices. However, application of 100% RDF along with either 40% *Wellgro soil* or FYM @ 10kg/plant recorded the maximum bunch weight, number of

hands and fingers/bunch and total yield (Table1). During 2010-11 and 2011-12, the highest bunch weight (23.9 and 25.3kg), number of hands (10.2 and 10.3) and fingers (136.3 and 145.2/bunch), finger weight (175.0 and 184.2 g) and maximum yield response (72.8 and 77.1 t/ha) respectively were obtained with application of 100% RDF along with 40% *Wellgro soil*. However, bunch weight was comparable with T_{12} (23.77 kg), T_9 (23.3 kg) and T_2 (23.0 kg) during 2010-11 and with T_{12} (25.3 kg) and T_9 (24.9 kg), T_2 (24.5 kg) and T_8 (23.7 kg) during 2011-12. Similarly, total yield was on par with T_{12} (72.5 t ha^{-1}), T_9 (71.0 t ha^{-1}), T_2 (70.1 t ha^{-1}) and T_8 (69.3 t ha^{-1}) during first year and T_{12} (77.1 t ha^{-1}), T_9 (75.9 t ha^{-1}), T_2 (74.7 t ha^{-1}) and T_8 (72.1 t ha^{-1}) during second year.

Table 1. Effect of integrated nutrient management on yield parameters of banana.

Treatments	2010-11					2011-12				
	Bunch weight (kg)	Number of hands/ bunch	Total no. of fingers/ bunch	Finger weight (g)	Yield (t/ha)	Bunch weight (kg)	Number of hands/ bunch	Total no. of fingers/ bunch	Finger weight (g)	Yield (t/ha)
T_1 - 100% RDF (Control)	21.2	8.6	125.2	167.3	64.6	21.6	9.6	131.3	173.3	65.8
T_2 - 100% RDF + 20% WS	23.0	9.5	132.0	172.7	70.0	24.5	10.3	139.0	182.3	74.7
T_3 - 100% RDF + 40% WS	23.9	10.2	136.3	175.0	72.8	25.3	10.3	145.2	184.2	77.1
T_4 - 75% RDF + 20% WS	21.0	8.6	123.3	169.3	64.0	21.6	9.5	124.1	178.0	65.7
T_5 - 75% RDF + 40% WS	22.5	9.2	126.4	171.0	68.5	22.5	10.0	128.7	180.3	68.6
T_6 - 100% RDF + WC spray	21.9	8.7	126.5	172.3	66.9	22.3	9.6	130.7	178.0	68.0
T_7 - 75% RDF + WC spray	20.5	8.5	118.6	170.0	62.5	21.0	9.1	124.0	176.3	64.1
T_8 - 100% RDF + 20% WG	22.5	9.8	130.7	173.7	69.3	23.7	10.0	136.1	181.0	72.1
T_9 - 100% RDF + 40% WG	23.3	9.5	133.4	178.7	71.0	24.9	10.2	139.8	184.7	75.9
T_{10} - 75% RDF + 20% WG	21.2	8.9	122.2	172.8	64.6	21.8	10.0	127.3	179.0	66.5
T_{11} - 75% RDF + 40% WG	21.4	9.3	123.1	171.7	65.2	21.7	9.9	129.0	178.3	66.1
T_{12} - 100% RDF + FYM	23.8	10.0	135.4	174.3	72.5	25.3	10.4	141.5	186.3	77.1
T_{13} - 75% RDF + FYM	21.3	9.7	126.3	170.4	65.0	21.9	9.6	130.9	179.0	66.9
S.Ed	0.6	0.5	3.1	5.3	2.1	0.8	0.5	3.4	5.4	2.4
CD(P=0.05)	1.2	1.0	6.3	10.1	4.2	1.6	1.1	7.0	11.2	5.0

Increase in yield attributes could be due to the increase in morphological traits such as plant height, girth, number of functional leaves, leaf area index, faster rate of leaf production and also higher nutrient uptake by the plants. Increased number of leaves might have increased the photosynthetic activity resulting in higher accumulation of carbohydrates. Relatively higher carbohydrates could have promoted the growth rate and in turn increased bunch weight. This was in accordance with the results of Chezhiyen et al. (1999) in banana. The increase in finger weight might be due to the increase in production of promoting endogenous and enhancement of nutrient uptake in addition to the role of nitrogen on productivity of banana plants (Nijjar, 1985). Any factor that stimulates higher finger production and favours better finger development leads to better bunch weight.

The increment of yield due to the application of 100% RDF along with 40% *Wellgro soil* was 11.2 and 14.7% as compared to control. Similarly, application of 100% RDF with FYM @ 10kg/plant registered 10.8 and 14.6% higher yield over control during 2010-11 and 2011-12, respectively. Higher yield response owing to application of organics ascribed to improved physical, chemical and biological properties of soil resulting in better supply of plant nutrients, which in turn led to good crop growth and yield. Humus substance present in organic product could have mobilized the reserve food materials to the sink through increased activity of hydrolyzing and oxidizing enzymes. These products would help the better availability and utilization of nutrients. All these positive effect might have facilitated quick mobilization and availability of nutrients that would aid in increased plant height, number of leaves, leaf area, leaf area index and photosynthetic rate. This in turn would have assisted for the increased yield of banana. This is in confirmation with the findings of Patel et al. (2010) and Aba et al. (2011) in banana.

Economics

The mean data on total variable cost (TVC) (Rs. ha^{-1}), gross return (Rs. ha^{-1}), net return (Rs. ha^{-1}) and benefit- cost (B: C) ratio are presented in Tables 2.

Gross income

Higher gross returns of Rs. 363850 and Rs. 385600 were recorded during 2010-11 and 2011-12 respectively with the application of 100 per cent recommended dose of fertilizer along with 40% *Wellgro soil* (T_3) followed by 100% RDF + FYM @ 10kg plant^{-1} (Rs. 362450 and Rs. 385300 during 2010-11 and 2011-12 respectively). The lowest gross return was obtained with T_7 (Rs. 312350 and Rs. 320250) during 2010-11 and 2011-12, respectively followed by T_4 and T_1 treatments.

Net income

During both the years of the study, the net return was higher (Rs. 225403 and Rs. 248364) with the application of 100% recommended dose of fertilizer along with 40% *Wellgro soil* (T_3) followed by 100% RDF + 40% *Wellgro grains* (T_9). The minimum net return of Rs. 167688 and Rs. 179149 was obtained with 75% RDF + FYM @ 10kg plant^{-1} (T_{13}) during 2010-11 and 2011-12 respectively followed by T_1 and T_4 during both the years.

***Benefit-cost ratio*(B: C ratio)**

The benefit-cost ratio was higher (2.63) with 40% *Wellgro soil* either with 100% RDF (T_3) or 75% RDF (T_5) followed by T_2, T_9 and T_8 during 2010-11. During 2011-12, application of 100% recommended dose of fertilizer along with 40% *Wellgro soil* (T_3) recorded the maximum benefit-cost ratio (2.81) followed by T_2 and T_9. The lowest benefit-cost ratio was recorded with T_{13} (2.07 and 2.15 during 2010-11 and 2011-12 respectively).

Efficacy of different fertilizer treatments was worked out by computing the gross and net returns and benefit cost ratio. Application of 100% recommended dose of fertilizer along with either *WG* organic manure or FYM resulted in higher yield reflected in terms of bunch weight yield ha^{-1} resulting in higher gross return. When the net profit and benefit-cost ratio were considered application of 100% RDF along with 40% *Wellgro soil* recorded the maximum net profit with a high benefit-cost ratio during both the years. Application of 100% recommended dose of fertilizer along with FYM @ 10 kg plant^{-1} and 75% recommended dose of fertilizer along with FYM @ 10 kg plant^{-1} recorded lower benefit-cost ratio due to high cost of inputs (FYM) than other organic sources (*Wellgro* manure).

Table 2. Effect of integrated nutrient management on economics of banana cultivation.

Treatments	2010-11					2011-12				
	Cost of cultivation (Rs. ha^{-1})	Yield (t ha^{-1})	Gross income (Rs. ha^{-1})	Net income (Rs. ha^{-1})	B: C ratio	Cost of cultivation (Rs. ha^{-1})	Yield (t ha^{-1})	Gross income (Rs. ha^{-1})	Net income (Rs. ha^{-1})	B: C ratio
T_1	133777	64.64	323200	189423	2.42	132566	65.79	328950	196384	2.48
T_2	136097	70.05	350250	214153	2.57	134886	74.67	373350	238464	2.77
T_3	138447	72.77	363850	225403	2.63	137236	77.12	385600	248364	2.81
T_4	128402	63.97	319850	191448	2.49	126591	65.74	328700	202109	2.60
T_5	130142	68.48	342400	212258	2.63	128331	68.63	343150	214819	2.67
T_6	134177	66.9	334500	200323	2.49	132966	67.96	339800	206834	2.56
T_7	127062	62.47	312350	185288	2.46	125051	64.05	320250	195199	2.56
T_8	136097	68.62	343100	207003	2.52	134886	71.43	357150	222264	2.65
T_9	138447	70.96	354800	216353	2.56	137236	75.85	379250	242014	2.76
T_{10}	128402	64.58	322900	194498	2.51	126591	66.49	332450	205859	2.63
T_{11}	130142	65.2	326000	195858	2.50	128331	66.08	330400	202069	2.57
T_{12}	164277	72.49	362450	198173	2.21	163066	77.06	385300	222234	2.36
T_{13}	157162	64.97	324850	167688	2.07	155351	66.9	334500	179149	2.15

Data statistically not analyzed

Conclusions

From the field investigations, it is concluded that banana responded favourably to *Wellgro* organic manure and FYM in combination with chemical fertilizers. Combined application of 100% RDF either with *Wellgro soil* or FYM @ 10kg plant^{-1} positively influenced the yield attributes along with economics. Taking into consideration of the yield of banana, it is inferred that application of 100% RDF along with either 40% *Wellgro soil* or FYM @ 10kg/plant could be a viable practice where resources are abundant. Application of 75% RDF along with 40% *Wellgro* organic manures also responded well and recorded high B: C ratio due to less quantity of input. It can be considered where resources are limited. Though FYM treated plot was prominent in higher yield and gross income, but, it recorded the lowest net return and benefit cost ratio due to high cost of input. So, it can be recommended to the farmers producing FYM on their own.

Hence, the integrated nutrient management practice of 100% recommended dose of fertilizer combined with 40% *Wellgro soil* in banana crop has been found to be an ideal option to improve yield besides being economically competitive and productive under the soil and climatic conditions of Western zone of Tamil Nadu.

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