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INFLUENCES OF ORGANIC MANURES AND AMENDMENTS IN SOIL PHYSIOCHEMICAL PROPERTIES AND THEIR IMPACT ON GROWTH, YIELD AND NUTRIENT UPTAKE OF BANANA

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ABSTRACT
An investigation was carried out during 2010-2011, to study the effect of organic manures (Farmyard manure, Vermicompost, Neem cake and Wood ash), organic amendments (*Arbuscular mycorrhizae*, *Azospirillum*, *Phosphate Solubilising Bacteria* and *Trichoderma harzianum*) and green manures (Sunhemp and Cowpea) in comparison with inorganic fertilizers on leaf nutrient and soil physiochemical properties of banana *cv*. Grand Naine. The treatment T_{10} with the combined application of organic manures, amendments and green manures (Farmyard manure @ 10 kg + Neem cake @ 1.25 kg + Vermicompost @ 5 kg and Wood ash @ 1.75 kg /plant + Triple green manuring with Sunhemp + Double intercropping of Cow pea + biofertilizers viz., Arbuscular Mycorrhizae @ 25 g , *Azospirillum* @ 50 g, *Phosphate Solubilizing Bacteria* @ 50 g and *Trichoderma harzianum* @ 50 g/plant) registered the maximum growth, yield and yield attributes, leaf nutrient status of N, P and K at 5th and 7th month after planting and soil physiochemical properties at harvesting stage because the role of organic manures and amendments to make the soil has healthy as well as possible and also, the unavailable form of soil nutrients to available form by enhancing mineralization and solubilization process in soil by adding organic manures and microbial agents make easy uptake of nutrients when crop required comparing to chemical fertilizers.

INTRODUCTION

Bananas (*Musa* sp.) are the fifth largest agricultural commodity in world trade after cereals, sugar, coffee and cocoa, and the second largest fruit crop in the world. They are a major staple food crop for many millions of people in areas of Central, East and West Africa, Latin America and the Caribbean. Banana being an exhaustive crop, the proper manuring and fertilizer application has to be resorted for obtaining highest yields. With changing scenario of banana production, efficient nutritional management system needs emphasis for reduced cost of production and increased productivity. During the last four decades, indiscriminate use of inorganic fertilizers, pesticides and fungicides without any organic manure caused environmental pollution, especially in soil thereby affecting its fertility on long term basis. An unabated upraise in the use of chemical fertilizers can inflict irreparable damage to land and environment (Katyal, 1989). Increasing fertilizer use may not give the expected yield particularly in areas where it is being used. Experts point out that the fertilizer use efficiency is only 30-35 per cent and the remaining 65-70 per cent of nutrient reached the underground water resources in the form of nutrient, which along with phosphates pollutes water bodies. To avert this, immeasurable decrease in fertilizer consumption without compromising on yield and quality can be achieved if the nutrient supply is given through the application of other nutrient generating components such as organic manures, biofertilizers and biocontrol agents not only to prevent contamination of food by chemicals but also to make sick soil healthy and productive. Banana response to organic manures and amendments (biofertilizers) were studied by many investigators. Bhalerao *et al*. (2010) reported that application of 25 % N through FYM + 75 % through inorganic fertilizer significantly increased the growth growth and yield parameters with reduced crop duration in banana cv. Rajapuri. Gaikwad *et al*. (2010) reported that application of 100 % RDF + *Azospirllium* @ 50 g / plant + PSB @ 50 g / plant + AMF @ 250 g / plant + *T. harzianum* @ 50 g / plant significantly increased the growth and yield attributes of banana *cv*. Grand Naine. Hazarika and Ansari (2010) revealed that in banana, combined application of fertilizer at 110:35:330 g NPK / plant + FYM 12 kg / pit + *Azospirillium* @ 50 g/ plant + PSB @ 50 g/ plant significantly increased the vegetative and reproductive characters of banana *cv*. Jahaji. Therefore, the present investigation was carried out to study the effect of organic manures and amendments on growth, yield, nutrient uptake and soil Physiochemical properties of banana cv. Grand Naine.

MATERIALS AND METHODS

The present investigation was carried out at Horticultural College and Research Institute, TNAU, Coimbatore, during the year 2010-11 with banana (*Musa* AAA) cv. Grand Naine.

The experiment was laid out in a Randomized Block Design with twelve treatments and four replications. The treatments comprised of organic manures, amendments and green manures *viz.,* FYM @ 10kg/plan + Neem Cake @ 1.25kg/ plant + Vermicompost @ 5 kg/plant and Wood ash @ 1.75 kg/plant (T_1), FYM @ 10kg/plant + Neem Cake @ 1.25kg/ plant + Vermicompost @ 5 kg/plant and Wood ash @ 3.75 kg/plant (T_2), FYM @ 15kg/plant + Neem Cake @ 1.875kg/ plant + Vermicompost @ 7.5 kg/plant and Wood ash @ 625 g/plant (T_3), FYM @ 15kg/plant + Neem Cake @ 1.875kg/ plant + Vermicompost @ 7.5 kg/plant and Wood ash @ 2.625 kg/plant (T_4), Control - absence of organic and inorganic sources (T_5), Triple green manuring with Sunhemp + Cow pea + Cow pea as inter - crop (T_6), Arbuscular Mycorrhizae @ 25 g/plant + *Azospirillum* @ 50 g/plant + *PSB* @ 50 g and *Trichoderma harzianum* @ 50 g/plant (T_7), $T_1 + T_6$ (T_8), $T_1 + T_7$ (T_9), $T_1 + T_6 + T_7$ (T_{10}) and the absolute control treatments (inorganic) 300: 100: 300 g NPK /plant (T_{11}), 110 : 35 : 330 g NPK /plant (T_{12}).

The recommended spacing of 1.8m x 1.8m was adopted for planting of suckers *cv*. Grand Naine obtained from organic field were planted for all the treatments. FYM and Neem Cake were applied as basal dose, Vermicompost, *Arbuscular mycorrhizae*, *Azospirillium*, *Phosphate solubilizing bacteria* and *Trichoderma harzianum* were applied after three month of planting and Wood ash was applied after five month of planting and the inorganic fertilizers were applied as three levels in 3rd, 5th and 7th month after planting of suckers. Recommended cultural practices (except nutrient management) and plant protection measures were carried out regularly.

Recording growth, yield and yield attributing characters

Four uniform plants were selected randomly in each treatment for recording the following observations on growth and yield characters of banana at vegetative and reproductive stage of plants. Height of pseudostem was measured from the base of the trunk to the axis of the youngest leaf and girth was measured at 30 cm height from the ground level expressed in centimeters (cm). The leaf area index was calculated using the formula suggested by Watson (1952). For yield and yield attributes the bunch weight was recorded including the peduncle measuring 20 cm above the first hand and expressed in kilograms (kg). The following finger characters were recorded from the middle finger of the second hand. Five middle fingers in the top and bottom rows of the second hand were selected as representative fingers (Gottreich *et al.,* 1964) to record the average weight of fingers. Pulp and peel weight was measured by weighing the fruit pulp and peel after removing the peel and expressed in grams (g).

Estimation of leaf nutrient status

Leaf samples were collected from both the sides of the midrib in the mid portion of the third youngest leaf (Hewitt, 1955) at 5th and 7th MAP, dried and analyzed. Nitrogen content was estimated by Micro Kjeldhal method (Humphries, 1956), phosphorus was estimated in a triple acid extract by adopting Vanado molybdate phosphoric yellow colour method (Jackson, 1973) and potassium was estimated by reading the flame photometer values of triple acid extract (Jackson, 1973) and the values are expressed in percentage.

Estimation of soil physical properties

A 'V' shape cut was made to a depth of 15 cm at each sampling spot. About 1.5 cm thick slices of soil were removed and collected in clean polythene bags. Samples of the same treatments were mixed thoroughly and the quantity was reduced by quartering for analysis. Determination of bulk density, particle density and porosity were described by using methods of Piper (1996).

Estimation of soil chemical properties

A 'V' shape cut was made to a depth of 15 cm at each sampling spot. About 1.5 cm thick slices of soil were removed and collected in clean polythene bags. Samples of the same treatments were mixed thoroughly and the quantity was reduced by quartering for analysis. Soil chemical properties like pH was estimated by using the pH of 1:2 soil and water suspension was determined using a pH meter model – 3310 of Jenway Company. The electrical conductivity of soil was estimated by measuring the electrical conductivity of 1:2 soils – water suspension in Elico Conductivity Bridge. The soil organic carbon content was estimated (Walkley and Black's titration method, 1934). The available soil nitrogen, phosphorous and potassium contents were estimated by using

Table 1: Effect of organic manures and amendments on growth, yield and yield attributes of banana cv. Grand Naine

Treatments	Pseudostem height (cm)	Pseudostem girth (cm)	Number of leaves	LAI	Yield (Kg/plant)	Finger weight (g)	Pulp weight (g)	Peel weight (g)
T_1	196.25	66.25	12.48	2.53	20.83	245.56	166.52	56.38
T_2	196.25	66.75	13.65	2.42	22.45	245.27	167.96	57.46
T_3	198.75	66.50	12.45	2.48	23.39	241.23	165.21	55.23
T_4	202.25	66.32	13.15	2.85	22.49	230.76	154.53	52.29
T_5	178.75	60.51	11.56	2.29	16.36	205.23	135.27	46.23
T_6	184.50	65.24	12.97	2.78	20.59	218.52	142.25	48.39
T_7	194.25	67.75	13.08	3.04	19.82	254.53	173.26	58.75
T_8	189.75	66.75	12.54	2.67	20.32	265.72	179.18	61.66
T_9	190.00	68.39	13.79	3.24	24.06	270.67	184.92	63.54
T_{10}	218.00	69.53	14.56	3.79	27.96	280.25	194.13	65.27
T_{11}	225.25	72.25	12.96	2.79	24.47	228.15	150.88	51.26
T_{12}	221.75	70.25	13.43	3.22	26.93	231.24	153.62	51.54
SEd	2.70	0.81	0.18	0.04	1.01	3.68	1.89	0.82
CD (0.05)	5.49	1.66	0.36	0.09	2.06	7.48	3.84	1.66

LAI - Leaf Area Index

Table 2: Effect of different organic manures and amendments on leaf nitrogen, phosphorous and potassium (per cent) in banana *cv.* Grand Naine

Treatments	5th MAP			7th MAP		
	N (%)	P (%)	K (%)	N (%)	P (%)	K (%)
T_1	2.46	0.17	3.41	2.63	0.49	3.67
T_2	2.57	0.18	3.54	2.78	0.50	3.74
T_3	2.68	0.19	3.42	2.83	0.51	3.62
T_4	2.76	0.21	3.55	2.82	0.53	3.78
T_5	2.09	0.12	2.93	2.25	0.29	3.31
T_6	2.33	0.14	3.03	'2.56	0.32	3.42
T_7	2.86	0.19	3.62	2.96	0.48	3.89
T_8	2.55	0.20	3.32	2.72	0.51	3.47
T_9	2.97	0.23	3.67	3.08	0.53	3.85
T_{10}	2.99	0.27	3.84	3.16	0.56	3.92
T_{11}	2.78	0.21	3.60	2.93	0.52	3.78
T_{12}	2.65	0.19	3.53	2.87	0.49	3.76
SEd	0.34	0.01	0.05	0.03	0.01	0.05
CD (0.05)	0.07	0.01	0.09	0.06	0.02	0.11

Table 3: Effect of different organic manures and amendments on physiochemical properties of experimental soil at harvesting stage in banana *cv.* Grand Naine

Treatments	B. D. ($g.cc^{-1}$)	P. D. ($g.cc^{-1}$)	Porosity (%)	Soil pH	Ec ($m.mhos.cm^{-2}$)	SOC (%)	N (Kg ha^{-1})	P (Kg ha^{-1})	K (Kg ha^{-1})
T_1	1.18	2.52	53.56	7.84	0.35	0.14	172.36	13.53	452.36
T_2	1.21	2.56	51.63	7.86	0.37	0.15	175.87	13.36	453.25
T_3	1.17	2.51	52.85	7.83	0.33	0.13	177.14	13.45	455.65
T_4	1.20	2.58	51.76	7.85	0.32	0.13	179.27	13.89	453.87
T_5	1.23	2.53	52.38	7.89	0.39	0.11	164.82	12.34	438.57
T_6	1.25	2.53	52.85	7.82	0.38	0.13	166.60	12.89	440.76
T_7	1.21	2.54	52.76	7.84	0.33	0.13	187.94	16.53	456.03
T_8	1.23	2.56	53.18	7.85	0.37	0.14	182.36	15.26	458.23
T_9	1.26	2.55	53.89	7.86	0.34	0.13	189.56	16.87	461.57
T_{10}	1.24	2.56	53.96	7.83	0.32	0.14	193.27	15.97	461.76
T_{11}	1.31	2.63	50.87	8.41	0.43	0.13	171.86	14.20	457.47
T_{12}	1.29	2.67	49.31	8.43	0.40	0.12	173.25	13.87	458.56
SEd	0.02	0.04	0.71	0.123	0.004	0.002	2.35	0.21	5.08
CD (0.05)	0.04	0.08	1.45	0.25	0.01	0.004	4.77	0.42	10.33

B.D - Bulk Density, P. D – Particle density, Ec – Electrical conductivity, SOC – Soil organic carbon, N – Nitrogen, P – Phosphorous and K – Potassium

alkaline potassium permanganate method (Subbiah and Asija, 1956), Klett Summerson colorimeter with red filter at 600 nm (Olsen *et al.,* 1954) and flame photometer (Hanway and Heidal, 1952) and the values were expressed as kg ha^{-1}.

RESULTS AND DISCUSSION

Growth and yield of banana

The growth characters like pseudostem height (225.25 cm) and girth (72.25 cm) was maximum in the treatment T_{11} (300: 100: 300 g NPK/plant) this might have been due to the effect of chemical fertilizers that supply the nutrients in readily available form to the plants immediately after application (Upadhyay, 1988) and more particularly with respect to nitrogen which helped in increasing the values of pseudostem height and girth (Table 1). The absorbed nitrogen ultimately leads to the formation of complex nitrogenous substances like proteins and amino acids to build up new tissues. The treatment T_{10} with combined application of organic manures, amendments and green manures registered the maximum leaf area index (3.79) and more number of leaves (14.56), bunch weight (27.96 kg), Finger weight (280.25 g) pulp weight (194.13 g) and peel weight (65.27 g) compared to inorganic treatments and control at harvesting stage due to the organic nutrient application might have first improved the internal nutritive condition of plant leading to increased growth and vigour associated with photosyn-thesis by which the organic sources of nutrients accelerated mobility of photosynthates from source to sink as influenced by the growth hormones and finally translocation of assimilates into the fruits (Sharma *et al.,* 2013). And also the vermicompost had the combined effect of various ingredients such as macro (N, P and K) and micro (Ca, Mg, Mn, Fe, S, Zn and Cu), plant growth hormones (IAA, IBA and GA), vitamins, enzymes (Adhikary and Gantayet, 2012). The efficiency of bio-agents can be well exploited with the use of organic manures and biofertilizers which might have improved the yield parameters through better availability and uptake of nutrients from plant roots and enhancing the source sink relationship and thereby increasing the movement of carbohydrates from the leaves to the fruits. Also, the enhancement in growth attributes of banana due to *Azospirillium* may be on account of its direct role in nitrogen fixation, uptake of nutrients more specifically nitrogen and also due to the production of phytohormones like indole acetic acid, gibberellins, cytokinin like substances Tien *et al.,* (1979).

Leaf nutrient status of banana

Plant nutrient analysis is more helpful for assessing the content

of nutrient in plant system (Turner, 1979). The actual nutrient concentrations, contents and the rate of changes of these nutrients during vegetative growth and transitional period between the vegetative and the reproductive phase might eventually determine the final reproductive mass. The leaf nutrient content in the leaf lamina of the present investigation revealed that the treatments T_{10} followed by T_9 at 5th and 7th MAP recorded the highest nutrient contents of N, P and K over the other treatments indicating that the critical level of NPK was maintained throughout the crop period. This might be due to the application and interaction between organic and bio fertilization treatments that resulted in the highest uptake of leaf nutrient contents like nitrogen, phosphorous and potassium (Table 2).

The increase in available nitrogen due to application of FYM, vermicompost and biofertilizer during mineralization convert organically bound N to inorganic form resulting in higher available nitrogen of soil. Similar results were also reported by Chavan *et al*. (1997) and Tolanur and Badanur (2003). Leaf phosphorus content observed at 7th MAP in the present study was due to the release of organic acids during microbial decomposition of organic matter that have helped in solubility of native phosphorus. The increase in P uptake with application of FYM along with biofertilizers may be attributed to better availability of P in rhizosphere. The complex organic anions chelate Al^{+3}; Fe^{+3} and Ca^{+2} decrease the phosphate precipitating power of these cations and thereby increase the phosphorus availability (Reddy *et al*., 2005). Also, Phosphobacteria might have helped in solubilising phosphorous that were immobilized and fixed in soil to utilizable form and aided in easy uptake (Krishnamoorthy and Rema, 2004). The increased availability of potassium might be due to the solubilisation action of certain organic acids produced during decomposition of organic manures and green manures and its greater capacity to hold K in available form in soil and also due to the interaction of organic matter with clay and direct addition of potassium to the available pool of soil.

Physiochemicalproperties of experimental soil

The soil organic carbon content was maximum in the treatment T_2 (0.15 per cent) followed by T_{10}, T_8 and T_1 which were on par with each other and with the same value of 0.14 per cent due to the supplementation of FYM, biomulching, green foliage lopping of glyricidia and sunhemp manuring in green gram increase organic carbon content in the soil from 1.79 to 3.92 per cent. The available soil nitrogen, phosphorous and potassium contents significantly different with different treatments (Table 3). Among the different treatments, the treatment (T_{10}) recorded the highest soil nitrogen (193.27 Kg / ha) and potassium (461.76 Kg /ha) while the highest soil available phosphorous contents were recorded in the treatment (T_9) 16.87 Kg / ha. The increase in soil N, P, K in the plots receiving both inorganic manures and amendments might be due to the consistent supply of organic matter and essential nutrients for plant growth. These results are in confirmation with the findings of Taiz and Zeiger (1998) who reasoned out that organic amendments had improved the physical structure of soil, enhanced the water retention during drought and increased the drainage in wet condition.

The highest soil nitrogen observed in soils applied with T_{10} may be attributed to the better availability of nitrogen from organic manures, green manures and biofertilizers (AMF, *Azospirllium,* PSB and *T. harzianum*) coupled with related nitrification process enabling the presence of nitrogen for a longer period in the soil dre to the regular application of organics and subsequently their decomposition resulted in gradual build up in available N, which might be due to direct addition of the N through organics and greater multiplication of soil microbes, which could mineralize the organically bound N to inorganic form. Inoculation of phosphobacteria resulted in the increased availability of phosphorous, since these bacteria helps to degrade the complex forms of phosphate into more soluble and simple forms of phosphorous. The present investigation is in agreement with that of Gaur (1985). Application of FYM, which helps to convert into soil humus substances and mobilization of potassium due to the exchange reaction with soil particles. This is in corroboration with the previous works of Adherkhin and Belyayer (1971). *Azospirillum* may also be ascribed to enhance the availability of potassium. Application of organics showed higher available P and K rather than direct addition through inorganic sources. The organic materials form a cover on sesquioxides, thus reducing the phosphate fixing capacity of the soil and solubilisation of insoluble P fractions resulting into release of available P.

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