

Original Research Article

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## Effect of Organic Manures on Physical, Chemical and Biological Properties of Soil and Crop Yield in Fingermillet-Redgram Intercropping System

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### ABSTRACT

Field experiment was conducted at University of Agricultural Sciences, Bangalore with an objective to enhance productivity of finger millet intercropping in organic system of production during Kharif 2006 and 2007. Different organic manures at 50 kg N equivalent used in the experiment are Farm yard manure (FYM), sewage sludge, poultry manure compost (PMC), urban garbage compost, enriched urban garbage compost and vermicompost (VC) compared to inorganic fertilizers alone. Irrigation water was provided during dry spells throughout the crop growth period. Application of sewage sludge recorded highest Soil microbial population viz., bacteria, fungi, actinomycetes population, microbial biomass carbon and microbial biomass N (23.54 X 10<sup>7</sup> cfu/g, 25.65 X 10<sup>4</sup> cfu/g and 23.04X10<sup>3</sup> cfu/g, 2131.8 mg/g and 239.7 mg/g of soil, respectively) followed by poultry manure compost and lowest in inorganic fertilizer. Organic sources of nutrients tended to improve soil physico-chemical properties viz., bulk density, water holding capacity, porosity and organic carbon. The highest organic carbon content was noticed with the application of sewage sludge (0.68 %) followed by poultry manure. Significantly higher grain and straw yield of Finger millet (2498 and 4075 kg ha<sup>-1</sup> respectively), redgram grain and stalk yield (370 and 1407 kg ha<sup>-1</sup>) was recorded with application of sewage sludge followed by poultry manure compost over all other treatments.

#### Keywords

Properties of soil, Finger millet, Redgram, Sewage sludge /Poultry manure

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### Introduction

In recent energy crisis, hike in the prices of the inorganic fertilizers and declining soil health and productivity necessitate the use of organic manures compulsorily in agricultural

crop production. The continuous use of inorganic fertilizers under intensive cropping system has caused widespread deficiency of secondary and micronutrients in soil (Anon, 2005). Green revolution brought about a great change in Indian agriculture, which was

rightly termed as "from begging bowl to bread basket". This was mainly achieved with high yielding, fertilizer responsive crop cultivars and increased fertilizer use led to deterioration of land and soil health there by slowly reduced the productivity (Mukesh Kumar Pandey *et al.*, 2008). Ragi + Redgram intercropping system (8: 2) under rainfed condition is a common practices in southern Karnataka. It can be evaluated as an additive intercrop Redgram would increase the productivity of soil and cropping system besides helps to supply protein to the farmers.

The research evidences conspicuously indicated that the yield advantages are possible through protective irrigation in inter cropping over sole cropping. It is necessary to manage the soil moisture through protective irrigation. Although the millet crops are reported to be most tolerant to moisture stress but even for short period of moisture stress during critical stages of growth, markedly reduces the yield (Udayakumar *et al.*, 1986). The information on sustainable productivity of fingermillet and pigeonpea with use of organic manures in fingermillet based intercropping system is very meagre. The present study was undertaken to evaluate the Finger millet and Pigeonpea intercropping system under organic production system.

### **Materials and Methods**

Field experiment was conducted during the *Kharif* season of 2006 and 2007 at Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore. The soil of the experimental site was red sandy loam in texture classified under the order *Alfisols*, Vijapura series, isohyperthermic family of *oxihaplustaf*. pH was slightly acidic (6.44) having low cation exchange capacity (7.50 C mol kg<sup>-1</sup>) with an electrical conductivity of 0.23 dSm<sup>-1</sup>. The organic carbon content was 0.47 per cent. The soil was low in available

nitrogen (202.8 kg ha<sup>-1</sup>), high in available phosphorus (26.2 kg ha<sup>-1</sup>) and medium in available potassium (217.10 kg ha<sup>-1</sup>). The average annual rainfall was 927 mm distributed in 62 rainy days (> 2.5 mm). An amount of 595 mm and 690 mm of rainfall was received during cropping period in 2006 and 2007 respectively. It was slightly lower than the normal rainfall (24.3 and 5 per cent respectively).

The experiment was laid out in RCBD with four replications. The treatments comprised of different organic sources of nutrients such as FYM, sewage sludge, poultry manure compost (PMC), urban garbage compost, vermicompost (VC) and enriched urban garbage compost were applied equivalent to recommended nitrogen basis and compared with recommended inorganic fertilizers (50:40:25 kg NPK/ha). The information on nitrogen content and quantity of organic manure used in the experiment is presented in Table 1.

### **Soil Physical Properties viz.,**

Bulk density of soil was recorded by Keen's cup method developed by Piper (1966). It is recorded after harvest of crops from each plot and expressed in g cm<sup>-3</sup>. Maximum water holding capacity was recorded by Keen's cup method developed by Piper (1966). It is recorded after harvest of crops from each plot and expressed in percentage. Per cent of pore space of soil was recorded by Keen's cup method developed by Piper (1966). It is recorded after harvest of crops from each plot and expressed in percentage.

### **Enumeration of soil micro organisms**

The rhizosphere soil samples collected from experiments were analyzed for different soil micro organisms *viz.*, total bacteria, total fungi and total actinomycetes, using standard

dilution plate count technique by using specific nutrient media such as Nutrient agar, Martin's Rose Bengal agar and Kuster's Agar respectively. The petriplates were incubated at 30°C for mesophiles and 50°C for thermophiles for three to six days and population was counted and expressed per unit dry weight of substrate.

Microbial biomass C and N -Microbial biomass was estimated following fumigation

$$\text{Biomass C g}^{-1} \text{ soil} = \frac{\text{Ninhydrin reactive in fumigated soil} - \text{Ninhydrin reactive-N in unfumigated soil}}{\text{Weight of the soil sample}} \times 24$$

$$\text{Biomass N g}^{-1} \text{ soil} = \frac{\text{Ninhydrin reactive-N in fumigated soil} - \text{Ninhydrin reactive-N in unfumigated soil}}{\text{Weight of the soil sample}} \times 2.8$$

and extraction method as proposed by Carter (1991). Ninhydrin – reaction nitrogen released during the fumigation of soil was determined by using Ninhydrin reagent. The suspension was filtered using Whatman No. 42 filter paper. In a similar manner unfumigated set of the same soil sample was extracted. The microbial biomass C and microbial biomass N were calculated using the following formulae.

Plant biometric observations were recorded at 30, 60, 90 DAS and at harvest in both the component crops. The weather conditions were favorable for raising crops and protective irrigations were provided during dry spells. Both the component crops were free from pest and diseases by timely prophylactic measures. The experimental data were analysed statistically by following Fischer's method of analysis of variance wherever 'F' test was significant at P=0.05. The results have been compared among treatments based on critical difference at same level of significance.

## Results and Discussion

### Biological properties

Soil microbial population viz., bacteria, fungi and actinomycetes fluctuated in soils due to different organic nutrient sources. Organic matter in soil plays an important role in

supplying nutrients to plants by a process called mineralization but under tropical conditions, the soil organic matter gets depleted faster due to rapid oxidation process (Lathwell and Bouldin, 1981). However, the rate of mineralization depends on rate of microbial activity, which in turn varies with kind of organic matter used its composition and local climatic condition.

Application of sewage sludge recorded highest Soil microbial population viz., bacteria, fungi, actinomycetes population, microbial biomass carbon and microbial biomass N (23.54 X 10<sup>7</sup> cfu/g, 25.65 X 10<sup>4</sup> cfu/g, 23.04X10<sup>3</sup> cfu/g, 2131.8 mg/g and 239.7 mg/g of soil, respectively) followed by poultry manure compost(22.94 X 10<sup>7</sup> cfu/g, 25.53 X 10<sup>4</sup> cfu/g, 22.70 X10<sup>3</sup> cfu/g, 2022.2 mg/g and 229.6 mg/g of soil, respectively) and lowest in inorganic fertilizer (14.14 X 10<sup>7</sup> cfu/g, 17.22 X 10<sup>4</sup> cfu/g, 14.68 X10<sup>3</sup> cfu/g, 1385.7 mg/g and 172.2 mg/g of soil,

respectively) (Table 2). Similar results were found by Anand (1995) that among the microbial population relatively more bacteria in soil because of the availability of simpler carbon compounds for growth of the bacteria and constant activity throughout the crop growth period. The increase in fungal population in treatments amended with different organic substrates was due to synergistic effect in supplying nutrients to microorganisms as these organic manures had higher nutrient composition. This could be due to actinomycetes prefer neutral or alkaline pH and are able to degrade relatively complex organic substances (Sandyarani and Ramaswamy (1996) and Anand (1995).

It may be due to a high microbial activity in soil as a result of faster mineralization and nitrification of dead cells there by an increase in NO<sub>3</sub>-N. It was also reported by earlier workers (Powlson *et al.*, (1987); Goyal *et al.*, (1992). This was attributed to carbon-limited growth after decomposition of organic manures (Aoyama and Nozama, 1993)

### **Physico-chemical properties**

Application of organic sources tended to improve soil physico-chemical properties viz, bulk density, water holding capacity, porosity, organic carbon and available NPK content of soil compared to initial status. Application of organic manures resulted in lower bulk density (1.40 to 1.43 g cm<sup>-3</sup>) and higher water holding capacity (39.95 to 41.53 %) and porosity (41.95 to 43.27 %) after the harvest of crops as compared to inorganic fertilizer (Table 3). They could have increased the looseness of soil resulting in increased soil volume and other favorable soil physical condition as compared to that of inorganic fertilizers. Therefore, it could be concluded that organic manures are good source of nutrients besides improving soil physical environment. Similar results were showed by

Rukmanagada Reddy *et al.*, (2007), Dinesh Kumar (2006), Poornesh *et al.*, (2004), Yogananda (2001) and Reddy *et al.*, (1999) Further, slow and steady rate of nutrient release into soil solution was also responsible for better absorption of nutrients by Finger millet (Devagowda, 1997 and Dosani *et al.*, 1999).

In the present investigation, the electrical conductivity and pH of the soil did not differ significantly among treatments. However, slight increase in pH was observed due to use of poultry manure compost, urban garbage compost and farm yard manure which could have been due to their alkaline nature. While application of recommended dose of fertilizer had maximum pH and electrical conductivity (6.63 and 0.24ds/m, respectively). Further, sewage sludge lowered the pH and EC of soil (6.33 and 0.21 ds/m, respectively) (Table 3). These results are in agreement with the findings of Rukmanagada Reddy *et al.*, (2007), Dinesh Kumar (2006), Poornesh *et al.*, (2004) and Yogananda (2001). Soil organic carbon content was significantly improved by the application of organic manures viz., sewage sludge, poultry manure compost, enriched urban garbage compost, vermicompost, urban garbage compost and farm yard manure as compared to inorganic fertilizer application. The highest organic carbon content was noticed with the application of sewage sludge (0.68 %) followed by poultry manure compost (0.67%). Nevertheless, application of nutrients in organic form would improve the crop growth and leaves behind several residues including crop roots. While, organics distinctly but not significantly had higher carbon content in soil. Perhaps, slow mineralization could lead to organic carbon accumulation in soil. The findings are in agreement with those of Subbaiah and Sree Ramulu (1979) and Dinesh Kumar (2006). Improved soil organic carbon could be mainly responsible for better soil

aggregation, porosity, water holding capacity and nutrient storage in soils. Besides, microbial populations and other flora of rhizosphere could have been enhanced by soil carbon.

### Grain and straw yield of finger millet

Among organic manures, application of either sewage sludge (equivalent to 50 kg N) or poultry manure compost produced higher grain and straw yield (Table 4) lowest by application of FYM. This could be ascribed to the higher nutrient composition (Table 1) coupled with pattern of nutrient release into soil solution to match the required absorption pattern (Anand, 1995).

The production of photosynthates and their translocation to sink depends upon the availability of mineral nutrients besides soil moisture in finger millet. Masthan Reddy *et al.*, (2005), Poornesh *et al.*, (2004) reported application of different organic manures profound impact on finger millet productivity. Many of the earlier reports have also indicated that the soil physico-chemical and biological properties were improved with the favourable application of either sewage sludge or poultry manure *viz.*, water storage,

bulk density, organic carbon, available nutrients, soil pH, EC, CEC and microbial population of the rhizosphere (Jha *et al.*, 2001). Further, slow and steady rate of nutrient release into soil solution was also responsible for better absorption of nutrients by finger millet (Devagowda, 1997 and Dosani *et al.*, 1999).

Sewage sludge contains about 60 per cent of its nitrogen as uric acid, 30 per cent as more stable organic form of N and less than 10 per cent as mineral N. The uric acid rapidly converts N to ammonical form subsequently into available  $\text{NO}_3$  and also contain growth promoting hormones and produce better root growth than fertilizers application. Similar results of higher yield were reported by Dinesh Kumar (2006) in finger millet. Favourable effects of sewage sludge and poultry manure compost on soil pH, EC, redox potential, CEC and microbial population of the rhizosphere is well documented by Reddy and Reddy (1998) and Yogananda and Reddy (2004). Therefore, it could be concluded that sewage sludge and poultry manure compost serves as a good amendment as well as store house of nutrients for plant growth

**Table.1** Composition of organic manures used in the experiment

Organic manure	2006		2007	
	N (%)	Quantity used(t/ha)	N (%)	Quantity used(t/ha)
<b>Farm yard manure</b>	0.55	9.1	0.47	<b>10.6</b>
<b>Urban Garbage Compost</b>	0.75	6.7	0.63	<b>8.0</b>
<b>Sewage Sludge</b>	1.43	3.5	1.24	<b>4.0</b>
<b>Poultry Manure Compost</b>	1.93	2.6	1.71	<b>3.0</b>
<b>Enriched Urban Garbage compost</b>	1.26	4	1.02	<b>5.0</b>
<b>Vermicompost</b>	<b>1.4</b>	<b>3.6</b>	<b>1.33</b>	<b>3.5</b>

**Table.2** Biological properties of soil in finger millet and redgram intercropping system under organic production system (Data pooled over two years)

Treatment	Biological properties of soil				
	Bacteria (1 X 10 <sup>7</sup> cfu g <sup>-1</sup> soil),	Fungi (1 X 10 <sup>7</sup> cfu g <sup>-1</sup> soil),	Actinomycetes (1 X 10 <sup>7</sup> cfu g <sup>-1</sup> soil),	Microbial Biomass-Carbon (µG G <sup>-1</sup> Soil)	Microbial Biomass – Nitrogen (µG/ G <sup>-1</sup> Soil)
Recommended NPK	14.14	16.22	13.68	1385.7	172.2
Farm yard manure	20.10	21.93	19.13	1823.1	212.3
Urban garbage compost	20.10	22.02	19.38	1834.8	212.6
Sewage sludge	23.54	25.65	23.04	2131.8	239.7
Poultry manure compost	22.94	25.53	22.70	2022.2	229.7
Enriched urban garbage compost	21.68	24.42	21.93	1936.2	221.3
Vermicompost	21.30	24.41	21.83	1912.1	219.4
S.Em ±	0.44	0.54	0.43	45.57	4.44
CD at 5 %	1.31	1.63	1.28	136.53	13.31

**Table.3** Physical and chemical properties of soil in finger millet and redgram intercropping system under organic production system (Data pooled over two years)

Treatment	Physical properties of soil			Chemical properties of soil		
	Bulk Density (g cc-1)	Maximum Water Holding Capacity (%)	Porosity (%)	pH	EC ds/m	Organic Carbon (%)
Recommended NPK	1.65	34.96	37.63	6.63	0.24	0.51
Farm yard manure	1.42	40..57	42.47	6.43	0.22	0.59
Urban garbage compost	1.43	39.95	41.95	6.40	0.22	0.59
Sewage sludge	1.40	41.53	43.27	6.33	0.21	0.68
Poultry manure compost	1.41	40.67	43.02	6.35	0.21	0.67
Enriched urban garbage compost	1.40	40.75	42.63	6.36	0.21	0.63
Vermicompost	1.41	40.47	42.24	6.36	0.21	0.62
S.Em ±	0.03	0.69	0.79	0.21	0.01	0.01
CD at 5 %	0.09	2.10	2.35	NS	NS	0.03

Note: Organic manures used were equivalent to recommended dose of 50 kg nitrogen ha<sup>-1</sup>

**Table.4** Productivity of finger millet and pigeonpea as influenced by application of different organic sources of nutrients (Data pooled over two years)

Treatment	Fingermillet			Intercrop Pigeonpea		
	Grain yield (kg ha <sup>-1</sup> )	Straw yield (kg ha <sup>-1</sup> )	Harvest index	Grain yield (kg ha <sup>-1</sup> )	Stalk yield (kg ha <sup>-1</sup> )	Harvest index
Recommended NPK	2045	3293	0.38	295	1137	0.206
Farm yard manure	1934	3307	0.37	263	1021	0.205
Urban garbage compost	2019	3395	0.37	282	1095	0.205
Sewage sludge	2498	4065	0.39	370	1407	0.208
Poultry manure compost	2475	4009	0.39	355	1350	0.208
Enriched urban garbage compost	2337	3769	0.38	335	1287	0.207
Vermicompost	2305	3702	0.38	322	1239	0.207
S.Em ±	51.7	83.7	0.02	7.63	29.83	0.003
CD at 5 %	155.1	251.1	NS	22.85	89.46	NS

Note: Organic manures used were equivalent to recommended dose of 50 kg nitrogen ha<sup>-1</sup>

### Grain and stalk yield of pigeonpea

Application of sewage sludge produced significantly higher pigeonpea grain yield (370 kg/ha) followed by poultry manure compost (355 kg/ha) and lower in FYM application (263 kg/ha) (Table 4). Stalk yield of pigeonpea was also significantly higher with the application of sewage sludge (1407 kg/ha) and poultry manure compost over FYM (1021 kg/ha). The synchrony of improved plant nutrient release and its availability had a profound influence on crop yield. Similar results of higher yield were also reported by Umesh (2002) in finger millet with pigeonpea intercrop; Dinesh Kumar (2006) in soybean and Dosani *et al.*, (1999) in groundnut. Not only the amount of nutrients present in soil but also their availability in rhythm with the pattern of crop growth is important, which in turn could influence on plant growth (Sheshadri Reddy *et al.*, 2004; Rukmanagada Reddy *et al.*, 2007).

In conclusion, application of sewage sludge and poultry manure compost was found to be effective as organic manure in enhancing productivity of soil and intercropping yield in

Finger millet + Redgram. Further, these manures are also cost effective and a potential substitute for chemical fertilizers to replenishing nutrient requirement of crops and found to be sustainable.

Note: Organic manures used were equivalent to recommended dose of 50 kg nitrogen ha<sup>-1</sup>

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