

Original Research Article

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Long term effect of Organic, Integrated and Inorganic Nutrient Management Practises on Soil Properties in a Vertisol

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A B S T R A C T

A long term experiment on paddy for eleven years (2005-06 to 2016-17) was conducted on a clayey textured Vertisol at Agricultural Research Station, Gangavati, UAS, Raichur to compare the influence of organic and conventional farming systems on soil physical, chemical and biological properties of soil with the following treatments viz., T₁: 100 % N through organics, T₂: 75 % N through organics, T₃: Integrated N management (50 % N through organics & 50 % N through organics), T₄: 100 % N through in-organics along with FYM @ 7 t/ha, T₅: 100 % RDF (150: 75:75 kg/ha). The experiment was laid out in a Randomized Block Design and treatments were replicated four times. Results revealed there was no such variation in physical properties of soil, particularly, bulk density and penetration resistance but maximum water holding capacity of soil differed significantly with different farming systems. The higher organic carbon content of 0.85 per cent was recorded due to 100 per cent substitution of N to paddy crop through organics. Available N (228 kg/ha⁻¹) was higher in treatment containing complete organic farming treatment whereas higher available P and K (55.87 & 688.4 kg/ha⁻¹) in treatment receiving 100 per cent N through in-organics along with FYM @ 7 t/ha. The DTPA extractable micronutrients Fe, Mn, Zn and Cu were significantly higher in treatment consisting of 100 per cent organics (7.4, 4.43, 0.73 and 0.56 ppm, respectively).

Keywords

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Introduction

Increased/ indiscriminate use of chemical fertilizers and pesticides during green revolution period resulted in several harmful effects on soil, water and air causing their pollution. This has reduced the productivity of the soil by deteriorating soil health in terms of soil fertility and biological activity. The excess/indiscriminate use of pesticides has led to the entry of harmful compounds into food chain, death of natural enemies and development of resurgence/resistance to pesticides.. It is believed that organic farming can solve many of these problems as this system is believed to maintain soil productivity and pest control by enhancing natural processes and cycles in harmony with environment. In this regard, a study was undertaken to know the impact of different farming system approaches on soil health over a period of 11 years.

Materials and Methods

The present investigation entitled “long term effect of organic, in-organic and integrated nutrient management practices on soil quality parameters” was studied in a Vertisol of TBP command area where paddy (var. BPT-5204) being grown since 2005-06 on a fixed location at ARS, Gangavathi, UAS, Raichur (Northern Dry Zone, Zone 3) of Karnataka state. Experiment consisted of 5 treatments, which were replicated four times and laid out in RCBD design. The treatments were: T₁: 100 % N through organics, T₂: 75 % N through organics, T₃: Integrated N management (50 % N through organics & 50 % N through in-organics), T₄: 100 % N through in-organics along with FYM @ 7 t/ha, T₅: 100 % RDF (150: 75:75 kg/ha). The experimental soil characteristics were: slightly alkaline (pH 8.1); non-saline (EC 0.45 dS/m); and medium soil organic carbon (0.65%) content. Soil available N was low (220 kg/ha); available phosphorus was medium (45.0 kg P₂O₅ /ha);

available potassium was high (650 kg K₂O /ha) .The organic sources used were: crop residue, FYM, neem cake and poultry manure. The recommended dose of inorganic fertilizers were given at the rate of 150:75:75 kg N, P₂O₅, K₂O/ha and 25 kg ZnSO₄ /ha were applied. Nitrogen was given in three equal splits at basal, maximum tillering and panicle initiation stages, while P, K and Zn were given as basal doses only. Through organics (crop residues, FYM, poultry manure & neem cake), N dose was adjusted to recommended level based on their moisture content and ‘N’ concentration on dry weight basis. Recommended cultural practises were followed. Soil quality parameters were recorded as per the standard procedures outlined by Piper (1966), Jackson (1973) and Sadasivam and Manickam (1992).

Physical properties of soil as influenced by different farming system are presented in Table 1.

Bulk density and Soil penetration resistance (PR)

Bulk density and penetration resistance of soil did not vary significantly with application of the organic or inorganic sources of nutrients. However, numerically lower bulk density and penetration resistance value was found in the treatment which received nitrogen through organic sources compared to those received the nutrients through in-organic sources. The similar findings were also reported Boydaş and Turgut (2007) and Katsvairo *et al.*,(2002).

Maximum water holding capacity

Maximum water holding capacity (MWHC) of soil differed significantly among different treatments at surface and subsurface. Significantly higher MWHC values recorded in treatment which received 100 per cent nitrogen through organic sources alone

(T1:74.62 %) compared to that received 100 per cent nitrogen through in-organics (T5:71.87 %). These results are in conformity with findings of Bhatia and Shukla (1982) and Acharya *et al.* (1988) who observed improvement in water holding capacity of soil due to addition of organic manures compared to only inorganic fertilizer application. Application of vermicompost @ 5 tonnes per ha increased MWHC compared to control as reported by Jadhav *et al.* (1993). Build up of soil organic matter and improvement in soil structure by application of residue and FYM to soil were responsible for significant increase in water holding capacity of soil (Sharma *et al.*, 2000).

Chemical parameters of soil as influenced by different farming system are presented in table 2.

Soil reaction and electrical conductivity

The pH and soluble salt content of soil was unaffected significantly by different treatments, consisting of supply of nitrogen through 100, 75 and 50 per cent through organics (T1, T2 and T3) and those supplying 100 per cent N through inorganic sources.

Organic carbon (OC)

Irrespective of the treatments, OC content was higher at surface and appears to decline as the depth increase (Table 2 and fig. 1). The content of OC at surface and subsurface soils in the treatment which received 100, 75 and 50 per cent nitrogen through organics recorded higher OC values (T1: 0.85 and 0.75 %, T2:0.7 and 0.7% and T3:0.68 and 0.6 %, respectively) were higher than that received the N through inorganic sources (T5:0.55 and 0.45 %, respectively). Continuous application of chemical fertilizers for rice over a period of ten years lowered the OC content of soil by about 54.5 per cent. The increase in organic

carbon content of soils under organic farming was quite obvious since the carbonaceous materials contribute to soil organic carbon after their decomposition. These observations are in agreement with the findings of Grawel *et al.* (1981), Sinha *et al.* (1983), Kaushik *et al.* (1984), Gupta *et al.* (1988) and Bhandari *et al.* (1992). Addition of higher quantity of organic manures and longer period of organic farming practice were responsible for buildup of organic carbon in soil. A significant increase in organic carbon content of Vertisol after four years of decomposition of organic manure over fertilizer application was observed by Bellakki and Badanur (1994).

The available major nutrient status of soil as influenced by farming system is presented in Table 3 and figure 2.

Available nitrogen

Available N content of soil at both depths differed significantly. The higher N content of soil recorded in treatment (T1:228.2 and 222.3 kg/ha) which received entire nitrogen through organic sources was on par with all other treatments including that containing recommended dose of fertilizers (T5:210.9 and 184.6 kg/ha, respectively). However, as per soil test rating available N status in the soil was found to be in low category (< 280 kg/ha) in all the treatments. Lower value of available N in fertilizer treated plot might be due to utilization of applied nitrogen by the crop and probably losses of nitrogen through leaching, volatilization etc. On contrary, application of the organic alone or in combination with inorganic fertilizers maintained higher N status in soil, because of the fact that direct addition of N through organics alone or in combination with inorganic fertilizer resulting in slow release of appreciable quantity of N to soil available N pool. An increase in available N by application of vermicompost and FYM was

also reported by Phule (1993) and Pawar (1996). The increase in available nitrogen due to organic matter application is also attributable to the greater multiplication of soil microbes caused by the addition of organic materials which mineralize organically bound N to inorganic form (Bellakki and Badanur, 1994).

Available phosphorus

Available P status was also differed significantly and the value was higher in the treatment which received N through inorganic fertilizer along with FYM @ 7t/ha (T4: 55.87 kg/ha) compared to all other treatment including those supplied with organic sources of nutrients (T1:45.6 kg/ha and T2: 40.1kg/ha) and integration of both organic and inorganic nutrient sources (T3:48.67 kg/ha). The higher available P recorded with application inorganic fertilizer along with FYM may be due to organic acid released from decomposition of organic sources which might have helped in release of insoluble phosphates from the soil and applied inorganic fertilizers. It is agreement with findings of Singh *et al.* (1982) who noticed an increase in available phosphorus content of soil due to incorporation of FYM alone or in combination with inorganic fertilizers and attributed it to the enhanced solubilisation of native phosphorus and added phosphorus by the decomposition product of organic manures. Venkateshwarulu (1983) noticed an increase in available phosphorus with the application of organic residues over a period of five years in red soils of Hyderabad. Tandon (1987) attributed the increase in available phosphorus with FYM application to the contribution of P by the organics to the soil available pool and coating of organic material on sesquioxides which reduces the phosphate fixing capacity of soil. Similar observations were also reported by Bharadwaj and Omanwar (1994). In contrast to soil

available N status, available P content was found to be much higher than soil test rating of high category (> 55kg/ha) in all the treatments.

Available potassium

Irrespective of the treatments available K was highest at surface and observed to decline as depth increases. The K content of surface soils was higher (T4: 688.4 kg/ha) in the treatment which received recommended dose of inorganic fertilizer along with FYM @ 7 t/ha and the lowest (T5:670.7 kg/ha) in the treatment which received inorganic fertilizer alone (T5). The higher available K registered in T4 treatment is due to application of recommended dose of K fertilizer to paddy crop along with gradual release of K from the organic sources. Similar observations of increase in available potassium due to addition of organic manures were made by Grawel *et al.* (1981) and Bharadwaj and Omanwar (1994). Relatively higher available K content found in treatment which received the nutrients through organic sources (T1 or T2) and integration of organic source along with inorganic sources (T3) compared to that receiving inorganic nutrients source alone (T5). This higher level of available K may be ascribed to greater capacity of organic matter to hold nutrients at the exchangeable surface and thereby reduce K fixation and thus help greater availability of K in soil.

DTPA-extractable micronutrients

The data of DTPA extractable micronutrients in soil (Table 4) revealed that available Zn, Fe, Mn and Cu in soil, irrespective of the treatments, were above the critical level concentration required for optimum yield in rice (0.5-0.8, 2.5-4.5, 1.0 and 0.2 ppm ,for Zn, Fe, Mn & Cu, respectively). Application of different organic material recorded comparatively higher available Zn, Fe, Mn and Cu than rest of the treatments. The

slightly higher content of Zn, Fe, Mn and Cu in the treatments consisting of organics is attributed to a formation of stable chalets with organic legends which decrease their adsorption, fixation and precipitation. Organic manures is not only rich source of micronutrients but also provide convenient physical, chemical and biological environment in soil for better nutrient availability. Addition of large quantities of organic manures every year under organic farming practice was the cause for such marked increase in the DTPA-extractable micronutrients.

Microbial population

The treatment which received fully organic manures had significantly more influence on the population of bacteria, fungi and actinomycetes than fully inorganic application (Table 5 & fig. 3).The reason behind this could be to the enhanced organic carbon content of the soil as a result of organic manure application as compared to inorganic fertilizers. Besides this, the application of organic manure would have resulted in increased secondary and micronutrients in the soil, which might have helped to increase the microbial population.

Table.1 Physical properties of soil as influenced by farming systems (after 11 years)

Treatment	Parameters							
	Bulk Density (g cc ⁻¹)		Porosity (%)		Maximum water holding (%) capacity (%)		Penetration resistance(MPa) (MPa)	
	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
T₁: 100 % N through organics	1.29	1.32	52.45	50.66	74.62	77.60	3.82	3.84
T₂: 75 % N through organics	1.31	1.36	50.66	48.01	73.82	76.27	3.92	3.92
T₃: 50 % N through organics & 50 % N through inorganic	1.32	1.37	50.09	48.30	73.32	76.92	3.61	3.86
T₄: 100 % N through in-organics and FYM @ 7 t/ha	1.30	1.39	51.88	50.28	72.07	75.07	3.79	4.17
T₅: 100 % RDF, 150: 75:75 kg/ha	1.34	1.40	50.94	48.49	71.87	73.30	4.03	4.47
SEm ±	0.21	0.02	0.36	0.49	0.59	0.42	0.48	0.34
CD@5%	NS	NS	NS	1.53	1.83	1.11	NS	NS

Table.2 Chemical properties of soil as influenced by farming systems (after 11 years)

Treatment	pH(1:2.5 w/v)		EC (dS m ⁻¹)		OC (%)	
	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
T₁: 100 % N through organics	8.02	8.26	0.56	0.59	0.85	0.75
T₂: 75 % N through organics	7.97	8.42	0.44	0.45	0.70	0.70
T₃: 50 % N through organics & 50 % N through inorganic	7.97	7.82	0.46	0.72	0.68	0.60
T₄: 100 % N through in-organics and FYM @ 7 t/ha	7.88	7.83	0.73	0.75	0.65	0.55
T₅: 100 % RDF, 150: 75:75 kg/ha	7.79	7.76	0.60	0.67	0.55	0.45
SEm ±	0.14	0.18	0.13	0.13	0.06	0.09
CD@5%	NS	NS	NS	NS	0.20	0.26

Table.3 Chemical properties of soil as influenced by farming systems (after 11 years)

Treatment	Available N (kg ha ⁻¹)		Available P ₂ O ₅ (kg ha ⁻¹)		Available K ₂ O (kg ha ⁻¹)	
	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
T₁: 100 % N through organics	228.2	222.3	45.60	43.27	684.2	668.2
T₂: 75 % N through organics	226.7	193.1	40.10	40.10	650.5	640.5
T₃: 50 % N through organics & 50 % N through inorganic	221.3	196.6	48.67	45.60	686.6	675.2
T₄: 100 % N through in-organics and FYM @ 7 t/ha	219.5	208.7	55.87	50.87	688.4	679.7
T₅: 100 % RDF, 150: 75:75 kg/ha	210.9	184.6	37.22	34.22	670.7	665.2
SEm ±	8.78	6.90	1.80	1.20	0.81	0.83
CD@5%	27.05	21.28	5.04	3.60	2.49	2.56

Table.4 Available micronutrient status of soil as influenced by farming systems (after 11 yrs)

Treatments	Fe		Mn		Zn		Cu	
	0-20 cm	20-40 cm						
T₁: 100 % N through organics	7.43	6.63	4.43	3.66	0.73	0.38	0.56	0.55
T₂: 75 % N through organics	7.32	5.97	4.22	3.45	0.51	0.31	0.51	0.43
T₃: 50 % N through organics & 50 % N through inorganic	6.73	6.00	4.34	3.50	0.66	0.25	0.54	0.47
T₄: 100 % N through in-organics and FYM @ 7 t/ha	6.77	5.86	4.01	3.44	0.49	0.28	0.46	0.43
T₅: 100 % RDF, 150: 75:75 kg/ha	7.02	6.31	4.38	3.51	0.67	0.32	0.54	0.52
SEm ±	0.38	0.24	0.22	0.14	0.06	0.04	0.05	0.05
CD@5%	1.18	0.75	0.70	0.45	0.18	0.13	0.16	0.16

Table.5 Microbial population and enzymatic activity of soil as influenced by farming systems

Treatment	Bacteria CFU g ⁻¹ x10 ⁷	Fungi CFUg ¹ x10 ³	Actinomycetes CFU g ⁻¹ x10 ⁷	Dehydrogenase µg TPF d ⁻¹ g ⁻¹	Alkaline phosphatise µg PNP g ⁻¹ h ⁻¹	Glycosidase µg NH ₄ ⁺ /g
T₁: 100 % N through organics	3.80	3.65	3.87	70.0	117.5	32.5
T₂: 75 % N through organics	3.77	2.95	3.85	50.5	101.0	25.0
T₃: 50 % N through organics & 50 % N through inorganic	2.52	2.87	3.75	45.5	74.5	19.2
T₄: 100 % N through in-organics and FYM @ 7t/ha	2.82	2.72	3.77	33.2	71.5	19.0
T₅: 100 % RDF, 150: 75:75 kg/ha	1.50	1.35	3.65	35.7	58.2	17.2
SEm ±	0.07	0.29	0.03	1.51	1.64	0.66
CD@5%	0.21	0.90	0.09	4.67	5.07	2.05

Fig.1 The organic carbon content of surface soil as influenced by farming systems

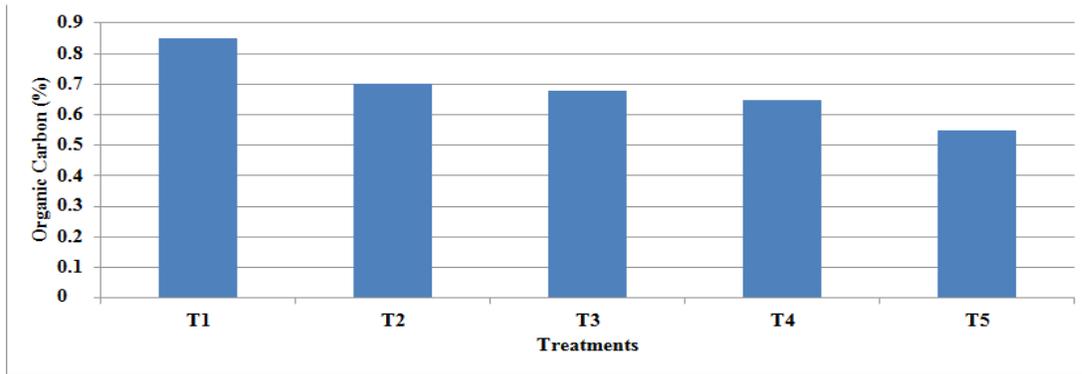
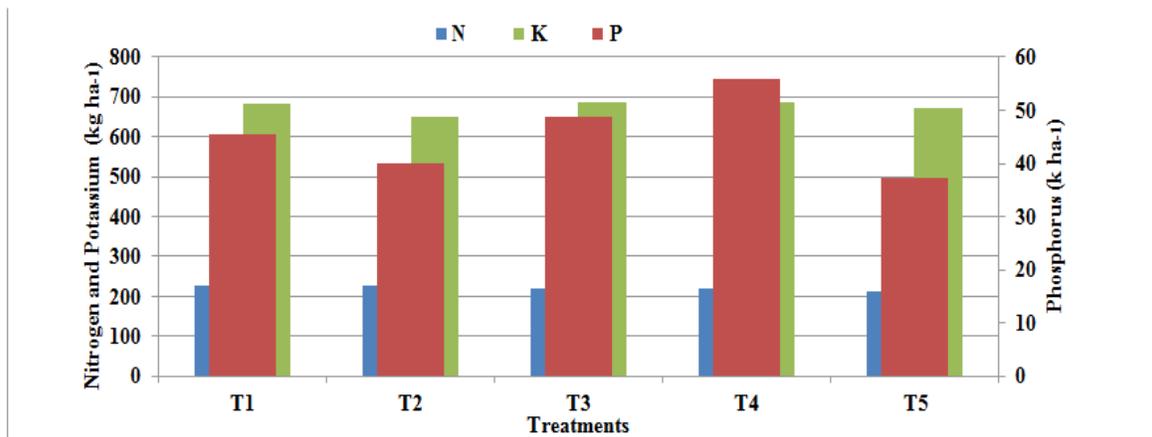


Fig.2 The major nutrient status of surface soil as influenced by farming system



Legend

- T1: 100 % N through organics
- T2: 75 % N through organics.
- T3: Integrated N management (50 % N through organics & 50 % N through inorganic)
- T4: 100 % N through in-organics and FYM @ 7 t ha⁻¹
- T5: 100 % RDF, 150: 75:75 kg ha⁻¹

Fig.3 Bacterial population of surface soil as influenced by farming system

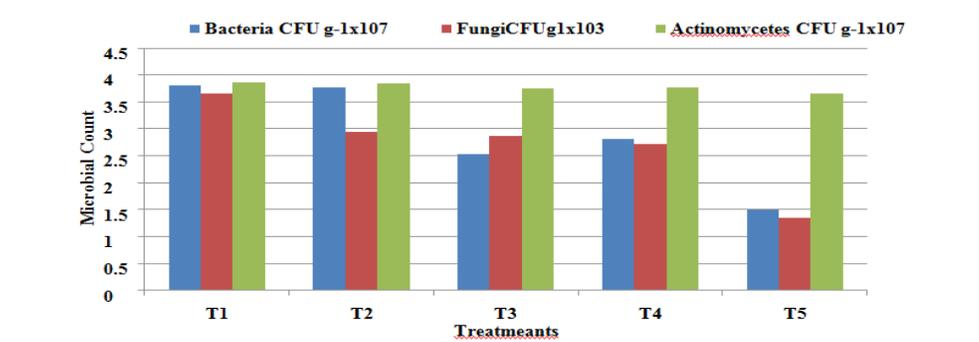
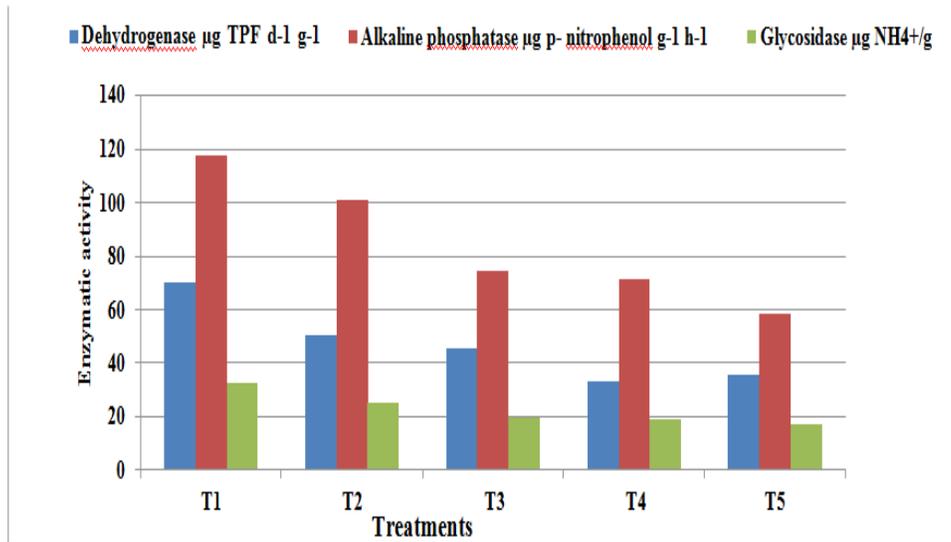


Fig.4 Enzyme activity of surface soil as influenced by farming system



T1: 100 % N through organics; T2: 75 % N through organics; T3: Integrated N management (50 % N through organics & 50 % N through inorganic); T4: 100 % N through in-organics and FYM @ 7 t ha⁻¹
 T5: 100 % RDF, 150: 75:75 kg ha⁻¹

Enzyme activity

Significant difference was noticed among the treatments in respect of enzyme activity, namely, dehydrogenase, phosphatase and glycosidase activity of soil (Table 5 and fig.4). The activity of dehydrogenase (70.3 µg TPF/g/day), phosphatase (117.5 µg PNP/g/h) and glycosidase (32.5 µg NH₄/g) was significantly higher in the treatments that received 100 per cent nitrogen through organic materials compared to that received 100 per cent nitrogen through inorganic source (35.7 µg TPF/g/day, 55.2µg PNP/g/h and 17.2 µg NH₄/g, respectively). The results of the present study are very close to the observations made by Krishnakumar *et al.* (2005) who showed that application of FYM + Neem Cake @ 90 kg N ha⁻¹ recorded highest urease, dehydrogenase activity and the phosphatase activity in the treatment receiving FYM + Neem Cake + Azolla. This might be due to higher organic manure application which would have favoured more microbial populations ultimately more

enzyme activity. Similarly, Ramesh *et al.*, (2010) came out with the results that dehydrogenase, alkaline phosphate, and microbial biomass carbon are higher in organic soils by 52.3%, 28.4%, and 34.4% respectively, as compared to conventional farms.

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