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LONG TERM EFFECT ON ORGANIC AND INORGANIC FERTILIZATION INFLUENCE ON SOIL QUALITY UNDER RICE-WHEAT CROPPING SYSTEM IN *VERTISOL*

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KEYWORDS

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ABSTRACT

An ongoing field experiment was conducted at long term fertilizer experiment (LTFE) , IGKV, Raipur. To study the effect of fertilization (both organic and inorganic) on soil physico-chemical properties of wheat under rice-wheat cropping system in *Vertisol*. Result showed that the highest hydraulic conductivity recorded 100%NPK+FYM and 50%NPK+GM. In general among all the other treatments and control gave poorest hydraulic conductivity. Incorporation of organic sources considerably improved the soil physical properties such as decrease in bulk density and increase in Hydraulic conductivity. Among different treatments, the grain and straw yield of wheat was highest in 150% NPK and 100%NPK+FYM. The long term integrated nutrient management through FYM in 100%NPK+FYM treatment had resulted in highest available N (250 kg/ha), available P (32.2 kg/ha) and available K (492 kg/ ha).Continuous monitoring of physico-chemical properties should be carried out for maintaining soil health, soil quality and enhancing the crop production.

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INTRODUCTION

Soil quality has been considered as one of the most dependable indicator of sustainable production system. A system is said to be sustainable when it improves or at least maintains the quality of soil , water and atmosphere. Soil quality concept has been strongly associated with efforts to address agricultural sustainability (Youngborg,1992; Parr *et al.,* 1992; Warkentin, 1995) and is defined as the capacity of the soil to Perform services including the production of plants animals and the Transport and regulation of matter present in or added to soits (Doran and parkin, 1994; karlen *et al.,* 1998) and the capacity of soil to resist and recover from degradation (Blum, 1998; Greenland and Szabolcs, 1994).

Quality of soil is a composite of and can be determined by physical , chemical and biological properties of the soil. These propertiesnot only are important for the soil's function as a medium for plant growth, but also influence its services as a buffer in the formation and destruction of hazardous compounds (larson and pierce, 1994). they are essential attributes on which the soil's productive capacity and its role as an envirmental moderator depend (action and padbury, 1993; bezdisk *et al.,*1996). consequently maintenance and enhancement of soil quality are dependent upon improvement of physical, chemical and biological properties of the soil that are useful indicators of quality change (doran *et al.,*1996). These changes in long term have significant influence on the quality and productive capacity of the soil. Long term cropping system along with fertilizer application can influence important soil properties such as soil structure, density, pH, quantity and quality of organic matter and nutrient cycle within soil profile (Divya *et al.*, 2012). Organic manures promotes the growth and activity of useful microorganisms in soils. More build up in available N and P is attributed to solubilization of nutrients from their native sources during decomposition and mineralization of organic manures. Organic matter binds soil particles into structural units, thus improves the soil structure and maintains favorable condition for aeration and permeability (Singh *et al.*, 2014).

In the face of regional energy crisis, increase in the cost of fertilizer and growing concern about deterioration of soil health and environmental quality, recycling of organic material is gaining significance in India. An integrated use of both organic manures and chemical fertilizers has emerged as a promising option not only for maintaining higher productivity but also for providing maximum stability to crop production in intensive farming systems. The interactive advantages of combining organic and inorganic sources of nutrients in integrated nutrient management have proved superior to the use of each component separately. Judicious use of organic manures, such as farmyard manure, green manuring and rice straw along with chemical fertilizers improves soil physical, chemical and biological properties and enhance productivity in both the seasons. It is essential to identify such practices which bring more sustainability to the production system, besides improving the productivity of the system and soil health (Urkurkar *et al.*, 2009).Therefore, in order to assess the long term effect on organic and inorganic fertilization influence on soil quality under rice-wheat cropping system in *Vertisol*.

MATERIALS AND METHODS

A long-term experiment was initiated in 1999 on a Vertisol under rice-wheat cropping system. The treatment combinations consist of control (no fertilizer application) and graded levels of NPK. During rainy season, chemical fertilizer were integrated with Farm yard manure (FYM+100 per cent NPK), Green Manure (GM-*Sesbania aculeate*+50 per cent NPK) and Blue Green Algae (BGA+50 per cent NPK) in wheat (Table 1).The soil under study are classified under clay textural class. In *Vertisol* of Chahhtisgarh state the percentage of clay increase with depth. This is might be due to loss of colloidal clay fraction from surface horizon due to heavy rainfall in this region. However, the percent contribution of the soil separates ranged from 20 to 23 per cent Sand, 30 to 34 per cent Silt and 45 to 50 per cent Clay. The soil have reaction and conductivity values within safe limit for most of the field crops, medium in organic carbon status and available N, P and K status was 236 kg ha^{-1}, 16 kg ha^{-1} and 474 kg ha^{-1} respectively (Table 2).

Soil Characteristics

The experimental soil (Vertisol) is fine montmorillonite, hyperthermic, udic chromustert, locally called as *Kanhar* and is identified as Arang II series. It is usually deep, heavy clayey (50 %), dark brown to black in colour and neutral to alkaline in reaction due to presence of lime concentrations. The soil was analyzed for its initial characteristics as per the methods mentioned below and some important physico-chemical properties of the soil are given in Table 3.1. The soil samples were analyzed for soil reaction (pH) and electrical conductivity (EC) using 1:2.5 soil water ratio. Organic carbon was determined using Walkley and Black's rapid titration procedure (Walkley and Black, 1934). Alkaline permanganate method was followed for estimation of available N (Subbiah and Asija, 1956). Available P content was determined spectrophotometrically following the procedure of Olsen using NaHCO3 (pH 8.5) as extractant. Avilable K by flame photometer (Hanway and Heidel, 1952).

Hydraulic conductivity

To determine hydraulic Conductivity, soil samples were collected in brass cylindrical rings with the help of core sampler. It was determined as per constant head method (Kulte and Dirksen, 1965) by using following equation.

$$K = Q.L / H.A.T$$

where,

Q = volume of water flowing out in time (cm^3/ sec),

L = Length of soil column (cm),

A = Cross sectional area (cm^2),

H = Difference in head at inlet and outlet (cm),

T = time (hour),

K = Hydraulic conductivity (cm / hr)

RESULTS AND DISCUSSION

Effect of organic and inorganic fertilization on physical properties (hydraulic conductivity) of wheat crop

The data presented in Table 3 and Fig. 1 indicated that hydraulic conductivity was significantly influenced by different treatments. The 100% NPK + FYM (0.95 cm hr^{-1}) treatment had the highest hydraulic conductivity that was on par with 50% NPK + GM (0.93 cm hr^{-1}) and followed by 150% NPK (0.91cm hr^{-1}) which had statistically high hydraulic conductivity results. The lowest hydraulic conductivity was observed under control (0.71 cm hr^{-1}). The increase in hydraulic conductivity might be due to addition of organic matter and subsequent increase in porosity of soil. The direct addition of organic matter through farm yard manure and increase in root biomass which helped in growth and development of soil micro-organisms causing beneficial effect on improvement in mean weight diameter, available water capacity and hydraulic conductivity. The continuous application of FYM along with inorganic fertilizer increase the hydraulic conductivity as reported by Prasad and Singh (1980). Similar results are in conformity with the findings of Mishra and Sharma (1997). Katkar *et.al* (2012) reported that the application of NPK + farm yard manure @ 10 tonnes/ha recorded higher hydraulic conductivity as compared to 100% NPK and 150% NPK through chemical fertilizers without organics.

Long- term application of organic materials along with fertilizers had significantly increased the saturated hydraulic conductivity. Higher values of soil saturated hydraulic conductivity indicate that long- term application of organic materials along with fertilizers had improved the soil structure due to increased organic carbon content and decreased soil bulk density. The influence of organic materials on hydraulic conductivity also diminished with soil depths as on SOC and bulk density. It was observed that fertilizers alone had also increased the hydraulic conductivity as compared to control. Again, this might be due to higher root biomass accumulated over the years in fertilized plots. Sharma *et al*. (2002) also reported that saturated hydraulic conductivity was higher with

Table 1: Organic and inorganic nutrient management treatments

Treatments	Fertilizer application
T_1	Control
T_2	50% of the recommended optimum NPK fertilizer schedule(50:30:20::N:P_2O_5:K_2O)
T_3	100% of the recommended optimum NPK dose(100:60:40::N:P_2O_5:K_2O)
T_4	150% of the recommended optimum NPK dose (150:90:60::N:P_2O_5:K_2O)
T_5	100% of recommended optimum NPK + $ZnSO_4$ @10kg /ha in *Rabi crops* only (100:60:40::N:P_2O_5:K_2O +$ZnSO_4$)
T_6	100% N and P of recommended N dose of fertilizer (100:60:0::N:P_2O_5:K_2O)
T_7	100% N of recommended optimum N dose (100:0:0::N: P_2O_5:K_2O)
T_8	100%NPK + FYM (5 t /ha in *kharif crop* only)
T_9	50% NPK +BGA (10 Kg/ha dry culture in *kharif* crop only)
T_{10}	50% NPK+GM (Sown in site cut and mixed in soil in *kharif* season only)

Table 2: Some important initial physico-chemical properties of the soil under study

Properties	Value
pH	7.7
EC (dSm^{-1})	0.20
organic carbon (g kg^{-1})	6.10
Available Nitrogen (kg ha^{-1})	236
Available Phosphorus (kg ha^{-1})	16.0
Available Potassium (kg ha^{-1})	474
Bulk density (Mg m^{-3})	1.37
Infiltration rate (cm hr^{-1})	0.5
Soil Texture (%)	
Sand	20
Silt	30
Clay	50
Texture class	Clay

Table 3: Effect of organic and inorganic fertilization on hydraulic conductivity of soil

Rice	Wheat	Hydraulic conductivity
Control	Control	0.71^{e}
50% NPK	50% NPK	0.84^{bcd}
100% NPK	100%NPK	0.86^{abc}
150% NPK	150%NPK	0.91^{ab}
100% NPK + Zn	100%NPK	0.87^{abc}
100% NP	100%NP	0.78^{cde}
100% N	100%N	0.76^{de}
100% NPK + FYM	100%NPK	0.95a
50% NPK + BGA	50%NPK	0.84^{bcd}
50% NPK + GM	50%NPK	0.93^{ab}
Mean		0.84
SEM		0.04
CD at 5%		0.09

*Same superscript shows the non-significant difference at 5%.

long-term application of fertilizers as compared to the control.

Significant residual effects were obtained due to application of organics in rice at both levels.The organics also gave similar effects at both treatments 100%NPK+FYM and 50%NPK+GM levels.

Different treatments effects on aggregation and bulk density were well reflected in hydraulic conductivity. Increasing levels of fertilizers significantly increased the hydraulic conductivity. Combined application of FYM, GM and NPK also resulted in significantly higher hydraulic conductivity than NPK alone (fig). Prasad and Singh (1980) also reported that application of FYM and orable effect on the hydraulic conductivity. Better aggregation and increased porosity as a consequence of the addition of organics had a favorable influence on the physical properties such as hydraulic conductivity that influences the soil water dynamics. Improvement in hydraulic conductivity due to continuous addition of organics in combination with inorganic compared to chemical fertilizers alone was reported by several workers (Nambir and Ghosh, 1984; Bellaki *et al.*,1998).

Effect of organic and inorganic fertilization on chemical cal properties of wheat crop

Soil pH and electrical conductivity

Soil pH is an intrinsic property which is decided by the exchangeable cations on clay surface and taken larger time to get change. The data depicted in Table 4 and indicate soil pH as influenced by various treatments under rice–wheat sequence. Continuous application of fertilizers over the year of cropping resulted slight reduction in soil pH.

The application of different levels of chemical fertilizer supplemented with FYM, BGA and Green manuring in some of the treatments not affected pH significantly. The pH of the soil was not statistically influenced by different treatments.

The application of FYM, rice straw and green manure along with inorganic fertilizers had decreased the soil pH and soluble salt concentration as compared to the fertilizers alone (Table 4). The decrease in soil pH may be attributed to production of organic acids during decomposition of organic materials. Antil *et al.* (2011) also reported decrease in soil pH with the long-term application of farmyard manure under pearl millet- wheat cropping system (Sunil Kumar *et al.*, 2012).

The data indicated that, application of manures and fertilizers caused slight increase in the electrical conductivity of soil irrespective of initial value (0.20 dS m^{-1}). The Electrical Conductivity (EC) of the soil was not significantly influenced by different treatments. The Electrical Conductivity of the soil

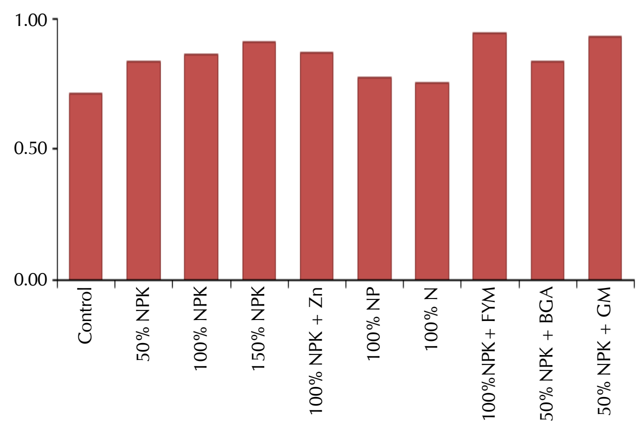

Figure 1: Influence of long- term application of fertilizers and organic materials on soil hydraulic conductivity (cm hr^{-1})

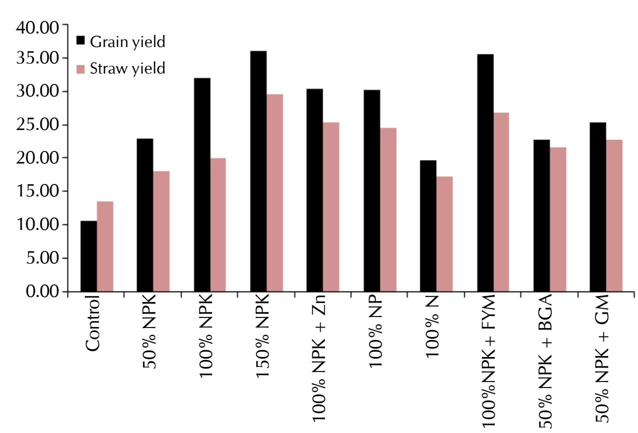

Figure 2: Influence of long- term application of fertilizers and organic materials on yield of grain and straw of wheat.

Table 4: Effect of organic and inorganic fertilization on chemical cal properties of wheat crop

Rice	Wheat	pH	EC (dSm^{-1})	Available nitrogen (kg ha^{-1})	Available phosphorus (kg ha^{-1})	Available Potassium (kg ha^{-1})
Control	Control	7.2^{ab}	0.20^{a}	193^{d}	8.7^{c}	356^{ef}
50% NPK	50% NPK	7.3^{a}	0.22^{a}	223^{c}	21.8^{b}	394^{cdef}
100% NPK	100% NPK	7.2^{ab}	0.22^{a}	242^{a}	24.8^{b}	429^{bc}
150% NPK	150% NPK	7.1^{ab}	0.24^{a}	247^{a}	31.6^{a}	482^{a}
100% NPK + Zn	100% NPK	7.1^{ab}	0.20^{a}	226^{bc}	22.7^{b}	404^{cde}
100% NP	100% NP	7.2^{ab}	0.21a	239^{ab}	25.1^{b}	350^{f}
100% N	100% N	7.1^{b}	0.21^{a}	218^{c}	9.4^{c}	377^{def}
100%NPK+ FYM	100%NPK	7.2^{ab}	0.23^{a}	250^{a}	32.2^{a}	492^{a}
50% NPK + BGA	50% NPK	7.2^{ab}	0.20^{a}	228^{bc}	21.7^{b}	415^{cd}
50% NPK + GM	50% NPK	7.2^{ab}	0.21^{a}	244^{a}	24.1^{b}	465^{ab}
Mean		7.2	0.21	231	22.2	416
SEM		NS	NS	4.64	1.53	16.99
CD at 5%		NS	NS	13.45	4.44	49.32

*Same superscript shows the non-significant difference at 5%.

Table 5: Wheat grain and straw yield in relation to integrated nutrient management

Rice	Wheat	Yield q ha^{-1} Grain	Straw
Control	Control	10.50^{f}	13.45^{f}
50% NPK	50% NPK	22.85^{de}	17.90^{def}
100% NPK	100%NPK	31.95^{ab}	19.85^{cdef}
150% NPK	150%NPK	36.00^{a}	29.55^{a}
100% NPK + Zn	100%NPK	30.30^{bc}	25.30^{abc}
100% NP	100%NP	30.10^{bc}	24.50^{abcd}
100% N	100%N	19.60^{e}	17.15^{ef}
100% NPK + FYM	100%NPK	35.40^{ab}	26.75^{ab}
50% NPK + BGA	50%NPK	22.70^{de}	21.60^{bcde}
50% NPK + GM	50%NPK	25.25^{cd}	22.70^{bcde}
Mean		26.47	21.88
SEM		1.84	2.33
CD at 5%		5.34	6.78

*Same superscript shows the non-significant difference at 5%.

ranged from 0.20 to 0.24 dS m^{-1}.

Available nitrogen, phosphorus and potassium

The available N, P and K were observed higher after application of organic materials along with inorganic fertilizers as compared to fertilizer alone (Table 4). The long term integrated nutrient management through FYM in 100%NPK + FYM treatment had resulted in highest available N (250 kg/ha), available P (32.2 kg/ha) and available K (492 kg/ha). Walia *et al.* (2010) also reported that long-term integrated nutrient management in rice - wheat cropping system increased the availability of N P K nutrients.

The manure and fertilizer application exhibited a significant effect on available nitrogen of the soil. The 100% NPK + FYM plot had significantly greater available nitrogen followed by 150% NPK plot compared to other treatments. Similar trends found in phosphorus and potassium.

Crop yield

The grain and straw yield of wheat also increased with the long-term application of organic materials along with inorganic fertilizers (Table 5 and Fig. 2) as compared to control. The application of 150% NPK (36.00 kg ha^{-1})and 100% NPK+FYM (35.40 kg ha^{-1}) resulted into highest grain and straw yield 150% NPK (29.55 kg ha^{-1}) and 100% NPK+FYM (26.75 kg ha^{-1}) of wheat (Fig. 2). This indicates the potential use of farmyard manure for sustaining the soil productivity. Similar effect of long-term application of FYM on yield of wheat in rice-wheat cropping system was reported by Antil et al. (2011). Although, the yields were recorded lower in treatments having wheat straw and green manure as compared to the fertilizers only, but they might be used promising alternatives for sustainable soil productivity (Sunil Kumar *et al.*, 2012).

Result concluded that the soil physic-chemical properties were affected by organic and inorganic fertilization in present experiment. Soil quality is related with nutrients status, physical and chemical properties of soils. The effect of NPK fertilizers alone and in combination with green manuring (GM), Farm yard manure (FYM) and BGA invertigation have influences soil quality. Study showed that wherever, nitrogen was substituted through GM, FYM or crop residue (rice straw) in rice, Hence, long- term integrated nutrient management by applying organic manures and inorganic fertilizers has potential for improving the soil fertility status for increasing the crop yield for sustainable agriculture. Further, the impact of long-term fertility management on soil biological and biochemical parameters, and their importance to nutrient cycling and crop yields would be addressed as future studies.Continuous monitoring of physical properties should be carried out for maintaining soil health and enhancing the crop production.

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