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Effect Long term fertilizer experiments on Bulk Density, Crack Volume, Soil Organic Carbon stock and Carbon sequestration rate Rice crop

Challa Venu Reddy*, Alok Tiwari, K. Tedia, Anil Verma and R. R. Saxena

Indira Gandi Krishi Vishwa Vidhyalaya, Raipur, Chattishgarh, India

*Corresponding Author E-mail: venureddychalla4u@gmail.com

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ABSTRACT

The permanent plot after fourteen years of rice cropping on Vertisol resulted that the continuous use of farm yard manure, blue green algae and green manure in conjunction with fertilizers decreased soil bulk density and crack volume. 100% NPK+FYM treatment resulted in lowest bulk density (1.29 Mg/m^3) and crack volume (625.73 cm^3/m^2) as compared to other treatments. Soil organic carbon (SOC) sequestration is important for improving soil fertility of cropland and for the mitigation of greenhouse gas emissions to the atmosphere. The efficiency of SOC sequestration depends on the quantity and quality of the organic matter, soil type, and climate. Little is known about the SOC sequestration efficiency of organic amendments in Vertisols. Thus, we conducted the research based on 14 years (1999–2013) of long-term fertilization experiment with a no fertilizer control, 50% NPK, 100% NPK, 150% NPK, 100% NPK+Zn, 100% NP, 100% N, 100% NPK+FYM, 50% NPK+BGA and 50% NPK+GM.. Mean SOC sequestration rate was 0.812 ton/ha/yr in 150% NPK treatment and 0.206, 0.13, -0.662, -0.821, -1.025, -1.082, -1.724, -2.817 and -3.302 t/ha/yr in 100% NPK, 100% NPK+FYM, 50% NPK+GM, 50% NPK, 100% NPK+Zn, 50% NPK+BGA, 100% NP, 100%N and Control respectively.

Key words: *Bulk density, Crack Volume, Soil Organic Carbon, SOC sequestration, Vertisols.*

INTRODUCTION

Fertilizers are usually applied to soil for increasing or maintaining crop yields to meet the increasing demand of food. Application of inorganic fertilizers results in higher soil organic matter (SOM) accumulation and biological activity due to increased plant biomass production and organic matter returns to soil in the form of decaying roots, litter and crop residues. Addition of SOM enhances soil organic carbon (SOC) content, which is an important indicator of soil quality and crop productivity[7]. Sequestration of SOC is key to reduce greenhouse gas emissions and lower the carbon footprint of farming[6]. Fertilizer additions also affect the chemical composition of soil solution which can be responsible for dispersion/flocculation of clay particles and thus, affects the soil aggregation stability[5]. A traditional agricultural practice of applying nutrients was through organic manures such as green manures, farmyard manure (FYM).

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Organic manure applications improved soil physical properties through increased soil aggregation, decrease in the volume of micropores while increasing macropores, increased saturated hydraulic conductivity and water infiltration rate and improved soil water-holding capacity at both field capacity and wilting point. Organic manures and compost applications resulted in higher SOC content compared to same amount of inorganic fertilizers applications[4]. Although, the accumulation of SOM through applied organic manures depends upon the rate of decomposition process. Significantly higher SOM content was found from depth 0–20 cm in winter wheat and summer maize rotation after 13 years of manure application along with NPK compared to non-treated control and only NPK treatment[13]. Several studies have reported that FYM plus inorganic N applications in irrigated systems resulted in reduced bulk density, higher SOC and hydraulic conductivity and improved soil structure and microbial communities[3]. Soil management practices greatly affect the SOM and soil fertility. The SOM levels depend upon factors such as crop rotation, tillage methods, fertility management including use of inorganic fertilizers and organic manures and other components of cropping system. Continuous cultivation of crops has resulted in reduction in SOC and soil physical properties in general. Maintaining SOM concentration above the threshold level is critical for improving soil quality. A judicious combination of organic amendments and inorganic fertilizers is widely recognized strategy of integrated nutrient management (INM) to sustain agronomic productivity and improve soil fertility. Fertilizer applications and crop rotation can regulate C cycling dynamics and soil C storage through its effects on biological activity in soil and the amount and quality of residue returned to the soil. Long-term experiments can be more useful for studying the changes in soil properties and processes over time and for obtaining information on sustainability of agricultural systems for developing future strategies to maintain soil health. Therefore, the objectives of this study were to assess the effect of long-term (14 years) use of farmyard manure and inorganic fertilizers in Rice–wheat rotation on SOC, SOC stock and crop yields.

MATERIAL AND METHODS

A field experiment was conducted on *Vertisol* of Research Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidhyalaya, Raipur, Chhattisgarh. Raipur is situated at 21^0 4' North Latitude and 81^0 4' East Longitude with the altitude of 293 meter above mean sea level.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 slightly 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.1. Treatment details are T_1 - Control, T_2 - 50% of the recommended optimum NPK dose, T_3 - 100% of the rec. optimum NPK dose, T_4 - 150% of the rec. optimum NPK dose, T_5 - 100% of the rec. optimum NPK + $ZnSO_4$ @ 10 kg ha^{-1} in *kharif* crop only, T_6 - 100% NP of rec. optimum N and P dose, T_7 - 100% N of rec. optimum N dose, T_8 - 100% NPK + FYM (5 t ha^{-1} in *kharif* crop only), T_9 - 50% NPK + BGA (10 kg ha^{-1} dry culture in *kharif* crop only), T_{10} - 50% NPK + GM (sown in site and mixed in soil in *kharif* season only). Bulk density was determined by the method as described by Smith and Mullins (1991)[11] on intact soil cores of undisturbed soil. Crack volume was determined by the measurement of crack in one m^2 area of each plot after harvest of crop. The length, width and depth of cracks developed in soil were measured. The length was measured with the help of thread stretched along the crack length and width directly. The depth was measured with a 0.2 mm diameter iron stick pushed into the crack, as described by Sharma *et al*. Analysis of variance (ANOVA) was carried out using the randomized block design method and Least Significance Difference (LSD) was calculated on soil data for treatment means at 5 per cent probability.

The soil organic carbon stock and C-sequestration rate was calculated according to the following equation:

RESULT AND DISCUSSION

Bulk Density

The bulk density of soil at beginning of the experiment was 1.37 Mg/m^3. Graded doses of major nutrients as well as integrated supply of nutrients have significant impact on the bulk density during the crop growth period. Bulk density was considerable less in organic manure plots and significant reduction in bulk density (1.29 Mg/m^3) at flowering stage of the crop was recorded in 100% NPK+ FYM treatment as compared to other treatments (Table.3). However, where organic manures were not incorporated, the bulk density increased over initial value during the course of experiment[9].The bulk density of soil decreased with the application of farm yard manure, green manure and blue green algae in combination with fertilizers. Use of imbalanced fertilizers increased the bulk density (Table.3), which might be due to deterioration of soil structure[2].

Soil Organic Carbon stock and Carbon sequestration Rate

Soil bulk density (BD) decreased in all fertilization treatments but not in the Control treatment (Table.2). The decrease was largest in the treatments receiving 100% NPK+FYM, which suggests that long-term application of organic amendments significantly improved soil physical conditions. The Mean SOC stock over the 14 years of experimental period ranged from 9.43 to 13.55 ton/ha. Higher values were recorded in 150% NPK (13.55 t/ha) followed by 100% NPK+FYM (12.87 t/ha) and the lower values were recorded in Control (9.43 t/ha) followed by 100% N (9.93 t/ha) Table.2 and Fig.1. The mean SOC sequestration rate ranged from -3.302 t0 0.812 t/ha/year in control to 150% NPK treatment. The mean SOC sequestration rate followed the

Soil organic carbon stock (Kg/ha)= D x OC (%) x BD/100

Where D is depth of the soil in cm, OC is soil organic carbon in percentage and BD is bulk density (Mg/m^3).C-sequestration rate (kg ha^{-1} yr^{-1}) = Final SOC (kg/ha) – initial SOC (kg/ha)/ Time(year)

order: 150% NPK > 100% NPK > 100% NPK +FYM>50% NPK+GM>50% NPK>100% NPK + Zn>50% NPK + BGA>100% NP>100%N>Control. These findings are consistant with a large body of evidence indicating that the long-term fertilizer and manure applications in SOC content of vertisols. The results were indicated that SOC sequestration rate changes were related to total 'C' inputs. The relationship between SOC stock and Bulk density was presented in Fig.2. There was a significantly positive linear correlation between SOC stock and Bulk density (R^2=0.295).Soil organic carbon (SOC) sequestration contributes to the mitigation of greenhouse gas emissions and to the improvement of soil fertility[8]. Net SOC sequestration is the balance of organic C inputs into the soil (via crop residues, organic amendments in compost, animal manure, etc.) and organic C decomposition by soil microbes. SOC sequestration efficiency is commonly expressed by the relationship between annual C input and SOC accumulation rate, which is an indicator of soil C sequestration ability[10]. Therefore, information about the C sequestration efficiency is useful for seeking high efficiency management strategies of enhancing the SOC stock and soil fertility. Continuous cropping and integrated use of organic and inorganic fertilizers increased soil C sequestration and crop yields. Balanced application of NPK fertilizers with FYM was best option for higher crop yields in maize–wheat rotation[1].

Crack volume

Cracks are unique feature in soil with high shrink-swell potential. Data presented in Table 3 showed that the highest (1407.36 cm^3m^{-2}) crack volume was recorded in control plot and its lowest (588.06 cm^3m^{-2}) value in treatment 100% NPK + FYM. The present study seems to agree with that increase in crack volume may be due to depth of crack much affected by length of dry period and width of crack is inversely proportional to moisture content of soil. The above results are in close conformity with the findings of Kadam Shivaji Vishwambharrao[12], who reported that increasing dose of chemical fertilizers alongwith organic manures there was decrease in crack volume, where as ommission of chemical fertilizer plot much higher crack volume than optimal and sub optimal application of chemical fertilizer.

Table 1: Some important initial physico-chemical properties of the soil under study

S.no	Properties	Value
1.	Mechanical composition	
	Sand (%)	20
	Silt (%)	34
	Clay (%)	46
2.	Texture	Clayey
3.	Bulk Density (Mg m^{-3})	1.37
4.	Hydraulic Conductivity (mm hr^{-1})	4.8
5.	Infiltration Rate (mm hr^{-1})	5
6.	Soil Classification	Fine montmorillonite hyperthermic, chromustert.
7.	pH - (1:2.5)	7.7
8.	Ec - (ds m^{-1})	0.20
9.	Organic Carbon (g Kg^{-1})	6.2
10.	CEC [c mol (p^+) Kg^{-1}]	38.0
11.	Available Nitrogen (Kg ha^{-1})	236
12.	Available Phosphorus (Kg ha^{-1})	16.0
13.	Available Potassium (Kg ha^{-1})	474
14.	DTPA extract Zn (mg kg^{-1})	1.2

Table 2: Effect of Long term fertilizer and manures on Bulk density, OC, SOC Stock and Carbon Sequestration Rate

Treatments	O.C	SOC stock	Carbon Sequestration Rate
Control	0.44	9.43	-3.302
50% NPK	0.58	11.91	-0.821
100% NPK	0.63	12.94	0.206
150% NPK	0.65	13.55	0.812
100% NPK+Zn	0.55	11.71	-1.025
100% NP	0.54	11.01	-1.724
100% N	0.45	9.93	-2.817
100% NPK+FYM	0.66	12.87	0.13
50% NPK+BGA	0.58	11.66	-1.082
50% NPK+ GM	0.61	12.07	-0.662

Table 3: Continuous application different treatments effect on Soil Bulk Density and Crack Volume'

Treatments	Bulk Density (Mg m^{-3})	Crack Volume*(cm^3/ m^2)
Control	1.40	1407.36
50% RDF	1.36	841.26
100% RDF	1.35	847.80
150% RDF	1.38	918.19
100% NPK + Zn	1.40	831.74
100% NP	1.39	1156.54
100% N	1.43	1298.57
100% NPK+FYM	1.29	625.73
50% NPK+ BGA	1.32	806.80
50% NPK+ GM	1.31	747.53
CD	0.17	750.18

*** Measured at after harvesting of rice crop**

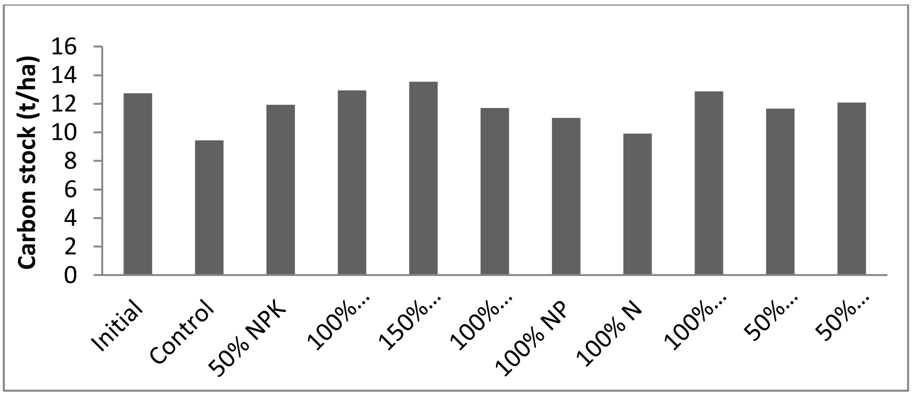

Fig. 1: Effect of Long-term fertilizer experiments on Soil Organic Carbon Stock

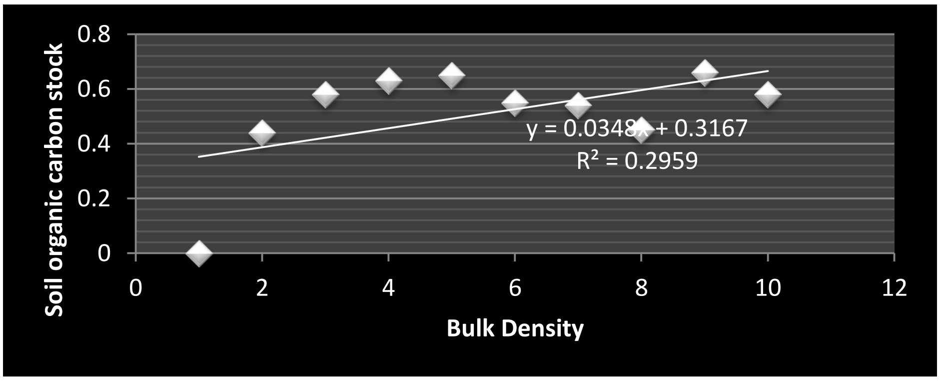

Fig 2: Effect of Bulk Density(Mg m^{-3}) on Soil Organic Carbon Stock

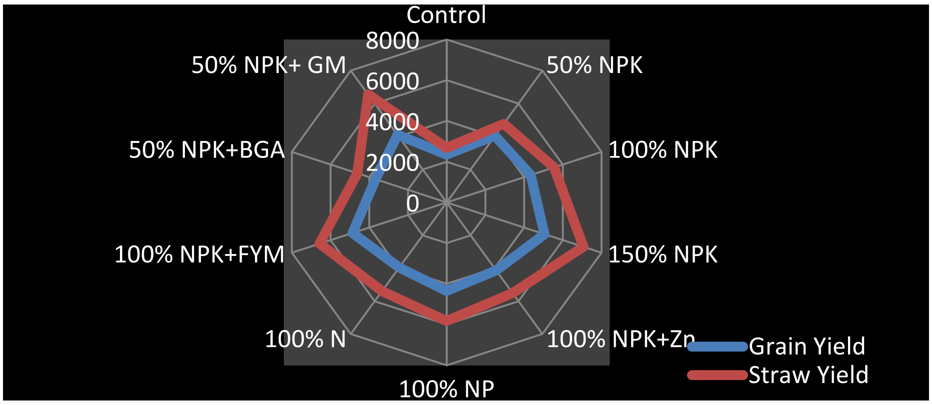

Fig 3: Effect of Integrated nutrient management treatments on Grain and Straw Yield (Kg/ha)

CONCLUSION

The prediction of future SOC sequestration potential demonstrated that under no fertilizer input, these soils would be a net source of CO_2. Even when inorganic nutrients were applied, the additional carbon input from increased plant residues could not meet the depletion of SOC. Manure or straw application could improve the carbon sequestration, with straw being a more likely option into the future. The loss of soil fertility in many developing countries due to continuous nutrient depletion by crops without adequate replenishment poses an immediate threat to food and environmental securities. There is a need to revive the age old practice of application of organic manures to maintain soil fertility and also to supplement many essential plant nutrients for crop productivity.

REFERENCES

1. Brar, B.S., Singh, J., Singh, G. and Kaur, G., Effects of Long Term Application of Inorganic and Organic Fertilizers on Soil Organic Carbon and Physical Properties in Maize–Wheat Rotation. *Agronomy* **5:** 220-238 (2015).
2. Bellaki, M.A. and Badanur, V.P., Long-term effect of integrated nutrient management on properties of Vertisols under dry land condition. *Journal of the Indian Society of Soil Science* **45:** 438-442 (1997).
3. Bhattacharyya, R., Chandra, S., Singh, R. Kundu, S., Srivastva, A. and Gupta, H., Long-term farmyard manure application effects on properties of a silty clay loam soil under irrigated wheat-soybean rotation. *Soil Till. Res.*, **94:** 386–396 (2007).
4. Gregorich, E., Drury, C, and Baldock, J.A., Changes in soil carbon under long-term maize in monoculture and legume-based rotation. *Can. J. Soil Sci*, **81:** 21–31 (2001).
5. Haynes, R. and Naidu, R., Influence of lime, fertilizer and manure applications on soil organic matter content and soil physical conditions: A review. *Nutr. Cycl. Agroecosys.* **51:** 123-137 (1998).
6. Jarecki, M.K. and Lal, R., Crop management for soil carbon sequestration. *Crit. Rev. Plant Sci*, **22:** 471–502 (2003).
7. Lal, R., Soil erosion and the global carbon budget. *Environ. Int.*, **29:** 437–450 (2003).
8. Lal, R., Soil carbon sequestration impacts on global climate change and food security. *Science* **304:** 1623–1627 (2004).
9. Mandal, U.K., Sharma, S.N., Singh, G. and Das, D.K., Effect of sesbania green manuring and green gram (*Phasiolus radiatus*) residue incorporation on physical properties of soil under rice-wheat cropping system. *Indian Journal of Agricultural Sciences* **69:** 615-620 (1999).
10. McLauchlan, K.K., Effects of soil texture on soil carbon and nitrogen dynamics after cessation of agriculture, *Geoderma* **136:** 289–299 (2006).
11. Smith, K.A. and Mullins, C.E., (Editors) *Soil Analysis: Physical Methods*. Marcel Dekker, New York (1991).

12. Vishwambharrao, K.S., Effect of integrated nutrient supply system on soil physical and chemical environment and productivity of rice in Rice - Wheat cropping sequence. M.Sc. (Ag.) Thesis. Indira Gandhi Agricultural University, Raipur (C.G.) (2005).
13. Zhang, S., Yang, X., Wiss, M., Grip, H. and Lövdahl, L., Changes in physical properties of a loesssoil in china following two long-term fertilization regimes. *Geoderma* , **136:** 579–587 (2006).

