International Journal of Farm Sciences **4(1)** :21-26, 2014

Impact of long term manures and fertilizers application on carbon sequestration and its efficiency under pearl millet-wheat cropping sequence

BH KUMARA, RS ANTIL and DEV RAJ

CCS Haryana Agricultural University, Hisar 125004 Haryana
Email for correspondence: kumara.kummi@rediffmail.com

ABSTRACT

Long term field demonstration was carried out in 1995 to evaluate the impact of continuous application of fertilizers and organic manures (FYM, poultry manure and pressmud) on soil organic carbon stock, carbon sequestration and soil organic carbon pools under pearl millet-wheat cropping sequence. Manures were applied once a year in winter at the time of wheat planting. It was observed that the fertilizers and manures alone applied were not encouraging for carbon sequestration rate and carbon efficiency. However treatment effect was prominently observed for carbon sequestration efficiency and carbon sequestration rate in combined application of organic manures and fertilizers. The results suggest that under pearl millet-wheat cropping sequence recommended doses of fertilizes and FYM maintain soil quality parameter which in turn enhance carbon sequestration rate and its efficiency.

Keywords: Manures; fertilizers; carbon sequestration; carbon sequestration efficiency

INTRODUCTION

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. The use of inorganic fertilizers in combination with organic manures has been found more advantageous than either of them alone for sustainable agriculture on long term basis (Narwal and Antil 2005). Integrated nutrient management is followed for enhancing crop productivity of intensive cropping systems, nutrient availability, biological properties and soil carbon pools for long term (Moharana et al 2012). Sequestered soil organic carbon (SOC) with a relatively long turnover time is returned to the recalcitrant soil pool thus decreasing the rate of accumulation of atmospheric CO_2 concentration. Diversified

cropping systems with better management substantially improved SOC in semiarid-tropical soils of India (Manna et al 2008). Keeping it in view the present experiment was done to assess C-sequestration efficiency under long term fertilizers and manures application.

MATERIAL AND METHODS

A field demonstration on the use of various organic manures and fertilizers was initiated in 1995 on soils where a pearl millet-wheat cropping sequence was practiced. The site is located between 29.16° N latitude and 75.75° E longitude in the north-west part of India. The climate of the experimental area is semi-arid with a mean annual precipitation of 443 mm and mean annual temperature of 24° C. The pH (1:2) of soil (0-15 cm depth) was 8.1, electrical conductivity (EC) (1:2) 0.36 dSm^{-1} and organic C 0.39 per cent. Available N, P and K were 98, 12.6 and 217 mg kg^{-1} respectively. The average nutrient compositions of FYM, poultry manure and pressmud applied in the experiment during this period are given in Table 1. The experiment was laid out with the various treatments in a randomized block design with three replications viz 75 kg N + 30 Kg P_2O_5 ha^{-1}, 150 kg N + 60 Kg P_2O_5 ha^{-1}, 15,000 kg FYM ha^{-1}, 15,000 kg FYM + 150 kg N ha^{-1}, 15,000 kg FYM + 150 kg N ha^{-1} + 30 Kg P_2O_5 ha^{-1}, 5,000 kg poultry manure ha^{-1}, 5,000 kg poultry manure + 75 kg N ha^{-1}, 7,500 kg press mud ha^{-1}, 7,500 kg press mud +75 kg N + 30 Kg P_2O_5 ha^{-1}, 7500 kg press mud +150 kg N + 30 Kg P_2O_5 ha^{-1}. FYM, poultry manure and pressmud were applied once a year in winter at the time of wheat planting. The plots were of 24 x 5 m in size.

Soil samples were collected from 0-15 depth after wheat harvesting. Organic C was determined by the wet digestion method of Walkley and Black (1934). 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:

$$\text{Soil organic carbon stock (kg ha}^{-1}) = \frac{D \times OC\ (\%) \times BD}{100}$$

Where A is area in hectare (10000 m^2), D is depth of the soil in cm, OC is soil organic carbon and BD is bulk density (Mg m^2).

$$\text{C-sequestration rate (kg ha}^{-1}\ \text{yr}^{-1}) = \frac{\text{Final SOC (kg ha}^{-1}) - \text{initial SOC (kg ha}^{-1})}{\text{Time (years)}}$$

Table 1. Mean nutrient composition of various organic manures used

Organic manure	Organic C (%)	N (%)	P (%)	K (%)	C:N
FYM	38.1	1.18	0.60	1.92	32.3
Poultry manure	22.8	2.55	1.80	1.15	8.9
Pressmud	38.0	3.10	0.90	0.80	12.3

RESULTS AND DISCUSSION

pH, EC and organic C

Addition of organic manures (FYM, poultry manure, pressmud) alone or in combination with N or NP fertilizers for 16 years brought variations in soil pH, EC and organic C over the initial value (Table 2). The decrease in pH was more with the addition of FYM compared to poultry manure and pressmud. Highest soil pH (7.87) was observed in plots where only NP fertilizers were applied. It might be due to the leaching of soluble salts from surface soil. A significant increase in EC of the soil was observed with the combined application of organic manures plus NP fertilizers over application of NP fertilizers alone. Continuous application of organic manures alone or in conjunction with NP fertilizers for 10 years decreased the soil pH and reverse trend was observed in same field in case of EC (Antil and Mandeep 2007). The highest content of organic C (1.12 %) was observed when 15 Mg FYM + 150 kg N ha^{-1} + 30 Kg P_2O_5 ha^{-1} for 16 years were applied. Increase or decrease in soil organic C was marginal from its initial value with the continuous application of NP fertilizers. The increase in organic C content of soil with the addition of organic manure plus NP fertilizers might be due to better crop growth with concomitant higher roots biomass generation and higher return of left over surface plant residues. It may be postulated that more production of roots and their subsequent decomposition increased organic C content of soil (Narwal and Antil 2005).

SOC Stock

The SOC stock decreased with greater magnitude (26,127.4 kg ha^{-1}) in 75 kg N + 30 Kg P_2O_5 ha^{-1} for 16 years (Table 3) whereas it was 71,129.9 kg ha^{-1} with 15 Mg FYM ha^{-1}. Taking into consideration the amount of FYM, poultry manure and pressmud were added during the period of 16 years of SOC stock of soil like 71,129.9, 36, 288.0 and 49,448.4 kg ha^{-1} respectively. The major portion of SOC is retained through clay-organic matter interactions indicating the importance of the inorganic part of the soil as substrate to bind the organic carbon. However recommended doses of NP fertilizers were tended to have more soil organic C stock in soil compared to half recommended

Table 2. Long term effect of organic manures and fertilizers on pH, EC and organic C after 16 cycles of pearl millet-wheat cropping sequence

Type of manure	Dose (Mg ha^{-1})	Fertilizer (kg ha^{-1})		pH	EC (dSm^{-1})	Organic C (%)
		N	P_2O_5			
No manure	0	75	30	8.10	0.39	0.36
	0	150	60	8.02	0.41	0.43
FYM	15	0	0	7.65	0.51	1.01
	15	150	0	7.67	0.51	0.98
	15	150	30	7.78	0.51	1.12
Poultry Manure	5	0	0	7.86	0.46	0.54
	5	150	30	7.85	0.44	0.58
Pressmud	7.5	0	0	7.78	0.48	0.73
	7.5	75	30	7.78	0.45	0.75
	7.5	150	30	7.77	0.48	0.76
$LCD_{0.05}$				8.10	0.39	0.36

Table 3. Long term effects of organic manures and fertilizers on soil organic carbon stock (kg ha^{-1}) and carbon sequestration rate (kg ha^{-1}yr^{-1}) in surface soil (0-15cm) after 16 cycles of pearl millet and wheat cropping sequence

Type of manure	Dose (Mg ha^{-1})	Fertilizer (kg ha^{-1})		Soil organic carbon stock	Carbon sequestration rate
		N	P_2O_5		
No manure	0	75	30	648	-18.8
	0	150	60	774	25.0
FYM	15	0	0	1818	387.5
	15	150	0	1764	368.8
	15	150	30	2016	456.3
Poultry Manure	5	0	0	972	93.8
	5	150	30	1044	118.8
Pressmud	7.5	0	0	1314	212.5
	7.5	75	30	1368	225.0
	7.5	150	30	1350	231.3
$LCD_{0.05}$				112	17.3

doses of NP fertilizers and further increase of SOC stock in combined application of fertilizers with FYM, poultry manure and pressmud. Higher C sequestration in a 33 year old rice–wheat system due to application of FYM and the cropping system has greater capacity to sequester C because of high C input through enhanced productivity (Kukal et al 2009).

Carbon sequestration rate

The carbon sequestration rate was shown in negative trends with greater magnitude (-18.8 kg $ha^{-1}yr^{-1}$) in 75 kg N + 30 Kg P_2O_5 ha^{-1} for 16 years (Table 3) whereas it was 387.5 kg $ha^{-1}yr^{-1}$ with 15 Mg FYM ha^{-1}. Taking into consideration the combined application of fertilizers with FYM, poultry manure and pressmud were added during the period of 16 years of carbon sequestration rate of soil like 456.3, 118.8 and 225.0 kg $ha^{-1}yr^{-1}$ respectively. The increase in carbon sequestration rate of soil with the addition of organic manures plus NP fertilizers might be due to better crop growth with concomitant higher root biomass generation and higher return of left over surface plant residues. The findings are in accordance with those of Lal (1997).

CONCLUSION

Incorporation of FYM with mineral fertilizers resulted in highest increase in soil organic pools followed by pressmud and poultry manures. Regular application of recommended doses of NP fertilizer reduced the negative SOC trends. The imbalanced fertilizer application (NP) was not encouraged for C-sequestration. However under high intensive cropping system recommended doses of NP and manures maintained soil quality parameters which in turn support better crop productivity and C-sequestration. Under pearl millet-wheat cropping sequence application of both organic manures and fertilizers maintained better C-sequestration.

REFERENCES

Antil RS and Mandeep S 2007. Effect of organic manures and fertilizers on organic matter and nutrients status of the soil. Archives of Agronomy and Soil Science **53(5)**: 519-528.

Kukal SS, Rasool R, Benbi DK 2009. Soil organic carbon sequestration in relation to organic and inorganic fertilization in rice–wheat and maize–wheat systems. Soil Tillage Research **102**: 87–92.

Lal R 1997. Residue management conservation tillage and soil restoration for mitigating greenhouse effect by CO_2 enrichment. Soil Tillage Research **43**: 81-107.

Manna MC, Swarup A, Wanjari RH, Ravankar HN, Mishra B, Saha MN, Singh YV, Sahi DK and Sarap PA 2005. Long term effect of fertilizer and manure application on soil organic cabon storage, soil quality and yield sustainability under sub-humid and tropical India. Field Crops Research **93**: 264-280.

Moharana PC, Sharma BM, Biswas DR, Dwivedi BS and Singh RV 2012. Long term effect of nutrient management on soil fertility and soil organic carbon pools under a 6 year old pearl millet-wheat cropping system in an incept sol of sub-tropical India. Field Crops Research **136**: 32–41.

Narwal RP and Antil RS 2005. Integrated nutrient management in pearl millet-wheat cropping system. In: Management of organic wastes for

crop production, KK Kapoor, KK Sharma, SS Dudeja and BS Kundu editors. Department of Microbiology, CCS Haryana Agricultural University, Hisar, Haryana, India, pp 205-213.

Walkley A and Black CA 1934. An estimation of the method for determination of soil organic matter and a proposed modification of the chromic acid titration method. Soil Science **37**: 29-38.

Received: 13.8.2013 ***Accepted: 17.11.2013***