www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(10): 880-883

www.thepharmajournal.com
Received: 05-07-2021
Accepted: 12-08-2021

Shikha Verma
Department of Soil Science and Agricultural Chemistry, BAU, Ranchi, Jharkhand, India

BK Agarwal
Department of Soil Science and Agricultural Chemistry, BAU, Ranchi, Jharkhand, India

P Mahapatra
Department of Soil Science and Agricultural Chemistry, BAU, Ranchi, Jharkhand, India

DK Shahi
Department of Soil Science and Agricultural Chemistry, BAU, Ranchi, Jharkhand, India

CS Singh
Department of Agronomy, BAU, Ranchi, Jharkhand, India

Pragyan Kumari
Department of Agro-meteorology and Environmental Science, BAU, Ranchi, Jharkhand, India

Arvind Kumar
Department of Soil Science and Agricultural Chemistry, BAU, Ranchi, Jharkhand, India

Reshma Shinde
ICAR RCER FSRCHPR, Ranchi, Jharkhand, India

Jai Prakash Kumar
Department of Soil Science and Agricultural Chemistry, BAU, Ranchi, Jharkhand, India

Corresponding Author:
Shikha Verma
Department of Soil Science and Agricultural Chemistry, BAU, Ranchi, Jharkhand, India

Evaluation of carbon management index of a long term fertilizer experiment under soybean-wheat cropping sequence on acid soils of Ranchi

Shikha Verma, BK Agarwal, P Mahapatra, DK Shahi, CS Singh, Pragyan Kumari, Arvind Kumar, Reshma Shinde and Jai Prakash Kumar

Abstract
The present experiment was undertaken in a long term fertilizer experiment (LTFE) which has been in progress since 1972-73 at Ranchi, Jharkhand, India an acidic red loam soil (Paleustalf) to determine the carbon management index (CMI) as influenced by different nutrient management practices involving the use of either chemical fertilizers alone or in integration with organic manure or lime. Sustainable yield index (SYI) of soybean-wheat cropping system over the years (1972-2019) was maximum in treatment receiving FYM along with 100% NPK followed by 100%NPK+Lime treatment. Use of organic manure along with balanced NPK fertilizer significantly increased the soil organic carbon content over control and treatments involving the use of only chemical fertilizers. 100%NPK+FYM+ Weedicide (W) treatment also recorded highest concentration of permanganate oxidizable soil carbon (POSC) followed by 100%NPK+lime+W treatment followed by 100%NPK+W. Treatment consisting of only N fertilizer had deleterious effect on soil organic carbon, total carbon as well as POSC, where all these carbon fractions were even lower than the control. With respect to CMI, all the treatments recorded higher index value compared to control which was taken as a reference except 100%N. Integrated application of FYM and 100%NPK registered highest CMI value followed by 100%NPK+Lime. The study indicated that integrated use of FYM or lime along with balanced NPK is superior in terms of carbon management together with increasing the sustainability of agricultural production system in acid soils of Ranchi.

Keywords: Evaluation, carbon, management, fertilizer, experiment, Ranchi

1. Introduction
Soil organic carbon (SOC) is thought to be important for a variety of soil functions and ecosystem services. The annual input of carbon to the soil from the atmosphere is about 15% of the atmospheric carbon dioxide (Bolin, 1983) [4]. Because of its role in improving the physical, chemical, and biological properties of the soil, soil organic carbon (SOC) is the most important component in maintaining soil quality. Changes in land use, agricultural practices and different nutrient management options have a significant impact on total soil organic carbon, its fractions, and overall soil health. Management of soil carbon is an important strategy for improving soil quality, increasing crop productivity and sustainability. Soil organic carbon fractions are mainly divided into three main pools: active or labile, intermediate or slow, and stable or passive (Schmidt *et al.*, 2011) [15]. Labile fractions of soil organic carbon include those compounds which are readily decomposed by soil microorganisms (Haynes, 2005) [7]. The labile fractions of SOC responds more quickly to changes in management practices because it has a much shorter turnover time and a higher turnover rate than more stable organic carbon in soils and hence may be regarded as the sensitive indicator of soil organic carbon changes. (Banger *et al.*, 2010) [1]. The labile organic carbon fractions include particulate organic carbon (POC), light fraction organic carbon (LFOC), soil microbial biomass carbon (SMBC), dissolved organic carbon and permanganate oxidizable soil carbon (POSC) (Weil *et al*., 2003; Mirsky *et al.*, 2008) [21, 12]. Determination of soil organic carbon (Walkley and Black, 1934) [20] has been done in many studies to assess the impact of nutrient management practices on soil quality and agricultural sustainability (Verma *et al*., 2013) [18] but high background levels make it difficult to detect small changes in SOC (Reddy *et al*., 2017) [13]. Although total soil carbon is affected by soil management, it is not as sensitive to short-term changes as the labile fractions (Liefeld and Kogel-Knabner, 2005) [8].

Therefore estimation of lability of SOC as influenced by different agricultural or nutrient management options serve as an early indicator suggesting whether a particular management practice is deteriorating or improving the soil condition. Blair *et al.* (1995) [2] suggested carbon management index (CMI) as one of the method to quantify changes in labile organic carbon and it mainly focuses on the permanganate oxidizable soil carbon (POSC). Soil organic carbon oxidized by potassium permanganate is more sensitive to management induced changes compared to total SOC (Blair *et al.*, 2000; Verma *et al.*, 2013) [3, 18] and therefore it is considered as a useful index of labile carbon. The carbon management index (CMI) is calculated using the total soil organic carbon pool and carbon lability, and it can be used to assess the ability of the management system to improve soil quality (Vieria *et al.,* 2007) [19] A higher value of CMI is indicative of improved and sustained system. The present study was carried out to study the effect of long term nutrient management practices on carbon lablity and carbon management index in intensively cultivated acid soil of Ranchi, Jharkhand.

2. Material and Methods

A long term fertilizer experiment (LTFE) was initiated during 1972-1973 at Research farm, Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Ranchi, Jharkhand, India. The experimental farm is situated at 85^0 19' East longitude, 23^0 17' North latitude and 625 m altitude above the mean sea level. The soil of the experimental site acidic red loam (Paleustalf) with sandy clay loam texture. Initial soil pH at the start of the experiment was 5.3.The climate of the experimental site is sub-tropical. Temperature can soar upto 42^0 C in summer. The monsoon season is July to September and the state receives an annual rainfall of 1450 mm. The experiment started with soybean-potato-wheat cropping system (1972-79) which was changed to soybean-toria-wheat (1980-1985) and later changed to soybean-wheat (since 1986). The treatments are: T_1 (50% NPK + Weedicide (W)), T_2 (100% NPK + Weedicide), T_3 (150% NPK + Weedicide), T_4 (100% NPK + Hand weeding), T_5 (100% NPK + lime + Weedicide), T_6 (100% NP + Weedicide), T_7 (100% N + Weedicide), T_8 (100% NPK + FYM + Weedicide), T_9 (100% N(S) PK + Weedicide) and T_{10} (control). The fertilizer dose based upon initial soil test for soybean and wheat was 25: 60:40 (N: P_2O_5: K_2O) + *Rhizobium* culture and 80:60:40(N: P_2O_5: K_2O), respectively. The level of P for both soybean and wheat was reduced and level of N for wheat was raised during further years. Presently, the level of fertilizer for soybean and wheat is 25:30:40 and 120:30:40 N: P_2 O_5: K_2O kg ha^-, respectively. The source of N, P and K fertilizer was urea, diammonium phosphate (DAP) and muriate of potash (MOP) in all treatments except in T_9 where source of P was single super phosphate (SSP). In T_9, initially the source of N was ammonium sulphate which has been replaced by urea from the year 2010-11. In T_5, lime is applied @1/10 of LR to *kharif* crop. In T_8, FYM is applied@ 10 t ha^{-1} on fresh weight basis to *kharif* crop. The original experimental set up is having 4 replications, but for the present study 3 replications were considered.

Surface soil samples (0-15 cm) collected after the harvest of wheat during 2018-19, were air dried, grounded in a wooden pestle and mortar and sieved through a 2mm sieve soil Soil organic carbon was determined using potassium dichromate oxidation method (Walkley and Black, 1934) [20] and labile organic carbon i.e. permanganate oxidizable soil carbon (POSC) according to modified method of Blair *et al.* (1995) [2]. Since the recovery of organic carbon by Walkley and Black (1934) [20] rapid titration method is 77%, accordingly total organic carbon for each of the sample was calculated.

Sustainability of soybean-wheat cropping system over the years as influenced by the different nutrient management was calculated using the equation suggested by Singh *et al*. (1990) [16]:

Sustainable yield index (SYI)=$(Y-\sigma_{n-1}) / Y_{m;}$

Y is the mean grain yield of a given treatment in the system;
σ_{n-1} is the standard deviation of yield for that treatment across years;
Y_m is the maximum yield obtained under a set of management practice for any of the treatment in any year of the experiment
Carbon management index (CMI) was calculated using control treatment as the reference soil sample following the mathematical procedures used by Blair *et al.* (1995) [2] as follows:

CMI=CPIX LI X 100

Where, CPI is the carbon pool index and LI is the lability index
CPI=Total organic carbon in fertilized treatment/ Total organic carbon in reference soil
LI=Lability of carbon in fertilized treatment/lability of carbon in reference soil

3. Results and Discussion

3.1 Sustainable yield index (SYI)

The value of the sustainable yield index (SYI) closer to 1 suggests the closeness to the condition that is suitable for sustaining maximum crop yields, whereas deviation from 1 indicates losses to sustainability (Reddy *et al.*, 1999) [14]. SYI of the soybean-wheat cropping system as influenced by different treatment combinations over the years (1972-2019) varied from the lowest value of 0.04 in 100%N treatment to the highest value of 0.57 in 100%NPK+FYM+W treatment followed by 100%NPK+Lime+W (0.55) (Table1). Balanced application of NPK fertilizer improved sustainability of the system over imbalanced treatments (100%NP+W and 100%N+W). SYI in treatments comprising of super optimal dose of chemical fertilizer (150%NPK+W) as well as the practice of hand weeding instead of weedicide along with 100%NPK (i.e.100%NPK+HW), were equal to 100%NPK+W treatment. The decline in productivity and hence the sustainability of the soybean-wheat cropping system with 100% N over the years was the most spectacular i.e. the SYI recorded in 100% N was less than the control. Increased level of chemical fertilizer from 50%NPK to 100%NPK increased the SYI from 0.35 to 0.46. Increased SYI value in 100%NPK+FYM and 100%NPK+Lime treatments advocated the beneficial impact of the amendments (i.e. FYM and lime) with NPK fertilizers Dawid and Hailu (2017) [5] showed the importance of lime application for sustaining crop production in an acid soil. Similarly, increase in SYI due to application of organic manure under different cropping system has been reported by Manna *et al.* (2005) [10].

Table 1: Effect of nutrient management on sustainable yield index (SYI) of the cropping system, soil organic carbon (SOC), total organic carbon (TOC), permanganate oxidizable organic carbon (POSC) and carbon management index (CMI)

Treatments	SYI	SOC (g kg^{-1})	TOC (ppm)	POSC (ppm)	CMI
50% NPK+W	0.35	4.3	5565.39	618.60	126.05
100% NPK+W	0.46	4.8	6221.30	732.75	150.39
150% NPK+ W	0.46	4.6	6024.53	718.35	148.25
100% NPK+Handweeding	0.46	5.0	6549.26	729.75	148.70
100% NPK+Lime+W	0.55	4.9	6418.08	795.00	164.34
100% NP +W	0.33	4.0	5237.44	582.90	118.79
100% N+W	0.04	3.9	5040.67	438.75	87.15
100% NPK+FYM+W	0.57	5.9	7598.71	840.90	171.55
100% N(S)PK+W	0.17	4.6	5972.06	680.70	139.09
Control	0.08	4.1	5316.15	500.70	100.25
CD	---	0.8	1062.33	67.22	15.50

3.2 Effect of long term manuring and fertilization on carbon pools and carbon management index

Soil organic carbon (SOC) was significantly influenced by the continuous application of farmyard manure along with 100% NPK as compared to other treatments after 48 years of intensive cropping and fertilization. SOC ranged from the lowest value of 3.9 g kg^{-1} in 100%N treatment to the highest value of 5.9 g kg^{-1} in 100%NPK +FYM treatment (Table 1). FYM treated plot recorded significant increase of 43.9% and 22.9% over control and 100% NPK treatment, respectively. This could be ascribed to the to the direct addition of organic matter through FYM continuously for over a period of 48 years, higher root biomass and stubbles and enhanced microbial activity leading to increased rate of decomposition of root biomass (Ghosh *et al.*, 2018b) [6]. Continuous application of balanced dose of NPK fertilizers increased the SOC content over 100%N and control which may be due to higher crop productivity with balanced application of inorganic fertilizer. Similar trend was observed for total organic carbon (Table 1.)

Soil $KMNO_4$-C is composed of amino acids simple carbohydrates a portion of microbial biomass and other simple organic compounds (Zou *et al*., 2005) [22]. Highest amount of labile organic carbon (i.e. POSC) was recorded in treatment receiving integrated application of NPK fertilizers and FYM (840.90ppm) which was significantly superior to rest of the treatments except 100%NPK+Lime (795 ppm) (Table 1). Increased content of POSC in FYM treated plot might be due to the readily metabolizable C and N in organic carbon as well as better root growth and more addition of plant residues. Similar results have been reported by Liang *et al*. (2012) [9]. Addition of lime in acid soils together with NPK fertilizer showed significant improvement in POSC content as compared to the treatments comprising of only chemical fertilizers, except 100%NPK+W and 100%NPK+HW. This may be attributed to the fact that lime has ameliorative effect on soil pH conducive for higher microbial growth and activity and balanced inorganic fertilizer provided readily accessible nutrients for microbes. All the treatments recorded significantly increased POSC content over control except 100% N. 100% N recorded significantly lowest labile organic carbon as compared to rest of the treatments which may be attributed to very low crop productivity leading to reduced plant residues and low soil pH.

A higher value of carbon management index (CMI) indicates better management. It was observed that all the treatments except for 100% N recorded greater value of CMI over control plot indicating positive impact of the nutrient management on carbon management over control. 100% N recorded significantly reduced CMI value of 87.15 (Table1). Balanced fertilization showed significant improvement of 72.5% and 26.6% in CMI value over imbalanced fertilization i.e.100% N and 100% NP treatments, respectively. Increasing the dose of chemical fertilizer from suboptimal to optimal level showed significant increase in the CMI value, whereas super optimal dose (150% NPK) was statistically at par with 100% NPK. It was also observed that practice of hand weeding did not differ significantly over the use of chemical weedicides along with 100%NPK. The highest value of CMI was recorded in 100%NPK+FYM (171.55) which was significantly superior to rest of the treatments except 100%NPK+lime (164.34). Verma *et al.* (2013) [18] also reported significantly higher value of CMI in FYM treated plots compared to control and treatments comprising of only inorganic fertilizer under soybean-wheat cropping system. Similarly, Reddy *et al*. (2017) [13] also reported higher value of carbon management index in integrated nutrient management treatments over control and inorganic treatment. Trivedi *et al*. (2020) [17] showed that use of lime or FYM along inorganic fertilizers or FYM alone recorded higher value of CMI over only inorganic fertilizers in an Alfisol. Mazumdar *et al.* (2018) [11] also advocated the use of organic manure together with balanced NPK fertilizers for long term sustainability in terms of carbon dynamics and CMI. The results showed that though balanced application of inorganic fertilizer has the potential to improve the carbon management over imbalanced application of inorganics and control, but further improvement in the long run can be achieved through the inclusion of lime or FYM along with NPK fertilizers under continuous cropping in acid soils.

4. Conclusions

Relatively high sustainable yield index and carbon management index in treatments receiving FYM or lime along with balanced NPK fertilizers highlights the importance of the use of amendments (FYM/lime) for ensuring long term sustainability in crop production together with better management of carbon under soybean-wheat cropping system in acid soils in the long run.

5. References

1. Banger K, Toor G, Biswas A, Sidhu S, Sudhir K. Soil organic carbon fractions after 16 years of applications of fertilizers and organic manure in a Typic Rhodalfs in semi-arid tropics. Nutrient Cycling in Agroecosystems 2010;86:391-399.
2. Blair GJ, Lefroy RDB, Lisle L. Soil carbon fractions based on their degree of oxidation, and the development of a carbon management index for agricultural systems. Australian Journal of Agricultural Research

1995;46:1459-1466.
3. Blair GJ, Lefroy R, Whitbread A, Blair N, Conteh A. The development of the $KMnO_4$ oxidation technique to determine labile carbon in soil and its use in a carbon management index. In Assessment methods for soil carbon, eds. Lal R, Kimble JM, Follett RF, Stewart BA, Boca Raton, FL: Lewis Publishers 2000, 323-37.
4. Bolin B. The carbon cycle. In The Major Biogeochemical Cycles and Their Interactions. Í Eds. Bolin B, Cook RB John Wiley & Sons: New York 1983, 41-5.
5. Dawid J, Hailu G. Application of Lime for Acid Soil Amelioration and Better Soybean Performance in South Western Ethiopia. Journal of Biology, Agriculture and Healthcare 2017, 7(5). ISSN 2224-3208 (Paper) ISSN 2225-093X (Online).
6. Ghosh A, Bhattacharyya R, Meena MC, Dwivedi BS, Singh G, Agnihotri R *et al*. Long term fertilization effects on soil organic carbon sequestration in an Inceptisol. Soil and Tillage Research 2018b;177:134-144.
7. Haynes RJ. Labile organic matter fractions as central components of the quality of agricultural soils: an overview. Advances in Agronomy 2005;85:221-68.
8. Leifeld J, Kogel-Knabner I. Soil organic matter fractions as early indicators for carbon stock changes under diferent land-use. Geoderma 2005;124(1):143-55.
9. Liang Q, Chen H, Gong Y, Fan M, Yang H, Lal R *et al*. Effects of 15 years of manure and inorganic fertilizers on soil organic carbon fractions in a wheat - maize system in North China plains. Nutrient Cycling in Agroecosystems 2012;92:21-33.
10. Manna MC, Swarup A, Wanjari RH, Ravankar HN, Mishra B, Saha MN *et al*. Long-term effect of fertilizer and manure application on soil organic carbon storage, soil quality and yield sustainability under sub-humid and semi-arid tropical India. Field Crops Research 2005;93:264-280.
11. Mazumdar SP, Kundu DK, Saha AR, Majumdar B, Saha R, Singh AK *et al*. Carbon and nutrient dynamics under long-term nutrient management in tropical rice-wheat-jute system. Archives of Agronomy and Soil Science 2018;64(11):1595-160.7.
12. Mirsky SB, Lanyon LE, Needelman BA. Evaluating soil management using particulate and chemically labile soil organic matter fractions. Soil Science Society of America Journal 2008;72(1):180-5.
13. Reddy DD, Blaise D, Kumrawat B, Singh AK. Evaluation of Integrated Nutrient Management Interventions for Cotton (*Gossypium hirsutum*) on a Vertisol in Central India. Communications in Soil Science and Plant Analysis 2017;48(4):469-475.
14. Reddy DD, Subba Rao A, Reddy Sammi K, Takkar PN. Yield sustainability and phosphorus utilization in soybean-wheat system on Vertisols in response to integrated use of manure and fertilizer phosphorus. Field Crops Research 1999;62:181-190.
15. Schmidt MWI, Torn MS, Abiven S, Dittmar T, Guggenberger G, Janssens IA *et al*. Persistence of soil organic matter as an ecosystem property. Nature 2011;478:49-56.
16. Singh RP, Das SK, Rao UMB, Reddy MN. Towards Sustainable Dryland Agricultural Practice, Central Research Institute for Dryland Agriculture: Hyderabad, India 1990.
17. Trivedi A, Bhattacharyya B, Biswas DR, Das S, Das TK, Mahapatra P *et al*. Long-term impacts of integrated nutrient management with equivalent nutrient doses to mineral fertilization on soil organic carbon sequestration in a sub-tropical Alfisol of India. Carbon Management 2020. DOI: 10.1080/17583004.2020.1808766.
18. Verma BC, Datta SP, Rattan RK, Singh AK. Labile and stabilized fractions of soil organic carbon in some intensively cultivated alluvial soils. Journal of Environmental Biology 2013;34:1069-75.
19. Vieria FCB, Bayer C, Zanatta A, Dieckow J, Mielniczuk J, He ZL. Carbon management index based on physical fractionation of sol organic matter in an Acrisol under long term no till cropping system. Soil and Tillage Research 2007;96(1-2):195-200.
20. Walkley A, Black IA. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science 1934;37:29-38.
21. Weil RR, Islam KR, Stine MA, Gruver JB, Samson-Liebig SE. Estimating labile carbon for soil quality assessment: A simplified method for laboratory and field use. American Journal of Alternative Agriculture 2003;18(1):3-17.
22. Zou XM, Ruan HH, Fu Y, Yang XD, Sha LQ. Estimating soil labile carbon and potential turn over rates using a sequential fumigation-incubation procedure. Soil Biology and Biochemistry 2005;37:1923-1928.