

## Original Research Article

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## Soil Organic Carbon, Carbon Sequestration, Soil Microbial Biomass Carbon and Nitrogen and Soil Enzymatic Activity as Influenced by Conservation Agriculture in Pigeonpea and Soybean Intercropping System

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### ABSTRACT

Field experiments were conducted during the year 2014-15 and 2015-16 at Conservation Agriculture Project plot, MARS, Dharwad, Karnataka to study the influence of conservation tillage, land configuration and residue management practices on soil health in a pigeonpea + soybean intercropping system. The experiment consisted of 6 tillage systems [CT<sub>1</sub>: Conservation tillage with BBF and crop residue retained on the surface, CT<sub>2</sub>: Conservation tillage with BBF and incorporation of crop residue, CT<sub>3</sub>: Conservation tillage with flatbed with crop residue retained on the surface, CT<sub>4</sub>: Conservation tillage with flatbed with incorporation of crop residue, CT<sub>5</sub>: Conventional tillage with incorporation of crop residue and CT<sub>6</sub>: Conventional tillage without crop residue]. The experiment laid out in strip block design and replicated thrice. The conservation treatments were found to significantly improve soil health. The pooled data revealed that, all the conservation tillage systems i.e. CT<sub>1</sub>, CT<sub>2</sub>, CT<sub>3</sub> and CT<sub>4</sub> recorded significantly higher soil organic carbon at 0-15 cm depth (0.62, 0.64, 0.60 and 0.62 %, respectively) and 15-30 cm depth (0.56, 0.56, 0.54 and 0.55 %, respectively), higher soil carbon sequestration (15.07, 15.39, 14.58 and 14.72 t ha<sup>-1</sup>, respectively) over conventional systems. However, biological soil quality such as soil microbial biomass carbon and nitrogen were significantly higher in all the tillage systems except conventional tillage without crop residue. While, significantly higher soil urease activity (11.76, 11.86, 11.10 and 11.44 μg NH<sub>4</sub>-N g<sup>-1</sup> day<sup>-1</sup>), dehydrogenase activity (32.29, 32.29, 31.14 and 31.55 μg TPF g<sup>-1</sup> day<sup>-1</sup>) and total phosphatase activity (173.21, 174.55, 170.09 and 173.21 μg PNP g<sup>-1</sup> hr<sup>-1</sup>) were recorded in CT<sub>1</sub>, CT<sub>2</sub>, CT<sub>3</sub> and CT<sub>4</sub> over CT<sub>5</sub> and CT<sub>6</sub>.

### Keywords

Soil organic carbon,  
Carbon sequestration,  
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### Introduction

Tillage is an oldest art associated with the development of agriculture. It includes all operations and practice that are followed for the purpose of modifying the physical characteristics of soil so as to provide favourable conditions. Tillage of soil is the

most difficult and time consuming work in production of crops. It has been estimated that on an average about 30 per cent of the total expenditure of crop production is towards tillage operations. There is plenty of scope in reducing this expenditure if the objectives of tillage are understood and if the operations are carried out at the right time with proper

implement (Rangaswamy, 2000). This intensive soil cultivation has worldwide resulted in the degradation of agricultural soils with decrease in soil organic matter, loss of soil structure, thus adversely affected soil health and caused a long term threat to future yields and soil health (Bujarbaruah, 2004).

Carbon is an important part of life on earth. It is found in all living organisms and is the major building block for life on earth and moves through the atmosphere, oceans, plant, soil and earth in short and long term cycles over a time. Carbon pools act as storage houses for large amount of carbon. Any movement of carbon between these carbon pools is called a flux. Soil plays a major role in maintaining balance between global carbon cycle through sequestration of atmospheric carbon as soil organic carbon. Soils store about three times as much carbon as the terrestrial vegetation. Soil C pool comprises soil organic carbon (SOC) and soil inorganic carbon (SIC) pool (Lal, 2004). Soil organic carbon and carbon sequestration builds soil fertility, improves soil quality, improves agronomic productivity, protect soil from compaction and nurture soil biodiversity. Increased organic matter in soil, improves soil aggregation, which in turn improves soil aeration, soil water storage, reduces soil erosion, improves infiltration, and generally improves surface and groundwater quality. This enhanced soil health, facilitates use of agricultural inputs in an efficient manner and helps in sustaining agricultural productivity at higher level. It is also helpful in the protection of streams, lakes, and rivers from sediment, runoff from agricultural fields, and enhanced wildlife habitat. Besides these, it has major roles in mitigating GHG gas emissions and tackling the effects of climate change.

Conservation tillage is defined as any tillage practice that minimizes the loss of soil and water, which often requires the presence of at

least 30% of the mulch or crop residue on the soil surface throughout the year. Conservation tillage minimizes soil erosion, conserves water within the root zone and improves soil fertility and productivity (Derpsch, 2005). Intercropping of short duration crops in the inter space between two rows of a wide spaced crops like pigeonpea, which has initial slow growth, can help in better resource utilization, soil cover and stabilize crop productivity by reducing impact of weather vagaries and increase the cropping intensity (Ghosh, 2010).

### **Materials and Methods**

Field experiments were carried out in the fixed experiment site of Conservation Agriculture Project plot at the Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad (Karnataka) during the year 2014-15 and 2015-16 on neutral pH (7.4) *vertic inceptisols* with initial soil organic carbon (0.52%). Dharwad is located at 15° 26' N latitude and 75° 7' East longitude and at an altitude of 678 m above the mean sea level. The region receives an average rainfall of 711.44 mm, which was well distributed from April to November.

During 2014 the total annual rainfall received was about 962.4 mm which was 34 per cent more than normal. The delayed onset of monsoon during *kharif* (July) resulted in delayed sowing of *kharif* crops. The rainfall received during *rabi* season mainly during October and November was 152.2 mm and the October rainfall was 17 per cent less than the normal. However the rainfall of 48.8 mm received in November which was 15 per cent higher than the normal helped to get good crop stand and optimum yield. The highest and lowest mean monthly maximum temperatures recorded were 37.8 °C and 27 °C, respectively during the months of May and August, respectively. Whereas mean monthly minimum temperature was ranged from 14.5

$^{\circ}\text{C}$  (December) to  $21.6^{\circ}\text{C}$  (June). Mean monthly maximum relative humidity of 89 per cent and mean monthly minimum relative humidity of 42 per cent were observed during the month of June and March, respectively. During 2015, the total rainfall received was 716.2 mm which was 3 percent less than the normal rainfall. The crops were sown early in *kharif* (June) as compared to last year. June and October there was 160.2 and 179.8 mm rainfall, respectively. During crop growth period (July, August and September) there was less rainfall received (42.8mm, 34.4 and 22.4 mm, respectively) and it was about 73, 66 and 79 percent lesser than the normal rainfall hence, one protective irrigation was given through sprinkler in the month of August (18th). Dry spells during August, September and October affected the growth and development of the crops during early stages of crops which resulted in lower productivity.

The highest and lowest mean monthly maximum temperatures observed were  $35.1^{\circ}\text{C}$  and  $28.6^{\circ}\text{C}$ , respectively during the month of April and January, respectively. Similarly, highest and lowest mean monthly minimum temperature were recorded in the month of May ( $21.9^{\circ}\text{C}$ ) and January ( $13.3^{\circ}\text{C}$ ). Mean monthly maximum relative humidity of 80% and monthly maximum relative humidity of 40% was observed during the month of June and February, respectively.

The experiment was laid out in strip block design and replicated thrice. A pigeonpea (*Cajanus cajan* L.) + soybean (*Glycine max* L.) intercropping system was conducted in the experimental site under six different tillage systems, viz., CT<sub>1</sub>: Conservation tillage with BBF and crop residue retained on the surface, CT<sub>2</sub>: Conservation tillage with BBF and incorporation of crop residue, CT<sub>3</sub>: Conservation tillage with flatbed with crop residue retained on the surface, CT<sub>4</sub>: Conservation tillage with flatbed with

incorporation of crop residue, CT<sub>5</sub>: Conventional tillage with incorporation of crop residue and CT<sub>6</sub>: Conventional tillage without crop residue.

The experiment was initiated during 2013-14 and conservation tillage plots were permanently maintained with bigger plot size of 15 m width and 9 m length. In convention plots, the land was ploughed with mould board plough once, cultivated and harrowed and soil was brought to fine tilth. In conservation tillage plots, minimum tillage for crop residue incorporation with rotovator two months before sowing and no tillage plots maintained with crop residue shredding and retention on the surface during 1<sup>st</sup> week of April, till than residues were maintained on the surface. Intercrops i.e. soybean (Dsb 21) was sown at 30 cm spacing with the help of tractor drawn seed drill by skipping one row for every two rows and in a skipped row pigeonpea (TS 3R) seeds were dibbled in the spacing of 90 cm x 30 cm. After every 6 rows (180 cm) a row was skipped for opening furrow (30 cm) which help to layout Broad Bed and Furrows (BBF) with 180cm bed and 30 cm furrow immediately after sowing of the crops. All the recommended package of practices for pigeonpea and soybean were followed to raise the healthy crops.

Paraquat a contact herbicide was sprayed to kill the established weeds at 10 days before sowing. The crop was weed free upto 30 days by pre-emergence application of pendimethalin (STOMP XTRA 38.7 CS) and later weeds were managed by post emergence application of imazethapyr 10 SL for pigeonpea + soybean at 30 DAS with the help of hand operated knapsack sprayer.

Soil samples were collected and analyzed for important soil properties after the harvest of crops. Three samples were collected from each plot and composited. The collected soil

samples were air dried, grinded, passed through 2mm sieve and stored in polythene bags for further analysis. Fresh soil samples at 20 cm depth were collected and kept under refrigeration for estimation of soil microbial biomass carbon (SMB-C) and nitrogen (SMB-N) and enzymatic activity.

### **Organic carbon (%)**

Organic carbon content in soil was estimated by Walkley and Black's wet oxidation method (Jackson, 1967).

### **Soil Microbial biomass carbon (SMB-C) and nitrogen (SMB-N)**

Soil microbial biomass carbon and nitrogen was estimated by fumigation and extraction method (Carter, 1991) by using following formula.

$$\text{MBC g of soil} = \frac{\text{Ninhydrin reactive N in fumigated soil} - \text{Ninhydrin reactive N in unfumigated soil}}{\text{Weight of soil sample}} \times 24$$

$$\text{MBN g of soil} = \frac{\text{Ninhydrin reactive N in fumigated soil} - \text{Ninhydrin reactive N in unfumigated soil}}{\text{Weight of soil sample}}$$

Soil urease activity at 75 DAS: Urease activity of the soil was determined by following the procedure as given by Pancholy and Rice (1973).

Dehydrogenase activity at 75 DAS: Dehydrogenase activity of the soil sample was determined by following the procedure as described by Casida *et al.*, (1964).

Phosphatase activity at 75 DAS: Phosphatase activity of soil sample was determined by following the procedure of Eivazi and Tabatabai (1979).

The data obtained from various studies were statistically analyzed following the procedure as described by Gomez and Gomez (1984). The level of significance used in 'F' tests was P = 5% and 1% and the mean values were separately subjected to Duncan's Multiple Range Test (DMRT) using the corresponding error mean sum of squares and degrees of freedom values under M-STAT - C program.

## **Results and Discussion**

### **Soil organic carbon (SOC)**

The data on SOC of soil after harvest of crops as influenced by tillage practices is presented in Table 1. The SOC was significantly influenced by tillage practices at 0-15 and 15-30 cm depths.

At 0-15 cm depth, pooled data showed that the conservation tillage with BBF and incorporation of crop residue (CT<sub>2</sub>) recorded significantly higher SOC (0.64 %) as compared to conventional tillage with incorporation of crop residue (CT<sub>5</sub>) and without crop residue (CT<sub>6</sub>) (0.56 and 0.48%, respectively) and it was on par with conservation tillage with BBF and crop residue retained on the surface (CT<sub>1</sub>, 0.62%) and conservation tillage with flat bed with incorporation of crop residue (CT<sub>4</sub>, 0.62%).

At 15-30 cm, all the conservation tillage practices such as CT<sub>1</sub>, CT<sub>2</sub>, CT<sub>3</sub> and CT<sub>4</sub>, recorded significantly higher SOC (0.56, 0.56, 0.54, 0.55 % respectively) as compared to conventional tillage with (CT<sub>5</sub>, 0.48 %) and without crop residue (CT<sub>6</sub>, 0.39 %). The higher amount of SOC in surface soil layer under conservation till might be due to higher accumulation of crop residue that derived carbon and lesser exposure of previous crop roots even after the crop harvest that reduced the oxidative losses of roots (West and Post 2002).

**Table.1** Soil organic carbon as influenced by different conservation agricultural practices

Tillage systems	Soil organic carbon (%)					
	0-15 cm			15-30 cm		
	2014	2015	Pooled	2014	2015	Pooled
CT <sub>1</sub> -Conservation tillage with BBF and crop residue retained on the surface.	0.60a	0.64a	0.62ab	0.53a	0.58a	0.56a
CT <sub>2</sub> -Conservation tillage with BBF and incorporation of crop residue.	0.63a	0.65a	0.64a	0.53a	0.59a	0.56a
CT <sub>3</sub> -Conservation tillage with flat bed with crop residue retained on the surface.	0.57ab	0.62a	0.60b	0.51a	0.56a	0.54a
CT <sub>4</sub> -Conservation tillage with flat bed with incorporation of crop residue.	0.59ab	0.64a	0.62ab	0.51a	0.58a	0.55a
CT <sub>5</sub> -Conventional tillage with crop residue incorporation.	0.53bc	0.58b	0.56c	0.43b	0.52b	0.48b
CT <sub>6</sub> -Conventional tillage without crop residue	0.50c	0.45c	0.48d	0.38b	0.39c	0.39c
S.Em ±	<b>0.02</b>	<b>0.01</b>	<b>0.01</b>	<b>0.02</b>	<b>0.01</b>	<b>0.01</b>
F test	5%	*	*	*	*	*
	1%	**	**	**	**	**

NS: Non significant, \*: Significant at 5%, \*\*: Significant at 1%

**Table.2** Soil microbial biomass carbon and nitrogen as influenced by different conservation agricultural practices

Tillage systems	Soil microbial biomass carbon (mg kg soil <sup>-1</sup> )			Soil microbial biomass nitrogen (mg kg soil <sup>-1</sup> )		
	2014	2015	Pooled	2014	2015	Pooled
CT <sub>1</sub> -Conservation tillage with BBF and crop residue retained on the surface.	372.00a	356.00a	364.00a	15.10a	14.83a	14.97a
CT <sub>2</sub> -Conservation tillage with BBF and incorporation of crop residue.	375.20a	335.20a	355.20a	15.23a	13.97a	14.60a
CT <sub>3</sub> -Conservation tillage with flat bed with crop residue retained on the surface.	342.40a	312.00a	327.20a	13.87a	13.00a	13.43a
CT <sub>4</sub> -Conservation tillage with flat bed with incorporation of crop residue.	383.20a	340.80a	362.00a	15.57a	14.20a	14.88a
CT <sub>5</sub> -Conventional tillage with crop residue incorporation.	342.13a	308.80a	325.47a	13.86a	12.87a	13.36a
CT <sub>6</sub> -Conventional tillage without crop residue	312.80b	275.20b	294.00b	12.63b	11.47b	12.05b
S.Em ±	<b>42.42</b>	<b>84.80</b>	<b>35.25</b>	<b>1.77</b>	<b>3.50</b>	<b>1.47</b>
F test	5%	*	*	*	*	*
	1%	NS	NS	NS	NS	NS

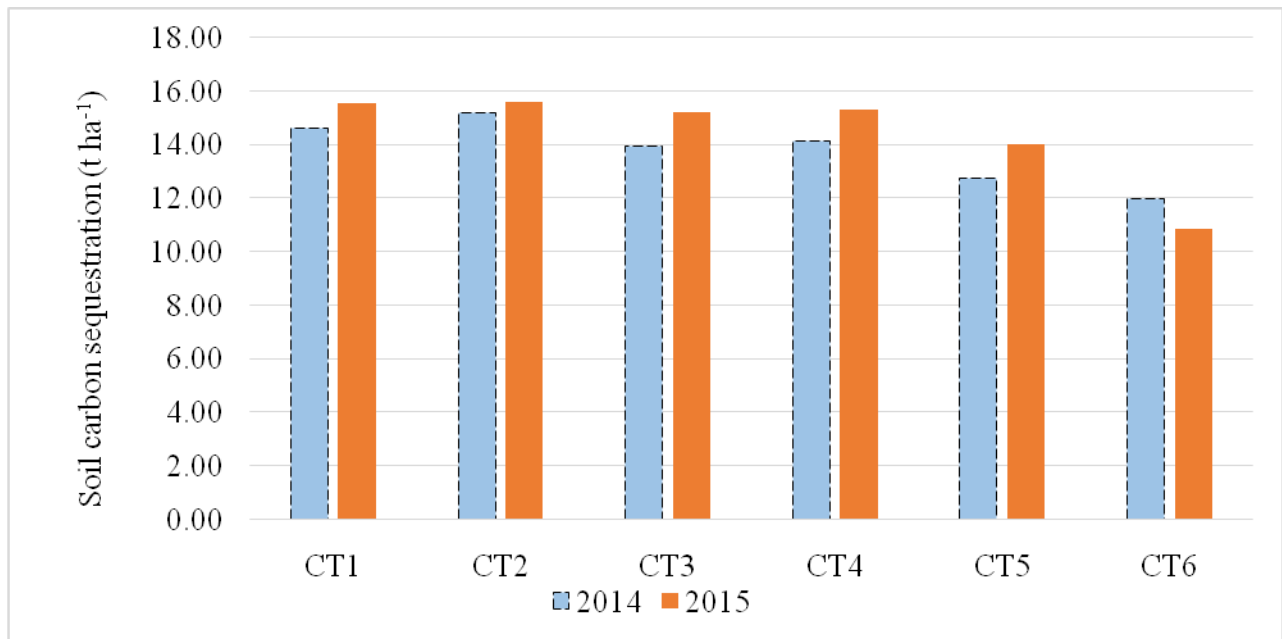
NS: Non significant, \*: Significant at 5%, \*\*: Significant at 1%

**Table.3** Soil urease, dehydrogenase and total phosphatase activity at 75 DAS as influenced by different conservation tillage practices and intercropping systems

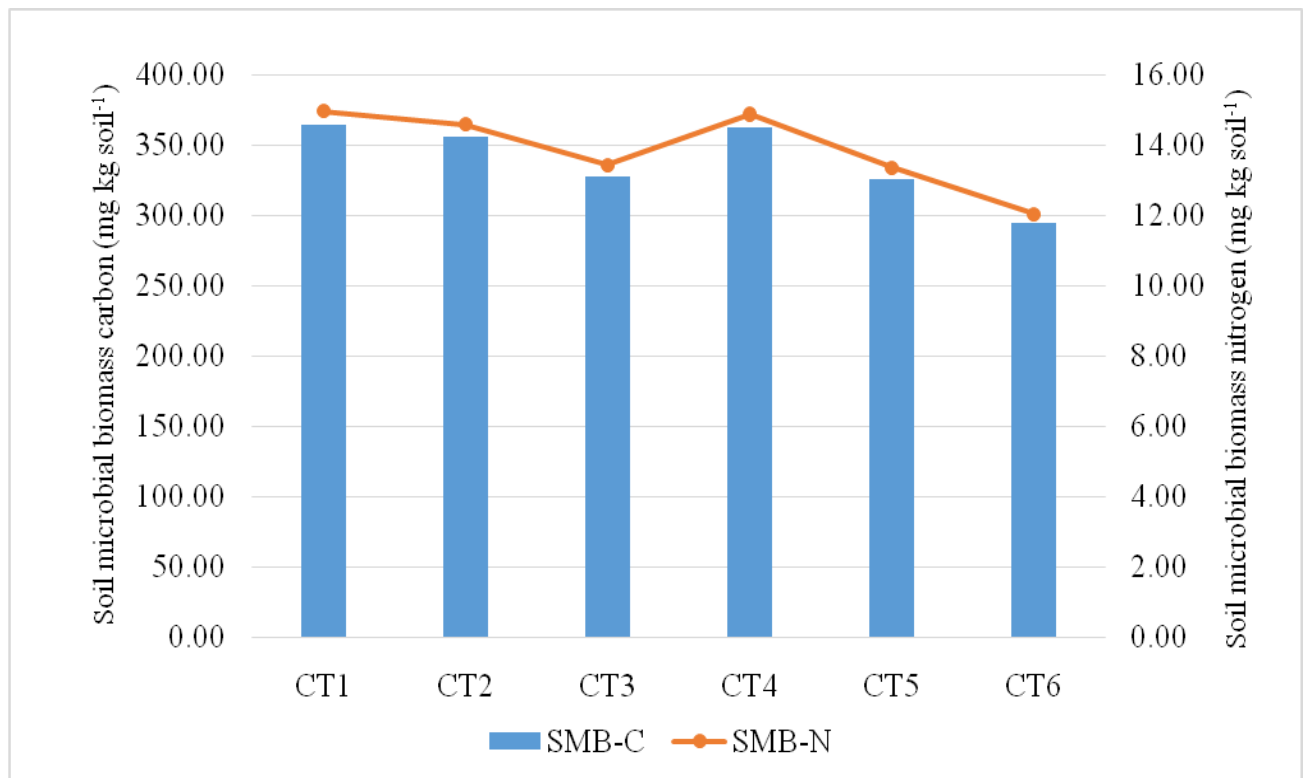
Tillage systems		Soil urease activity ( $\mu\text{g NH}_4\text{-N g}^{-1} \text{ day}^{-1}$ )			Soil dehydrogenase activity ( $\mu\text{g TPF g}^{-1} \text{ day}^{-1}$ )			Total phosphatase activity ( $\mu\text{g PNP g}^{-1} \text{ hr}^{-1}$ )		
		2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>CT<sub>1</sub> -Conservation tillage with BBF and crop residue retained on the surface.</b>		12.85a	10.67ab	11.76a	34.27a	30.31ab	32.29a	175.00a	171.43a	173.21a
<b>CT<sub>2</sub> -Conservation tillage with BBF and incorporation of crop residue.</b>		12.84a	10.89a	11.86a	33.88a	30.71a	32.29a	177.38a	171.73a	174.55a
<b>CT<sub>3</sub> -Conservation tillage with flat bed with crop residue retained on the surface.</b>		12.59ab	9.60cd	11.10ab	33.49a	28.79cd	31.14b	175.89a	164.29b	170.09b
<b>CT<sub>4</sub> -Conservation tillage with flat bed with incorporation of crop residue.</b>		12.92a	9.97bc	11.44a	33.62a	29.48bc	31.55ab	177.98a	168.45a	173.21a
<b>CT<sub>5</sub> -Conventional tillage with crop residue incorporation.</b>		12.58ab	9.66cd	11.12ab	31.31b	28.09d	29.70c	170.54b	150.30c	160.42c
<b>CT<sub>6</sub> -Conventional tillage without crop residue</b>		11.74b	9.04d	10.39b	29.04c	25.82e	27.43d	163.39c	145.24d	154.32d
<b>S.Em <math>\pm</math></b>		<b>0.30</b>	<b>0.26</b>	<b>0.27</b>	<b>0.46</b>	<b>0.34</b>	<b>0.34</b>	<b>1.39</b>	<b>1.20</b>	<b>0.82</b>
<b>F test</b>	<b>5%</b>	*	*	*	*	*	*	*	*	*
	<b>1%</b>	NS	**	NS	**	**	**	**	**	**

NS: Non significant, \*: Significant at 5%, \*\*: Significant at 1%

**Fig.1** Soil carbon sequestration ( $\text{t ha}^{-1}$ ) as influenced by conservation agricultural practices during 2014 and 2015



**Fig.2** Soil microbial biomass carbon (SMB-C) and soil microbial biomass nitrogen (SMB-N) as influenced by conservation agricultural practices



While conventional tillage cause the grater incorporation of residues in the soil, its physical breakdown, overturning of soil and increase aeration, improve soil residue contact and disruption of soil aggregates that leading to oxidation of SOM and erosion which lowers SOC content in the surface soil (Roldan *et al.*, 2003). Conventional tillage incorporates residue into moister environment where decomposition is fast as compared to residues left in soil surface (Halvorson *et al.*, 2002).

The higher SOC content in the plots under conservation tillage than conventional tillage plots might be attributed in part to less disruption of soil structure and aggregates (Das *et al.*, 2013). During summer, conventional tilled soils tend to expose to sunlight which increases the loss of soil organic carbon due to increase in accelerate rate of decomposition of soil organic matter. Retention of crop residues and soil surface cover under conservation till during summer resulted in declining soil organic carbon loss, protect the SOC from water and wind erosion. Combined effect of conservation tillage with effective utilization of crop residue increased the soil organic carbon due to addition of organic matter through residue resulted in better root growth, decomposition of these residues and plant root exudates by microbial activity which resulted in leaching of organic matter constituents from the residue enriched layer to just above the bottom of plough zone (Gal *et al.*, 2007).

Higher SOC is might be due to addition of organic matter through biomass of pigeonpea as well as soybean, root nodules and huge leaf fall decomposition in the system which led to the increase of microbial population that hastened decomposition of crop residues resulting in buildup of organic carbon in soil (Srinivasulu *et al.*, 2000 and Kevizhalhou *et al.*, 2014).

### **Soil organic carbon sequestration (SOCS)**

Tillage practices had significant effect on SOCS after harvest of crops. Two years pooled data showed that, all the conservation tillage practices *viz.*, CT<sub>1</sub>, CT<sub>2</sub>, CT<sub>3</sub> and CT<sub>4</sub> recorded significantly higher SOCS (15.07, 15.39, 14.58 and 14.72 t ha<sup>-1</sup>, respectively) as compared to conventional tillage with (CT<sub>5</sub>, 13.40 t ha<sup>-1</sup>) and without crop residue (CT<sub>6</sub>, 11.42 t ha<sup>-1</sup>) (Fig. 1). The impacts of conservation tillage and crop residues combination have shown the remarkable potential in SOCS as compared to conventional tillage systems. Higher soil carbon sequester under conservation tillage practices might be due to high crop residue addition tends to accumulate more carbon in the soil than is released into the atmosphere and also legume based cropping system helped in nutrient cycling and SOC accumulation under conservation tillage system and also improvement in conserving soil moisture, reducing soil erosion, improving soil structure, enhancing SOC concentration, and reducing the rate of enrichment of atmospheric CO<sub>2</sub> resulted in higher SOCS (Lal, 2004). Conservation tillage, residues are retained on soil surface and partially incorporated into soil, the organic materials decompose slowly, and thus, CO<sub>2</sub> emission into the atmosphere is also slow. Thus in the total balance, net fixation or sequestration of carbon takes place and the soil becomes a net sink of carbon (Bot and Benites, 2005).

### **Soil microbial biomass carbon and nitrogen (SMB-C and SMB-N)**

Conservation tillage systems had significant effect on SMB-C and SMB-N (Table 2 and Fig. 2). Pooled data on SMB-C and SMB-N showed that, all the tillage systems (CT<sub>1</sub>, CT<sub>2</sub>, CT<sub>3</sub>, CT<sub>4</sub> and CT<sub>5</sub>) recorded significantly higher SMB-C (364.00, 355.20, 327.20 and



362.00 mg kg soil<sup>-1</sup>, respectively) and SMB-N (14.97, 14.60, 13.43 and 14.88 mg kg soil<sup>-1</sup>, respectively) except conventional tillage without crop residue (CT<sub>6</sub>, 294.00 and mg kg soil<sup>-1</sup>, respectively). The positive response of conservation tillage practices as compared to conventional tillage systems were probably due to higher levels of C substrates available for microorganism growth, as well as better soil physical conditions and higher water retention due to the altered land configurations and applied residues (Singh *et al.*, 2009). The improvement in SMB- C and N is mainly due to rate of organic carbon input from plant biomass which is the dominant factor controlling the amount of SMB in soil. Reduction in loss of soil organic carbon in conservation tillage and continuous, uniform supply of carbon from crop residues serves as an energy source for microorganisms. Minimum soil disturbance under conservation tillage and crop residue retention/incorporation tend to better aggregation in soil might be attributed to increase in soil organic carbon as well as SMB-C and N (Alvear *et al.*, 2005 and Kumar 2012).

### **Soil enzymatic activity**

Tillage practices had a significant effect on soil enzymatic activity at 75 DAS of crops. Significantly higher soil urease activity (11.76, 11.86, 11.10 and 11.44 µg NH<sub>4</sub>-N g<sup>-1</sup> day<sup>-1</sup>), higher dehydrogenase activity (32.29, 32.29, 31.14 and 31.55 µg TPF g<sup>-1</sup> day<sup>-1</sup>) and total phosphate activity (173.21, 174.55, 170.09 and 173.21 µg PNP g<sup>-1</sup>hr<sup>-1</sup>) were recorded in all the conservation tillage systems such as CT<sub>1</sub>, CT<sub>2</sub>, CT<sub>3</sub> and CT<sub>4</sub> respectively as compared to conventional tillage without crop residue (CT<sub>6</sub>, 10.39 µg NH<sub>4</sub>-N g<sup>-1</sup> day<sup>-1</sup>, 27.43 µg TPF g<sup>-1</sup> day<sup>-1</sup> and 154.32 µg PNP g<sup>-1</sup>hr<sup>-1</sup>, respectively) (Table 3). Higher soil enzymatic activity under conservation tillage practices could be

attributed to the minimum soil disturbance, retention as well as incorporation of residues, root exudates from crops, availability of soil moisture, better aeration, optimum temperature and higher organic matter present increases the carbohydrate content which act as an energy source for microbes which resulted in higher soil enzymatic activity (Mina *et al.*, 2008 and Nurbekov, 2008).

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### **References**

- Alvear, M., Rosas, A., Rouanet, J. L. and Borie, F., 2005. Effect of three soil tillage systems on some biological activities in an Ultisol from southern Chile. *Soil Tillage and Research* 82: 195-202.
- Bot, A. and Benites, J., 2005. The role of conservation agriculture in organic matter deposition and carbon sequestration. In: *The importance of soil organic matter: key to drought-resistant soil and sustained food production*. FAO Soils Bulletin, FAO Land and Plant Nutrition Management Service, Food and Agriculture Organization of the United Nations Rome. 80: 47-50.
- Bujarbaruah, K. M., 2004. Organic farming: opportunities and challenges in North-eastern region of India. (*In*) *Souvenir, International conference on organic food*. 14-17 February 2004, ICAR Research Complex for NEH region, Umiam, Meghalaya, pp. 7-13.
- Carter, M. R., 1991. Ninhydrin-reactive N released by the fumigation extraction

- method as a measure of microbial biomass under field conditions. *Soil Biology and Biochemistry*. 23:139-143.
- Casida, L. E., Klen, D. A. and Santoro, J., 1964. Soil dehydrogenase activity. *Soil Science*. 98:371-376.
- Das, T. K., Ranjan, B., Sharma, A. R., Das, S., Saad, A. A. and Pathak, H., 2013. Impacts of conservation agriculture on total soil organic carbon retention potential under an irrigated agroecosystem of the western Indo-Gangetic Plains. *European Journal of Agronomy*. 51: 34-42.
- Derpsch, R., 2005. The extent of conservation Agriculture adoption worldwide: Implications and impact. *Proceedings of the Third International Congress of Conservation Agriculture*, 3-7 October, Nairobi, Kenya, pp 15.
- Eivazi, Z. and Tabatabai, M. A., 1979. Phosphatase in soils. *Soil Biology and Biochemistry*. 9:167-172.
- Gal, A., Vyn, T. J., Michéli, E., Kladienko, E. J. and McFee, W. W., 2007. Soil carbon and nitrogen accumulation with long-term no till versus moldboard plowing overestimated with tilled zone sampling depths. *Soil Tillage and Research*. 96:42-51.
- Ghosh, P. K., 2010. Effect of land configuration on water economy, crop yield and profitability under rice based cropping systems in north east India. *Indian Journal of Agricultural Sciences*. 80 (1): 16-20.
- Gomez, K. A. and Gomez, A. A., 1984. *Statistical Procedures for Agricultural Research*, An international Rice Research Institute Book, Wiley- Inter Science Publication, New York, USA, 680.
- Halvorson, A. D., Wienhold, B. J. and Black, A. L., 2000. Tillage, nitrogen and cropping system effects on soil carbon sequestration. *Soil Science Society of American Journal*. 66: 90-912.
- Jackson, M. L., 1967. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi, India.
- Kevizhalhou, K., Munda, G. C., Anup, D. and Verma, B. C., 2014. Soil health as affected by altered land configuration and conservation tillage in a groundnut (*Arachis hypogaea*) - toria (*Brassica campestris* var toria) cropping system. *Indian Journal of Agricultural Sciences*. 84 (2): 241-247.
- Kumar, R., 2012. Effect of conservation tillage on growth, yield and quality of pigeonpea based Intercropping system under rainfed. *Journal of Indian Society of Soil Science*. 56 (1): 80-85.
- Lal, R., 2004. Soil carbon sequestration to mitigate climate change. *Geoderma*. 123: 1-22.
- Mina, B. L., Saha, S., Kumar, N., Srivastava, A. K. and Gupta, H. S., 2008. Changes in soil nutrient content and enzymatic activity under conventional and zero-tillage practices in an Indian sandy clay loam soil. *Nutrient Cycling in Agroecosystems*. 82: 273-281.
- Nurbekov, A., 2008. Microbial community responses to tillage and residue management on different soil types in southern Finland. *Soil Tillage and Research*. 23: 221-239.
- Pancholy, S. K. and Rice, E. L., 1973. Soil enzymes in relation to old field succession: Amylase, invertase, cellulose, dehydrogenase and urease. *Soil Science Society American Proceeding*. 37:47-50.
- Rangaswamy, R., 2000. Effect of different tillage methods on weed infestation under different crops viz., sorghum, chilli, groundnut and cowpea. M. Sc. (Agri.) Thesis, University Agriculture Sciences, Dharwad (India).

- Roldan, A., Caravaca, F., Hernandez, M. T., Garcia, C., Sanchez, B. C., Velasquez, M. and Tiscareno, M., 2003. No-tillage, crop residue additions, and legume cover cropping effects on soil quality characteristics under maize in Patzcuaro watershed (Mexico). *Soil Tillage and Research*. 72: 65-73.
- Singh, G., Marwaha, T. S. and Kumar, D., 2009. Effect of resource conserving techniques on soil microbiological activities parameters under long term maize (*Zea mays*) – wheat (*Triticum aestivum*) crop rotation. *Indian Journal of Agricultural Sciences*. 79(2): 94–100.
- Srinivasulu, K., Singh, R. P. and Madhavi, K., 2000. Performance of rainfed pigeonpea-based intercropping systems under varying plantings. *Crop Research*. 20: 56-61.
- West, T. O. and Post, W. M., 2002. Soil organic carbon sequestration rates by tillage and crop rotation: A global data analysis. *Soil Science Society of American Journal*. 66: 1930-1946.

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