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**Priti Kumari**
Department of Soil Science and Agricultural Chemistry, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

**Sanjeev Kumar**
Department of plant pathology, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

**Dr. RC Singh**
Associate Professor-cum-Sr. Scientist, Department of Soil Science and Agricultural Chemistry, Bihar Agricultural University, sabour, Bhagalpur, Bihar, India

**Dr. Rakesh Kumar**
Assistant Professor-cum-Jr. Scientist, Department of Soil Science and Agricultural Chemistry, Bihar Agricultural University, sabour, Bhagalpur, Bihar, India

**Dr. Shweta Shambhavi**
Assistant Professor-cum-Jr. Scientist, Department of Soil Science and Agricultural Chemistry, Bihar Agricultural University, sabour, Bhagalpur, Bihar, India

**Corresponding Author:**
**Sanjeev Kumar**
Department of plant pathology, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

# Effect of different soil conservation practices on soil microbial biomass carbon, nitrogen and phosphorus under rice based cropping system in Bihar

**Priti Kumari, Sanjeev Kumar, Dr. RC Singh, Dr. Rakesh Kumar and Dr. Shweta Shambhavi**

**Abstract**
An experiment based on conservation agriculture was conducted to assess the effect of different tillage systems such as zero-tillage (T1), permanent raised bed (T2) and Conventional Tillage (T3) and cropping systems such as rice+wheat (C1), rice+maize (C2) and rice+lentil (C3) on soil microbial biomass carbon (MBC), soil microbial biomass nitrogen (MBN) and soil microbial biomass phosphorus (MBP) were studied in Inceptisol soil in BAU, Sabour, Bihar. Due to change in microbial biomass C, N, P in soil microbial count and biological enzymes in soil influenced and by virtue of which physical, chemical and biological properties imbalanced. Our aim of study to determine how three tillage practices and three cropping systems affect MBC, MBN and MBP content in soil. The result reveals that MBC (583 mg/kg soil), MBN (39 mg/kg soil), MBP (19 mg/kg soil) was highest under T1 with C3 system as compare to other 2 systems of tillage and cropping (403 mg/kg soil), (20 mg/kg soil), (6 mg/kg soil). From this experiment, we observed that among three tillage practices and cropping system combination, zero-tillage (T1) with legume based cropping system (C3) found significantly highest MBC, MBN, MBP as compared to other tillage- cropping combination based systems.

**Keywords:** Soil conservation, biomass carbon, nitrogen and phosphorus, Bihar

## Introduction
Agriculture faces significant challenges to meet the need of food production without significantly increasing the area under cultivation and degrading the environment. Due to continuous intense tilling, soil organic carbon (SOC) of soils is being lost, which is a key indicator of soil health and quality thus soil health is deteriorating continuously. Soil organic matter (SOM) plays vital role in soil agro-ecosystems and it's an important indicator soil fertility as well as crop productivity because of its very important role in soil physical, chemical and biological properties (Gregorich *et al.*, 2001) [8]. Conservation agricultural (CA) is one concept for natural resource conservation and mitigation of adverse climatic effects and higher profitability (Das *et al.*, 2014) [5]. Beare *et al.* (1993) [2] and ( Yang *et al.* 2015) [12] consider Zero tillage and Minimum tillage can promote growth of mycorrhizal fungi and fungi, at the same time, significantly increased soil microbial biomass and microbial species which can be fixed more unstable carbon accumulation, reduce the loss caused by mineralization; also conducive to the formation of large aggregates body. Freixo *et al.* (2002) [6] found that, after 13 years of farming trials under conventional tillage, topsoil organic carbon of 0 ~ 5 cm reduced by 60%, while Zero tillage conditions reduce 43%. . MBC, MBN, MBP are important biologically active fractions of organic materials. Therefore, microbial biomass measurement is a viable tool for understanding and predicting long term effects on changes in land use and associated soil conditions. No-tillage system causes minimal soil disturbance and combined with crop rotation may hold potential to maintain good soil health and microorganisms in the soil strongly influence soil processes, fulfil key roles in the decomposition of organic matter, the cycling of carbon and nitrogen and the formation and stabilization of soil structure. Rice (*Oryza sativa* L.), wheat (*Triticum aestivum*L.) maize (*Zea mays*) and lentil ((*Lens culinaris*) are widely grown under different cropping system in Bihar, especially in the Indo Gangetic region. Rice is the crop of tropical climate but grown successfully in humid region of sub tropics and temperate climate. In India, Rice is one of the most important food crops and feeds more than 60 per cent population and it is the main source of protein (15%) and energy (21%) for the population.

## Materials and Methods

### Experimental site

The present investigation will be carried out during 2017 in *kharif* season at area specified Conservation agriculture near maize section at Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India. Taxonomically, the soils of the study area fall in the order "Inceptisols" and sub group "Typic Ustifluvents". The geographical location of Bhagalpur comes under the Middle Gangetic plain region of Agro-climatic Zone III A. It is situated between 25° 50' N latitude and 87°19' E longitude at an altitude of 52.73 meters above mean sea-level. Bhagalpur is located in sub-tropical climate characterized with hot desiccating summer, cold winter and moderate rainfall. May is the hottest month with an average maximum temperature of 35 to 39˚C. January is the coldest month of the year with mean minimum temperature varying from 5 to 10˚C. The average annual rainfall is 1231.4 mm, precipitating mostly between mid-June to mid-October (during south west monsoon).

### Soil sampling

Collect sample with Soil auger in 0-15 cm, 15-30 cm soil, for each treatment were randomly selected three replicates of five points, taking a mixed sample. Keeping in mind that soil sample should contain much amount of moisture (wet condition should be maintained).

### Experimental design

The experiment was laid out in Split plot design having three establishment methods of rice in main plots, i.e. Zero tillage, permanent bed and conventional puddled rice and three cropping systems in sub-plot, i.e. rice-wheat, rice-maize and rice-lentil.

### Analysis methods

Microbial Biomass Carbon was determined by fumigation - extraction method (Vance *et al.*, 1987) [11]. External heating potassium dichromate volumetric method for the determination of organic carbon, Microbial biomass carbon using a modified chloroform fumigation. Microbial Biomass Nitrogen was determined by fumigation- extraction method (Brookes *et al.*, 1985) [3]. Microbial Biomass Phosphorus was determined by fumigation- extraction method (Brookes *et al.*, 1982) [4]. Microbial Biomass Carbon was determined by fumigation - extraction method (Vance *et al.*, 1987) [11]. Twenty gram of each sample in three replicates was weighed into 50 ml capacity beakers and fumigated with 50 ml of ethanol free chloroform in a dessicator. Dessicator was evacuated with water jet or vaccum pump. After 24 hours of incubation at room temperature, chloroform was removed and the dessicator was evacuated 5-6 times. The samples were extracted with 80 ml potassium sulfate (0.5 M) for 30 minutes on a rotary shaker at 160 rpm and the contents were filtered through Whatman No. 1 filter paper. Three replicates each of unfumigated sample was extracted at the time of fumigation. Then 8 ml of filtrate was refluxed with 2 ml of $K_2Cr_2O_7$ and 15 ml of diacid mixture for half hour on hot plate at $150^0$C. Three drops of indicator solution was added and titrated with ferrous ammonium sulphate solution. During titration, first brown colour appears followed by green and then brown again. A cold blank was prepared by taking 2 ml of $K_2Cr_2O_7$, 8 ml of potassium sulfate (0.5 M) and 15 ml of diacid mixture. The mixture was titrated with Ferrous Ammonium Sulphate (FAS). A hot blank was prepared by taking 2 ml of $K_2Cr_2O_7$, 8 ml of potassium sulfate (0.5 M) and 15 ml of diacid mixture refluxed at $150^0$C, cooled and titrated with FAS.

### Calculations

Normality of FAS was calculated by titrating it with cold blank by using the following formula:

$$\text{Exact normality of FAS (x)} = \frac{0.04 \text{ x } 2}{y}$$

Where,
0.04 = Expected normality of FAS
2 = Millilitre of potassium dichromate
Y = Millilitre of FAS used for cold blank

$$\text{Extractable C } (\mu g/g) = \frac{[\text{Volume of FAS for hot blank} - \text{volume of FAS for sample}] \text{ x Normality of FAS x } 12 \text{ x } 1000 \text{ x } (80 + \text{water content})}{4 \text{ x } 8 \text{ x dry weight of sample}}$$

$$\text{Biomass C (mg/kg soil)} = 2.64 \text{ x (Extractable C in fumigated sample} - \text{Extractable C in unfumigated sample)}$$

Microbial Biomass Nitrogen was determined by fumigation-extraction method (Brookes *et al.*, 1985) [3]. 20 ml of $K_2SO_4$ extract prepared in case of microbial biomass C estimation, 10 ml of digestion mixture and 300 mg of Zn powder was added and allowed to stand for two hours. Then 0.6 ml of 0.19 M $CuSO_4$ and 5 ml of conc. $H_2SO_4$ was added and digested on Kjeldatherm digester for two hours. Then 10 ml of boric acid indicator solution was taken in 100 ml Erlenmeyer flask and marked to indicate volume of 50 ml. The flask was placed under condenser of steam distillation apparatus. The digested mixture was taken in distillation flask and attached to steam distillation apparatus. Forty per cent NaOH was added till green colour turned black. The distillation was started and when the distillate reached 50 mark of receiver flask, it was stopped. The distillate was then titrated with 0.005N $H_2SO_4$. The colour change at the end point was green to permanent faint pink. The extractable N and biomass N were calculated as below:

### Calculations

1 ml of N/200 $H_2SO_4$ = 70 µg N.

$$\text{Extractable N/g} = \frac{\text{ml of N/200 } H_2SO_4 \text{ used x } 70 \text{ x wet weight of sample}}{20 \text{ x dry weight of sample}}$$

$$\text{Biomass N(mg/kg soil)} = 2.22 \text{ x (Extractable N in fumigated sample} - \text{Extractable N in unfumigated sample)}$$

### c) Microbial Biomass Phosphorus

Microbial Biomass Phosphorus was determined by fumigation- extraction method (Brookes *et al.* 1982) [4]. From the $K_2SO_4$ extract prepared in case of microbial biomass C estimation, 10 ml of filtrate was taken into 25 ml volumetric flask and 2 to 3 drops of 2,4- DNP was added as indicator (pink colour developed ) and then a few drops of $H_2SO_4$ was added to make solution colourless. To it 8 ml of mixed reagent (6g Ammonium Molybdate, 0.145 g antimony K tartrate, and 140 ml conc $H_2SO_4$ in 500 ml water. 1.056 g

ascorbic acid was mixed to 200 ml of the solution). Blue colour was developed. The absorbance of the blue colour of the sample solutions was measured on Spectrophotometer at 660 nm, after 30 minutes.

**Calculations**

$$\text{Extractable P/g} = \frac{\text{Absorbance measured x 25 x 4}}{10}$$

Biomass P(mg/kg soil)=0.4 x (Extractable P in fumigated sample – Extractable P in unfumigated sample)

**Statistics**

The data so generated during the course of present investigation were subjected to analysis of variance for split plot design vis-à-vis correlation (Gomez and Gomez, 1984) [7] through the requisite statistical computations to predict the cause and effect relationship of various treatments with the productivity of rice and various soil properties. The level of significance was kept at 5 per cent.

**Result and Discussion**

**Table 1:** Effect of different tillage and cropping systems on Microbial Biomass Carbon content (mg/kg soil) of soil after sixth cropping cycle

| Microbial Biomass Carbon (mg/kg soil) | | | | |
|---|---|---|---|---|
| 0 – 15 cm | | | | |
| **Treatment** | **$T_1$: Zero Tillage** | **$T_2$: Permanent Raised Bed** | **$T_3$: Conventional Tillage** | **Mean** |
| $C_1$ : Rice- Wheat | 583.00 | 490.00 | 429.00 | 500.67 |
| $C_2$ : Rice- Maize | 538.00 | 473.00 | 403.00 | 471.33 |
| $C_3$ : Rice- Lentil | 598.00 | 515.00 | 447.00 | 520.00 |
| Mean | 573.00 | 492.67 | 426.33 | |
| CD (P=0.05) C at Same T | | 24.429 | | |
| CD (P=0.05) T at Same C | | 20.604 | | |
| CD (P=0.05) T x C | | 38.833 | | |
| 15- 30 cm | | | | |
| $C_1$ : Rice- Wheat | 535.00 | 442.00 | 381.00 | 452.67 |
| $C_2$ : Rice- Maize | 490.00 | 425.00 | 355.00 | 423.33 |
| $C_3$ : Rice- Lentil | 550.00 | 467.00 | 399.00 | 472.00 |
| Mean | 525.00 | 444.67 | 378.33 | |
| CD (P=0.05) C at Same T | | 15.191 | | |
| CD (P=0.05) T at Same C | | 11.823 | | |
| CD (P=0.05) T x C | | 24.125 | | |

The data under Table 1 shows that microbial biomass carbon was found to be significantly higher under rice-lentil cropping system as compared to rice-wheat and rice- maize cropping systems. Among tillage system microbial biomass carbon was higher under zero tillage as compared to conventional tillage. Heidari *et al.* (2016) [9] reported that microbial biomass carbon was higher under no tillage compared to conventional tillage because there is higher amount of organic matter or residue under no till. When organic matter is applied and MBC decreases with decrease in pH and it is the most important chemical factor controlling soil microbial communities (microbial population directly proportional to microbial biomass) and increase in MBC after applying organic manures indicates that soil organic carbon provided by organic manures may have been consumed as energy source by microorganism

**Table 2:** Effect of different tillage and cropping systems on Microbial Biomass Nitrogen content (mg/kg soil) of soil after sixth cropping cycle

| Microbial Biomass Nitrogen (mg/kg soil) | | | | |
|---|---|---|---|---|
| 0 – 15 cm | | | | |
| **Treatment** | **$T_1$: Zero Tillage** | **$T_2$: Permanent Raised Bed** | **$T_3$: Conventional Tillage** | **Mean** |
| $C_1$ : Rice- Wheat | 38.00 | 35.00 | 23.00 | **32.00** |
| $C_2$ : Rice- Maize | 37.00 | 31.00 | 20.00 | **29.33** |
| $C_3$ : Rice- Lentil | 39.00 | 36.00 | 27.00 | 34.00 |
| Mean | 38.00 | 34.00 | 23.33 | |
| CD (P=0.05) C at Same T | | 1.245 | | |
| CD (P=0.05) T at Same C | | 1.476 | | |
| CD (P=0.05) T x C | | 3.932 | | |
| 15- 30 cm | | | | |
| $C_1$ : Rice- Wheat | 29.00 | 26.00 | 14.00 | 23.00 |
| $C_2$ : Rice- Maize | 28.00 | 22.00 | 11.00 | 20.33 |
| $C_3$ : Rice- Lentil | 30.00 | 27.00 | 18.00 | 25.00 |
| Mean | 29.00 | 25.00 | 14.33 | |
| CD (P=0.05) C at Same T | | 0.967 | | |
| CD (P=0.05) T at Same C | | 0.998 | | |
| CD (P=0.05) T x C | | 2.148 | | |

Table 2 reflects that under rice based cropping system, significantly higher mean value of microbial biomass nitrogen was observed under rice – lentil system as compared to rice-maize cropping system whereas under established tillage technique, zero tillage system was found significantly superior to other techniques. King and Hofmockel (2017) [10] observed that the increased retention of organic inputs in microbial biomass in diverse crop rotations coincided with greater return on enzymatic investment and thus they suggested that the microbial efficiency may be promoted by moldboard plough incorporated with green manure or perennial legume. Increased content of soil organic carbon (SOM) depolymerised with diversification are consistent with retention of residue inputs in microbial biomass N and they suggest that depolymerisation was primarily limited by soil protein concentration.

**Table 3:** Effect of different tillage and cropping systems on Microbial Biomass Phosphorus content (mg/kg soil) of soil after sixth cropping cycle

| Microbial Biomass Phosphorus (mg/kg soil) | | | | |
|---|---|---|---|---|
| 0 – 15 cm | | | | |
| **Treatment** | **$T_1$: Zero Tillage** | **$T_2$: Permanent Raised Bed** | **$T_3$: Conventional Tillage** | **Mean** |
| $C_1$ : Rice- Wheat | 16.00 | 10.00 | 7.00 | **11.00** |
| $C_2$ : Rice- Maize | 15.00 | 9.00 | 6.00 | **10.00** |
| $C_3$ : Rice- Lentil | 19.00 | 13.00 | 8.00 | **13.33** |
| Mean | 16.67 | 10.67 | 7.00 | |
| CD (P=0.05) C at Same T | | 0.578 | | |
| CD (P=0.05) T at Same C | | 0.526 | | |
| CD (P=0.05) T x C | | 0.543 | | |
| 15- 30 cm | | | | |
| $C_1$ : Rice- Wheat | 12.00 | 6.00 | 3.00 | 7.00 |

| | | | | |
|---|---|---|---|---|
| $C_2$ : Rice- Maize | 11.00 | 5.00 | 2.00 | 6.00 |
| $C_3$ : Rice- Lentil | 15.00 | 9.00 | 4.00 | 9.33 |
| Mean | 12.67 | 6.67 | 3.00 | |
| CD (P=0.05) C at Same T | | 0.127 | | |
| CD (P=0.05) T at Same C | | 0.051 | | |
| CD (P=0.05) T x C | | 0.004 | | |

Table 3 reported that microbial biomass phosphorus was found to be significantly higher under rice-lentil cropping system as compared to rice-wheat and rice-maize cropping systems. Among tillage system microbial biomass phosphorus was higher under zero tillage as compared to conventional tillage. Balota *et al.* (2003) [1] reported that the general increase of microbial biomass under no till (NT) over conventional tillage (CT), especially under tropical/subtropical conditions, could be attributed to several factors, such as a lower temperature, higher moisture content, greater soil aggregation and higher C content. The lack of a major disturbance event with NT likely provides a steady source of organic C to support the microbial community compared to CT where a temporary flush of microbial activity with each tillage event results in large losses of C as $CO_2$. Less organic matter on the soil surface and as a consequence increased the abundance of microbial population (Mathew, 2012).

## Conclusion

Our study reveals that zero tillage system under legume based cropping system having higher MBC, MBN, MBP as compared to conventional tillage in non- leguminous cropping system.

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