

## Influence of Different Nutrient Management Practices and Cropping Systems on Physico-Chemical Properties in Vertisol of Northern Transition Zone of Karnataka

Jahnavi R. K., Math K. K.

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**Abstract** A long term field experiment on Influence of different nutrient management practices and cropping systems on physico-chemical properties in Vertisol of Northern Transition Zone of Karnataka was initiated in 2004-05 on a Typic Haplustert. Organic manure application to the soil for long duration recorded favorable values for maximum water holding capacity (65.4%), bulk density ( $1.14 \text{ Mg m}^{-3}$ ), porosity (56.5%), aggregate stability (66.8%) when com-

pared to other nutrient management practices. Similarly chemical properties like soil pH (7.5), EC ( $1.13 \text{ dSm}^{-1}$ ), CEC [ $51.5 \text{ cmol (p}^+) \text{ kg}^{-1}$ ] and  $\text{CaCO}_3$  (2.1%) recorded favorable values for plant growth when compared to inorganic nutrient management practices.

**Keywords** Chemical properties, Cropping systems, Nutrient management practices, Physical properties.

### Introduction

Soil is the most precious natural resource and is the basic medium of life support system for human beings, animals, plants, insects and micro organisms, soil is rightly considered as Soul of Infinite Life. Following the unprecedented expansion and intensification of agriculture in India, there is a clear evidence of decline in the soil organic carbon (SOC) contents in many soils; on one hand while on the other hand good farming practices such as balanced fertilization and addition of crop residues either maintain or result in build up or depletion of SOC stock [1]. The process of decline in soil organic matter is accelerated by the processes of nutrient depletion [2], soil erosion and other forces of land degradation. The benefits of SOC are linked closely to the fact that it acts as a store house for nutrients and contributes to soil aeration,

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Jahnavi R. K.<sup>1\*</sup>, Math K. K.<sup>2</sup>  
Department of Soil Science & Agric. Chemistry  
University of Agricultural Sciences,  
Dharwad 580005,  
Karnataka, India  
e-mail : <sup>1</sup>jahnavi.jk@gmail.com;  
<sup>2</sup>kkmath\_05@rediffmail.com

\*Correspondence

**Table 1.** Methods for analysis of soil samples.

| Sl. No. | Particulars                     | Author(s)      | Methodology              | Unit                      |
|---------|---------------------------------|----------------|--------------------------|---------------------------|
| I       | Physical properties             |                |                          |                           |
| 1.      | Aggregated stability            | Kemper (1965)  | Yoder wet sieve method   | Percentage                |
| 2.      | Bulk density                    | Black (1965)   | Clod method              | Mg/m <sup>3</sup>         |
| 3.      | Soil porosity                   |                |                          | Percentage                |
| 4.      | Maximum water holding capacity  | Piper (2002)   | Keen's cup method        | Percentage                |
| II      | Chemical properties             |                |                          |                           |
| 1.      | Soil reaction (1:2.5)           | Jackson (1967) | pH meter                 |                           |
| 2.      | Electrical conductivity (1:2.5) | Jackson (1967) | EC bridge                | dS/m                      |
| 3.      | Cation exchange capacity        | Jackson (1967) | Sodium saturation method | cmol (p <sup>+</sup> )/kg |
| 4.      | Calcium carbonate               | Piper (2002)   | Acid neutralizing method | Percentage                |

thereby reducing soil compaction. Sustaining SOC is important for recycling of plant nutrients and improving the physical, chemical and biological properties of soil to sustain crop productivity as well as soil and environmental quality.

## Materials and Methods

The long term field trial on the performance evaluation of important crops/cropping systems under organic farming is in progress on a fixed site since 2004-

**Table 2.** Effect of nutrient management practices and cropping systems on maximum water holding capacity (%) of soil at two depths. CS<sub>1</sub> : Groundnut-Sorghum, CS<sub>2</sub> : Soybean-Wheat, CS<sub>3</sub> : Maize-Chickpea, CS<sub>4</sub> : Pigeonpea + Soybean, CS<sub>5</sub> : Cotton + Peas, NM<sub>1</sub> : Organic, NM<sub>2</sub> : Integrated, NM<sub>3</sub> : RDF+FYM, NM<sub>4</sub> : Inorganic.

| Cropping systems (CS) | Nutrient management practices (NMP) |                 |                 |                 |      |                 |                 |                 |                 |      |
|-----------------------|-------------------------------------|-----------------|-----------------|-----------------|------|-----------------|-----------------|-----------------|-----------------|------|
|                       | 0-30 cm                             |                 |                 |                 |      | 30-60 cm        |                 |                 |                 |      |
|                       | NM <sub>1</sub>                     | NM <sub>2</sub> | NM <sub>3</sub> | NM <sub>4</sub> | Mean | NM <sub>1</sub> | NM <sub>2</sub> | NM <sub>3</sub> | NM <sub>4</sub> | Mean |
| CS <sub>1</sub>       | 64.3                                | 62.0            | 64.0            | 61.1            | 62.9 | 54.0            | 47.3            | 44.4            | 40.2            | 46.5 |
| CS <sub>2</sub>       | 65.7                                | 64.8            | 62.7            | 61.1            | 63.6 | 52.4            | 46.9            | 42.3            | 41.2            | 45.7 |
| CS <sub>3</sub>       | 66.0                                | 62.8            | 63.8            | 61.2            | 63.4 | 53.4            | 45.7            | 45.1            | 40.8            | 46.3 |
| CS <sub>4</sub>       | 65.5                                | 63.7            | 63.4            | 61.1            | 63.4 | 52.6            | 46.0            | 43.5            | 42.2            | 46.1 |
| CS <sub>5</sub>       | 65.3                                | 62.2            | 64.2            | 61.4            | 63.3 | 52.4            | 44.8            | 43.4            | 40.9            | 45.4 |
| Mean                  | 65.4                                | 63.1            | 63.6            | 61.2            |      | 52.9            | 46.2            | 43.8            | 41.1            |      |
|                       | SEm±                                |                 | CD at 5%        |                 |      | SEm±            |                 | CD at 5%        |                 |      |
| NM                    | 1.24                                |                 | 2.26            |                 |      | 1.36            |                 | 4.71            |                 |      |
| CS                    | 0.98                                |                 | NS              |                 |      | 0.88            |                 | NS              |                 |      |
| NM×CS                 | 1.57                                |                 | NS              |                 |      | 1.62            |                 | NS              |                 |      |

**Table 3.** Effect of nutrient management practices and cropping systems on aggregate stability (%) of soil at surface layer. CS<sub>1</sub> : Groundnut-Sorghum, CS<sub>2</sub> : Soybean-Wheat, CS<sub>3</sub> : Maize-Chickpea, CS<sub>4</sub> : Pigeonpea + Soybean, CS<sub>5</sub> : Cotton + Peas, NM<sub>1</sub> : Organic, NM<sub>2</sub> : Integrated, NM<sub>3</sub> : RDF+FYM, NM<sub>4</sub> : Inorganic.

| Cropping systems (CS) | Nutrient management practices (NMP) 0–30 cm |                 |                 |                 |      |
|-----------------------|---------------------------------------------|-----------------|-----------------|-----------------|------|
|                       | NM <sub>1</sub>                             | NM <sub>2</sub> | NM <sub>3</sub> | NM <sub>4</sub> | Mean |
| CS <sub>1</sub>       | 68.2                                        | 65.6            | 64.5            | 62.7            | 65.3 |
| CS <sub>2</sub>       | 67.7                                        | 65.0            | 65.5            | 63.0            | 65.3 |
| CS <sub>3</sub>       | 67.0                                        | 65.5            | 65.1            | 63.8            | 65.3 |
| CS <sub>4</sub>       | 65.5                                        | 65.1            | 65.0            | 63.4            | 64.8 |
| CS <sub>5</sub>       | 65.8                                        | 65.7            | 65.1            | 63.5            | 65.0 |
| Mean                  | 66.8                                        | 65.4            | 65.0            | 63.3            |      |
|                       | CSm±                                        |                 | CD at 5%        |                 |      |
| NM                    | 0.59                                        |                 | 1.15            |                 |      |
| CS                    | 0.52                                        |                 | NS              |                 |      |
| NM×CS                 | 0.87                                        |                 | NS              |                 |      |

05 under Network Project of Organic Farming at the Institute of Organic Farming, Univ of Agricultural Science, Dharwad. The present investigation was under taken during 2012-13 *rabi* season. The average annual rainfall (past 62 years) was 711.8 mm which was fairly well distributed from April to November. The mean maximum temperature varied from 27.3°C (July,

August) to 36.9°C (April) whereas, mean minimum temperature varied from 12.7°C (December) to 21.8°C (May). The mean monthly highest and the lowest relative humidity was 89% (July) and 47% (January) respectively.

The organic, inorganic, integrated and RDF +FYM strips of 15 m were laid out with the cropping systems as sub plots of 20 m length. Across the four main strips of nutrient management practices, five cropping systems mainly groundnut- sorghum, soybean- wheat, maize- chickpea, pigeonpea + soybean and cotton + peas were laid out. The design followed was strip plot with three replication.

The soils were collected from the field after the *rabi* crop of the year 2012-13 from 2 depths (0—30 cm and 30—60 cm) for the analysis of physical and chemical properties by employing standard methods (Table 1). The data collected from the laboratory analysis were subjected to statistical analysis [3].

## Results and Discussion

The different nutrient management practices significantly influenced maximum water holding capacity of soil at both the depth (0—30 cm and 30—60

**Table 4.** Effect of nutrient management practices and cropping systems on bulk density (Mg/m<sup>3</sup>) of soil at two depths. CS<sub>1</sub> : Groundnut-Sorghum, CS<sub>2</sub> : Soybean-Wheat, CS<sub>3</sub> : Maize-Chickpea, CS<sub>4</sub> : Pigeonpea + Soybean, CS<sub>5</sub> : Cotton + Peas, NM<sub>1</sub> : Organic, NM<sub>2</sub> : Integrated, NM<sub>3</sub> : RDF+FYM, NM<sub>4</sub> : Inorganic.

| Cropping systems (CS) | Nutrient management practices (NMP) |                 |                 |                 |      |                 |                 |                 |                 |      |
|-----------------------|-------------------------------------|-----------------|-----------------|-----------------|------|-----------------|-----------------|-----------------|-----------------|------|
|                       | 0–30 cm                             |                 |                 |                 |      | 30–60 cm        |                 |                 |                 |      |
|                       | NM <sub>1</sub>                     | NM <sub>2</sub> | NM <sub>3</sub> | NM <sub>4</sub> | Mean | NM <sub>1</sub> | NM <sub>2</sub> | NM <sub>3</sub> | NM <sub>4</sub> | Mean |
| CS <sub>1</sub>       | 1.14                                | 1.20            | 1.25            | 1.35            | 1.23 | 1.22            | 1.26            | 1.28            | 1.35            | 1.27 |
| CS <sub>2</sub>       | 1.13                                | 1.24            | 1.25            | 1.35            | 1.24 | 1.22            | 1.24            | 1.26            | 1.40            | 1.28 |
| CS <sub>3</sub>       | 1.16                                | 1.23            | 1.25            | 1.34            | 1.24 | 1.23            | 1.25            | 1.27            | 1.38            | 1.28 |
| CS <sub>4</sub>       | 1.14                                | 1.24            | 1.25            | 1.36            | 1.24 | 1.23            | 1.25            | 1.28            | 1.40            | 1.29 |
| CS <sub>5</sub>       | 1.15                                | 1.24            | 1.26            | 1.33            | 1.24 | 1.24            | 1.24            | 1.28            | 1.40            | 1.29 |
| Mean                  | 1.14                                | 1.26            | 1.25            | 1.34            |      | 1.22            | 1.24            | 1.27            | 1.38            |      |
|                       | SEm±                                |                 | CD at 5%        |                 |      | SEm±            |                 | CD at 5%        |                 |      |
| NM                    | 0.01                                |                 | 0.03            |                 |      | 0.01            |                 | 0.04            |                 |      |
| CS                    | 0.01                                |                 | NS              |                 |      | 0.01            |                 | NS              |                 |      |
| NM×CS                 | 0.02                                |                 | NS              |                 |      | 0.02            |                 | NS              |                 |      |

**Table 5.** Effect of nutrient management practices and cropping systems on soil porosity (%) of soil at two depths. CS<sub>1</sub> : Groundnut-Sorghum, CS<sub>2</sub> : Soybean-Wheat, CS<sub>3</sub> : Maize-Chickpea, CS<sub>4</sub> : Pigeonpea + Soybean, CS<sub>5</sub> : Cotton + Peas, NM<sub>1</sub> : Organic, NM<sub>2</sub> : Integrated, NM<sub>3</sub> : RDF+FYM, NM<sub>4</sub> : Inorganic.

| Cropping systems (CS) | Nutrient management practices (NMP) |                 |                 |                 |      |                 |                 |                 |                 |      |
|-----------------------|-------------------------------------|-----------------|-----------------|-----------------|------|-----------------|-----------------|-----------------|-----------------|------|
|                       | 0–30 cm                             |                 |                 |                 |      | 30–60 cm        |                 |                 |                 |      |
|                       | NM <sub>1</sub>                     | NM <sub>2</sub> | NM <sub>3</sub> | NM <sub>4</sub> | Mean | NM <sub>1</sub> | NM <sub>2</sub> | NM <sub>3</sub> | NM <sub>4</sub> | Mean |
| CS <sub>1</sub>       | 56.9                                | 55.2            | 52.6            | 49.1            | 53.4 | 53.7            | 52.5            | 51.7            | 48.8            | 51.7 |
| CS <sub>2</sub>       | 57.2                                | 55.1            | 52.5            | 48.9            | 53.4 | 54.0            | 53.0            | 52.2            | 47.2            | 51.6 |
| CS <sub>3</sub>       | 56.1                                | 55.3            | 52.8            | 50.3            | 53.6 | 53.5            | 52.6            | 52.1            | 47.8            | 51.5 |
| CS <sub>4</sub>       | 57.0                                | 55.1            | 52.7            | 48.5            | 53.3 | 53.3            | 52.7            | 51.4            | 46.9            | 51.1 |
| CS <sub>5</sub>       | 55.4                                | 55.1            | 52.3            | 49.6            | 53.1 | 53.7            | 53.1            | 51.7            | 45.5            | 51.0 |
| Mean                  | 56.5                                | 55.1            | 52.6            | 49.3            |      | 53.6            | 52.8            | 51.8            | 47.2            |      |
|                       | SEm±                                |                 | CD at 5%        |                 |      | SEm±            |                 | CD at 5%        |                 |      |
| NM                    | 0.30                                |                 | 0.13            |                 |      | 0.48            |                 | 1.67            |                 |      |
| CS                    | 0.36                                |                 | NS              |                 |      | 0.65            |                 | NS              |                 |      |
| NM×CS                 | 0.64                                |                 | NS              |                 |      | 1.13            |                 | NS              |                 |      |

cm) (Table 2). It ranged from 61.2% to 65.4% in surface soil and 41.1% to 52.9% in sub surface soil. The higher maximum water holding capacity of 65.4% and 52.9% in soil at 0–30 cm and 30–60 cm was recorded in organic nutrient management practice and was significantly higher than conventional management practice but at par with others. The higher maximum water holding capacity of soil could be attributed to the addition of organic materials for several years from external sources as well as due to continuous return of large amount of crop residues in the form of roots and stubbles to soil [4].

Aggregate stability of soil varied significantly with different nutrient management practices ranging from 63.3% to 66.8% at the surface layer of soil (Table 3). The organic nutrient management practices recorded higher aggregated stability of 66.8% and was significantly superior to other nutrient management practices. Higher value of aggregate stability of soil under organic nutrient management practice might be due to addition of organic manures which release organic acids that bind the soil particles. Application of chemical fertilizers, lime and organic amendments increases soil organic carbon content. Increase in soil

**Table 6.** Effect of nutrient management practices and cropping systems on soil reaction (pH 1:2.5) at two depths. CS<sub>1</sub> : Groundnut-Sorghum, CS<sub>2</sub> : Soybean-Wheat, CS<sub>3</sub> : Maize-Chickpea, CS<sub>4</sub> : Pigeonpea + Soybean, CS<sub>5</sub> : Cotton + Peas, NM<sub>1</sub> : Organic, NM<sub>2</sub> : Integrated, NM<sub>3</sub> : RDF+FYM, NM<sub>4</sub> : Inorganic.

| Cropping systems (CS) | Nutrient management practices (NMP) |                 |                 |                 |      |                 |                 |                 |                 |      |
|-----------------------|-------------------------------------|-----------------|-----------------|-----------------|------|-----------------|-----------------|-----------------|-----------------|------|
|                       | 0–30 cm                             |                 |                 |                 |      | 30–60 cm        |                 |                 |                 |      |
|                       | NM <sub>1</sub>                     | NM <sub>2</sub> | NM <sub>3</sub> | NM <sub>4</sub> | Mean | NM <sub>1</sub> | NM <sub>2</sub> | NM <sub>3</sub> | NM <sub>4</sub> | Mean |
| CS <sub>1</sub>       | 7.7                                 | 7.7             | 7.8             | 7.9             | 7.7  | 7.6             | 7.5             | 7.8             | 7.8             | 7.6  |
| CS <sub>2</sub>       | 7.7                                 | 7.6             | 7.7             | 8.0             | 7.7  | 7.4             | 7.6             | 7.8             | 7.9             | 7.6  |
| CS <sub>3</sub>       | 7.6                                 | 7.7             | 7.7             | 7.9             | 7.7  | 7.4             | 7.4             | 7.9             | 7.8             | 7.6  |
| CS <sub>4</sub>       | 7.4                                 | 7.5             | 7.8             | 8.0             | 7.6  | 7.6             | 7.6             | 7.7             | 7.9             | 7.7  |
| CS <sub>5</sub>       | 7.4                                 | 7.6             | 7.8             | 7.9             | 7.6  | 7.4             | 7.5             | 7.9             | 8.0             | 7.7  |
| Mean                  | 7.5                                 | 7.6             | 7.7             | 7.9             |      | 7.4             | 7.5             | 7.8             | 7.9             |      |
|                       | SEm±                                |                 | CD at 5%        |                 |      | SEm±            |                 | CD at 5%        |                 |      |
| NM                    | 0.03                                |                 | 0.09            |                 |      | 0.02            |                 | 0.07            |                 |      |
| CS                    | 0.10                                |                 | NS              |                 |      | 0.03            |                 | NS              |                 |      |
| NM×CS                 | 0.09                                |                 | NS              |                 |      | 0.09            |                 | NS              |                 |      |

**Table 7.** Effect of nutrient management practices and cropping systems on total soluble salts content (EC, dS/m) (1:2.5) in soil at two depths. CS<sub>1</sub> : Groundnut-Sorghum, CS<sub>2</sub> : Soybean-Wheat, CS<sub>3</sub> : Maize-Chickpea, CS<sub>4</sub> : Pigeonpea + Soybean, CS<sub>5</sub> : Cotton + Peas, NM<sub>1</sub> : Organic, NM<sub>2</sub> : Integrated, NM<sub>3</sub> : RDF+FYM, NM<sub>4</sub> : Inorganic.

| Cropping systems (CS) | Nutrient management practices (NMP) |                 |                 |                 |      |                 |                 |                 |                 |      |
|-----------------------|-------------------------------------|-----------------|-----------------|-----------------|------|-----------------|-----------------|-----------------|-----------------|------|
|                       | 0–30 cm                             |                 |                 |                 |      | 30–60 cm        |                 |                 |                 |      |
|                       | NM <sub>1</sub>                     | NM <sub>2</sub> | NM <sub>3</sub> | NM <sub>4</sub> | Mean | NM <sub>1</sub> | NM <sub>2</sub> | NM <sub>3</sub> | NM <sub>4</sub> | Mean |
| CS <sub>1</sub>       | 0.13                                | 0.19            | 0.21            | 0.26            | 0.19 | 0.14            | 0.21            | 0.23            | 0.26            | 0.21 |
| CS <sub>2</sub>       | 0.14                                | 0.17            | 0.21            | 0.25            | 0.19 | 0.15            | 0.20            | 0.23            | 0.26            | 0.21 |
| CS <sub>3</sub>       | 0.12                                | 0.18            | 0.21            | 0.25            | 0.19 | 0.14            | 0.21            | 0.25            | 0.26            | 0.21 |
| CS <sub>4</sub>       | 0.14                                | 0.18            | 0.21            | 0.23            | 0.19 | 0.13            | 0.21            | 0.23            | 0.26            | 0.20 |
| CS <sub>5</sub>       | 0.14                                | 0.19            | 0.20            | 0.23            | 0.18 | 0.13            | 0.21            | 0.24            | 0.26            | 0.20 |
| Mean                  | 0.13                                | 0.18            | 0.20            | 0.24            |      | 0.13            | 0.20            | 0.23            | 0.26            |      |
|                       | SEm±                                |                 | CD at 5%        |                 |      | SEm±            |                 | CD at 5%        |                 |      |
| NM                    | 0.01                                |                 | 0.02            |                 |      | 0.01            |                 | 0.05            |                 |      |
| CS                    | 0.01                                |                 | NS              |                 |      | 0.01            |                 | NS              |                 |      |
| NM×CS                 | 0.01                                |                 | NS              |                 |      | 0.02            |                 | NS              |                 |      |

organic carbon content improves soil aggregation by way of forming clay-organic complexes in soil [5].

The bulk density at various nutrient management practices ranged from 1.14 Mg m<sup>-3</sup> to 1.34 Mg m<sup>-3</sup> and from 1.22 Mg m<sup>-3</sup> to 1.38 Mg m<sup>-3</sup> at surface and sub-surface layers of soil, respectively (Table 4). Significantly lower bulk density of 1.14 Mg m<sup>-3</sup> at surface layer and 1.22 Mg m<sup>-3</sup> at sub surface was recorded in organic nutrient management practice followed by other nutrient management practices Brar et al. [6] reported that decrease in bulk density over the years could be attributed to the addition of root and plant biomass and to the conversion of some micro pores to macro pores due to cementing action of organic acids and polysaccharides formed during the decomposition of organic residues by higher microbial activities.

The soil porosity differed significantly with nutrient management practices at both the depths of soil (0–30 cm and 30–60 cm) (Table 5) ranging from 49.3% to 56.5% and 47.2% to 53.6% at surface and sub surface layer of soil, respectively. Significantly higher soil porosity of 56.5% at 0–30 cm and 53.6% at 30–60 cm was recorded in organic nutrient management practice than other nutrient management practices. Addition of FYM or any other organic manure for seven years improved the physical proper-

ties like BD, maximum water holding capacity, aggregate stability and soil porosity thereby improving the aeration providing favorable condition for the root proliferation in the soil and increasing above ground growth of the crop, contributing to the higher yield [7].

The different nutrient management practices significantly influenced soil pH, at both the depths (0—

**Table 8.** Effect of nutrient management practices and cropping systems on cation exchange capacity (CEC, cmol (p<sup>+</sup>)/kg) of soil at surface layer. CS<sub>1</sub> : Groundnut-Sorghum, CS<sub>2</sub> : Soybean-Wheat, CS<sub>3</sub> : Maize-Chickpea, CS<sub>4</sub> : Pigeonpea + Soybean, CS<sub>5</sub> : Cotton + Peas, NM<sub>1</sub> : Organic, NM<sub>2</sub> : Integrated, NM<sub>3</sub> : RDF+FYM, NM<sub>4</sub> : Inorganic.

| Cropping systems (CS) | Nutrient management practices (NMP) |                 |                 |                 |      |
|-----------------------|-------------------------------------|-----------------|-----------------|-----------------|------|
|                       | 0–30 cm                             |                 |                 |                 |      |
|                       | NM <sub>1</sub>                     | NM <sub>2</sub> | NM <sub>3</sub> | NM <sub>4</sub> | Mean |
| CS <sub>1</sub>       | 52.1                                | 50.3            | 48.9            | 46.4            | 49.4 |
| CS <sub>2</sub>       | 51.9                                | 51.6            | 47.0            | 46.2            | 49.1 |
| CS <sub>3</sub>       | 51.9                                | 49.5            | 47.3            | 45.5            | 48.5 |
| CS <sub>4</sub>       | 50.2                                | 49.1            | 48.1            | 46.1            | 48.3 |
| CS <sub>5</sub>       | 51.2                                | 50.6            | 47.8            | 45.6            | 48.8 |
| Mean                  | 51.5                                | 50.2            | 47.8            | 45.9            |      |
|                       | CSm±                                |                 | CD at 5%        |                 |      |
| NM                    | 0.42                                |                 | 1.19            |                 |      |
| CS                    | 1.11                                |                 | NS              |                 |      |
| NM×CS                 | 0.91                                |                 | NS              |                 |      |

**Table 9.** Effect of nutrient management practices and cropping systems on free  $\text{CaCO}_3$  content (%) in soil at two depths.  $\text{CS}_1$  : Groundnut-Sorghum,  $\text{CS}_2$  : Soybean-Wheat,  $\text{CS}_3$  : Maize-Chickpea,  $\text{CS}_4$  : Pigeonpea + Soybean,  $\text{CS}_5$  : Cotton + Peas,  $\text{NM}_1$  : Organic,  $\text{NM}_2$  : Integrated,  $\text{NM}_3$  : RDF+FYM,  $\text{NM}_4$  : Inorganic.

| Cropping systems (CS) | Nutrient management practices (NMP) |               |               |               |      |               |               |               |               |      |
|-----------------------|-------------------------------------|---------------|---------------|---------------|------|---------------|---------------|---------------|---------------|------|
|                       | 0–30 cm                             |               |               |               |      | 30–60 cm      |               |               |               |      |
|                       | $\text{NM}_1$                       | $\text{NM}_2$ | $\text{NM}_3$ | $\text{NM}_4$ | Mean | $\text{NM}_1$ | $\text{NM}_2$ | $\text{NM}_3$ | $\text{NM}_4$ | Mean |
| $\text{CS}_1$         | 2.1                                 | 2.5           | 2.9           | 3.6           | 2.8  | 3.6           | 3.9           | 4.1           | 4.3           | 4.0  |
| $\text{CS}_2$         | 2.2                                 | 2.4           | 2.8           | 3.5           | 2.7  | 3.7           | 3.9           | 4.2           | 4.4           | 4.0  |
| $\text{CS}_3$         | 2.1                                 | 2.5           | 2.7           | 3.6           | 2.8  | 3.6           | 3.8           | 4.1           | 4.3           | 3.9  |
| $\text{CS}_4$         | 2.1                                 | 2.5           | 2.8           | 3.6           | 2.7  | 3.6           | 3.9           | 4.2           | 4.2           | 3.9  |
| $\text{CS}_5$         | 2.2                                 | 2.6           | 2.9           | 3.4           | 2.8  | 3.7           | 3.8           | 4.1           | 4.3           | 4.0  |
| Mean                  | 2.1                                 | 2.5           | 2.8           | 3.5           |      | 3.6           | 3.9           | 4.1           | 4.3           |      |
|                       | SEm±                                |               | CD at 5%      |               |      | SEm±          |               | CD at 5%      |               |      |
| NM                    | 0.12                                |               | 0.32          |               |      | 0.03          |               | 0.10          |               |      |
| CS                    | 0.11                                |               | NS            |               |      | 0.05          |               | NS            |               |      |
| NM×CS                 | 0.09                                |               | NS            |               |      | 0.06          |               | NS            |               |      |

30 cm and 30–60 cm) (Table 6). It ranged from 7.5 to 7.9 in surface soil and 7.4 to 7.9 in sub surface soil. pH of soil in organic nutrient management practice (7.5 at 0–30 cm and 7.4 at 30–60 cm) was significantly lower than other nutrient management practices. The decreases in pH under the organic nutrient management practice might be due to the release of organic acids during the microbial decomposition of added organic manures and increased enzymatic activity in soil. The results of the present investigation corroborate the findings of Ghosh et al. [8].

The different nutrient management practices significantly influenced total soluble salts (EC) and it ranged from  $0.13 \text{ dS m}^{-1}$  to  $0.24 \text{ dS m}^{-1}$  at the surface layer and  $0.13 \text{ dS m}^{-1}$  to  $0.26 \text{ dS m}^{-1}$  at sub surface layer of soil (Table 7). The organic nutrient management practice recorded lower electrical conductivity of  $0.13 \text{ dS m}^{-1}$  at both the layers of soil as compared to other nutrient management practices. The higher EC of soil under inorganic nutrient management practice might be attributed to the fertilizer application over the long period which leads to slight increase in the soluble salts in the soil. The findings are in consonance with the results reported by Sharma et al. [9].

The cation exchange capacity (CEC) in soil differed significantly with nutrient management practices at 0–30 cm soil depth (Table 8) ranging from

$45.9 \text{ cmol kg}^{-1}$  to  $51.5 \text{ cmol kg}^{-1}$ . The highest CEC of  $51.5 \text{ cmol kg}^{-1}$  in soil at 0–30 cm was recorded in organic nutrient management practice and was significantly higher than other nutrient management practices. Increase in CEC is related to the organic matter content of soil [10] while lower CEC values under inorganic nutrient management practice might be attributed to the mineralization of organic carbon and its non replenishment through organic matter.

The free  $\text{CaCO}_3$  content in soil differed significantly with nutrient management practices at both the depths of soil (0–30 cm and 30–60 cm) (Table 9). It ranged from 2.1% to 3.5% at surface layer of soil. The  $\text{CaCO}_3$  content under organic nutrient management practice was 2.1% and was significantly lower than integrated (2.5%), RDF+FYM (2.8%) and inorganic (3.5%) nutrient management practices. Decrease in  $\text{CaCO}_3$  content in soil under organic nutrient management practice might be due to the production of organic acids that neutralize some amount of  $\text{CaCO}_3$  as a result  $\text{CaCO}_3$  content reduces [10].

## References

1. Kong YY, Angela SJ, Bryant C, Denish DF, Kessel CV (2005) The relationship between carbon input, aggregation and soil organic carbon stabilization in sustainable cropping systems. *Soil Sci Soc Am J* 69 : 1078–1085.

2. Lal R (2002) Soil carbon dynamics in cropland and rangeland. *Environ Pollut* 116 : 353—362.
3. Gomez KA, Gomez AA (1984) Statistical procedures for agricultural research. An Int Rice Res Institute Book, A Wiley Interscience, John Wiley and Sons Inc., New York, USA.
4. Babu R, Reddy VC (2000) Effect of nutrient sources on growth and yield of direct seeded rice (*Oryza sativa* L.). *Crop Res* 19 : 189—193.
5. Bhushan L, Sharma PK (2002) Long-term effects of lantana (*Lantana* spp. L.) residue additions on soil physical properties under rice-wheat cropping I. Soil consistency, surface cracking and clod formation. *Soil Till Res* 65 : 157—167.
6. Brar BS, Kamalbir Singh, Dheri GS, Balwinder Kumar (2013) Carbon sequestration and soil carbon pools in a rice-wheat cropping system: Effect of long term use of inorganic fertilizers and organic manures. *Soil Till Res* 128 : 30—36.
7. Prasad B, Sinha SK (2000) Long-term effect of fertilizer and organic manures on crop yield, nutrient balance and soil properties in rice-wheat cropping system in Bihar. In: Abrol IP, Bronson KE, Duxbury JM, Gupta RK (eds). Longterm Soil Fertility Experiments in Rice-Wheat Cropping System. Rice-Wheat Consortium Paper Series 6, New Delhi, India, pp 105—199.
8. Ghosh S, Brian Wilson, Subrata K, Ghoshal, Nimai Senapati, Biswapati Mandal (2010) Management of soil quality and carbon sequestration with long term application of organic amendments, pp 1—6 Aug 2010. Soil Solution for Changing World, Brisbane, Australia: 19<sup>th</sup> World Congress of Soil Science.
9. Sharma M, Mishra B, Singh R (2007) Long term effect of fertilizers and manure on physical and chemical properties of Mollisol. *J Ind Soc Soil Sci* 55 : 523—524.
10. Manjula MN (2003) Recycling of organic residues and their influence on physical, chemical and biological properties of an Alfisol. MSc (Agric) thesis. Univ Agric Sci, Bangalore, Karnataka, India.