www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(12): 690-696

www.thepharmajournal.com
Received: 03-10-2021
Accepted: 09-11-2021

Ipsita Pattanaik
Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Vidyanand Mishra
Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Anusuiya Panda
Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Uttam Kumar
Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Biplab Choudhari
Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Chandrabhooshan Singh
Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Sushma
Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Corresponding Author:
Ipsita Pattanaik
Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Comparative examination of different soil physical and chemical attributes under long term rice-based croplands under *Vertisols* in Dhamtari district of Chhattisgarh

Ipsita Pattanaik, Vidyanand Mishra, Anusuiya Panda, Uttam Kumar, Biplab Choudhari, Chandrabhooshan Singh and Sushma

Abstract
Rice based cropping systems are different from other long term cropping systems as they undergo varying cycles of continuous wetting and drying which alters soil physical, chemical properties as well as the microbial activities to great extent. The productivity of the rice-based cropping system is comparatively low, and it continues to decline in India due to various soil-related constraints. Keeping in view the significance of soil quality in rice-based intensive cropping system, the present study was undertaken with the objective of identifying several physical and chemical attributes of *Vertisols* of Dhamtari district of Chhattisgarh under rice based cropping systems. Soil properties varied significantly between the cropping systems and subsequently it is concluded that the soil attributes recorded better under rice-legume i.e. rice-chickpea (RC) and rice-lathyrus (RL) cropping systems compared to that under rice-rice (RR), rice-wheat (RW) and rice- fallow (RF) cropping systems.

Keywords: *Vertisols*, chickpea, Lathyrus, rice, wheat, cropping systems

Introduction

Soils are a vital part of the global ecosystem, just as the hydrosphere and atmosphere are for its proper functioning and is a basic natural resource that directly benefits mankind's products and services from varied environments. During the late twentieth century, people's perceptions of soil's relevance in environmental issues shifted. On a human life scale, soil is increasingly considered as a non-renewable resource since its recovery is an exceedingly sluggish process once deteriorated (Camarsa *et al*., 2014; Lal, 2015) [9, 27]. Intensification and conflicting uses of soils for agriculture, forestry, pasture, and urbanization are having an increasingly negative influence on the provision of life-sustaining services such as food production, clean drinking water, flood mitigation, and plant and animal habitat. To manage the use of agricultural soils well, decision-makers need science based easy-to-apply and cost-effective tools to assess changes in soil quality and function.

Researchers from all around the world have been working hard to examine soil quality and management strategies in order to reduce the harmful consequences of poor soil management. It is critical for humans since it influences not just food production but also ecosystem variety and function (Askari and Holden 2014; Nakajima *et al*. 2015) [27]. Developing a suitable methodology for assessing soil health is urgent and has great implications in agricultural production.

Various soil attributes have been used to examine the influence of agricultural methods and crop production on the soil (Govaerts *et al*., 2006) [14], as well as the regional implications of soil management (Juhos *et al*., 2016; Gong *et al*., 2015) [18, 13].

Soil health and condition cannot be quantified thoroughly with a single indicator, examinations of it frequently focus on identifying soil variables that have the greatest impact on it. Various datas have been offered, each corresponding to a distinct selection and combination of these qualities based on the location, scale, and objectives of various researches. According to reports, the following attributes are appropriate for examining the quality and productivity of the soil: (a) Texture, bulk density, hydraulic characteristics, water retention, aggregation state, aeration, surface crusting, and uniformity are examples of physical attributes. (b) Chemical properties, for example, pH, salt substance, dissolvable carbon, mineral nitrogen, phosphorus, potassium, calcium, magnesium, micro elements, contaminants and cations ability to change. Dhamtari district is the part of Chhattisgarh state of India and classified under Chhattisgarh plain of Agro-climatic zone of the country. The average annual rainfall for the district is 1197.1 mm. Rice based cropping systems are predominantly practiced by the farmers in the district which include chickpea, wheat, linseed, field pea, fallow etc.

Evaluation of different physical and chemical properties of soil will provide information on the suitability and relative value of land for various types of rice-based cropping systems, as well as information on the impact of agricultural practices on land and environmental degradation, and it will be possible to determine which types of rice-based cropping systems are best suited to achieve sustainability in a given ecosystem (Kennedy and papendick, 1995) [19]. Keeping all theses points in mind the present study has been performed to analyze and summarize which cropping system will be most suitable to maintain soil quality for ecological sustainability in the study area and provide a base for further, generic decision-making on recommended agricultural practices.

Materials and Methods

Research area description

Dhamtari district is situated at 21°.15' N latitude and 81°.41 E longitude with elevation 289 m above the mean sea level, comes under Chhattisgarh plains agro-climatic zone. The Dhamtari district covers an area of 408200 hectare with annual rainfall 1197.1 mm. Physiographically, the district is a part of Eastern plateu and hills. The district having total cropped area of 218400 hactare out of which 155900 hactare area is irrigated. Major soil types of study area are *Entisols* (gravely), *Inceptisols* (sandy loam), *Alfisols*(clay loam) and *Vertisols* (clayey).

Stratified-random soil sampling was done from the 10% of the total villages in the" district. In each village, "based on the cropping" system, soil "samples were taken from" *Vertisols*. Composite "surface (0- 15 cm) soil samples were collected from each site after the harvest of cropping" system, where the crop rotation was followed since 2010. From each site, five soil samples were collected and pooled as composite sample (0- 15 cm depth) after the harvest of cropping system. The average yield of the crop taken for ten year period (2010–2020) was recorded by farmer's interactions.

Sampling and survey

The Dhamatri district is having four Blocks (Tehsils) namely Dhamtari, Kurud, Magarlod and Nagri. There are a total of 651 Village Panchayats in the district. A total of 105 samples were collected from five most prominent cropping systems for study. A soil survey of Dhamtari district was carried out and identified one important soil order i.e. *Vertisols* (clayey).

Following most prominent cropping sequences were identified for further detailed study: 1.Rice – Rice (RR) 2.Rice – Wheat (RW) 3.Rice – Chickpea (RC) 4. Rice – Lathyrus (RL) 5.Rice-Fallow (RF)

Laboratory analysis

Among the physical properties, particle-size distribution was measured by International Pipette method (Jackson 1973), bulk density (BD), and particle density (PD) was estimated as per the method no. 39, USDA Hand book no. 60 (Richards 1954). Soil porosity was calculated using the data of BD and PD. The water holding capacity (WHC) was measured by Keen raczkowski box method described by Kumar *et al*., (2018) [20], SMC determined by Gravimetric method as prescribed by Kumar *et al*., (2018) [20] and aggregate size distribution by Yodar modified wet sieving method as described by Yoder (1936) as mean weight diameter (MWD). Soil pH and electrical conductivity (EC) were measured with 1: 2.5 soil: water ratio as per method described by Richards (1954); organic carbon (OC) was determined by Walkley Black's wet digestion method (Walkley and Black 1934). The available N was determined by using alkaline potassium permanganate ($KMnO_4$) solution by determining the ammonia liberated (Subbiah and Asija 1956) [39]. The available P was determined by Olsen method by using 0.5 M $NaHCO_3$extractant (Olsen *et al*., 1954) [29]. The available K was determined by using neutral ammonium acetate method by using flame photometer (Jackson 1973). Soil available S was measured by turbidimetic method as described by Kumar *et al*., (2018) [20]. Available micronutrient cations (Fe, Mn, Cu, and Zn) were extracted by DTPA-$CaCl_2$ extractant at pH 7.3 (Lindsay and Norvell 1978) and were measured by using Atomic Absorption Spectrophotometer (AAS). Available B was estimated by hot water method (Berger and Troug 1939) [7].

Statistical analysis

The statistical analysis of the data was administered using SPSS Statistics (version 25.0, IBM, Armonk, NY, USA).

Results and Discussion

Soil physical quality

Bulk density

Bulk density (BD) is one of the important physical aspects of soils that determine the porosity, aggregate stability and water holding capacity and root development of soils. The BD for different rice based cropping systems varied from 1.22 to 1.38 (mean 1.29) Mg m^{-3}, 1.38 to 1.55 (mean 1.48) Mg m^{-3}, 1.27 to 1.39 (mean 1.34) Mg m^{-3}, 1.37 to 1.54 (mean 1.46) Mg m^{-3}, 1.35 to 1.48 (mean 1.43) Mg m^{-3} for RC, RR, RL, RW and RF respectively (Table 1). The higher amount of added biomass from leguminous crops made soil loose, porous and less squeezed therefore, the lower bulk density was found under rice-legume cropping system (RC and RP)) (Husnjak *et al*., 2002; Rahman *et al*., 2007; Kumar *et al*., 2018, 2020) [16, 33, 20, 21].

Particle density

Particle density is the mass of soil solid per unit volume without pore spaces (Hillel 1980) [15] and is important parameter to understand soil physical environment including bulk density and porosity. The particle density of soils was varied from 2.58 to 2.69 (mean 2.64) Mg m^{-3}, 2.50 to 2.61 (mean 2.56) Mg m^{-3}, 2.47 to 2.67 (mean 2.58) Mg m^{-3}, 2.56 to 2.67 (mean 2.61) Mg m^{-3}, 2.61 to 2.70 (mean 2.66) Mg m^{-3} for RC, RR, RL, RW and RF respectively (Table 1). Among the cropping systems, the particle density was found to be varying insignificantly (Table 1).

Porosity

Soil porosity is the best indicator of soil structural quality. Quantification of the pore space in terms of shape, size, continuity, orientation and arrangement of pores in soil allows us to define the complexity of soil structure and to understand its modifications induced by management practices. The porosity of soils was varied from 47.53 to 53.61 (mean 50.9) per cent, 39.22 to 45.02 (mean 42.17) per cent, 44.76 to 51.71

(mean 48.15) per cent, 41.67 to 48.11 (mean 43.98) per cent, 44.15 to 49.06 (mean 46.32) per cent for RC, RR, RL, RW and RF respectively (Table 1). The porosity of soils under RC cropping system was higher than that of soils under RM, RP, RL, and RF cropping systems. Legume based cropping systems is having high carbon sequestration capacity that make soil become more porous and loose than that of other cropping systems (Kumar *et al*., 2018, 2020) [20, 21] per cent.

Water holding capacity (WHC)

Soil water holding capacity (WHC) is the amount of water that, a given soil can hold for crop use. Field capacity is the point where the soil water holding capacity has reached its maximum for the entire field. The key is for farmers to understand the nuances of soil water holding capacity and how to manage it, so that the farm does not need to irrigate or suffer from a drought. Soil texture and organic matter are the key components that determine water holding capacity of soils. The WHC of soils was varied from 34.58 to 49.7 (mean 42.67) percent, 25.62 to 37.91 (mean 31.97) percent, 31.35 to 42.03 (mean 38.32) percent, 22.15 to 44.15 (mean 32.24) percent, 28.05 to 46.75 (mean 35.79) percent for RC, RR, RL, RW and RF respectively (Table 1). The WHC of soils under RC cropping system was higher than that of soils under RM, RP, RL, and RF cropping systems. Further, WHC of soils under RP cropping system was higher than that of soils under RL and RF cropping systems. In this consequence the WHC of soils under RL cropping system was higher than that of soils under RF cropping systems. Rice-legume cropping system (RC) stores large extant of carbon in to the soil. Which bind soil particles, increase mean weight diameter, improve water stable aggregates, and consequently increase in water holding capacity of soil (Schjonning *et al*., 2002 and Bama and Somasundaram 2017) [35, 6].

Hydraulic conductivity (HC)

Soil hydraulic conductivity is usually confined in assessing the productive potential of soils. Additions of organic matter improve the hydraulic conductivity by formation of large number of water stable aggregates. The HC of soils was varied from 0.72 to 0.95 (mean 0.85) cm $hr.^{-1}$, 0.65 to 0.76 (mean 0.7) cm $hr.^{-1}$, 0.72 to 0.86 (mean 0.79) cm $hr.^{-1}$, 0.65 to 0.81 (mean 0.73) cm $hr.^{-1}$, 0.69 to 0.82 (mean 0.76) cm $hr.^{-1}$ for RC, RR, RL, RW and RF respectively (Table 1). Rice-legume cropping system notable for organic carbon build-up in soils, which improves soils aggregation, (Cotching *et al.* 2002) [10], reduces pH and ESP and enhance the hydraulic conductivity of the soils (Bhattacharyya *et al.* 2000) [8]. However in rice-rice cropping system aggregation of soil paticles is not good enough to enhance the hydraulic conductivity of the soil. In addition, improve the water retention of soil mainly by way of developing surface and sub-surface macro-porosity, reducing surface runoff and controlling soil erosion.

Mean Weight diameter (MWD)

The mean weight diameter is commonly used to express aggregate stability as it determines the size distribution of aggregates and is essentially a measure of macro-aggregate stability, as the aggregates that remained on each sieve must be stable to the wetting and sieving processes (Amezketa 1999). The mean weight diameters of soils was varied from 0.80 to 0.90 (mean 0.84) mm, 0.60 to 0.90 (mean 0.69) mm, 0.70 to 0.90 (mean 0.83) mm, 0.60 to 0.80 (mean 0.7) mm, 0.60 to 0.80 (mean 0.71) mm for RC, RR, RL, RW and RF respectively (Table 1). The MWD of soils under RC cropping system was higher than that of soils under RM, RP, RL, and RF cropping systems. Further, the MWD of soils under RP cropping system was higher than that of soils under RL and RF cropping systems. In this consequence the MWD of soils under RL cropping system was higher than that of soils under RF cropping systems. Rice-legume cropping system (RC and RL) having high root mass density, mean root diameter, root diameter diversity and the percentage of fine roots was all positively linked to the stability of soil aggregates by increasing soil organic carbon content. Higher root biomass of leguminous crops helped to accumulation of higher amount of soil organic carbon through roots and leaf-fall with increased macro-aggregate formation (Kumar *et al*., 2018, 2020) [20, 21]

Soil moisture content

Availability of soil moisture is one of the most limiting factors for getting sustainable crop production. However, under changing scenario of climate the available water content is decline continuously. Therefore, it is necessary to adopt the cropping systems that can use list amount of water and maintain soil moisture for longer period of time. The soil moisture content of soils was varied from 27.93 to 39.55 (mean 33.95) percent, 16.25 to 29.88 (mean 23.44) percent, 26.34 to 39.73 (mean 31.93) percent, 18.10 to 35.03 (mean 26.43) percent, 19.70 to 36.22 (mean 28.13) percent for RC, RR, RL, RW and RF respectively (Table 1). The soil moisture content of soils under RC cropping system was higher than that of soils under RM, RP, RL, and RF cropping systems. Ricelegume cropping system (RC and RL) added large amount of biomass in to the soil, which make surface soil loose and porous, improve the aggregation, thus enhance the capacity of soil to store and retain more moisture. Therefore the SMC of rice-legume cropping system (RC and RL) was higher than other cropping system of RW and RF. (Rahman *et al*., 2007 and Alam and Salahin 2013 and Kumar *et al*., 2018, 2020) [33, 2, 20, 21].

Soil chemical quality

Soil reaction (pH)

Soil reaction is an indication of acidity, neutrality or salinity/alkalinity of the soil. It is measured and expressed in pH units. Soil pH is defined as the negative logarithm of the hydrogen ion activity. Soil pH affects the soil's physical, chemical, and biological properties and processes, as well as plant growth. The nutrition, growth, and yields of most crops decrease where pH is low and increase as pH rises to an optimum level (6.5 to 7.5). The pH of soil was varied from 5.00 to 6.50 (mean 5.77), 6.50 to 8.00 (mean 7.27), 5.30 to 6.60 (mean 5.9), 6.50 to 8.00 (mean 7.16), 6.20 to 7.30 (mean 6.8) for RC, RR, RL, RW and RF respectively (Table 1). The pH of soils under RC cropping system was lower than that of soils under RM and RF cropping systems. For other cropping systems the differences in organic carbon were found to be insignificant. Leguminous crop fix atmospheric N in crop root zone with the help of rhizobium bacteria. Nitrogen is acid forming nutrient that reduce the soil pH under legume- based cropping systems.

Electrical conductivity (EC)

Soil EC is a measure of the amount of salts in soil (salinity of soil). It is an important indicator of soil quality. It affects crop yields, crop suitability, plant nutrient availability, and activity of soil microorganisms which influence key soil processes including the emission of greenhouse gases such as nitrogen oxides, methane, and carbon dioxide. Excess salts hinder plant growth by affecting the soil-water balance. The EC of soils was varied from 0.09 to 0.18 (mean 0.15) dS m^{-1}, 0.17 to 0.29 (mean 0.22) dS m^{-1}, 0.09 to 0.19 (mean 0.16) dS m^{-1}, 0.17 to 0.26 (mean 0.22) dS m^{-1}, 0.14 to 0.24 (mean 0.2) dS m^{-1} for RC, RR, RL, RW and RF respectively (Table 1). The studied soils are acidic in nature, while the EC of soils characterize the soil salinity. Therefore, among the cropping systems EC of soils was differing insignificant.

Organic carbon (OC)

Soil carbon is probably the most important component in soils as it affects the soil properties. Carbon as soil organic matter influences the physical, chemical, and biological properties of the soils. Soil organic carbon is often considered as the largest contributor to soil quality (Shukla *et al*., 2006 and Abid and Lal 2008) [1]. Improvements in soil organic matter create a more favourable environment, leading to increases in crop productivity. The organic carbon of soils was varied from 5.70 to 7.20 (mean 6.55) g kg^{-1}, 3.60 to 6.00 (mean 4.58) g kg^{-1}, 5.20 to 6.60 (mean 6.02) g kg^{-1}, 4.50 to 5.80 (mean 5.3) g kg^{-1}, 4.70 to 6.40 (mean 5.63) g kg^{-1} for RC, RR, RL, RW and RF respectively (Table 1). The organic carbon of soils under RC cropping system was higher than that of soils under RM, RP, RL, and RF cropping systems. Further, the organic carbon of soils under RP cropping system was higher than that of soils under RL and RF cropping systems. Higher soil organic carbon was observed in the ricelegume cropping system (RC and RL) may be attributed to these rotations was considered to have high root biomass, higher carbon sequestration capacity and less carbon release than that of soils under RW and RF cropping system (Orchard and Cook 1983 and Mitsch *et al*., 2010) [30, 26]. Similarly, the lower amounts of biomass production in the continuous wheat system in our study ledto lower recovery rates of organic carbon. Moreover, the increment in organic carbons in rice-legume cropping systems (RC and RL) might also have contributed to the increase in soil porosity (Bhattacharyya *et al*., 2006), soil aggregate stability (Pagliai *et al*., 2004) [31], plant available water content (Mc Garry *et al*., 2000) [25], and reduced susceptibility to soil compaction.

Cation exchange capacity (CEC)

The capacity of soil to absorb cation in an exchangeable form is called cation exchange capacity. Thus CEC is measure of the quantity of readily exchangeable cation, neutralizing the charges. The CEC of soil depend upon type of soil texture, amount and kind of clay, and organic matter content. Soils with large amount of clay and organic matter will have higher CEC. The organic carbon of soils was varied from 34.58 to 53.62 (mean 46.8) cmol (p^+) kg^{-1}, 23.55 to 45.14 (mean 32.01) cmol (p^+) kg^{-1}, 30.38 to 49.42 (mean 42.6) cmol (p^+) kg^{-1}, 28.08 to 41.37 (mean 36.16) cmol (p^+) kg^{-1}, 31.18 to 44.47 (mean 39.26) cmol (p^+) kg^{-1} for RC, RR, RL, RW and RF respectively (Table 1). Rice-legume cropping system (RC) store large extant of carbon content in to soil and high carbon content might be responsible for higher CEC. Skjemstad (2002) [37] studied that the humic fraction of soil organic matter is considered the principal pool in contributing to the soil CEC.

Table 1: Descriptive statistics of soil properties based on cropping system

Properties	RC (n=21)		RR (n=21)		RL (n=21)		RW (n=21)		RF (n=21)	
	Mean (range)		Mean (range)		Mean (range)		Mean (range)		Mean (range)	
BD (Mg m^{-3})	1.29	(1.22-1.38)	1.48	(1.38-1.55)	1.34	(1.27-1.39)	1.46	(1.37-1.54)	1.43	(1.35-1.48)
PD (Mg m^{-3})	2.64	(2.58-2.69)	2.56	(2.50-2.61)	2.58	(2.47-2.67)	2.61	(2.56-2.67)	2.66	(2.61-2.70)
Porosity (%)	50.9	(47.53-53.61)	42.17	(39.22-45.02)	48.15	(44.76-51.71)	43.98	(41.67-48.11)	46.32	(44.15-49.06)
WHC (%)	42.67	(34.58-49.7)	31.97	(25.62-37.91)	38.32	(31.35-42.03)	32.24	(22.15-44.15)	35.79	(28.05-46.75)
HC (cm $hr.^{-1}$)	0.85	(0.72-0.95)	0.7	(0.65-0.76)	0.79	(0.72-0.86)	0.73	(0.65-0.81)	0.76	(0.69-0.82)
MWD (mm)	0.84	(0.80-0.90)	0.69	(0.60-0.90)	0.83	(0.70-0.90)	0.7	(0.60-0.80)	0.71	(0.60-0.80)
SMC (%)	33.95	(27.93-39.55)	23.44	(16.25-29.88)	31.93	(26.34-39.73)	26.43	(18.10-35.03)	28.13	(19.70-36.22)
pH	5.77	(5.00-6.50)	7.27	(6.50-8.00)	5.9	(5.30-6.60)	7.16	(6.50-8.00)	6.8	(6.20-7.30)
EC (dS m^{-1})	0.15	(0.09-0.18)	0.22	(0.17-0.29)	0.16	(0.09-0.19)	0.22	(0.17-0.26)	0.2	(0.14-0.24)
OC (g kg^{-1})	6.55	(5.70-7.20)	4.58	(3.60-6.00)	6.02	(5.20-6.60)	5.3	(4.50-5.80)	5.63	(4.70-6.40)
CEC [cmol (p^+) kg^{-1}]	46.8	(34.58-53.62)	32.01	(23.55-45.14)	42.6	(30.38-49.42)	36.16	(28.08-41.37)	39.26	(31.18-44.47)
Av. N (kg ha^{-1})	238.7	(189.81-267.76)	179.88	(147.68-209.71)	219.79	(175.88-240.70)	188.8	(146.68-234.62)	202.8	(166.62-243.66)
Av. P (kg ha^{-1})	20.63	(16.00-25.40)	11.93	(6.60-16.60)	17.83	(12.60-23.00)	13.73	(8.70-18.30)	14.05	(5.70-20.10)
Av. K (kg ha^{-1})	438.0	(375.87-498.82)	352.51	(311.73-425.68)	411.65	(361.80-458.75)	376.69	(321.78-419.68)	395.5	(357.81-422.69)
Av. S (kg ha^{-1})	17.7	(13.20-22.10)	9.92	(5.50-14.80)	15.97	(11.20-20.50)	11	(6.90-15.80)	12.15	(7.00-16.90)
Av. Fe (ppm)	29.84	(16.50-40.50)	18.45	(8.30-23.90)	26.45	(16.30-31.90)	21.08	(13.20-26.10)	23.49	(14.60-30.00)
Av. Mn (ppm)	16.57	(10.40-22.40)	8.66	(4.40-12.70)	13.26	(7.00-18.00)	9.24	(5.70-12.00)	11.93	(5.80-17.90)
Av. Cu (ppm)	1.26	(0.60-1.80)	0.89	(0.30-1.60)	1.2	(0.60-1.80)	0.85	(0.20-1.60)	0.92	(0.30-1.70)
Av. Zn (ppm)	0.6	(0.20-0.90)	0.38	(0.10-0.70)	0.49	(0.10-0.90)	0.38	(0.10-0.80)	0.41	(0.10-0.90)
Av. B (ppm)	0.71	(0.30-1.50)	0.57	(0.26-0.88)	0.61	(0.10-1.10)	0.46	(0.20-0.90)	0.59	(0.20-0.90)

Available N

Nitrogen (N) is a vitally important plant nutrient. Plants contain 1 – 5% N by weight. It is an essential constituent of proteins having physiological importance in plant metabolism. In soil, N that is present in organic form appears to be unavailable to plants. The available N in soil is that portion which is present in mineral forms usually in the form of ammonium and nitrate in the soil solution. The available N of soils was varied from 189.81 to 267.76 (mean 238.7) kg ha^{-1}, 147.68 to 209.71(mean 179.88) kg ha^{-1}, 175.88 to 240.70 (mean 219.79) kg ha^{-1}, 146.68 to 234.62 (mean 188.8) kg ha^{-1}, 166.62 to 243.66 (mean 202.8) kg $ha^{-1}$for RC, RR, RL, RW and RF respectively (Table 1) The available N of soils under RC cropping system was higher than that of soils under RM, RP, RL, and RF cropping systems. Further, the available N of soils under RP cropping system was higher than that of soils under RL and RF cropping systems. Legume is a natural mini-nitrogen manufacturing factory in the field (Ghosh *et al*.,

2017) [12] and the farmers by growing these crops can play a vital role in increasing indigenous N production. Legumes playing a pivotal role especially in N supply to the cereals. Through their symbiotic associations with rhizobium (bacteria in their root nodules), legumes have the ability to fix atmospheric N into forms that can be utilized by plants. As a result, ricelegume cropping system (RC and RL) store more N rather than RW and RF (Ghosh *et al*., 2017; Das and Ghosh 2012; Patrick *et al*., 2013; Kumar *et al*., 2018, 2020) [12, 11, 32, 20, 21].

Available P

Phosphorus (P) is an essential element classified as a macronutrient because of the relatively large amounts required by plants. It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plants. The available P of soils was varied from 16.00 to 25.40 (mean 20.63) kg ha^{-1}, 6.60 to 16.60 (mean 11.93) kg ha^{-1}, 12.60 to 23.00 (mean 17.83) kg ha^{-1}, 8.70 to 18.30 (mean 13.73) kg ha^{-1}, 5.70 to 20.10 (mean 14.05) kg ha^{-1} for RC, RR, RL, RW and RF respectively (Table 1). The available P of soils under RC cropping system was higher than that of soils under RM, RP, RL, and RF cropping systems. Further, the available P of soils under RP cropping system was higher than that of soils under RF cropping systems. A greater P availability was observed under RC cropping system presumably due to the lower pH, which is discussed earlier. Crop rotations, especially those with legumes, can increase root colonization by mycorrhizae. Mycorrhizal associations have the greatest impact on increasing P availability for crops by colonizing root. These results are in line with the findings of Newton *et al*., (2011) [28] and Smith *et al*., (2011) [38]. P supply is enhanced in legume based cropping system through a range of mechanisms which include development of mycorrhizal symbiosis, formation of cluster roots, alteration in root architecture, production of root exudates, as well as induction of phosphatase enzyme activity (Maseko and Dakora 2013; Kumar *et al*., 2018, 2020) [24, 20, 21].

Available K

The total K content of soils frequently exceeds 20,000 ppm. Nearly all of this K is in the structural component of soil minerals and is not available for plant growth. Because of large differences in soil parent materials and the effect of weathering of these materials, only a little amount of soil K available to plant as soil solution and exchangeable form. The available K of soils was varied from 375.87 to 498.82 (mean 438.04) kg ha^{-1}, 311.73 to 425.68(mean 352.51) kg ha^{-1}, 361.80 to 458.75 (mean 411.65) kg ha^{-1}, 321.78 to 419.68 (mean 376.69) kg ha^{-1}, 357.81 to 422.69 (mean 395.52) kg ha^{-1} for RC, RR, RL, RW and RF respectively (Table 1). The available K of soils under RC cropping system was higher than that of soils under RM, RP, RL and RF cropping systems. Further, the available K of soils under RP cropping system was higher than that of soils under RF cropping systems. In this consequence the available K of soils under RL cropping system was higher than that of soils under RF cropping systems.

Available S

Sulphur (S) is an essential secondary nutrient, is required by plants in approximately the same amount as P. Approximately 95 percent of the total amount of S in soils is found in the organic matter. As the soil organic matter is decomposed the organic forms of the S is mineralized to sulfate-sulfur. This SO_4^{2-}S is the only form of S that is absorbed by plant roots. The available S of soils was varied from 13.20 to 22.10 (mean 17.7) kg ha^{-1}, 5.50 to 14.80(mean 9.92) kg ha^{-1}, 11.20 to 20.50 (mean 15.97) kg ha^{-1}, 6.90 to 15.80 (mean11.0) kg ha^{-1}, 7.00 to 16.90 (mean 12.15) kg ha^{-1} for RC, RR, RL, RW and RF respectively (Table 1). The available S of soils under RC cropping system was lower than that of soils under RM cropping systems. The available S of soils under RC cropping system was higher than that of soils under RL and RF cropping systems. Further, the available S of soils under RP cropping system was higher than that of soils under RF cropping systems. In this consequence the available S of soils under RL cropping system was higher than that of soils under RF cropping systems. These differences were insignificant for other cropping systems. The Legume based cropping systems retain more amount of C in to the soil and by the mineralization of this C, sulphur content of the soil enhanced. (Kumar *et al*., 2018, 2020) [20, 21].

Available Fe

Fe is the fourth most abundant element found in soil though it is largely present in forms that cannot be taken up by plants. Soil is typically between 50 to 150 ppm Fe but most of this Fe is unavailable. Soil factors *viz*; pH, organic matter content, moisture, aeration and alkali soil condition dominantly affect the Fe availability. The available Fe of soils was varied from 13.20 to 22.10 (mean 17.7) ppm, 5.50 to 14.80(mean 9.92) ppm, 11.20 to 20.50 (mean 15.97) ppm, 6.90 to 15.80 (mean11.0) ppm, 7.00 to 16.90 (mean 12.15) ppm for RC, RR, RL, RW and RF respectively (Table 1). The available Fe of soils under RC cropping system was higher than that of soils under RM, RP, RL, and RF cropping systems. Further, the available Fe of soils under RP cropping system was higher than that of soils under RF cropping systems. In this consequence the available Fe of soils under RL cropping system was higher than that of soils under RF cropping systems. For other cropping systems the differences in organic carbon were found to be insignificant.

Available Mn

Mn is a micronutrient cation. It plays a number of roles and used in photosynthesis, chlorophyll synthesis, and N absorption. Mn deficiency is most common on alkaline and poorly drained soils as well as those high in available Fe. The available Mn of soils was varied from 10.40 to 22.40 (mean 16.57) ppm, 4.40 to 12.70 (mean 8.66) ppm, 7.00 to 18.00 (mean 13.26) ppm, 5.70 to 12.00 (mean 9.24) ppm, 5.80 to 17.90 (mean 11.93) ppm for RC, RR, RL, RW and RF respectively (Table 1). The available Mn of soils under RC cropping system was higher than that of soils under RM, RL, and RF cropping systems. Further, the available Mn of soils under RP cropping system was higher than that of soils under RF cropping systems. In this consequence the available Mn of soils under RL cropping system was higher than that of soils under RF cropping systems. For other cropping systems the differences in organic carbon were found to be insignificant.

Available Cu

Copper (Cu) is one of eight essential plant micronutrients. The amount of Cu available to plants varies widely among soils. Ideally, for healthy and productive soil, the concentration of Cu should be 2 -50 ppm. Cu in the soil is held with clay minerals as a cation and in association with organic matter and its deficiency more likely to be seen in plant grown in alkaline soils. The available Cu of soils was varied from 0.06 to 1.80 (mean 1.26) ppm, 0.03 to 1.60 (mean 0.89) ppm, 0.60 to 1.80 (mean 1.2) ppm, 0.20 to 1.60 (mean 0.85) ppm, 0.30 to 1.70 (mean 0.92) ppm for RC, RR, RL, RW and RF respectively (Table 1). Among the cropping systems, the available Cu was found to be varying significantly (Table 1).

Available Zn

Zinc is a trace element found in varying concentrations in all soils. Ideally, for healthy and productive soils the concentration of Zn should be 1-200 ppm. Zn deficiency is most commonly seen on alkaline soil especially if the soil is boggy. Excess levels of P and Cu as well as low levels of N in the oil can also increase the chance of Zn deficiency. The available Zn of soils was varied from 0.20 to 0.90 (mean 0.6) ppm, 0.10 to 0.70 (mean 0.38) ppm, 0.10 to 0.90 (mean 0.49) ppm, 0.10 to 0.80 (mean 0.38) ppm, 0.10 to 0.90 (mean 0.41) ppm for RC, RR, RL, RW and RF respectively (Table 1). The available Zn of soils under RC cropping system was higher than that of soils under RM and RF cropping systems. Further, the available Zn of soils under RP cropping system was higher than that of soils under RF cropping systems. In this consequence the available Zn of soils under RL cropping system was higher than that of soils under RF cropping systems. For other cropping systems the differences in organic carbon were found to be insignificant.

Available B

Boron (B) is one of the essential micronutrient found as anion in soil and required by plant in very small quantity. The available boron is range from 0.03-12 ppm. However, only a small fraction of this amount is available to the crop. B deficiency is highly prevalent in sandy acidic soils with low organic matter, due to the potential for B leaching. Soils with high adsorption and retention capacity (e.g. soils with high pH and rich in clay minerals and iron or aluminum oxides) are also commonly impacted by B deficiency. The available B of soils was varied from 0.30 to 1.50 (mean 0.71) ppm, 0.26 to 0.88 (mean 0.57) ppm, 0.10 to 1.10 (mean 0.61) ppm, 0.20 to 0.90 (mean 0.46) ppm, 0.20 to 0.90 (mean 0.59) ppm for RC, RR, RL, RW and RF respectively (Table 1). The available B of soils under RC cropping system was higher than that of soils under RR, RL, RW and RF cropping systems. Further, the available B of soils under RL cropping system was higher than that of soils under RR, RW &RF cropping systems.

Conclusion

Different rice based cropping systems affects the physical and chemical properties of soils of Chhattisgarh. Among the cropping systems, rice-legume cropping systems (RC and RL) sustain better physical and chemical properties of soils in terms of lower BD, higher porosity, soil moisture content, water holding capacity, hydraulic conductivity, mean weight diameter, organic carbon, cation exchange capacity, available N, P, K, S, micronutrients than that of soils under RR, RW and RF cropping systems. Inclusion of legumes in to rice based cropping systems sustain better soil quality than that of soils under RR, RW and RF cropping systems. Therefore, present study recommended that to sustain soil health to become productive for next generation rice legume cropping systems could be more effective.

Acknowledgement

The authors are thankful to the vice-chancellor of Indira Gandhi Krishi Viswavidyalaya, Raipur, the head of the department and all the staff members of the department of Soil science and agricultural chemistry, IGKV, Raipur for providing the laboratory and all the resources required for completing this research work.

Reference

1. Abid M, Lal R. Tillage and drainage impact on soil quality – I. aggregate stability, carbon and nitrogen pools. Soil and Tillage Research 2008;100:89-98.
2. Alam MK, Salahin N. Changes in soil physical properties and crop productivity as influenced by different tillage depths and cropping patterns. Bangladesh Journal of Agricultural Research 2013;38(2):289-299.
3. Amezketa E. Soil aggregate stability-A Review. Journal of Sustainable Agriculture 1999;14:83-151. http://dx.doi.org/10.1300/J064v14n0208.
4. Andrews SS, Karlen DL, Cambardella CA. The soil management assessment framework: A quantitative soil quality evaluation method. Soil Science Society of America Journal 2002;68:1945-1962.
5. Askari MS, Holden N. Quantitative soil quality indexing of temperate arable management systems. Soil and Tillage Research 2015;150:57-67.
6. Bama KS, Somasundaram E. Soil quality changes under different fertilization and cropping in a *Vertisol*of Tamil Nadu. International journal of chemical studies 2017;5(4):1961-1968.
7. Berger KC, Troug K. Boron determination in soil and plants. Industrial and Engineering Chemistry Analytical 1939;II:540-545.
8. Bhattacharyya T, Pal DK, Velayutham M, Chandran P, Mandal C. Carbon stock in Indian soils – issues, priorities and management. International Seminar on Land Resource Management for Food, Employment and Environmental Security (ICLRM), 2000, 1-46.
9. Camarasa-Belmonte AM, Soriano J. Emprical study of extreme rainfall intensity in a semi-arid environment at different time scales. Journal of Arid Environments 2014;100:63-71.
10. Cotching WE, Cooper J, Sparrow LA, McCorkell BE, Rowley W, Hawkinds K. Effects of agricultural management on *Vertisols*in Tasmania. Australian Journal of Soil Research 2002;40:1267-1286.
11. Das A, Ghosh PK. Role of legumes in sustainable agriculture and food security: an Indian perspective. Outlook on Agriculture 2012;41(4):279-284.
12. Ghosh PK, Hazra KK, Venkatesh MS, Nath CP, Singh J, Nadarajan N. Increasing soil organic carbon through crop diversification in cereal–cereal rotations of Indo-Gangetic plain. Proc National AcadSci India Sec B Biol Sci 2017;89:429-440.https://doi.org/10.1007/s40011-017-0953-x
13. Gong L, Ran QY, He GX, Tiyip T. A soil quality assessment under different land use types in Keriya river basin, Southern Xinjiang, China. Soil and Tillage Research 2015;146:223-229.
14. Govaerts B, Sayre KD, Deckers J. A minimum data set for soil quality assessment of wheat and maize cropping in the highlands of Mexico. Soil and Tillage Research

2006;87:163-174.
15. Hillel D. Fundamentals of Soil Physics. Academic Press 1980, 413.
16. Husunjak S, Filipovic D, Kosutic S. Influence of different tillage systems on soil properties and crop yield. Rostlinna Vyroba 2002;48(6):249-254.
17. Jackson ML. Soil Chemical Analysis.(Indian Edition), Prentice Hall of India Ltd. Delhi 1950.
18. Juhos K, Szabo S, Ladanyi M. Explore the influence of soil quality on crop yield using statistically- derived pedological indicators. Ecological indicators 2016;63:366-373.
19. Kennedy AC, Papendick RI. Microbial characteristics of soil quality. Journal of Soil Water Conservation 1995;50:243-248.
20. Kumar U, Mishra VN, Kumar N, Rathiya GR. Methods of Soil Analysis.Kalyani Publishers, Ludhiana 2018, 17-22.
21. Kumar U, Mishra VN, Kumar N, Srivastava LK, Bajpai RK. Soil Physical and Chemical Quality under Long-Term Rice-based Cropping System in Hot Humid Eastern Plateau of India, Communications in Soil Science and Plant Analysis 2020;51(14):1930-1945.
22. Lal R. Restoring soil quality to mitigate soil degradation. Sustainability 2015;7(5):5875-5895.
23. Lindsay WL, Norwell WA. Development of DTPA soil test for zinc, iron, manganese and copper. Soil Science Society of America Journal 1978;42:421-428.
24. Maseko ST, Dakora FD. Rhizosphere acid and alkaline phosphatise activity as a marker of P nutrition in nodulatedCyclopia and Aspalathus species in the Cape fynbos of South Africa. South African Journal of Botany 2013;89:289-295.
25. McGarry D, Bridge BJ, Radford BJ. Contrasting soil physical properties after zero and traditional tillage of an alluvial soil in the semiarid subtropics. Soil and Tillage Research 2000;53:105-115.
26. Mitsch WJ, Nahlik A, Wolski P, Bernal B, Zhang L, Ramberg L. Tropical wetlands: seasonal hydrologic pulsing, carbon sequestration, and methane emissions. Wetlands Ecology and Management 2010;18:573-586.
27. Nakajima T, Lal R, Jiang S. Soil quality index of a Crosby silt loam in central Ohio. Soil and Tillage Research 2015;146:323-328.
28. Newton ZL, Kennedy AN, Chirwa RM. Grain legume impacts on soil biological processes in sub-Saharan Africa. African Journal of Plant Science 2011;5(1):1-7.
29. Olsen SR, Col SCW, Wantable FS, Dean LA. Estimation of available phosphorus in soil by extraction with HNO3. United State Department of Agriculture 1954, 931.
30. Orchard VA, Cook FJ. Relationship between soil respiration and soil moisture. Soil Biology and Biochemistry 1983;15:447-453.
31. Pagliai M, Vignozzi N, Pellegrini S. Soil structure and the effect of management practices. Soil and Tillage Research 2004;79:131-143.
32. Patrick M, Tenywa JS, Fbanyat P, Tenywa MM, Mubiru DN, Basamba TA. Soil organic carbon thresholds and N management in tropical agroecosystems: concepts and prospects. J. Sustain. Dev 2013;6:31-43.
33. Rahman MN, Rahman MM, Islam MB, Begum RA, Mondol ATMAI. Effect of tillage practices on soil properties and moisture conservation under Maize -GM-T.Aman cropping sequence. Annual Research Report, Soil Science Division, Bangladesh Agricultural Research Institute, Gazipur 2007.
34. Richards LA. Diagnosis and improvement of saline-alkali soils. USDA Handbook No. 60, U.S. Department of Agriculture, Will Washington, D.C 1954.
35. Schjonning P, Elmholt S, Munkholm LJ, Debosz K. Soil quality aspects of humid sandy loams as influenced by organic and conventional long-term management. Agriculture, Ecosystems and Environment 2002;88(3):195-214.
36. Shukla MK, Lal R, Ebinger M. Determining soil quality indicators by factor analysis. Soil and Tillage Research 2006;87(2):194-204.
37. Skjemstad JO. Importance of soil organic matter fractions to crop production, soil structure and soil resilience. Grains Research and Development Corporation Final Report 2002,195.
38. Smith SE, Jakobsen I, Gronlund M, Smith FA. Roles of arbuscular mycorrhiz as in plant phosphorus nutrition: interactions between pathways of phosphorus uptake in arbuscular mycorrhizal roots have important implications for understanding and manipulating plant phosphorus acquisition. Plant Physiology 2011;156:1050 -1057.
39. Subbiah BV, Asija GL. A rapid procedure for the determination of available nitrogen in soils. Current Sciences 1956;25:259-260.
40. Walkley A, Black IA. Rapid titration method of organic carbon of soils. Soil science 1934;37:29-33.