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Ranjeet Singh Rajpoot
Indira Gandhi Agriculture University, Raipur, Chhattisgarh, India

RK Bajpai
Indira Gandhi Agriculture University, Raipur, Chhattisgarh, India

Satyendra Gupta
Indira Gandhi Agriculture University, Raipur, Chhattisgarh, India

Shri Satyendra Patley
Indira Gandhi Agriculture University, Raipur, Chhattisgarh, India

Kishan Kumar Sharma
Indira Gandhi Agriculture University, Raipur, Chhattisgarh, India

Corresponding Author:
Ranjeet Singh Rajpoot
Indira Gandhi Agriculture University, Raipur, Chhattisgarh, India

Evaluation of soil chemical and biological properties under rice-wheat cropping system in *Alfisol* of Korea district under Northern hill region of Chhattisgarh

Ranjeet Singh Rajpoot, RK Bajpai, Satyendra Gupta, Shri Satyendra Patley and Kishan Kumar Sharma

Abstract
An experiment was conducted during 2018-19 and 2019-20 at Korea district under northern hills region of Chhattisgarh to evaluate soil chemical and biological properties of Rice-wheat cropping system in *Alfisol*. The data indicated that, the studied soils are classified under sandy clay loam (SCL) texture, which is slightly good for plant growth and development. The Soil bulk density, particle density and porosity values ranged from 1.35 to 1.48 (mean 1.43) Mg m^{-3}, from 2.60 to 2.69 (mean 2.64) Mg $m^{-3}$and from 43.46 to 48.28 (mean 45.75) percent, respectively. Among the rice-wheat cropping systems, Soil pH, EC and OC ranged from 6.32 to 7.18 (mean 6.88), from 0.04 to 0.24 (mean 0.15) dS m^{-1} and from 3.89 to 4.96 (mean 4.20) g kg^{-1} respectively. The pH of soils is slightly acidic in nature, as the *Alfisols* was derived from acidic parent materials. These soils had medium to high microbial bio-mass carbon, MBN, and dehydrogenase acid and alkaline phosphatase activity.

Keywords: Physical, chemical and biological properties of *Alfisol*

Introduction
Soil is a basic natural resource which directly benefits the goods and services of various ecosystems for mankind. Its degradation and loss cannot be restored in the human life cycle. Soil is the reference note for the production of fuel, food, fibre, and many key ecosystem servicing. Although the production function of soil has long been recognized, the importance of protecting and enhancing the ecosystem services illustrated by soil (such as carbon sequestration, water purification, groundwater recharge, pathogen control, biological nitrogen fixation, and biodiversity conservation) has not yet been valued. The problem of maintaining/improving soil quality appeared long after the maintenance of water and soil quality. The soil process makes the soil itself regarded as an ecosystem, rather than an integral part of the ecosystem (Filip 2002 and Nortcliff 2002) [6].

Although many indicators on soil health and soil quality have been suggested, there is no globally accepted and applicable definition and method for evaluating soil quality or soil health. In addition, compared with the prediction of the ability of the soil to continue to function under a certain range of stress and disturbance, existing knowledge can better understand the current ability of the soil to operate. Another limitation of most existing studies is that efforts have been made to measure the characteristics of topsoil rather than the entire profile (Sparling *et al*. 2004) [14].

The Soil quality indicators have been well-known as soil procedures and attributes that are touchy to adjustments in soil work. It must be extremely major to set up a basic, delicate and achievable strategy for assessing soil quality (Aparicio and Costa 2007; Dumanski and Pieri 2000) [1, 5]. Soil quality indicators should consolidate physical, chemical, and biological attributes (Karlen *et al.*, 1998; and Aparicio and Costa 2007) [8, 1]. As indicated by reports, when directing SQ examines, the accompanying qualities are reasonable for use as SQ markers: (a) Physical attributes, for example, surface, mass thickness, water maintenance, air penetrability, compressibility, pressure driven qualities, collection state, consistency qualities and surface outside layer ; (b) Chemical properties, for example, pH, salt substance, all out natural carbon, dissolvable carbon, mineral nitrogen, complete phosphorus, extractable ammonium, nitrate, phosphorus, potassium, calcium, magnesium, follow components, contaminants and cations ability to change; (c) Biological qualities, for example, microbial carbon, microbial nitrogen, soil breath, organic movement, catalyst action, root improvement, germination and

development. Considering the above facts regarding soil quality assessment the present study was undertaken as "Evaluation of soil chemical and biological properties for rice-wheat cropping system in *Alfisol* of Korea District under Northern Hill region of Chhattisgarh"

Material and Methods

Collection of soil samples

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" *Alfisols.* 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. Because 0-15 cm is the most common sampling depth for soil testing, only those data are considered for the indices. The average yield of the crop taken for last ten years period (2010-2019) was recorded by farmer's interactions.

Methods of Soil Analysis

The collected soil samples were prepared (dried, grinded and sieved by 2 mm sieve) and analyzed for various physical, chemical and biological parameters using standard laboratory procedures.

1. Physical parameters

1.1 Soil texture

Soil texture was estimated by international pipette method, as described by Piper (1950). The estimation of soil texture included scattering and fractionation of soil samples. The entire scattering of all soil aggregates in to their individual primary soil particles was finished by destructing the cementing specialists like organic matter by warming the soil with 30 percent H_2O_2 in middle 60-70 °C on water shower, and oxides of iron and aluminum were expelled by heating the soil with oxalic acid and sodium sulphide on water bath and calcium carbonate by treating the soil with dilute hydrochloric acid and afterward filtered. The fractionation of soil isolates was practiced by detachment of sand part by sieving and from size littler than 0.063 mm is finished by sedimentation guideline. The time span for various soil isolates was picked supported temperature of the suspension. 25 ml of the suspension was pipetted out at every essential time at a moderate speed. The instance gathered was moved to a gauge 100 ml measuring beaker. Than it had been oven dried at 105 °C to a consistent weight. The weight of silt was ascertained by taking away weight of clay from that of silt + clay. The substance of measuring beaker was dried during a oven and weight was taken and therefore the fine sand in the soil sample was calculated.

1.2 Bulk density

About 3-4 cm diameter size soil clods were gathered. Clod was immovably tied in one end of string. The clod alongside the thread was weighed. The clod was plunged in the melted paraffin and was permitted the overabundance wax to empty. The clod and paraffin were weighed together. The wax covered clod was suspended from the snare of the balance, drenched into water without touching the rock bottom of the beaker and weighed. A comparative clod was weighed, dried in an oven at 105 °C for about 24 hours to urge a continuing weight, cooled in room temperature and weighted again to acquire the oven dry weight (Kumar *et al.* 2018) [10].

Bulk density (Mg m^{-3}) = Weight of oven dry soil (Mg)/Volume of soil (m^3)

1.3 Particle density

Particle density of a soil sample was determined from two estimated amounts in particularly mass of the soil solid and its volume. As pycnometer was used for estimation of the particle density and therefore the method is understood as "Pycnometer method". Particle density was calculated by the subsequent formula (Kumar *et al.* 2018) [10].

Particle density (Mg m^{-3}) = Mass of soil solid (Mg)/Volume of soil solid (m^3)

1.4 Total porosity

Total porosity was calculated from the bulk and particle density of soil by using the relationship between them:

Total porosity (%) = 100 (1 - Bulk density/Particle density)

1.5 Water holding capacity (WHC)

Water holding capacity of soil was estimated by Keen Raczkowski Box Method as depicted by Black (1965) [4]. Soil was filled in sharp Raczkowski box and kept in water tray at around zero tension to totally saturate the soil with water. Because of retention of water the volume of soil increases. The boxes were removed from the water tray and were allowed the drainage to continue for 30 minutes. Their weight was taken alongside wet soil. The soil was dried with sharp Raczkowski box in an oven at 105 °C and reweighing the oven dry evacuated soil. The quantity of water held in soil at zero tension was determined by oven drying the soil in an oven at 105 °C.

% MWHC = (Y –Z – W/ Z – X) x 100

Where
Y – Weight of keen box + with wet soil (g)
Z – Weight of keen box + oven dry soil (g)
W – The average weight of water held by one filter paper (g)
X – Weight of keen box + filter paper (g)
MWHC – Maximum water holding capacity

1.6 Soil Moisture Content (SMC)

SMC determined by Gravimetric method as prescribed by Kumar *et al.* (2018) [10] as follow-

- Moisture determination from undisturbed soil sample: When the soil is neither dry nor wet, select a site which is level and free from weeds and crop residues.
- A cylindrical core sampler is harmed to insert into the soil. When the core sampler is uniformly filled with the soil up to its top, lift the cylinder and make a clean cut at the cylinder base removing extra soil adhering. Keep core cylinder filled with soil core inside a tray over wire gauze lined with a filter paper. Take more than one samples.
- The core sampler with soil is carefully transport into laboratory. The soil of the sampler is transferred completely in a previous weighted moisture box. Moist weight of soil is taken with moisture box and dried in oven at 105 °C for 24 hour to get a constant weight.
- Remove the sample from oven and let it cool at room temperature in about 3-4 hour time. Weighed again to obtain the oven dry weight.

% Soil moisture content on weight basis
= (Weight of moist soil – Weight of oven dry soil /Weight of oven dry soil) X 100

1.7 Mean weight diameter

The procedure used for aggregate analysis was Modified Yoder's wet sieving method (Yoder 1936). Soil samples were collected from 0 – 15 cm "depth after harvest of cropping system. At the time of sampling the samples were broken gently at their natural cleavage and air dried in the laboratory. Air dried soil samples were passed through 4 mm sieve". These samples were cleaned by removing roots, lime, concretion etc. A set of five sieve having 2, 1, 0.5, 0.25 and 0.125 mm opening were mounted on sieve holders in the Yoder type wet sieving machine. "Air dried triplicate soil samples were used for analysis. Out of them one sample was kept for estimation of moisture content and remaining two samples were used for aggregate analysis. In the sieve set soil sample was kept on the top sieve". Immediately prior to sieving, water level was raised rapidly to at a point where it fairly covers the sample when sieve set at its highest position. "Subsequently the Yoder's wet sieving standard procedure was followed".

$$\text{Mean weight diameter (MWD) in mm} = \sum_{i=1}^{N} X\, iWi$$

Where
X i -Mean diameter of aggregate (mm)
Mi - Aggregated sand clod

2. Chemical parameters

2.1 Soil pH

Soil pH was estimated by glass electrode pH meter in 1: 2.5 soil water suspensions as described by Richards (1954) [13]. 20 g of 2 mm sieved soil sample was taken in a 100 ml beaker and add 50 ml distilled water. Mix it with a glass rod for 30 minutes. This time is sufficient for the soil and water to succeed in at equilibrium. This equilibrium can likewise be attained, in the event that we shake the sample on a mechanical shaker for 5 minutes. pH meter is about at room temperature and adjusted by submerging the electrodes in several buffer solutions of pH 4.0, 7.0 and 9.2. Take the beaker of saturation paste or soil extract or 1:2.5 soils: water suspension and dunk the electrodes into it and note the pH perusing.

2.2 Electrical conductivity (EC)

The electrical conductivity (EC) of the supernatant fluid was estimated by conductivity meter as depicted by Richards (1954) [13].

The soil sample utilized for pH determination was permitted to calm down for 24 hours. Modify the temperature compensation knob at 25 °C temperatures. The instrument was tartan with 0.01*N* KCl solution (conductivity 1.41 d Sm-1 at 25 °C) or immersed CaSO4 solution (conductivity 2.2 d Sm-1 at 25 °C). Peruse legitimately the reading on the EC meter and ascertain the conductance.

2.3 Organic carbon (OC)

Organic carbon was determined by Walkley and Black's quick titration technique as described by Black (1965) [4]. 1 g of soil was taken through 2 mm sieve and moved in it to a 500 ml conical flask. 10 ml of 1*N* K2Cr2O7was addedby pipette, then 20 ml of conc. H_2SO_4 was added gradually along the inward wall of the flask. The flask was kept on asbestos sheet for 20-30 minutes for finishing of the oxidation of organic carbon. After oxidation of organic carbon, 100 ml of distilled water was added, 10 ml of 85% H3PO4, 10 ml of 2% NaF (or 0.2 g NaF) and a couple of ml diphenylamine indicator was also added in to the flask. The solution was titrated by adding Fe (NH4)2 (SO4) in small portion until the solution shading changed from blue violet to green or brilliant green. The flask was swirled after each expansion of titre. Additionally a blank was run without soil sample.

2.4 Available N

Available Nitrogen (N) in soil was determined by of potash permanganate method as described by Subbiah and Asija (1956). A 5 g of soil was weighed and transferred in 800 ml Kjeldahl flask. The soil was soaked with about 10 ml of distilled water, and adds 30 ml of 0.32% KMNO4. The Kjeldahl flask is fitted with distillation apparatus right away. (Note - Soil: KMNO4 ratio used – 1:5). 20 ml of 2.0% boric acid containing blended indicator was measured in a 250 ml conical flask and was put it under the receiving tube. The receiving tube end was dipped in the boric acid. Tap water was run in condenser. 30 ml of 2.5% NaOH solution was added and quickly connected to the rubber stopper fitted in the alkali trap. The heater was switched on and distillation was proceeded until about 100 ml of distillate was gathered. The conical flask was first removed containing distillate and then heater was cut to avoid back pull. The distillate was titrated against 0.02 *N* H_2SO_4 taken in burette until pink color begin showing up. A blank was run without soil.

2.5 Available P

Soil available Phosphorus (P) was measured by using 0.5 M $NaHCO_3$ (Olsen extractant) solution at 8.5 pH as described by Olsen *et al.* (1954) [12]. Weigh 2.5 g of soil sample in 250 ml conical flask. Add pinch out Darco G-60 (activated charcoal) and 50 ml of Olsen"s reagent, shake for 30 minutes on a mechanical shaker, and afterward filter through Whatman No. 1 filter paper. Pipette 5 ml of clear and dull filtrate into a 25 ml volumetric flask. Step by step add 1 ml of 5*N* H_2SO_4 solution. Shake gradually and cautiously to drive out the CO2 developed. Add 4 ml of Reagent B, shake a little and make the volume to 25 ml. Read the blue color intensity at 660 nm frequency (red filter) in colorimeter or at 882 nm frequency in spectrophotometer.

2.6 Available K

Soil available Potassium (K) was estimated by neutral normal ammonium acetate method (Kumar *et al.* 2018) [10]. 5 g of soil sample was taken in 100 ml conical flask, trailed by addition of 25 ml of 1 *N* ammonium acetate solution and was shaked with mechanical shaker for 5 minutes. Filtered through Whatman no. 1 filter paper, K concentration was estimated within the filtrate utilizing flame photometer.

2.7 Available S

Soil available Sulphur (S) was determined by turbidimetric method (Tabatabai 1982). 10 g air dried soil was taken in a 150 ml conical flask, at that point 50 ml of 0.15% CaCl2 solution was added and shaken for 30 minutes. It was filtered through Whatman No. 42 filter paper. 10 ml of clean filtrate was taken in 25 ml volumetric flask, add 1 g of BaCl2 crystal to each flask and swirl to break down the crystals, at that point add 1 ml of 0.25% gum acacia solution, make up the structure the quantity

distilled water and shake well physically. Inside 10-30 minute of advancement of turbidity (white color). The absorbance was taken at 420 nm on a spectrophotometer, or on a colorimeter using blue filter.

2.8 Available B

Available Boron (B) in soil was determined by hot water soluble boron method by using Azomethine-H reagent as described by Berger and Troug (1939) [2]. 25 g of air-dry soil was moved into a 100 ml quartz or low boron beaker; 50 ml of distilled water was added. Add 1.0 g of enacted charcoal and bubble for 30 minutes on a water shower, filter quickly in 100 ml volumetric flask, through whatman No. 42 filter paper. Pipette 5 ml filtrate in 25 ml volumetric flask, add 2 ml EDTA solution, 2 ml buffer solution and 2 ml azomethine-H reagent and blend. After 30 minute structure the quantity up to 25 ml. Similarly run the blank. The absorbance at 420 nm wavelength was taken on a spectrophotometer.

2.9 Available micronutrient (Fe, Mn, Cu and Zn)

Available micronutrient (Fe, Mn, Cu and Zn) were extracted by utilizing 0.005 *M* DTPA (diethyl triamine penta acetic acid) + 0.01 *M* CaCl2.2H2O + 0.1 *M* TEA (tri-ethanol amine) cushion stocked at 7.3 pH (Lindsay and Norwell 1978) [11]. 20 g of soil was transferred into a 100 ml conical flask, add 40 ml of DTPA extractant (ratio 1:2). The flask was shaken for 2 hours on a mechanical shaker. The material is filtered through Whatman No. 42 filter paper. The next filtrate is employed for determination of micronutrient using atomic absorption spectrophotometer (AAS).

3. Biological parameters

3.1 Microbial biomass carbon (MBC)

Soil microbial biomass carbon was estimated by fumigation extraction method according to the procedure of Jenkinson and Powlson (1976) [7]. Duplicate 20 g fresh soil samples were weighed into a 100 ml beaker. A moisture determination was conducted on soil sub-samples so that the outcomes can be communicated on an oven-dry-weight basis. Spot the beakers into the two desiccators. Spot a 100 ml beaker containing 50 ml chloroform (alcohol free) into the focal point of the first desiccators and adding pumice bubbling granules and keep it on until the chloroform bubbles for 2 minutes. The outlet was closed and put the desiccators in dim for 24 hours. Keep second desiccators without chloroform for 24 hrs in dim and are fill in as unfumigated control. Following 24 hours discharge the vacuum and expel the soil samples from both fumigated and unfumigated desiccator. Move the fumigated/non-fumigate soil samples to 250 ml conical flasks. Add 25 ml of 0.5*M* K2SO4 and shake for 30 minutes. Filter the suspension through Whatman No.42 filter paper. Pipette out 10 ml of the filtrate into a 250 ml conical flask. Add 2 ml 0.2 *N* potassium dichromate solution, 10 ml conc. sulphuric acid and 5 ml of orthophosphoric acid to each flask. Correspondingly run a blank. Keep the flask on hot plate at 100 °C for 30 minutes, let flasks and add about 250 ml of distilled water right away. The content was permitted to cool at room temperature. 2-3 drops diphenylamine indicator was added, and titrates against 0.005 *N* ferrous ammonium sulfate solutions, until the color changed from bluishgreen to brick-red end point.

MBC (µg g^{-1}or ppm) = EC (µg ml^{-1}) x ECf – Ecuf / K EC

Where

KEC - 0.45 ± 0.05 and represents the efficiency of extraction of MBC

ECf - Extractable carbon in the fumigated soil sample

ECuf - Extractable carbon in the non fumigated soil sample

3.2 Microbial biomass nitrogen (MBN)

Soil microbial biomass nitrogen was evaluated by fumigation extraction method as the procedure of Jenkinson and Powlson (1976) [7]. The estimation of MBN is same as MBC up to fumigation. After fumigation and filtration, 10 ml of the filtrate was pipette out into processing tubes. 2-3 g of the digestion mixture was added and 10 ml of conc. H_2SO_4. The digestion system was set to accomplish a temperature of about 300 °C and afterward the digestion tubes were placed to the heating unit. The temperature aws raised to 400 °C. The hoods were spoted on the tube. The digestion was proceded as long as 4 hours, to let tubes cool to room temperature. The digestion tubes was kept in the distillation unit, the programme was set that would add 40 ml of distilled water, 40 ml of 40% NaOH to the digestion tube and 15 ml 4% boric acid into the flask kept below NH3 out let naturally. The distillation was proceeded for 3-6 minutes (according to the calibration of the machine), from that point forward, the conical flask was removed from the distillation unit. The distillate gathered in conical flask was titrated against 0.02 *N* H_2SO_4 till advancement of a slight purple colour/pink color as end point.

MBN (ppm) = (Nf– Nuf)/KEC

Where

Nf- concentration of N in fumigated sample

Nuf- concentration of N in unfumigated sample

KEC - Efficiency of extraction of MBN, and the value is 0.68 (Brookes *et al.* 1985).

3.3 Dehydrogenases activity

Soil dehydrogenases activity was determined according to the strategy described by Klein *et al.* (1971) [9]. 3 g fresh soil was taken in air tight screw top test tube; 0.1 g of $CaCO_3$, 0.2 ml of three TTC solutions were added in each of test tubes to soak the soil. 0.5 ml of 1 percent glucose solution was added in each tube. The bottom of the tube was delicately tapped to drive out totally trapped oxygen, and hence a water seal is made over the soil. It was ascertained that no air bubbles are shaped. The tubes were incubated at 28±0.5 °C for 24 hours. After incubation 10 ml methanol was added and shake enthusiastically. Permit to face for six hours. The caps of tubes were opened and the suspension was filtered through Whatman No.1 filter paper in to 100 ml volumetric flask. The filtrate was diluted to 100 ml volume with methanol. The intensity of pink shading was measured by spectrophotometer at 485 nm wavelength (blue filter). The quantity of TPF formed was extrapolated from the quality curve drawn inside the range of 10 to 50 µg TPF ml^{-1}.

DHA = Concentration/ It x D/W

Where

DHA – Dehydrogenase activity (µg TPF h-1 g-1 soil)

It – Incubation time (24 hour)

D – Dilution (100 ml)

W – Dry weight of soil (g)

3.4 Acid and Alkaline phosphatase activity

Acid and Alkaline Phosphatase activity was determined using p nitrophenyl-phosphate as substrate (Tabatabi and Bremner 1969) [18]. For each sample take two sets of 1 g oven dry soil was taken in 50 ml conical flasks. Out of those two sets one will be utilized as control. 0.2 ml toluene and 4 ml of MUB (pH 6.5 and 11) was included to all flasks. 1 ml of p-nitrophenyl phosphate solution was added to just one set of samples. The flasks of both the sets were swirled for few moments to consolidate the contents. They were plugged and incubated at 37 °C for one hour. After incubation, stopper was evacuated and added 1 ml 0.5 M $CaCl_2$ and 4 ml 0.5 M NaOH. The flasks were swirled the for few moments. 1 ml p-nitrophenyl phosphate solution was added to the remaining set of samples. All the suspensions were filtered through Whatman No. 2 filter paper. The intensity of yellow shading developed was measured at 440 nm wavelength by spectrophotometer. The acid and alkali phosphate content of the aliquot was determined with regard to a adjustment graph plotted from the outcomes obtained with standards.

Acid and alkali phosphate activity = Concentration/ It xD/W (µg p-nitrophenol released $h^{-1}g^{-1}$soil)

Where
It – Incubation time (1 hour)
D – Dilution
W – Dry weight of soil (g)

Results and Discussion

1. Soil physical properties

The soil physical properties studied under rice-wheat cropping systems are summarized in Table 1. The clay content ranged from 28.97 to 30.96 (mean 30.05) percent, whereas silt and sand content varied from 24.45 to 25.18 (mean 24.73) percent and from 44.05 to 46.32 (mean 45.22) percent, respectively. The data indicated that, the studied soils are classified under sandy clay loam (SCL) texture, which is slightly good for plant growth and development. The Soil bulk density, particle density and porosity values ranged from 1.35 to 1.48 (mean 1.43) Mg m^{-3}, from 2.60 to 2.69 (mean 2.64) Mg $m^{-3}$and from 43.46 to 48.28 (mean 45.75) percent, respectively. From the results, it is clear that bulk density was found slightly higher than that of normal range. The particle density fall under normal ranges, whereas, the porosity of soils was slightly lower than that of optimum level, might be due to high sand content (mean 45.22) of the studied soils. The soil moisture content and available water holding capacity from 21.70 to 23.90 (mean 22.71) percent and from 27.83 to 32.98 (mean 30.02) respectively. The soil moisture content and available water holding capacity fall under the far better range, which is slightly good indicator of soil quality. These results might attribute to better aggregation of soil particles from fibrous root systems of rice-wheat cropping systems. The range of mean weight diameter was recorded from 0.66 to 0.71 (mean 0.69) mm. The size of mean weight diameter was found suitable for plant growth. The fibrous root systems of rice-wheat cropping systems help the soils for improve the MWD of soils.

2. Soil chemical properties

Data on chemical properties of Alfisols, studied under rice-wheat cropping systems, are illustrated in Table 2. Soil pH, EC and OC ranged from 6.32 to 7.18 (mean 6.88), from 0.04 to 0.24 (mean 0.15) dS m^{-1} and from 3.89 to 4.96 (mean 4.20) g kg^{-1} respectively. The pH of soils is slightly acidic in nature, as the Alfisols was derived from acidic parent materials. The EC of soils are classified in normal range. The organic carbon range was within low to medium category. This might be due to low clay content of *Alfisols*. The available N, P, K and S ranged from 186.66 to 238.05 (mean 207.54) kg ha^{-1}, from 9.00 to 16.45 (mean 12.86) kg ha^{-1}, from 282.77 to 428.38 (mean 341.57) kg ha^{-1}, and from 7.48 to 15.87 (11.79) kg ha^{-1}, respectively. The available N content was found in lower category. The intensive rice-wheat cropping system might be responsible for N depletion from soils. As most of the farmers are not applied the required balance doses for N to crops. The available P, K and S was found in medium category. The respective micronutrient content of soil show the average values of Fe, Mn, Cu, Zn, and B were 24.91, 20.00, 0.95, 0.37 and 0.50 ppm, respectively. All these micronutrient contents were found medium in category, could be attribute to acidic pH of Alfisols (mean 6.88). As the favourable pH conditions for micronutrient cation availability is 6.32 to 7.18.

3. Soil biological properties

These soils had medium to high microbial biomass carbon, MBN, and dehydrogenase acid and alkaline phosphatase activity. These types of soils are more suitable for crops that can good response with microbial activity and can fix atmospheric nitrogen, leguminous crops and crop that can suitable for biofertilizers have intrinsic property to withstand such conditions. Therefore, rice-wheat cropping system seems to be suitable for such type of soils. These observations are in good agreement with the findings of Singh and Marwah (2009) [14] and Bhagmal (2007) [3]. Data on biological properties of Alfisols, studied under rice-wheat cropping systems, are depicted in Table 3. The microbial biomass carbon (MBC) and microbial biomass nitrogen (MBN) were recorded in range of 128.00 to 208.05 (mean 154.57) ppm and from 32.68 to 43.87 (mean 39.14) ppm, respectively. Acid phosphatase activity and alkaline phosphatase activity were analyzed in the soil for screening soil health were found in the range of 62.21 to 86.26 (mean 74.10) µg p-nitrophenol $g^{-1}24$ $hr^{-1}$and from 131.90 to 204.04 (mean 175.30) µg p-nitrophenol $g^{-1}24$ hr^{-1}, respectively which is good indication of soil health. The dehydrogenase activity of soil was found in the range of 21.25 to 40.55 (mean 31.39) µg TPF $g^{-1}24$ hr^{-1}, respectively. All the biological properties were found in medium to high category, which indicated that the Alfisols is suitable for intensive cultivation with improved management practices.

4. Crop Yield

Maximum yields of rice and wheat crop were recorded 41.25 and 30.00 q $ha^{-1}$with an average 31.00 and 23.00 q ha^{-1}, respectively. The yields of rice and wheat crop were found in medium range as per average yield of the country as well as Chhattisgarh.mali.

Table 1: Soil Physical Properties of Alfisols under rice-wheat cropping system

S.No.	Particle Size			BD (Mg m^{-3})	PD (Mg m^{-3})	Total Porosity %	AWHC %	SMC %	MWD (mm)
	Sand (%)	Silt (%)	Clay (%)						
1	45.00	25.01	29.99	1.41	2.64	46.54	30.81	22.57	0.67
2	44.27	25.06	30.67	1.45	2.68	45.90	31.92	22.70	0.69
3	45.97	24.51	29.52	1.48	2.61	43.46	32.96	22.85	0.71
4	45.58	24.59	29.83	1.47	2.68	45.26	30.97	21.70	0.66
5	44.79	24.45	30.76	1.46	2.66	45.22	32.98	22.53	0.70
6	46.20	24.82	28.98	1.47	2.61	43.62	28.97	22.80	0.69
7	44.59	24.67	30.74	1.44	2.69	46.42	29.93	21.72	0.71
8	44.71	24.64	30.65	1.46	2.62	44.22	28.83	22.65	0.71
9	45.26	24.79	29.95	1.35	2.61	48.28	27.84	22.77	0.66
10	46.32	24.71	28.97	1.43	2.64	46.00	27.85	22.75	0.67
11	44.79	24.72	30.49	1.48	2.67	44.52	28.99	23.62	0.69
12	46.20	24.59	29.21	1.40	2.61	46.36	29.90	23.75	0.69
13	44.59	24.45	30.96	1.40	2.60	46.15	28.91	23.58	0.66
14	44.27	24.82	30.91	1.45	2.66	45.44	30.00	23.90	0.69
15	45.97	24.67	29.36	1.35	2.61	48.23	30.88	22.70	0.71
16	45.58	24.64	29.78	1.43	2.69	46.79	30.97	22.85	0.67
17	44.79	24.82	30.39	1.46	2.62	44.22	30.98	21.70	0.67
18	46.20	24.67	29.13	1.43	2.64	45.83	28.97	22.53	0.71
19	44.05	25.18	30.77	1.41	2.62	46.13	29.93	22.80	0.70
20	45.26	24.79	29.95	1.42	2.65	46.36	27.83	21.72	0.71
Mean	45.22	24.73	30.05	1.43	2.64	45.75	30.02	22.71	0.69

Note: BD – Bulk Density, PD – Particle Density, AWHC – Available Water Holding Capacity, SMC– Soil Moisture Content, MWD – Mean Weight Diameter.

Table 2: Soil chemical properties of *Alfisols* under rice-wheat cropping system

S. No.	pH	EC (dS m^{-1})	OC (g kg^{-1})	Av. N	Av. P	Av. K	Av. S	Av. Fe	Av. Mn	Av. Cu	Av. Zn	Av. B
				(kg ha^{-1})				(ppm)				
1	6.75	0.19	4.01	215.00	11.17	313.86	9.98	26.20	21.20	1.06	0.45	0.53
2	6.53	0.22	4.08	195.91	10.90	328.53	7.88	24.34	19.34	0.98	0.49	0.49
3	6.64	0.20	3.89	186.66	13.23	344.32	8.90	19.36	14.36	0.86	0.27	0.54
4	6.75	0.17	4.37	209.96	10.55	380.04	11.97	21.74	16.74	0.96	0.31	0.50
5	6.43	0.06	3.91	221.00	13.77	337.77	10.91	27.30	22.30	0.92	0.39	0.56
6	7.07	0.16	4.01	192.40	10.01	428.38	12.22	23.92	18.92	1.06	0.59	0.57
7	7.18	0.18	4.22	202.70	12.88	313.62	7.48	25.24	20.24	0.86	0.59	0.44
8	7.07	0.05	4.14	198.60	12.97	337.65	10.08	34.93	29.93	0.96	0.23	0.63
9	7.07	0.20	3.98	191.23	14.58	362.84	8.38	28.80	23.80	0.92	0.29	0.50
10	7.18	0.21	4.11	197.43	15.00	390.45	11.37	23.24	18.24	1.06	0.31	0.73
11	7.07	0.05	4.52	216.98	16.45	282.77	15.87	22.52	17.52	0.98	0.39	0.39
12	6.86	0.24	4.69	225.18	16.45	306.05	12.18	23.20	18.20	0.86	0.43	0.43
13	6.96	0.21	4.52	216.98	14.58	308.25	14.48	22.30	17.30	0.96	0.29	0.42
14	6.32	0.05	4.96	238.05	12.52	322.82	15.21	20.80	15.80	0.92	0.29	0.46
15	6.96	0.04	4.40	211.13	11.53	345.82	13.21	23.00	18.00	1.06	0.49	0.47
16	6.43	0.09	3.91	215.00	12.97	339.30	13.94	27.30	22.30	0.86	0.39	0.42
17	7.07	0.20	4.01	224.00	9.00	305.53	14.35	22.00	18.92	0.96	0.25	0.53
18	7.18	0.08	4.22	202.70	14.49	355.93	15.87	25.24	20.24	0.82	0.41	0.56
19	7.07	0.21	4.14	198.60	11.53	370.09	11.24	27.82	22.82	1.02	0.15	0.44
20	7.07	0.16	3.98	191.23	12.61	357.32	10.27	29.00	23.80	1.06	0.29	0.39
Mean	6.88	0.15	4.20	207.54	12.86	341.57	11.79	24.91	20.00	0.95	0.37	0.50

Table 3: Soil biological properties of *Alfisols* under rice-wheat cropping system

S. No.	MBC (ppm)	MBN (ppm)	Dehydrogenase activity (µg TPF g^{-1} 24 hr^{-1})	Acid phosphatase activity (µg p-nitrophenol g^{-1} 24 hr^{-1})	Alkaline phosphatase activity (µg p-nitrophenol g^{-1} 24 hr^{-1})	Rice yield (q ha^{-1})	Wheat yield (q ha^{-1})
1	150.89	33.51	32.20	71.25	202.04	27.50	17.50
2	151.99	40.69	30.24	68.65	203.42	26.25	25.00
3	187.00	37.24	31.00	65.34	181.23	25.00	15.00
4	183.05	35.07	32.21	62.29	180.40	37.50	27.50
5	186.06	43.81	35.20	74.25	143.50	25.00	20.00
6	208.05	38.40	37.11	72.24	168.11	30.00	22.50
7	187.06	32.68	36.11	68.26	189.29	32.50	22.50
8	152.06	38.26	38.20	71.29	131.90	35.00	25.00
9	129.08	40.63	37.25	70.21	198.41	25.00	20.00
10	128.00	38.45	31.31	85.74	177.39	27.50	20.00
11	136.95	43.87	21.25	83.36	169.03	36.25	25.00
12	141.16	35.29	24.23	86.26	162.30	30.00	30.00
13	152.06	42.23	35.20	62.48	153.41	35.00	25.00
14	142.95	41.79	25.31	81.21	183.33	41.25	27.50
15	146.86	39.56	40.55	85.21	182.50	35.00	30.00
16	144.09	40.93	31.99	81.31	179.29	28.75	17.50
17	132.98	37.84	31.61	83.21	204.04	32.50	22.50
18	143.09	42.00	30.25	62.21	135.76	36.25	25.00
19	144.95	39.03	21.33	69.00	180.79	26.25	20.00
20	143.06	41.51	25.33	78.23	179.90	20.00	15.00
Mean	154.57	39.14	31.39	74.10	175.30	31.00	23.00

Note: MBC – Microbial Biomass Carbon, MBN – Microbial Biomass Nitrogen

Conclusion

Rice wheat cropping systems significantly affects the physical, chemical and biological properties of soils of North hill region of Chhattisgarh. Rice-wheat cropping systems sustain significantly better physical, chemical and biological properties of soils in terms of lower BD, higher porosity, soil moisture content, water holding capacity, mean weight diameter, organic carbon, available N, P, K, S, micronutrients, MBC, MBN, acid and alkali phosphatase activity, and dehydrogenase activity.

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