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Evaluation of soil chemical and biological properties under Rice-chickpea cropping system in *Alfisol* of Korea District under Northern Hill region of Chhattisgarh

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Abstract
A "study was conducted on the *Alfisols* under" rice-based cropping system of Korea district of Chhattisgarh in order to identify sustainable rice-based cropping" system, and "to develop soil quality index for monitoring soil health" in the area. The data indicated that, The data indicated that, the studied soils are classified in sandy clay loam soils, which is slightly good for plant growth and development. The bulk density, particle density and porosity were found in optimum levels. The large amount of organic carbon was added by rice chickpea cropping system, might be responsible for optimum levels of soil bulk density, particle density and porosity. The soil moisture content from 25.16 to 38.38 (mean 31.34) was found followed with available water holding capacity ranged from 36.23 to 48.32 (mean 41.37) percent respectively. The higher root biomass of rice chickpea cropping system increased macro-aggregate formation. The soils of the studied area fall under acidic in nature, might be attributed to acidic parent material along with legume based cropping system that make soils acidic in nature. The organic carbon range was within medium to high in category, could be attributed to high carbon sequestration capacity of rice-chickpea cropping system. The available N, P, and S were found in medium category, whereas, the available K was found in high level. All the biological properties were fall under higher Level, which indicated that the rice-chickpea cropping system under Alfisols is suitable for maintaining soil quality and environmental sustainability.

Keywords: Physical, chemical and biological properties, *Alfisol*, rice-chickpea cropping system

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.

Soil quality indicates its functionality, which indicates what soil can do for plant, human and animal health. Soil quality influences basic soil functions including medium for plant growth, regulator of water supplies, recycler of raw materials, and habitat for soil organisms (Karlen *et al.* 1997) [8]. The attribute of high soil quality is to keep up high profitability without evident soil or ecological debasement. Acton and Gregorich (1995) figure the actual interpretation of soil quality is "the suitability of soil to support crop growth without causing soil degradation or other damage to the environment." Soil quality is specifying through interaction of specific quantifiable biological, chemical, and physical qualities of soil.

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) [1, 8].

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.

Korea District is the part of Chhattisgarh state of India and classified under hot humid eastern plateau Agro-climatic zone of the country. The average annual rainfall for the district is 1130 mm. Rice based cropping systems are predominantly practiced by the farmers in the district which include chickpea, wheat, linseed, field pea, fallow etc. The soil and climate of these regions are more favourable for rice cultivation in *Kharif*, and subsequent crops are chosen by farmers as per soil type, available recourses, and irrigation facilities in *Rabi*. Farmers cultivate intensive rice based cropping system with improper management practices that involves imbalance and injudicious use of nutrients, low farm input, and removal of residues from field which may lead to diminish in the SOC of the studied soils. The low level of SOC decline the productivity and sustainability of intensive rice based cropping system. The decline in SOC ultimately deteriorates the soil quality in long run as SOC is the key contributor of soil quality. However, we hypothesized that inclusion of legumes into in rice-based cropping system improves the soil quality. Many workers have studied the improvement in soil quality due to incorporation of legumes either as green manures or as residues. However the detailed information regarding impacts of different rice-based cropping systems, including rice-legume, on soil quality in particular is not available especially for soils of hot humid eastern plateau of India.

Materials 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.

Physical parameters

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 ºC 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.

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)

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)

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)

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 ºC 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 ºC.

% 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

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

- Moisture determination from undistuturbed 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 ºC 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

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".

$$\text{Mean weight diameter (MWD) in mm} = \sum_{i=1}^{N} X_i W_i$$

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

Chemical parameters
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.

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 ºC temperatures. The instrument was tartan with 0.01*N* KCl solution (conductivity 1.41 d Sm-1 at 25 ºC) or immersed CaSO4 solution (conductivity 2.2 d Sm-1 at 25 ºC). Peruse legitimately the reading on the EC meter and ascertain the conductance.

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 added by pipette, then 20 ml of conc. H2SO4 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.

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* H2SO4 taken in burette until pink color begin showing up. A blank was run without soil.

Available P

Soil available Phosphorus (P) was measured by using 0.5 M NaHCO3 (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* H2SO4 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.

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.

Available S

Soil available Sulphur (S) was determined by turbidimetric method (Tabatabai 1982) [17]. 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.

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.

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). 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).

Biological parameters

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

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. H2SO4. The digestion system was set to accomplish a temperature of about 300 ºC and afterward the digestion tubes were placed to the heating unit. The temperature aws raised to 400 ºC. 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* H2SO4 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).

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)

Acid and Alkaline phosphatase activity
Acid and Alkaline Phosphatase activity was determined using p nitrophenyl-phosphate as substrate (Tabatabi and Bremner 1969). 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 wirled the for few momments. 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
Soil physical properties
From the data it can be observed that all the sites chosen for study belongs to Alfisols soil order as evidently indicated by high sand content, low to mediumclay and silt content and high permeability. Data on soil physical properties studied under rice-chickpea cropping systems are conferred in Table 1. From the data it is clear that clay content varied from 31.76 to 39.51 (mean 35.60) percent; whereas silt and sand content varied from 21.54 to 25.51 (mean 23.57) percent and from 36.37 to 45.78 (mean 40.83) percent, respectively. The data indicated that, the studied soils are classified in sandy clay loam soils, which is slightly good for plant growth and development. Bulk density, particle density and porosity values ranged from 1.30 to 1.41 (mean 1.34) Mg m^{-3}, from 2.58 to 2.71 (mean 2.63) Mg $m^{-3}$and from 47.13 to 50.00 (mean 49.14) percent, respectively. From the results, it is clear that bulk density, particle density and porosity were found in optimum levels. The large amount of organic carbon was added by rice chickpea cropping system, might be responsible for optimum levels of soil bulk density, particle density and porosity. The soil moisture content from 25.16 to 38.38 (mean 31.34) was found followed with available water holding capacity ranged from 36.23 to 48.32 (mean 41.37) percent respectively. The soil moisture content and available water holding capacity fall under the normal ranges, which is good indicator of soil quality and suitable for rice-chickpea cropping system. These results might be due high higher amount of microbial biomass, added by rice-chickpea cropping system. The range of mean weight diameter was recorded from 0.77 to 0.91 (mean 0.81) mm. The size of mean weight diameter was found appropriate for plant growth. The higher root biomass of rice chickpea cropping system increased macro-aggregate formation.

Soil chemical properties
The data presented in table on soil chemical properties studied under rice-chickpea cropping systems are depicted in Table 2. The soil pH, EC and OC ranged from 5.71 to 7.89 (mean 6.29), from 0.11 to 0.24 (mean 0.15) dS m^{-1} and from 6.03 to 7.11 (mean 6.35) g kg^{-1}, respectively. The soils of the studied area fall under acidic in nature, might be attributed to acidic parent material along with legume based cropping system that make soils acidic in nature. The organic carbon range was within medium to high in category, could be attributed to high carbon sequestration capacity of rice-chickpea cropping system.
The available N, P, K and S in ranged from 280.61 to 321.34

(mean 293.66) kg ha^{-1}, from 13.50 to 24.54 (mean 19.82) kg ha^{-1}, from 316.25 to 549.70 (mean 434.22) kg ha^{-1} and from 12.15 to 21.14 (mean 16.61) kg ha^{-1}, respectively. The available N, P, and S were found in medium category, whereas, the available K was found in high level. However, the available N, P, K, and S were found higher than that of soils under rice-wheat cropping system. Further it was observed that the micronutrient content of soil show the average values of 36.69, 25.56, 1.28, 0.64 and 0.72 ppm for Fe, Mn, Cu, Zn, and B, respectively. All these micronutrient contents were found medium in category, might be due to optimum pH, which was registered under rice-chickpea cropping system (mean 6.29).

Soil biological properties

From the data it can be that all the twenty sites chosen for study belongs to *Alfisols* soil order as evidently indicated by medium to high MBC, MBN and diminutive enzymatic activity of phosphatases and dehydrogenase. 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 bio fertilizers have intrinsic property to withstand such conditions. Therefore, cropping system rice-chickpea seems to be appropriate for such type of soils. Data on soil biological properties studied under rice-chickpea cropping systems are depicted in Table 3. The MBC and MBN were recorded in range of 223.50 to 237.60 (mean 229.31) ppm and from 43.69 to 54.89 (mean 50.15) ppm, respectively. Acid phosphatase activity and alkaline phosphatase activity were analyzed in the soil for screening soil health were ranged from 96.21 to 120.26 (mean 108.10) µg pnitrophenol $g^{-1}24$ $hr^{-1}$and from 241.35 to 313.49 (mean 284.75) µg p-nitrophenol $g^{-1}24$ hr^{-1}, respectively which is good indication of soil health. The dehydrogenase activity of soil was varied from 41.80 to 49.70 (mean 46.26) µg TPF $g^{-1}24$ hr^{-1}. All the biological properties were fall under higher level, which indicated that the rice-chickpea cropping system under *Alfisols* is suitable for maintaining soil quality and environmental sustainability.

Crop yield

Maximum yield of rice and chickpea crops were recorded 52.50 and 12.50 q $ha^{-1}$with an average 41.43 and 7.43 q ha^{-1}, respectively.

Table 1: Soil physical properties of *Alfisols* under rice-chickpea cropping system

S. No.	Particle Size			BD ($Mg\ m^{-3}$)	PD ($Mg\ m^{-3}$)	Total Porosity%	AWHC%	SMC%	MWD (mm)
	Sand (%)	Silt (%)	Clay (%)						
1	40.58	23.88	35.54	1.30	2.59	49.81	42.16	31.20	0.78
2	39.85	23.93	36.22	1.31	2.58	49.22	43.27	31.33	0.80
3	41.55	23.38	35.07	1.32	2.61	49.43	44.31	31.48	0.82
4	41.16	23.46	35.38	1.33	2.61	49.04	42.32	30.33	0.77
5	40.37	23.32	36.31	1.35	2.65	49.06	44.33	31.16	0.81
6	41.78	23.69	34.53	1.36	2.67	49.06	40.32	31.43	0.80
7	40.17	23.54	36.29	1.38	2.61	47.13	41.28	30.35	0.82
8	40.29	23.51	36.20	1.34	2.68	50.00	40.18	31.28	0.82
9	40.84	23.66	35.50	1.36	2.67	49.06	39.19	31.40	0.77
10	41.90	23.58	34.52	1.39	2.68	48.13	39.20	31.38	0.78
11	40.37	23.59	36.04	1.32	2.61	49.43	40.34	32.25	0.80
12	41.78	23.46	31.76	1.32	2.62	49.62	41.25	38.38	0.80
13	40.17	23.32	39.51	1.35	2.66	49.25	40.26	32.21	0.91
14	39.85	23.69	36.46	1.41	2.69	47.58	41.35	32.53	0.80
15	41.55	21.54	34.91	1.38	2.71	49.08	36.23	31.33	0.82
16	41.16	25.51	35.33	1.31	2.60	49.62	48.32	31.48	0.78
17	36.37	23.69	35.94	1.30	2.59	49.81	42.33	30.33	0.78
18	45.78	23.54	34.68	1.32	2.60	49.23	40.32	25.16	0.82
19	40.17	23.51	36.32	1.32	2.63	49.81	41.28	31.43	0.81
20	40.84	23.66	35.50	1.32	2.61	49.43	39.18	30.35	0.82
Mean	40.83	23.57	35.60	1.34	2.63	49.14	41.37	31.34	0.81

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-chickpea 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	6.38	0.14	6.15	286.17	17.62	429.24	14.25	38.24	27.12	1.38	0.69	0.75
2	6.03	0.12	6.23	289.57	17.35	431.64	12.15	36.38	25.26	1.30	0.73	0.71
3	6.11	0.15	6.03	280.61	19.68	428.58	13.17	31.40	20.28	1.18	0.51	0.76
4	5.95	0.12	6.52	303.18	16.99	438.05	16.24	33.78	22.66	1.28	0.55	0.72
5	6.08	0.16	6.06	281.63	13.50	438.51	15.18	39.34	28.22	1.24	0.63	0.78
6	6.07	0.11	6.15	286.17	16.45	434.03	16.49	35.96	24.84	1.38	0.83	0.79
7	7.89	0.13	6.37	296.15	19.32	438.67	17.15	37.28	26.16	1.18	0.83	0.66
8	5.71	0.15	6.28	292.18	19.41	316.25	14.35	39.86	28.74	1.28	0.47	0.85
9	6.22	0.15	6.13	285.03	21.02	431.07	12.65	40.84	29.72	1.24	0.53	0.72
10	6.38	0.16	6.26	294.17	20.93	438.69	15.64	35.28	24.16	1.38	0.55	0.95
11	6.11	0.11	6.67	313.32	22.45	433.98	20.14	34.56	23.44	1.30	0.63	0.61
12	6.76	0.24	6.84	321.34	19.05	549.70	16.45	35.24	24.12	1.18	0.67	0.65

13	6.82	0.16	6.67	293.00	24.54	434.33	18.75	34.34	23.22	1.28	0.53	0.64
14	6.63	0.17	7.11	297.00	22.00	431.89	19.48	32.84	21.72	1.24	0.53	0.68
15	6.78	0.14	6.54	297.00	23.00	437.43	17.48	35.04	23.92	1.38	0.73	0.69
16	5.75	0.17	6.06	284.66	19.41	438.60	18.21	39.34	28.22	1.18	0.63	0.64
17	5.78	0.15	6.15	289.24	21.02	434.07	18.62	35.96	24.84	1.28	0.83	0.75
18	6.27	0.12	6.37	299.33	22.74	437.67	20.14	37.28	26.16	1.24	0.83	0.78
19	5.76	0.16	6.28	295.32	20.78	431.77	21.14	39.86	28.74	1.24	0.47	0.66
20	6.31	0.11	6.13	288.10	19.05	430.34	14.54	40.84	29.72	1.38	0.53	0.61
Mean	6.29	0.15	6.35	293.66	19.82	434.22	16.61	36.69	25.56	1.28	0.64	0.72

Note: EC – Electrical Conductivity, OC – Organic Carbon, Av. - Available

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

S. No.	MBC (ppm)	MBN (ppm)	Dehydrogenase Activity (µg TPF g^{-1} 24 hr^{-1})	Acid phosphatase activity (µg pnitrophenol g^{-1} 24 hr^{-1})	Alkaline phosphatase Activity (µg pnitrophenol g^{-1} 24 hr-1)	Rice Yield (q ha^{-1})	Chickpea Yield (q ha^{-1})
1	224.50	44.52	41.80	105.25	311.49	37.50	3.75
2	226.40	51.71	43.50	102.65	312.87	35.00	3.75
3	234.40	48.26	45.50	99.34	290.68	35.00	3.75
4	232.50	46.08	49.70	96.29	289.85	50.00	10.00
5	237.60	54.82	48.90	108.25	252.95	36.25	6.25
6	231.50	49.41	43.30	106.24	277.56	32.50	5.00
7	224.40	43.69	46.40	102.26	298.74	43.75	7.50
8	223.50	49.27	45.50	105.29	241.35	40.00	7.50
9	227.60	51.64	49.70	104.21	307.86	37.50	6.25
10	229.80	49.47	48.90	119.74	286.84	41.25	7.50
11	230.40	54.89	43.30	117.36	278.48	46.25	10.00
12	228.60	46.30	49.70	120.26	271.75	45.00	8.75
13	234.40	53.24	48.90	96.48	262.86	47.50	11.25
14	232.50	52.80	43.30	115.21	292.78	50.00	12.50
15	237.60	50.57	46.40	119.21	291.95	47.50	10.00
16	231.50	51.94	45.50	115.31	288.74	35.00	3.75
17	224.40	48.85	43.30	117.21	313.49	36.25	6.25
18	223.50	53.01	46.40	96.21	245.21	52.50	8.75
19	227.60	50.04	45.50	103.00	290.24	42.50	8.75
20	223.50	52.53	49.70	112.23	289.35	37.50	7.50
Mean	229.31	50.15	46.26	108.10	284.75	41.43	7.43

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

Conclusion

Rice chickpea cropping systems significantly affects the physical, chemical and biological properties of soils of North hill region of Chhattisgarh. Rice-chickpea 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.

References

1. Aparicio V, Costa JL. Soil quality indicators under continuous cropping systems in the Argentinean Pampas. Soil and Tillage Research. 2007;96(1-2):155-165.
2. Berger KC, Troug K. Boron determination in soil and plants. Industrial and Engineering Chemistry Analytical, Ed. 1939;II:540-545.
3. Bhagmal. The Indian Journal of Agricultural Sciences Forage Research in India. Online Journal; c2007.
4. Black CA. Methods of Soil Analysis. American Society of Agronomy, Inc. Publication Madison, Wisconsin, USA; c1965.
5. Dumanski J, Pieri C. Land quality indicators: Research plan. Agriculture Ecosystem and Environment. 2000;81:93-102.
6. Filip Z. Filip International approach to assessing soil quality by ecologically-related biological parameters. Agriculture, Ecosystems and Environment. 2002;88:169–174.
7. Jenkinson DS, Powlson DS. The effect of biological treatments on metabolism in soil. A method for measuring soil biomass. Soil Biology and Biochemistry. 1976;8:209-213.
8. Karlen D, Mausbach M, Doran J, Cline R, Harris R, Schuman G. Soil quality: A concept, definition, and framework for evaluation (a guest editorial). Soil Science Society of America Journal. 1998;61:4–10.
9. Klein DA, Loh TC, Goulding RL. A rapid procedure to evaluate dehydrogenases activity of soils low in organic matter. Soil Biology and Biochemistry. 1971;3:385–387.
10. Kumar U, Mishra VN, Kumar N, Rathiya GR. Methods of Soil Analysis. Kalyani Publishers, Ludhiana; c2018. p. 17-22.
11. 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.
12. Olsen SR, Col SCW, Wantable FS, Dean LA. Estimation of available phosphorus in soil by extraction with HNO3.United State Department of Agriculture; c1954. p. 931.
13. Richards LA. Diagnosis and improvement of saline-alkali soils. USDA Handbook No. 60, U.S. Department of Agriculture, Will Washington, D.C; c1954.

14. Singh G, Marwah JS. Effect of resource conservation technique on soil microbiological parameter. Indian Journal of Agricultural Sciences. 2009;79(2):94-100.
15. Sparling G, Schipper L. Soil quality monitoring in New Zealand: trends and issues arising from a broad-scale survey. Agriculture, Ecosystems and Environment. 2004;104:545–552. 10.1016/j.agee.2003.11.014.
16. Subbiah BV, Asija GL. A rapid procedure for the determination of available nitrogen in soils. Current Science. 1956;25:259-260.
17. Tabatabai MA. Sulphur in Methods of Soil Analysis, Part 2, chemical and microbiological properties, 2nd ed. (A.L. Page Ed.) No. 9 (Part 2) in the series Agronomy. American Society of Agronomy and Soil Science Society of America, Inc., Madison, Wisconsin, USA; c1982.
18. Tabatabi MA, Bremner JM. Use of p-nitro phenyl phosphate for asses of phosphate activity. Soil Biology and Biochemistry. 1969;1:301-307.