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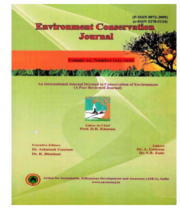

Effect of various soil health indicators on rice productivity in old alluvium of Bihar: A correlation study

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ABSTRACT

Conventional method of rice-wheat cropping system leads to deteriorate soil health drastically day by day. An appropriate idea of particular soil health indicator that effects soil health directly should be known to make the crop productivity high. In order to determine the direct and indirect associations among various soil health properties with rice yield in rice-wheat cropping system a survey was done in farmer's field. Overall 100 soil samples were collected randomly from 100 farmer's field and studied to find out the soil health. Soil chemical properties (pH, EC, SOC, Avl. N, Avl. P_2O_5, Avl. K_20), Soil physical properties (sand, silt, clay and Available water capacity) and soil biological properties (active carbon, soil respiration and autoclaved citrate extractable protein) were studied to find out the principal indicator for soil health that effects directly to rice yield. The study revealed that mainly soil organic carbon effects rice yield directly along with clay content of soil and soil respiration. Soil microbial activity is also very important in order to achieve good rice yield and positive correlated soil respiration value is evidence of it. Thus the results suggest that farmers should focus on enhancing soil organic carbon and microbial activity by means of soil respiration with best sustainable management practices in order to achieve higher productivity of rice.

Introduction

Unbalanced fertiliser application causes yield stagnation and soil health degradation (Surekha *et al.,* 2013). The soil system regulates plant growth in terrestrial ecosystem (Nath *et al.,* 2021; 2022) Nutrient balance is one of the most critical variables in enhancing crop yield. Nutrient mining from the soil has come from excessive and imbalanced fertiliser use. Organics, as well as organic and inorganic mixes, replenish vital nutrients, which has a direct impact on soil health and crop productivity (Kumar *et al.,* 2015). On the other hand, due to various current production system practises, such as the indiscriminate use of chemical fertilisers and pesticides, the rotational farming of rice and wheat is facing a sustainability challenge (Prasad *et al.,* 2010). The impacts of agrochemicals on soil structure, microbiota, food, and fodder are all plainly detrimental. The current rice-wheat farming method has raised concerns about lower factor productivity, soil organic carbon depletion, and mineral nutrient depletion (Yadav, 2008). Long-term fertiliser trials are essential for determining changes in crop physical, chemical, and microbiological features, as well as crop production. Continuous application of manures and fertilisers for a long time causes quantifiable changes in soil properties. Rice nutrient management is crucial for long-term crop viability.

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Following the 1960s, Indian agriculture made significant progress. The success of agricultural output has been attributed to the widespread use of high yielding cultivars. The cornerstone in the change of Indian agriculture from subsistence to excess has been fertiliser, among other inputs. Rice yield is a complex trait that is influenced by a number of soil parameter variables. A effective selection requires knowledge of genetic diversity and the relationship between soil parameters variables and grain production. At the moment, agriculture's top objective is to prevent future crop output and soil health decreases (Bhatt *et al.,* 2019). In agriculture, the phrase soil quality refers to the soil's ability to sustain crop development without degrading. It is a vital component of sustainable agriculture and consists of a combination of physical, chemical, and biological properties that allow the soil to perform a variety of functions (Dwivedi and Thakur, 2000). Using Pearson's correlation coefficient analysis, this study attempted to investigate the influence of various soil properties on rice yield and some physical, chemical, and biological aspects of soil.

Material and Methods

Brief description about study area

A total of 100 GPS based soil samples were collected from Rohtas. The latitude and longitude of the district is 24˚30' - 25 ˚ 25' (N) and 83˚45' - 84˚22' (E) respectively. Agro-climatic zone is South Bihar Alluvial Plain Zone (III-B). Soils are old alluvium with slight reddish to yellow in colour. Net sown area is 231.8 thousands ha along with 155.7 thousands ha area sown more than once.The electrical conductivity and soil pH was tested in 1:2 soil-water extract (Jackson, 1967)." Soil texture was determined using the Comprehensive Assessment of Soil Health (Kettler *et al.,* 2001) and available water capacity (Reynolds *et al*., 2008). Soil Organic C was determined using Rapid titration method (Walkley and Black; 1934). Available N was Alkaline permanganate method (Subbiah and Asija, 1956) used to determine Available N. Available P was determined following Watanabe and Olsen's method (1965). Available Potassium was determined using Jackson (1958) described using a flame photometer to assess the potassium content of the extract. Available S was determined turbidimetrically (Chesnin and Yien, 1950).Available micronutrient cations (Cu, Zn, Fe, Mn) determined using DTPA (Diethylene triamine penta-acetic acid) extracting solution (Lindsay and Norvell, 1978). Soluble B method (Berger and Troug,1939) was used to know the bio-availability of B in soil. Among soil biological properties, Active C was determined following Comprehensive Assessment of Soil Health (Stiles *et al.,* 2011); ACE protein were extracted using a method modified from Wright and Upadhyaya (1998) and soil respiration following Haney and Haney (2010).

Statistical analysis

For the statistical analysis of the data, SPSS Windows version 20.0 (SPSS Inc., Chicago, IL, USA) was used (Pearson's correlations and coefficient of determination (R^2).

Results and Discussion

Table 1 shows the relationship between soil chemical parameters and rice yield, indicating that SOC (0.853**), Avl. N (0.050), Avl. P_2O_5 (0.056), Avl. K_2O (0.022) were positively and significantly associated with rice yield, whereas pH (-0.245*), EC(-0.013) were negatively associated with rice yield. The highest value was recorded in SOC (0.853**) for rice yield (Table 1) while the minimum value was shown in pH and EC (-0.245** and - 0.013**). However, SOC had a positive correlation with P_2O_5 (0.217). SOC improves soil organic matter in soil as a result it makes chelation with P_2O_5, hence availability increases. Soil organic carbon and rice yield (t/ha) shows a positive trend (R^2=0.93) along with soil organic matter too (Fig. 1). Also as Organic acids were formed during the degradation of organic matters, reducing the pH of the soil. Similarly, the decrease in electrical conductivity might be due to the creation of different organic acids during the breakdown process, which solubilized the salt and allowed it to be leached down by irrigation. The increase in soil SOC was due to the crop residue incorporation along with application of organic manure and a greater amount of crop waste (Bellakki *et al.,* 1998). The soil system regulates plant growth in terrestrial ecosystem (Nath *et al.,* 2021; 2022). Kumar *et al.,* 2015 observed that organic carbon and agricultural yield had a positive association. This might be attributed to a change in the physical

Table 1. Correlation studies of rice yield with physico-chemical properties of soil

	pH	EC	SOC	Avl. N	Avl. P_2O_5	Avl. K_2O	Rice yield (t/ha)
pH	1						
EC	0.492**	1					
SOC	-0.078	0.233*	1				
Avl. N	0.236*	-0.093	0.630**	1			
Avl. P_2O_5	0.025	-0.099	0.217	0.100	1		
Avl. K_2O	0.360**	0.343**	0.407**	0.111	0.011	1	
Rice yield	-0.245*	-0.013	0.853**	0.750**	0.256*	0.322*	1

****. Correlation is significant at the 0.01 level (2-tailed).**
***. Correlation is significant at the 0.05 level (2-tailed).**

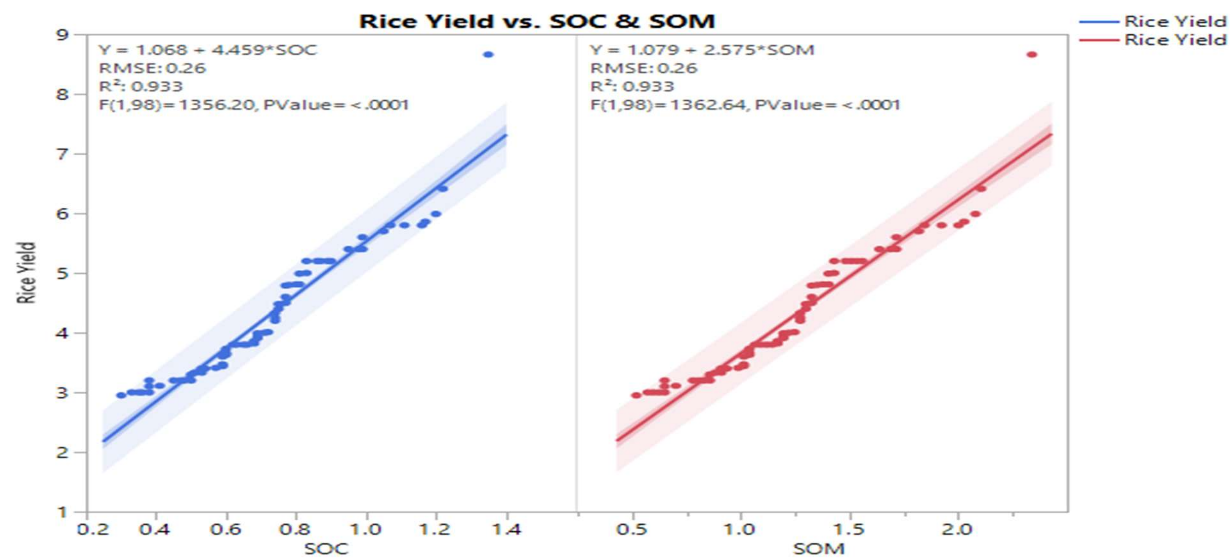

Figure 1: Variation of rice yield (t/ha) with soil organic carbon (SOC) and soil organic matter (SOM).

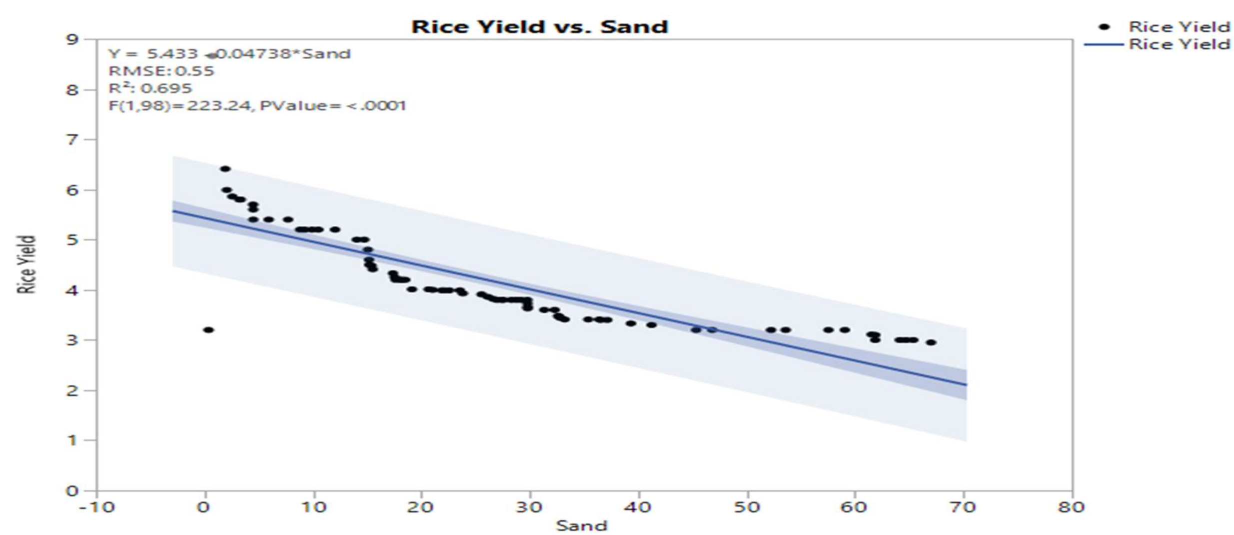

Figure 2: Variation of rice yield (t/ha) with sand (%) in old alluvium.

environment of the soil as a result of the combined application of compost, crop debris, and chemical fertiliser, which increased productivity (Chaudhary and Thakur, 2007). Kumari *et al.,* 2022 also observed that SOCstock can be tremendously increased with water aggregate stability and clay content of alluvial soils of Bihar as a result productivity of crop is in increasing trend. Except for sand content, which had a negative relationship with yields, the findings showed that other physical properties of soil were positively and substantially linked to rice yield (Table 2 and Fig.2.) Sand content in soil results in less water holding capacity and also less nutrient content along with less soil organic matter content leads to less rice yield. Also the R^2 value in the correlation graph is 0.69 which shows that there is a positive trend with sand and reducing yield. Sand (-0.219*) had the lowest value whereas silt (0.201*) had the highest value in rice yield. Clay and available water capacity (AWC) had also positive correlation with yield.

Table 2 also shows the correlation coefficients of several biological properties associated with rice productivity. All biological metrics, namely active carbon, soil respiration, and protein, were shown to be positively and strongly linked with rice yield. Under rice yield, the ACE protein (autoclaved citrate extractable protein) content had the highest value (0.107) while the soil respiration and active carbon had the lowest value (0.099 and 0.019) (Table. 3). The crop residue incorporation along with use of organic manure may enriched microbial proliferation (Singh *et al.,* 2019). As a consequence, integrated fertilisation modifies the soil's organic material content, resulting in increased crop yield. Because of improvements in soil physical, chemical, and biological properties, the combined use of chemical fertilisers and organic manure may have increased SOC apart from soil organic matter enrichment, which increased rice yield (Thakur *et al.,* 2011).

Table 2: Correlation studies of Rice yield with soil physical properties

	Sand (%)	**Silt (%)**	**Clay (%)**	**AWC (%)**	**Rice yield (t/ha)**
Sand (%)	1				
Silt (%)	-0.878**	1			
Clay (%)	-0.130	0.360**	1		
AWC (%)	-0.147	0.205**	0.138	1	
Rice yield (t/ha)	-0.219**	0.201*	0.219*	0.212*	1

****. Correlation is significant at the 0.01 level (2-tailed).**
***. Correlation is significant at the 0.05 level (2-tailed).**

Table 3: Correlation studies of Rice yield with soil biological properties

	Active C (mg/kg)	**Soil Respiration ($mgCO_2/g$)**	**ACE Protein (g/kg)**	**Rice yield (t/ha)**
Active Carbon (mg/kg)	1			
Soil Respiration ($mgCO_2/g$)	0.254**	1		
ACE Protein (g/kg)	0.200*	0.810**	1	
Rice yield (t/ha)	0.019	0.299**	0.107	1

****. Correlation is significant at the 0.01 level (2-tailed).**
***. Correlation is significant at the 0.05 level (2-tailed).**

Conclusion

The study revealed that soil organic carbon (SOC) is the principal component that effects rice yield directly along with clay content of soil and soil respiration. SOC was much higher in soils with the sand (%). The main influential factors on rice yield were SOC, clay (%) and soil respiration in the soil, according to correlation analysis. Soil microbial activity is also very important in order to achieve good rice yield and positive correlated soil respiration value is evidence of it. Thus, the results suggest that farmers should focus on enhancing soil organic carbon (SOC) along with soil organic matter (SOM) with various sustainable management practices, as SOC coupled with SOM will leads to higher productivity of rice. Future studies should focus on the primary reasons of SOC sequestration in old alluvium of Bihar in component C fractions, as well as potential protective factors.

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Conflict of interest
The authors declare that they have no conflict of interest.

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