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Correlation Studies of Soil Properties with Yield of Rice in a Calciorthents

Amit Kumar Pandey[1*] and Ashutosh Singh[1]

[1]Mandan Bharti Agriculture College, Agwanpur, Saharsa (Bihar), India.

Authors' contributions

This work was carried out in collaboration among all authors. Author AKP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AS managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Imbalanced use of nutrients through fertilizer have a deleterious effects on soil health, leading to unsustainable productivity. The present investigation was carried out to study the comparative effectiveness of compost and crop residue either alone or in combination of chemical fertilizer on physico chemical properties of soil, soil microbial biomass and crop yield in rice-wheat cropping system in Calciorthents at experimental farm of Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar in light texture and medium fertile soil. There were sixteen treatments which were replicated thrice in split plot design. Four level of NPK *viz*., no NPK, 50% NPK, 100% NPK and 150% NPK were kept as main plot treatments whereas four levels of organics viz., no manure, compost @ 10 t ha^{-1}, crop residue and compost + crop residue were treated as sub-plot treatments. The correlation between rice yield and some physico-chemical and microbial attributes of soil were evaluated. Most of soil physical, chemical and microbiological parameters were positively correlated with grain and straw yield of rice. Thus the results suggest that integrated use of balanced inorganic fertilizers in combination with organic manure sustains a soil physico-chemical and microbiological environment of soil that is better for enhancing higher crop productivity.

Keywords: Correlation; physical; chemical; microbiological; rice; yield.

**Corresponding author: E-mail: amitpandeybau@gmail.com;*

1. INTRODUCTION

Imbalanced fertilizer use results stagnant yield and deteriorated soil health [1]. Nutrient balance is one of the key component to increase crop productivity. Excess and imbalance use of nutrients has caused nutrient mining from the soil. Replenishment of these nutrients through organics and in combination with organic and inorganic has a direct impact on soil health and crop productivity [2]. The production of rice and wheat in a rotation is however facing a sustainability problem due to some practices of the modern production system with its indiscriminate use of chemical fertilizer and pesticides [3]. The deleterious effects of agro-chemical are clearly visible on soil structure, microflora, food and fodder. The concerns such as declining factor productivity depletion of soil organic carbon and mineral nutrient [4] are the consequence of the modern rice-wheat production system. Long term fertilizer experiment play an important role in understanding the changes in physical, chemical and microbiological properties and productivity of crop. Continuous application of manures and fertilizer for a longer time bring definite change in soil properties.

Nutrient management in rice is of pivotal importance to achieve sustainability in production. Indian agriculture has made tremendous progress after the sixties. The success of agricultural production has been attributed to the widespread use of high yielding varieties. Among several inputs, fertilizer have been the kingpin for the transformation on Indian agriculture from subsistence to surplus. Presently, the major concern in agriculture is to arrest any further decline in crop productivity and soil quality [5]. About agriculture, the term soil quality has been used to measure soil's fitness to support crop growth, without its degradation. It is a critical component of sustainable agriculture and it comprises the combination of physical, chemical and biological characteristics the enable the soil to perform a wide range of function [6]. Hence, the study with the objective to assess the impact of different organic amendments on system productivity of rice-wheat cropping system and some physical, chemical and microbiological properties of soil was undertaken.

2. MATERIALS AND METHODS

A field experiment was conducted at the Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar on a calcareous soil starting from *rabi* 1988-89 under rice-wheat cropping system. The experiment was laid out in a split plot design with three replication and sixteen treatments. The treatments consisted of no NPK, 50% NPK, 100% NPK and 150% NPK as main plot treatment whereas no manure, compost @ 10 t ha^{-1}, crop residue and compost + crop residue as sub-plot treatments. The recommended dose of fertilizer NPK (120: 60: 40: N: P_2O_5:K_2O) were applied to each crop rice and wheat as urea, single super phosphate and muriate of potash. Rice and wheat crop were grown continuously under rice-wheat cropping system. Rice *cv*. Rajshree was 37th and 39th test crop and wheat *cv*. HD 2733 as 38th and 40th test crop during the reported period. The grain and straw yield was taken at the harvest of rice and wheat crops. Soil samples were collected from each 48 sub plot after harvest of wheat and before transplanting of rice at a depth of 0-15 cm. These samples were air dried processed and stored in polythene bags for analysis. All the analysis were carried out as per the standard methods. Bulk density of soil under field condition was determined with the help of core sample as described by Richard [7]. Per cent pore space of soil was calculation by using the following formula

$$\text{Per cent pore space} = \left(\frac{1 - \text{BD})}{\text{PD}}\right) x\ 100$$

Where,
BD = Bulk density in Mg m^{-3}
PD = Particle density in Mg m^{-3}

Water holding capacity was determined by means of Keen box as described in the soil survey manual of IARI [8]. Total bacterial population was counted by soil dilution and plating technique using Asparagine-Mannitol-agar medium [9]. The fungal population in soil sample was estimated on Rose Bengal Streptomycin agar medium [10] by pour plate technique. Population of actinomycetes was enumerated using Kenknight and Munaier's medium by pour plate method. The pH of the suspension of soil in water with a soil : water ratio of 1:2 was determined with the help of glass electrode pH meter [11] and EC was determined by method given by [12]. CEC and free $CaCO_3$ were determined by method proposed by [7] and [12].

Simple coefficient of correlation were worked out soil physical properties such as bulk density, per cent pore space, water holding capacity and

organic carbon pH, EC, CEC, free $CaCO_3$, available N, P, K, S, Zn and B and microbiological properties such as bacterial population, fungal population and actinomycetes population with grain and straw yield of rice. The experimental data were analysed using statistical programme STPR of G.B. Pant University of Agriculture and Technology, Pantnagar. Analysis of variance and critical difference between treatments was calculated at 5% level of significance. Correlation coefficients were computed using SPSS version 16.

3. RESULTS AND DISCUSSION

The data revealed that most of the physical parameters were positively and significantly correlated with grain and straw yield of rice, except bulk density of soil with showed negative correlation with yields (Table 2). The highest value was found in organic carbon (0.850** and 0.865**) and minimum value was found in bulk density (-0.804** and -0.808**) under grain and straw yield of rice, respectively. Kumar et al [2] also observed positive correlation between organic carbon and yield of crop. This might be due to improvement of physical environment of soil with the integrated use of compost, crop residue and chemical fertilizer that resulted in increased productivity [13]. Application of organic manure viz compost, crop residue, FYM improves soil physical properties through improvement of soil organic matter. The increase plant biomass produced by fertilizers, resulted in the increased return of organic material to the soil in the form of decaying roots, litter and crop residues. Thus integrated fertilization influences soil organic material content, resulting increased crop productivity. The correlation coefficient of different microbiological attributed with grain and straw yield of rice has been presented in Table 3. The data revealed that all the microbial parameters such as bacterial population, fungal population and actinomycetes population were positively and significantly correlated with grain and straw yield of rice. The maximum value was found in bacterial population (0.908** and 0.910) and minimum was found in actinomycetes population (0.820** and 0.836**) under grain and straw yield of rice, respectively. The organic matter might have supplied food for the microorganism which in turns enhance their proliferation [14]. Correlation of chemical characteristics of soil with yield of crop has been depicted in Table 4; which showed that only CEC was positively and significantly correlated with grain and straw yield of rice whereas pH, EC and free $CaCO_3$ were negatively correlated with grain and straw yield of rice. Maximum value was recoded in CEC (0.815** and 0.824**) and minimum value was noted in EC (-0.888** and -0.909**) under grain and straw yield of rice, respectively. Organic material released organic acids during their decomposition, which decreased the soil pH. Similarly, the decrease in electrical conductivity might be due to release of several organic acid during decomposition process, which solubilized the salt and may be leached down through irrigation. Build-up of soil humus due to application of organic manure and higher amount of crop residue resulted in improvement of CEC of soil [15].

The integrated use of chemical fertilizers with organic manure might have added organic matter in soil that increased the grain and straw yield of rice and this might be due to improvement in physical, chemical and microbiological properties of soil [16].

Table 1. General properties of initial experimental soil

Parameter	Value
Bulk density (Mg m^{-3})	1.44
Pore space (%)	48.76
Water holding capacity (%)	31.22
pH (1:2 soil : water)	8.4
Electrical conductivity (dSm^{-1})	0.37
Cation Exchange Capacity [Cmol(P^+)kg^{-1}]	9.82
Free calcium carbonate (%)	34.34
Total bacteria (x 10^6 cfu g^{-1})	28
Total fungi (x 10^4 cfu g^{-1})	16
Total actinomycetes (x 10^5 cfu g^{-1})	7
Organic carbon (g kg^{-1})	5.0

Table 2. Relationship of yield of rice with physical parameters of soil

Parameters	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
Bulk density	-0.804**	-0.808**
Per cent pore space	0.808**	-0.808**
Water holding capacity	0.839**	-0.849**
Organic carbon	0.850**	0.865**

Table 3. Relationship of grain and straw yield of rice with microbiological characteristics of soil

Parameters	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
Bacterial Population	0.908**	0.910**
Fungal Population	0.705**	0.715**
Actinomycetes Population	0.820**	0.836**

Table 4. Relationship of yield of rice with soil chemical attributes

Parameters	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
pH	-0.720**	-0.729**
Electrical conductivity (EC)	-0888**	-0.909**
Cation exchange capacity (CEC)	0.815**	0.824**
Free $CaCO_3$	-0.031**	0.001

4. CONCLUSION

Most of the soil parameters were positively correlated with grain and straw yield of rice. The conjoint use of compost, crop residue and inorganic sources of nutrient increased the availability of nutrients by improvement in soil physical, chemical and biological properties, thereby increased the yield of wheat. Integration of compost @ 10 ton ha^{-1} crop residue and inorganic fertilizers sustained higher productivity to modest economic status of farmers in a delicate ecosystem. It not only restore the original fertility status of soil but also improved nutrient status and biological health which may be advantageous for sustaining the productivity of the system.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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