

Soil Physico-chemical Properties and Crop yield under Long-term Integrated Plant Nutrient System in Temperate Conditions

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ABSTRACT

Long term fertilizer experiments play an important role in understanding the complex interactions involving soils, plants, climate and management practices and their effects on crop productivity. It is well recognized that long term fertilizer experiments are repositories of valuable information regarding the sustainability of intensive agriculture. The LTFE serves as an important tool to understand the changes in soil properties due to intensive cropping and continuous fertilization. The experiment was carried out at Mountain Research Centre for Field Crops, Khudwani and was laid out in Randomized Block Design with eleven treatments replicated thrice during kharif season (2014) to study "Soil Physico-chemical properties and crop yield under Long-term Integrated Plant Nutrient System in Temperate Conditions". The soil of experimental site at harvest was silty clay loam in texture with pH ranging from (6.40 to 6.72), EC (0.45 to 0.58 dSm⁻¹) and CEC [8.33 to 13.60 (c mol (p+) kg⁻¹)]. Application of organic and inorganic sources of nutrient in combination [50% NPK+50% N (FYM) T₆] remarkably increased yield of rice than control. Higher straw and grain yield 10.81 and 6.87 t ha⁻¹ was also in treatment T₆.

Key words : FYM, LTFE, NPK, Rapeseed, Rice, Soil properties.

1.INTRODUCTION

Rice (*Oryza sativa*) is most extensively grown cereal crop in the world and is staple food of about 2.9 billion or more. India is one of the most important producer as well as consumer of rice. Rice crop plays a significant role in livelihood of people of Jammu and Kashmir State. Although area under rice is about 0.27 M ha, but it plays an important role in the state economy. Rice productivity in the state is high (2.2 t ha⁻¹) compared to the national

average productivity of about 1.9 t ha^{-1} . The total annual rice production in the state is about more than 0.59 MT. In Kashmir valley the cultivation of rice extends from the area having altitude 1600 m above the mean sea level to high hills 2300m above mean sea level [1].

Long-term fertilizer experiments (LTFEs) are valuable assets for determining yield trends, changes in nutrient dynamics and balances, predicting soil carrying capacity, assessing soil quality and system sustainability. LTFEs have been reported from samples obtained at the beginning or at the end of the cropping sequence [2, 3]. Furthermore, after continuous cropping for nine years the treatments receiving FYM alone exhibited significantly lower bulk density compared to all the chemical fertilizer and control treatments. In maize-wheat cropping system in an acid Alfisol (pH 6.5) of Jharkhand [4]. Application of chemical fertilizers either alone or in conjunction with organic materials increased CEC of the soil significantly over control [5]. The recommended dose of NPK fertilizers alone does not sustain productivity under continuous intensive cropping system [6], whereas inclusion of organic manures improves physical properties, soil fertility and crop yields [7].

Therefore in view of the above considerations, the proposed study was carried out to evaluate the Soil Physico-chemical properties and crop yield under Long-term Integrated Plant Nutrient System in Temperate Conditions, with the following objectives :

1. Effect of continuous application of organics and chemical fertilizers on soil properties
2. Effect of continuous application of organics and chemical fertilizers on crop yield

II.MATERIALS AND METHODS

The investigation entitled, “*Soil Physico-chemical properties and crop yield under Long-term Integrated Plant Nutrient System in Temperate Conditions*”, was undertaken in the Division of Soil Science at SKUAST-K, Shalimar, Srinagar, during 2014-2015. The experiment was carried out at Mountain Research Centre for Field Crops, Khudwani which is located at a latitude of $33^{\circ}43.260' \text{ N}$ and longitude of $75^{\circ}05.803' \text{ E}$ with an altitude of 1650 m above mean sea level.

2.1. Experimental details:

The experiment consisted of eleven treatments. The treatment details are as follows:

Treatment	Rice (SR-1)	Rapeseed (KS-101)
T ₁	Control	Control
T ₂	50% NPK of recommended dose	50% NPK of recommended dose
T ₃	50% NPK of recommended dose	100% NPK of recommended dose
T ₄	75% NPK of recommended dose	75% NPK of recommended dose
T ₅	100% NPK of recommended dose	100% NPK of recommended dose
T ₆	50% NPK + 50% FYM of recommended dose	100% NPK of recommended dose
T ₇	50% NPK + 50% FYM of recommended dose	50% NPK of recommended dose
T ₈	75% NPK + 25% FYM of recommended dose	75% NPK of recommended dose
T ₉	50% NPK+50% (Rice straw)	100% NPK of recommended dose
T ₁₀	50% NPK + 25% (Rice straw)	75% NPK of recommended dose
T ₁₁	Farmers practice (60-80 kg N + 30-40 kg P ₂ O ₅ + 5-10 t FYM)	Farmers practice (30-40 kg N + 40 kg P ₂ O ₅ + 5 t FYM)

No. of replications : 03

- Recommended doses
- 1) Rice (120 kg N, 60 kg P₂O₅, 30 kg K₂O, 10-15 kg Zn and 10 t FYM)
 - 2) Rapeseed (80 kg N, 50 kg P₂O₅, 40 kg K₂O, 25-30 kg S, 1 kg B and 10 t FYM)

2.2. Design of an experiment

The experiment was laid out in a randomized block design having eleven treatments and replicated thrice on fixed plots.

2.3. Research Methodology

2.3.1. Soil analysis

Composite soil samples were collected from surface (0-15 cm) after harvesting of Rice. The soil samples were collected by core sampler of diameter 10 cm and all the samples were weighed. Bulk density was then

calculated from the measurements of the bulk volume using core length and diameter of cutting edge of the sampler. The samples were brought to the laboratory, air dried and crushed to pass through 2.0 mm mesh sieve. The processed samples were subjected to appropriate mechanical and chemical analyses to estimate its physico-chemical status. The results obtained from the mechanical analysis of soil are presented in below table. The detailed description of procedures is given under the following heads.

2.3.2. Physico-chemical properties

2.3.2.1. Mechanical analysis (particle size distribution)

The mechanical analysis of the soil samples was done by following the International Pipette method [8]. One per cent sodium hexametaphosphate salt solution was used for chemical dispersion of soil fractions. Each suspension was mechanically stirred for 10 minutes. Sand (0.2-0.02 mm) was separated by wet sieving, silt (0.02-0.002 mm) and clay (<0.002 mm) were separated by decantation and sedimentation. The International Society of Soil Science textural triangle was used for determining the textural class.

2.3.2.2. Bulk density (gcm^{-3}): Soil bulk density of each site was determined by the core method [9] .

2.3.2.3. Soil reaction (pH) : Soil reaction (pH) was determined in 1:2.5 soil : water suspension with a digital glass electrode pH meter [10].

2.3.2.4. Electrical conductivity (dSm^{-1}): Electrical conductivity (EC) was determined in 1:2.5 soil : water suspension using digital electrical conductivity bridge [11].

2.3.2.5. Cation Exchange Capacity (CEC): Cation exchange capacity (CEC) of soils was determined according to the procedure which involves saturation of the cation exchange sites with barium, equilibration, removal of the excess barium with ethanol, replacement and leaching replacement with ammonium. Other cations such as sodium have been used as the exchanging cation with measurement by atomic absorption spectrophotometer [12].

III.YIELD PARAMETERS

The net area of plot was harvested. The grain and straw yield of each net plot was recorded after thoroughly cleaned and sun dried. The yield from each plot was recorded at about 14% moisture content separately as t ha^{-1} .

IV.STATISTICAL ANALYSIS

Analysis of variance (ANOVA) test was done to see the presence of significant difference among the treatments.

V.RESULTS AND DISCUSSION

5.1. Physico-chemical characteristics of soils under long-term integrated plant nutrient system

5.1.1. Particle size distribution (soil texture): Particle size distribution is a governing factor for assessing nutrient supplying power, aeration and drainage of soils. Many researchers suggested that fineness or coarseness of a soil governs the level and availability of plant nutrients including microelements[13]. The distribution of various soil separates (sand, silt and clay) reveals that the percentage of sand fraction contributes 15.40%, silt fraction contributes 58.50% and clay contributes 26.10%. Our results are in accordance with the available literature [14,15 16].

Mechanical composition

Textural class	Sand (%)	Silt (%)	Clay (%)
Silty clay loam	15.40	58.50	26.10

5.1.2. Bulk density (g cm^{-3}): The bulk density of soil at harvest significantly decreased from 1.30 g cm^{-3} in control to 1.21 g cm^{-3} with application of 50 % NPK + 50 % N (FYM) (Table 1). The highest reduction in bulk density was recorded in treatments T_6 . Application of fertilizers alone or in combination with organics decreased bulk density of soil significantly over control and the extent of reduction was more when organic manures were applied along with chemical fertilizers. Marginal reduction in bulk density in NPK treated plots over control could be ascribed to the increased root biomass production that might have increased organic matter content of the soil [17]. Continuous application of chemical fertilizers along with organics for twenty cropping cycles caused significantly highest decrease in the bulk density of soil may be due to the addition of higher organic matter that resulted in more pore space and good soil aggregation [18,19, 4] .

5.1.3. Soil reaction (pH): It is evident from the results presented in (Table 1), that the soil pH did not differ significantly with nutrient management practices, similar results were reported in a study conducted by various scientists [20, 21].

5.1.4. Electrical conductivity (dSm^{-1}): The soil EC of the soil did not differ significantly with nutrient management practices (Table 1). The results were in conformity with the study conducted by various scientists [20, 22] who found that neither residue nor fertilizer treatments had significant influence on soil EC values.

5.1.5. Cation exchange capacity [cmol (p+) k^{-1}]: The cation exchange capacity (CEC) is a measure of the quantity of adsorption sites on soil surface that can retain positively charged ions by electrostatic forces. An examination of the results in Table 1, reveals that the cation exchange capacity of the soils varied from 8.33 to 13.60 cmol (p+) k^{-1} . The values were significantly higher in INM than inorganic treatments. This might be due to release of cations with the decomposition of organic matter which would have increased the CEC and due to more exchange sites on humus[4,5].

5.2. Straw and grain yield of Rice under long-term integrated plant nutrient system :

Based on the data in the (Table 2), the highest grain and straw yields were obtained in integrated treatment (FYM + NPK) and lowest in control. This showed the superiority of integrated nutrient management over either fertilizers or FYM. Significantly higher yield was obtained in 50% NPK + 50% N (FYM) as compared to chemical fertilizers only. Combined use of organic and inorganic sources of nutrient could be attributed to better synchrony of nutrient availability to the wheat crop, which was reflected in higher grain yield and biomass production and also the higher nutrient use efficiency. The higher wheat yield obtained on FYM + NPK fertilizer-treated plots was possibly caused by other benefits of organic matter such as improvements in microbial activities, better supply of secondary and micronutrients which are not supplied by inorganic fertilizers, and lower losses of nutrients from the soil besides supply of N, P and K [23]. The improved soil physical properties in the FYM-treated plots as observed in the present study might have also contributed to the improvement in crop yields. The present results corroborate the findings of other workers [24,25, 26].

Table 1 : Long-term effect of integrated nutrient management on soil properties

	Treatment (Rice)	Treatment (Rapeseed)	Bulk density (g cm^{-3})	pH (1:2.5)	EC (dSm^{-1})	CEC (cmol (p+) kg^{-1})
T ₁	Control	Control	1.30	6.40	0.45	8.33
T ₂	50% NPK	50% NPK	1.29	6.30	0.47	8.86
T ₃	50% NPK	100% NPK	1.25	6.35	0.46	9.16
T ₄	75% NPK	75% NPK	1.24	6.23	0.46	9.22
T ₅	100% NPK	100% NPK	1.24	6.24	0.54	9.24

T ₆	50% NPK + 50%N (FYM)	100% NPK	1.20	6.72	0.58	13.60
T ₇	50% NPK + 50% N(FYM)	50% NPK	1.22	6.63	0.46	11.90
T ₈	75% NPK + 25%N(FYM)	75% NPK	1.23	6.55	0.47	12.10
T ₉	50% NPK + 50% N (Rice straw)	100% NPK	1.21	6.61	0.51	12.73
T ₁₀	50% NPK + 25% N (Rice straw)	75% NPK	1.21	6.53	0.48	10.02
T ₁₁	Farmers practice	Farmers practice	1.26	6.50	0.49	10.86
C.D (p _{≤0.05})			0.04	NS	NS	0.28

Table 2 : Long-term effect of integrated nutrient management on yield (t ha⁻¹)

Treatment (Rice)	Treatment (Rapeseed)	Yield (t ha ⁻¹)	
		Straw	Grain
T ₁ Control	Control	7.19	4.20
T ₂ 50% NPK	50% NPK	9.11	5.33
T ₃ 50% NPK	100% NPK	8.25	5.48
T ₄ 75% NPK	75% NPK	10.06	6.07

T ₅	100% NPK	100% NPK	9.91	6.34
T ₆	50% NPK + 50%N (FYM)	100% NPK	10.81	6.87
T ₇	50% NPK + 50% N(FYM)	50% NPK	10.61	6.71
T ₈	75% NPK + 25%N(FYM)	75% NPK	9.71	6.37
T ₉	50% NPK + 50% N (Rice straw)	100% NPK	8.68	5.86
T ₁₀	50% NPK + 25% N (Rice straw)	75% NPK	9.05	5.79
T ₁₁	Farmers practice	Farmers practice	9.22	6.05

C.D (p_{≤0.05})			0.20	0.15

VI. SUMMARY AND CONCLUSION

The present investigation entitled, “*Soil Physico-chemical properties and crop yield of Rice-Brown sarson sequence under Long-term Integrated Plant Nutrient System in Temperate Conditions*”, was conducted at Mountain Research Centre for Field Crops Khudwani, SKUAST-Kashmir. Two nutrient management practices viz., inorganic and integrated were laid for the period of seven years from 2008 using randomized block design with three replications with the following main objectives:

1. Effect of continuous application of organics and chemical fertilizers on soil properties
2. Effect of continuous application of organics and chemical fertilizers on crop yield

The important findings are summarized here under :

- The soil bulk density was lower in FYM plots than in control plots especially in the surface creating a good

environment for growth and development of the crop.

- The soil pH and EC did not differ significantly, but CEC differ significantly with respect to integrated nutrient management practices.
- Incorporation of organic and inorganic fertilizers enhanced the contents of micronutrients in plants and obviously, their uptake in plant and grain and straw at harvest in comparison to rest of treatments.
- Application of organic and inorganic sources of fertilizers together brought about significant improvement in grain and straw yields of rice crop.

These results suggest that for successful soil quality management, input of FYM and straw are of major importance. Generally, soil productivity and health may be more sustainable with the integrated application of farmyard manure and inorganic fertilizers than with the use of inorganic fertilizers alone. To manage nutrients and soil fertility, soil test based integrated nutrient management by combining organic with inorganic fertilizer should be followed to increase crop productivity.

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