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Assessment of Physicochemical Properties of Rhizosphere Soil Samples from Basmati and Non-basmati Rice Growing Areas of Jammu Region, Jammu and Kashmir, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In the current study, rhizosphere soil samples were collected from six different locations of rice fields in Jammu, Kathua and Samba districts of Jammu region of UT of Jammu and Kashmir, The soil samples were processed and analysed from their physicochemical characteristics. Soil samples were collected from each sampling site and analysed for Organic Carbon (OC), soil pH, Salinity, Nitrogen, Phosphorus, and Potassium, along with this the micronutrient profiling of the samples was also conducted following the standard protocols. The overall mean results for soil pH level, OC, N,P,

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and K content of the majority of rice fields in the research locations were favourable for rice production; nevertheless, the ideal pH and NPK levels should be evaluated on a regular basis to ensure the best potential rice harvests.

Keywords: Soil samples; physicochemical properties; Rhizosphere; Basmati; Non-Basmati.

1. INTRODUCTION

Analysing the composition of the soil samples derived from agricultural fields has become an important factor and prerequisite, as it directly or indirectly effects the production and development of the crops cultivated in those fields. The proportions of micronutrients and macronutrients in the soil determine the overall productivity of the economic crops. Reason being, these nutrients play pivotal role in development of plant [1,2].

Soil and water along with sunlight being the most crucial resources from the cultivation point of view of crops. Essential and non-essential elements are absorbed from the soil by plants in response to a concentration gradient and selective ion absorption or diffusion. The level of absorption of certain elements varies depending on the plant species [3]. The active uptake of metal ions is significantly assisted by root. The mechanism is primarily triggered by metal ion absorption in the root tissue, with ions of Co, Cu, Fe, Mn, Mo, Ni, and Zn dissociating from their complex forms at the root surface. The metals have collected significantly in the root apoplast and due to the presence of cellulose, pectins, and glycoprote, heavy metals adsorb on the root surface in cationic form with a negative cell wall [2,3]. Nutrient management based on soil tests has emerged as a crucial concern in efforts to boost agricultural output. Agriculture has evolved in recent years from conventional and traditional farming methods to more intensive operations involving chemical fertilizers and pesticides, as well as irrigation facilities. Prolonged use of chemical fertilizers gradually altered soil qualities, reducing production in the long run and chemicals have leached into surface and ground water as a result on the other hand. Monoculture cropping patterns have exacerbated the deterioration of water and soil quality as a result of rising demand for cash crops [4].

The main objective of the study was to assess the present condition of soil in context to its physicochemical properties like, available Nitrogen (N), Phosphorous (P), Potassium (K), Magnesium (Mg), Organic Carbon (OC), pH, Salinity, Electrical Conductivity (EC) and to assess the concentration of micronutrients and heavy metals in the rhizosphere of the soil samples collected from the fields of basmati and non-basmati rice varieties of RS Pura, Samba and Kathua regions of Jammu, Jammu and Kashmir. These regions are top amongst the basmati rice growing belts /areas of the Union territory of Jammu and Kashmir. Thus, the information generated after conducting this study would help the farmers to know about the condition of the soil in context to the quality of soil and nutrients present in the soil and furthermore design strategies for incorporation of adequate fertilizers to enhance the productivity and development of the crops.

2. MATERIALS AND METHODS

2.1 Sample Collection

The rhizosphere soil samples were collected from the fields of two rice varieties such as Basmati 370 (basmati variety) and SJR-5 (non-basmati rice variety) at flowering stage of the crop. The sampling was done from three regions *viz.,* Jammu, kathua and samba districts of Jammu region, Jammu and Kashmir, India, following the random sampling method. The soils of these three areas are classified as alluvial soils. Composite rhizosphere samples were collected from five randomly selected plants distanced at least 5 meters in each field. The Composite rhizosphere samples were collected from five randomly selected plants distanced at least 5 meters in each field. For rhizosphere samples, rice plant was gently and cautiously uprooted and the complete root systems of five plants per plot were collected after removing loosely adhering soil and transported to the laboratory and stored at 4^{o}C. In total 6 composite samples [1] composite sample (5 soil samples from each field mixed in equal proportions) × six locations × triplicates] were processed in triplicate in the laboratory. Further, the soil was sieved through a 2 mm sieve in order to remove any debris, pebbles or plastics stick to the soil so that they do not interfere during the further experiments. The details related to the areas of sample collection during the study are given in Table1.

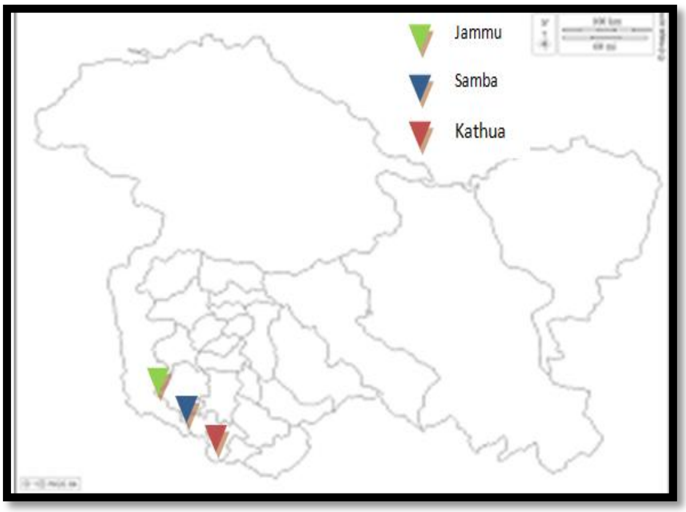

Fig. 1. Sample collection sites (Source: Google)

Table 1. Areas of sampling collection during the study

Region	Sample code	Variety	GPS	Study site	District
RS Pura, J&K	JMU1	Basmati 370	N 32°39'15.4", E 74°42'42.4"	Badyal Brahmana, Ranbir Singh Pura	Jammu
	JMU2	SJR-5	N 32°39'12.9", E 74°42'41.9"	Badyal Brahmana, Ranbir Singh Pura	Jammu
Samba, J&K	SMB1	Basmati 370	N 32°34'03.4", E 74°59'57.0"	Channi Kartholi, Samba	Samba
	SMB2	SJR-5	N 32°34'04.0", E 74°59'55.3"	Channi Kartholi, Samba	Samba
Kathua, J&K	KTU1	Basmati 370	N 32°22'46.7", E 75°59'57.0"	Krishi Vigyan Kendra, Pratap Nagar	Kathua
	KTU2	SJR-5	N 32°22'47.2", E 75°30'44.1"	Krishi Vigyan Kendra, Pratap Nagar	Kathua

2.2 Physicochemical Analysis

Physicochemical analysis of the soil sample done using standard protocols mentioned in APHA 23rd Edition and standard protocols including kjeldahl method for determining the nitrogen content in soil samples, colorimetric assay [5] for phosphorous estimation (0.5M $NaHCO_3$ (pH 8.5)- Dissolve 42g of $NaHCO_3$ in 500ml of distilled water and makeup the volume to 1 lit. The pH was adjusted to 8.5 using 20% NaOH Solution) and potassium content determination by flame photometric method [6,7]. Prior to the analysis soil samples were air dried and pulverized and sieved through a 2 mm sieve to ensure homogeneity. soil samples were processed by sieving them through 2 mm sieve in order to pebbles, stones and unwanted materials which could interfere with the analysis procedures and were stored in clean, sealed polythene bags for further analysis. Standard methods were used to determine micronutrients such as Cu, Zn, Fe, and Mn using an Atomic Absorption Spectrophotometer [8]. Iron, manganese, zinc, copper, boron, chlorine, and molybdenum are all micronutrients. The word relates to a plant's requirements rather than its abundance in the soil. They're only needed in trace levels, yet they're critical for plant health since they help plants speed up their metabolisms.

3. RESULT AND DISCUSSION

3.1 Physicochemical Attributes

Physicochemical characteristics and the results obtained for the same are summarized in the table below (Table 2).

Table 2. Physicochemical attributes of the soil samples under study

Sample code	OC(%)	Salinity/ Electrical Conductivity (EC) (mmhos/cm)	pH	Nitrogen (mg/kg)	Phosphorous (mg/kg)	Potassium (mg/kg)	Magnesium (mg/kg)
JMU1	0.60	0.18	8.52	156.64	22.53	132.31	117.50
JMU2	0.54	0.21	8.70	140.60	31.10	178.20	119.70
SMB1	0.48	0.14	8.30	145.60	19.90	138.80	138.40
SMB2	0.39	0.16	8.44	142.38	27.50	106.90	126.01
KTU1	0.56	1.00	8.68	158.70	29.80	118.97	144.04
KTU2	0.44	0.34	8.88	148.00	26.13	120.45	106.90
Standard Deviation	0.08	0.33	0.21	7.47	4.29	24.95	13.81
Standard Error	0.01	0.06	0.03	1.24	0.71	4.16	2.30

3.2 Organic Content (OC)

Organic matter is an important constituent of the soil that helps to maintain soil fertility. The foundation of soil fertility is organic carbon in the soil. It releases nutrients that help plants flourish. Increasing the amount of organic carbon in the soil enhances the health and fertility of the soil [9]. The organic carbon content in the samples under study ranges from 0.39 - 0.6% that shows medium to on an average sufficient organic content in the respective samples.

3.3 Salinity/ Electrical Conductivity (EC)

The Electric Conductivity (EC) of the soil sample provides an idea about the amount of salts present in the sample. Salinity up to 1 is average whereas the increased values of more than 1 or 2 mmhos/cm are harmful for the crop in context to its germination and development [4]. The salinity of the 6 soil samples ranges from 0.14 – 1.00 mmhos/ cm, which is favourable for the rice production.

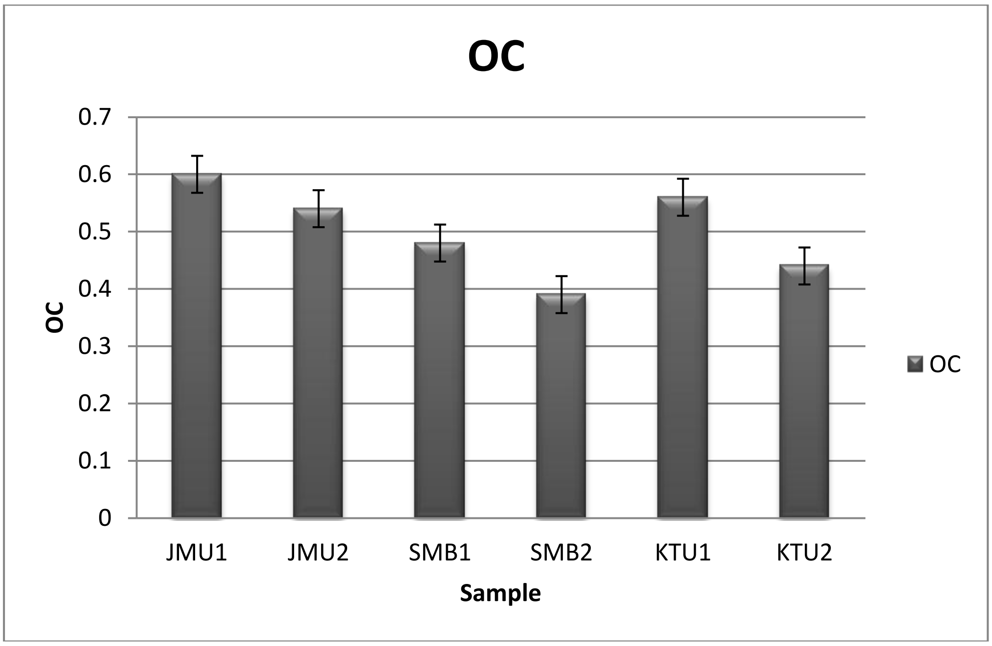

Fig. 2. Organic Content of soil samples

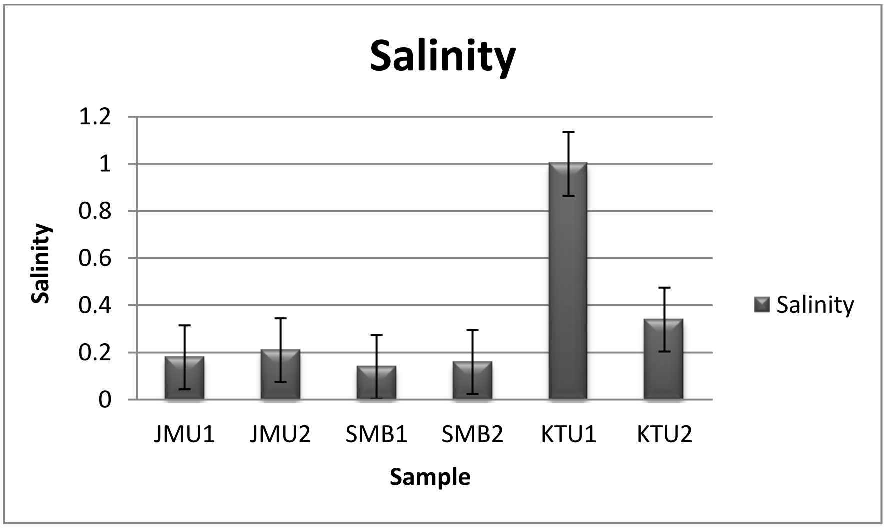

Fig. 3. Salinity of soil samples

3.4 pH

The relative concentration of hydrogen ions in a solution is measured by pH. The pH values of the soil sample were determined in 1:2.5 soil: water ratio (w/v) with the help of digital pH meter [10]. The pH values for the soil samples ranges from 8.30 to 8.89. The soil pH values depict alkaline nature of the soil. Among the samples, the sample number 6 shows the highest alkalinity.

3.5 Nitrogen

Nitrogen is an essential nutrient for the rice plant growth and development. It increases the plant height and the number of tillers per plant. It also aids in synthesis of the enzymes, nucleic acids, various hormones, vitamins and alkaloids [1,3]. The nitrogen concentration in the 6 soil samples ranges from 140.60 - 158.70 mg/kg. From the results obtained it is evident that the soil samples show medium to higher availability of the nitrogen.

3.6 Phosphorous

An essential component of the nucleic acids, phosphorous plays crucial role in energy distribution and protein metabolism. It also is a component of sugar phosphates, phospholipids and co-enzymes [1,3]. The value of phosphorous in the six soil samples under study ranges from 19.90 - 31.10 mg/kg.

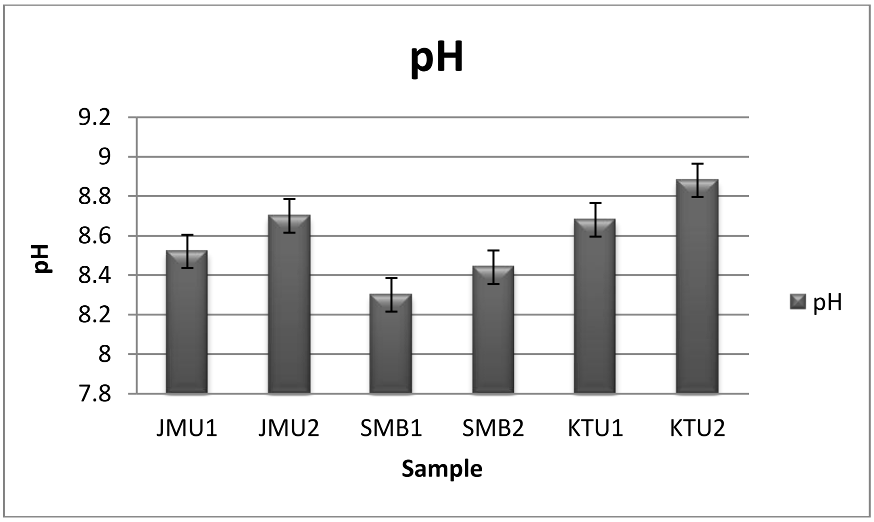

Fig . 4. pH of soil samples

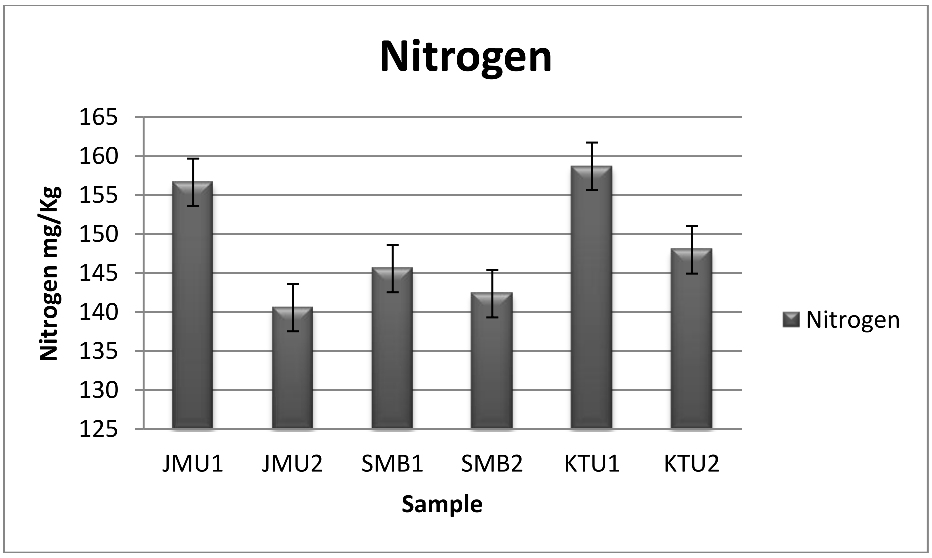

Fig. 5. Nitrogen content of soil samples

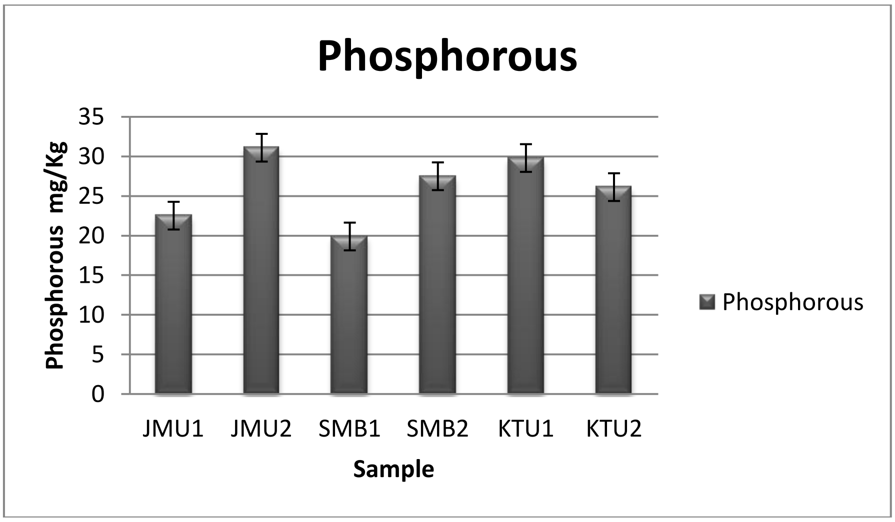

Fig. 6. Phosphorous content of soil samples

3.7 Potassium

Potassium plays important role in the development of roots, improving plant vigor, enhancing cell division and optimizing osmotic pull. It also provides resistance to pests and diseases. Deficiency of potassium in rice leads to loss of overall yield and decreased rice grain weight and size [1,3]. In the 6 samples under study the potassium content ranges from 106.90 - 178.20 mg/kg .Majority of the samples show low to medium levels of potassium.

3.8 Magnesium

Magnesium is an essential component of ribosomes. This is the most important and central part of the chlorophyll. Some enzymes involved in the phosphate transfer reactions require magnesium [1,3]. The magnesium concentrations in the six soil samples range from 106.90 - 144.04 mg/kg.

3.9 Micronutrient Profiling

Proportionally low quantity of a nutrient necessary for plant growth is referred to as a micronutrient. It participates in metabolic processes, enzymatic processes, and catalysts, among other things. As a result, all of these factors contribute to plant growth and development, both directly and indirectly. Micronutrients such as boron (B), zinc (Zn), manganese (Mn), iron (Fe), copper (Cu), molybdenum (Mo), chlorine (Cl), and silicon (Si). are vital plant nutrients [1,2,3]. They make up less than 1% of the dry weight of the majority of plants but their presence aids the plant's growth and development. They're also known as minor or trace elements. Accumulation of arscenic and other heavy metals like lead and cadmium etc could be a matter of concern from the environmental and human health perspective. Micronutrient profiles and observed values of the micronutrients and trace elements (mg/kg) in the six soil samples under study are provided in the table below (Table 3).

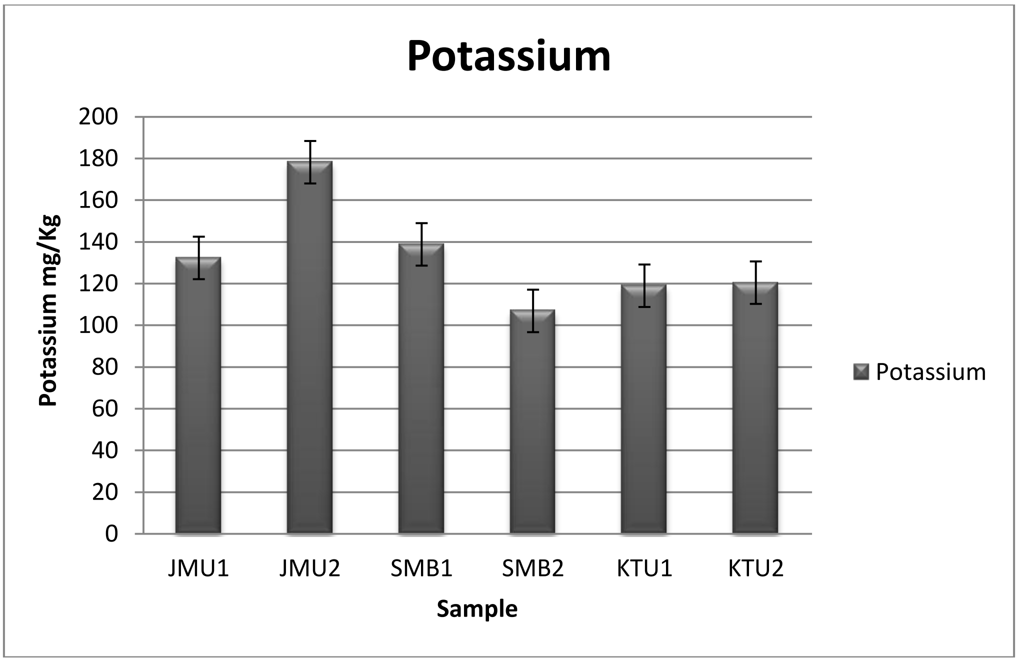

Fig. 7. Potassium content of soil samples

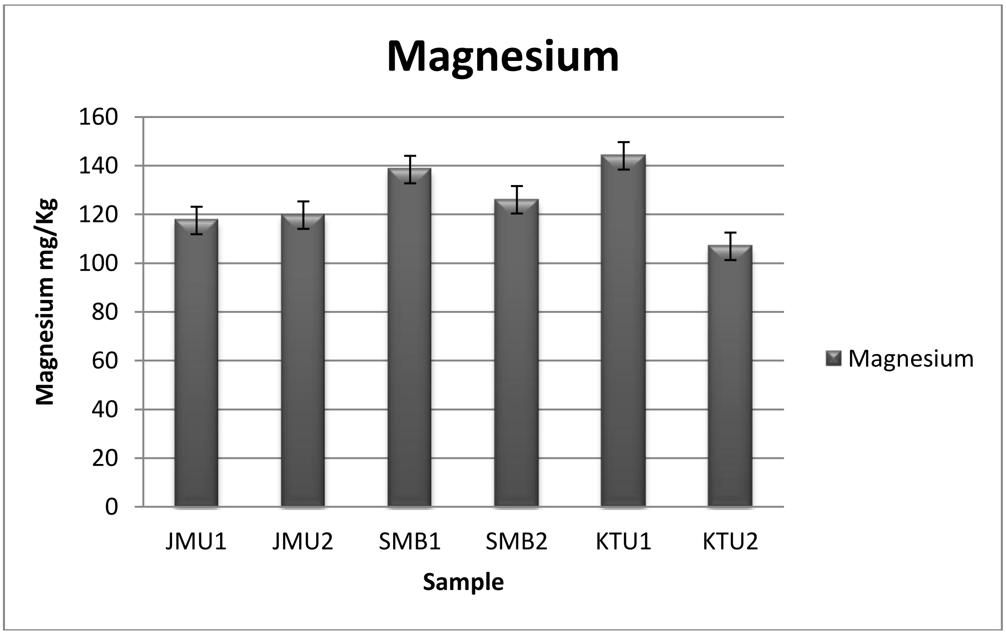

Fig. 8. Magnesium content of soil samples

Table 3. Micronutrient profiling of the soil samples

Sample Code	Aluminium (mg/Kg)	Arsenic (mg/Kg)	Cadmium (mg/Kg)	Chromium (mg/Kg)	Copper (mg/Kg)	Iron (mg/Kg)	Mercury (mg/Kg)	Nickel (mg/Kg)	Lead (mg/Kg)	Selenium (mg/Kg)
JMU1	0.64	0.50	0.18	0.015	19.29	106.83	0.10	4.73	0.04	0.12
JMU2	0.53	0.49	0.42	0.020	14.27	90.62	0.07	4.10	0.03	0.23
SMB1	0.32	0.08	0.28	0.018	11.72	50.20	0.00	3.87	0.04	0.15
SMB2	0.45	0.08	0.43	0.015	4.06	55.58	0.02	2.31	0.04	0.17
KTU1	0.65	0.13	0.34	0.011	14.60	101.61	0.01	3.57	0.07	0.33
KTU2	0.37	0.13	0.18	0.017	6.04	48.17	0.00	3.34	0.04	0.08
Standard Deviation	0.50	0.20	0.11	0.003	5.71	54.63	0.04	0.81	0.012	0.09
Standard Error	0.08	0.03	0.02	0.0005	0.95	9.11	0.01	0.14	0.002	0.01

Rice photosynthesis relies heavily on iron (Fe) and because of its shortage, it may obstruct K absorption. Because of their immobile character, the youngest rice leaves display the first signs of insufficiency. The onset of Fe deficiency in growing plants is marked by interveinal yellowing and chlorosis. The micronutrient copper is involved in the regulation of enzyme activity and the acceleration of oxidative reactions in nitrogen, Proteins, hormone exchange, respiration as well as photosynthesis. Boron is involved in the precipitation of excess cations, buffering, regulating other nutritional elements, and the formation of new cells in meristematic tissue, among other things. Boron deficiency also leads crops to grow shorter during the panicle development stage. It greatly affects the panicle development. Since boron is a less mobile nutrient the deficiency symptom is much pronounced in the emerging leaves having white and rolled tips. Boron is preferably incorporated into the soil (1 - 2 kg/ha) rather than foliar sprays.

The micronutrient profile of the soil samples under study show lower concentration of the major nutrients like N, P, K in comparison with the soils of Punjab Bhatti *et al.,[*11]. Heavy metal levels in the soils examined were below the different maximum permissible limits.This could be attributed to metals leaching into lower soil layers as a result of the sandy nature of the soil and precipitation during the kharif season.

4. CONCLUSION

The findings of this study reveal the values or percentages of physicochemical parameters. Soil physicochemistry is important to agricultural chemists for plant growth and soil management. The pH of the soils in the study area was normal, according to the classification criteria [12,4].The majority of soil samples recorded a low status of available phosphorous, and all soil samples recorded a high status of available phosphorous. The driven nutrient status information can be an efficient tool for farmers and policymakers in adopting site-specific nutrient management practises. Rice growth, development, and production are all dependent on nutrient availability in the soil. Understanding the role of each nutrient in the plant can aid in determining specific nutrient that cause deficiency or toxicity symptoms. Rice's nutrient deficiency symptoms all through the growth period serve as a significant diagnostic tool for nutrient management planning. Further farmers can benefit from an integrated nutrient management approach in the form of increased productivity and profitability. The average overall results for soil pH level, OC, N, P, and K composition of the most of rice fields in the Jammu region were favourable for lowland rice cultivation; however, the ideal pH and NPK levels should be checked on a regular basis according to the recommendations given to ensure the best possible rice harvests.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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