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SOIL ANALYSIS AND CHARACTERIZATION OF JHELUM DISTRICT: A COMPARATIVE STUDY

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Abstract

A comprehensive soil analysis project was carried out at the Soil & Water Testing Laboratory in Jhelum, focusing on 4658 soil samples collected from various tehsils in the district during 2020-22. The study adhered to SFRI guidelines and involved soil sampling from different depths (0-15 cm and 15-30 cm) to assess soil fertility. The soil analysis encompassed multiple key parameters, including Soil Electrical Conductivity (ECe), pH levels, Soil texture, Soil Organic Matter (SOM), Available Phosphorus, Extractable Potassium and saturation percentage. All samples were meticulously handled in accordance with the Soil Fertility Research Institute (SFRI) guide of the Directorate of Soil Fertility Research Institute, Punjab, Lahore. The findings revealed that the majority of soils in the region, like much of Pakistan, suffer from nutrient deficiency. This deficiency can be attributed to a lack of awareness regarding the proper application of soil nutrients, following the 4R formula - Right Nutrient, Right Quantity, Right Time and Right Method. Soil-based information offers a valuable resource for farmers, enabling them to enhance their agricultural practices and increase soil productivity. Our analysis indicated that 89.76 percent of the soil samples had pH levels within the range of 7.5-8.5while 56.441 percent of the samples were within acceptable salinity and sodicity levels (EC < 4 dS/m. Furthermore, 76.363 percent of the samples exhibited a medium texture. However, the soil samples were notably deficient in organic matter (88.493% had less than 0.86% OM) and available phosphorus (99.012% had less than 7 mg P/kg soil). While, more than 99% soils were under the satisfactory range of K(80-180 mg/Kg). Based on these soil analysis, farmers were guided about balanced fertilizer application tailored to specific crops, soil conditions, and water/rainfall patterns, with the aim of enhancing crop yields while taking guidelines from KHAD HISAB APP developed by Soil Fertility Research Institute, Punjab, Lahore.

Key words: *Jhelum, pH, Soil analysis, Soil fertility, Texture*

INTRODUCTION

Soil analysis is a key factor in agriculture to investigate soil attributes. Soil Analysis helps the agricultural experts to formulate site specific fertilizer application in a field. The Department of Agriculture (Research) Punjab developed an application KHAD HISAB APP with the technical guidance of Soil fertility Research Institute, Punjab, Lahore to suggest site specific fertilizer recommendation for different crops on kilogram basis. The said application is user friendly & has a variety of options for fertilizer selection. Jhelum District, situated in the Punjab province of Pakistan, is marked by its historical prominence and

administrative centrality within the region. The district's nucleus is the City of Jhelum, renowned for its historical heritage and it functions as the economic and administrative epicenter of the district. Located in the northeastern sector of Punjab, Jhelum encapsulates a myriad of compelling facets. Here are elucidated key attributes of Jhelum District. The region boasts a deeply ingrained historical legacy, having played a pivotal role during ancient and medieval epochs. It witnessed the ascendancy and decline of various rulers and empires, including the Maurya, Gupta, and Mughal dynasties. Geographically, it lies between latitudes 32.10 and 33.15 north and longitudes 71 and 74 east. The district shares borders with Gujrat to the east, Chakwal and Sargodha to the south, Rawalpindi and Attock to the southwest, and District Mirpur, Azad-Jammu Kashmir, to the north (1).

The Jhelum District, situated in a semi-arid to sub-humid region, encompasses four tehsils: Jhelum, P.D. Khan, Dina, and Sohawa comprising of 883310 acre geographical area out of which only acre is 320663 acre is cultivated (2).

The soil within the district primarily exhibits sandy loam to loam texture. The main sources of irrigation are wells and tube wells, covering approximately 0.28 lakh acres of cultivated land. Hilly terrains are also present in the district. The precise population of Jhelum is as per the latest census of 2023 is about 1382308 (3). According to Department of Agriculture (Extension), the district experiences an annual rainfall of approximately 628mm, with the highest recorded rainfall during the same period, followed by other months. The predominant crops in the region include wheat, maize, sorghum, and rice, while farmers are increasingly exploring new crops such as garlic, grapes, and strawberries. Unfortunately, many farmers in the area remain unaware of the significance of soil analysis in maximizing their agricultural profitability. This study aims to bridge that knowledge gap by providing insights into soil characteristics, which can assist farmers in optimizing their agricultural practices.

METHODOLOGY

This study was conducted at the Soil and Water Testing Laboratory in Jhelum, Pakistan, over the course of 2020-2022 with the aim of deriving stimulus for the farmers of the area having 4R formula (4, 5). It involved the analysis of 4658 soil samples collected from two depths of 0-15 and 16-30 cm from all tehsils in the Jhelum district, with 901 samples from Jhelum, 1164 from Sohawa, 2192 from Pind Dadan Khan (P. D. Khan) and 401 samples from Dina. The soil samples were collected from 2 depths only as the concerned farmers grew only wheat, maize and some other fodders in their fields. Samples were placed in polyethylene bags and then in cloth bags labeled with lead water proof ink. One small label was also placed inside the bag and same number was written on the bag. Soil samples were brought to the laboratory and dried in plastic trays under shade and where fumes were not present. Higher temperature was avoided as reversible changes might take place. During drying, the plastic trays were also numbered. After drying, the air-dried samples were ground with a wooden pestle and mortar so that the soil aggregate could be crushed. After grinding, Air dried soil were screened through a sieve of 2mm mesh opening for general purpose and 100 mesh (0.45mm.After sieving, soil samples were transferred into wide mouthed screw topped, numbered plastic bottles/jars.

The soil samples were analyzed for all parameters observing the procedures as prescribed in SFRI Guide. The soil samples were analyzed for several key parameters, including soil reaction (pH 1:10), electrical conductivity (EC 1:10), soil texture, soil organic matter, plant-available phosphorus (Olsen-P), Extractable K & Soil Texture. All analytical procedures were performed in accordance the SOPs of Soil Fertility Research Institute, Punjab, Lahore (6).

Table I. Soil Textural Classification based on Saturation Percentage Source. *Source: Malik *et al.,* 1954 (7)

Saturation (%)	Textural Class
Up to 19	Sand
20-30	Sandy Loam
31-45	Loam
46-60	Clay Loam
More than 60	Clay

Table II. Classification of salt affected soils

Parameters	Saline Soil	Non-Saline/Sodic Soil	Alkali/Aline- Sodic Soil
Soil ECe	≥4mS/cm	<4mS/cm	>4mS/cm
Soil pHs	<8.5	≥8.5	≥8.5
ESP	<15	≥15	≥15
SAR	<13	≥13	≥13

*Source: Malik *et al.,* 1954 (7)

Table III. Soil classification for fertility status

Soil quality Parameter	Category		
	Poor	Medium	Adequate
Soil Organic Matter (%)	<0.86	0.87-1.29	>1.29
Available Phosphorus (mg P/Kg)	<7	7-14	>14
Available Potassium (mg P/Kg)	<80	80-180	>180

*Source: Malik *et al.,* 1954 (7)

RESULTS AND DISCUSSION

SOIL TEXTURE

Soil texture was determinend on the basis of saturation percentage.It is a well known fact that understanding soil texture is essential for effective agriculture and land management. Different soil textures, such as sandy, loamy, or clayey soils, exhibit varying water-holding capacities and nutrient retention abilities. Farmers and land managers use this information to implement suitable practices for irrigation, fertilization, and overall soil health maintenance (7).

The results indicated that 16.939 percent of soils in the Jhelum district exhibited a sandy loam texture(Light Textured), while 73.363 percent had a loam texture(Medium Textured). Clay loam, a heavier textured soil, was observed in a limited number of sites (6.698 percent). Notably, in Tehsil Jhelum, 42.43 percent of soils were sandy loam, with 57.16 percent being loam. In TehilsSohawa and Dina, 80.24 percent and 64.09 percent of soils, respectively, exhibited a loam texture. In P.D. KHAN, 1.41 percent of soils were sandy loam, and 84.4 percent were loam. These findings highlight the heterogeneous and variable nature of soils in the region (8).

DISSOLVED SALTS (ELECTRICAL CONDUCTIVITY)

Electrical Conductivity (EC) is the measure of the ability of a solution to conduct an electric current which is proportionate to the concentration of soluble salts in the sample at any particular temperature. The EC is measured in the field or in the laboratory using a conductivity meter, which is basically a Wheatstone bridge that measures the resistance of the solution between two parallel platinum electrodes. It is normally measured by extracting the soil sample with water (1:5or 1:10 soil: water ratio, w/v) or in an extract saturated paste

Dissolved salts in soils can interfere with the normal nutrient uptake process due to ion imbalances, antagonistic effects, and osmotic effects. For this study, electrical conductivity of soil extract (ECe) was used to measure total dissolved salts, while a soil-water suspension of EC1:10 was used to assess soil salinity and sodicity for advisory purposes. The data revealed that 63.504 percent of the soil samples in the Jhelum district were free from salinity/sodicity issues. Sodic characteristics were not found in the area. The lowest EC value (0.06dS/m) was observed in Tehsil Sohawa, while the highest value (13.85 dS/m) was recorded in Tehsil Dina during the study period. Due to favorable drainage conditions, the low electrical conductivity (EC) may be attributed to the efficient removal of released bases through percolation. This observation aligns with findings reported by Rathi *et al.,* 2018 and Singaravel *et al.,* 2000 (9, 10). Elevated EC levels were also found in Jhelum (7.91dS/m) and Pind Dadan Khan (4.01dS/m).

SOIL REACTION (pH)

"Soil pH is often regarded as the 'master variable' in soil chemistry, given its profound influence on numerous chemical reactions involving essential plant nutrients" (11). In a related paper by Barrow and

Hartemink 2023 (12), a conceptual soil pH-nutrient availability diagram was discussed, aiming to illustrate how the pH level affects the availability of both major and minor nutrients in the soil. Understanding this relationship is crucial for optimizing nutrient availability to plants and, consequently, influencing overall soil fertility and plant health (13).

Table IV. Oil chemical characteristics of district Jhelum (2020-2022)

		Parameters															
		Ec		pH			Organic Matter			Available Phosphorus			Available Potash				Texture	
Tehsil	soil Samples Analyzed	Saline	Non Saline	<7.5	7.5 - 8.5	> 8.5	Poor (<0.86)	Satisfactory (0.86-1.29)	Adequate (>1.29)	Poor (<7ppm)	Satisfactory (7ppm-14ppm)	Adequate (>14ppm)	Poor (<80ppm)	Satisfactory (80ppm-180ppm)	Adequate (>180ppm)	Light	Medium	Heavy
Jhelum	901	14	887	119	771	11	881	20	0	898	3	0	4	897	0	385	515	1
Sohawa	1164	16	1148	60	1102	2	1057	78	29	1133	29	2	6	1157	1	230	934	0
Pind Dadan Khan	2192	1651	541	156	2008	28	1806	384	2	2191	1	0	6	2166	20	31	1851	310
Dina	401	19	382	96	300	5	378	23	0	390	11	0	1	399	1	143	257	1
Total	4658	1700	2958	431	4181	46	4122	505	31	4612	44	2	17	4619	22	789	3557	312
%		36.49	63.50	9.253	89.760	0.988	88.493	10.84	0.666	99.012	0.945	0.043	0.365	99.16	0.472	16.93	76.363	6.698

This measurement is crucial for identifying the chemical nature of the soil, as it reflects the concentration of hydrogen ions in the soil and provides insights into its acidic or alkaline characteristics (14). Understanding soil pH is fundamental in agriculture and environmental science, as it influences nutrient availability, microbial activity, and overall soil health. Different plants thrive in specific pH ranges, making it essential for farmers and researchers to monitor and manage soil pH to optimize crop growth and sustainability. (15)Soil pH in this study was measured with a pH meter. pH meter was standardized before taking the reading of a sample with buffer solutions of ph 4, pH 7 & ph 10The analysis revealed that 9.253 percent of soils in the district had pH levels below 7.5, which are considered ideal for high-value crops, fruits, and vegetables. The majority of soils (89.76 percent) had pH levels ranging from 7.5 to 8.5, which are also suitable for agriculture. However, soils with a pH above 8.5 require special attention and potential amendments (such as acid or gypsum application) for reclamation. Fortunately, such soils were rare in the district (0.988 percent).While soils in all tehsils exhibited pH levels above 8.5, their prevalence was quite low. The alkaline nature of the soils is primarily due to the indigenous parent material, calcareousness, and low organic matter content, which is a common characteristic of soils in the region.

ORGANIC MATTER

Walkley Black method was used to determine soil organic matter level in soil samples. The decrease in soil organic matter percentage with increasing soil depth can be attributed to the greater addition of plant residues and farmyard manure (FYM) to the surface soil compared to the sub-surface soil.(16) This phenomenon is likely a result of agricultural practices and organic matter inputs being concentrated near the surface. Similar findings have been reported by Gautam *et al.,* 2018 (17), indicating a consistency in the observation that organic carbon content tends to decrease with depth, influenced by the distribution of organic inputs within the soil profile (18) concluded the same results.

`The data indicated that 88.493 percent of soils in the Jhelum district were deficient in organic matter, while only 0.666 percent had satisfactory organic matter content. Tehsil Jhelumhad the highest deficiency, with 97.78 percent of soils lacking adequate organic matter. In contrast, Tehsil P.D.Khan exhibited the highest proportion of soils with satisfactory organic matter levels (17.51 percent). Organic matter content ranged from traces in some soils of Tehsils P.D.Khan and Sohawa to a maximum of 1.67 percent & 1.93 percent respectively. The low organic matter levels in these tehsils can be attributed to high summer temperatures, which accelerate decomposition, as well as the practice of removing crops entirely (including grain and straw) from the soil without green manure. Additionally, green manuring is not a common practice in the region.

PLANT AVAILABLE PHOSPHORUS

The sodium bicarbonate (NaHCO3) procedure of Olsen *et al.,* 1954 is generally accepted as a suitable index of P "availability" for alkaline soils, where the solubility of calcium phosphate is increased because of the precipitation of Ca as CaCO3.Spectrophotometer is used to determine Phosphorus level in soil.The analysis of plant available phosphorus revealed that 99.012 percent of soils in the Jhelum district were deficient in this essential nutrient. This deficiency was consistent across all tehsils, with only traces of plant available phosphorus found in some soils of Tehsil P.D. Khan. The highest recorded value of plant available phosphorus (18.5 mg P/kg) was observed in Tehsil Sohawa.In a recent study by Obaid *et al.,* 2021 (19) also claimed the same results for Gujar Khan area. The poor availability of plant phosphorus can be attributed to farmers not adhering to recommended phosphatic fertilizer applications, primarily due to the higher cost of phosphatic fertilizers compared to nitrogenous fertilizers. The N:P ratio in current agronomic practices is considerably skewed, with nitrogen dominating. These findings align with the observations of previous researchers who noted the deficiency of available phosphorus in soils in this region.

SOIL EXTRACTABLE AVAILABLE K

Extractable potassium (K) represents the combined amount of water-soluble and exchangeable K in soil. The process involves using a 1 N neutral ammonium acetate solution to displace cations from the soil exchange complex. This K is considered accessible to plants and is typically quantified using a flame photometer.

The soil analysis data revealed that more than 99 percent soils of Jhelum falls under satisfactory range in case of available K. But this portion is not actually available to plants might be due to the following possible reasons. e.g;

The available, soluble and exchangeable, K fractions have been reduced in Pakistani soils due to cultivation of high yielding crop varieties and no inputs of K fertilizers. With high crop demands for K, there is also plausibility of its depletion from these soil fractions. Based on average production of crops, Pakistani soils are removing 100–150 K2O kg ha^{-1} per year. The data provided by soil fertility research institute also revealed obvious decrease in available K under different cropping systems (20). Therefore, severe deficiency of K is expected in coming years with more depletion if K use in fertilization practices is neglected and even soil fertility may be at alarming risk of sustainability.

CONCLUSION

The soil analysis and characterization of Jhelum district provide valuable insights into the soil's physical and chemical properties. Understanding soil characteristics is crucial for farmers to make informed decisions and optimize their agricultural practices. The results indicate that both districts face similar challenges, including nutrient deficiencies, low organic matter content, and poor availability of plant phosphorus. Addressing these issues through proper soil testing and balanced fertilizer application can significantly enhance crop yields and support sustainable agriculture in the region.

Recommendations:

Increasing Organic Matter: Soil organic matter and fertility status can be enhanced through green manuring practices, such as the cultivation of crops like sesbania and guar once every three years. This can help conserve moisture for rabi crops like wheat and canola.

Balanced Fertilizer Application: Inorganic fertilizers (NPK) should be applied in a balanced form based on soil test values. Band placement can improve the efficiency of fertilizer use for row-sown crops.

Crop-Specific Fertilizer Recommendations: Fertilizer recommendations for different crops in the Attock district are as follows:

Wheat: The recommended fertilizer rates differ based on the mode of irrigation, soil fertility, rainfall& type of fertilizer. KhadHisab App is the best tool to develop one own fertilizer combination keeping in view capital and available fertilizer sources.

Other crops, including chickpea, lentil, mung, mash, maize, groundnut, millet, sorghum, raya, potato, onion, tomato, peas, and more, should receive nutrient recommendations based on their specific soil conditions and crop types.

Fertilizer Application for Citrus and Peach Orchards: Fertilizer recommendations for citrus and peach orchards should be tailored to the age of the plant. The recommended rates for FYM, N, P, K, Zn, and Fe should be followed as per the guidelines.

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Conflict of interest:

Authors have no conflict of interest.

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