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Soil Quality Assessment of Different Villages of Malpura Block in Tonk District of Rajasthan, 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

A study was conducted in the Malpura block of Tonk district, Rajasthan, during 2021-2022 to assess the soil fertility status. To ascertain 60 soil samples were collected from 6 different villages Lawa (V1), Borkhandi (V2), Kadila (V3), Jankipura (V4), Diggi (V5), and Nukkad (V6), at a depth of 0-15 cm. Collected soil samples were examined for various physico-chemical parameters which includes BD, PD, WHC, Porosity, pH, EC, OC, also macro nutrient like N, P, K, Ca, Mg, and S by using standard analytical methods. Results showed that the soil was neutral to alkaline in pH (6.8 to 8.8), low in organic carbon (0.2 to 0.88%) and available sulfur (6.92 to 19.08 mg kg-1). The

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nitrogen content in the soil, ranging from 143.2 to 356.84 kg ha-1, was deemed insufficient. On the other hand, the levels of calcium and manganese were identified as ranging from medium to high in the soil sample.

Keywords: Soil fertility; organic matter; available nutrients; physico-chemical properties etc.

1. INTRODUCTION

Soil plays a crucial role in determining the sustainable productivity of agro-ecosystems by supplying essential nutrients to growing plants. The uptake of macronutrients by plants is influenced by various factors, including interactions between major nutrients, as noted by [1]. However, soil degradation is becoming increasingly prevalent due to both natural processes and human activities, adversely impacting productivity. With the continuous growth of the human population, there is a greater demand on soil to provide essential nutrients for food and fiber production. Unfortunately, the soil's inherent ability to supply these nutrients has diminished, largely due to increased plant productivity associated with rising food demand [2,3]. Consequently, a significant challenge today is the development and implementation of soil, crop and nutrient management technologies that improve plant productivity while maintaining the quality of soil, water and air. Assessing soil fertility involves measuring available plant nutrients and estimating the soil's capacity to sustain a continuous supply of nutrients for crops [4]. Nutrient availability is influenced by factors such as soil type, irrigation methods, pH levels, and organic matter content. [5], the degradation of soil quality concerning productivity or fertility encompasses physical, chemical, and biological processes. Understanding and addressing these degradation processes are essential prerequisites for implementing appropriate conservation activities to monitor and safeguard our natural resource base [6,7,8].

In Rajasthan, the soil types typically consist of sandy, saline, alkaline, and calcareous soils, which were traditionally referred to as clay, loamy and black lava soils [9]. The groundwater level in the region is notably low due to the average annual rainfall of around 360 mm, resulting in groundwater being accessible at depths ranging from 100 to 61 meters. Rajasthan is segmented into three agro-climatic zones: Zone VI, covering the Trans-Gangetic Plains region; Zone VIII, encompassing the Central Plateau and Hills region; and Zone XIV, representing the Western Dry region. The soil in Rajasthan falls under various classifications according to the USDA Land Division program, including Aridisols, Alfisols, Entisol, Inceptisols, and Vertisol. There has been limited research conducted on the fertility status of soils in the Malpura block within the Tonk district region, and there have been observed variations in nutrient availability. The soils in the Malpura block generally exhibit a neutral to alkaline pH, low levels of soil organic carbon (SOC), and available nitrogen (N), while phosphorus (P) levels are medium and potassium (K) levels are high. Additionally, sulfur (S) deficiency has been identified in the village soils [10]. While these findings provide valuable insights into the fertility level of the block, obtaining a comprehensive understanding of soil fertility across the region/block requires evaluating a significant number of samples from various locations. This approach is essential for effective planning and implementation of policies related to nutrient and fertilizer management in the area. In response to this need, a considerable number of soil samples were collected from the Malpura region for this research, and the soil fertility status was assessed for both macro and micronutrients. Moreover, the research aimed to illustrate and describe the variability in soil fertility status at the block level. Efforts were also made to establish correlations between soil nutrient content and key soil parameters. The current research aimed to assess the macro nutrient levels in the soils of Malpura and explore any correlations with other soil properties. This investigation provided valuable insights into identifying deficiencies in various elements and determining appropriate fertilizer use based on their status. The study covered an analysis of macro nutrient status and its relationship with physicochemical properties in the soils of Malpura Block, Tonk District, Rajasthan.

2. MATERIALS AND METHODS

2.1 Present Study Area

Malpura is a block in Tonk district Rajasthan and it is located at latitude: 26° 16' 48.00" N longitude: 75° 22' 48.00" E. It has an average elevation of 132 metres (401 feet). located at a

distance of 90 km from Jaipur. Malpura is also known for Avikanagar – 4 km from Malpura. It is known for the Central Sheep and Wool Research Institute (CSWRI). the total geography area of malpura block is 3164.46 hectares. Tonk district is situated in agro-climatic zone 3-A, specifically the semi-arid eastern plain zone climate of malpura is different from typical semi-arid Rajasthan and is more sub-humid climate. The area does remain dry for almost part of the year and humidity increases only during the monsoon months. Summers are hot and during the peak summer months of May-June the temperature soars to more than 45°C. In winter months that stretch from November to February the mean temperature is low, around 22 °C but the lowest temperatures dip to around 4-5°C. Rainfall is moderate as the average annual rainfall in this district is about 508 mm and rains are received during the monsoon months of July to September.

2.2 Soil Samples Collection Sites

Sixty representative Soil samples (0-15 cm) were collected in the year 2021 from 6 different villages of Malpura block with the help of a spade.10 soil samples collected from each villages These villages include Lawa (V_1), Borkhandi (V_2), Kadila (V_3), Jankipura (V_4), Diggi (V_5) and Nukkad (V_6). Firstly, grass, dead plants, and other residual material were removed before sampling. A ‘‘V” shaped cut of 0–15 cm depth was made at random sites and soil samples were collected in a labelled polythene bag.

2.3 Process of Soil Sampling

The soil samples, once collected, were taken to the laboratory for further analysis. To begin with, these samples were carefully dried in the shade to ensure accuracy in subsequent processing steps. The first step in the processing involved removing any unwanted materials such as roots and stones from the samples. Additionally, any clods present in the samples were broken down using a wooden mallet. Following this, the samples were sieved using a 2 mm sieve to ensure uniformity (Table 1). The sieved samples were then carefully stored in polybags for later assessment of various physico-chemical parameters. Throughout this process, all necessary precautions were taken, adhering to the methodology outlined by Jackson. Furthermore, the chemical properties of the soil were estimated using the standard procedure outlined by [11].

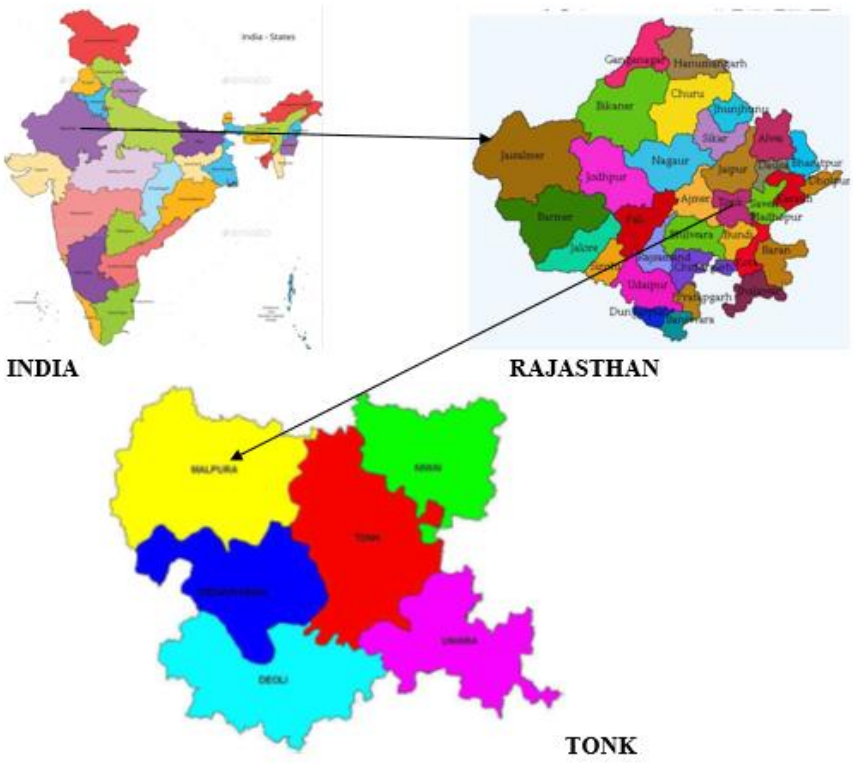

Fig. 1. Location of Malpura Block in Tonk District Rajasthan

Table 1. Procedure used for physical and chemical analysis of soil

S. No.	Parameters	Method	Scientist
		Physical properties	
1.	Bulk density (Mg kg^{-1})	Pycnometer	Black et al. (1965)
2.	Particle density (Mg kg^{-1})	Pycnometer	Black et al. (1965)
3.	Water holding capacity	Keen box	Piper (1966)
		Chemical properties	
4.	pH	Glass electrode pH meter	Jackson (1973)
5.	EC (dSm^{-1})	Electrical conductivity meter	Jackson (1973)
6.	Organic carbon (%)	Wet oxidation method	Walkey and Black [12]
7.	Available nitrogen	Alkaline Potassium permanganate	Subbiah and Asija (1956)
8.	Available phosphorus	Modified Olsen's method	Olsen et al. [13]
9.	Available potassium	Extractable K_2O Ammonium acetate	Schollenberger and Simon (1945)
10.	Exchangeable calcium and magnesium	EDTA titration method	Jackson (1973)
11.	Available sulfur	Turbidimetric method	Chesnin and Yien (1950)

3. RESULTS AND DISCUSSION

3.1 Physico-chemical Properties

The pH of the soil is an important property because it affects nutrients availability and supply, microbial growth and the physical state of the soil. The pH values represents, the combined effect of acid-base reactions occurring in the soil environment [11]. Soil pH of the study area ranged from 6.8 to 8.8 with a mean value of 7.7. Result of this study showed that soil was moderately alkaline to alkaline in nature. Whereas the pH of the groundwater samples in different village of Malpura block viz Lawa (V_1), Borkhandi (V_2), Kadila (V_3), Jankipura (V_4), Diggi (V_5), and Nukkad (V_6), respectively was in the range of 7.2 to 8.5 with an average of 7.85, 6.9 to 7.8 with an average of 7.35, 7.5 to 8.3 with an average of 7.9, 6.9 to 8.8 with an average of 7.85, 6.8 to 8.1 with an average of 7.45, 7.7 to 8.2 with an average of 7.9 respectively. It indicates that most of the sample comes under slightly saline to alkaline in nature [14]. EC is a measurement of the total dissolved solids and ionised species in water that provides insight into the level of inorganic contamination. The mean EC values of different villages of malpura block varied from 0.81 dS m^{-1}, 0.60 dS m^{-1}, 0.48 dS m^{-1}, 0.47 dS m^{-1}, 1.04 dS m^{-1}, 0.60 dS m^{-1}, in Lawa (V_1), Borkhandi (V_2), Kadila (V_3), Jankipura (V_4), Diggi (V_5), and Nukkad (V_6), respectively. Minimum EC was found 0.1 dS m^{-1} in Kadila (V_3), and maximum was found 1.2 dS m^{-1} in Diggi (V_5), due to more soluble salts in soil because of high salty water application in field [15]. The soil organic carbon of the study area is low to medium ranged from 0.2 to 0.88% with a mean value of 0.52%. It was observed that Jankipura (V_4) had a high value (0.88%) for organic carbon, while the majority of the samples were in the low organic carbon category (<0.5%) (Table 4). because in soil if organic matter increase then soil organic carbon also increase these are inter correlated to each other so O.M. highest found in Jankipura (V_4) had a high value (1.52%) with an average of 0.91%.While lowest O.M. was found in Lawa (V_1) 0.34% respectively. The particle and bulk density of the soil samples ranged from 2.13 to 2.69 Mg m^{-3} 1.13 to 1.54 Mg m^{-3} with a mean value of 2.42 Mg m^{-3} and 1.31 Mg m^{-3} respectively. The water holding capacity and porosity of soil sample ranged from 31.95 to 55.75% and 40.77 to 55.86% with an average value of 40.90% and 45.51%, respectively [16].

3.2 Status of Macronutrients

The perusal data presented in Table 3 revealed that there is low available nitrogen in majority of the areas. The nitrogen content of the soil samples varied from 143.2 to 356.84 kg ha^{-1} with a mean value of 228.13 kg ha^{-1} [17]. The lowest (143.2 kg ha^{-1}) range was observed in village Lawa (V_1) while highest (356.84 kg ha^{-1}) was observed in village Nukkad (V_6). As per limits suggested "[18], 69% of the soil samples obtained had low nitrogen levels and 31% had medium nitrogen levels (Table 5). The available phosphorus of the soil samples varied from 10.35 to 28.36 kg ha^{-1} with an average value of 17.92 kg ha^{-1}. The lowest (10.35 kg ha^{-1}) value was observed in village Diggi (V_5), while highest (28.36 kg ha^{-1}) was observed in village Lawa (V_1)

[1]. About 75.5% of the samples, showed high phosphorus content and remaining samples were medium in phosphorus which account for 24.5%. Similar results were also observed in Tonk District of Rajasthan [11].

Whereas the potassium content in the study area was medium and ranged between maximum 354.29 kg ha^{-1} and minimum 124.36 kg ha^{-1} with a mean value of 212.93 kg ha^{-1} [5]. different village of Malpura block viz Lawa (V_1), Borkhandi (V_2), Kadila (V_3), Jankipura (V_4), Diggi (V_5), and Nukkad (V_6), respectively was in the range of 124.36 kg ha^{-1} to 254.95 kg ha^{-1} with an average of 189.66 kg ha^{-1}, 145.27 to 354.29 kg ha^{-1} with an average of 249.78 kg ha^{-1}, 132.78 to 245.54 kg ha^{-1} with an average of 189.16 kg ha^{-1}, 195.45 to 310.85 kg ha^{-1} with an average of 253.15 kg ha^{-1}, 154.56 to 258.2 kg ha^{-1} with an average of 206.38 kg ha^{-1}, 154.92 to 224.02 kg ha^{-1} with an average of 189.47 kg ha^{-1} respectively.

The data analyzed showed, high status of calcium content in the majority of the study area (88% samples). The range of calcium content determined was 0.45 to 19.54 Meq/100 g with a mean value of 8.12 Meq/100 g. The lowest (0.45 Meq/100g) range was observed in village Borkhandi (V_2), while highest (19.54 Meq/100 g) was observed in village Diggi (V_5), 88% of the soil samples were in high levels of calcium content and only 12% of soil samples were in low levels of calcium content.Magnesium is a major constituent of chlorophyll and act as powerhouse behind photosynthesis in plants. The magnesium content in the study area ranged from 1.45 to 48.5 Meq/100 g with an average value of 19.28 Meq/100 g. The lowest (1.45 Meq/100 g) value of magnesium was observed in village Lawa (V_1), while highest (48.5 Meq/100 g) was observed in village Borkhandi (V_2). The data revealed that the magnesium level of all the samples (95%) was in the high range [19]. The sulfur content in study area was low which varied from 6.92 to 19.08 kg/ha with a mean value of 12.25 kg/ha. The lowest (6.92 kg/ha) value of sulfur was observed in village Diggi (V_5), while highest (19.08 kg/ha) was observed in village Borkhandi (V_2). About 77% of the samples showed low sulfur content, 23% of the samples were marginal and 0% samples were high in sulfur content [10].

Less organic matter were observed in the soil of Malpura because of degradation of organic matter due to high temperature or nutrient loss increased due to farmers continuing ploughing and grazing by animals.

3.3 Soil Nutrient Index

To assess soil fertility across various regions, a singular metric for each nutrient was required, as proposed by [20]. This approach, known as the nutrient index (N.I), quantifies the soil's capacity to supply nutrients to plants, as outlined by [16]. Soil fertility is categorized as low (<1.67), medium (1.67-2.33), or high (>2.33) based on the nutrient index values obtained. The nutrient index values for macro of soil samples are given in Table 3. The NI was evaluated for the soil samples analyzed using following formula: Nutrient Index (N.I.) = (NL × 1 + NM × 2 + NH × 3) / NT

Where,

NL: Indicates number of samples falling in low class of nutrient status,

NM: Indicates number of samples falling in medium class of nutrient status,

NH: Indicates number of samples falling in high class of nutrient status,

NT: Indicates total number of samples analyzed for a given area.

Table 2. Nutrient rating of the soil test values

Parameters	Low	Medium	High
Organic carbon (%)	<0.5	0.5-0.75	>0.75
Available N (kg/ha)	<280	280-560	>560
Available P (kg/ha)	<12.5	12.5-25	>25
Available K (kg/ha)	<135	135-335	>335
Available S (kg/ha)	<10	10-20	>20
Deficient		Sufficient	
Calcium (Meq/100 g)	<1.0	>1.0	
Magnesium (Meq/100 g)	<1.5	>1.5	

Source: [18]

Table 3. Nutrient index values of Malpura Block Tonk District of Rajasthan. Available nutrients Nutrient index values Category

Available nutrients	Nutrient index values	Category
Nitrogen	1.5	Low
Phosphorus	2.4	High
Potassium	2.1	Medium
Organic carbon	1.3	Low
Sulfur	1	Low
Calcium	1	High
Manganese	1.70	Medium

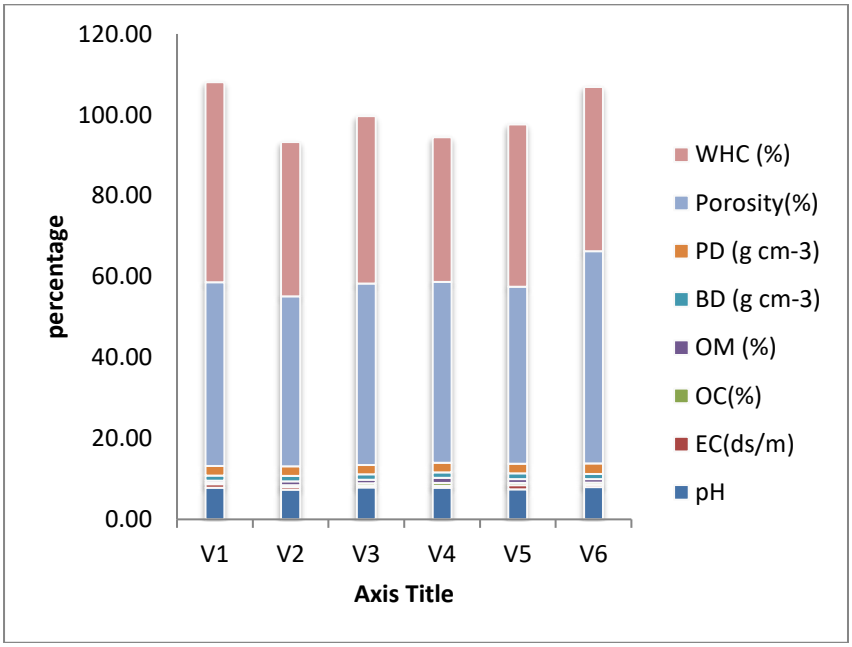

Fig. 2. Soil physio-chemical parameters of different villages of Malpura Block

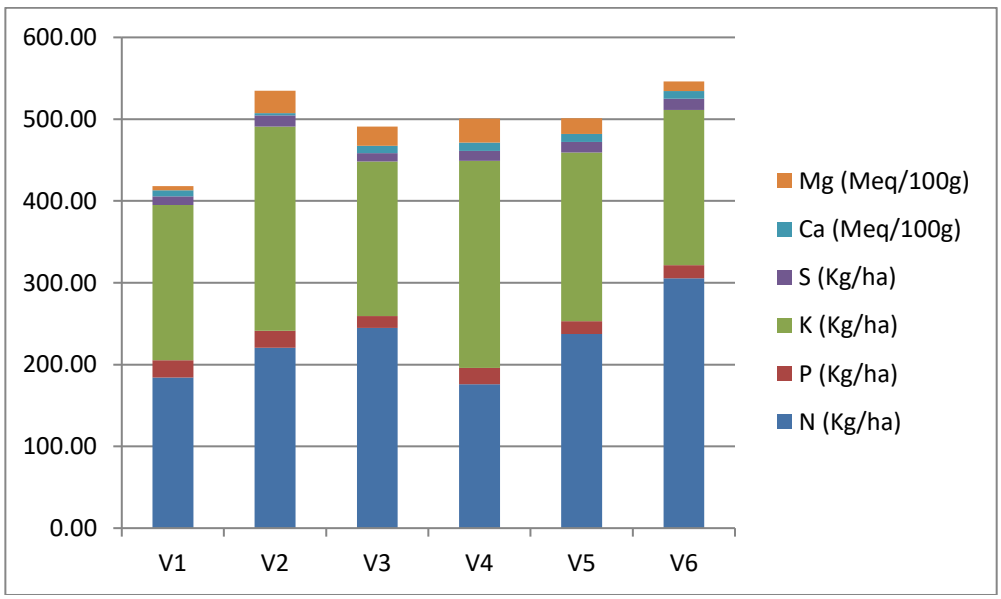

Fig. 3. Status of available macro nutrients viz. N, P, K, Ca, Mg, S

Table 4. Soil physio-chemical parameters of different villages of Malpura Block Tonk District Rajasthan

Name of blocks	No. of sample	Range/Mean	pH	EC(dsm^{-1})	OC (%)	OM (%)	BD (g cm^{-3})	PD (g cm^{-3})	Porosity (%)	WHC (%)
lawa	10	Min	7.2	0.51	0.2	0.34	1.25	2.23	43.95	43.11
		Max	8.5	1.1	0.47	0.81	1.3	2.45	46.94	55.75
		Mean	**7.85**	**0.81**	**0.34**	**0.58**	**1.28**	**2.34**	**45.44**	**49.43**
Borkhandi	10	Min	6.9	0.41	0.5	0.86	1.21	2.13	43.19	32.12
		Max	7.8	0.78	0.57	0.98	1.54	2.6	40.77	44.21
		Mean	**7.35**	**0.60**	**0.54**	**0.92**	**1.38**	**2.37**	**41.98**	**38.17**
kadila	10	Min	7.5	0.1	0.28	0.48	1.26	2.16	41.67	36.85
		Max	8.3	0.85	0.78	1.34	1.32	2.54	48.03	45.87
		Mean	**7.90**	**0.48**	**0.53**	**0.91**	**1.29**	**2.35**	**44.85**	**41.36**
Jankipura	10	Min	6.9	0.36	0.53	0.91	1.23	2.33	47.21	31.95
		Max	8.8	0.57	0.88	1.52	1.47	2.54	42.13	39.54
		Mean	**7.85**	**0.47**	**0.71**	**1.22**	**1.35**	**2.44**	**44.67**	**35.75**
Diggi	10	Min	6.8	0.88	0.44	0.76	1.27	2.28	44.30	38.58
		Max	8.1	1.2	0.65	1.12	1.48	2.6	43.08	41.67
		Mean	**7.45**	**1.04**	**0.55**	**0.94**	**1.38**	**2.44**	**43.69**	**40.13**
Nukkad	10	Min	7.7	0.46	0.31	0.53	1.13	2.56	55.86	33.72
		Max	8.2	0.76	0.71	1.22	1.37	2.69	49.07	47.51
		Mean	**7.95**	**0.61**	**0.51**	**0.88**	**1.25**	**2.63**	**52.47**	**40.62**

Table 5. Status of available macro nutrients viz. N, P, K, Ca, Mg, S, in the soil of Malpura Block

Name of blocks	No. of sample	Range/Mean	N (Kg/ha)	P (Kg/ha)	K (Kg/ha)	S (Kg/ha)	Ca (Meq/100g)	Mg (Meq/100g)
lawa	10	Min	143.2	13.68	124.36	9.18	0.56	1.45
		Max	225.28	28.36	254.95	12.54	14	8.54
		Mean	**184.24**	**21.02**	**189.66**	**10.86**	**7.28**	**5.00**
Borkhandi	10	Min	156.28	19.4	145.27	8.35	0.45	5.7
		Max	285.19	21.47	354.29	19.08	5.36	48.5
		Mean	**220.74**	**20.44**	**249.78**	**13.72**	**2.91**	**27.10**
kadila	10	Min	198.2	12.98	132.78	7.51	0.9	1.86
		Max	291.39	15.87	245.54	12.85	16.89	45.08
		Mean	**244.80**	**14.43**	**189.16**	**10.18**	**8.90**	**23.47**
Jankipura	10	Min	163.48	15.54	195.45	8.56	2.03	22.1
		Max	188.46	24.58	310.85	15.87	18.25	36.2
		Mean	**175.97**	**20.06**	**253.15**	**12.22**	**10.14**	**29.15**
Diggi	10	Min	187.28	10.35	154.56	6.92	0.48	12.54
		Max	287.68	20.57	258.2	18.65	19.54	25.75
		Mean	**237.48**	**15.46**	**206.38**	**12.79**	**10.01**	**19.15**
Nukkad	10	Min	254.32	13.49	154.92	9.25	2.56	9.15
		Max	356.84	18.75	224.02	18.26	16.43	14.56
		Mean	**305.58**	**16.12**	**189.47**	**13.76**	**9.50**	**11.86**

Table 6. Correlation between soil physico-chemical properties of Malpura block of Tonk District in Rajasthan

	pH	EC	OC	BD	PD	Porosity	WHC	N	P	K	S	Ca	Mg
pH	1												
EC	.459*	1											
OC	-0.086	-0.430	1										
BD	-0.841	0.233	0.516	1									
PD	0.299	-0.007	0.228	-0.349	1								
Porosity	0.682	-0.134	-0.150	-0.798*	0.843**	1							
WHC	0.282	0.401	-0.947	-0.575*	-0.289	0.150*	1						
N	-.142**	0.117*	0.073**	-0.423*	-0.289	0.687	-0.098	1					
P	-.169*	-0.103*	0.128*	0.201	0.719	-0.317	0.139	0.714	1				
K	-0.493	-0.312	0.674	0.755	-0.174	-0.539	-0.713	-0.504*	0.560	1			
S	-0.474	0.135**	0.674	0.319	0.628	0.218	-0.510	0.400	0.117	0.422	1		
Ca	0.574**	0.108	0.303	-0.272*	0.442	0.449	-0.075	-0.165**	-0.531	-0.366	-0.249	1	
Mg	-0.367	-0.481	0.856	0.692	-0.193	-0.529	-0.877	-0.206	-0.033	0.766	0.160	-0.125	1

**Represents significant at p≤0.05 level **Represents significant at p≤0.01 level*

3.4 Correlation between Physical and Chemical Properties of Soil

The pH of the soil samples showed positive and significant correlation with EC (r = 0.459*) at 5% level of significance in overall sample observation and negative correlation with nitrogen (r = -0.142*) and phosphors (r = -0.169*). The EC of soil samples showed positive and significant correlation with nitrogen (r = 0.117*) and sulfur (r = 0.135**) at 5% and 1% level of significance in overall sample observation. OC of soil also showed positive and significant correlation with nitrogen (r = 0.073**), phosphors (r = 0.128**). The bulk density of soil samples showed negative and significant correlation with porosity (r = -0.798**), water holding capacity (r = -0.575**), calcium (r = -0.272**), at 5% and 1% level of significance. The particle density of soil samples showed positive and significant correlation with porosity (r = 0.843**) at 5% and 1% level of significance. The available nitrogen in soil samples showed negative and significant correlation with calcium (r = -0.165**) and potassium (r = -0.504**) and positively non-significant correlation with phosphorus (r = 0.714).

4. CONCLUSIONS

The soil fertility of Malpura block was investigated by analysing 60 soil samples collected from the surface horizon (0-15 cm). The findings indicated that the soil in the study area has an alkaline pH. The low organic carbon content observed is attributed to insufficient incorporation of organic manures such as green manure and organic manure, compounded by the high temperatures in the region. These elevated temperatures accelerate decomposition through increased microbial and enzymatic activity. Assessing the nutrient index, the soils in Malpura block were found to be deficient in nitrogen, organic carbon, and sulfur, while possessing medium levels of potassium and high levels of phosphorus. In light of this study, it is evident that regular soil monitoring is imperative to track residual soil nutrients due to the variable nature of nutrient levels in the soil. This underscores the importance of applying appropriate quantities of both macro and micronutrients. Conclusively, the study suggests that farmers should conduct consistent soil monitoring to determine the precise amounts of fertilizers and nutrients required. This knowledge will aid in enhancing the quality of crops and maximizing yield percentages by applying the necessary fertilizers and nutrients judiciously.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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