International Journal of Plant & Soil Science

Volume 36, Issue 8, Page 229-240, 2024; Article no.IJPSS.120312
ISSN: 2320-7035

High Density Soil Survey of CRC -1 by the Use of Laboratory Methods

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Authors' contributions

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

Article Information

DOI: https://doi.org/10.9734/ijpss/2024/v36i84852

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/120312

Original Research Article

Received: 18/06/2024
Accepted: 20/07/2024
Published: 24/07/2024

ABSTRACT

A field experiment was carried out during the year 2024 in the Department of Soil Science & Agricultural Chemistry, School of Agriculture, ITM, Gwalior. Surface (0-15 cm) and sub surface (15-30 cm) soil sample were collected by systematic survey with location data using global position system from CRC-1 farm, ITM, Gwalior District, Madhya Pradesh. A total numb of collected soil sample was 120 sample. pH was varied between 7.21 to 8.69 at 0–15 cm depth and 7.18 to 8.57 at 15–30 cm depth. The pH is slightly alkaline. The Electrical conductivity (EC) ranging from 0.23 to 0.52 dsm^{-1} at 0 -15 cm depth and 0.31 to 0.59 dsm^{-1} at 15 -30 cm depth emphasizing that the fact that the soil is safe limit of EC. Organic carbon was varied between 0.31 to 0.39% in 15–30 cm depth and 0.35 to 0.42% in 0–15 cm depth. The OC status is low to medium. Nitrogen (N) was

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Cite as: *Arunkumar, Laiphrakpam, Sandip Kr Gautam, Vipin Kumar, Pradeep Rajpoot, Aheibam Lamjingba, and Laishram Samprass. 2024. "High Density Soil Survey of CRC -1 by the Use of Laboratory Methods". International Journal of Plant & Soil Science 36 (8):229-40. https://doi.org/10.9734/ijpss/2024/v36i84852.*

ranged between 134.5 to 139.9 kg ha^{-1} at a depth of 0–15 cm and 132.4 to 135.5 kg ha^{-1} at a depth of 15–30 cm. Phosphorus(P) ranging from 8.42 to 12.20 cm at 0–15 cm depth and 6.28 to 10.68 cm at 15–30 cm depth. Potassium (K)ranging from 8.42 to 12.20 kg ha $^{-1}$ at 0–15 cm depth and 6.28 to 10.68 kg ha $^{-1}$at 15–30 cm depth. Sulphur(S) was ranged between 15.36 to 20.54 kg ha^{-1} at a depth of surfaced and 13.64 to 18.74 kg ha $^{-1}$ at a depth of sub surfaced.

Keywords: Soil survey; soil pH; electrical conductivity; organic carbon; nitrogen; phosphorus; potassium; sulphur.

1. INTRODUCTION

Madhya Pradesh is the second-largest state area in the nation. It lies between latitudes $21^0$6' and $26^0$54' N and longitudes 74^0 and 82^0 47'E. There are 50 districts and 10 divisions. Approximately 9.38% of India's total land area, or 308,245 square kilometers, are occupied by it. The distance between the ground and the water table is always 300 kilometers or more. It is located on the Central Indian tableland, which is bordered to the north by the Upper Gangetic plains, to the south by the Godavari valley, to the west by the Gujarat plains, and to the east by the plateaus of Bundelkhand and Chhattisgarh. The State extends east-west by the Vindhya, Satpura, and Maikal hill ranges. There are 87.2 million people living there, according to the 2023 census. The state has three distinct seasons with a typical tropical climate: winter, summer, and monsoon. Every year, 1200 millimeters of rain fall on Madhya Pradesh. These regions also don't have as much forest cover as the state's eastern and central regions. Due to its location in the state's western and north western districts, this state district is regarded as being susceptible to desertification. Its soils are rich, clayey, and gravelly, ranging widely. The state's soils can be divided into four primary categories: alluvial, medium and deep black, shallow and medium black, and mixed red and black.

The most important variables are drainage, plant nutrition interactions, soil pH and organic matter, and parent material type. The soil's micronutrient shortage is one of the primary micronutrient barriers to crop productivity in Madhya Pradesh. However, Madhya Pradesh, India, has a lot of Zn, S, and Fe-poor soil. The fact that a large area of Madhya Pradesh is affected by the pH of the soil has exacerbated the problem. The steady depletion of native reserves in Madhya Pradesh's rain-fed and irrigated systems is caused by crop removal, fertilizer application to the soil, and the use of organic manures [1]. A dynamic natural feature that is susceptible to change as a result of both natural and man-made influences are the nutrients in the soil.

The soil-forming elements that influence the characteristics and formation of soil are climate, relief, parent material (bedrock), organisms, and time [2,3]. Since soil scientists are continuously creating local, regional, and global databases, they are essential to the creation of spatial data. Although human activity can degrade productive soils in a matter of decades, it takes nature thousands of years to generate a unit soil out of sterile bedrock [4]. Consequently, farmers are preventing land degradation in the field of agricultural management (White, 2006).

2. MATERIALS AND METHODS

The CRC-1, ITM University, Gwalior, Madhya Pradesh, where the research work is conducted in 2024 under the Department of Soil Science & Agricultural Chemistry, School of Agriculture. We take surface (0-15 cm) and sub surface (15-30 cm) depth are soil sample are collected by systematic survey were collected using global position system from CRC-1 farm, ITM, Gwalior District, Madhya Pradesh. The region is exposed to both summer and winter conditions. A humid subtropical climate characterises Gwalior with dry hot summer (late march to June) and winter (Mid November to February).

Chemical Parameter

1. Soil pH

Soil pH was convenient way of expressing acidity. Weigh out about 10 gram of soil and 50ml of distilled water. Ensuring a 1:5 diluted will suffice respectively. Shake the container and settle the soil for 10 minutes. Measure the pH value on the water above the soil.

2. Electrical conductivity (EC)

Using an electrical conductivity meter, the electrical conductivity of the soils was ascertained in soil water extract. Wait ten minutes after activating conductivity bridge. Using 0.01NKCI and saturated Ca SO_4 solution give the device a test. Use the same soil water solution that was used to measure pH to calculate EC. Give the mixture a brief swirl and then let the dirt to sit for five minutes. The electrodes should be well cleaned before being immersed in a dirt solution. Make the required temperature adjustment. This point's readings on the scale display the electrical conductivity. Multiply this by the cell constant (given on the cell itself) to get a specific conductivity.

3. Organic carbon

Walklcy-Black (1934) method was used to estimate organic carbon. By using concentrated H_2SO_4 and potassium dichromate ($K_2Cr_20_7$) in combination with the heat of dilution of H_2SO_4, organic matter in the soil is oxidised in this process back-titrating $K_2Cr_2O_7$ with ferrous ammonium sulphate.

4. Available nitrogen (N)

Alkaline permanganate method was used to determine the amount of available nitrogen. Using this method, fill a digestive tube with 5 g of dirt and a tiny amount of water. After mixing the sample with 20 milliliters of a 0.32% $KMn0_4$ solution, place the tube into the distillation machine. Apply 20 ml of 2.5% NaOH solution with the Kjeldahl Distillation System. About 20 ml of 2.5% boric acid into the conical flask, then clip the distyl-receiving em's end. Take the ammonia gas out of the tube and combine it with the acid that was given. After that, titrate with $0.02NH_2S0_4$ and add 5 drops of mixed indicator. A blank correction (without soil) must be included in the final calculations.

5. Available phosphorus(P)

Olsen's method was used to calculate the availability of phosphorus in the soil [5]. About 2.5 g of the soil sample was shaken for 30 minutes in a 100 ml, conical flask on a mechanical shaker with 50 ml of 0.5N $NaHC0_3$ (adjusted to pH 8.5) as an extractant and I g of Darco G-60.

6. Available potassium(K)

A flame photometer is used to measure the potassium concentration in the filtrate obtained from filtering the TC suspension through Whatman No. 42 filter paper. M.L. Jackson (1973) uses the Neutral Ammonium Acetate Method to determine the accessible potassium concentration in the soil. The material was transferred into a 100 ml conical flask, and five minutes were spent shaking it. Twenty-five milliliters of 1 N ammonium were added to the flame photometer.

7. Available Sulphur

Available sulphur was determined by the method given by Chesnin, L and Yien, C.H. (1951)

i) Preparation of standard curve

Dissolved 0.5434 grams of oven-dried K_2SO_4 (A.R.) in one litter of purified water. 100 parts per million of sulfur were present in this solution. A range of concentrations ranging from 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50 parts per million was created using S solution. 25 millilitre volumetric flasks were filled with 10 milliliters of standard solution at different concentrations. Each flask was then shaken after adding one millilitre of the 0.25 per gum acacia solution and one millilitre of 6N HCl (seed solution). With distilled water, the final volume was adjusted. After transferring the contents of the flasks to a beaker, 0.5 g of crystals of barium chloride (30 mesh) were added, and the mixture was gently stirred for half a minute. The transmittance per cent was used to measure the resultant turbidity using a spectrophotometer set at 420 mμ. Plotting the transmittance percent against the sulfur concentration (ppm) in solution led to the construction of a standard curve.

ii) Extraction

A 10g sample of soil was collected, and after being thoroughly agitated for approximately half an hour and filtered using Whatman number 40 filter paper, 50 ml of extractant (CH_3CooNH_4 + CH_3CooH) and 0.5 g of sulfur-free activated charcoal were added.

ii) Development of turbidity

In a 25 ml volumetric flask, 10 ml of the aforementioned extract was shaken. It was shaken after adding 1 ml of 0.25 per pent gum acacia solution and 1 ml of 6 N HCl (seed solution). Distilled water was used to get the final volume up to par. The flask's contents were moved into a beaker. After adding 0.25 g of barium chloride crystals (30 mesh), gently stir for a duration of two minutes. The transmittance per cent was used to measure the resultant turbidity using a spectrophotometer set at 420 mμ. Once the device has been calibrated to read 100%

transmittance, prepare a blank. The sulfur content was computed as S kg/ha.

3. RESULTS AND DISCUSSION

3.1 pH

The pH range of the CRC-1 soil under study was 7.18 to 8.57 at 15–30 cm depth and 7.21 to 8.69 at 0–15 cm depth. In general, the pH trended downward with depth. In response, the soils ranged from slightly acidic to slightly alkaline. In addition to the calcium carbonate concentration, bases may leach from the surface and deposit at lower layers, causing the pH to fall with depth. Previous reports of the pH decreasing with depth came from Rajeshwar et al. [6].

Table 1. Soil pH of surface and sub surface

Location	pH	
	Depth(cm)	
	0-15	15-30
Block-1	7.44	7.37
Block-2	7.79	7.65
Block-3	7.52	7.45
Block-4	7.21	7.18
Block-5	8.56	8.26
Block-6	7.81	7.76
Block-7	7.56	7.49
Block-8	8.70	8.57
Block-9	7.58	7.45
Block-10	8.34	8.25
Block-11	7.42	7.38
Block-12	8.67	8.52
Block-13	8.27	8.12
Block-14	8.34	8.29
Block-15	7.49	7.38
Block-16	8.44	8.35
Block-17	7.97	7.82
Block-18	8.35	8.28
Block-19	7.45	7.32
Block-20	7.67	7.45
C.D.	0.04	0.03
SE(m)	0.01	0.01
SE(d)	0.02	0.01
C.V.	0.28	0.21

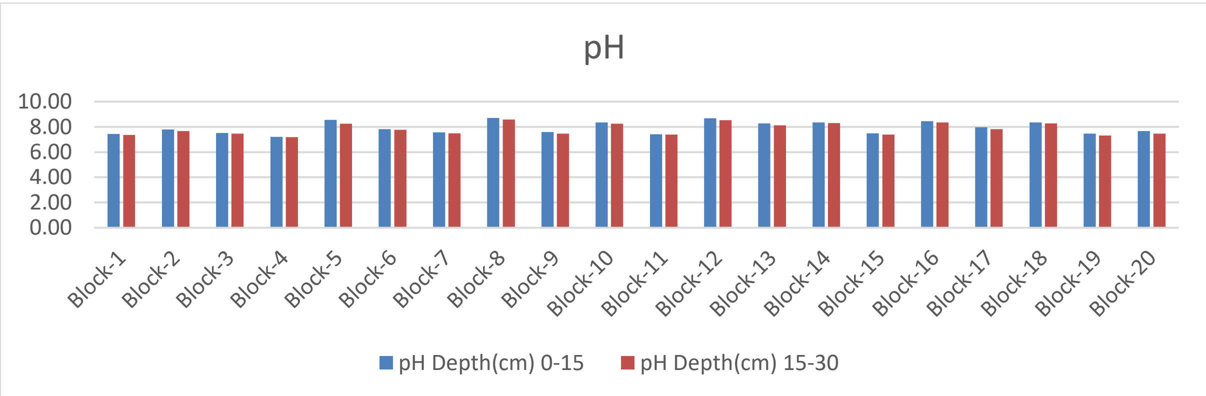

Fig. 1. Graphical presentation of Soil pH

3.2 Electrical Conductivity (dsm^{-1})

The soil in the CRC-1 study area had electrical conductivity ranging from 0.23 to 0.52 dsm^{-1} at 0 to 15 cm depth and 0.31 to 0.59 dsm^{-1} at 15 to 30 cm depth. As soil depth increased, it displayed an increasing trend. It was discovered that every soil sample was normal (EC< 1.0 dSm-^{1}). One possible explanation for the depth-dependent increase in electrical conductivity is the leaching of bases from surface to subsurface horizons. The outcomes concur with those of Tuba and Kaleem [7] and Najar (2009).

Table 2. Electrical conductivity of surface and sub surface

Location	EC (dsm^{-1}) Depth(cm) 0-15	15-30
Block-1	0.34	0.423
Block-2	0.45	0.53
Block-3	0.37	0.44
Block-4	0.23	0.31
Block-5	0.43	0.49
Block-6	0.35	0.43
Block-7	0.46	0.48
Block-8	0.52	0.59
Block-9	0.45	0.52
Block-10	0.24	0.32
Block-11	0.27	0.34
Block-12	0.43	0.51
Block-13	0.25	0.32
Block-14	0.38	0.41
Block-15	0.29	0.34
Block-16	0.28	0.32
Block-17	0.29	0.33
Block-18	0.25	0.32
Block-19	0.33	0.37
Block-20	0.51	0.58
C.D.	0.03	0.032
SE(m)	0.01	0.011
SE(d)	0.015	0.016
C.V.	5.018	4.593

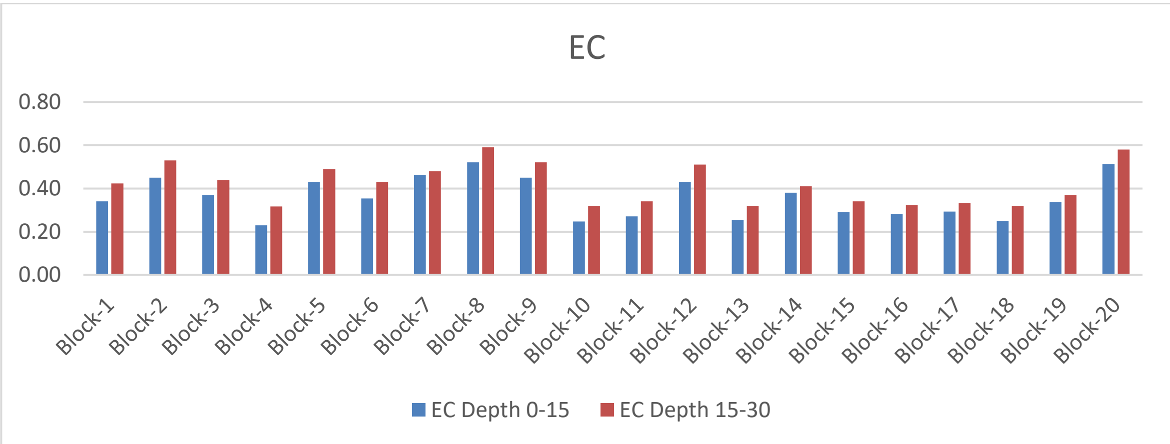

Fig. 2. Graphical presentation of EC in the soil

3.3 Organic Carbon

The range of organic carbon in the soil of the CRC-1 study area was 0.31 to 0.39 in 15–30 cm depth and 0.35 to 0.42 in 0–15 cm depth. With depth, the organic carbon content showed a declining tendency. The reduced organic carbon was caused by erosion removing surface soils with high levels of organic carbon [6]. These soils have a medium level of organic carbon because of the rapid burning of organic matter brought on by the high temperatures in the area. Similar findings were observed by Lathwal [8].

Table 3. Organic carbon in CRC-1 of surface and sub surface

Location	OC% Depth(cm) 0-15	OC% Depth(cm) 15-30
Block-1	0.38	0.33
Block-2	0.36	0.31
Block-3	0.39	0.35
Block-4	0.35	0.34
Block-5	0.39	0.36
Block-6	0.36	0.33
Block-7	0.41	0.37
Block-8	0.42	0.39
Block-9	0.37	0.34
Block-10	0.39	0.35
Block-11	0.36	0.32
Block-12	0.38	0.35
Block-13	0.39	0.34
Block-14	0.37	0.32
Block-15	0.36	0.33
Block-16	0.38	0.34
Block-17	0.37	0.34
Block-18	0.36	0.33
Block-19	0.40	0.36
Block-20	0.42	0.37
C.D.	0.033	0.031
SE(m)	0.011	0.011
SE(d)	0.016	0.015
C.V.	5.218	5.353

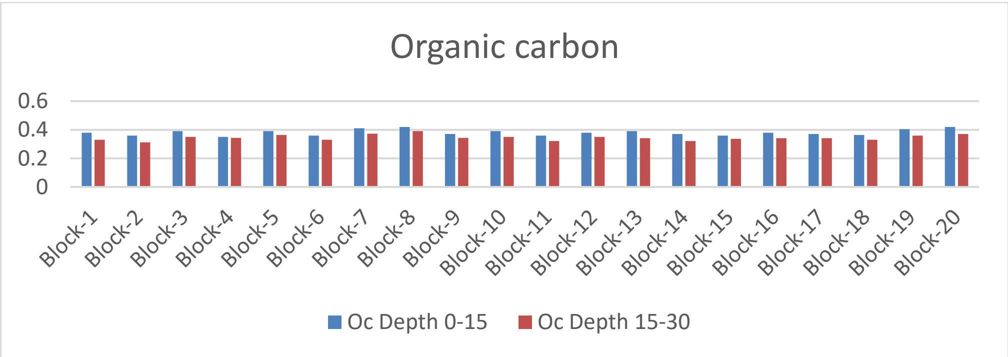

Fig. 3. Graphical presentation of organic carbon in the soil

3.4 Available Nitrogen

The range of available nitrogen in the soil of the CRC-1 study area was 134.5 to 139.9 cm at a depth of 0–15 cm and 132.4 to 135.5 cm at a depth of 15–30 cm. Higher levels of nitrogen were found in surface soils, however the amount of nitrogen that was available decreased with depth. These data points are also noted by Dar et al. [9], Najar.G. (2009). Surface soils had larger levels of accessible nitrogen, which decreased linearly as soil depth increased.

Table 4. Available nitrogen in CRC-1 of surface and sub surface

Location	Nitrogen (kg ha^{-1}) Depth(cm) 0-15	15-30
Block-1	135.4	131.4
Block-2	136.3	133.0
Block-3	135.6	131.3
Block-4	135.5	131.4
Block-5	136.9	133.4
Block-6	135.2	130.6
Block-7	138.6	133.8
Block-8	139.6	135.5
Block-9	138.5	134.6
Block-10	135.1	132.9
Block-11	136.9	134.5
Block-12	135.1	132.9
Block-13	138.5	133.9
Block-14	136.7	133.6
Block-15	138.5	132.6
Block-16	137.3	133.3
Block-17	135.7	131.9
Block-18	136.3	130.3
Block-19	138.9	132.6
Block-20	139.5	134.2
C.D.	2.423	1.556
SE(m)	0.843	0.542
SE(d)	1.192	0.766
C.V.	1.066	0.706

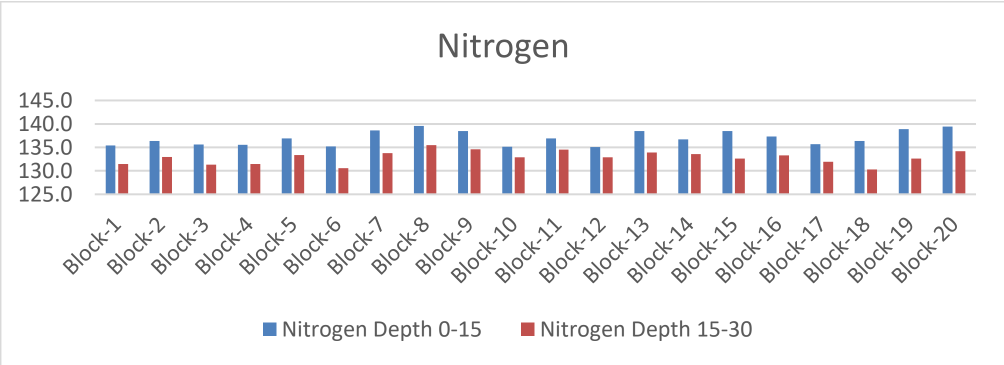

Fig. 4. Graphical presentation of Nitrogen in the soil

3.5 Available Phosphorus

The soil in the CRC-1 study region had available phosphorus ranging from 8.42 to 12.20 kg ha-1at 0–15 cm depth and 6.28 to 10.68 cm at 15–30 cm depth. With depth, the amount of phosphorus that was available trended downward; the highest level was found in surface soils. The present results are consistent with those of Mostara (2002), who reported that a medium amount of phosphorus was present in most Karnataka soils, particularly in the Mal Prabha command. The Nirawar. G.V et al. (2009) and Kumar et al. [10] samples from Jharkhand's Dumka had moderate levels of phosphorus.

Table 5. Available Phosphorus in CRC-1 of surface and sub surface

Location	Phosphorus (kg ha^{-1}) Depth 0-15	15-30
Block-1	9.34	7.52
Block-2	11.45	9.63
Block-3	10.32	8.54
Block-4	8.42	6.28
Block-5	11.32	9.52
Block-6	9.68	7.84
Block-7	11.12	9.72
Block-8	12.21	10.68
Block-9	10.52	8.74
Block-10	10.36	8.58
Block-11	8.48	6.64
Block-12	11.52	9.72
Block-13	10.62	8.48
Block-14	9.82	7.18
Block-15	8.54	6.74
Block-16	10.74	8.52
Block-17	9.32	7.48
Block-18	10.34	8.52
Block-19	11.12	9.38
Block-20	12.13	10.42
C.D.	0.016	0.017
SE(m)	0.006	0.006
SE(d)	0.008	0.008
C.V.	0.095	0.117

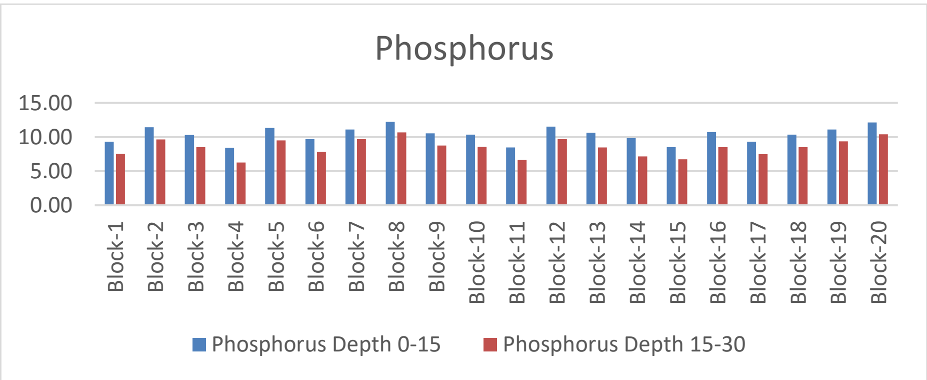

Fig. 5. Graphical presentation of Phosphorus in the soil.

3.6 Available Potassium (kg ha^{-1})

The range of available potassium in the soil of the CRC-1 study area was 296.2 to 302.7 cm at a depth of 0–15 cm and 291.2 to 297.8 cm at a depth of 15–30 cm. These data points are also noted by Verma et al. [11], Nirawar. G.V et al. (2009) and Sharma et al. [12]. The comparable predominance of K-rich micaceous and feldspar minerals may be responsible for this higher valve outcomes in the-soils of Sardulgarh, Bhikhi, and Budhlada block sand.

Table 6. Available potassium in CRC-1 of surface and sub surface

	Potassium (kg ha^{-1})	
Location	Depth(cm)	
	0-15	15-30
Block-1	295.4	290.1
Block-2	297.9	292.5
Block-3	300.4	295.8
Block-4	296.2	291.2
Block-5	298.3	293.5
Block-6	297.3	292.7
Block-7	301.3	289.4
Block-8	302.7	297.8
Block-9	298.7	292.3
Block-10	296.6	291.5
Block-11	301.4	296.8
Block-12	297.3	292.3
Block-13	299.3	294.8
Block-14	296.7	291.3
Block-15	301.3	296.4
Block-16	297.2	292.8
Block-17	299.3	294.4
Block-18	296.8	291.7
Block-19	298.8	293.3
Block-20	302.4	297.3
C.D.	1.701	4.317
SE(m)	0.592	1.502
SE(d)	0.837	2.124
C.V.	0.343	0.887

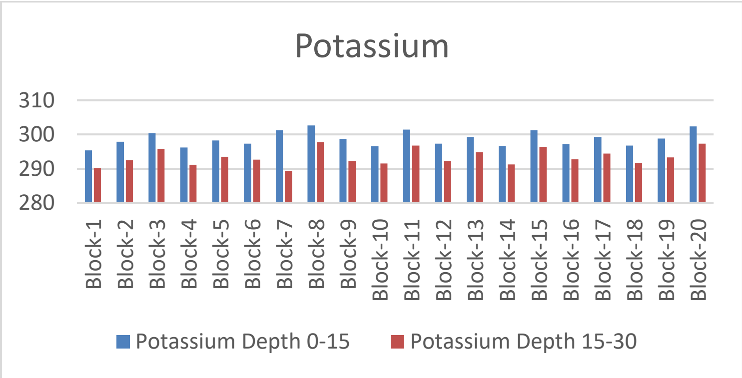

Fig. 6. Graphical presentation of Potassium in the soil

3.7 Available Sulphur (kg ha^{-1})

The range of available sulphur in the soil of the CRC-1 study area was 15.36 to 20.54 cm at a depth of 0 -15 cm and 13.64 to 18.74 cm at a depth of 15 - 30 cm. For the Rewa district as a whole 45.10 per cent samples were tested low in available sulphur. Similar findings were reported by Bhatnagar et al. [13] and Singh and Bansal (2007). The correlation coefficients were found to be significant at 5 percent level of significance (r=0.1502) [14-20].

Table 7. Available sulphur in CRC-1 of surface and sub surface

Location	Sulphur (kg ha^{-1}) Depth(cm) 0-15	15-30
Block-1	18.63	16.463
Block-2	18.72	16.32
Block-3	16.24	14.58
Block-4	15.36	13.64
Block-5	17.82	15.35
Block-6	19.29	17.42
Block-7	20.23	18.64
Block-8	20.54	18.74
Block-9	18.28	16.84
Block-10	17.52	15.36
Block-11	19.82	17.62
Block-12	18.64	16.82
Block-13	16.25	14.63
Block-14	17.32	15.71
Block-15	18.63	16.43
Block-16	16.25	14.63
Block-17	17.84	15.43
Block-18	15.46	13.74
Block-19	20.18	18.35
Block-20	20.21	18.32
C.D.	0.029	0.027
SE(m)	0.01	0.009
SE(d)	0.014	0.013
CV	0.097	0.101

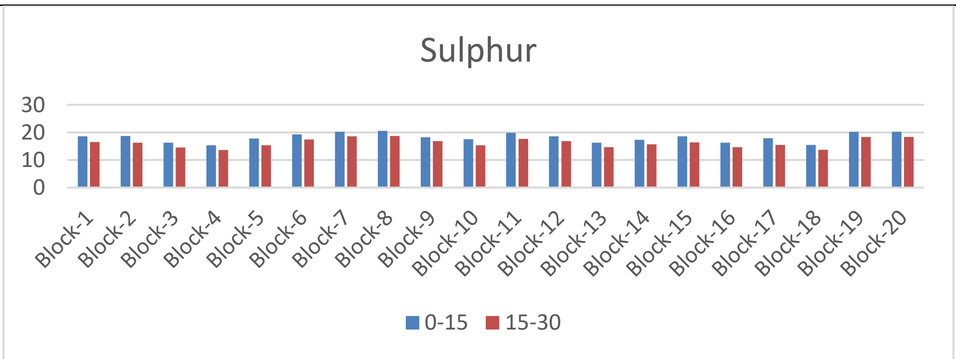

Fig. 7. Graphical presentation of Sulphur in the soil

4. CONCLUSIONS

The research examined the simultaneous prediction of chemical characteristics. As soil depth increased, pH moved upward and EC moved downward. The research farms at ITM University have a pH that is between neutral and slightly alkaline, and the outcomes are typical. The soils of the ITM research farm had low levels of phosphate, nitrogen, and organic carbon. It is suggested that integrated nutrient management and fertilizer be employed in order to grow crops.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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