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Assessment of Soil Fertility Status in Marori Block of Pilibhit District, Uttar Pradesh, 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

This study aims to evaluate the agricultural productivity potential of soils in several villages in Marori block of Pilibhit district during 2022-23. 40 soil samples were collected using a random sampling technique, air-dried, and analyzed for physical and chemical properties. The results showed that the soil content varied significantly, with sand content ranging from 8.2-78.4% silt content from 9.2-67.3%, and clay content from 4.2-39.2%. Bulk density, particle density, porosity, pH levels, electrical conductivity, and organic carbon were also measured. The available nutrients varied, with nitrogen, phosphorus, potassium, calcium, magnesium, and sulphur ranging from 149.13-265.63 kg/ha, 13.59-49.72 kg/ha, 99.34-300.53 kg/ha, 3.3-6.9 cmol (P+)/kg, 1.53-4.20 and 11.29-19.23 kg/ha, respectively. The results showed that 99.5% of the soil samples had normal pH levels, and 0.5% was acidic. The majority of the soil samples had low organic carbon, with 72.5% having the

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highest available P. The majority of the soil samples were adequate in terms of exchangeable Ca and Mg content, and 60% had the greatest available sulphur. In a nutshell, the study highlights the importance of soil fertility in sustainable agricultural production.

Keywords: GIS; Marori block; nutrient index; soil fertility.

1. INTRODUCTION

Soil is a vital natural dynamic body that sustains all living things on Earth [1]. Soil fertility evaluation is the most fundamental decision-making tool for efficiently planning a specific land use system [2]. There are various procedures for determining soil fertility status, but soil testing is the most widely used and most suited. Soil testing offers information about nutrient availability in soils, which is used to make fertilizer recommendations for crop productivity. Soil analysis comprises physical features (texture, structure, color, bulk density, and so on) as well as chemical properties (soil pH, organic matter, macro and micronutrients, and so on), which are required for long-term soil management [3]. According to Wilding and Lin [4] soil contains various amounts of air, water, minerals, organic materials, untold numbers of creatures, and other elements that are necessary for life. The availability of nutrients to growing crop plants as well as the total amount of nutrients present affect the overall crop growth and development [5]. Therefore, it is important to regularly and systematically examine the sufficiency of major, secondary, and micronutrients as well as nutrient deficits. Therefore, the data from soil tests is the most accurate source of information on the availability of plant nutrients and how to modify fertilizer recommendations for different crops. Prior to the development of new technologies like Global Positioning Systems (GPS) and Geographic Information Systems (GIS), it was challenging to describe the spatial diversity of soil fertility throughout a field. For the purpose of creating thematic soil fertility maps, it is crucial to collect soil samples using GPS [6] Keeping the above aid matter in view, for improving productivity in rice-based systems, soil fertility was assessed using the following parameters: organic matter content (OC), soil pH, accessible sulphur, electrical conductivity (EC), total nitrogen (TN), C/N ratio, available phosphorus, exchangeable calcium (Ca), magnesium (Mg), and texture (sand, silt, and clay). For the aforementioned fertility indicators, they used average weighted data from topsoil samples taken at depths ranging from 0 to 15 cm [7] In this paper, the fertility rates of various villages in the Pilibhit area of Uttar Pradesh are discussed. It might be helpful in suggesting the best crops, cropping patterns, and methods for managing the soil for the region's sustained yields.

2. MATERIALS AND METHODS

2.1 Site Description

The present investigation was carried out in the Marori block which is situated between latitude 28˚64’ North and longitude 79˚81’ East (Table 1; Fig. 1). The existing crops in this block are rice, wheat, sugarcane, mustard, and seasonal vegetables etc. Pilibhit experiences winter from November to February. It experiences pleasant windy days, clear skies, and cool nights from November to the end of February. The day temperature hovers around 14 °c (57°F) while night temperature is below 7°C (45°F) for most of December and January, often dropping to 3°C (37°F) or 4°C (39°F). Rain is expected to occur in February with a rainfall distribution of 1300-1400mm. The climate of the area is sub-humid with max temp. 38.4^{0}C and min temp 4.3^{0}C.

2.2 Soil Sampling and Analysis

Altogether 40 surface soil samples (0-15cm depth) were collected prior to the sowing of crops during the month of January 2023 from Marori block covering different villages Araji Chant, Baldevpur, Bilgaon, ChidiaDih, Deshnagar, Devipura, Himmatnagar, Junapuri, Kaim, Lalpuriya SahibSingh, Mohanpur, Mundiaratanpuri (Fig. 2). The soil samples were collected in zigzag manner from the different locations of crop field &near about 0.5 kg collected samples from each field were stored in the polythene bag. The samples were collected along with the geo-coordinates, and recorded from each location by using global positioning system (GPS) tool. A varied number of soil samples were gathered from each hamlet and placed in a polythene bag with appropriate labeling. While collecting the soil samples, the specifics of the farmer's field, crops cultivated in that area, and fertilizers applied were noted. Soil samples were dried at room temperature and pulverized with a wooden roller on a wooden plank before being sieved at 2 mm. Then, soil samples that had been homogenized were placed in polythene bags for further analysis to determine the physicochemical properties of the soil. The Department of Ag Chemistry and Soil Science's macronutrient lab examined soil samples in accordance with standard operating procedures.

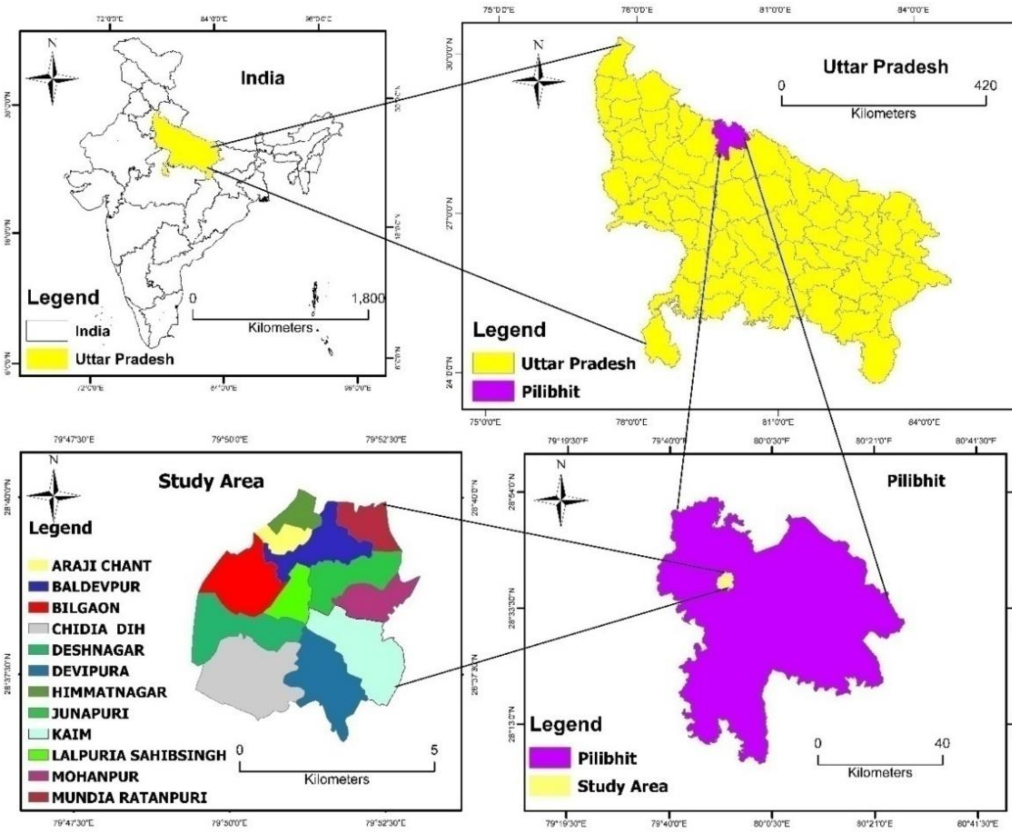

Fig. 1. Representing study map of Pilibhit area

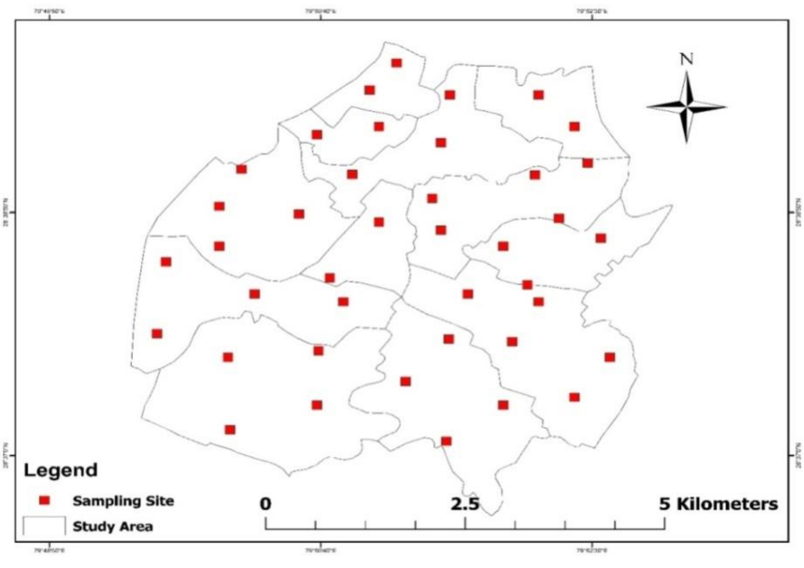

Fig. 2. Representing sampling map of site area

Table 1. Location of soil samples collected in different villages of Marori block of Pilibhit district

S. No.	Village name	Longitude (DD)	Latitude (DD)	Cropping History Previous year	Current year
S_1	Bilgaon	28.6480	79.8330	Sugarcane	Sugarcane
S_2	Himmatnagar	28.6626	79.8500	Sugarcane	Sugarcane
S_3	Bilgaon	28.6527	79.8355	Sugarcane	Sugarcane
S_4	Lalpuria SahibSingh	28.6390	79.8455	Paddy Mustard,	Sugarcane
S_5	Mohanpur	28.6381	79.8677	Wheat, Sugarcane	Sugarcane
S_6	Devipura	28.6313	79.8589	Sugarcane	Wheat
S_7	Devipura	28.6185	79.8586	Sugarcane	Sugarcane
S_8	ChidiaDih	28.6230	79.8440	Sugarcane	Wheat
S_9	Araji Chant	28.6580	79.8510	Sugarcane	Wheat
S_{10}	Kaim	28.6370	79.8610	Sugarcane	Wheat
S_{11}	Devipura	28.6260	79.8540	Sugarcane	Paddy
S_{12}	Deshnagar	28.6320	79.8260	Mustard, Sugarcane	Paddy
S_{13}	Deshnagar	28.6360	79.8470	Sugarcane	Paddy
S_{14}	Baldevpur	28.6620	79.8590	Paddy Wheat	Wheat
S_{15}	Mohanpur	28.6430	79.8650	Paddy	Sugarcane
S_{16}	Lalpuria SahibSingh	28.6460	79.8510	Paddy Mustard	Sugarcane
S_{17}	Kaim	28.6310	79.8660	Sugarcane	Sugarcane
S_{18}	Himmatnagar	28.6660	79.8530	Mustard, Sugarcane	Paddy
S_{19}	Bilgaon	28.6470	79.8420	Paddy, Sugarcane	Paddy
S_{20}	Bilgaon	28.6430	79.8330	Sugarcane	Sugarcane
S_{21}	ChidiaDih	28.6298	79.8442	Paddy, Sugarcane	Sugarcane
S_{22}	ChidiaDih	28.6199	79.8342	Paddy	Sugarcane
S_{23}	ChidiaDih	28.6290	79.8340	Sugarcane	Sugarcane
S_{24}	Araji Chant	28.6570	79.8440	Paddy Mustard	Sugarcane
S_{25}	Kaim	28.6290	79.8770	Wheat Paddy	Sugarcane
S_{26}	Kaim	28.6240	79.8730	Paddy Mustard	Sugarcane
S_{27}	kaim	28.6360	79.8690	Sugarcane	Paddy
S_{28}	Mundia Ratanpuri	28.6580	79.8730	Sugarcane	Sugarcane
S_{29}	Deshnagar	28.6370	79.8370	Sugarcane	Paddy
S_{30}	Deshnagar	28.6410	79.8270	Sugarcane	Sugarcane
S_{31}	Baldevpur	28.6560	79.8580	Sugarcane	Sugarcane
S_{32}	Junapuri	28.6450	79.8580	Paddy Mustard	Wheat
S_{33}	Junapuri	28.6490	79.8570	Sugarcane	Paddy
S_{34}	Baldevpur	28.6520	79.8480	Sugarcane	Sugarcane
S_{35}	Mohanpur	28.6440	79.8760	Paddy, Mustard	Sugarcane
S_{36}	Mundia ratanpuri	28.6620	79.8690	Sugarcane	Sugar cane
S_{37}	Devipura	28.6230	79.8650	Sugarcane	Sugarcane
S_{38}	Junapuri	28.6465	79.8713	Sugarcane	Paddy
S_{39}	Junapuri	28.6519	79.8686	Sugarcane	Sugarcane
S_{40}	Junapuri	28.6534	79.8745	Sugarcane	Wheat

2.3 Nutrient Index Evaluation

The soils of the individual blocks were classified into three fertility classes based on nutrient index values obtained from soil test summaries and their percentage distribution into low, medium, and high categories. Parker et al. [8] devised the nutritional index.

Nutrient Index= [% in high category x 3+ % in medium category x 2 + % in low category x 1] /100

In this percent assessment a nutrient index less than 1.5 denotes a low category and that falls between 1.5 and 2.5 represents the medium fertility class. A value of 2.5 and above (maxi 3.00) signifies a high fertility class with respect to the particular nutrient (Ghosh and Hasan, 1976).

2.4 Statistical Analysis

Snedecor and Cochran's [9] technique for doing simple statistical analysis was used. These analyses included maximum, minimum, mean, coefficient of variation and correlation. The Coefficient Variation was determined by using formula:

C.V. = Standard Deviation Mean X 100

The relationship between relevant soil properties and available cationic macronutrient of soils were calculated by using standard statistical methods. The correlation coefficient was determined by using the formula:

Where:

r = Correlation coefficient
SP (xy) = Sum product of x, y variables
SS (x) = Sum of square of x variable
SS (y) = Sum of square of y variable.

3. RESULTS AND DISCUSSION

3.1 Physical Properties

In the soils of Marori block, the sand, silt and clay content of samples ranged from 8.2-78.4, 9.2-67.3 and 4.2-39.2 (Table 4) respectively. There is no trend in the study area [10] The bulk density of the studied soils varied from 1.12-1.47 g/cm^3. The lowest bulk density was found in samples S_{30} and S_{40} from the villages of Deshnagar and Junapuri; this may be due to the presence of high organic carbon content. The bulk density exhibited a significant and negative correlation (r = -0.810*) with organic carbon (Table 6). A similar result was observed by Khadka *et al*. [10] in the Agricultural Research Station, Vijayanagar, Jumla, Nepal. A similar result was observed by Patel *et al*. [11] in the Jaunpur District of eastern Uttar Pradesh. The average particle density of the studied soils was 2.25 g/cm^3. Devipura, ChidiaDih, Junapuri and Divipura village samples S_7, S_{23}, S_{33} and S_{37} had the highest value of particle density, while Himmatnagar village samples S_2 had the lowest. The Particle density exhibited a significant and negative correlation (r = -0.811**) with organic carbon (Table 6). Deolin *et al*. [12] found comparable outcomes in the Saheshpur block of Dehradun. The distributions of physical properties are presented in Fig.3.

Table 2. Procedure used for physico-chemical analysis of soil of different villages of Marori block of Pilibhit district

a. Physical properties		**Method applied**	**Reference**
1	Particle size analysis (%)	Hydrometer method	Bouyoucos [21]
2	Bulk density (g/cm^3)	Pycnometer	Black *et al.* [22]
3	Particle density (g/cm^3)	Pycnometer	Black *et al*.[22]
b. Chemical properties			
1	Soil reaction (pH)	pH meter	Jackson [23]
2	Electrical Conductivity(dS/m)	EC bridge	Jackson [23]
3	Organic Carbon (%)	Wet oxidation method	Walkley and Black [24]
c. Available nutrient			
4	Available N (kg/ha)	Alkaline $KMnO_4$ method	Subbiah and Asija [17]
5	Available P (kg/ha)	Olsen's method	Olsen *et al*. [25]
6	Available K (kg/ha)	Ammonium acetate method	Hanway and Heidal [26]
7	Available S (kg/ha)	Calcium chloride method	Chesnin and Yien [27]
8	Exchangeable Ca and Mg (Cmol(p$^+$)/kg)	EDTA Method	Cheng and Bray [28]

Table 3. Characterization of soil test values for different nutrients

Nutrient	**Rating of the soil test values**		
	Low	**Medium**	**High**
E.C. (dS/m)	<0.8	0.8-2.5	>2.5
O.C. (%)	< 0.5	0.5-0.75	> 0.75
Available N (kg/ha)	<280	280-560	>560
Available P (kg/ha)	<10	10-25	>25
Available K (kg/ha)	<108	108-280	>280
Available S (mg/kg)	<10	10-20	>20
	Deficient	**Sufficient**	**Insufficient**
Ex. Ca (Cmol(p$^+$) kg^{-1})	<1.5	1.5-4.5	>4.5
Ex. Mg (Cmol(p$^+$) kg^{-1})	<1.5	1.5-4.5	>4.5

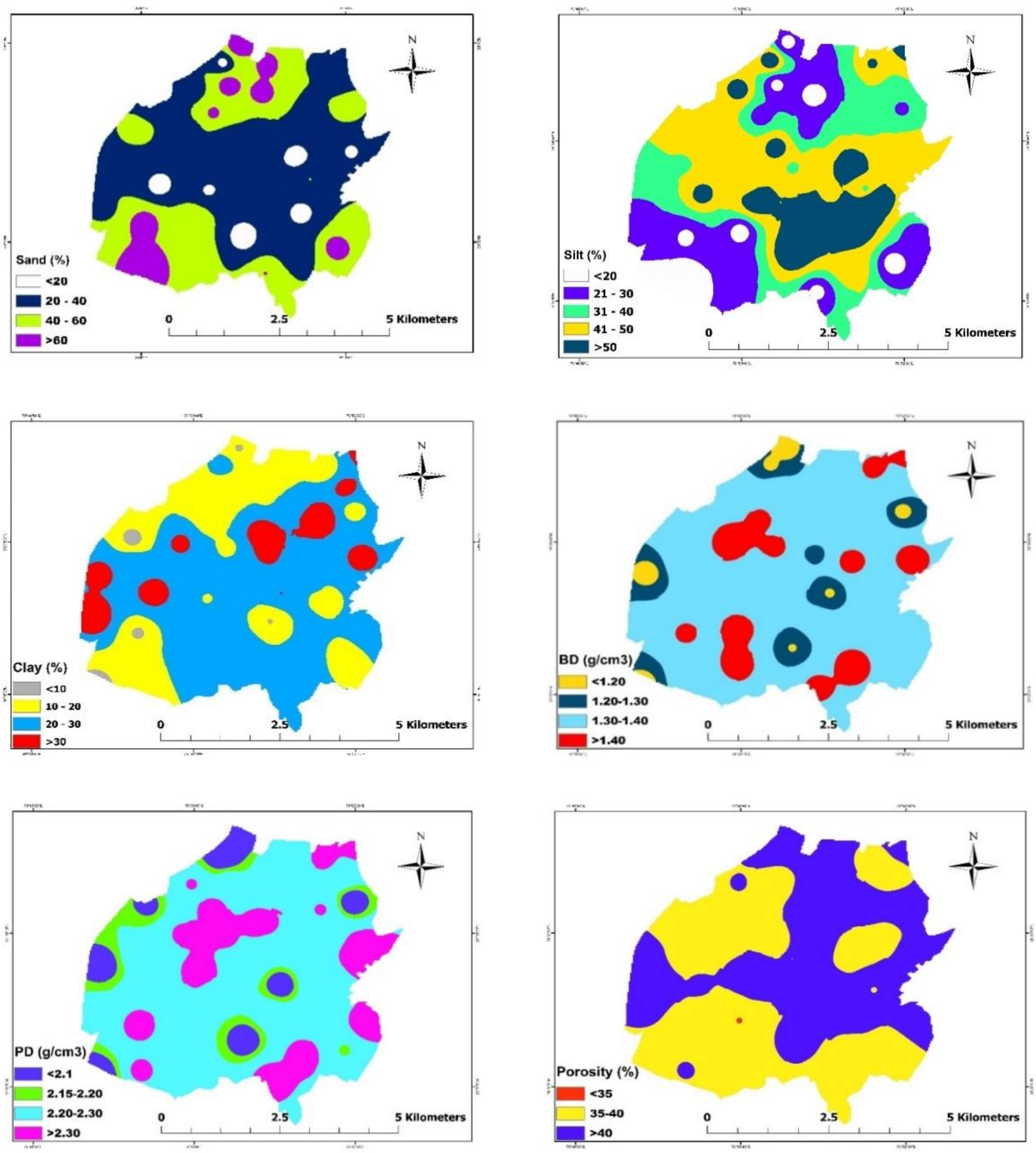

Fig. 3. Spatial variability of sand, silt, clay. bulk density, particle density, and porosity in Marori block of Pilibhit district, Uttar Pradesh

3.2 Chemical Properties

The pH of Marori block ranged from 5.9 -7.7 heaving a mean value of 7.08 (Table 5). The results indicate that 98% pH was normal (6.5-7.5) and 1% of the samples were acidic (pH <6.5). Kumar *et al*. [13] recorded similar results in different blocks of Rampur district Uttar Pradesh. A positive and significant correlation with porosity (r = 0.346*) in the soil (Table 6) (Ramana *et al*. 2015; Kashiwar *et al.* 2018). The electrical conductivity of the analyzed soil sample ranged from 0.03-0.37. The coefficient of variation and standard deviation were 0.55 and 56.65, respectively (Table 5). Bilgaon was found to have the highest electrical conductivity in S_1, while Deshnagar had the lowest in S_{13}. Kumar et al. [14] reported similar trends in the soil fertility status of some Muzaffarnagar, Uttar Pradesh. On the basis of the limits suggested by Muhar et al. [15] for judging the salt problem of soils, most of the samples (99%) were found normal (EC < 1.0 dS/m) and the remaining 1% samples were found in the category of soluble salt content critical for germination (EC 1 to 2 dS/m). The organic carbon content of the soils under investigation exhibited a range of 0.23-0.83% (Table 5). In the study conducted, it was seen that S_2 and S_{31} Himmatnagar and Deshnagar villages exhibited the highest organic carbon.

Conversely, S_{39} situated in Junapuri village displayed relatively low organic carbon content. Furthermore, 50% of the soil samples analyzed exhibited low organic carbon levels, while 40% exhibited medium levels, and the remaining 10% exhibited high organic carbon content. The organic carbon exhibited a significant and negative correlation (r = -0.810**), (r = -0.811**) with bulk density and particle density (Table 6). Sonkar et al. [16] documented similar occurrences in the Sakaldiha block situated inside the industrial region of Chandauli District in Uttar Pradesh. The distributions of chemical properties are presented in Fig. 4.

Table 4. Physical properties of soils of different villages in Marori block of Pilibhit district, Uttar Pradesh

S. No.	Sand (%)	Silt (%)	Clay (%)	PD (g/cm3)	BD (g/cm3)	Porosity (%)
S_1	50.3	45.5	4.2	2.2	1.35	38.64
S_2	14.2	60.5	25.3	1.98	1.17	40.91
S_3	35.5	45.8	18.7	2.1	1.36	35.24
S_4	33.9	41.7	24.4	2.35	1.34	42.98
S_5	40.5	38.2	21.3	2.26	1.32	41.59
S_6	23.2	67.3	9.5	2.28	1.36	40.35
S_7	60.3	16.5	23.2	2.36	1.42	39.83
S_8	54.1	20.6	25.3	2.22	1.43	35.59
S_9	72.4	16.1	11.5	2.24	1.39	37.95
S_{10}	22.3	47.6	30.1	2.02	1.18	41.58
S_{11}	8.6	66.1	25.3	2.04	1.19	41.67
S_{12}	36.4	25.5	38.1	2.24	1.33	40.63
S_{13}	16.7	64.1	19.2	2.29	1.36	40.61
S_{14}	64.4	25.2	10.4	2.25	1.34	40.44
S_{15}	12.1	62.3	25.6	2.28	1.47	35.53
S_{16}	24.3	58.6	17.1	2.31	1.43	38.10
S_{17}	13.1	65.2	21.7	2.28	1.34	41.23
S_{18}	74.4	16.2	9.4	2.04	1.13	44.61
S_{19}	20.3	45.5	34.2	2.32	1.45	37.50
S_{20}	35.1	38.3	26.6	2.25	1.38	38.67
S_{21}	59.6	13.3	27.1	2.21	1.44	34.84
S_{22}	78.4	9.2	12.4	2.33	1.39	40.34
S_{23}	73.7	18.1	8.2	2.36	1.42	39.83
S_{24}	27.2	56.5	16.3	2.31	1.38	40.26
S_{25}	53.1	23.3	23.6	2.35	1.33	43.40
S_{26}	72.3	12.4	15.3	2.19	1.39	36.53
S_{27}	21.5	65.3	13.2	2.28	1.37	39.91
S_{28}	27.7	38.2	34.1	2.24	1.4	37.50
S_{29}	8.2	55.3	36.5	2.26	1.35	40.27
S_{30}	35.3	31.6	33.1	2.04	1.12	45.10
S_{31}	68.2	12.7	19.1	2.26	1.34	40.71
S_{32}	24.4	41.1	34.5	2.28	1.25	45.18
S_{33}	36.7	24.1	39.2	2.36	1.38	41.53
S_{34}	64.3	23.6	12.1	2.34	1.42	39.32
S_{35}	18.1	48.4	33.5	2.45	1.45	40.82
S_{36}	37.5	51.2	11.3	2.33	1.42	39.06
S_{37}	26.2	48.1	25.7	2.36	1.45	38.56
S_{38}	28.4	42.2	29.4	2.27	1.39	38.77
S_{39}	29.6	32.1	38.3	2.31	1.37	40.69
S_{40}	58.1	27.5	14.4	2.02	1.14	43.56
Max.	78.40	67.30	39.20	2.45	1.47	45.18
Min.	8.20	9.20	4.20	1.98	1.12	34.84
Mean	39.02	38.53	22.46	2.25	1.35	39.99
SD	21.07	18.00	9.61	0.11	0.09	2.54
SE	3.33	2.85	1.52	0.02	0.01	0.40
CV	54.01	46.71	42.79	5.01	6.94	6.36

Table 5. Chemical and nutrient properties of soils of different villages in Marori block of Pilibhit district, Uttar Pradesh

S. No.	pH	EC (dS/m)	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S (kg/ha)	Ca (cmol(p+)/kg)	Mg (cmol(p+)/kg)
S_1	5.9	0.37	0.68	172.66	22.50	225.89	25.40	4.8	2.67
S_2	7.0	0.17	0.83	201.45	31.95	139.65	16.93	6.7	3.7
S_3	6.9	0.11	0.64	169.87	27.47	176.31	22.58	5.8	2.55
S_4	7.5	0.11	0.53	161.76	27.63	103.50	28.22	6.9	4.2
S_5	7.4	0.09	0.68	173.54	22.74	99.34	11.29	6.5	3.96
S_6	7.1	0.06	0.53	161.32	13.59	250.87	22.58	5.4	2.7
S_7	7.1	0.10	0.39	199.65	22.67	300.53	14.34	6.3	3.2
S_8	6.7	0.23	0.48	155.44	24.43	210.32	18.54	5.8	2.75
S_9	6.9	0.12	0.38	149.13	40.15	222.41	22.37	5.7	2.97
S_{10}	7.5	0.13	0.80	210.67	36.63	180.45	14.11	6.2	2.42
S_{11}	7.0	0.12	0.79	255.94	31.58	103.50	17.78	5.9	2.36
S_{12}	6.9	0.09	0.68	179.61	27.41	199.67	12.56	5.3	2.21
S_{13}	7.2	0.03	0.67	171.43	40.53	279.21	26.81	6.3	3.89
S_{14}	6.8	0.08	0.68	175.32	31.67	240.56	20.89	5.7	2.32
S_{15}	6.7	0.07	0.29	166.56	27.58	222.60	18.91	5.2	2.41
S_{16}	6.9	0.08	0.38	156.31	31.94	198.32	15.81	5.0	1.97
S_{17}	7.3	0.10	0.63	153.27	18.73	240.43	16.88	3.3	1.53
S_{18}	7.5	0.08	0.76	250.87	36.14	140.31	26.81	5.3	2.25
S_{19}	7.5	0.09	0.24	152.76	45.34	280.17	13.56	6.4	3.22
S_{20}	7.2	0.07	0.53	153.14	31.32	252.65	25.12	5.8	2.87
S_{21}	7.5	0.10	0.45	163.35	22.38	221.69	16.89	4.7	2.22
S_{22}	7.3	0.08	0.42	211.47	49.72	231.38	18.63	6.5	3.23
S_{23}	7.1	0.06	0.27	171.51	27.65	241.13	14.87	5.8	2.79
S_{24}	7.0	0.10	0.42	169.48	40.50	226.54	27.10	4.3	2.22
S_{25}	7.1	0.06	0.47	168.76	31.87	293.67	12.53	6.2	3.21
S_{26}	7.3	0.12	0.56	164.56	27.78	132.83	23.14	6.5	3.1
S_{27}	7.1	0.07	0.39	169.37	18.00	139.63	13.83	6.1	2.96
S_{28}	7.2	0.10	0.54	182.54	27.43	156.45	21.25	5.7	2.59
S_{29}	7.3	0.08	0.50	230.45	36.76	133.61	14.96	4.8	2.24
S_{30}	7.1	0.10	0.83	200.89	31.50	210.66	19.34	5.4	2.21
S_{31}	7.2	0.14	0.53	166.32	49.50	154.98	21.56	6.2	3.25
S_{32}	7.7	0.08	0.45	162.38	27.65	123.54	15.52	5.2	2.2
S_{33}	6.8	0.07	0.35	240.46	40.85	130.16	23.71	4	1.87
S_{34}	6.6	0.08	0.36	177.12	22.35	220.63	21.17	6.3	3.4
S_{35}	7.0	0.10	0.24	152.53	31.56	123.76	26.25	6.4	3
S_{36}	6.9	0.10	0.35	156.56	40.22	130.50	14.39	5.6	2.43
S_{37}	6.7	0.07	0.38	222.34	27.39	220.75	23.99	6.2	2.86
S_{38}	7.2	0.05	0.23	149.76	22.76	160.68	20.32	5	2.2
S_{39}	6.8	0.06	0.27	153.97	40.85	295.67	16.46	4.9	1.97
S_{40}	7.4	0.06	0.78	265.63	23.67	110.21	11.85	4.7	2.22
Max.	7.70	0.37	0.83	265.63	49.72	300.53	28.22	6.90	4.20
Min.	5.90	0.03	0.23	149.13	13.59	99.34	11.29	3.30	1.53
Mean	7.08	0.10	0.51	181.25	30.81	193.13	19.23	5.62	2.71
SD	0.33	0.06	0.18	31.65	8.46	59.59	4.85	0.79	0.61
SE	0.05	0.01	0.03	5.00	1.34	9.42	0.77	0.12	0.10
CV	4.62	56.66	35.19	17.46	27.45	30.85	25.24	14.04	22.36

Table 6. Correlation between physico-chemical and nutrient properties of different villages of Marori block of Pilibhit district, Uttar Pradesh

	Sand	Silt	Clay	BD	PD	Poro	pH	EC	OC	N	P	K	S	Ca	Mg
Sand	1														
Silt	-0.891**	1													
Clay	-0.525**	0.080	1												
BD	0.038	-0.035	-0.019	1											
PD	0.014	-0.045	0.054	0.808**	1										
Poro	-0.045	0.003	0.091	-0.719**	-0.172	1									
pH	-0.033	-0.090	0.241	-0.311	-0.144	0.346*	1								
EC	0.126	-0.038	-0.205	-0.066	-0.269	-0.213	-0.506**	1							
OC	-0.016	0.080	-0.115	-0.810**	-0.811**	0.392*	0.129	0.280	1						
N	0.042	-0.077	0.052	-0.589**	-0.485**	0.423**	0.102	-0.072	0.472**	1					
P	0.109	-0.208	0.149	-0.024	0.062	0.117	0.112	-0.097	-0.114	0.122	1				
K	0.137	-0.114	-0.087	0.369*	0.315*	-0.240	-0.258	-0.079	-0.261	-0.349*	0.067	1			
S	0.061	0.029	-0.188	0.127	0.109	-0.086	-0.233	0.157	-0.007	-0.078	0.125	-0.012	1		
Ca	0.174	-0.145	-0.110	0.040	0.034	-0.031	0.134	0.004	0.033	-0.080	0.132	-0.062	0.027	1	
Mg	0.168	-0.085	-0.209	0.121	0.170	-0.010	0.100	0.074	0.019	-0.168	0.064	-0.012	0.152	0.848**	1

***. Correlation is significant at the 0.01 level (2-tailed).*
**. Correlation is significant at the 0.05 level (2-tailed).*

3.3 Primary and Secondary Nutrient Status

The soil in the research region exhibited a range of available nitrogen content, spanning from 149.13-265.63 kg/ha with a mean value of 181.25 kg/ha (Table 5). Among the samples, sample number S_{40} from the village Junapuri exhibited the greatest nitrogen content, while sample number S_9 from the village ArajiChant exhibited the lowest nitrogen content [13]. Out of 40 soil samples, 82.48% of samples had less than 280 kg/ha, 17.52% of samples had between 280 and 560 kg/ha, and no sample had more than 560 kg/ha based on the classification proposed by Subbiah and Asija [17] (Devastu et *al.* 2017). Nitrogen has a significant and positive correlation (r = 0.472**) with organic carbon (Table 6) Bharteey *et al*. (2023). The phosphorus concentration in the soil of the research region exhibited a range of 13.59-49.72 (kg/ha), with a mean value of 30.81 P_2O_5 (kg/ha). In the study, it was seen that sample number S_{22} from ChidiaDih village exhibited the highest phosphorus content of 49.72. Additionally, it was found that 73% of the soil samples had the highest P_2O_5 (kg/ha) level, while 27% of the soil samples exhibited a medium P_2O_5 (kg/ha) content. Based on the limit proposed by Muhr et al. [15] The available potassium content in these soils ranged from 99.34-300.53 kg/ha, with a mean of 193.13 kg/ha. No. S_7 village Devipura has the maximum potassium content, while No. S_5 village Mohanpur has the lowest potassium content. 75% of 40 soil samples had medium potassium content, 25% had low potassium content, and no samples had high potassium content. Singh et al [18] reported a similar trend in the soil fertility status of Arajiline block Varanasi district Uttar Pradesh. The available calcium ranged from 3.3-6.9 (Cmol(p+)/kg) in the soils of the Marori block of the Pilibhit district, with a mean value of 5.62 (Cmol(p+)/kg). Lalpuriya village had the highest calcium availability, while Kaim village had the lowest calcium availability. A similar result was also obtained by Sharma et al. [19] in the vegetable-growing soil of the Varanasi district with a mean value of 1764 ppm of available calcium. The available magnesium ranged from 1.53-4.20 (Cmol(p+)/kg), Lalpuriya village sample No. S_4 had the highest Mg^{2+}, while Kaim village sample no. S_{17} had the lowest Mg^{2+}. Total samples were found to be within the adequate range for Mg^{2+} availability. Similar result is also

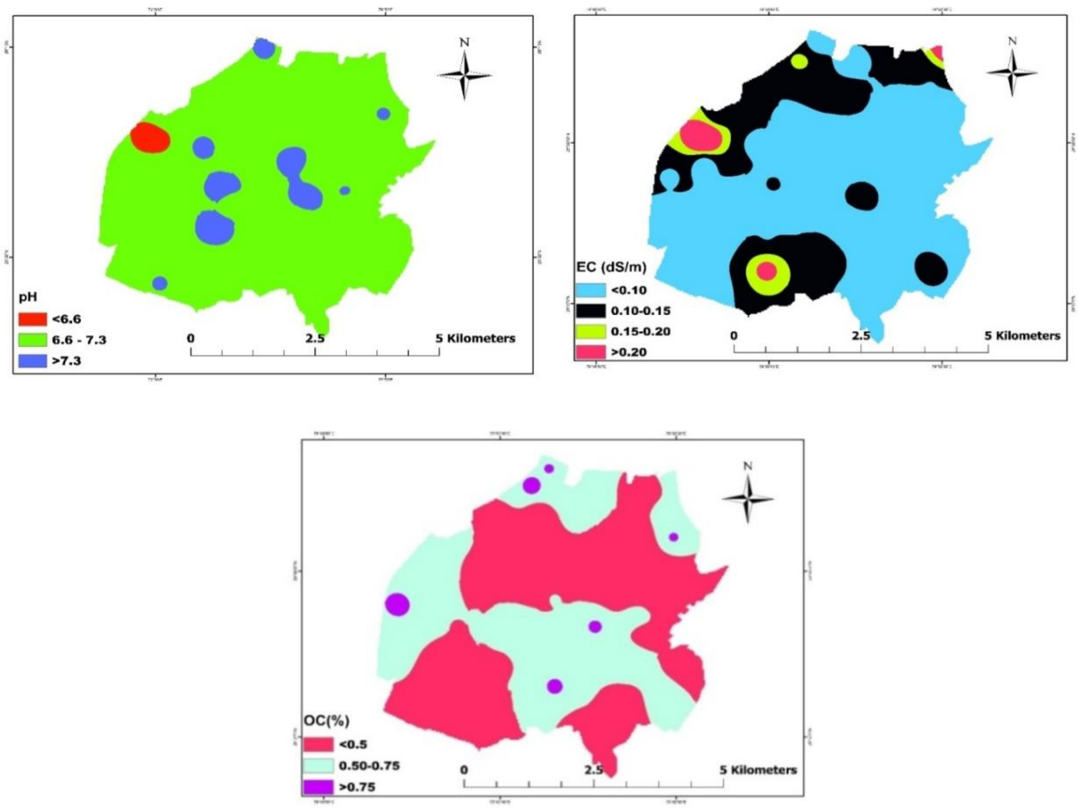

Fig. 4. Spatial variability of pH, EC and OC in Marori block of Pilibhit district, Uttar Pradesh

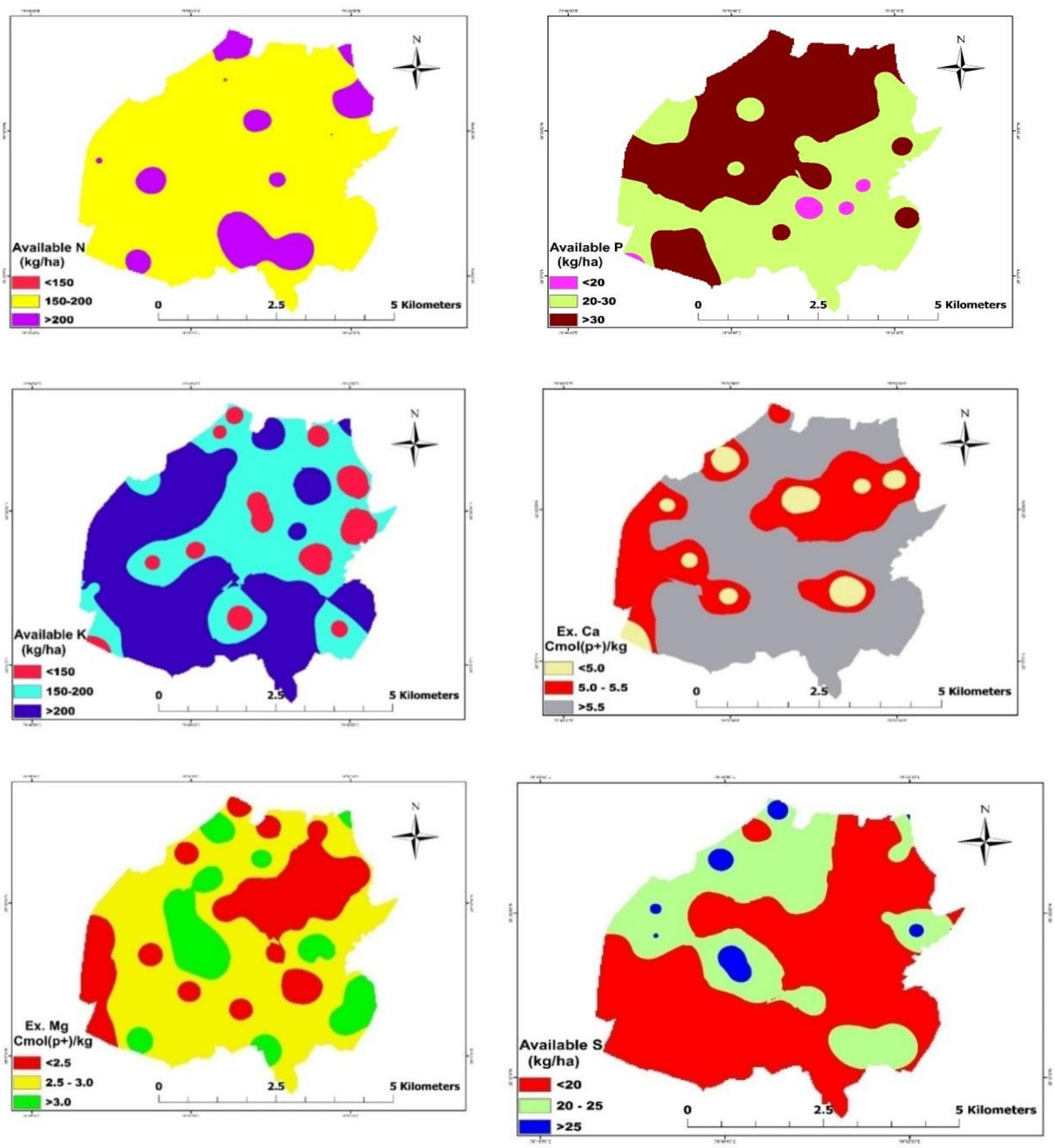

Fig. 5. Spatial variability of Available N, P, K, Ca, Mg, and S in Marori of block of Pilibhit District, Uttar Pradesh

obtained by Sharma et al. [19] The range of sulphur content in Marori block soils was between 11.29-28.22 kg/ha. Sample No. S_4 from the village of Lalpuriya had the highest available sulphur content, while sampled no. S_5 from the village of Mohanpur had the lowest. Similar results were also found by Rai *et al*. [20]in black soil of Varanasi district of eastern Uttar Pradesh.The geographical distribution of available primary and secondary nutrients in the study area is presented in Fig 5.

3.4 Nutrient Index Value of Study Area

The Nutrient index value (NIV) for available primary nutrients *i.e.* N, P, K, and S. Marori block of the Pilibhit district were given below in Fig. 1. The nutrient index value for the soils of the Marori block was low for the available nitrogen, Phosphorus, potassium and Sulphur. It was analyzed that NIV for N, P, K and S were 1.20, 0.8, 0.81 and 0.98 respectively, against the nutrient index value less than 1.5 for low, 1.5 to 2.5 for medium and greater than 2.5 for high [18]

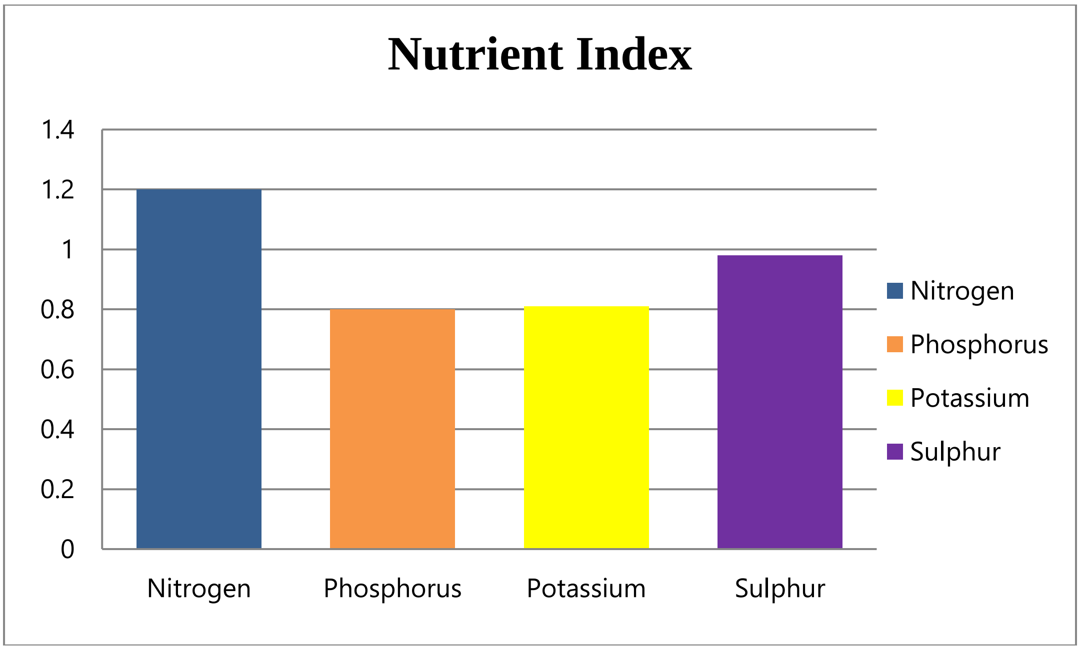

Fig. 6. Nutrient index value of Marori block of Pilibhit district

4. CONCLUSION

It can be concluded the Marori block of Pilibhit district's soil can be classified as sandy loam, clay loam, and silt clay loam, with a normal pH. Out of 40 soil samples, 50% had low organic carbon, 40% medium, 10% high, and 100% low available nitrogen. 73% had high available P, 75% medium and 25% low available K. The soil contained exchangeable Ca and Mg was 100% sufficient. This could be attributed to Soil deterioration in the district as a result of bad agricultural practices, intensive farming, monoculture and excessive irrigation. Integrated nutrient management (INM), which rationally combines chemical fertilizers with biofertilizers and organic manures, should be put into place to address these problems of Pihibit District which could be environmentally safe and economically viable. The advantages of biofertilizers and bio inoculants in crop production for increasing soil fertility and nutrient status should be made known to farmers. Soil mapping using GIS may generate an idea about the soil fertility state, and it could be very useful for fertilizer management for a specific area simply by applying previously analyzed soil data, leading to site-specific smart nutrient management. Camps, rallies, training sessions, and frontline demonstrations should be arranged to have a greater and more persistent impact on farmers regarding the benefits of soil testing.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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