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Studies on the Physical, Chemical, and Biological properties of the soil of Jasra village of Prayagraj district, Eastern Uttar Pradesh, India

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ABSTRACT

An assessment of the soil fertility status of Jasra village of Prayagraj District, Uttar Pradesh carried out in 2022-2023. The prime objectives of this study were to carry out the Physical, Chemical and Biological properties of soil at different depths of various sites of Jasra village, to determine the availability of macro and micronutrients on the soil of these soil samples and provide Soil Health Card for the village. For the assessment, 10 sampling locations were selected. Soil samples were collected at the depth of 0-15 cm and 15-30 cm respectively. The Soil colour (Dry Condition) of soil varied from Olive yellow to Olive grey and Soil (wet Condition) varied from Olive brown to Dark greyish brown. Soil textural class was sandy loam. It clearly indicated that the soil has good Water Holding capacity (33.45 to 42.82%) and good physical condition, Bulk density (1.23 to 1.37 Mg m^{-3}). Particle density (2.223 to 2.405 Mg m^{-3}). % Pore Space (38.45 to 48.34 %). The pH of the soil is slightly saline in nature (7.50 to 7.92) and the Electrical conductivity (0.10 to 0.35 dS m^{-1}) was suitable for all the crops. Organic carbon ranged from low to medium (0.25 to 0.43%). These soils have low to medium Nitrogen (126.42 to 234.68 kg ha^{-1}), Phosphorus (11.48 to 24.82 kg ha^{-1}), and Potassium (141.53 to 178.33 kg ha^{-1}), in all the sites. Calcium (1.20 to 2.90 Meq $100g^{-1}$ of soil) and Magnesium (0.20 to 2.20 Meq $100g^{-1}$ of soil) are sufficient in soil. Sulphur (3.58 to 9.35 ppm) content was found deficient in the sites of the village. The Zinc (0.36 to 1.28 ppm) was also found low to medium at the different sites of the village. The bacterial (32 to 260 CFU g^{-1} of soil) and fungal (15 to 29 CFU g^{-1} of soil) colony was found low in cereals-grown fields but found sufficient in vegetable-grown fields. There is an awareness of the need to pay greater attention to the role of macronutrients and micronutrient enhancement for good soil health and proper nutrition of plants to attain optimum economic yield and soil is suitable for all major tropical and sub-tropical crops.

Key words: *Prayagraj District, Uttar Pradesh, Jasra, Physical, Chemical, Biological properties, Soil Health, Tropical, etc.*

Introduction

Soil is a complex and dynamic natural resource that plays a critical role in supporting life on Earth. It is composed of a mixture of minerals, organic matter, water, air, and a diverse array of microorganisms (Brady and Weil, 2016). It is the product of biochemical weathering of the parent material and its formation is influenced by the soil formation factors like climate, organism, parent material, relief, and time (Belwal and Mehta, 2014). An independent body in nature with a singular morphology from the surface to the parent materials is expressed by the sample profile (Tan, 1995). Soil properties can be broadly categorized into physical, chemical, and biological parameters. The physical properties include Bulk Density (g/cc), Particle Density (g/cc), Pore Space (%), Water Holding Capacity (%), Soil

Color, And Soil Texture. The chemical properties encompass pH, Electrical Conductivity, % Organic Carbon, Available Nitrogen, Available Phosphorus, Potassium, Calcium, Magnesium, Sulphur, And Zinc. Finally, the biological parameters comprise The Colony Forming Unit Of Bacteria And Fungi.Understanding these properties is critical for effective soil management and sustainable productivity. In this study, we investigated the impact of different land systems on the chemical, physical, and biological properties of soils in the village of Jasra, U.P., aiming to establish appropriate guidelines for the optimal utilization and management of the soil for specific land use. The fertility and health of soil form the foundation for the healthy existence of flora, fauna, and humans. The organic matter present in the soil serves as the fundamental constituent of fertile and productive soil. It is of paramount importance to comprehend the significance of organic matter in the health of the soil to develop ecologically sustainable farming practices. The green revolution in India, which transformed the country's agriculture from a state of destitution to self-sufficiency, was predominantly accomplished through the cultivation of high-yielding crops responsive to fertilizers. However, the increased use of fertilizers after the green revolution led to a decline in the health and quality of land and soil, which in turn gradually reduced productivity Under India's current exploitative agricultural pattern, the soil's ability to supply nutrients declined steadily under continuous and intensive cropping systems. Therefore, the use of balanced fertilizers has become more critical than ever in preserving and sustaining the soil's quality (Pandey *et al.,* 2008). Soil testing refers to the qualitative analysis of soils and is well recognized as a scientific means for quick characterization of the inherent fertility status of soils (Meena *et al.,* 2018). Soil test-based fertility management is an efficient tool for increasing the productivity of agricultural soils that have a high degree of spatial variability resulting from the combined effects of physical, chemical, or biological processes (Majumdar *et al.,* 2015). Keeping all these facts in view the village Jasra of Prayagraj district of Uttar Pradesh was selected for the study.

Materials and Methods

Study area

The sampling has been done at Jasra Village of Prayagraj district, Eastern U.P (India). The area of the Prayagraj district comes under subtropical and semi-arid climates. Due to the subtropical climate prevailing in the southeast part of the U.P. the extremes in temperature drop 1-2 °C in December and January and are very hot in summer with temperatures ranging between 46-48 °C in the month of May-June. The average rainfall is around 1013.4mm with a maximum concentration from July to September and occasional frost in winter and hot wind (Loo) in summer.

Data analysis

10 composite soil samples were collected only from open places and avoided collecting the soil samples under shady tree areas or from areas near the main bund and irrigation channels. The collection of soil sampling dates was selected in such a way that these represent the major seasons of the year viz. autumn, winter, spring, dry summer, and wet summer and these samples were analyzed for Soil texture, Soil colour, Bulk density (Db), Particle density (Dp), Percent Pore space, Water holding capacity, pH, Electrical conductivity (EC), organic carbon(OC), Available Nitrogen, Available Phosphorus, Available Potassium, Calcium, Magnesium, Available Sulphur, zinc, Available bacterial colonies in soil and available fungal colonies in soil by Bouyoucos-hydrometer (1927), Munsell colour chart (1971), gravimetrical method (1992), gravimetrical method (1992), gravimetrical method (1992), gravimetrical method (1992), digital pH meter (1958), digital EC meter (1950), wet oxidation method (1947), Alkaline permagnet oxidation (1956), Olsen spectrophotometric (1954), Flame photometric (1949), Titration (1973), Titration (1973), Chesnin and Yien method (1950), DTPA extraction method (1978), serial dilution method and serial dilution method respectively.

Results and Discussions

The major findings of the experiment are summarized as follows:

Soil colour

The color of the soil sample in a dry condition varies at different depths from Olive yellow to Olive grey and in wet conditions; it also varies at different depths from Olive brown to dark greyish brown.

Soil Texture

The sand, silt, and clay percent range from 67% - 68.64%, 14.10% - 19.82%, and 11.80% - 18.70% respectively.

Bulk density

The maximum bulk density 1.33 and 1.37 Mg m^{-3} of soil was recorded at 0-15 and 15-30 cm depths at S_2, S_5, S_6 and S_2, S_5, S_6 and the minimum 1.23 and 1.27 Mg m^{-3} of soil was recorded at S_7, S_8 and S_8.

Particle density

The maximum particle density 2.400 and 2.405 Mg m^{-3} of soil was recorded at 0-15 and 15-30 cm depths at S_3 and S_3 and the minimum 2.223 and 2.226 Mg m^{-3} of soil was recorded at S_6 and S_6.

Percent pore space

The maximum percent pore space 48.34 and 46.73 of soil was recorded at 0-15 and 15-30 cm depths at S_8 and S_8 and the minimum 40.17 and 38.45 of soil was recorded at S_6 and S_6.

Water holding capacity

The maximum water holding capacity 42.82 and 41.63 % of the soil was recorded at 0-15 and 15-30 cm depths at S_{10} and S_3 the minimum 35.02 and 33.45 of soil was recorded at $S_5$and S_5.

Soil pH

The maximum pH 7.92 and 7.98 of soil was recorded at 0-15 and 15-30 cm depths at S_6 and S_5 and the minimum 7.50 and 7.69 of soil was recorded at S_3 and S_2.

Soil Electrical conductivity(EC)

The maximum EC 0.35 and 0.30 dS m^{-1} of soil was recorded at 0-15 and 15-30 cm depths at S_5 and S_5 and the minimum 0.13 and 0.10 dS $m^{-1}$of soil was recorded at S_8 and $S_{3,}$ S_8.

Soil Organic carbon

The maximum organic carbon 0.43 and 0.38 % of the soil was recorded at 0-15 and 15-30 cm depths at S_3 and S_3 and the minimum 0.31 and 0.25 of soil was recorded at S_6 and S_6.

Available Nitrogen

The maximum nitrogen 234.68 and 213.71 kg ha^{-1} of soil was recorded at 0-15 and 15-30 cm depths at S_2 and S_2 and the minimum 148 and 126.42 kg ha^{-1} of soil was recorded at S_6 and S_6.

Available Phosphorus

The maximum phosphorus 24.82 and 19.78 kg ha^{-1} of soil was recorded at 0-15 and 15-30 cm depths at S_3 and S_3 and the minimum 14.58 and 11.48 kg ha^{-1} of soil was recorded at S_6 and S_6.

Available potassium

The maximum potassium 178.33 and 169.83 kg ha^{-1} of soil was recorded at 0-15 and 15-30 cm depths at S_3 and S_3 and the minimum 150.33 and 141.53 kg ha^{-1} of soil was recorded at S_6 and S_6.

Available Sulphur

The maximum sulphur 9.35 and 7.80 ppm of soil was recorded at 0-15 and 15-30 cm depths at S_3 and S_3 and the minimum 4.73 and 3.58 ppm of soil was recorded at S_5 and S_5.

Available Calcium

The maximum calcium 2.90 and 2.63 meq/100g of soil was recorded at 0-15 and 15-30 cm depths at S_2 and S_2 and the minimum 1.45 and 1.20 meq/100g of soil was recorded at S_8 and S_5.

Available Magnesium

The maximum magnesium 2.20 and 1.80 meq/100g of soil was recorded at 0-15 and 15-30 cm depths at S_1 and S_1 and the minimum 0.26 and 0.20 meq/100g of soil was recorded at S_6 and S_6.

Available Zinc

The maximum zinc 1.28 and 1.21 ppm of soil was recorded at 0-15 and 15-30 cm depths at S_4 and S_7 and the minimum 0.48 and 0.36 ppm of soil was recorded at S_9 and S_9.

Available bacterial colonies in the soil

The maximum bacterial colony of 260 and 218 CFU/g of soil was recorded at 0-15 and 15-30 cm depth at S_7, $S_{10,}$ and $S_{10,}$ and the minimum 38 and 32 CFU/g of soil was recorded at S_1 and S_1.

Available fungal colonies in the soil

The maximum fungal colony of 29 and 27 CFU/g of soil was recorded at 0-15 and 15-30 cm depth at S_6, $S_{8,}$ and $S_{7,}$ and the minimum 18 and 15 CFU/g of soil was recorded at S_{10} and S_1, S_{10}.

Table 1. Physical parameters of the Soil

- **Soil colour (Dry condition)** * **Soil colour (Wet condition)**

Sampling sites	Depth (0-15 cm)	Depth (15-30 cm)	Depth (0-15 cm)	Depth (15-30cm)
S_1	5Y 6/6 OLIVE YELLOW	5Y 5/2 OLIVE GREY	2.5Y 4/4 OLIVE BROWN	2.5Y 4/2 DARK GREYISH BROWN
S_2	5Y 6/6 OLIVE YELLOW	5Y 5/2 OLIVE GREY	2.5Y 4/4 OLIVE BROWN	2.5Y 4/2DARK GREYISH BROWN
S_3	5Y 6/6O LIVE YELLOW	5Y 5/2 OLIVE GREY	2.5Y 4/4 OLIVE BROWN	2.5Y 4/2DARK GREYISH BROWN
S_4	5Y 6/6 OLIVE YELLOW	5Y 5/2 OLIVE GREY	2.5Y 4/4 OLIVE BROWN	2.5Y 4/2DARK GREYISH BROWN
S_5	5Y 6/6 OLIVE YELLOW	5Y 5/2 OLIVE GREY	2.5Y 4/4 OLIVE BROWN	2.5Y 4/2DARK GREYISH BROWN
S_6	5Y 6/6 OLIVE YELLOW	5Y 5/2 OLIVE GREY	2.5Y 4/4 OLIVE BROWN	2.5Y 4/2DARK GREYISH BROWN
S_7	5Y 6/6 OLIVE YELLOW	5Y 5/2 OLIVE GREY	2.5Y 4/4 OLIVE BROWN	2.5Y 4/2DARK GREYISH BROWN
S_8	5Y 6/6 OLIVE YELLOW	5Y 5/2 OLIVE GREY	2.5Y 4/4 OLIVE BROWN	2.5Y 4/2DARK GREYISH BROWN
S_9	5Y 6/6 OLIVE YELLOW	5Y 5/2 OLIVE GREY	2.5Y 4/4 OLIVE BROWN	2.5Y 4/2DARK GREYISH BROWN
S_{10}	5Y 6/6OLIVE YELLOW	5Y 5/2OLIVE GREY	5Y 6/6OLIVE YELLOW	5Y 5/2OLIVE GREY

- **Soil texture**

Sampling sites	% Sand	%Silt	% Clay	Textural Class
S_1	68.50	19.20	12.30	Sandyloam
S_2	68.38	19.82	11.80	Sandyloam
S_3	68.00	18.30	13.70	Sandyloam
S_4	67.20	14.10	18.70	Sandyloam
S_5	67.10	14.70	18.20	Sandyloam
S_6	67.00	14.30	18.70	Sandyloam
S_7	68.00	17.64	14.36	Sandyloam
S_8	67.20	17.00	15.80	Sandyloam
S_9	68.64	18.00	13.36	Sandyloam
S_{10}	68.00	18.30	13.70	Sandyloam

- **Rest physical parameters of soil**

Sampling sites	Bulk density		Particle density		%Pore space		Water holding capacity	
Sampling depth	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
S_1	1.25	1.29	2.352	2.356	46.85	45.25	41.58	40.52
S_2	1.33	1.37	2.383	2.388	44.19	42.63	38.91	37.36
S_3	1.25	1.29	2.400	2.405	47.92	46.36	42.29	41.63
S_4	1.25	1.30	2.322	2.325	46.17	44.09	41.71	38.90
S_5	1.33	1.37	2.224	2.229	40.20	38.54	35.02	33.45
S_6	1.33	1.37	2.223	2.226	40.17	38.45	35.71	33.54
S_7	1.23	1.28	2.353	2.357	47.73	45.69	41.37	40.96
S_8	1.23	1.27	2.381	2.384	48.34	46.73	44.43	41.37
S_9	1.25	1.31	2.324	2.328	46.21	43.73	41.12	39.37
S_{10}	1.24	1.30	2.352	2.356	47.28	44.82	42.82	39.28

Table 2. Chemical parameters of the Soil

Sampling site	pH		EC		OC		N		P		K		S		Ca		Mg		Zn	
Sampling depth	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
S_1	7.84	7.85	0.18	0.13	0.34	0.29	221.27	208.54	16.88	14.56	154.78	148.50	7.65	6.42	2.50	2.32	2.20	1.80	0.85	0.73
S_2	7.66	7.69	0.25	0.20	0.41	0.37	234.68	213.71	21.82	17.95	176.05	167.71	6.33	5.82	2.90	2.63	2.10	1.15	1.10	0.98
S_3	7.50	7.70	0.15	0.10	0.43	0.38	224.64	206.10	24.58	19.78	178.33	169.83	9.35	7.80	1.70	1.40	1.30	1.10	0.87	0.74
S_4	7.67	7.69	0.30	0.20	0.40	0.37	188.16	164.50	20.28	16.35	173.30	165.27	8.75	7.63	1.80	1.50	1.20	0.90	1.28	1.14
S_5	7.78	7.98	0.35	0.30	0.38	0.32	154.86	135.57	16.15	12.11	165.42	157.69	4.73	3.58	1.80	1.20	0.39	0.25	0.95	0.86
S_6	7.92	7.93	0.20	0.15	0.31	0.25	148.12	126.42	14.58	11.48	150.33	141.53	5.64	4.81	1.65	1.30	0.26	0.20	0.74	0.66
S_7	7.76	7.85	0.15	0.13	0.39	0.36	216.43	192.13	21.42	17.25	170.00	163.36	7.89	6.51	1.60	1.39	1.21	1.06	1.30	1.21
S_8	7.76	7.85	0.13	0.10	0.40	0.36	197.36	154.20	17.87	12.36	169.26	160.57	5.35	4.31	1.45	1.30	1.30	1.02	1.08	0.85
S_9	7.78	7.83	0.15	0.11	0.39	0.33	188.16	172.00	16.09	13.25	161.70	153.72	5.89	5.13	1.61	1.24	1.10	0.72	0.48	0.36
S_{10}	7.80	7.91	0.18	0.13	0.36	0.31	220.27	207.62	15.88	12.56	156.50	149.09	6.65	5.42	2.59	2.22	2.11	1.70	0.88	0.74

Table 3. Biological parameters of the Soil

Sampling site	Bacterial colonies		Fungal colonies	
Sampling depth	0-15 cm	15-30 cm	0-15 cm	15-30 cm
S_1	38	32	22	15
S_2	240	173	27	21
S_3	256	211	26	21
S_4	142	80	24	16
S_5	65	52	35	30
S_6	49	41	29	24
S_7	260	118	34	27
S_8	141	98	29	25
S_9	136	68	24	21
S_{10}	260	218	18	15

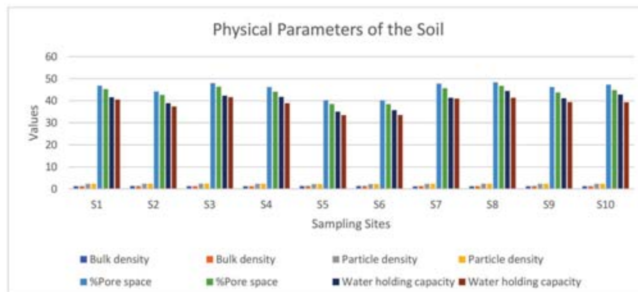

Fig. 1. Physical Parameters of the soil

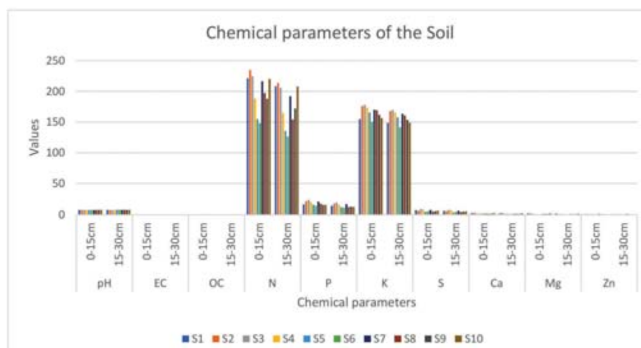

Fig. 2. Chemical parameters of the soil

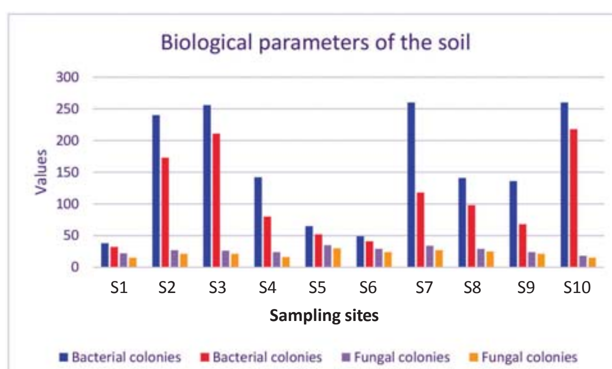

Fig. 3. Biological parameters of the soil

Table 4. Correlation matrix of Chemical and Biological parameters of the soil of 0-15 cm depth of soil.

	pH	EC	% OC	% OM	N	P	K	Ca	Mg	S	Zn	Bacteria	Fungus
pH	1												
EC	0.8	1.0											
% Organic Carbon	-0.9	0.0	1.0										
% Organic Matter	-0.9	0.0	1.0	1.0									
Nitrogen	-0.5	-0.4	0.5	0.5	1.0								
Phosphorus	-0.9	-0.1	0.8	0.8	0.6	1.0							
Potassium	-0.9	0.1	0.9	0.9	0.4	0.9	1.0						
Calcium	0.1	0.2	-0.1	-0.1	0.6	0.0	-0.1	1.0					
Magnesium	0.2	0.3	-0.2	-0.2	0.9	0.3	0.1	0.8	1.0				
Sulphur	-0.6	-0.2	0.4	0.3	0.5	0.7	0.4	0.0	0.4	1.0			
Zinc	-0.3	0.3	0.4	0.4	0.3	0.5	0.6	0.0	0.1	0.3	1.0		
Bacteria	-0.6	-0.3	0.6	0.6	0.7	0.7	0.6	0.2	0.4	0.4	0.4	1.0	
Fungus	0.0	0.3	0.1	0.1	-0.4	0.1	0.3	-0.5	-0.7	-0.3	0.3	-0.1	1.0

- pH is +vely correlated with EC, Ca, Mg and Fungus but -vely correlated with %OC, %OM, N, P, K, S, Zn and Bacteria.
- EC is +vely correlated with K, Ca, Mg, Zn and Fungus and -vely correlated with %OC, %OM, N, P, S and Bacteria.
- %OC is +vely correlated with %OM, N, P, K, S, Zn, Bacteria and Fungus but -vely correlated with Ca and Mg.
- %OM is +vely correlated with N, P, K, S, Zn, Bacteria and Fungus but -vely correlated with Ca and Mg.
- Nitrogen is +vely correlated with P, K, Ca, Mg, S, Zn, and Bacteria but -vely correlated with Fungus.
- P is +vely correlated with K, Ca, Mg, S, Zn, Bacteria and Fungus.
- K is +vely correlated with Mg, S, Zn, Bacteria and Fungus but -vely correlated with Ca and Mg.
- Ca is +vely correlated with Mg, S, Zn, and Bacteria but -vely correlated with Fungus.
- Mg is +vely correlated with S, Zn, and Bacteria but -vely correlated with Fungus.
- S is +vely correlated with Zn, and Bacteria but -vely correlated with Fungus.
- Zn is +vely correlated with Bacteria and Fungus.
- Bacteria is -vely correlated with Fungus.

Conclusion

The results of the experiment are concluded as soil colour, soil texture, Db, Dp, percent Pore space, percent Solid Space and water holding capacity of the soil of Jasra village were found good for plant growth. The Soils of Jasra village were found slightly saline in nature which is suitable for crop growth. The percent Organic Carbon, N, P, K, and the content of the soil varied from Low to Medium. Calcium and Magnesium are sufficient in the soil. Sulphur content of the soil was found deficient in the soil of the village. The bacterial and fungal colony was found low in the cereals-grown field but found sufficient in the vegetable-grown field.

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