Original Research Article

Study of Physico-chemical and Nutrient Status of the Soil in Chiraigaon Block, Varanasi District, Uttar Pradesh

Abstract

A study was conducted to evaluate the soil fertility and their quality parameters of Chiraigaon Block of Varanasi district Uttar Pradesh which is located at Latitude 25.3°N, and Longitude is 82.9°E and at elevation of 81m (AMSL)in the centre of Gangatic plain of Northern India. Totalof54 soil samples were collected from the six different villages of Chiraigaon Block. Physico-chemical properties analysis showed average bulk density and particle density of 1.22 and 2.37 Mg/m^3 respectively whereas water holding capacity ranged from 29.80 to 51.70 %, pH ranged from 7.1 to 8.3, EC ranged from 0.18 to 1.68 dSm^{-1} and organic carbon content ranged from 0.21 to 0.76 % withlow organic carbon content in 70.37% of the soil samples. Macro-nurient analysis showed low to medium range for nitrogen, phosphorus and sulphur with average values of 244.15 Kg ha^{-1},14.78 Kg ha^{-1} and 10.60 mg kg^{-1} respectively whereas medium to high range of potassium (481.7 Kg ha^{-1}) and high range of exchangeable calcium (11.82 Meq/100g) and magnesium (9.89 Meq/100g). Micro-nutrient analysis showed low to high range for manganese and zinc with value range of 3.08 to 56.1 mg $kg-^{1}$ and 0.58 to 19.62 mg $kg-^{1}$ respectively, whereas medium to high range for iron (5.1 to 72 mg $kg-^{1}$) and high range for available copper (2.2 to 4.08 mg $kg-^{1}$). The current study is expected to help the farmers of study location in guiding techniques required for long-term soil fertility management and to improve soil quality and for developing resistant crop varieties that can grow without any yield reduction**.**

Keywords: *Macronutrient; Micronutrient; Nutrient Status; Physico-chemical;Soil Fertility*

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Introduction

Soil gives medium for plant growth and support for animals and human activity. Soil health referred to soil quality and is described as the continued potential of soil which work as vital living ecosystem that sustains human, plants and animals. Mostly the soils are supplemented with the chemical fertilizers, organic manures and composts in which they meet their nutritional requirements of plants [1]. Soil is the natural body of minerals and organic constituents, which differentiated into horizons of variable depths below in morphology, which differs from parent material, chemical composition, biological properties and their physical makeup [2]. The plant needs essential nutrients for their completion of life cycle, so deficiency of an essential nutrients element makes it impossible for plant to complete their vegetative and reproductive stages of their life cycle. So it will be necessary to analyse the

soils to know the deficient nutrients and to add it in right quantity. Requirement of macro-nutrients in plants is needed relatively higher amount than micro-nutrients [3].

Nitrogen is an important part of chlorophyll, nucleic acids, enzymes, amino acids and proteins, which promote root growth and induces vegetative growth. In plant Phosphorus work as energy storage in plant, stimulates root development and seed formation. Potassium acts as enzyme activator, it help in disease and drought resistance in plants, helps in stomata functioning, also helpful for formation and translocation of sugar, carbohydrate. Ca, Mg and S are secondary nutrients which play a very important role in the growth and development of plant, it promotes nodule formation in leguminous plants roots [4]. "The capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or improve water and air quality, and promote the plant and animal health" [5].Uttar Pradesh is fortunate with the fertile Indo-Gangetic plains region and, it is a significant contributor to the food security of the nation.Chiraigaon Block is placed in thenVaranasi district in Uttar Pradesh.

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A good knowledge of physio-chemical and nutrient statusin the soil is essential to improve soil productivity, to find the quantity and type of fertilisers and manures or compost to be used on a particular crop. It helps to avoid financial losses in fertilisers. In this context, the detailed soil survey of Chiraigaon block of 6 different villages namely Umaraha,Khanpur,Bariyasanpur, Sion,Paterwan andSathwa, were taken for study to provide a site specific database for the planning optimum and the efficient use of soil nutrients status, inChiraigaon Block, Varanasi U.P.

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MATERIALS AND METHODS

Description of Study Location

i. Experimental Site

Chiraigaon block is one among the 8 blocks in Varanasi district which is located in the centre of the Gangetic plain of northern India, in the eastern part of the state of Uttar Pradesh, at an elevation of 80.71 meters form mean sea level [6]. From Chiraigaon block 54 representative surface soil samples were collected from the six selected villages namely Umaraha, Khanpur, Bariyasanpur, Sivon, Paterwan, Sathwa.

ii. Weather and Climate

The climate of Chiraigaon block of Varanasi is mild and generally warm and temperate. The rainfall in Varanasi is significant, with precipitation even during the driest month. The Köppen-Geiger climate classification is Cfa [7]. In Varanasi, the average annual temperature is 25.7 °C and the annual rainfall around 982 mm with the lowest precipitation in April (average of 6 mm) [8].

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iii. Soil Characteristics

The soils of Varanasi districts resembles that of the alluvial plains of river Ganga and varies from sandy, sandy loam, clay loam, sodic or saline soil, wasteland and ravines**.** The soil fertility status ranges from moderate to poor. The major cropping patterns followed in the district are rice- maize, wheat-mustard, barley, vegetables.

Method of sampling and processing

Collection of Soil Samples

The soil samples were collected randomly from each villages of Varanasi districts from a depth of 0-15 cm by making a V-shape notch which were mixed thoroughly, and 500 gram of soil samples were collected from each site.

Processing of soil samples

Surface soil samples were collected and air-dried then crushed and grounded with a wooden roller and then it is sieved by using a 2.0 mm sieve. At last processed samples were put in a labelled polythene bag and bring in the laboratory for further analysis.

Physical and Chemical Analysis of Soil Samples

The collected soil samples were brought in the laboratory for analysing various physical-chemical parameters such as particle density, bulk density, pH, electrical conductivity, water holding capacity and organic carbon.

Determination of Particle Density and Bulk Density

The collected soil samples of particle density and bulk density were determined by the help of Pycnometer which was suggests by Black (1965).

Particle density = $\frac{Ws}{(W2+Ws)-W3}$

Where, 'Ws = Mass of soil

W_2 = Mass of pycnometer + water

W_3 = Mass of pycnometer + water + soil

Bulk density = $\frac{Mass\ of\ the\ soil}{Volume\ of\ the\ soil}$

Determination of Water Holding Capacity

Water holding capacity of the soil samples done with the help of Piper'sMethod (1966), by using following equation-

Water Holding Capacity (%) = $\frac{Wet\ wt.-Dry\ wt.}{Dry\ wt.}\ X\ 100$

Determination of soil pH and Electrical Conductivity (EC)

Soil pH was determined by using the digital pH meter illustrated by Jackson, in 1973. In the soil, soluble salt was determined by using EC meter described by Jackson, 1973 (in dSm^{-1}).

Determination of Organic Carbon

Organic carbon of soil sample was estimated by Walkey and Black (1934) method of wet oxidation, using the formula-

$$\% \text{ Organic carbon} = Organic\ Carbon \frac{(B-C)}{Weight\ of\ the\ soil} \text{ X } 0.0003 \text{ X } 100$$

Where, A = Volume of 0.5N ferrous ammonium sulphate required to neutralize 10 ml of 1N of $K_2Cr_2O_7$ i.e. blank titration (blank reading).

B = Volume of 0.5N ferrous ammonium sulphate needed for titration of soil sample (reading with soil).

Determination of Available Nitrogen

The available nitrogen in soil was determined with the help of Kjeldahl semi auto-analyser which was given by Subbiah and Asija (1956).

$$\text{Available N (kg ha}^{-1}) = \frac{(S-V) \times 0.02 \times 14 \times 2.24 \times 106}{1000 \times 5}$$

Where, S = Sample titration reading

V = Blank titration reading

Determination of Available Phosphorus

Estimation of available Phosphorus content in soil samples was determined by Olsen's method for neutral and alkaline soil using 0.5 M NaHCO3 solution (pH 8.5).

Determination of Available Potassium

Estimation of available potassium in soil samples was done with the help of Flame photometer (Schollenberger and Simon, 1945), and by using neutral normal ammonium acetate.

Determination of Exchangeable Calcium

The estimation of exchangeable calcium in soil sample was determined by use of neutral normal ammonium acetate solution which was given by Jackson, 1973.

Determination of Exchangeable Calcium and Magnesium

The estimation of exchangeable calcium + magnesium in soil was determined by use of neutral normal ammonium acetate solution, given by Jackson, 1973.

$$\text{Amount of Ca + Mg (Meq L}^{-1}) = \frac{R\ X\ Normality\ of\ EDTA\ X\ 1000}{Aliquot\ (ml)\ taken}$$

Amount of Ca + Mg (Meq/100g) = $\frac{100}{Soil\ wt.(g)}\ X\ \frac{Extracted\ Volume\ (ml)}{100} X\ Ca\ in\ Meq\ L^{-1}$

Amount of Mg (Meq L^{-1}) = Ca + Mg (Meq L^{-1}) – Ca (Meq L^{-1})

Where, R= Volume (ml) of standard EDTA used in titration

Determination of available sulphur

Estimation of Sulphur in the soil by Turbidity method (Chesnin and Yien, 1950).

Available Sulphur (mg Kg^{-1}) = $R\ X\ \frac{50}{10}\ X\ \frac{1}{10}$

Where, R stands for S content in µg as read on X-axis

Available micronutrient

Cationic micronutrient iron, zinc, copper and manganese in the soil samples were measured on the atomic absorption spectrophotometer.

Evaluation of soil nutrient status

To compare the levels of soil fertility of one area with those of another area soil fertility then it was necessary to obtain a single value for each nutrient. Nutrient index (N.I) value is a measure of nutrient supplying capacity of soil to plants.

Nutrient Index (N.I.) = (NL × 1 + NM × 2 + NH × 3) / NT

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

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

NH Indicates number of samples falling in the high class of nutrient status

NT Indicates the total number of samples analyzed for a given area

Result and Discussions

Bulk Density

Study showed that the bulk density of soil samples values ranged from 1.08 to 1.6 Mg m^{-3} with a mean value of 1.22 Mg m^{-3}(Table1). The highest bulk density was observed in Sivo village whereas the lowest bulk density was observed in the Paterwan village. This study showed that the bulk density depends on the consolidation of the soil and compaction, but it is negatively correlated to the organic content. Similar results were also recorded by Lego and Buraka (2021) [9].

Table1: Statistical Analysed Data on Physico-chemical Parameters of Soil.

Soil Parameter	Mean	Range	S.D. (±)	C.V (%)

Bulk density (Mg/m^3)	1.22	1.08 – 1.66	0.11	9.42
Particle density (Mg/m^3)	2.37	2.08 – 2.67	0.12	5.19
Water holding capacity (%)	40.12	29.80 – 51.70	5.40	13.60
pH	7.52	7.10 – 8.30	0.30	4.00
Organic carbon (%)	0.59	0.24 – 0.95	0.19	33.35
EC(dSm^{-1})	1.45	0.18 – 2.85	0.47	33.05

Particle Density

The particle density values ranged from 2.08 to 2.67 Mg m^{-3} with a mean value of 2.37 Mg m^{-3}. The standard deviation of particle density is 0.12 and the coefficient of variation is 5.19 %. The highest particle density was observed in Umraha village whereas lowest in Bariyasanpur village.

Water Holding Capacity

Soil samples' collected from study locations showed water holding capacity from 29.80 to 51.70 %, with an average value of 40.12 %. The standard deviation of water holding capacity is 5.4 and the coefficient of variation is 13.6%. The result shows that variation in water holding capacity is due to organic carbon content in the soil. Such a similar results were also reported by Tale and Ingole (2015) [10].

Soil pH

The values of pH ranged from 7.1 to 8.3, with a mean value of 7.52 with an SD value of 0.30 and a CV value of 4.0 %. The pH of the cultivated lands of the Chiraigaon block of Varanasi district showed mostly (59.25 % area) slightly alkaline in reaction, 11.11 % area moderately alkaline in reaction and the rest 29.64 % area were neutral in reaction. The neutral to alkaline pH may be attributed to the reaction of applied fertilizer material with soil colloids, which resulted in the reaction of basics cation on the exchangeable complex of the soil.

Soil EC

The EC of soil samples ranged from 0.18 to 1.68 dSm^{-1} with an average value of 0.57 dSm^{-1} with standard deviation and coefficient of variation of 0.24 and 43.70 %, respectively. The results showed that 87.04 % of the samples were in the permissible range, and 12.96 % of the samples were slightly higher than the permissible range [11].

Soil Organic Carbon

The organic carbon content of soil samples ranged from 0.21 to 0.76 %, with a mean value of 0.45 %. The standard deviation of organic carbon content was 0.11, and the coefficient of variation was 25.06. The lowest organic carbon value was observed in the Sion village whereas the highest value observed in Paterwan village of Chiraigaon block. The majority of the soil samples found to be in low organic carbon (70.37 %) content which might be due to low moisture content in the soil and high temperature, which increases decomposition

process by microorganisms and enzymes and decreases the accumulation of organic matter in the soil.

Avialable Nitrogen

Nitrogen content in soil samples ranged from 163.07 to 305.21 kg ha^{-1} with a mean value of 244.15 kg ha^{-1}(Table2). The standard deviation and coefficient of variation of the available nitrogen were 42.02 and 17.21 %, respectively. The lowest nitrogen content was observed in the Bariyasanpur while the highest nitrogen content was in Sion village. The study region showed nitrogen content is low due to low organic carbon content present in the soil(Singh *et al.*, 2018) [12].

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Table2: Statistical Data on Primary Macro-nutrients of Soil.

Soil parameters	Mean	Range	SD±	C.V (%)
Nitrogen (kg ha-1)	244.15	163.07-305.21	42.02	17.21
Phosphorus (kg $ha^{-1)}$	14.78	8.8 – 22.09	3.80	25.71
Potassium (kg ha-1)	229.11	111.98-305.43	51.05	22.28

Available Phosphorus

Available phosphorus content of soil samples were ranged from 8.8 to 22.09 kg ha^{-1} with an average value of 14.78 kg ha^{-1}. The lowest value of phosphorus content was observed in Umraha village, whereas the highest value was in Paterwan village. About 50% of phosphorus is found in organic form and decomposition of the organic matter produces humus which form complex with Al and Fe and protect the P fixation[13].

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Available Potassium

Available potassium content of soil samples were ranged from 111.98 to 305.43 kg ha^{-1} with a mean value of 229.11 kg ha^{-1}. The lowest phosphorus content value observed in Paterwan, while the highest was in Sathwa village, with SD and CV value of 51.05 and 22.28%, respectively. The study region potassium content is high, may be due to elite, rich potassium minerals found in the soil [14].

4.1.3 Status of available secondary Macro-nutrients in the soil

Available Calcium

Calcium content of soil samples ranged from 6.2 to 19.3 Meq/100g with a mean value of 11.82 Meq/100g (Table3). The lowest calcium content was observed in Patrewan village while, the highest calcium content was observed in Umraha village. High calcium content was observed for all locations under study.

Table 3: Statistical Data on Secondary Macro-nutrients of Soil.

Soil parameters	Range	Mean	SD±	C.V (%)

Magnesium (Meq/100g)	2.9 - 18.1	9.89	3.04	30.80
Calcium (Meq/100g)	6.2 – 19.3	11.82	3.13	26.49
Sulphur (mg kg^{-1})	3.4 – 15.8	10.60	2.44	23.06

Available Magnesium

Magnesium content of soil samples were ranged from 2.9 to 18.1 Meq/100g with a mean value of 9.89 Meq/100g. The lowest calcium content was observed in Khanpur village, whereas the highest value was observed in Sathwa village. Out of 54 soil samples collected, 100% were in the high range, and no one of the samples (0%) was present in the low range.

Available Sulphur

Sulphur content of soil samples were ranged from 3.45 to 15.8 mg kg-1 with an average value of 10.60 mg kg-1. The lowest sulphur content was observed in the Khanpur village, while the highest was in Bariyasanpurvillage. Out of 54 soil samples collected, 42.59% of the samples were in low sulphur status, 57.41% were in medium, and none were in the high range of sulphur content.

4.1.3 Status of available secondary Micro-nutrients in the soil

During the intensive cropping system the use of harmful fertilizer and high yielding varieties leads to micronutrient deficiency in the soil, so it is necessary to monitor the micronutrients (Fe, Cu, Zn, and Mn) concentration in the soil. The analysed data of the micronutrients of soil are given in Table4

Table 4: Statistical Data on Available Micro-nutrients of Soil.

Soil parameters	**Range**	**Mean**	**SD±**	**C.V (%)**
Available Fe (mg kg^{-1})	5.18- 72.0	29.41	13.42	45.65
Available Cu (mg kg^{-1})	2.20-4.08	3.14	0.51	16.27
Available Zn (mg kg^{-1})	0.58-19.62	7.89	5.32	67.46
Available Mn (mg kg^{-1})	3.08-56.18	26.37	9.68	36.74

Available Iron

The soil samples' iron content ranged from 5.1 to 72 mg kg^{-1} with a mean value of 29.41 mg kg^{-1}. The lowest Fe content was observed in Umraha village while the highest Fe content was in Khanpur village. 9.25 % of the soil samples were in medium range iron concentration, 90.75 % were in high, and 0 % were in low iron concentration similar results were reported by Kumar and Babel (2010) [15].

Available Copper

The values of copper content in samples were ranged from 2.2 to 4.08 mg kg^{-1} with a mean value of 3.14 mg kg^{-1}. The values of standard deviation and coefficient of variation of Cu were 0.51 and 16.27 %, respectively. Out of total 54 soil samples, 100 % of samples were high in available copper content as per the critical limit suggested by Lindsay and Norvell (1978) [16].

Available Zinc

Values of Zn content in soil samples ranged from 0.58 to 19.62 mg kg^{-1} with a mean value of 7.89 mg kg^{-1}. The values of standard deviation and coefficient of variation of zinc were 5.32 and 67.4 %, respectively. Out of 54 soil samples, 88.88% of the samples were in high zinc content, and 9.28% were found medium in Zn content and 1.84% sample low in zinc content.

Available Manganese

Values of manganese content in soil samples ranged from 3.08 to 56.1 mg kg^{-1} with an average value of 26.37 mg kg^{-1}. The values of standard deviation and coefficient of variation were 9.68 and 36.74 %, respectively. 96.29 % of soil samples are high in available Mn content, and 3.70 % of the samples are at the low level of Mn content (as per the critical limit suggested by Lindsay and Norvell, 1978 [17].

4.1.6 Soil nutrient index value

The nutrient index approach is used to calculate the nutrient supplying capacity of soil to plants. This index is measures soil fertility status based on the sample percentage in each of three class i.e. low, medium and high. The nutrient index values for the Chiraigaon block Varanasi district were medium for organic carbon and low in nitrogen and phosphorus and medium for potassium and high in micronutrient cations (Fe, Cu, Zn, and Mn) (Table5).

Table5: Nutrient Index (NI) Values of Chiraigaon block of Uttar Pradesh.

S.No.	Available nutrient	Available nutrient	Category
1	Nitrogen	1.29	Low
2	Phosphorus	1.64	Low
3	Potassium	1.96	Medium
4	Sulphur	1.57	Low
5	Calcium	1.31	Low
6	Magnesium	3.00	High
7	Iron	2.90	High
8	Copper	3.00	High
9	Zinc	2.80	High
10	Manganese	2.92	High

Conclusion:

Based on the experimental results, it is concluded that the soils ofChiraigaon block of Varanasi district it has been found thatbulk density was negatively correlated with organic carbon content in soil and variation in water holding capacity was varied with organic carbon content in the soil.The results showed 70.37 % of the soil samples were low, 27.7 % of the soil samples were medium and 1.8 % of the soil samples were high in organic carbon content. According to the Nutrient index value nitrogen, phosphorus, calcium and sulphur content in low category, potassium content in medium category and magnesium, iron, copper, zinc and manganese content in high category. Nitrogen is actually considered the most important component for supporting plant growth its deficiency so it is recommended to use composted manure and green manure crop. For low phosphorus content it is recommended to supply organic manures which are rich sources of phosphorus like raw bone meal, poultry manure which increases the phosphorus availability of the soil. Low sulphur content in the soil it is recommended to add poultry manure or gypsum fertilizer. Potassium content in soil help in disease and drought resistance in the soil so adequate amount of potassium is added to the soil pig manure content high potassium content which is recommended to the soil. The micronutrients (Fe, Cu, Zn, Mn) of the soil content is high category. The information of the present study could be useful for farmers regarding the quality of produce, increasing the percentage yield of crops through soil conservation and better environmental protection.

Comment [S7]: make it clear

Comment [S8]: too long

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