

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. A Total total of 54 soil samples were collected from the six different villages of Chiraigaon Block. Physico-chemical properties property analysis analyses showed average bulk density and particle density of 1.22 and 2.37 Mg/m³ 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 % with low organic carbon content in 70.37% of the soil samples. Macro-nutrient analysis showed low to medium range for nitrogen, phosphorus and sulphur with average values of 244.15 Kg kg ha⁻¹, 14.78 Kg kg ha⁻¹ and 10.60 mg kg⁻¹ respectively, whereas medium to high range of potassium (481.7 Kg kg ha⁻¹) and high range of exchangeable calcium (11.82 Meq/100g⁻¹) and magnesium (9.89 Meq/100g⁻¹) were found. Micro-nutrient analysis showed low to high range for manganese and zinc with values range ranging from of 3.08 to 56.1 mg kg⁻¹ and 0.58 to 19.62 mg kg⁻¹ respectively, whereas with iron in the medium to high range for iron (5.1 to 72 mg kg⁻¹) and high range for available while available copper (2.2 to 4.08 mg kg⁻¹) was in the high range in the tested samples. The current study is expected to help the farmers of the study location in providing guiding techniques guidelines 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*

Introduction

Soil gives medium for plant growth and support for animals and human activity. Soil health referred refers to soil quality and is described as the continued potential of soil which works as a 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 the right quantity.

Comment [A1]: From the guidelines for authors of this journal: The abstract should be concise and informative. Different sub-sections, should be used.

Comment [A2]: What does this stand for? You can use the abbreviation later, but declare it here

Comment [A3]: Did you collect it from the villages or from farmland near the villages? It would make a big difference.

Comment [A4]: In the keywords you write: micronutrient. Stick to one format.

Comment [A5]: I do not see that you explain any techniques?

Comment [A6]: Resistant to what?

Comment [A7]: I agree, soils are alive. Pity you did not measure one single biological attribute of these soils

Comment [A8]: You will have to check with the journal; do they prefer British English or American and stick to ONE language. Fertiliser and centre are British, while fertilizer and center are American. But you cannot use both in one paper.

Requirement of ~~macro-nutrient~~ macronutrients in plants is needed in relatively higher amounts than ~~micro-nutrients~~ micronutrients [3].

Nitrogen is an important part of chlorophyll, nucleic acids, enzymes, amino acids and proteins, which promotes root growth and induces vegetative growth. In plants, Phosphorus phosphorus works as energy storage in plant, stimulates root development and seed formation. Potassium acts as enzyme activator, it helps in disease and drought resistance in plants, helps in stomata functioning ~~– and is~~ also helpful ~~for in the~~ formation and translocation of sugars ~~– (carbohydrates)~~. Ca, Mg and S are secondary nutrients which play a very important role in the growth and development of plants, it promotes nodule formation in nitrogen binding 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 fortunately situated with in the fertile Indo-Gangetic plains region and, it is a significant contributor to the food security of the nation. The Chiraigaon Block is ~~plaeed~~ located in the Varanasi district in Uttar Pradesh.

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

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~~ metres from mean sea level [6]. From Chiraigaon block 54 representative surface soil samples were collected from the six selected villages namely Umaraha, Khanpur, Bariyanapur, Sion, Paterwan and 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

Comment [A9]: Of a plant (singular) OR of plants (plural).

Comment [A10]: Because not all legumes are nodule forming; only those that bind nitrogen

Comment [A11]: Never a good idea to quote any text verbatim, even if you cite it properly. Rather give the essence in your own words.

Comment [A12]: Can a region or a place be 'fortunate'? I would think being fortunate is reserved for humans. Maybe something like: Uttar Pradesh is located in the fertile Indo-Gangetic plains region and is a significant contributor to the food security of the nation.

Comment [A13]: In the previous paragraph you wrote Chiraigaon Block and here you write Chiraigaonblock. The 'block' is either part of the name (like South in South America) or it is not (the south of London). I will not know which one is correct, but you should know and use the correct one.

Comment [A14]: Cultivated fields near six villages?

Comment [A15]: You cannot take the villages anywhere

Comment [A16]: I presume you mean Uttar Pradesh. But you will have to give the full name and the abbreviation you are using in the beginning before using the abbreviation.

Comment [A17]: Numbering must be according to the journal's guidelines for authors.

Comment [A18]: In the villages? Or in fields (crops or natural?) near the villages? I think here I a lack of information about the site, since the specific crop, the season, rain fed or irrigated, tilling or not, will influence a lot of the results.

is 25.7 °C and the annual rainfall around 982 mm with the lowest precipitation in April (average of 6 mm) [8].

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 of the 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 was sieved by using a 2.0 mm sieve. P-At last processed samples were put in a labelled polythene bag and bring in transported to the laboratory for further analysis analyses.

Physical and Chemical Analysis Analyses of Soil Samples

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

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 as described by Black (1965).

$$\text{Particle density} = \frac{W_s}{(W_2 + W_s) - W_3}$$

Where, 'Ws = Mass of soil

W₂ = Mass of pycnometer + water

W₃ = Mass of pycnometer + water + soil

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

Determination of Water Holding Capacity

Comment [A19]: I am unsure what you mean with 'cropping patterns'. I understand cropping sequences, or even crop rotations. Or do you mean these crops are the common crops in the area? If so, then: The major crops cultivated in the district are rice, maize, wheat, mustard, barley and vegetables

Comment [A20]: The season and which crop was growing will have a big influence on your results. Also – when last were which fertilisers (if any) applied?

Comment [A21]: It sounds as if you sampled IN the villages themselves. Surely you sampled fields near the villages?

Comment [A22]: I have a problem with the way you sampled. Surely, making a v-shaped notch will result in much more soil from the top than from the bottom. Also – it is unclear how many samples you took from each village. Yes, you used 500 g, but I fail to see you weighing the samples in the field. And with your V-shape sampling – were all the samples the same size?

Comment [A23]: The present tense is grind; past tense ground. Grounded is what happens to a bird with a broken wing.

Comment [A24]: Your research has been completed – this is a report on what happened in the PAST, so everything except reference to a figure/table in the text, is in the PAST TENSE.

Comment [A25]: You have done no analysis at this stage, so it cannot be "for further analysis". Also – you are doing more than one analysis, thus plural analyses.

Comment [A26]: Since this is what you call it in your title

Comment [A27]: Since I doubt if Black actually suggested it to you?

Water holding capacity of the soil samples ~~were done with the help of~~ according to Piper's Method (1966), by using following equation—:

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

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 samples was estimated by Walkey and Black (1934) method of wet oxidation, using the formula-

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

Where, A = Volume of 0.5N ferrous ammonium sulphate required to neutralize 10 ml of 1N of $\text{K}_2\text{Cr}_2\text{O}_7$ 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 a Kjeldahl semi auto-analyser which was given described by Subbiah and Asija (1956).

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

Where, S = Sample titration reading

V = Blank titration reading

Determination of Available Phosphorus

Estimation of available Phosphorus-phosphorus content in soil samples was determined by Olsen's method for neutral and alkaline soil using 0.5 M NaHCO_3 - NaHCO_3 solution (pH 8.5).

Determination of Available Potassium

Estimation of available potassium in soil samples was done with the help of Flame-a 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 described by Jackson, 1973.

Comment [A28]: So many people make the mistake of using mass and weight as synonyms, that I think you should say what wet wt stand for, as you did in the density formula.

Comment [A29]: Not in your reference list

Comment [A30]: I think that these instruments (EC an pH) are so common now, you do not have to give a citation. But you have to say what you used in the soil slurry for pH, since some people use KCl and other use H₂O.

Comment [A31]: Not in reference list

Comment [A32]: Neutralize is American, neutralise is English.

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Comment [A33]: Which forms of nitrogen is measured here? I think you need to say. Organic or non-organic or both?

Comment [A34]: Reference? Since there are other ways to determine P

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Comment [A35]: Not in your reference list. Again, I think you should rather say which make of flame photometer you used, since I think the method is quite standard. This from the internet: "flame photometry" is a traditional instrumental analysis method

Comment [A36]: I understand the 'neutral' though I thought that neutral is usual for ammonium acetate. But what is meant by 'normal' since I doubt that it can be abnormal?

Comment [A37]: You need a reference number that will be the number in the reference list

Determination of Exchangeable Calcium and Magnesium

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

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

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

$$\text{Amount of Mg (Meq L}^{-1}\text{)} = \text{Ca + Mg (Meq L}^{-1}\text{)} - \text{Ca (Meq L}^{-1}\text{)}$$

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

Determination of available sulphur

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

$$\text{Available Sulphur-sulphur (mg Kkg}^{-1}\text{)} = R \times \frac{50}{10} \times \frac{1}{10}$$

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

Available micronutrients

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.

$$\text{Nutrient Index (N.I.)} = (\text{NL} \times 1 + \text{NM} \times 2 + \text{NH} \times 3) / \text{NT}$$

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

Results and Discussions

Bulk Density

This 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} (Table 1). The highest bulk density was observed in Sivo village whereas the lowest bulk density was observed in the Paterwan

Comment [A38]: See above

Comment [A39]: See above comment

Comment [A40]: Reference list number

Comment [A41]: Not in reference list and if you put the corresponding number (from the reference list) you do not need to give the year in this reference style

Comment [A42]: Remember, K (capital) is the unit for Kelvin. Keep to kg

Comment [A43]: I think add the manufacturer's name

Comment [A44]: Unless you write in American, then analyze. But most of you writing is in (British) English.

Comment [A45]: Stick to mg, otherwise it looks like magnesium

village. This study showed that the bulk density ~~depends~~ depended on the consolidation of the soil and ~~compaction~~, but it ~~is~~ was negatively correlated to the ~~organic~~ content. Similar results were also recorded by Lego and Buraka (2024) [9].

Comment [A46]: I am not sure about this. Yes, compaction will impact bulk density. But did you measure compaction at all?

Comment [A47]: You measured organic carbon. But that is not equal to organic content. From the internet: **Soil organic carbon is a component of soil organic matter.** Stick to what you actually measured.

Comment [A48]: Not necessary to put the date if you use this reference style

Table 1: Statistical Analysed Data on Physico-chemical Parameters of Soil.

| Soil Parameter | Mean | Range | S.D. (\pm) | C.V (%) |
|---------------------------------------|-------|---------------|----------------|---------|
| Bulk density ($Mg\ mg\ m^{-3}$) | 1.22 | 1.08 – 1.66 | 0.11 | 9.42 |
| Particle density ($Mg\ mg\ m^{-3}$) | 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 $Mg\ mg\ m^{-3}$ with a mean value of 2.37 $Mg\ mg\ m^{-3}$ (Table 1). The standard deviation of particle density ~~is~~ was 0.12 and the coefficient of variation ~~is~~ was 5.19 %. The highest particle density was observed in Umraha village whereas the lowest occurred in Bariyasanpur village.

Comment [A49]: Remember – you HAVE to refer to ALL your tables and figures in the text.

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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~~ was 5.4 and the coefficient of variation ~~is~~ was 13.6%. The results ~~shows~~ showed that variation in water holding capacity ~~is~~ was probably due to organic carbon content in the soil. ~~Such a similar~~ Similar results were also reported by Tale and Ingole (2015) [10].

Comment [A50]: In if you took the samples IN the village. But I assume they were taken on a field outside of the village?

Comment [A51]: Be careful of making absolute statements. Yes, I agree, most probably organic carbon, but not only that. There could be other things influencing the water holding capacity. Soil fungi for one. Soil aggregation. Different vegetation cover. Things you did not measure.

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 % (Table 1). The pH of the cultivated lands of the Chiraigaon block of Varanasi district ~~showed~~ was mostly (59.25 % area) slightly alkaline in reaction, while 11.11 % of the area was moderately alkaline in reaction and the rest (29.64 % area) ~~were~~ was 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 basic cation on the exchangeable complex of the soil.

Comment [A52]: You do not need to repeat yourself

Comment [A53]: Are you talking about base cations? If not, I do not know what basic cations are.

Comment [A54]: I think you can explain this a bit better. Were there a difference in fertiliser application in the different blocks? Because if you do not have data on the fertiliser applications, you cannot make this statement.

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 (Table 1) 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].

Comment [A55]: What exactly do you mean by permissible? Because permissible means 'allowed' or 'permitted'. But no-one has the power to permit anything in the soil, unless it is something we as humans add. Like pesticides. Maybe acceptable range? Preferable range?

Soil Organic Carbon

As shown in Table 1, ~~The-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 was found to be ~~in-low~~ in organic carbon (70.37 %) content which might be due to low moisture content in the soil and high temperature, which ~~could increas~~increase decomposition processed by microorganisms and enzymes and ~~decreases~~ the accumulation of organic matter in the soil.

Comment [A56]: There are a lot of other things that could influence the organic carbon. Agricultural practices, for instance. Are cover crops planted? Is crop rotation practiced? What happens to residues – left on the soil, grazed by animals, cut and removed, burnt? Cash crop on cash crop, or fallow? Are herbicides used or not? When you sampled, which crop was on the field? In which season did you sample? All these things will ultimately influence the soil organic carbon.

~~Avialable~~Available 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 (Table 2). The standard deviation and ~~coef~~are you going 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 of the soils in the study region is low, probably due to low organic carbon content present in the soil (Singh *et al.*, 2018) [12].

Comment [A57]: But the above also holds true. Many things apart from low carbon will influence the nitrogen content. Are any of the vegetables grown N-binding legumes, for instance? How – if any – does the fertiliser application differ between the villages?

Table 2: Statistical Data on Primary ~~Macro-nutrient~~Macronutrients 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 |

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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~~ at Umraha village, whereas the highest value was ~~in-at~~ at Paterwan village. About 50% of phosphorus is found in organic form and decomposition of the organic matter produces humus which ~~forms~~ complexes with Al and Fe and protect the P fixation [13].

Comment [A58]: Can you speculate on the reason for this difference?

Comment [A59]: Are you going to leave a space between the number and the % or not? Decide and stick to one. You use both, but I think this one without the space is the more common one. Since it is not an SI unit.

Available Potassium

~~Avaiable~~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 (Table 2). The lowest phosphorus ~~content~~ value was observed ~~in-at~~ at Paterwan, while the highest was ~~in-at~~ at Sathwa village, with SD and CV value of 51.05 and 22.28%, respectively. ~~The~~ In the study region, potassium content is high, may be due to elite, rich potassium minerals found in the soil [14].

Comment [A60]: Again, the specific crop/crop sequence as well as the amount of fertiliser applied at what time will all play a role in the measurable phosphorus in the soil.

4.1.3 Status of available secondary ~~Macro-nutrient~~Macronutrients in the soil

Available Calcium

Calcium content of soil samples ranged from 6.2 to 19.3 Meq/100g⁻¹ with a mean value of 11.82 Meq/100g⁻¹(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 in this study~~.

Comment [A61]: Why is that? Did they apply lime, gypsum? Is the parent material high in Ca?

Table 3: Statistical Data on Secondary ~~Maero-nutrient~~Macronutrients of Soil.

| Soil parameters | Range | Mean | SD± | C.V (%) |
|-------------------------------------|------------|-------|------|---------|
| Magnesium (Meq/100g ⁻¹) | 2.9 - 18.1 | 9.89 | 3.04 | 30.80 |
| Calcium (Meq/100g ⁻¹) | 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~~The magnesium content of the soil samples ~~were~~ ranged from 2.9 to 18.1 Meq/100g⁻¹ with a mean value of 9.89 Meq/100g⁻¹(Table 3). The lowest calcium content was observed ~~in at~~Khanpur village, whereas the highest value was observed ~~in at~~Sathwa village. Out of 54 soil samples collected, 100% were in the high range, and ~~no~~none of the samples (0%) was present in the low ~~range~~.

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Comment [A62]: I don't understand. If none were in the low range, where was that from Khanpur, if not 2.9? Or are you referring to another range? Explain fully. And WHY do you have these different values?

Available Sulphur

As can be seen in Table 3, ~~the~~ sulphur content of the 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~~.

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Comment [A63]: See above comment. What is seen as high or low?

4.1.3 Status of available secondary ~~Micro-nutrients~~Micronutrients in the soil

~~During the~~Inintensive cropping systems, the use of harmful ~~fertilizer~~fertilisers and high yielding ~~crop~~ varieties lead~~s~~ 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~~Micronutrients 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-at~~ Umraha village while the highest Fe content was ~~in-at~~ Khanpur village. ~~Of the soil sampled, 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].

Comment [A64]: Never start a sentence with a number

Comment [A65]: You will have to say what is deemed "high" or "low", because you are clearly not referring to your range of samples. See above comments for Mg and S.

Available Copper

The values of copper ~~content~~ in ~~the studied~~ samples ~~were~~ ranged from 2.2 to 4.08 mg kg⁻¹ with a mean value of 3.14 mg kg⁻¹ (Table 4). 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].

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Comment [A66]: This is correct, for here you say where your "high" comes from.

Available Zinc

~~The v~~Values ~~of-for~~ Zn ~~content~~ in ~~the~~ soil samples ranged from 0.58 to 19.62 mg kg⁻¹ with a mean value of 7.89 mg kg⁻¹ (Table 4). 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~~ ~~in~~ zinc ~~content~~, and 9.28% ~~were found~~ had medium ~~in-levels~~ of Zn ~~content~~ and 1.84% sample low in zinc ~~content~~.

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Comment [A67]: Do as you did for Cu an Mn and say where your high and low values originate.

Available Manganese

~~Values of manganese~~ Manganese content in ~~the studied~~ soil samples ranged from 3.08 to 56.1 mg kg⁻¹ with an average value of 26.37 mg kg⁻¹ (Table 4). The values of ~~the~~ standard deviation and coefficient of variation were 9.68 and 36.74 %, respectively. ~~96.29 % of~~ ~~Of the~~ soil ~~samples sampled, are~~ ~~96.29 % were~~ high in available Mn ~~content~~, and 3.70 % of the samples ~~are were~~ at the low level of Mn content (as per the critical limit suggested by Lindsay and Norvell, 1978 [17]).

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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 classes 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) (Table 5).

Comment [A68]: You need a reference. From what I understand these values differ from area to area.

Comment [A69]: You said earlier in this paper: The majority of the soil samples was found to be low in organic carbon (70.37 %) content. And now you call it "medium". It cannot be low and medium?

Table 5: Nutrient Index (NI) Values of Chiraigaon block of Uttar Pradesh.

| S.No. | Available nutrient | Available nutrient | Category |
|-------|--------------------|--------------------|----------|
|-------|--------------------|--------------------|----------|

Comment [A70]: I thought it was high? You stated earlier: In the study region, potassium content is high

| | | | |
|----|------------|------|--------|
| 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, in the soils of Chiraigaon block of Varanasi district, ~~it has been found that~~ bulk 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~~ Index value, nitrogen, phosphorus, calcium and sulphur content ~~were in low category~~, potassium content in the 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~~ amendments which are rich sources of phosphorus like raw bone meal, poultry manure which should increase the phosphorus availability of the soil. For Low-low sulphur content in the soil, it is recommended to add poultry manure or gypsum ~~fertilizer~~ fertiliser. Potassium content in soil helps in disease and drought resistance in the soil, so adequate amount of potassium ~~is added to the soil, such as found in~~ pig manure ~~content high potassium content which~~ is recommended for adding to the soil. The micronutrients (Fe, Cu, Zn, Mn) of the soil content ~~is was in the~~ 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.

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Comment [A71]: Did you do a correlation? Then you need to show the results.

Comment [A72]: Varied doesn't say much. Is organic carbon correlated (and if so, positively or negatively) with water holding capacity? And you need to show the correlation results.

Comment [A73]: Capital letter, since I think it is part of the name: Nutrient Index

Comment [A74]: I am not saying nitrogen is not important, but you will get nowhere if all the other things are not in balance.

Comment [A75]: Do not understand what you mean here with 'its deficiency'??

Comment [A76]: Different crops will add different things to the soil. If you want nitrogen, you need N-binding legumes.

Comment [A77]: Since bone meal is not a manure

Comment [A78]: Adhere to the author guidelines of this paper. Your format is wrong. 1. Hilly M, Adams ML, Nelson SC. A study of digit fusion in the mouse embryo. ClinExp Allergy. 2002;32(4):489-98. Note: List the first six authors followed by et al.

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- | 17. Lindsay, Willard L., and WAaNorvell. "Development of a DTPA soil test for zinc, iron, manganese, and copper." *Soil science society of America journal* 42, no. 3 (1978): 421-428.

Comment [A79]: These two (16, 17) are exactly the same. You only write it down once and refer to it by number in the text.

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