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## RESEARCH ARTICLE

ASSESSMENT OF SOIL PHYSICO-CHEMICAL PROPERTIES OF SUGARCANE RESEARCH PROGRAM, JITPUR, BARA, NEPAL.

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**Abstract**

Soil test-based fertility management is an effective tool in the context of sustainable farm improvement. Thus, presented study was conducted to determine soil physicochemical properties of the Sugarcane Research Program, Jitpur, Bara, Nepal. The research farm is situated at the latitude 27° 6'48.31''N and longitude 84°57'15.8''E as well 85masl altitude. Altogether, thirty eight soil samples were collected randomly at a depth of 0-20 cm. A GPS device was used to identify the location of the soil sampling points. Soil samples thus collected were analyzed for their texture, pH, OM, N, P, K, Ca, Mg, S, B, Fe, Zn, Cu and Mn status following standard methods in the laboratory of Soil Science Division, Khumaltar. The soil fertility status maps were prepared on Arc-GIS 10.1 software. Assessment of soil test data showed that the soil was grayish brown in color, sub-angular blocky in structure and varied in texture ranging among loamy, sandy loam and silt-loam, acidic in pH (5.96±0.12) and low in organic matter (1.0±0.07%). Regarding the nutrients; total nitrogen (0.06±0.002%), extractable calcium (1012.11±87.96 ppm) and available boron (0.17±0.02 ppm) status were low. Similarly, extractable magnesium (135.47±22.04 ppm), available sulphur (10.08±0.76 ppm), available copper (1.14±0.16 ppm) and available zinc (1.58±0.16 ppm) status were medium. Whereas, available phosphorus (33.76±7.33 ppm), extractable potassium (145.29±8.6 ppm) and available manganese (29.29±2.74 ppm) status were high, while available iron (167.91±14.57 ppm) status was very high. From this finding, it can be concluded that future sugarcane research strategy should be built based on the soil physicochemical properties of the research farm.

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**Introduction:-**

Soil is the top layer of the earth's crust that performs many vital functions such as food and biomass production, storage, filtration and transformation of many macro and micro nutrients (Kaur *et al.*, 2014). The proper functions of soil can only be imagined when they have capacity to supply essential plant nutrients. Soil fertility is defined as the ability of a soil to supply essential elements for plant growth without a toxic concentration of any element (Foth, 1990).

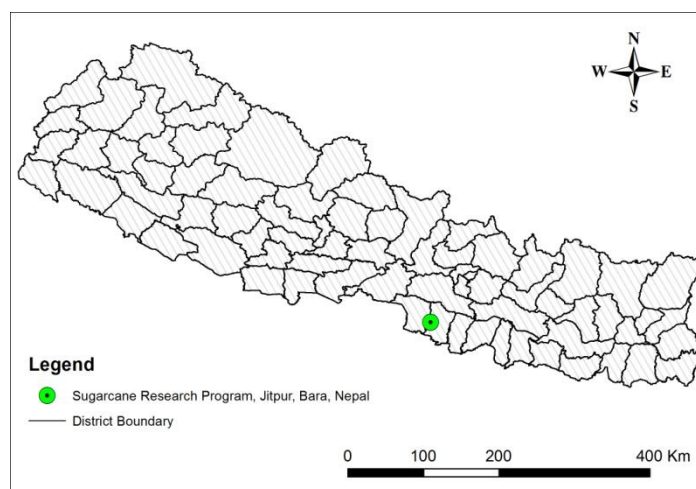
Soil characterization in relation to evaluation of fertility status of soils of an area or region is an important aspect in context of sustainable agricultural production. Soil testing is a management tool that can help accurately determine the available nutrient status of soils and guide the efficient use of fertilizers (Hak-Jin *et al.*, 2009). Describing the spatial variability of soil fertility across a field has been difficult until new technologies such as Global Positioning Systems (GPS) and Geographic Information Systems (GIS) were introduced. GIS is a powerful set of tools for collecting, storing, retrieving, transforming and displaying spatial data (Burrough and McDonnell, 1998).

Nepal Agricultural Research Council (NARC) was established to conduct agricultural research in the country to uplift the economic level of the people. Sugarcane Research Program, Jitpur, Bara, Nepal is an important wing among the research farms of NARC, in order to generate appropriate sugarcane production technologies for Nepal. Studies related to the soil fertility status of Sugarcane Research Program, Jitpur, Bara, Nepal are scant. Therefore, it is important to investigate the soil fertility status and may provide valuable information relating sugarcane research. Keeping these facts, the present study was initiated with the objective to assess the soil physicochemical properties of Sugarcane Research Program, Jitpur, Bara, Nepal.

## Materials and methods:-

### Location/Site description:-

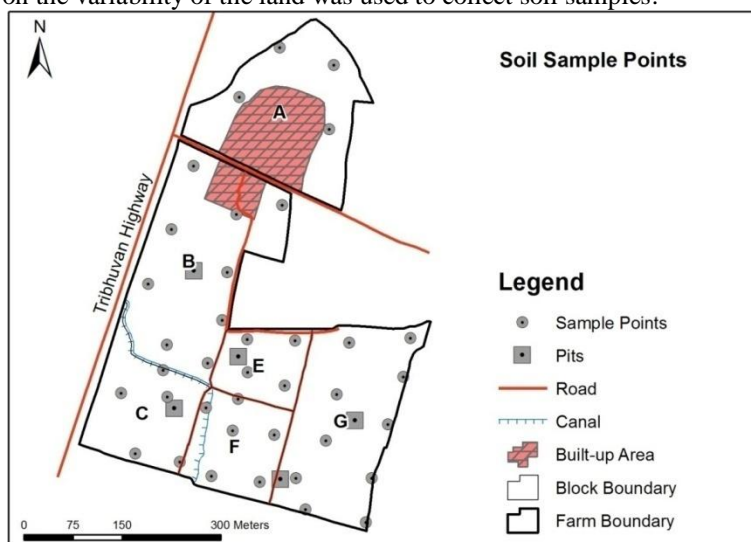
The study was carried out at Sugarcane Research Program, Jitpur, Bara, Nepal (Figure 1). The research site is situated at the latitude  $27^{\circ} 6' 48.31''\text{N}$  and longitude  $84^{\circ} 57' 15.8''\text{E}$  as well at altitude 85 m above sea level.



**Figure 1:-** Location map of Sugarcane Research Program, Jitpur, Bara, Nepal

### Soil sampling:-

Surface soil samples (0-20 cm depth) were collected from Sugarcane Research Program, Jitpur, Bara, Nepal during 2015. Altogether, thirty eight soil samples were collected from the different blocks namely; A, B, C, E, F and G of the research farm (Figure 2). The exact locations of the samples were recorded using a handheld GPS receiver. The random method based on the variability of the land was used to collect soil samples.



**Figure 2:** Distribution of soil sample points during soil sampling at Sugarcane Research Program, Jitpur, Bara, Nepal.

**Laboratory analysis:-**

The collected soil samples were analyzed in Soil Science Division, Khumaltar. The different soil parameters tested as well as methods adopted in labs to analyze is shown on the Table 1.

**Table 1:** Parameters and methods adopted for the laboratory analysis at Soil Science Division, Khumaltar, Lalitpur, Nepal

S.N.	Parameters	Methods
<b>1.</b>	<b>Physical</b>	
	Soil texture	Hydrometer (Bouyoucos, 1927)
	Soil colour	Munshell colour chart
	Soil structure	Field-feel
<b>2.</b>	<b>Chemical</b>	
2.1	Soil pH	Potentiometric 1:2 (Jackson, 1973)
2.2	Soil organic matter %	Walkely and Black (Walkely and Black, 1934)
<b>2.3</b>	<b>Macro-nutrients</b>	
2.3.1	Total nitrogen %	Kjeldahl (Bremner and Mulvaney, 1982)
2.3.2	Available P <sub>2</sub> O <sub>5</sub> ppm	Olsen (Olsen et al., 1954)
2.3.3	Extractable K <sub>2</sub> O ppm	Ammonium acetate (Jackson, 1967)
2.3.4	Extractable Ca ppm	EDTA Titration (El Mahi, et.al.,1987)
2.3.5	Extractable Mg ppm	EDTA Titration (El Mahi, et.al.,1987)
2.3.6	Available S ppm	Turbidimetric (Verma., 1977)
<b>2.4</b>	<b>Micro-nutrients</b>	
2.4.1	Available B ppm	Hot water (Berger and Truog, 1939)
2.4.2	Available Fe ppm	DTPA (Lindsay and Norvell, 1978)
2.4.3	Available Zn ppm	DTPA (Lindsay and Norvell, 1978)
2.4.4	Available Mn ppm	DTPA (Lindsay and Norvell, 1978)
2.4.5	Available Cu ppm	DTPA (Lindsay and Norvell, 1978)

**Statistical analysis:-**

Descriptive statistics (mean, range, standard deviation, standard error) of soil parameters were computed from the MS Excel 2007 package. Rating (very low, low, medium, high and very high) of determined value was based on Soil Science Division, Khumaltar. Arc Map 10.1 with spatial analyst function of Arc GIS software was used to prepare soil fertility maps and interpolation method employed was ordinary kriging. Similarly, The nutrient index was also determined by the formula given by Ramamoorthy and Bajaj (1969) which were given below:

$$\text{Nutrient index (N.I.)} = (N_L \times 1 + N_M \times 2 + N_H \times 3) / N_T$$

Where, N<sub>L</sub>, N<sub>M</sub> and N<sub>H</sub> are number of samples falling in low, medium and high classes of nutrient status, respectively and N<sub>T</sub> is total number of samples analyzed for a given area. Whereas, interpretation was done as value given by Ramamoorthy shown on the Table 2.

**Table 2:** Interpretation of nutrient index value.

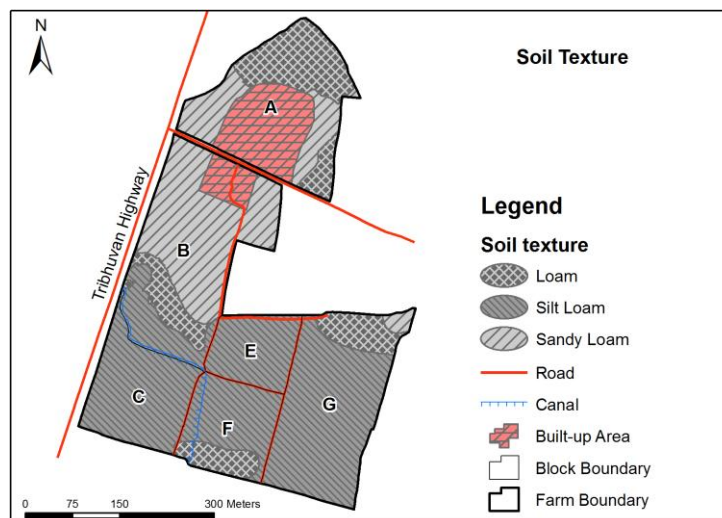
S.N.	Nutrient Index	Value
1.	Low	<1.67
2.	Medium	1.67-2.33
3.	High	>2.33

**Result and discussion:-**

For evaluation of the soil physico-chemical properties of the study area; structure, colour, texture, pH, OM, primary nutrients, secondary nutrients and micronutrients (B, Fe, Zn, Cu and Mn) were determined and results obtained are presented and discussed in the following headings.

### Soil Texture:-

Soil texture is an important physical property of soils. It affects the infiltration and retention of water, soil aeration, absorption of nutrients, microbial activities, tillage and irrigation practices (Gupta, 2004). The data regarding soil texture status of Sugarcane Research Program, Jitpur, Bara, Nepal is shown on the Table 3. The % sand of soil samples were ranged from 8.6 to 63.2% with the mean value of 35.37% and that of % silt were 32.2 to 68.2% with an average of 52.13% while the range of % clay were 4.0 to 23.2% with an average of 12.50% (Table 3). In overall, three kinds of soil texture as silt loam, sandy loam and loam were observed on the research farm (Figure 3).



**Figure 3:-** Soil texture status of Sugarcane Research Program, Jitpur, Bara, Nepal

**Table 3:-** Soil texture Status of Sugarcane Research Program, Jitpur, Bara, Nepal.

Descriptive Statistics	Soil Separates		
	Sand	Silt	Clay
	%		
Mean	35.37	52.13	12.50
Standard Deviation	13.76	9.08	5.54
Standard Error	2.23	1.47	0.90
Minimum	8.6	32.2	4
Maximum	63.2	68.2	23.2
<b>Texture Class</b>	<b>Loam, Silt Loam and Sandy Loam</b>		

### Soil Colour:-

Soil colour is a cheap indicator of soil quality which provides valuable clues to the nature of other soil properties and conditions. In general, grayish brown (10YR 5/2) coloured soil was determined.

### Soil Structure:-

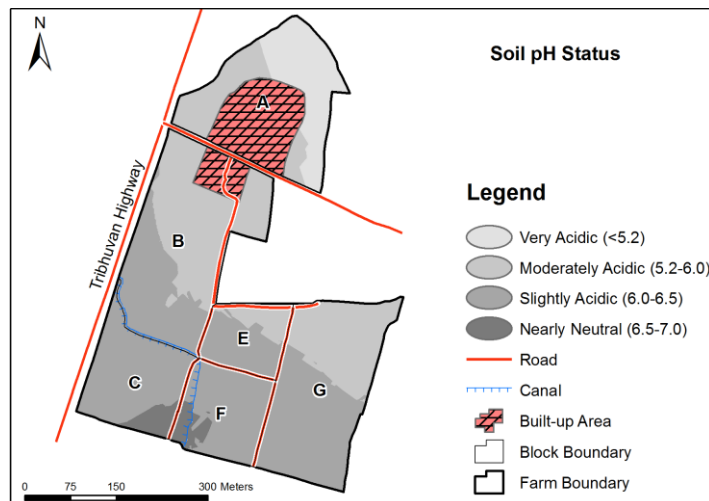
Soil structure describes the physical configuration of the soil. Good soil structure is vital for growing crops (Brady and Weil, 2004). In the majority of the area, sub-angular blocky structured soil was observed.

**Table 4:** Soil fertility status of Sugarcane Research Program, Jitpur, Bara, Nepal.

Descriptive Statistics	Soil Fertility Parameters				
	pH	OM	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
	%			ppm	
Mean	5.96	1.00	0.06	33.76	145.29
Standard Deviation	0.73	0.43	0.01	45.16	53.04
Standard Error	0.12	0.07	0.002	7.33	8.60
Minimum	4.23	0.10	0.04	1.00	75.26
Maximum	7.20	2.46	0.11	220.86	303.74

### Soil pH:-

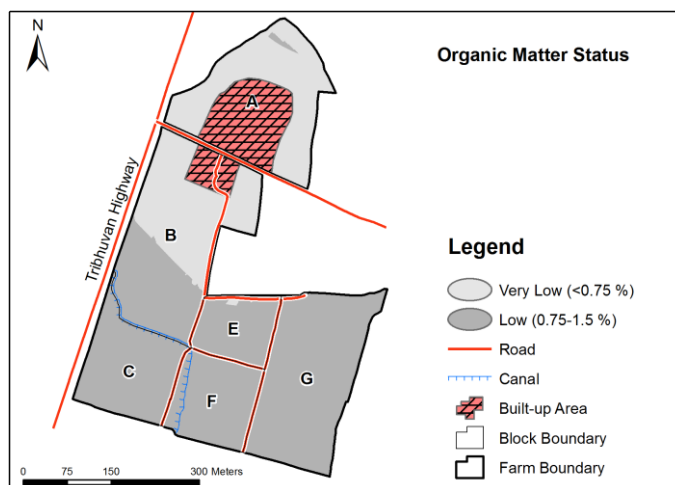
The most significant property of soil is its pH level, it is regarded as a useful indicator of other soil parameters (Havline et al. 2010). The data regarding soil pH status of Sugarcane Research Program, Jitpur, Bara, Nepal is shown on the Table 4. The soil pH was ranged from 4.23 to 7.20 with a mean value 5.96. In overall, moderately acidic soil pH was determined on the research farm (Figure 4).



**Figure 4:-** Soil pH status of Sugarcane Research Program, Jitpur, Bara, Nepal.

### Organic Matter:-

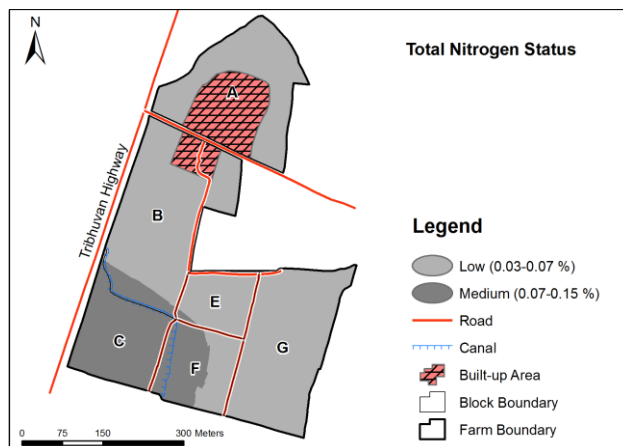
Soil organic matter is a key attribute of soil quality as it has a profound effect on soil physical, chemical and biological properties (Gregorich et al., 1994). The organic matter content was varied from 0.10-2.46% with a mean value 1.0% in Sugarcane Research Program, Jitpur, Bara, Nepal (Table 4). The low status of organic matter was observed on the study area (Figure5 and Table 7).



**Figure 5:** Organic matter status of Sugarcane Research Program, Jitpur, Bara, Nepal

### Total Nitrogen:-

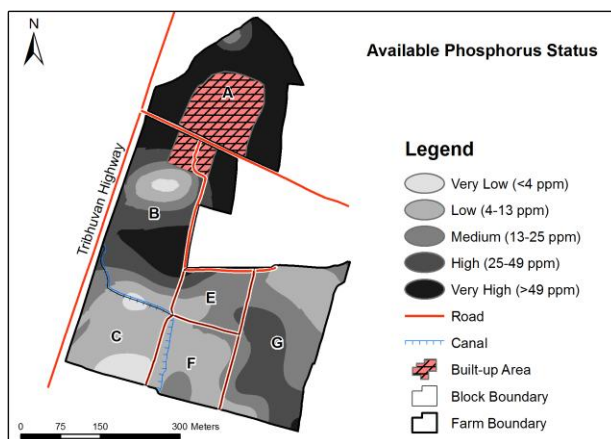
Nitrogen is one of the main building blocks of proteins in plants, and is responsible for photosynthesis and sugar accumulation in sugarcane. The total nitrogen content exhibited in the range of 0.04-0.11% with a mean value of 0.06% (Table 4). In overall, the total nitrogen status was low (Figure 6 and Table 7). When N is deficient, the growth of the whole plant is affected; stalks will be thin and stunted and tillering and root mass will be reduced (Garside et al., 1999). Therefore, the different organic and inorganic source of nitrogen adding materials incorporation in the field is important for nitrogen management.



**Figure 6:** Total nitrogen status of Sugarcane Research Program, Jitpur, Bara, Nepal

**Available Phosphorus:-**

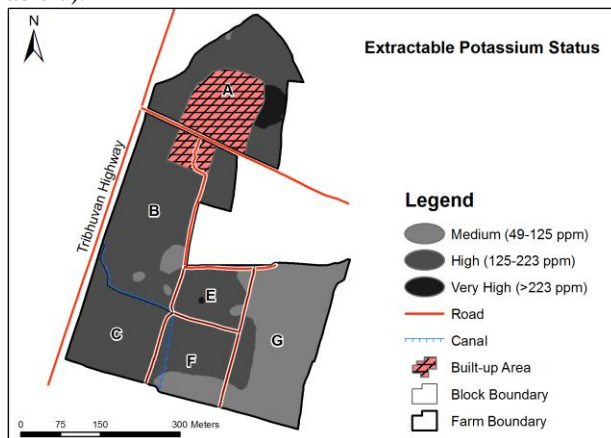
Phosphorus is essential for tillering, root and shoot growth of sugarcane (Kingston, 2014). The available phosphorus content was varied from 1.00 to 220.86 ppm with a mean value of 33.76 ppm (Table 4). The high status of available phosphorus was investigated on the study area (Figure 7 and Table 7).



**Figure7:** Available phosphorus status of Sugarcane Research Program, Jitpur, Bara, Nepal

**Extractable Potassium:-**

Potassium plays a key role on osmoregulation, which is important for cell extension, stomata movement, and enzyme activation in sugarcane ( Kingston, 2014). The extractable potassium content was ranged from 75.26 to 303.74 ppm with a mean value of 145.29 ppm (Table 4). In general, extractable potassium status was high on the research farm (Figure 8 and Table 7).



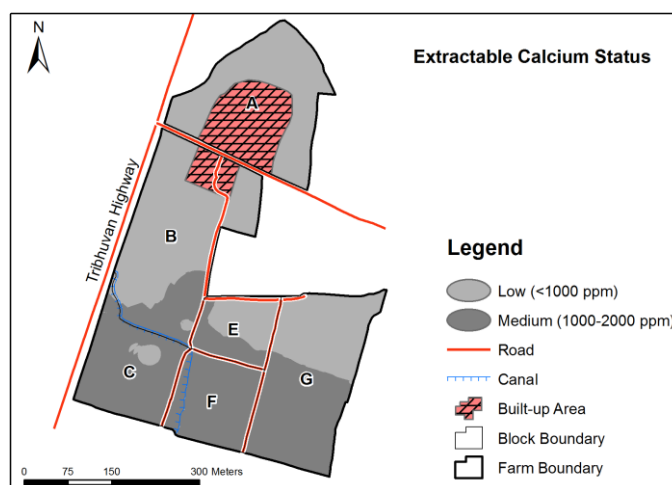
**Figure 8.** Extractable potassium status of Sugarcane Research Program, Jitpur, Bara, Nepal.

**Table 5.** Soil fertility status of Sugarcane Research Program, Jitpur, Bara, Nepal

Descriptive Statistics	Soil Fertility Parameters			
	Ca	Mg	S	B
	ppm			
Mean	1012.11	135.47	10.08	0.17
Standard Deviation	542.20	135.85	4.69	0.11
Standard Error	87.96	22.04	0.76	0.02
Minimum	180.00	12.00	4.20	0.03
Maximum	2220.00	492.00	23.27	0.51

**Extractable Calcium:-**

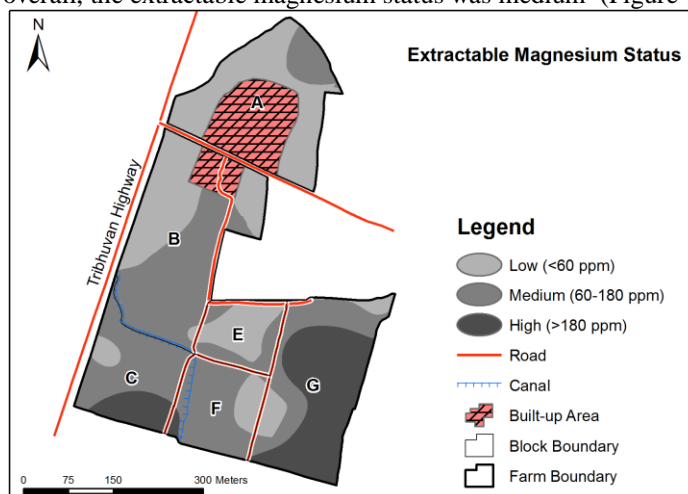
Calcium is essential for the growth and development of the spindle, leaves and roots of sugarcane. The extractable calcium content was ranged from 180 to 2220 ppm with a mean value of 1012.11 ppm (Table 5). In general, medium status of extractable calcium was observed (Figure 9 and Table 7).



**Figure 9.** Extractable calcium status of Sugarcane Research Program, Jitpur, Bara, Nepal.

**Extractable Magnesium:-**

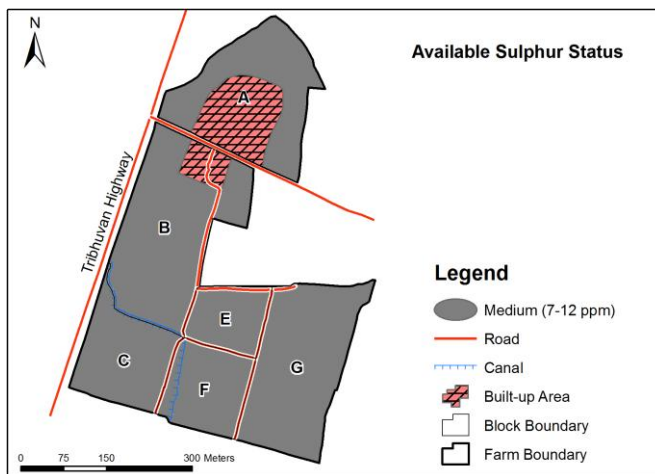
Magnesium is an essential constituent of chlorophyll, and therefore is important in photosynthesis, growth and sugar accumulation of sugarcane. The extractable magnesium content ranged from 12 to 492 ppm with a mean value of 135.47 ppm (Table 5). In overall, the extractable magnesium status was medium (Figure 10 and Table 7).



**Figure 10:** Extractable magnesium status of Sugarcane Research Program, Jitpur, Bara, Nepal

**Available Sulphur:-**

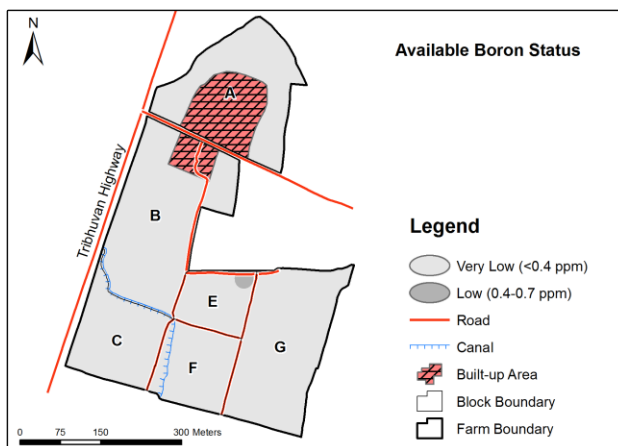
Sulphur is essential for chlorophyll formation, cell metabolism and plant growth of sugarcane (Calcino et al., 2000). The available sulphur content was varied from 4.20 to 23.27 ppm with a mean value of 10.08 ppm (Table 5). The medium status of available sulphur was determined on the research farm (Figure 11 and Table 7).



**Figure 11.** Available sulphur status of Sugarcane Research Program, Jitpur, Bara, Nepal.

**Available Boron:-**

Boron is an essential nutrient involved in sugar translocation, protein synthesis, seed and cell wall formation (Anderson and Bowen, 1990). The available boron content was varied from 0.03 to 0.51 ppm with the mean value of 0.17 ppm (Table 5). In overall, very low status of available boron was observed on the research farm (Figure 12 and Table 7). Therefore, the different organic and inorganic sources of boron adding materials should be applied to make boron balanced in the soils.



**Figure 12:** Available boron status of Sugarcane Research Program, Jitpur, Bara, Nepal

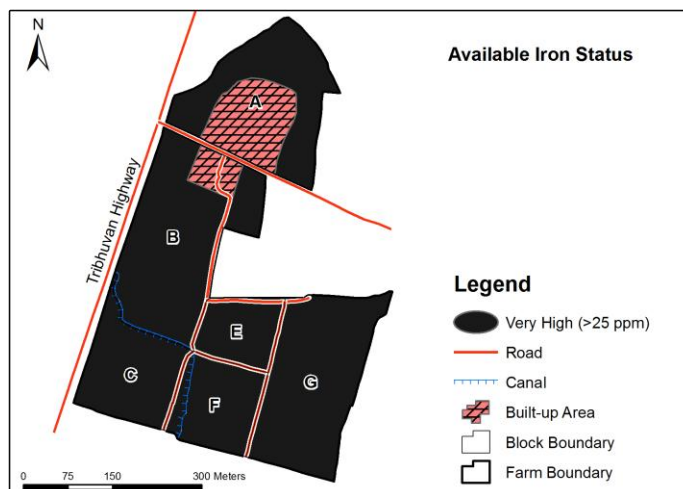
**Table 6:-** Soil fertility status of Sugarcane Research Program, Jitpur, Bara, Nepal.

Descriptive Statistics	Soil Fertility Parameters			
	Fe	Zn	Cu	Mn
	ppm			
Mean	167.91	1.58	1.14	29.29
Standard Deviation	89.84	1.02	0.45	16.91
Standard Error	14.57	0.16	0.07	2.74
Minimum	41.20	0.60	0.46	0.99
Maximum	479.20	5.58	2.31	86.60



**Available Iron:-**

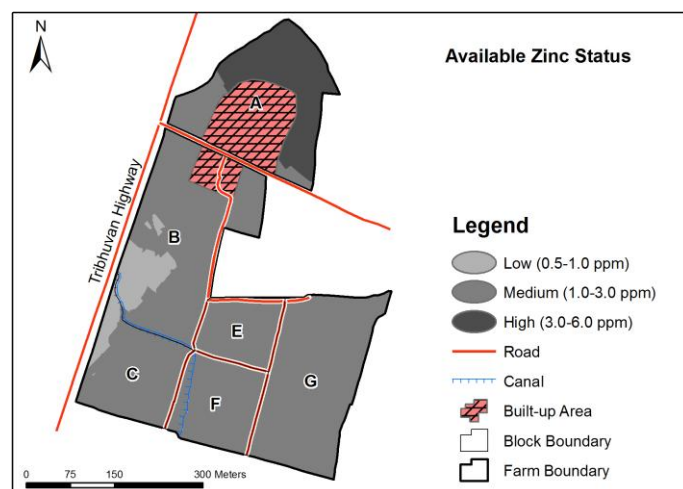
Iron deficiency and toxicity are important yield limiting factor for the sugarcane cultivation. The available iron content was varied from 41.20 to 479.20 ppm with the mean value of 167.91 ppm (Table 6). The very high status of available iron was investigated (Figure 13 and Table 7). Due to high iron availability, it might cause iron toxicity for the sugarcane. "Freckle leaf" in sugarcane is also associated with localized accumulations of iron in leaves (Clements et al., 1974). Therefore, for reduction of iron toxicity problem other nutrient should be applied in adequate amounts.



**Figure 13:** Available iron status of Sugarcane Research Program, Jitpur, Bara, Nepal.

**Available Zinc:-**

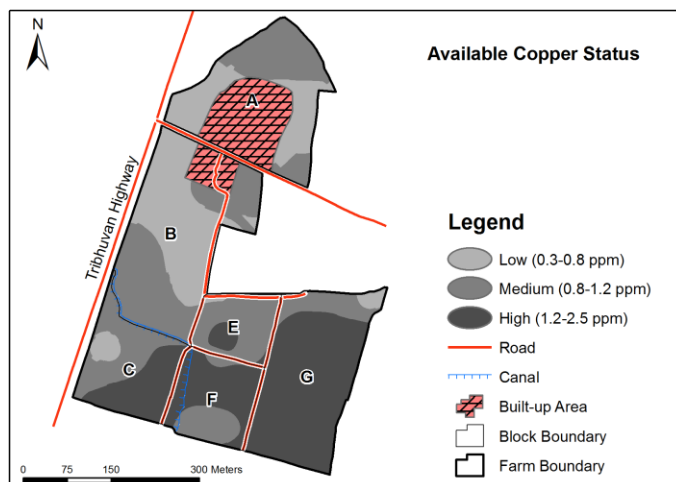
Zinc plays important role for tillering, growth and ratoon longevity of sugarcane. The available zinc content was ranged from 0.60 to 5.58 ppm with an average value of 1.58 ppm (Table 6). In overall, available zinc content was medium in status (Figure 14 and Table 7).



**Figure 14:** Available zinc status of Sugarcane Research Program, Jitpur, Bara, Nepal.

**Available Copper:-**

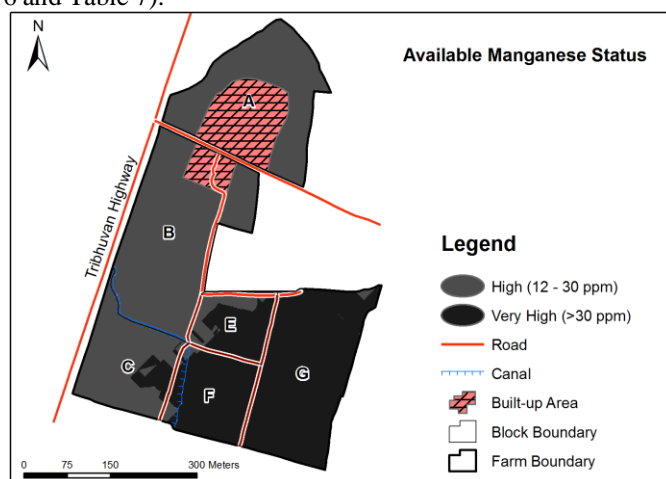
Copper is important for the formation of lignin in plant cell walls which contributes to the structural strength of the cells, and the cane. The available copper content was varied from 0.46 to 2.31 ppm with the mean value of 1.14 ppm (Table 6). In overall, available copper content was medium in status (Figure 14 and Table 7).



**Figure 15:** Available copper status of Sugarcane Research Program, Jitpur, Bara, Nepal.

**Available Manganese:-**

Manganese is one of the main micronutrients, which has an important role in sugarcane as a component of enzymes involved in photosynthesis and other processes.. The available manganese content was ranged from 0.99 to 86.60 ppm with an average value of 29.29 ppm (Table 6). In overall, high status of available manganese was determined on the study area (Figure 16 and Table 7).



**Figure 16:** Available manganese status of Sugarcane Research Program, Jitpur, Bara, Nepal.

**Table 7:-** Nutrient indices of studied parameters of Sugarcane Research Program, Jitpur, Bara, Nepal

S.N.	Parameters	Nutrient Indices	Remarks
1.	OM	1.05	Low
2.	N	1.45	Low
3.	P <sub>2</sub> O <sub>5</sub>	1.9	Medium
4.	K <sub>2</sub> O	2.5	High
5.	Ca	1.5	Low
6.	Mg	2.0	Medium
7.	S	2.0	Medium
8.	B	1.0	Low
9.	Fe	3.0	High
10.	Zn	1.8	Medium
11.	Cu	2.1	Medium
12.	Mn	2.8	High

### Conclusion:-

In overall, the color of soil was grayish brown, and structure was sub-angular blocky. Soils were moderately acidic in reaction (pH) and require application of agricultural lime periodically at A and B blocks. The organic matter, nitrogen, calcium and boron status were low. Similarly, magnesium, sulphur, copper and zinc content were medium. Whereas, phosphorus, potassium and manganese status were high, while iron contains high status. The organic matter adding materials like, FYM, compost, crop residue retention etc. should be requires for maintaining soil organic matter. From this study, it can be concluded that for enhancing efficacy of the sugarcane research, future research strategy should built based on the soil physico-chemical properties of the research farm.

### Acknowledgement:-

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