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# Evaluation of soil fertility status in Kanti block under Muzaffarpur district of North Bihar

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**Abstract**
A study was undertaken to evaluate the available nutrient status of farmer's field from Kanti block in Muzaffarpur district of North Bihar, India in the year 2014-15. By using GPS, the 53 soil samples were randomly collected at the depth of 0-15 cm as per standard procedure. The soil analysis showed that the pH value ranged from 8.15–9.08 with an overall mean of 8.57 reflecting slight to strongly alkaline soils. E.C. ranges between 0.15–0.92 $dSm^{-1}$ and Organic carbon content of the soil varied from 0.42–0.51 per cent. The available nitrogen content of representative soil ranged from 111.99 to 137.50 kg $ha^{-1}$ with an overall mean of 129.61 kg $ha^{-1}$ and the overall nutrient index value of this soil was 1.0. Besides, available phosphorus was observed from 23.70 to 95.30 kg $ha^{-1}$ with overall nutrient index value was 2.94 and available potassium content from 137.24 to 244.70 kg $ha^{-1}$ with nutrient index value was 1.57. It indicates that the analyzed soils of concerned block were low in available nitrogen, high in available phosphorus and medium in available potassium. Though, the sulphur content of the soils ranged from 4.09 to 21.00 ppm with an overall mean value 10.83 ppm, whereas micronutrients *i.e.* available zinc and iron (DTPA-extractable) content of soil was ranged from 0.02 to 1.34 ppm and 9.42 to 31.78 ppm with an overall mean of 0.60 ppm and 18.93 ppm respectively, which indicate that the soils are sufficient in the micro-nutrients.

**Keywords:** nitrogen, pH, phosphorus, potassium, soil

## Introduction
Soil health makes it possible to identify biological and physical constraints in addition to those identified by standard nutrient testing. Soil health constraints beyond nutrient deficiencies and excesses limit agro-ecosystem sustainability, resilience to drought and extreme rainfall, as well as progress in soil and water conservation. In India, during the past three decades, intensive agriculture involving exhaustive high-yielding varieties of rice and wheat has led to heavy withdrawal of nutrients from the soil. Furthermore, imbalanced use of chemical fertilizers by farmers has deteriorated soil health. The widely practiced rice-wheat system in India is one such instance, where sustainability is under threat. Bihar is yet to realize actual productivity potential of existing cropping system at farmers' field level. In this state, indiscriminate and injudicious use of fertilizer and non-incorporation of legumes in cereal-cereal cropping system are the major factors to cause plateauing of production level and deterioration of soil health. Though soil fertility is key factor among various other production factors but knowledge of available soil nutrient status is still lacking. Actually, knowledge of soil status warrants utmost care in fertilizer use, consequently assuring the higher agriculture production.
The soils of Bihar categorize under 4 orders, 10 sub-orders, 18 great groups and 66 families. *Inceptisols* are dominantly observed to cover nearly 41.90 percent area followed by *Entisols, Alfisols* and *Vertisols* covering 36.80, 16.70 and 0.80 percent of the total geographical area, respectively (Chandra, 2013) [3]. The topography of this area is practically leveled with a slope towards south-east. Several big rivers such as Ganges, Gandak, Kosi, Kamala balan and Baghmati regularly flood these areas, which originate from the lime rich foothills of the Himalayas. Thus, the soils under the influence of these rivers are mostly calcareous light-heavy in texture and having more than 10 per cent of free calcium carbonate. While rice-wheat cropping system is a dominant cropping system covering nearly 70 percent total cropped area. Both the components crops of aforesaid cropping system require application of balance doses of nutrients, particularly nitrogen (N) application, to achieve full yield potential. The indiscriminate use of fertilizers over a period of time has resulted in building up of nutrients element like unavailable Phosphorus, deficiency of sulphur (Sharma, 2004) [19] and also

micronutrient deficiency in many locations. Without prior knowledge of soil fertility status, application of fertilizers by the farmers in the fields might lead to adverse effects on soils and crops both in respect to quality and quantity changes. Moreover, nutrient deficiency and toxicity may appear due to inadequate or over use of fertilizers, respectively. Soil, as medium of plant support and growth, is bound to affect profoundly and substantially the rate of growth as well as development and eventually the final and economical yield through its biotic and abiotic activities and properties. Challenge can be met by greater and more efficient use of fertilizers and organic sources. Adoption of integrated plant nutrient supply and management strategies for enhancing soil quality, input use efficiency and crop productivity is extremely important for food and nutritional security in Indian agriculture (Swarup, 2010) [23]. Hence, soil testing will determine the current fertility status and provides information regarding nutrient availability in soils which forms the basis for the fertilizer recommendations for maximizing crop yields and further to maintain the optimum fertility in soil year after year. Therefore, the present study was undertaken to find out the nutritional status of Kanti Block situated in Muzaffarpur district of North Bihar.

## Material and Methods

The study area forming a part of Indo-Gangetic North-West Alluvial Plain is situated between 26.2032° N latitudes, 85.2925° E longitudes at an elevation of 59 m above mean sea levels (Fig. 1). The area has a tropical humid to sub-humid climate with having average rainfall in the area 1234 mm. The soil samples were collected from the field on GPS based. The 53 soil samples have been taken in a *zig-zag* pattern from the depth of 0-15 cm. systematically across a grid of 2.5 hectare for irrigated land. Within each of such sample point, samples were randomly taken for further analysis, to represent the 2.5 ha. The collected soil sample should be thoroughly mixed and air dried. After air drying, soil samples were crushed gently in pestle and mortar and sieved through a 2 mm sieve. The material larger than 2 mm is discarded. The selected samples were analyzed for soil pH and EC (1:2.5) soil: water suspension after stirring for 30 minutes by glass electrode pH meter as suggested by Piper (1967) [17] and EC was measured by Conductivity Bridge. The organic carbon was estimated by rapid titration method Walkley and Black's(1934) [26], available nitrogen was analyzed by alkaline potassium permanganate method (Subbiah and Asija,1956) [22], available phosphorus was extracted using the method of 0.5 M$NaHCO_3$ extractable colorimetric method (Olsen *et al.*, 1954) [15], available potassium was measured by shaking the requisite amount of soil sample with 1 N $NH_4OAc$ (pH 7.0) solution (1:5 soil: solution ratio) for 5 minutes (Jackson, 1973) [6] and available Sulphur in soil was determined by the $CaCl_2.H_2O$ (0.15% Solution) by turbid metric method (Williams and Steinbergs, 1969) [27]. The available Zn and Fe were determined by DTPA method developed by Lindsay and Norvell (1978) [11] using atomic absorption spectrophotometer. Surface soil samples were rated in low, medium and high categories as per the limits suggested by Muhar *et al.* (1965) [13] for available N, P and K. Nutrient indices (NI) for available N, P and K in surface soil samples were worked out as per the formula given by Parker *et al.* (1951) [16]. The nutrient index in soil was evaluated for the soil samples analyzed using the following formula:

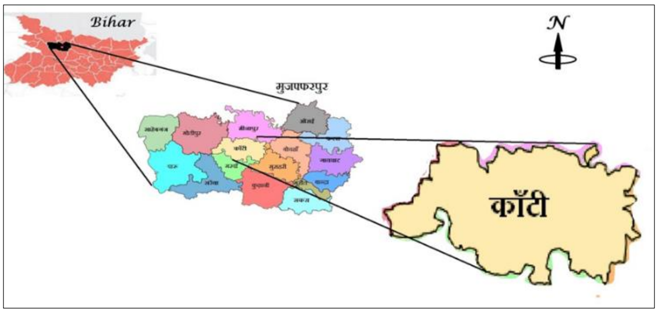


**Fig 1:** Location of the Study area

$$\text{Nutrient Index} = \frac{(1 \text{ X no. of samples in low category}) + (2 \text{ X no. of samples in medium category}) + (3 \text{ X no. of samples in high category})}{\text{Total number of samples}}$$

## Results and Discussion

### Chemical Properties of soil

### Soil reaction (pH)

The measure of soil pH is an important parameter which helps in identification of chemical nature of the soil (Shalini *et al.*, 2003) [18] as it measures hydrogen ion concentration in soil to indicate its acidic and alkaline nature of the soil. The pH of analyzed soils ranged from 8.15 to 9.08 with an overall mean of 8.57 in the soil samples of Kanti block of Muzaffarpur (Table1). Nearly 98% soil samples were strongly alkaline had pH between 8.10 to 9.00 and remaining 2 % were very strongly alkaline had pH more than 9.0 (Fig 2). It means the soils are strongly to very strongly alkaline in reaction. The alkaline reaction of soils is probably due to the presence of sufficient free lime content as reported by Jibhkate *et al.* (2009) [7]. The presence of soluble salts like Ca, Mg and $NaCO_3$, also gives a preponderance of $OH^-$ ions over $H^+$ ions in the soil solution, was also reported by Mehlich (1964) [12]. At higher pH values the exchangeable bases predominate, while at intermediate value Al $(OH)^{2+}$ ions are prominent. Alkalinity occurs when there is a comparatively high degree of base saturation. Results of soil samples analysis of Kanti Block revealed that pH is strongly alkaline in reaction, which alarms and invites immediate stringent action towards rectification of pH in order to bring it in preferred range. Because ideal soil reaction, according to need of crop plants, requires for achieving targeted yield and economical return.

**Table 1:** Chemical properties of soils (kg $ha^{-1}$) in Kanti block of Muzaffarpur

| Parameter | Mean | Minimum | Maximum |
|---|---|---|---|
| pH(1:2.5, Soil: water) | 8.57 | 8.15 | 9.08 |
| EC (dS $m^{-1}$) | 0.46 | 0.15 | 0.92 |
| OC (%) | 0.48 | 0.42 | 0.51 |
| Avail. N (kg $ha^{-1}$) | 129.61 | 111.99 | 137.50 |
| Avail. P (kg $ha^{-1}$) | 54.81 | 23.70 | 95.30 |
| Avail. K (kg $ha^{-1}$) | 76.70 | 137.24 | 244.70 |
| S (ppm) | 10.83 | 4.09 | 21.00 |
| Zn (ppm) | 0.60 | 0.02 | 1.34 |
| Fe (ppm) | 18.93 | 9.42 | 31.78 |

EC – Electrical Conductivity, OC- Organic Carbon

### Salt concentration (Electrical Conductivity)

The electrical conductivity (EC) of the representative soils of Kanti block was varied from 0.15 to 0.92 $dSm^{-1}$ with an average value of 0.46 $dSm^{-1}$ (Table 1). Accordingly, the majority of soil samples were in the normal EC range (<0.8 $dsm^{-1}$).Soil conductivity is influenced by many factors, high conductivities are usually associated with clay-rich soil and low conductivities are associated with sandy and calcareous soils (Kumar and Somashekar, 2013) [10]. The normal EC may be ascribed to leaching of salts to lower horizons. According to US Salinity Laboratory (1954) [25], alkali soils are characterized by pH more than 8.5 and EC < 4 $dSm^{-1}$ at $25^0$C. However, experiences about Indian alkali soils shows that the EC is limitless if originating from high concentration $CO_3$ and $HCO_3$ of sodium and partial pressure of $CO_2$ (P $CO_2$) in the soil solution. Electrical conductivity (EC) is the reciprocal of the electrical resistance of the extract of the soil, which is one centimeter long and a cross sectional area of one square centimeter. It is generally expressed as $dSm^{-1}$ at $25^o$ and is used to express the salinity of the soil. The conductivity of a solution extract is generally recommended for appraising soil salinity in relation to plant growth.

## Organic carbon (OC)
Maximum value of organic carbon (OC) was observed 0.51% in the soil samples of Kanti block but on the other hand its minimum value was found in the tune of 0.42%. The overall mean value of soil samples was thus calculated to be 0.48% (Table 1). On the basis of organic carbon content, soils are generally categorized in three major groups namely low, medium and high, which contain organic carbon in range of □□0.50%, 0.50- 0.75 % and □0.75%, respectively (Table 1). According to aforesaid classification, 53% analysed soil samples of block was fallen under low category and rest was in medium range (Fig 2). It means the majority of the soils of block are alarmingly low in their organic carbon status. As organic carbon matter not only in general influences the physico-chemical properties of soils but particularly affects the availability of nutrients, cation exchange capacity, soil structure, C: N ratio and C:N:S ratio etc. are well recognized. Similarly, Korschens (1998) [8] stated that carbon is an indispensable necessity for soil fertility, because it is strongly correlated with nitrogen and fuels the microbial engine that drives the nitrogen cycle.

## Macro-nutrient Status of the Soil
## Available nitrogen
The available nitrogen content of surface soil samples ranged from111.99 to 137.50 kg $ha^{-1}$ with an overall mean value of 129.61 kg $ha^{-1}$of the block under study (Table 1). However, the overall nutrient index value of this block was 1.00 (Table 2). The overall per cent sample category under low. According to Singh *et al.* (1983) [20], alkali soils are generally low in organic matter and thereby poor in available N content. Besides, hydrolysis of urea (nitrogenous fertilizer) is slower (Nitant and Bhumble, 1974) [14] and nearly 10-60% of the applied N is lost through volatilization (Kumar *et al.*, 1995) [9] in these soils than that of normal soils. As the soils of concerned block were by and large found critically low in available nitrogen content, thus the farmers are advised to apply either nitrogenous fertilizer on soil test basis.
Nitrogen supplies either excess or insufficient, both are responsible for lowering crop production. Insufficient N supply results impaired carbohydrate utilization and eventually lead to deposition of carbohydrate in vegetative cells, causing them to thicken. On the other hand, an excess of N expedites carbohydrate utilization and more protoplasm is formed, because protoplasm is highly hydrated, a more succulent plant results. Excessive succulence may make a plant more susceptible to diseases or insect attack as well as crop lodging in addition to delay crop maturity.

## Available Phosphorus
The available phosphorus content of soils varied from 23.70 to 95.30 kg $ha^{-1}$, thus averaging to 54.81 kg P $ha^{-1}$(Table 1).The overall nutrient index value of this block was 2.94 (Table 2), which indicates that the nearly 94 percent soil samples were found to be high in available phosphorus and remaining 6 percent soil samples was under medium category (Fig. 2). Adequate amount of phosphorus in majority of soils may be attributed to continuous application of phosphatic fertilizers to the crops, which resulted in building up of phosphorus in the soil. As the soil fertilizer use efficiency of applied phosphorus is very low and it comes in available form very slowly and plants take up only 10-40% of applied P during the growing season (Aulakh and Pasricha, 1999) [1] and the rest resides in the soil as less soluble forms.
Soil reactions of current soil samples show that the P fixing capacity of Kanti block is high. Hence, prior to P application, farmers must go for soil testing. If soil testing is not possible, then 75% recommended dose of P, they may be applied in general. As surplus amount fixed P is present in soils, the farmers may understand and utilize the role of PSB in such conditions.

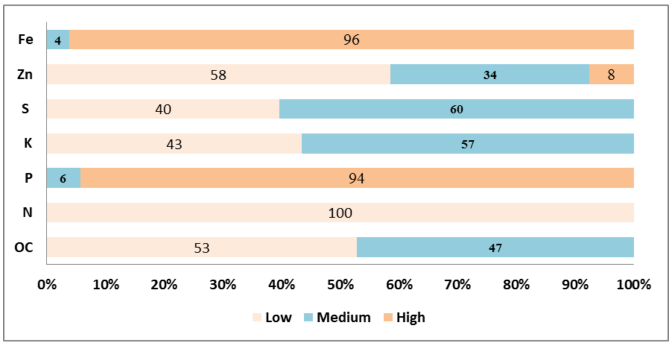


**Fig 2:** Soil samples (%) falling in different ranges of Micro and Micronutrients

## Available Potassium
The available potassium (K) values varied from 137.24 to 244.70 kg $ha^{-1}$ in Kanti block of Muzaffarpur district. Thus, average figure of available K was 76.70kg $ha^{-1}$ (Table 1), whereas an overall index value is 1.57 (Table 2). Majority of the soil samples in the block had medium category (60 %) and low (40 %) supply of potassium, it indicates that the soils are medium to low in available potassium (Fig. 2). In future, due to excessive exhaust, K may become limiting factor in crop production in soils of Kanti Block. At the current level of productivity, the K removal must have been much higher than its application, but still the changes in available $K_2O$ after continuous rice-wheat cropping was of smaller magnitude probably because the crop requirement of K was largely met with non- exchangeable pool of soil (Swarup and Singh, 1989) [24]. The readily available K constitutes only 1-2% of total K and exists in soil in two forms *viz.* solution and exchangeable K adsorbed on soil colloidal surface (Brady and Well, 2002) [2]. Potassium (K) is the third most required element by the plants, which plays a key role in water balance in plants or regulation of osmosis (Singh and Tripathi, 1993) [21]. However, potassium nutrition is considered as an essential nutrient for successful completion of life cycle of crop plants, because over 80 plants' enzymes require K for their

activation. Besides, its key important role in water relation, energy relation, translocation of assimilates as well as N-uptake and protein synthesis. When K is limiting, crop lodging and insect-pest attack may be visibly observed. In fact, serious yield reduction may also observe without appearance of K deficiency symptoms.

**Table 2:** Nutrient Index values for the soil samples of Kanti block, Muzaffarpur

| Characteristics | Nutrient index values | Remarks |
|---|---|---|
| Organic carbon (OC) | 1.47 | Low |
| Available nitrogen (N) | 1.00 | Low |
| Available phosphorus (P) | 2.94 | High |
| Available potash (K) | 1.57 | Low |
| Sulphur (S) | 1.60 | Low |
| Zinc (Zn) | 1.49 | Low |
| Iron (Fe) | 2.96 | High |

### Micro-nutrients status of soil

The available sulphur status ranged between 4.09 ppm to 21.00 ppm with mean value of 10.83ppm (Table 1), whereas an overall index value is 1.60 and the soil test rating for available sulphur is (<10.00 as low, 10.00-30 as medium and >30 ppm as high level (Table 2) and approximately 40 % samples falls under low and 60% medium rating (Fig. 2). Similarly Goswami *et al.* (2016) [5] reported that available sulphur (S) found 14.28 % samples under low, 38.09 % in medium and 47.61 % in high category of Sulphur of soil. The available micronutrient as Zinc and Iron status was found 0.02-1.34 ppm, and 9.42-31.78 ppm respectively with mean value of 0.69 ppm and 18.93 ppm respectively (Table 1).Where as an overall index value is 1.49 and 2.96 respectively (Table 2). Approximately 58% and 34% samples of zinc fall under low and medium fertility class. 96% soil samples of iron falls under high fertility class (Fig.2). Similarly, Dameshwar *et al.* (2018) [4] reported that available micronutrients low to high category of the soil.

### Conclusion

It can be concluded from the above results that the soils of Kanti block under Muzaffarpur district of North Bihar has showed the status of organic carbon low to medium category and 100 per cent low available nitrogen. The available phosphorus and potassium content was high (96%) and medium (57%) level respectively and characterized under strongly alkaline in soil reaction (pH). The soluble salt content (EC) found less than 1 dS $m^{-1}$ that comes under safe limit for soils. The sulphur content of the soils was low, whereas micronutrients *i.e.* available zinc content of soil was low categories. The iron content of the soil high, which indicate that the soils are sufficient in the both micro-nutrients. Hence, the soils of the study area need proper attention for balanced fertilization so that optimum level of crop production can be achieved. The soils of the study area need regular monitoring to avoid any possible deficiency of the plant nutrients.

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