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## DTPA-extractable micronutrients in Inceptisols of Chunar, Mirzapur and its correlation with physicochemical properties of soil

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**Abstract**

Micronutrients are considered as inevitable elements in the production of quality food produce because of their involvement in various enzymatic as well as metabolic processes. The deficiency of micronutrients in plants is reflected as significant reduction in yield and quality. During last few years imbalanced nutrient fertilization and decrease in nutrient use efficiency leads to soil mining and its sickness which ultimately result to decline in crop yield and production potential in Indo-Gangetic plain (IGP) an intensively cultivated area of India. Ignorance of micronutrients in long run may cause malnutrition too later on. Considering this fact micronutrients viz. Fe, Mn, Cu, Zn and B were analyzed using standard methods along with the factors affecting its availability (pH, soil organic matter and soil texture and availability of major nutrients). The range (mean) values of DTPA-extractable Fe, Mn, Cu and Zn were 16.20 to 43.60 (24.16), 1.02 to 6.46 (2.95), 0.44 to 3.17 (1.56), and 0.50 to 1.80 (0.75) in Gangpur; 13.20 to 35.60 (22.79), 0.70-7.00 (3.45), 0.38 to 1.72 (1.23) and 0.52 to 1.14 (0.73) mg kg<sup>-1</sup> soil in Bhawanipur village. Results revealed the sufficiency of all the micronutrients in the selected region but giving an indication to maintain such levels in future also.

**Keywords:** DTPA-extractable micronutrients, Indo-Gangetic plain (IGP), Inceptisols, imbalanced nutrient fertilization, soil sickness

**Introduction**

Among the 8 most essential micronutrients to crop iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), nickel (Ni) are cationic and boron (B), molybdenum (Mo) and chlorine (Cl) are anionic one. They are as essential to crops as macronutrient but required in minuscule amounts. Their deficiency may lead to severe consequences in terms of checking plant growth and development. Thus micronutrients are the “magic wand” which in extremely small quantity is capable of triggering production and release of enzymes, hormones and other substances essential to crops. Lack of few micronutrients (Zn and Fe) in food produce may result to lowering of working ability and increase in healthcare cost. Thus micronutrients are inevitable elements in production of quality food. They are peculiar in the sense that we don't need to supply them externally i.e. concentration of micronutrients in soil or in source of primary nutrient is enough good to sustain plant but adoption of Mexico originated green revolution brought abrupt change in agricultural practices and intensified farming over the globe. During the era we were suffering acute food shortage and frequent famine green revolution, came to us as boon and enabled to overcome “ship to mouth” situation by bouncing the food production 3-4 folds. For atleast couple of decades we enjoyed the benefits of green revolution, later on suffering started in terms of nutrient mining, degradation of soil quality and lowering of nutrient use efficiency (NUE). During the recent past we observed a sharp decline in per capita arable land area from 0.136 ha (in 2006) to 0.118 ha (2018), renewable water resources from 4,085 m<sup>3</sup> (1962) to 1,427 m<sup>3</sup> (2017), increase in non-agricultural land area from 2.85% in 1950 to 8% by 2010 along with decrease in production potential of cultivable land (Rattan Lal, 2020). India is an agriculture based country and most of the economic activity is centered around agriculture. Out of 329 Mha of total geographical area ~60% is associated with agriculture and allied sector (Rattan Lal, 2020). This all are putting tremendous pressure on available land resources to feed budding population. Thus we chose a shortcut i.e. applying high dose of NPK based fertilizers to crops avoiding micronutrients essentiality to increase productivity.

The situation is even worse to the region where intensive cropping of high yielding varieties of rice and wheat mined soil nutrients excessively and lead to soil sickness. Imbalanced or blind fertilizers use without knowing soil fertility and nutrient requirement of crop pose additional constrain to crop production. Ramifications of low SOC content in the root zone, low and variable agronomic yield of major crops, large yield gap of major food crops in the world versus India, diluted nutritional quality of food grains, unbalanced application of chemical fertilizers without adequate use of any organics, uncontrolled grazing and in-field burning of crop residues, extractive farming and jeopardize ecosystem are the reason why we need to take care our arable land and to supply balanced nutrients to our cropland (Rattan Lal, 2013a).

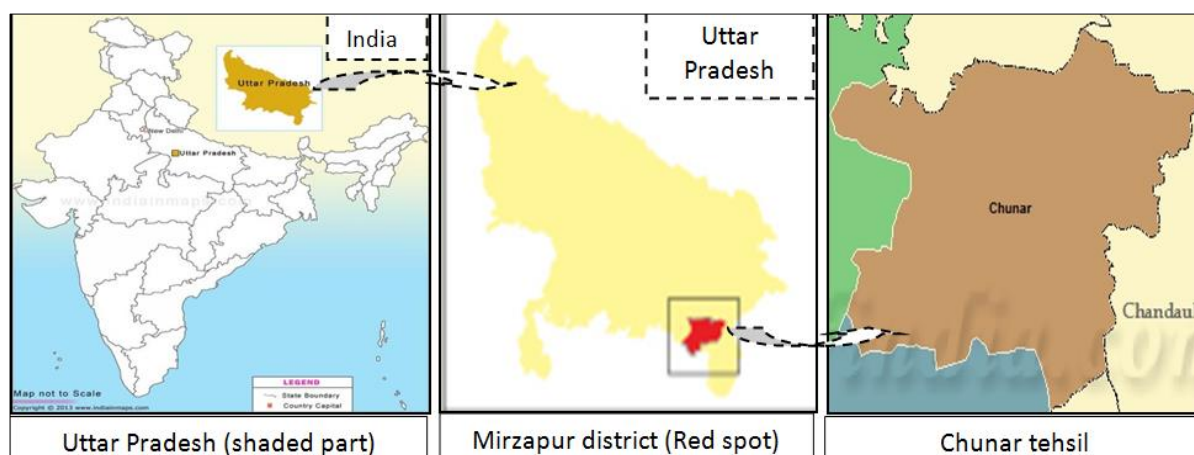
As per report of MV Singh (2008) 49% of soils in India are deficient in Zn, 12% in Fe, 5% in Mn, 3% in copper (Cu), 33% in boron (B) and 11% in molybdenum (Mo). Thus detecting nutrient deficiencies at early stage of crop growth is quit essential otherwise it may result to irreversible yield and quality. The easiest way to diagnose nutrient deficiency is studying the visual symptoms but sometimes overlapping of symptoms among different nutrient deficiency may cause problems. Another shortcoming associated with this method it ensure nutrient deficiency at the stage when plant has already suffered considerable damage. Thus soil test-based micronutrient recommendation is an effective management strategy for maximizing crop yields (Singh *et al.*, 2019) [11-12]. Appropriate and efficient use of fertilizers for getting the maximum crop yield is possible through target oriented fertilizer scheduling which is based on the principles of balanced fertilization (Ramamoorthy *et al.* 1967) [8]. Thus testing the individual plot to avoid over or under fertilizer application and to cut excessive fertilizer expenditure is better

option rather than going through blind application. Moreover not only the micronutrient status but there are many other related parameters like soil pH, SOM, and sand-silt-clay content in soil are responsible to administrating micronutrient availability to crops. In the present endeavour, an attempt has been made to develop a village level soil nutrient information regarding micronutrient status of the soils belonging to Gangpur and Bhawanipur village of Mirzapur district and their correlation with other soil factors so that decline in fertility can be arrested.

### Materials and Methods

**Location:** The experimental site is Mirzapur, Uttar Pradesh, situated at 25.15 latitude, 82.57 longitude and elevation of 89 meters above mean sea level (msl). Annual precipitation of this area is around 1043mm. Two villages Gangpur and Bhawanipur of Chunar tehsil were selected for study because of sharp decline in crop production during last few years. Major crop cultivated here are rice, wheat, jowar, bajra, maize, gram, arhar, mustard and groundnut.

**Methodology:** 51 surface soil samples collected from 0-15cm depth from Gangpur and Bhawanipur village of Mirzapur. The entire field of each individual farmer was divided into homogenous unit and samples are collected from 4-5 points following a “zigzag” or “W” pattern. A “V” shaped wedge of above mentioned depth was prepared and a slice of soil (1 inch or 2.5 cm) was taken out. After collection soil was mixed thoroughly and processed in soil processing laboratory of the Department of Soil Science and Agricultural Chemistry, IAS, BHU, Varanasi. The quantity of samples brought to 1kg by “quartering method” i.e. discarding two opposite side out of four every time.



**Fig 1:** Location map of Chunar tehsil

Collected samples were dried (under shade), sieved (2mm sieve), stored (clean unused polythene bags) and analyzed for different soil parameters as described ahead. Soil pH was measured by combined electrode method (Chopra and Kanwar, 1982). A soil-water suspension was prepared in the ratio of 1:2.5 and activity of  $H^+$  ions was measured using pH meter. For analysis of soil organic carbon wet digestion method was followed (Walkley and Black, 1934) where organic matter was digested by the mixture of  $H_2SO_4 + K_2Cr_2O_7$  and unused  $K_2Cr_2O_7$  was titrated with FAS. Cationic micronutrients (Fe, Mn, Cu and Zn) were extracted by DTPA extractant (0.005M DTPA+0.01M  $CaCl_2$ +0.1M TEA) and analyzed under AAS as per Lindsay and Norvell (1978) [7] and elemental concentration was determined by multiplying

AAS reading with dilution factor. Anionic micronutrient boron was measured by hot water method (Berger and Troug 1939) [1]. Here B is extracted using  $CaCl_2$  and solution is allowed to react with azomethine- H dye to form yellow colored boron complex which is measured at 420 nm using the spectrophotometer. The percentage of sand, silt and clay in the inorganic fraction of soil was measured by hydrometer method (Bouyoucos, G.J. 1962) [3] and the calculation for the same was done using following formula:

- Percent clay:  $\% \text{ clay} = R \times 100 / \text{wt. of sample (where R = corrected hydrometer reading at 6 hrs, 52 min)}$
- Percent silt:  $\% \text{ silt} = R \times 100 / \text{wt. of sample} - \% \text{ clay (where R = corrected hydrometer reading at 40 sec.)}$
- Percent sand:  $\% \text{ sand} = 100\% - \% \text{ silt} - \% \text{ clay}$

### Correction factors

- Add 0.2 units to the readings of the samples for every 1° F above 67° F, and subtract 0.2 units for every 1° F below 67° F.
- Subtract the density of the blank at each reading, from the corresponding density readings for the samples.
- Corrections are made for the density and temperature of the dispersing solution.

### Results and Discussion

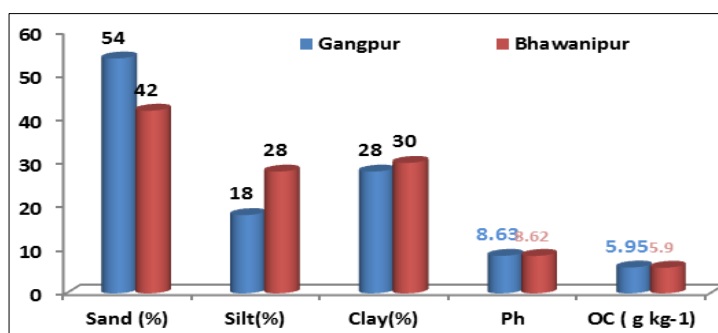
#### Physicochemical properties of the soil

The range and mean obtained for different physicochemical properties of soil has been represented in table 1. In Gangpur village a slightly higher value was observed for sand fraction while in Bhawanipur same was observed for clay fraction because of difference in soil textural class. The soil of Gangpur and Bhawanipur belong to sandy clayey loam and clay loam, respectively. A very slight non- significant difference was detected in case of pH and OC content among both the village (fig.2). Range and mean SOC observed was 3.10-8.81 g kg<sup>-1</sup> and 5.95 in Gangpur while 4.31- 7.69 g kg<sup>-1</sup> and 5.90 in Bhawanipur. Similar result was reported by Singh

*et al.* (2017) [10]. A majority of soil samples were low to medium in soil sample as India fall in tropical region to offer faster SOM decomposition leaving no scope for soil carbon sequestration. Only ~ 25% soil samples (including both the villages) reported were rich in OC content (> 0.75 g kg<sup>-1</sup>) which may be due to application of FYM or other organic material to those plots. Bhattacharya *et al.* (2007) also suggested an increase in SOC stock of IGP from 1980 to 2007 on applying FYM, Organic manure or crop residue incorporation.

**Table 1:** Physicochemical properties of soils belonging to Chunar tehsil, Mirzapur

Soil parameters	Gangpur		Bhawanipur	
	Range	Mean	Range	Mean
Sand (%)	40-70	54	36-56	42
Silt (%)	13-26	18	18-36	28
Clay (%)	14-44	28	24-41	30
Soil pH	7.96-9.15	8.63	8.45-8.83	8.62
OC(g kg <sup>-1</sup> )	3.10-8.81	5.95	4.31-7.69	5.90
Textural class	Sandy clay loam		Clay loam	



**Fig 2:** Graphical representation of soil physicochemical properties in Gangpur and Bhawanipur

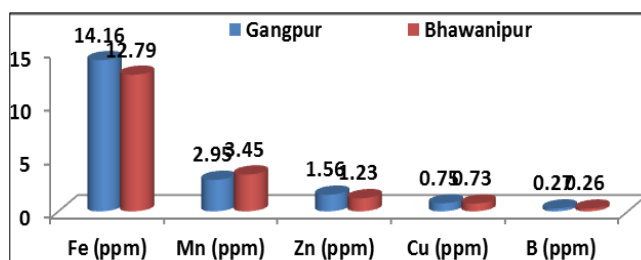
#### Available micronutrient in Inceptisol soil of Chunar

DTPA- extractable micronutrients were found to be sufficient in soil samples analyzed from both the villages (see table 2) especially in case of Fe and Cu while for Mn and Zn there was distribution of samples over low, medium and high status. Reverse was observed in case of anionic

micronutrients analyzed (*i.e.* B). The region belong to middle IGP and receive copious of cationic nutrients coming from higher topography thus enriched in cationic micronutrients however not such adequacy has been reported for anionic micronutrient.

**Table 2:** Available micronutrients status in soil of chunar (Gangpur and Bhawanipur villages)

Soil parameters (unit=ppm)	Critical level of micronutrients in soil			Gangpur village		Bhawanipur village	
	Low	Medium	High	Range	Mean	Range	Mean
Iron (Fe)	<4.5	4.5- 9.0	>9.0	16.20-43.60	24.16	13.20-35.60	22.79
Manganese (Mn)	<2.0	2.0- 4.0	>4.0	1.02-6.46	2.95	0.70-7.00	3.45
Copper (Cu)	<0.2	0.2- 0.4	>0.4	0.44-3.17	1.56	0.38-1.72	1.23
Zinc(Zn)	<0.6	0.6-1.2	>1.2	0.50-1.80	0.75	0.52-1.14	0.73
Boron (B)	<0.1	0.1-0.6	>0.6	0.03-1.87	0.27	0.13-0.37	0.26



**Fig 3:** Comparative analysis of micronutrient level in soil of Chunar

Variation in mean of essential micronutrients among the two villages are compared in fig. 3, showing Fe and Zn was

comparatively higher in Gangpur while Mn in Bhawanipur. Availability of Cu and B were almost same for both the

region. In case of few plots boron concentration was extremely low indicating constrain in crop production as B is an essential element to crop particularly reproductive stage.

### Correlation study of micronutrients with other soil properties in Gangpur

Between soil physicochemical properties and available micronutrients:

**Table 3:** Correlation co-efficient between soil physicochemical properties and available micronutrients in alluvial soil of Gangpur

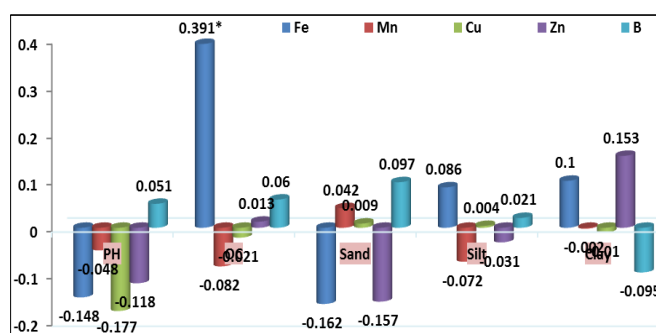
	pH	OC	Sand	Silt	Clay	N	P	K	Ca	Mg	S
Fe	-0.148	0.391**	-0.162	0.086	0.100	-0.028	0.403**	0.403**	0.069	0.260	0.027
Mn	-0.048	-0.082	0.042	-0.072	-0.002	-0.174	0.104	0.125	0.168	-0.193	-0.089
Cu	-0.177	-0.021	0.009	-0.004	-0.010	0.017	-0.013	0.255	0.346*	0.126	0.092
Zn	-0.118	0.013	-0.157	-0.031	0.153	0.103	-0.095	-0.053	-0.088	-0.028	-0.275
B	0.051	0.060	0.097	0.021	-0.095	0.103	0.209	0.043	-0.083	-0.009	-0.049

\*correlation is significant at 5% level of significance

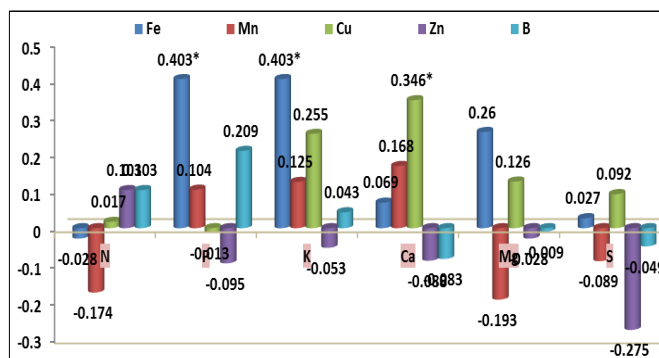
\*\*correlation is significant at 1% level of significance

We see a significant positive correlation of iron with OC ( $r = 0.391$ ), P ( $r = 0.403$ ), K ( $r = 0.403$ ) and of copper with Ca ( $r = 0.346$ ) (Table 3). pH show positive correlation with cationic micronutrient and negative with boron (Fig. 4). Higher solubility of cationic micronutrient at low pH is reason behind such outcome. At lower pH the negative site of soil phase is in equilibrium with  $H^+$  which is ample in soil not letting soil to bind plant nutrients (Z. Rengel, 2015). Boron is the nutrient

available at pH between 5.5 -7.0 and again when pH is greater than 10. The samples analyzed under the study were reported to have pH between 7.96-9.15 thus showed low levels of boron in soil. OC represent positive correlation with all micronutrients except Cu as this element offer a highly stable complexation with OC next to Ni. Moreover Fe showed significant positive correlation with P ( $r = 0.403$ ) and K ( $r = 0.403$ ) while Cu with Ca.



**Fig 4:** Correlation between micronutrients and basic soil properties (Gangpur)



**Fig 5:** Correlation between micronutrients and macro nutrients (Gangpur)

### Correlation study of micronutrients and soil properties in Bhawanipur

Between soil physicochemical properties and available micronutrients: In case of Bhawanipur there is lack of clarity

in correlation of micronutrients and soil properties. Value of correlation coefficient is too small to be categorized as significant or non-significant. The results obtained are expressed in table 4 and fig 6 & 7 as well.

**Table 4:** Correlation co-efficient between soil properties and available nutrients in alluvial soil of Bhawanipur

	pH	OC	Sand	Silt	Clay	N	P	K	Ca	Mg	S
Fe	-0.558	-0.470	-0.128	0.505	-0.388	0.562	0.309	0.783	0.130	0.769	0.399
Mn	0.187	-0.768	0.277	0.183	-0.553	-0.204	-0.043	0.290	-0.616	0.406	-0.066
Cu	-0.273	-0.458	-0.626	0.321	0.450	0.623	-0.480	0.297	-0.058	0.035	0.115
Zn	-0.495	0.466	0.245	-0.315	0.031	0.438	0.182	0.052	0.250	-0.340	-0.250
B	-0.056	0.111	-0.059	0.731	-0.724	-0.188	0.280	-0.134	0.163	0.044	-0.283

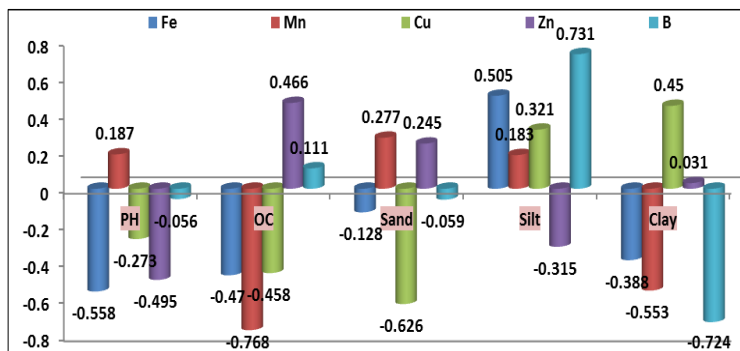


Fig 6: Correlation between micronutrients and basic soil properties (Bhawanipur)

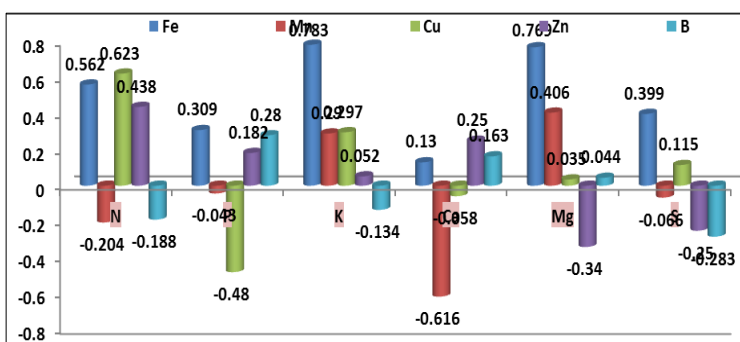


Fig 7: Correlation between micronutrients and macro nutrients (Bhawanipur)

#### Factors showing significant correlation with micronutrients

On meticulous observation we get Fe is significantly and positively correlated with OC, phosphorus and potassium content in soil. the functional group present in organic compound chelate Fe and prevent its leaching and other associated losses simultaneously like precipitation, oxidation or any other alteration. This binding is not so strong in order to ensure detachment of micronutrients from organic matter when plant suffers deficiency. Mn maintained positive correlation with secondary nutrients C and S. While Cu maintained the same with Zn.

agriculture practices which can reduce our reliance on agrochemicals and environmental pollution too. Soil test based fertilizer recommendation can be utilized as efficient tool to bring alteration in fertilizer application as per nutrient status of the soil. This study suggest that studied area are rich in cationic micronutrient so we need not to be worried about cationic nutrients while applying fertilizers or we can go for cutting of 25% recommended fertilizer dose to save input and get higher B: C ratio but since the soil are low in boron we must turn our focus towards anionic micronutrients as leaching or low retention of anionic nutrients is a big challenge of middle IGP.

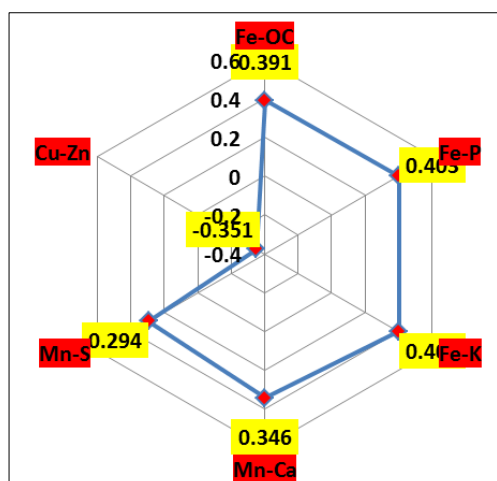


Fig 8: Factors showing significant correlation with micronutrients (Gangpur)

#### Conclusion

Per capita land availability and quality of arable land are decreasing constantly in India due to intensification of farming practices so we are to use our resources very precisely. We as responsible citizen must be aware of our responsibility and right of soil too. We should go for

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