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Micronutrient Indexing of Soils Located in Attock District of Pakistan: A Guide to Replenish the Nutrient Deficiency.

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Abstract:

The agricultural land of Attock district falls in Pothwar area of the Punjab Pakistan which is mostly rainfed (*barani*) and agriculture in the area depends on rainfall which is erratic and scanty. Therefore, soil health becomes more crucial for crop growth while application of micronutrients is negligible in this area. During the years from 2016 to2018, 15,337 soil samples were collected from the district Attock to determine micronutrient status of the soil. These soil samples were analyzed for Zinc (Zn), copper (Cu), Iron (Fe) and Manganse (Mn) using DTPA extraction method while dilute HCl method for Boron (B). The results indicated that nutrient index value of plant available Zn was in the marginal category (1.84) with 30.7% soil samples falling in low, 54.1% in marginal and 15.2% in adequate category. Nutrient index value of plant available Cu was in the adequate category (2.18) with 16.9 % soil samples in low, 47.9% in marginal and 35.2% in adequate category. Nutrient index value of plant available Fe was 1.46 (low) where 76.8% soil samples were found to be low and 23.2% adequate. Nutrient index value of plant available Mn was 1.11 (very low) where 89.3% soil samples were low, 9.9% marginal and only 0.8% adequate. Nutrient index value of plant available B was also in very low category (1.25) with 74.2% soil samples low and 25.8% marginal. The results indicated depletion and low concentration of micronutrient in most soil of Attock district which ultimately urges the use of balanced fertilizer for higher crop yield.

Key Words: *DTPA, Micronutrient, Nutrient Index, Soil analysis.*

Introduction

The district of Attock lies between 33.46º N latitude and 72.22ºE longitude comprising 692 thousand hectares of land area with 46 % under cultivation while 54 % is non cultivated. Major portion of area is comprised of plain agriculture land, mountains and barren land. Major crops grown in the district are wheat, maize and ground nut. The climate of the area varies from hot humid summers to dry cold winters. The maximum summer temperature is 50^0C while minimum winter temperature is -2^0C. Attock district falls in rainfed (barani) areas of Pakistan where rainfall pattern is erratic and unpredictable. Average annual rainfall is around 783 mm (Yunas *et al*., 2015). Thus, crop growth is dependent on rainfall and soil fertility status. Various nutrients, both macro and micro are required for achieving optimum yield potentional. However, micronutrient status of the soils is ignored in most of the cases which adversely affect quality and quantity of the produce. Microelements play a vital role in the growth and development of crops through regulating specific functions. Plants tend to maintain a balanced physiology by utilizing micronutrients as evident from various studies. The plants are prone to damage due to micronutrient deficiency. Key growth processes like cell development, protein synthesis, carbohydrate metabolism, chlorophyll synthesis, synthesis of growth hormones, respiration and redox reactions are regulated by micronutrients (Ahmed *et al*., 2017). There is widespread deficiency of micronutrients in plants and consequently in humans, specifically in developing countries like Pakistan. There are many reasons for micronutrient deficiency in soil including calcareousness, alkaline pH, low organic matter, and improper fertilizer usage (Malakouti, 2008). Micronutrient deficiency in plants results in symptoms like leaf chlorosis, de shaped leaves and stunted growth which ultimately deteriorate the fruit quality. Evaluation of micronutrient status of the soil can help in promoting balanced use of inputs and 4R nutrient stewardship i.e right nutrient, right rate, right time, right place (Soil Fertility Atlas of Pakistan, FAO 2017). The most prevalent micronutrient deficiency is of Zn in crops in the rain fed Pothowar plateau of Pakistan.

It has been reported by Imtiaz *et al*., (2010) that most of the arable soils of Pakistan originated from alluvium and loess parent material and are naturally deficient in organic matter and most of the essential nutrients. It was ascertained through a research study by Malakouti, (2008) that keeping in view the vital role of micronutrients in elimination of hidden hunger and maintaining normal human health, more work is needed to evaluate the benefits of using their optimum level instead of viewing critical level as threshold with regard to crop yield and grain quality. Our farmers are still unaware about the role of micronutrient in crop production, micronutrient analysis and recommendation facilities. Hence, there is need to know the status of micronutrients in soils which will help to promote the use of micronutrient for crop production in rainfed areas.

Material and methods

During the period 2016-18, 15,337 soil samples were collected from the various location of Attock district to determine micronutrient status. The sampling depth was 0-15 cm. The samples were dried in the shade and were sieved using 2 mm sieve. The DTPA extractant was used to determine Fe, Cu, Zn and Mn in soil (Lindsay and Norvell, 1978) and diluted HCL was used for soil B extraction (Bingham, 1982). The micronutrient (Fe, Cu, Zn and Mn) contents were measured by Atomic Absorption Spectrometer and Boron by Spectrophotometer. The results were interpreted by statistical parameters like minimum, maximum, average and standard deviation etc.

Nutrient index values: Nutrient index value was tabulated from the categorization of soil in low, medium and high nutrient levels as displayed by the following equation NIV = $[(P_H*3) + (P_M*2) + (P_L*1)]$ 100

Where,
NIV = Nutrient index value
P_L, P_M and P_H are the %age of the soil samples found in the categories of low, medium and high nutrients status with numbering weightage of 1, 2 and 3 respectively (Ramamoorthy and Bajaj, 1969).

Classification of nutrient index value

Less than 1.33 = Very low 1.33 to 1.66 = Low
1.67 to 2.0 = Marginal 2.0 to 2.33 = Adequate
2.33 to 2.66 = High > 2.66 = Very high

Results

Micronutrient status of soil in district Attock on the basis of soil analysis for Fe, Cu, Zn, Mn, and B are presented in Table

Table 1. Micronutrient status in the soils lying under district Attock.

Nutrient	Criteria	Samples	%age
Zinc (Zn)	Low <0.5 mg kg^{-1}	4,713	30.7
	Marginal 0.5-1.0 mgkg^{-1}	8,293	54.1
	Adequate >1.0 mg kg^{-1}	2,331	15.2
Iron (Fe)	low<4.5 mg kg^{-1}	11,785	76.8
	Adequate >4.5 mg kg^{-1}	3,552	23.2
Copper (Cu)	Low <0.2 mg kg^{-1}	2,593	16.9
	Marginal 0.2-0.5 mg kg^{-1}	7,344	47.9
	Adequate >0.5 mg kg^{-1}	5,400	35.2
Manganese (Mn)	Low <1.0 mg kg^{-1}	13,701	89.3
	Marginal 1.0-2.0 mg kg^{-1}	1,519	9.9
	Adequate >2.0 mg kg^{-1}	117	0.8
Boron(B)	Low <1.0 mg kg^{-1}	11,387	74.2
	Marginal 1.0-2.0 mg kg^{-1}	3,950	25.8

Soil analysis for Zn indicated > 80 % soil samples ranged between low (<0.5 mg kg^{-1}) to marginal (0.5-1.0 mg kg^{-1}) while <20 % of the soil samples were adequate (>1.0 mg kg^{-1}). However, nutrient index value of plant available Zn was falling in the marginal category (1.84) as shown in Table 8.

The data analysis showed that up to 79 % soils were low in Fe and Fe content ranged 0.56-4.49 mgkg^{-1}. Around 25% soils were adequate in Fe with content ranging from 4.5 to12.30 mg kg^{-1} (Table 3). Nutrient Index Value of plant available Fe was 1.46 (low) as shown in Table 8.

Soil analysis of tehsil Attock revealed that 35% of soil samples had adequate level of Cu i.e. 2.01-4.63 mg kg^{-1} while almost 45% soils were marginal i.e. 0.2- 0.49 mg kg^{-1} and almost 20% were low i.e. 0.04-0.19 mg kg^{-1} (Table 4). Nutrient index value of plant available Cu was in the adequate category (2.18) as shown in Table 8.

Nutrient index value of plant available Mn was 1.11 (very low) as shown in Table 8. The analytical results regarding Mn expressed that in tehsil Attock 86% soil samples had low Mn content ranging from 0.07 mg kg^{-1} to 0.99 mg kg^{-1} while 13% soil samples had marginal Mn between 1.0 mg kg^{-1} to 1.99 mg kg^{-1}.Only 1% soil samples had adequate iMn content varying from 2.0 mg kg^{-1} to 4.6 mg kg^{-1} (Table 5).

The Nutrient index value of plant available B also fell in very low category (1.25). The analysis reflected that soil in tehsil Attock had low B in 75% soils containing B in range of 0.1 to 0.44 mg kg^{-1} while 25% soil samples had marginal level i.e. 0.45 to 0.91 mg kg-1. Boron status in tehsil Fateh Jang indicated that 74% soil samples had low B level ranging from 0.1 to 0.44 mg kg^{-1} while 26% soil samples had marginal level ranging from 0.45 to 0.90

mg kg^{-1}. In tehsil Hassan Abdal, 75% soil samples were low in B and ranged from0.11 to 0.44 mg kg-1 while 25% soil sample had marginal B ranging from 0.45 to 0.88 mg kg^{-1}. In tehsil Hazro, 75% soil samples had low B level falling in the range 0.1 to 0.44 mg kg^{-1} while 25% soil samples had marginal B status in the range of 0.45 to 0.90 mg kg^{-1}. In tehsil Jand, 73% soil samples were low in B ranging from 0.09 to 0.44 mg kg^{-1} while 27% soil samples had marginal B range from 0.45 to 0.88 mg kg^{-1}. In tehsil Pindi Gheb, 77% soil samples contained B in range of 010 to 0.44 mg kg^{-1} while 23% soil samples have marginal B content from 0.45 to 0.86 mg kg^{-1} (Table 6).

Table 2. Status of available Zn in soil

Tehsil	**Low**	**Marginal**	**Adequate**	**Total**	**Tehsil wise %age**		
					Low	Marginal	Adequate
Attock	748	1406	415	2569	29	55	16
Fateh Jang	924	1667	500	3091	30	54	16
Hassan Abdal	377	681	214	1272	30	54	17
Hazro	710	1160	404	2274	31	51	18
Jand	1369	2317	557	4243	32	55	13
Pindi Gheb	585	1062	241	1888	31	56	13
Total	4713	8293	2331	15337	31	54	15

Iron status in soil: Iron is the second most important micronutrient after zinc for boosting crop production. It is taken up by plants in the form of ferrous (Fe^{+2}) ion from soil. It is a pivotal component of several enzymes engaged in energy transfer, nitrogen reduction, C fixation and lignin synthesis. The present study is in line with Ahmed *et al.* (2017) reporting 60% soil samples deficient in Fe. Iron deficiency was reported in Pakistan by Zia *et al.* (2006). Imtiaz *et al*. (2010) conducted a study in rainfed area of Pakistan and observed that application of Fe fertilizer enhanced yields of peanut, potato and chickpeas by 30, 16 and 15%, respectively.

Table 3. Status of Iron (Fe) in soil

Tehsil	**Low**	**Adequate**	**Total**	**Tehsil wise %age**	
				Low	Adequate
Attock	1963	606	2569	76	24
Fateh Jang	2327	764	3091	75	25
Hassan Abdal	949	323	1272	75	25
Hazro	1793	481	2274	79	21
Jand	3294	949	4243	78	22
Pindi Gheb	1459	429	1888	77	23
Total	11785	3552	15337	76.8	23.2

Copper status in soil: Copper tends to activate some of the enzymes which catalyze key reactions in plant growth process. Its presence mediates production of vitamin A , and it also ensures protein synthesis in plants. Ahmed *et al*, (2017) showed that Cu concentration of all soil samples was adequate. Same trend was observed in Tehsil Hazro where 19% soil samples were low range (0.05-0.19 mg kg^{-1}) while45% were in marginal range (0.20-0.49 mg kg^{-1}) and 36% in adequate range (0.50-1.13 mg kg^{-1}). In tehsil Hassan Abdal, 12% soil samples were in low range (0.09-0.19 mg kg^{-1}), 47% were in marginal range (0.20-0.49 mg kg^{-1}). Zia *et al*. (2006) reported occasional deficiency of Fe in Pakistan. On the other hand, it was ascertained by Dahar *et al*, 2014 that there was no deficiency of Cu in Pakistani soil

Table 4. Status of copper (Cu) in soil

Tehsil	**Low**	**Marginal**	**Adequate**	**Total**	**Tehsil wise %age**		
					Low	Marginal	Adequate
Attock	512	1145	912	2569	20	45	35
Fateh Jang	370	1517	1204	3091	12	49	39
Hassan Abdal	154	596	522	1272	12	47	41
Hazro	425	1031	818	2274	19	45	36
Jand	795	2133	1315	4243	19	50	31
Pindi Gheb	337	922	629	1888	18	49	33
Total	2593	7344	5400	15337	16.9	47.9	35.2

Manganese status in soil: Manganese is basically an integral part of enzyme system of plants. It tends to activate many crucial metabolic reactions and has a direct role in photosynthesis reaction. Manganese promotes germination and maturity by enhancing availability of P and Ca. almost same trend was observed in tehsil Fateh Jang, Hasan Abdal, and Pindi Gheb while in tehsil Hazro and Jand >90% soil samples had low range of Mn from 0.07 – 0.99 mg kg^{-1} while only 1 % soil samples had Mn in adequate range (2.04 to 3.07 mg kg^{-1}) in Hazro which indicates the deficiency of Mn in soil ultimately affecting the quality of fruits, vegetables and crops in the area. However, some researchers reported the Mn status as

adequate in the Pakistan like Ahmed *et al*, (2017) showed that Mn concentration of all soil samples was adequate. Dahar *et al.* (2014) also reported that all the soil series analyzed were found adequate in Mn

Table 5. Manganese (Mn) status in soil

Tehsil	Low	Marginal	Adequate	Total	Tehsil wise %age		
					Low	Marginal	Adequate
Attock	2216	329	24	2569	86	13	1
Fateh Jang	2746	316	29	3091	89	10	1
Hassan Abdal	1076	184	12	1272	85	14	1
Hazro	2111	155	08	2274	93	7	0
Jand	3904	312	27	4243	92	7	1
Pindi Gheb	1648	223	17	1888	87	12	1
Total	13701	1519	117	15337	89.3	9.9	0.8

Boron status in soil: Boron is found in soil solution as BO_3^{-3} anion and taken up by plants in the same form. After Zn, boron is most vital microelement supporting membrane and structural stability in plants. Boron deficiency symptoms at first appear at young leaves and also depends on soil texture as sandy soils tend to have more B deficiency. Zia *et al.*, 2006 described that B deficiency in Banana and apple orchards is widespread. It may be due to monsoon as B is highly soluble. Boron application offers resistance to premature fruit drop and improves fruit quality through its impact on Ca nutrition of fruits.

Table 6. Status of Boron (B) in soil

Tehsil	Low	Marginal	Adequate	Total	Tehsil wise %age		
					Low	Marginal	Adequate
Attock	1923	646	-	2569	75	25	-
Fateh Jang	2274	817	-	3091	74	26	-
Hassan Abdal	949	323	-	1272	75	25	-
Hazro	1702	572	-	2274	75	25	-
Jand	3082	1161	-	4243	73	27	-
Pindi Gheb	1457	431	-	1888	77	23	-
Total	11387	3950	-	15337	74.25	25.75	

Table 7. Statistical description of micronutrients in soils of Attock district

Micronutrient	n	Mean	Minimum	Maximum	SD
Zn	2569	0.68	0.10	2.69	0.32
Fe	2569	3.74	0.71	10.01	1.34
Cu	2569	0.39	0.04	1.26	0.18
Mn	2569	0.52	0.07	4.76	0.42
B	2569	0.36	0.10	0.91	0.14

Table 8. Nutrient index values of micronutrients in soils of Attock district

Micronutrient	Nutrient index value
Zn	1.84
Fe	1.46
Cu	2.18
Mn	1.11
B	1.25

Discussion

The data revealed that the soils in the Attock district are low in Zn, Fe, Mn and B, Therefore, the quality of crops grown in micronutrient deficient soils may be affected and there is need for application of nutrient supplement. Zia *et al.*, 2006 reported a largescale deficiency of soil Zn followed by Fe in Pakistan while there was occasional deficiency of Cu and Mn. The soils deficient in micronutrients not only result in rediced crop productivity but also grain quality is deteriorated (Imtiaz *et al*, 2010). The soils currently falling under marginal category regarding macro and micro nutrients would further degrade into low category in the coming years, hence the sustainable crop production techniques should be adopted (Ahmed *et al*, 2017). A study showed an increment of 4 to 11 % in wheat grain yields grown at 815 irrigated sites in Iran by the application of micronutrients (Fe, Zn, Cu and B) alone and in combination with NPK fertilizers (Malakouti, 2000).

Zinc status in soil: Zinc plays a key role in synthesis of auxin from tryptophane, its solubility is related with pH, as the pH increases, Zn solubility decreases. The low status of zinc in all tehsils may be the result of alkaline nature of soils. Most of the samples fell under alkaline range of pH and 75% samples were found to be in low to marginal category of soil Zn as

narrated by Ahmed *et al*, 2017. As the soil has inadequate zinc content to be available for crop plants, there is a dire need for ample provision of Zn fertilization to enhance soil nutrient pool in order to ensure optimum crop production (Dahar *et al*, 2014). As zinc was the first element in micronutrients which was categorized as essential nutrients for plant growth and it is impossible to get higher crop yields without its application. Harvest Plus project suggests that Zn and Fe contents in cereals grains must be in the range of 50-60 mg kg^{-1} to cope with malnutrition in human beings (Imtiaz *et al*, 2010). There was no zinc toxicity detected in plants as well as in soil in spite of some higher Zn concentrations (Malakouti, 2008). The results are in coincidence with Dahar *et al*, 2014 who indicated that 40 % of the soil samples were low in available Zn content.

Recommendations

It is critical that the available micronutrients status of cultivated soil should be known on a sustained basis to make sure its application as and when required so as to avoid decline in crop productivity and food quality. The status of micronutrient in the district Attock compel the farming community for following actions:

1. Organic matter improves micronutrient uptake to plants through metal organic chelation process occurring naturally in presence of it. Therefore, application of organic matter will help to improve micronutrient status of soils
2. The regular application of micronutrients to plants will ensure high productivity and quality.
3. Biofortification or more precisely Ferti-fortification will enrich edible part of the plants with micronutrients through fertilization. This strategy needed to be adopted in order to reduce human malnutrition.
4. Use of chelates to cope with the deficiency of micronutrients.
5. The calcareous soils are the other hindrance in availability of micronutrients to plants because theses soils have high pH. It is very important to apply micronutrients to crops on regular basis to improve crop health.

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