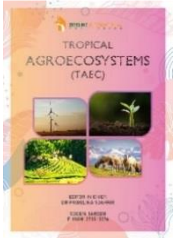
ZIBELINE INTERNATIONAL PUBLISHING

Tropical Agroecosystems (TAEC)

DOI: http://doi.org/10.26480/taec.01.2021.37.43

ISSN: 2735-0274 (Online)
CODEN: TARGDB



RESEARCH ARTICLE

MICRONUTRIENT STATUS OF TISTA MEANDER FLOODPLAIN SOILS UNDER MAJOR CROPPING PATTERNS IN MITHAPUKUR UPAZILA

S. M. Shahriar Zaman, Md. Sanaul Islam*

Soil, Water and Environment Discipline, Khulna University, Khulna-9208, Bangladesh
****Corresponding Author Email: msislam@swe.ku.ac.bd***

ARTICLE DETAILS

Article History:

Received 18 February 2021
Accepted 22 March 2021
Available online 30 April 2021

ABSTRACT

Soil micronutrients from their finite source are strongly affected by the inclusion of high-yielding crop cultivars in the cropping patterns and their fertilization practices. A study was conducted to identify the dominant cropping patterns and to evaluate their impacts on soil micronutrients' (Zn, B, Cu, Fe, Mn) status in Tista Meander Floodplain Soils at Mithapukur upazila of Rangpur district, Bangladesh. The study revealed that potato-rice-rice (P-R-R) (18.26%), rice-fallow-rice (R-F-R) (15.65%), and maize-fallow-rice (M-F-R) (13.91%) were the most prevalent among the existing cropping patterns. Zn and B fertilizers are used by 35% and 23% of farmers. The concentrations of Zn, B, and Mn increased while Cu and Fe decreased under all dominant patterns. The highest accumulation of Zn by 281.63%, B by 139.36%, and Mn by 83.13% were obtained under P-R-R while, the highest depletion of Cu by 52.58% and Fe by 24.48% were obtained under P-R-R and M-F-R cropping patterns, respectively. An increasing trend of soil toxicity index (STI) values was observed with Zn, B, and Mn. A deleterious shift of B from lower to higher STI class was obtained under the P-R-R and R-F-R patterns while an ameliorating shift of Cu from higher to lower class was obtained under P-R-R and M-F-R patterns. The recent STI status of Fe and Mn under all cropping patterns rendered in the 'highly toxic' class. This investigation emphasizes that the concentrations of selected micronutrients were found above their respective critical limits and that the studied micronutrients except Zn imposed toxicity in the soil.

KEYWORDS

Micronutrient, Cropping pattern, STI, Critical limit.

1. INTRODUCTION

Soil micronutrients play many important and complex roles in agriculture towards profitable plant growth, crop yield quality and quantity, and sustainable crop production (Sharma et al., 2017; Nziguheba and Smolders, 2008). Although plants need in trace amounts, a shortage of micronutrients in soil can limit plant growth and crop yields and an excessive or toxic concentration of any of them can cause extensive cellular damage, reduction in crop yield, and deterioration in quality (Morgan and Connolly, 2013; Singh, 2012; Barker and Pilbeam, 2007). The micronutrients are also essential for their macro role in enhancing the use efficiency and partial factor productivity of NPK fertilizers and it has declined over the years due to the emerging deficiency of micronutrients (Shukla et al., 2009). The omission of micronutrients from the balanced fertilization schedule caused the decline in the productivity of rice-wheat sequence in the range of 3.5-17.5%. P use efficiency increment in the rice-rice system was recorded with the addition of Zn (35.4%) followed by B (28.7%) and Mn (15.6%) in a balanced fertilization schedule (Tiwari, 2008).

The green revolution led adoption of intensive cropping practices by the high-yielding crop cultivars in the cropping patterns, the use of high-analysis fertilizers with low micronutrient content, decreased use of organic manures and crop residues, allowance to consistent mining away of micronutrients from their finite soil source resulted in the deterioration of soil fertility with the emergence of micronutrient deficiency and their phyto-availability (Takkar and Shukla, 2015; Sarker et al., 2020). The cropping intensity of Bangladesh is rapidly increasing. It was 171% in 1983-84, 195% in 2017-18 and 197% in 2018-19 (BBS, 2018; BBS, 2020). Furthermore, the application of micronutrient fertilizers has long been overlooked in Bangladesh like many parts of the world. Only Zn and B fertilizer input has only begun in recent years in Bangladesh. (Banglapedia, 2015). Zinc deficiencies in rice and maize were observed in the early 1980s in Bangladesh (Alam et al., 2000). Frequent cases of B deficiency and sporadic cases of Cu and Mn deficiencies in varying crops have been reported in the early 1990s (Ferdoush et al., 2003).

Cropping patterns and fertilization practices strongly affect soil

Quick Response Code	Access this article online	
	Website: www.taec.com.my	**DOI:** 10.26480/taec.01.2021.37.43

Cite the Article: S. M. Shahriar Zaman, Md. Sanaul Islam (2021). Micronutrient Status of Tista Meander Floodplain Soils Under Major Cropping Patterns in Mithapukur Upazila. *Tropical Agroecosystem, 2(1): 37-43.*

micronutrient status (Li et al., 2007; Wei et al., 2006). The fertility status of soils is variable and in most of the areas in Bangladesh it has declined (SRDI, 2008). Siddique et al. (2014) reported consequences of conventional agriculture and long term (1991-2002) impacts of chemical fertilizer-based farming in Piedmont soil area and concluded that soil fertility characteristics, such as soil acidity, organic matter content, and some plant nutrients have been declined and some even reached beyond their critical levels. Among other recent studies, Hassan et al. (2017) carried out a comparative study on soil chemical data of different Upazillas generated between 1996 and 2016. Islam et al. (2017) conducted a study in the Tista Meander Floodplain (AEZ 3) to determine the requirement of selected micronutrients (B, Zn, Cu, Mn, Fe, and Mo) for crops and cropping patterns and to evaluate their effect on crop yield and found that across the experimental sites, the crops were quite responsive to the added Zn and B and selectively to Cu and that Zn application at 4 kg ha^{-1} coupled with B application at 1.5 kg ha^{-1} to the first crop can meet their requirement for the subsequent two crops in a pattern. In general, cropping pattern-based micronutrient research is limited and very few in number and the information about micronutrient status in the Tista Meander Floodplain soil is far more limited.

This study was conducted in Tista meander floodplain soils (AEZ-3) to identify the major cropping patterns and their fertilization practices and to evaluate their combined impacts on soil micronutrient (Zn, B, Cu, Fe, and Mn) status.

2. MATERIALS AND METHODS

2.1 Study area

The study was conducted in 'Tista Meander Floodplain' (Agroecolozical zone-3) soils under 'Tista Floodplain' physiography at Mithapukur upazila in Rangpur district, which is situated in the north-western part of Bangladesh and located between 25°26' N to 25°41' N and 89°06' E to 89°27' E (Figure 1). Most of the land is flat with some undulation. Land types comprise high land (44.76%), medium high land (51.78%), medium low land (1.08%), and others (2.38%) (SRDI, 2005).

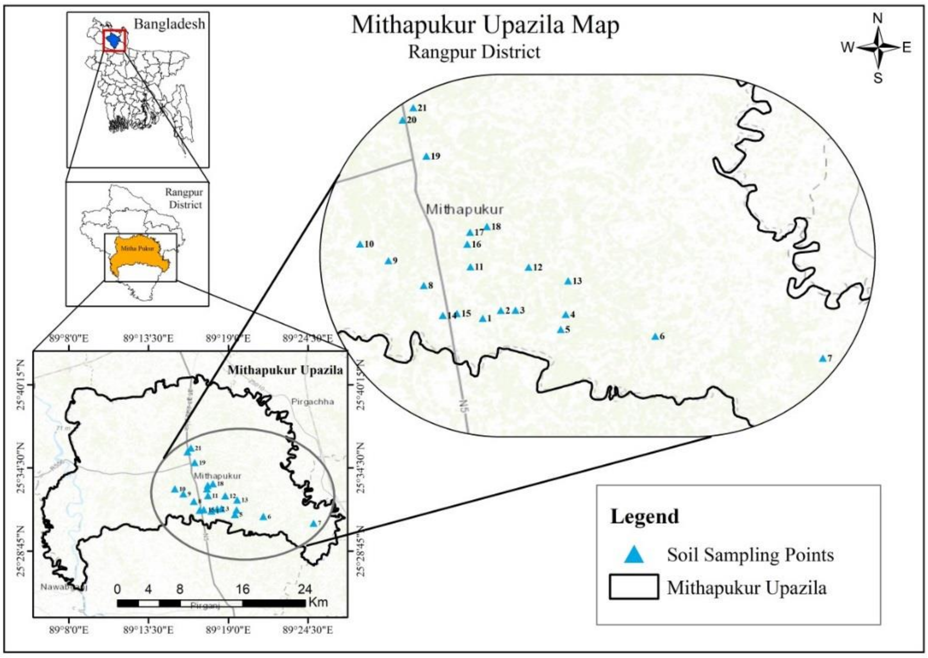


Figure 1: Map of the study area with sampling points

The climate of this area is characterized by tropical monsoon climate. The average temperature and rainfall data of Mithapukur upazila under three cropping seasons are given in table 1.

Table 1: Average temperature and rainfall data of Mithapukur upazila under three cropping seasons

SL. No.	Cropping Seasons	Temperature (ºC)		Rainfall (mm)
		Range	Average	
1	Rabi (November-February)	17.3-22.5	19.4	33
2	Kharif-I (March-May)	23.3-27.3	25.7	373
3	Kharif-II (June-October)	26.5-29.2	28.3	1717

Source: Land and Soil Resource Utilization Guide, Mithapukur, Rangpur (SRDI, 2005).

2.2 Identification of the sampling locations of baseline study

The "Land and Soil Resource Utilization Guide" (popularly known as 'Thana Nirdeshika') of Mithapukur upazila and the map generated by the SRDI staff in 2005 were selected as the baseline information sources for this research. By using this map and GIS tool, sampling points used by SRDI staff in 2005 for soil fertility assessment were properly located with the accuracy level of ±4 m. To identify the sampling points, the soil and land type map of Mithapukur upazila was scanned by digital scanner and projected and interpreted with google earth map using ArcGIS 10.4 software and the coordinates (Latitude and Longitude) of the sampling points were determined to locate the sampling points. A total of 135 sampling points of the SRDI (2005) study were identified those fall within the boundary Tista Floodplain (AEZ-3) in Mithapukur upazila.

2.3 Questionnaire survey and selection of cropping patterns_

A total of 115 out of 135 sampling points within AEZ-3 were surveyed. A questionnaire survey was carried out in the study area to enlist the existing (≥15 years) cropping patterns and to record their respective fertilizer input practices. The farmers above 40 years of age having farming experience of ≥15 years were considered as the reliable respondents (n=115: taking one respondent from each sampling location) of the survey study. Questionnaires were designed as such, the existing cropping patterns in the study area could be identified and ranked thus three most widely practiced cropping patterns with a minimum of 7 replicated fields could be selected.

2.4 Soil Sample collection

A total of 21 (3 cropping patterns x 7 replicated fields) surface soil samples (0-15 cm) were collected (Table 2) in the month of February 2018. Soil samples from each field were collected and mixed thoroughly and homogenized to obtain composite samples as suggested by the Soil Survey Staff of the USDA (1951). During sampling, the potato was standing under P-R-R pattern, rice had just been transplanted under R-F-R pattern, and maize was standing under M-F-R cropping pattern. A portable Global

Positioning System (GPS) was used to record the location of each sampling point.

2.5 Laboratory analysis of soil sample

A total of twenty-one (21) soil samples were analyzed for determining pH, soil organic matter (SOM) and micronutrient (Zn, B, Cu, Fe, Mn) status of sampling sites. Soil sample analyses were carried out in the Regional Laboratory of Soil Resource Development Institute (SRDI), Khulna. The methods followed in 2005 and in this study in 2018 were similar. The Soil pH was measured by the glass electrode pH meter method (soil: water = 1: 2.5) (McLean, 1982). Soil organic carbon was determined by Walkley and Black wet oxidation method (Walkley and Black, 1934), and the amount of organic matter was calculated by multiplying the percent organic carbon with the van Bemmelen factor 1.73 (Piper, 1950). Zn, Fe, Cu, and Mn were determined by DTPA-extraction method at a soil: DTPA ratio of 1:2 using Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978). B was determined by $CaCl_2$ extraction using Atomic Absorption Spectrophotometer (SRDI, 2012).

Table 2: General information of sampling points

Sampling points	Location (GPS)	Soil series	Land Type	Texture	Cropping Pattern
1	25° 31' 30.95'' N 89° 17' 50.76'' E	Gangachara	Medium High land	Loamy	Potato-Rice-Rice (P-R-R)
2	25° 31' 40.59'' N 89° 18' 13.38'' E	Gangachara	High land	Loamy	Rice-Fallow-Rice (R-F-R)
3	25° 31' 40.97'' N 89° 18' 31.60'' E	Gangachara	High land	Loamy	Maize-Fallow-Rice (M-F-R)
4	25° 31' 35.79'' N 89° 19' 33.90'' E	Gangachara	High land	Loamy	Maize-Fallow-Rice (M-F-R)
5	25° 31' 17.08'' N 89° 19' 27.56'' E	Kaunia	Medium High land	Loamy	Rice-Fallow-Rice (R-F-R)
6	25° 31' 8.81'' N 89° 21' 24.97'' E	Gangachara	Medium High land	Loamy	Potato-Rice-Rice (P-R-R)
7	25° 30' 41.28'' N 89° 24' 52.78'' E	Imadpur	Medium High land	Loamy	Maize-Fallow-Rice (M-F-R)
8	25° 32' 11.75'' N 89° 16' 37.81'' E	Gangachara	Medium High land	Loamy	Rice-Fallow-Rice (R-F-R)
9	25° 32' 42.53'' N 89° 15' 53.81'' E	Gangachara	Medium High land	Loamy	Rice-Fallow-Rice (R-F-R)
10	25° 33' 3.15'' N 89° 15' 18.62'' E	Gangachara	Medium High land	Loamy	Rice-Fallow-Rice (R-F-R)
11	25° 32' 34.87'' N 89° 17' 35.47'' E	Gangachara	High land	Loamy	Potato-Rice-Rice (P-R-R)
12	25° 32' 34.34'' N 89° 18' 47.67'' E	Gangachara	High land	Loamy	Potato-Rice-Rice (P-R-R)
13	25° 32' 17.33'' N 89° 19' 36.86'' E	Kaunia	Medium High land	Loamy	Maize-Fallow-Rice (M-F-R)
14	25° 31' 34.58'' N 89° 17' 1.28'' E	Gangachara	Medium High land	Loamy	Rice-Fallow-Rice (R-F-R)
15	25° 31' 36.88'' N 89° 17' 18.91'' E	Gangachara	Medium High land	Loamy	Rice-Fallow-Rice (R-F-R)
16	25° 33' 2.916'' N 89° 17' 31.56'' E	Gangachara	High land	Loamy	Maize-Fallow-Rice (M-F-R)
17	25° 33' 17.69'' N 89° 17' 35.00'' E	Kaunia	Medium High land	Loamy	Potato-Rice-Rice (P-R-R)
18	25° 33' 24.93'' N 89° 17' 55.96'' E	Kaunia	Medium High land	Loamy	Maize-Fallow-Rice (M-F-R)
19	25° 34' 52.34'' N 89° 16' 40.91'' E	Jamun	High land	Loamy	Maize-Fallow-Rice (M-F-R)
20	25° 35' 37.24'' N 89° 16' 11.31'' E	Gangachara	Medium High land	Loamy	Potato-Rice-Rice (P-R-R)
21	25° 35' 52.35'' N 89° 16' 24.73'' E	Gangachara	Medium High land	Loamy	Potato-Rice-Rice (P-R-R)

Source: Land and Soil Resource Utilization Guide, Mithapukur, Rangpur (SRDI, 2005)

2.6 Secondary data collection and comparison

The baseline information of the soil pH, soil organic matter (SOM) and concentrations of micronutrients (Zn, B, Cu, Fe, Mn) of 2005 were collected from Land and Soil Resource Utilization guide of Mithapukur upazila prepared by the staff of Soil Resource Development Institute under Ministry of Agriculture, Bangladesh. The critical limits of the micronutrients (the minimum soil concentration needed for crop production) given in Land and Soil Resource Utilization guide of Mithapukur upazila (SRDI, 2005) was also used as the critical limit for this study. The concentrations obtained under the scope of this study in 2018 were compared with those obtained in 2005.

2.7 Soil toxicity index (STI) of micronutrients

The soil pollution index (SPI) equation given by Zang et al. (2017) was modified and Soil toxicity index **(**STI) for micronutrients was calculated by following equation (i):

$$STI = \frac{Ci}{Cbi} \text{ ……………………………… (i)}$$

where, STI is the soil toxicity index, Ci is the concentration of the ith micronutrient in the soil, and Cbi is its highest reference level. Micronutrients can become harmful and toxic when present in the soil in larger amounts (Weil and Brady, 2016). In this case, concentration class ‘very high’ (Table 3) for respective micronutrients was considered as the reference level (Cbi).

Cite the Article: S. M. Shahriar Zaman, Md. Sanaul Islam (2021). Micronutrient Status of Tista Meander Floodplain Soils Under Major Cropping Patterns in Mithapukur Upazila. *Tropical Agroecosystem, 2(1): 37-43.*

Table 3: Classification of micronutrients' concentration level

Nutrients	Class					
	Very Low	Low	Medium	Optimum	High	Very High
Zn (ppm)	0.45	0.451-0.9	0.91-1.35	1.351-1.8	1.81-2.25	>2.25
B (ppm)	0.15	0.151-0.3	0.31-0.45	0.451-0.6	0.61-0.75	>0.75
Cu (ppm)	0.15	0.151-0.3	0.31-0.45	0.451-0.6	0.61-0.75	>0.75
Fe (ppm)	3.0	3.1-6.0	6.1-9.0	9.1-12.0	12.1-15.0	>15.0
Mn (ppm)	0.75	0.76-1.5	1.51-2.25	2.26-3.0	3.1-3.75	>3.75

Source: Land and Soil Resource Utilization Guide, Mithapukur, Rangpur (SRDI, 2005).

Based on the STI values, toxicity can be classified into five categories: nontoxic (STI ≤ 1), slightly toxic (1 < STI ≤ 2), mildly toxic (2 < STI ≤ 3), moderately toxic (3 < STI ≤ 5), and highly toxic (STI > 5) (Zang et al., 2017).

2.8 Data analysis

After analysis of 21 soil samples and the collection of secondary data, processing, and interpretation were carried out. Seven soil samples were analyzed under each of the three cropping patterns. The data were screened and the outliers were discarded. Finally, five representative soil samples under each cropping pattern were considered for statistical analysis and used in results and discussion. Descriptive statistics such as means, standard deviation, minimum and maximum were used for data analysis and MS- Excel and statistical package software such as SPSS 16 were used for the illustration.

3. RESULTS AND DISCUSSION

3.1 Survey Result

3.1.1 Major Cropping Patterns

Survey result showed that 18.26% of the farmers practiced potato-rice-rice cropping pattern followed by rice-fallow-rice by 15.65% and maize-fallow-rice by 13.91% of the farmers (Table 4). These three major cropping patterns were selected for this research.

Table 4: Major cropping patterns of the study area

Major Cropping Patterns	Frequency	Percentage (%)	Rank
Rice-Fallow-Rice	18	15.65	2
Potato-Rice-Rice	21	18.26	1
Potato-Jute-Rice	12	10.43	5
Maize-Fallow-Rice	16	13.91	3
Maize-Jute-Rice	11	9.57	6
Wheat-Jute-Rice	6	5.22	8
Wheat-Fallow-Rice	9	7.83	7
Wheat-Rice-Rice	9	7.83	7
Others	13	11.30	4
Total	115	100.00	

3.1.2 Fertilizer Inputs

The survey was carried out to know the common fertilizer inputs by the farmers in the study area. Survey results found that all the farmers use Urea, TSP, and MoP in their fields. Farmers of the study area are recently getting interested to apply Zn and B fertilizer in their fields to increase the production of the crops. It was also found that 35.65% of farmers applied Zn-Fertilizer and 23.48% of farmers applied B-Fertilizer (Table 5).

Table 5: Common fertilizer inputs by the farmers

Inorganic Fertilizer	Frequency	Percentage (%)
Urea	115	100.00
TSP	115	100.00
MoP	115	100.00
DAP	57	49.57
Zn-Fertilizer	41	35.65
B-Fertilizer	27	23.48
Organic Manure	Frequency	Percentage (%)
Cattle Manure	83	72.17
Compost	39	33.91
Crop Residue	44	38.26

The survey result of this study found similarity with the report of Banglapedia (2015), in which it was stated that soils, particularly under constant waterlogging and irrigation have been found to respond to zinc (Zn) and boron (B) applications during the recent past. The calcareous floodplain soils are one of them. The demand for zinc fertilizers has been increased from 3 thousand metric tons in 2000-01 to 42 thousand metric tons in 2010-11.

3.2 Result of Soil Sample Analysis

3.2.1 Soil pH

The soil pH data obtained in 2005 were compared with those obtained in this study (Table 6). The result showed that soil pH ranged from 5.00 to 5.40 in 2005 which lies in the pH class strongly acidic (4.5-5.5). In 2018, the highest pH (5.72) was found under P-R-R cropping pattern followed by 5.65 in R-F-R and 5.55 in M-F-R cropping pattern which lies in the pH class slightly acidic (5.6-6.5). A comparative study showed that soil pH increased under all cropping patterns and the increment was highest in the M-F-R cropping pattern by 11.04% followed by R-F-R and P-R-R patterns by 8.16% and 5.89% respectively.

Table 6: Soil pH status under three cropping patterns

Cropping Pattern	Soil pH								
	2005 (SRDI)				2018				% Change*
	Mean	SD	Min	Max	Mean	SD	Min	Max	
P-R-R	5.40	0.34	5.10	5.90	5.72	0.33	5.22	6.07	5.89
R-F-R	5.22	0.20	4.90	5.40	5.65	0.34	5.19	6.07	8.16
M-F-R	5.00	0.23	4.60	5.20	5.55	0.19	5.25	5.73	11.04

**Negative (-) sign denotes the decrease of the rate*

According to the annual report of SRDI 2017-18 (SRDI, 2018) soil pH ranged in Rangpur division from 4.8-6.5 and 64% samples of which were slightly acidic which showed similarity with this study.

3.2.2 Soil organic matter (SOM) (%)

The soil organic matter (SOM) contents obtained in 2005 were compared with those obtained in this study (Table 7). The result showed that SOM ranged from 1.95% to 2.83% in 2005 which lies in the SOM class, medium (1.7-3.4%) while in 2018, SOM (%) sharply decreased in all the three cropping patterns and ranged from 1.16% to 1.49% which lies in the SOM class, low (1.0-1.7%). The comparison between the cropping patterns showed that the maximum decline of SOM was found in in M-F-R cropping pattern by 47.75% followed by R-F-R and P-R-R patterns by 40.16% and 33.13%.

SRDI (2018) reported in the annual report of 2017-18 that the soil organic matter content of Rangpur division ranged from 1.55-1.82% in which 50% of samples was low in the SOM class.

Table 7: Soil organic matter (SOM) (%) under three cropping patterns

Cropping Pattern	SOM (%)								
	2005 (SRDI)				2018				% Change*
	Mean	SD	Min	Max	Mean	SD	Min	Max	
P-R-R	1.95	0.34	1.54	2.32	1.31	0.21	1.03	1.54	-33.03
R-F-R	1.94	0.26	1.73	2.26	1.16	0.08	1.08	1.28	-40.16
M-F-R	2.83	0.99	1.55	3.95	1.49	0.45	0.97	1.91	-47.75

**Negative (-) sign denotes the decrease of the rate*

3.2.3 Status of micronutrients

The concentration of the micronutrients (Zn, B, Cu, Fe, Mn) in surface soils under three most widely practiced cropping patterns (P-R-R, R-F-R, M-F-R) of Mithapukur upazila were determined. Mean values (n=5) of micronutrient contents obtained under the scope of this research in 2018 and that carried out in 2005 by SRDI staff are presented in Table 8.

Table 8: Satus of micronutrients under three cropping patterns

Cropping Pattern	2005 (SRDI)				2018				% Change*	Critical Limit
	Mean	SD	Min	Max	Mean	SD	Min	Max		
Zn (ppm)										
P-R-R	0.39	0.13	0.23	0.52	1.50	0.63	0.75	2.28	281.63	0.6 (ppm)
R-F-R	0.58	0.10	0.41	0.68	1.53	0.24	1.10	1.69	164.71	
M-F-R	0.63	0.25	0.23	0.88	1.24	0.15	1.09	1.45	96.83	
B (ppm)										
P-R-R	0.38	0.09	0.30	0.52	0.90	0.32	0.50	1.32	139.36	0.2 (ppm)
R-F-R	0.35	0.06	0.28	0.43	0.80	0.11	0.63	0.90	131.21	
M-F-R	0.53	0.06	0.48	0.63	0.75	0.07	0.63	0.80	42.21	
Cu (ppm)										
P-R-R	3.02	0.72	1.95	3.84	1.43	0.16	1.26	1.67	-52.58	0.2 (ppm)
R-F-R	3.07	0.55	2.53	3.78	2.45	0.42	2.07	3.17	-19.96	
M-F-R	3.90	2.11	2.06	6.24	2.10	0.50	1.39	2.66	-46.15	
Fe (ppm)										
P-R-R	147.00	42.58	91.20	203.70	135.47	41.86	73.85	181.50	-7.84	4 (ppm)
R-F-R	156.60	21.69	136.80	190.10	124.58	21.47	102.69	159.48	-20.45	
M-F-R	189.80	42.49	142.60	237.60	143.33	38.97	99.86	195.62	-24.48	
Mn (ppm)										
P-R-R	13.78	2.84	8.90	16.30	25.24	6.55	19.14	35.44	83.13	1 (ppm)
R-F-R	20.34	7.10	12.00	28.40	28.43	3.83	24.51	34.64	39.75	
M-F-R	23.74	7.00	14.20	32.50	26.16	7.07	15.60	35.01	10.20	

**Negative (-) sign denotes the decrease of the rate*

This study shows that the concentration of Zn increased in all cropping patterns compared to the concentration obtained in 2005. Increment of Zn was much higher with double rice cropping patterns such as with P-R-R by 281.63% and with R-F-R by 164.71% than with M-F-R by only 96.83%. In 2005, Zn concentration was lower than the critical limit (0.6 ppm) (SRDI, 2005) in rice-based cropping patterns (P-R-R and R-F-R) and slightly above the critical limit under M-F-R cropping pattern while the Zn levels obtained in this study in 2018 were fairly above the critical limit (Table 8).

The increment of Zn content in soil might be caused by the recent trend of Zn fertilizer application by the farmers. Farmers of Bangladesh were not habituated with the use of micronutrients in crop production (Rijpma and Jahiruddin, 2004). Recent survey results of this study and Banglapedia (2015) report suggest for an increase in Zn fertilizer application which might have increased the Zn concentration in soil. Other studies showed that addition of decomposable organic matter enhances the bioavailability and accumulation of Zn due to its decomposition in soil (Dhaliwal et al. 2019; Fuente et al. 2011). Fageria (2008) stated that Zn deficiency decreased to 22% in the last decade.

A similar increasing trend was noticed for B in soils under all three cropping patterns. The increment was highest under P-R-R, R-F-R and M-F-R cropping patterns by 139.36%, 131.21%, and 42.21%, respectively. Organic fertilizer input on regular basis (Table 5) might have increased its contents in soil. Pakrashi and Haldar (1992) stated that addition of organic matter to soil upsurged B content and its availability to plants. On the contrary, Liu et al. (1989) and Valk et al. (1989) argumented for B deficiency with high organic matter content due to high affinity of organic matter to B. However, B concentrations obtained both in 2005 and 2018 were fairly above the critical limit (Table 8).

Comparative study of past and recent concentrations showed a remarkable change in Cu concentration in soil over a successive year of cropping practice. The concentration of Cu decreased with P-R-R, R-F-R and M-F-R cropping patterns by 52.58%, 19.96%, and 46.15% respectively. The rate of decrease is highest in P-R-R and lowest in R-F-R patterns. The concentrations of Cu obtained by SRDI (2005) under all cropping patterns were fairly higher than the critical limit (0.2 ppm). Although Cu concentration under all patterns decreased, the concentration of Cu in soils obtained by this study under all cropping patterns is still fairly higher than the critical limit. The depletion might be due to Cu uptake by hybrid crop in practice for more than 15 years without further Cu input.

Fe concentration showed a similar trend of change as Cu did. The concentration of Fe decreased with P-R-R, R-F-R, and M-F-R cropping patterns by 7.84%, 20.45% and 24.48% respectively. The rate of decrease is highest in M-F-R and lowest in P-R-R patterns. The concentration of Fe both in 2005 and 2018 under all patterns was much higher than the critical limit (4.0 ppm). Decrease in Fe content may be the result of continuous Fe uptake by the crops. This finding disagrees with the experimental finding of Antil and Singh (2007) where they reported that the application of organic manures with or without NP fertilizers increased DTPA extractable Zn, Fe, Mn, and Cu content of the soil.

The concentration of Mn increased in soil under all cropping patterns; P-R-R, R-F-R, and M-F-R by 83.13%, 39.75% and 10.20%. The critical limit of Mn for loamy soil is 1.0 ppm (SRDI, 2005). Values of Mn obtained by both SRDI staff (2005) and in this study in soils under all cropping patterns are fairly higher than the critical limit. The increase of Mn concentration in soil may be due to the inorganic and organic fertilizer (livestock manure - cow dung) application (Table 5) because the survey results reported that farmers did not apply any Mn fertilizer ever. Nziguheba and Smolders (2008) stated that usually, rock phosphorus fertilizers (e.g., superphosphate) containing Mn may increase concentrations of Mn in the soil after long-term application which is relevant to the findings of this study. Dach and Starmans (2005) stated that livestock manures contain micronutrients and they observed a remarkable increase in soil micronutrients after application of livestock manures. A good number of researches reported that organic fertilizers contain micronutrients. This might be the reason for the increment of Zn, B, and Mn in the soil of the study area.

The comparison between the cropping patterns revealed that the increment of Zn, B, and Mn concentration in soil was the highest with P-R-R cropping pattern and the lowest with M-F-R cropping pattern. In contrast to this finding, the highest Cu depletion was found under P-R-R and the highest Fe depletion were found under M-F-R cropping pattern. This study also found that Zn, B and Mn increased in the potato-based cropping pattern (P-R-R). Sharma et al. (2017) in their study in Punjab on the status of micronutrients in soils under-potato-based cropping system found that Zn, Fe, Cu, and Mn was higher than in the soils of non-potato based cropping system which partially agrees with the findings of this study for Zn and Mn.

However, micronutrient occurs in different forms and their transformation from one to another are affected by various cropping sequences (Sekhon et al. 2006). Practice of different fertilization method and cropping sequences are responsible for variation in behavior of Fe Mn, Zn, Cu, and B in soil and crops. Both their availability in soil as well as their concentrations in different crops could be enhanced by the application of NPK fertilizers (Zhang et al., 2004).

3.2.4 Soil toxicity index (STI) of micronutrients

A comparison of the soil toxicity index (STI) status obtained in 2005 with those obtained in this study was carried out (Table 9). It was noticed that the toxicity index values increased for Zn, B and Mn and decreased for Cu and Fe, irrespective of cropping pattern. B toxicity under P-R-R and R-F-R cropping patterns amplified and the toxicity class shifted from 'nontoxic to 'slightly toxic'. Although STI values of Zn increased, STI classes however, were still found to remain in the same (nontoxic) class. An opposite scenario was observed with Fe. Although the STI values declined irrespective of cropping patterns, the STI classes still remained in the same toxicity class 'highly toxic'. A favorable change was noticed for Cu as its STI class shifted from higher to lower classes (Table 9).

Table 9: Soil toxicity index (STI) status of micronutrients

Cropping Pattern	STI (2005)		STI (2018)	
	Value	Class	Value	Class
		Zn		
P-R-R	0.17	Nontoxic	0.66	Nontoxic
R-F-R	0.26	Nontoxic	0.68	Nontoxic
M-F-R	0.28	Nontoxic	0.55	Nontoxic
		B		
P-R-R	0.50	Nontoxic	1.20	Slightly toxic
R-F-R	0.46	Nontoxic	1.07	Slightly toxic
M-F-R	0.70	Nontoxic	1.00	Nontoxic
		Cu		
P-R-R	4.03	Moderately toxic	1.91	Slightly toxic
R-F-R	4.09	Moderately toxic	3.27	Moderately toxic
M-F-R	5.19	Highly Toxic	2.80	Mildly toxic
		Fe		
P-R-R	9.80	Highly toxic	9.03	Highly toxic
R-F-R	10.44	Highly toxic	8.31	Highly toxic
M-F-R	12.65	Highly toxic	9.56	Highly toxic
		Mn		
P-R-R	3.67	Moderately toxic	6.73	Highly toxic
R-F-R	5.42	Highly toxic	7.58	Highly toxic
M-F-R	6.33	Highly toxic	6.98	Highly toxic

Both Fe and Mn concentration levels obtained in 2005 and in this study were found in the 'highly toxic' STI class except that Mn under P-R-R cropping pattern in 2005 was in 'moderately toxic', which shifted up to 'highly toxic' class, which might be due to cumulative accumulation during 2005 to 2018. Hassan et al. (2017) in their study found an excessive concentration of Fe and Mn in Tista Floodplain soils.

4. CONCLUSION

The survey conducted in this study found that the order of the cropping pattern in practice was potato-rice-rice (18% farmers) > rice-fallow-rice (16% farmers) > maize-fallow-rice (14% farmers). All the respondent farmers apply Urea, TSP and MoP to all crops. DAP, Zn, and B are used by 49%, 35%, 23% of farmers, respectively. Cattle manure and compost are used by 72% and 33% of farmers and only 38% of farmers leave and incorporate crop residues.

In the study area, the soils under maize-fallow-rice cropping pattern had higher soil pH and lower SOM content. The soils under all cropping pattens had an increasing trend of accumulation of Zn, B, and Mn, and the higher rate of accumulation was observed under potato-rice-rice croppping pattern. A decreasing trend of accumulaiton of Cu and Fe was obtained under all cropping patterns and the lower rate of accumulation of Cu and Fe were observed under potato-rice-rice and maize-fallow-rice cropping pattern, respectively.

As compared to the values obtained in 2005 the soil toxicity index (STI) values of Zn, B, and Mn were found in increasing phase while those of Cu and Fe were found in decreasing phase. According to toxicity class obtained in in this study, Fe and Mn were found in the 'highly toxic' class, B and Cu in the 'slightly toxic' and 'moderately toxic' class, and only Zn was found in the 'nontoxic' class.

An evaluation of micronutrient status in 'Tista Meander Floodplain' soils revealed that Zn, B, Fe, Cu, and Mn contents, however, were still higher than their respective critical limits and all but Zn were found in toxic level.

ACKNOWLEDGEMENT

We would like to acknowledge the supports given by the Soil, Water and Environment Discipline of Khulna University and Soil Resource Development Institute (SRDI), Ministry of Agriculture, Bangladesh. Authors are greatly indebted to those institutes for laboratory support and for the successful accomplishment of the research.

AUTHORS' CONTRIBUTION

Md. Sanaul Islam designed and supervised the execution of the entire research work. S. M. Shahriar Zaman conducted the questionnaire survey, analyzed the soil samples, complied and interpreted the data. Mr. Shahriar prepared the manuscript and Mr. Sanaul edited, reviewed and formatted it.

REFERENCES

Alam, M.S., Islam, N., Jahiruddin, M., 2000. Effects of zinc and boron application on the performances of local and hybrid maize. Bangladesh Journal of Soil Science, 26: 95-101.

Antil, R.S., Singh, M., 2007. Effects of organic manures and fertilizers on organic matter and nutrients status of the soil. Archives of Agronomy and Soil Science, 53(5), 519-528.

Banglapedia, 2015. Soil fertility. On-line document, Retrieved on February 19, 2019. Web (URL) address: http://en.banglapedia.org/index.php?title=Soil_Fertility.

Barker, A.V., Pilbeam, D.J., 2007. Introduction, in: Barker, A.V., Pilbeam, D.J. (Eds.), Handbook of plant nutrition. Boca Raton: CRC/Taylor & Francis, pp. 3-18.

BBS, 2018. Yearbook of Agricultural Statistics-2017, Bangladesh Bureau of Statistics (BBS). Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

BBS, 2020. Yearbook of Agricultural Statistics-2019, Bangladesh Bureau of Statistics (BBS). Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Dach, J., Starmans, D., 2005. Heavy metals balance in Polish and Dutch agronomy: actual state and previsions for the future. Agriculture, Ecosystem and Environment, 107: 309-316.

Dhaliwal, S.S., Naresh, R.K., Mandal, A., Singh, R., Dhaliwal, M.K., 2019. Dynamics and transformations of micronutrients in agricultural soils as influenced by organic matter build-up: A review. Environmental and Sustainability Indicators, 1-2: 1-14. https://doi.org/10.1016/j.indic.2019.100007

Fageria, N.K., Baligar, V.C., Li, Y.C., 2008. The role of nutrient efficient plants in improving crop yields in the twenty first Century. Journal of Plant Nutrition, 31: 1121-1157.

Ferdoush, J.N., Jahiruddin, M., Islam, M.R., 2003. Response of wheat to micronutrient in Old Brahmaputra Floodplain soil. Bangladesh Journal of Seed Science and Technology, 7(1&2): 35-38.

Fuente, C., Clemente, R., MartõÂnez-AlcalaÂ, I., Tortosa, G., Bernal, M.P., 2011. Impact of fresh and composted solid olive husk and their water-soluble fractions on soil heavy metal fractionation; microbial biomass and plant uptake. Journal of Hazardous Materials. 186: 1283-1289. https://doi.org/10.1016/j.jhazmat.2010.12.004.

Hassan, M., Ahmed, A.A.S, Hassan, M.A., Nasrin, R., Rayhan, A.B.M.S., Musfiq-Us- Salehin, S., Rahman, M.K., 2017. Changes of soil fertility status in some soil series of Tista Floodplain Soils of Bangladesh, during 1996-2016. Asian Research Journal of Agriculture, 5(3): 1-9. https://doi.org/10.9734/ARJA/2017/34365.

Islam, F.M., Islam, M.R., Jahiruddin, M., Sharmin, T., 2017. Cropping pattern based micronutrient application for wheat-mungbean-T. aman crop sequence under Tista Meander Floodplain soil at Rangpur. Journal of Bangladesh Agriculture University, 15(2): 140-147. https://doi.org/10.3329/jbau.v15i2.3505.

Li, B.Y., Zhou, D.M., Cang, L., Zhang, H.L., Fan, X.H., Qin, S.W., 2007. Soil micronutrient availability to crops as affected by long-term inorganic and organic fertilizer applications. Soil and Tillage Research, 96 (1-2), 166-173.

Lindsay, W.L., Norvell, W.A., 1978. Development of DTPA soil test for zinc, iron, manganese and copper. Soil Science Society of America Journal, 42, 421-428.

Liu, W.C., Lund, L.J., Page, A.L., 1989. Acidity produced by leguminous plants through symbiotic dinitrogen fixation. Journal of Environmental Quality, 18 (4), 529-534.

McLean, E.O., 1982. Soil pH and Lime Requirement. In: Methods of soil analysis. Part 2 Chemical and microbiological properties. 2nd edn. Page, A.L., Miller, R.H., Keeney, D.R., (Eds.), American Society of Agronomy Inc., Madison, WI, USA. pp. 199-224.

Morgan, J.B., Connolly, E.L., 2013. Plant-soil interactions: Nutrient uptake. Nature Education Knowledge, 4(8), 2.

Nziguheba, G., Smolders, E., 2008. Inputs of trace elements in agricultural soils via phosphate fertilizers in European countries. Science of the Total Environment, 390, 53-57.

Pakrashi, A.C., Haldar, M., 1992. Effect of moisture regime and organic matter application on the changes in hws B an acid soil of terai region of North Bengal. Environment and Ecolology, 10, 292-296.

Piper, C.S., 1950. Soil and Plant Analysis. Adelaide University Hassel press. Australia.

Rjpma, J., Jahirudddin, M., 2004. Strategy and plan for use of soil nutrient balance in Bangladesh, Final Report of Short-term Assignment. SFFP/DANIDA.

Sarker, M.M.H., Jahiruddin, M., Moslehuddin, A.Z.M., Islam, M.R., 2020. Changing dynamics of micronutrients in piedmont soil of Bangladesh. Eurasian Journal of Soil Science, 9(1), 43 - 51. https://doi.org/10.18393/ejss.642221.

Sekhon, K.S., Singh, J.P., Mehla, D.S., 2006. Long-term effect of organic/inorganic input on the distribution of zinc and copper in soil fractions under a rice-wheat cropping system. Archives of Agronomy and Soil Science, 52: 253-261.

Sharma, J., Kumar, P., Dua, V.K., Sharma, V., Kumar, D., Kumar, S., Rawal, S., Khan, M.A., 2017. Status of micronutrients in intensively cultivated potato growing soils of Punjab. Potato Journal, 44(1): 58-64.

Shukla, A.K., Dwivedi, V.K., Singh, Gill, M.S., 2009. Macro role of micronutrients. Indian Journal of Fertilisers, 5(5): 11-30.

Siddique, M.N.A., Halim, M.A., Kamaruzzaman, M., Karim, D., Sultana, J., 2014. Comparative Insights for Investigation of Soil Fertility Degradation in a Piedmont Area which Cover the Anjamkhor Union of Baliadangi Upazila, Thakurgoan, Bangladesh. Journal of Environmental Science, Toxicology and Food Technology, 8(4), 82-87.

Singh, S.K., 2012. Annual Report, Preparation of GPS and GIS based soil fertility map of the selected district of the country, funded by IISS (ICAR), Bhopal and MOA, New Delhi.

SRDI, 2005. Land and Soil Resource Utilization Guide. Mithapukur, Rangpur. Soil Resource and Development Institute (SRDI), Ministry of Agriculture, Farmgate, Dhaka.

SRDI, 2008. GIS map, Zinc status of Bangladesh soils. Soil Resource and Development Institute (SRDI), Ministry of Agriculture, Farmgate, Dhaka.

SRDI, 2012. Analytical Methods: Soil, Water, Plant material, Fertilizer. 2nd edn. Soil Resource and Development Institute (SRDI), Ministry of Agriculture, Farmgate, Dhaka.

SRDI, 2018. Annual Report 2017-18. Soil Resource and Development Institute (SRDI), Ministry of Agriculture, Farmgate, Dhaka.

Takkar, P.N., Shukla, A.K., 2015. In: State of Indian agriculture - soil. Pathak, H., Saynal, S.K., Takkar P.N., (Eds.). NAAS, New Delhi, India. pp. 121-152.

Tiwari, K.N., 2008. Future plant nutrition research in India. Journal of the Indian Society of Soil Science, 50: 327-336.

USDA, 1951. Soil Survey Manual by Soil Survey Staff. Bureau of plant industry, United States Department of Agriculture (USDA). Soil and Agriculture Engineering, Handbook No. 18, pp. 205.

Valk, G.M., Bruin, P.N.A., 1989. Nutrition of tulips on fresh soil boron application limits early losses. Bioembollenculture, 100(26), 44-47.

Walkley, A., Black I.A., 1934. An examination of the digestion method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science, 37, 29-38. http://doi.org/10.1097/00010694-193401000-00003.

Wei, X.R., Hao, M.D., Shao, M.G., Gale, W.J., 2006. Changes in soil properties and availability of soil micronutrients after 18 y ears of cropping and fertilization. Soil and Tillage Research, 91, 120-130.

Weil, R.R., Brady, N.C., 2016. The Nature and Properties of Soils. 15th Edition. Pearson Education, United States of America (USA).

Zang, F., Wang, S., Nan, Z., Ma, J., Zhang, Q., Chen, Y., Li, Y., 2017. Accumulation, spatio-temporal distribution, and risk assessment of heavy metals in the soil-corn system around a polymetallic mining area from the Loess Plateau, northwest China. Geoderma, 305, 188-196. https://doi.org/10.1016/j.geoderma.2017.06.008.

Zhang, R., Guo, Y.X., Nan, C.Q., 2004. Study of trace elements of wheat grain in different fertilizer treatments. Acta Botanica Boreali-Occidentalia Sinica, 24: 125-129.

* * *

Cite the Article: S. M. Shahriar Zaman, Md. Sanaul Islam (2021). Micronutrient Status of Tista Meander Floodplain Soils Under Major Cropping Patterns in Mithapukur Upazila. *Tropical Agroecosystem, 2(1): 37-43.*