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Changes of Soil Fertility Status in Some Soil Series of Tista Floodplain Soils of Bangladesh, during 1996-2016

Masud Hassan[1*], Abdullah Abu Syeed Ahmed[1,2], Md Arafat Hassan[3], Rubaya Nasrin[4], A. B. M. Sadique Rayhan[1,5], Sk. Musfiq-Us- Salehin[1] and Md Khaliur Rahman[1]

[1]Department of Soil, Water and Environment, University of Dhaka, Dhaka 1000, Bangladesh.
[2]Deprtment of Agriculture and Forestry, University of Helsinki, Helsinki, Finland.
[3]Department of Geography and Environment, University of Dhaka, Dhaka 1000, Bangladesh.
[4]Department of Environmental Sciences, Jahangirnagar University, Bangladesh.
[5]Department of Marine Affairs, Xiamen University, Fujian, China.

Authors' contributions

This work was carried out in collaboration between all authors. Authors MKR, MH and AASA designed the study. Authors MH and MAH performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MAH and MH managed the analyses of the study. Authors ABMSR, RN and SMUS managed the editing section. All authors read and approved the final manuscript.

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ABSTRACT

The study of several soil series of Tista Floodplain soils were carried out to find the changing trend of nutrients status from 1996 to 2016. The studied values of different soil quality variables were changed likewise pH 5.87 ± 0.47 to 5.95 ± 0.33, organic matter 1.37 ± 0.31% to 1.47 ± 0.41%, ,total nitrogen 0.49 ± 0.13 cmol/kg to 0.64 ± 0.07 cmol/kg , phosphorous 0.10 ± 0.04 cmol/kg to 3.19 ±

**Corresponding author: E-mail: jibonswe@gmail.com;*

0.34 cmol/kg, potassium 0.31 ± 0.29 cmol/kg to 2.93 ± 0.26 cmol/kg, sulfur 0.19 ± 0.05 cmol/kg to 8.66 ± 2.74 cmol/kg, iron 1.09 ± 0.46 cmol/kg to 2.07 ± 0.99 cmol/kg, manganese 0.10 ± 0.02 cmol/kg to 0.31 ± 0.30 cmol/kg, copper 0.03± 0.01 cmol/kg to 0.02 ± 0.01 cmol/kg, zinc 0.01 ± 4.8E-20 cmol/kg to 0.01 ± 0.01 cmol/kg in 1996 and 2016 respectively. Almost all variables changed over significantly at 5% ($P < 0.05$) level except pH, organic matter, total Nitrogen and Copper content whose were not significant at 5% ($P < 0.05$) level not even 10% ($P < 0.10$) level. The increasing trends of total Nitrogen, Phosphorous, and Iron were positively correlated from 1996 to 2016 than other variables. The copper and zinc content did not showing any effective change over these 20 years. The overall nutrients were adequate except organic matter and total nitrogen content. But, the trends had positive direction of all nutrients due to application of organic and inorganic fertilizer that might be correlated with increasing concern about nutrients management concept among the farmer.

Keywords: Soil fertility; Tista floodplain; nutrients status; change analysis; organic matter.

1. INTRODUCTION

Thirty Agro-Ecological Zones (AEZs) have been identified in Bangladesh and their crop species and productiveness status vary considerably. Tista Floodplain is located in the north-eastern most physiographic unit of the country. Tista Floodplain is the sub-region between old Himalayan piedmont plain in the west and right bank of north-south flowing Brahmaputra in the east. The studied fields are located in Dashier chora village of Fulbari Thana under Kurigram district [1]. Tista Floodplain soil is intensively cultivated with Rice as the main crop. Wheat, Potato, Jute, Mustard, Sugarcane, Cabbage, Tomato, Onion etc are also grown to feed the ever-growing population [2]. The major cropping patterns are Rice-fallow-Rice, Wheat-Jute-Rice, and Potato-Jute-Rice [2]. The land in the Tista Flood Plain areas falls mainly under high land and Middle high land categories. High land can be defined as the land above normal flood level in the rainy season, while medium high land is normally flooded up to 90 cm depth in the rainy season continuously for more than two week [3]. Most of the land shallowly flooded during the monsoon season.

Soil fertility status is a complex and dynamics system that is the important quality indicator of soil.Sustainable agriculture requires sustainability of its nutrients content. Soil reaction, organic matter, micro and macro nutrients are the main definition of soil fertility. Organic matter is the key factor for retaining water and all other micro and macro nutrients [4]. Soil organic matter itself nutrients because it holds Nitrogen and Phosphorous [4]. Soil pH is the most important indicator of soil environment which determines the availability of soil nutrients for plant nutrients as well as plant growth. In order to application of organic or inorganic fertilizer and pesticides application, cropping pattern, under prevailing different climatic condition, organic matter and other plant nutrient trigger the soil fertility and productivity. As organic matter decomposes, organic and inorganic acids are formed. The simplest and perhaps the most widely found is carbonic acid (H_2CO_3) product of the reaction of carbon dioxide and water. The slow but persistent solvent action of the soil is responsible for the removal of base forming cation by leaching and dissolution [5]. Maintenance of soil organic carbon (SOC) as a major component of SOM is essential for the sustainable agricultural production as declining SOC generally leads to decreased crop productivity [6]. The positive effect of increased soil C on soil quality and crop yield is well established. The improvement in land uses and management systems that enhance and maintain high level of SOC pools can be considered as an important feature of agricultural sustainability [6]. Identifying agricultural land-use and management practices that are capable of increasing carbon sequestration will be a better option to address production problems and environmental problems [7].

A few research works has been done on the changing soils fertility status of the Tista Floodplain soils. Literature review reveals that the information regarding the Tista Floodplain soil is very limited [8]. In 2003, Rahman and Rana revealed that the total carbon and nitrogen content were low in amount whereas the concentration of total P, K, S, Fe, Mn, Cu and Zn were very high in the studied soils. But there was no study found on changes analysis of Tista floodplain soil over a long period of time.

1.1 Objective

Thus, an attempt was taken to assess the changing nutrients status of the Tista Floodplain soil of Bangladesh over 20 years. As an economics resources, land and its production capacity must be carefully assessed and periodically monitored in order to sustain the production of food and other basic human needs [9]. Considering the above perspective the present study was conducted to achieve the objective to find out the relationship between the nutrient conditions over time period 1996 to 2016 that will helps to determine the future technique development in order to more production and sustainability of food and agriculture.

2. MATERIALS AND METHODS

The baseline soil chemical properties were taken from the Phulbari Upazilla land and soil resources utilization guide which was published in the year 1996 [1]. A comparative study was made between the soil chemical data of the Upazilla of the year 1996 and those generated in 2016. The average value of similar soil series that were collected from Upazilla land and soil resources utilization guide published in 1996. The initial soil reaction, soil organic matter, total N, P, K, S, Fe, Ni, Cu and Zn content were 5.87 ± 0.47, 1.37 ± 0.31%, (0.49 ± 0.13, 0.10 ± 0.04, 0.31 ± 0.29, 0.19 ± 0.05, 1.09 ± 0.46, 0.10 ± 0.02, 0.03± 0.01, 0.01 ± 4.8E-20) cmol/kg found in 1996 among studied soil series..

The studied soil series were Peergasa, Palashbari, Kauniya, Jamun, Gangachara (MHL), Tista Silty Soil, Loskora, Gangachara (HL), Tista Sandy soil and, Chilmari. 30 soil samples were collected from in year 2016 from Phulabari upazilla under Kurigram district with GPS co-ordinations and chemical analysis were done in soil laboratory. Composite soil samples were collected from the surface soil (0-15 cm) in June 2016. 30 soil samples were collected from ten different soil series with 3 replication. These samples were then placed separately on trays and dried in shed condition. After drying, samples were prepared for analysis by grinding and sieving using 2 mm size sieve. Then, these samples were kept in polyethylene bags with proper labeling. After that, these samples were analyzed in the laboratory. Then, these samples were kept in polyethylene bags with proper labeling. The particle size analysis of soil was carried out by hydrometer method [10]. and that of textural classes by Marshall Triangular coordinates [11]. Soil pH was measured electronically using a corning glass electrode pH meter at a soil to water ratio of 1: 2.5 [12]. The organic carbon of soils was determined volumetrically by wet oxidation method [12].Soil organic matter was calculated by multiplying the percent value of organic carbon by the conversion factor of 1.724. Total nitrogen content in soil was determined by the Micro Kjeldahl's method following concentrated sulfuric acid (H_2SO_4) digestion and alkali distillation [12]. Total P, K, and S were determined by digestion with a mixture (1:3) of concentrated HCl/HNO_3 [13]. Total P was determined by yellow color method [12]. S was determined after developing turbidity [14]. and total K was measured by a flame photometer [14].. Total concentration of Fe, Mn, Cu and Zn in soil was analyzed by digesting the soil with aqua rezia (1:10) [12]. Total Fe, Mn, Cu and Zn were analyzed by AAS (Atomic Absorption Spectrophotometer) [15]. The methodology for determining all these chemical properties were similar in 1996 and 2016. Past and present study were carried out within June 1996 and June 2016 respectively to identify the changes of soil reaction, soil organic matter, total N, P, K, S, Fe, Ni, Cu and Zn were compared over 20 years (1996-2016) of Studied soil samples.t-test and standard deviation was done by Stata software to analyze studied data To interpret the soil test values, the critical levels of each elements were used as given in the fertilizer recommendation guide [1].

3. RESULTS AND DISCUSSION

The average of studied soils were ranged from moderately acidic to slightly acidic in nature. In 1996, the soil pH ranges from 5.50 to 7.10 with an average of 5.87 ± 0.47, whereas in 2016 the pH ranges from 5.67 to 6.78 with an average of 5.95 ± 0.33. The pH value of all studied soil series were in an increasing trend except Chilmari (7.60 to 5.67) and Peergasa (6.20 to 5.77) soil series during 1996 to 2016 (Fig. 1). The t-test value indicated that the two sources of soil material (1996 and 2016) have not significant differential effect in modulating at 5% ($P < 0.05$) level. The average value of pH was slightly increased which has a significant impact on nutrient availability of soil. Various factors are responsible for soil acidity like the removal of basic cautions, decomposition of organic matter and H+ ion released [16].

Likewise, organic matter content is also slightly increasing over 20 years. In 1996, total organic matter content were ranged from 1.08% to 1.78% with an average of 1.37 ± 0.31% whereas, In 2016 the organic matter content was ranged from 1.05% to 2.10% with an average of 1.47% ± 0.41%. Average trend of organic matter was increased except Loskora, Jamun, Kauniya and Peergasa (Fig. 2). The overall changed in modulating organic matter have not significant at 10% level. In 1996 and 2016, the overall organic matter content of studied soil series had very low to low organic matter content compared with the standard values [17]. As humus, the finest decomposed product of organic matter has 500 times more potentiality to hold nutrient elements in soil than silicate clay colloids [6]. So the present of slightly more organic matter in soil have a positive significant on soil fertility condition.

Almost all nutrients in the studied soils series increased over time that correlated with organic matter in the studied soils samples. As a consequence, the total amount of nitrogen was also increased over time. Soil organic matter itself nutrients because it holds Nitrogen and Phosphorous. As a result, soil organic play important role to increase the amount of total nitrogen of studied soil series. An average of 0.49 ± 0.13 cmol/kg and 0.64 ± 0.07 cmol/kg of total Nitrogen were found in 1996 and 2016 respectively in the studied soils series. Over 20 years, the changes of Total Nitrogen content was increasing trend, but not significant at 5% ($P < 0.05$) level among all studied soils series. The overall Nitrogen content of studied soils samples had very low Nitrogen content with comparing to standard values [17]. An average of 30% total Nitrogen content was increase over time due to application of organic and inorganic fertilizer.

The t-test value indicated that, the total amount of P, K, and S content of studied soils series were increased significantly at 5% ($P < 0.05$) level over 20 years (1996 - 2016). The P, K and S content of all studied soils series ware in an increasing trend over 20 years (Figs 4, 5 & 6). The increasing trend of P, K and S were increased due to agricultural knowledge development and advance fertility management among the farmers by different government agricultural program which helps to enhance fertility status in the field. The average P content was about 0.10 ± 0.04 cmol/kg and 3.19 ± 0.34 cmol/kg in 1996 and 2016 respectively. (Fig. 4)

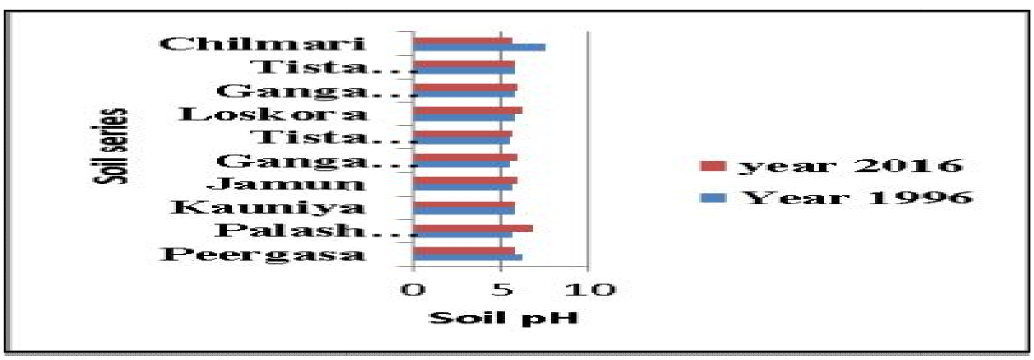

Fig. 1. Changes of soil pH content in studied soils under 20 years (1996 - 2016)

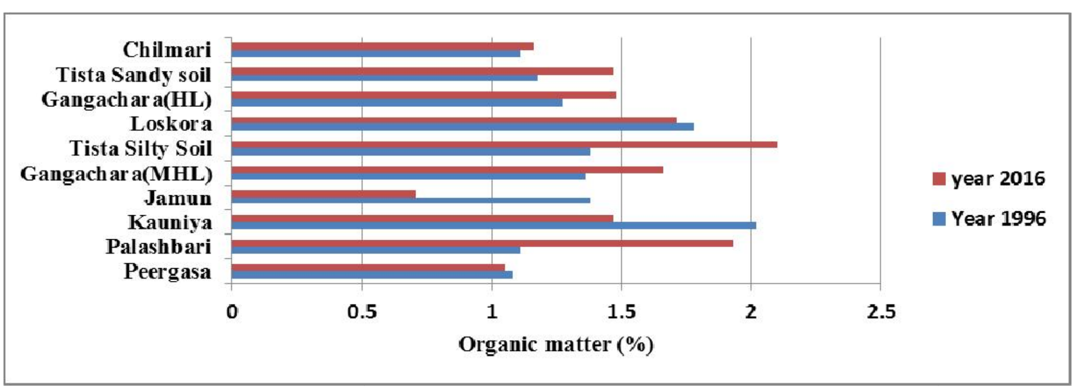

Fig. 2. Changes of soil organic matter content in studied soils under 20 years (1996 - 2016)

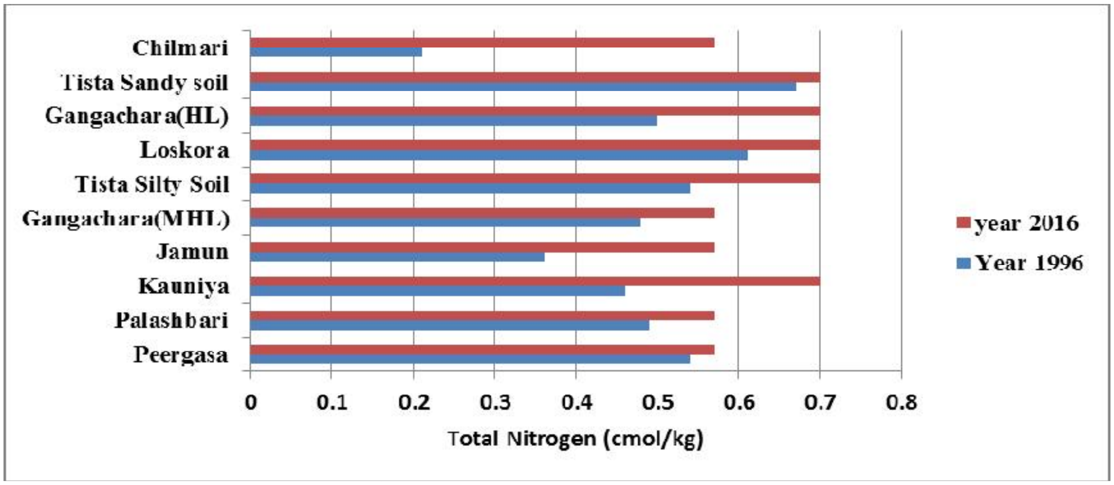

Fig. 3. Changes of total nitrogen content in studied soils under 20 years (1996 – 2016)

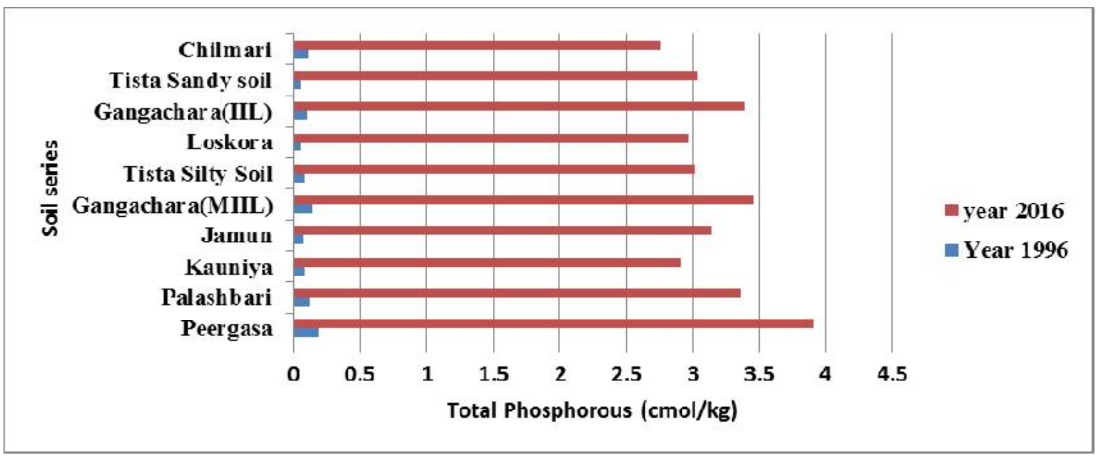

Fig. 4. Changes of total phosphorous content in studied soils under 20 years (1996 – 2016)

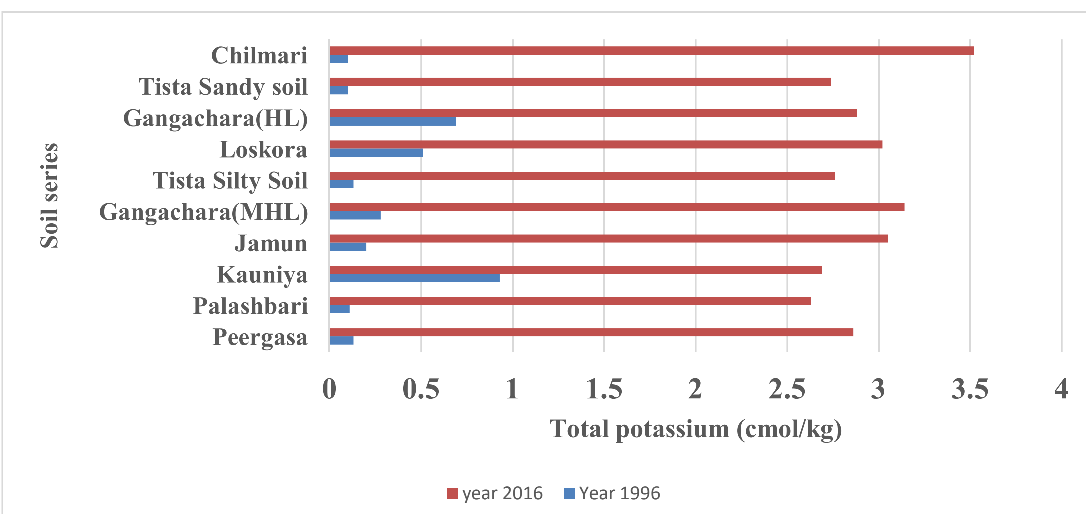

Fig. 5. Changes of total potassium content in studied soils under 20 years (1996 – 2016)

Similarly, the average K content was increased almost 2.59 cmol/kg. The average K content was 0.31 ± 0.29 cmol/kg in 1996 and 2.93 ± 0.26 cmol/kg in 2016. (Fig. 5) On the same way, the sulfur content of the studied soils samples was increased more significantly than any other nutrients of the examined soils samples. The increased sulfur content was around 8.47 cmol/kg over 20 years. The average value of sulfur was 0.20 ± 0.05 cmol/kg and 8.67 ± 2.74 cmol/kg in 2016. (Fig. 6)

The amount of P, K, and S content of studied soils series are increasingly whereas S content increasing more significantly due to use to application of inorganic fertilizers and other process (Figs. 4, 5, 6). From 1996 to 2016, the total Phosphorus, Potassium and Sulfur content of studied soils series might be increased due to application of organic and inorganic fertilizer in the field and proper agricultural practices among the farmers.

In 1996, the soil iron ranges from 0.15 cmol/kg to 1.85 cmol/kg with an average of 1.70 ± 0.46 cmol/kg whereas in 2016, the iron ranges from 0.76 cmol/kg to 3.64 cmol/kg with an average of 2.07 ± 0.99 cmol/kg of different soil series of Tista Floodplain soils. (Fig. 7) The t-test value indicated that, the change of soil iron content was significant at 5% level ($P < 0.05$). All soils series were in an increasing trend from 1996 to 2016 except Jamun (1.11 to 0.98 cmol/kg) And Kauniya (1.85 to 1.75 cmol/kg). (Fig. 7)

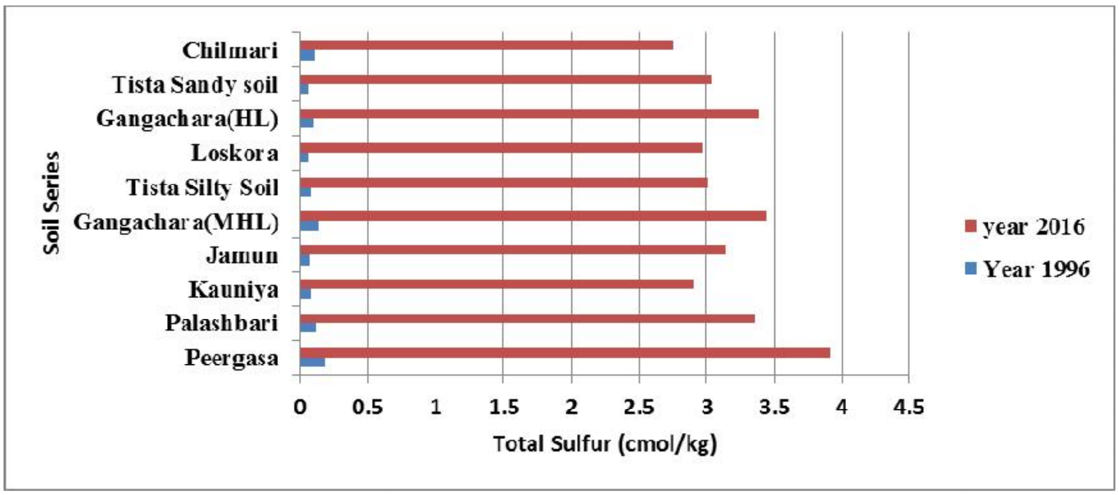

Fig. 6. Changes of total sulfur content in studied soils under 20 years (1996 – 2016)

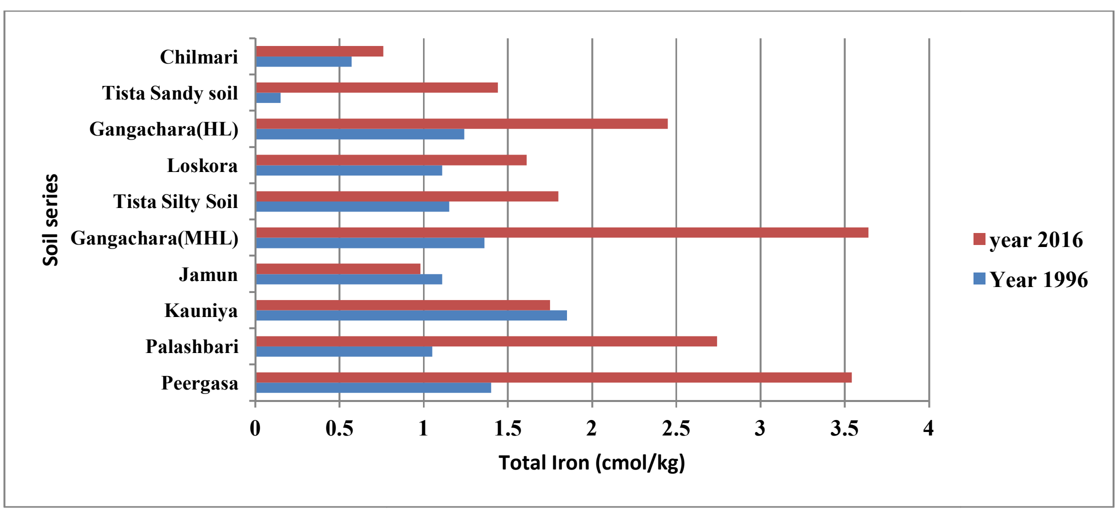

Fig. 7. Changes of total iron content in studied soils under 20 years (1996 – 2016)

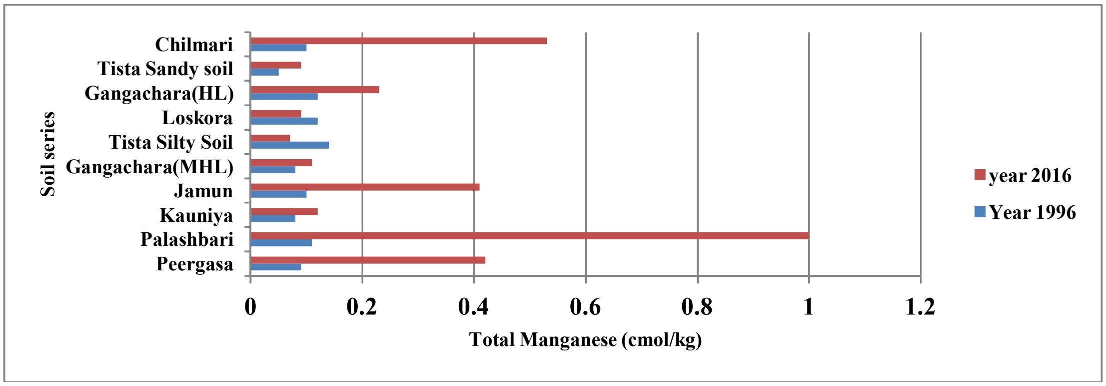

Fig. 8. Changes of total manganese content in studied soils under 20 years (1996 – 2016)

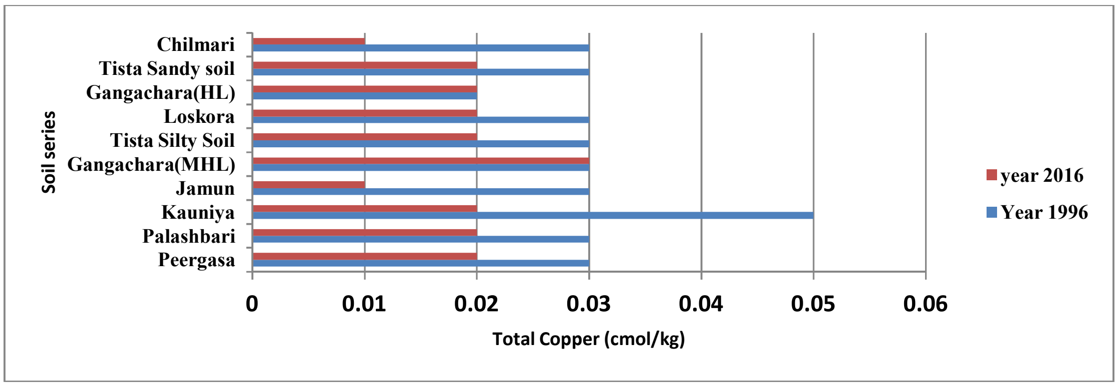

Fig. 9. Changes of total copper content in studied soils under 20 years (1996 – 2016)

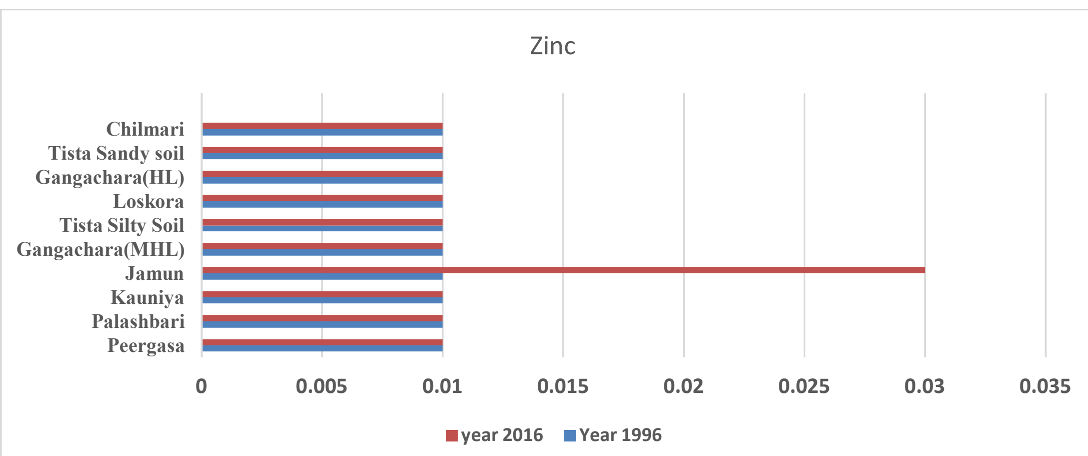

Fig. 10. Changes of total Zinc content in studied soils under 20 years (1996 – 2016)

Similarly, the Mn content of studied soils samples had an average of 0.10 ± 0.02 cmol/kg and 0.31 ± 0.30 cmol/kg in 1996 and 2016 respectively. The overall Mn content of studied soils series were in an increasing trend except Loskora and Tista silty soil series (Fig. 8). The t-test value indicated that, the studied soil series provided a significant changed over 20 years at 5% level ($P < 0.05$). Fe and Mn in Tista Floodplain soils were very high. This may lead to Fe and Mn toxicity for paddies in acidic soils (Prasad and Power 2003). The sufficient amount of Fe and Mn were found in Tista Floodplain soils from siltation of Tista River.

The total Copper content of the studied soil samples were ranged from 0.01 cmol/kg to 0.02 cmol/kg with an average of 0.02 ± 0.01 cmol/kg in 2016 whereas the average values for Copper were 0.03 ± 0.01 cmol/kg in 1996 (Fig. 9). The copper content of all studied soils series were in a decreasing trend. The t-test value indicated that, the changed of Cu content was significant at 5% level. Those values were very closely related and no more deviated with one another. The Copper content of studied soil samples is sufficient level [9].

The total Zinc content of the studied soil samples ranged from 0.01 to 0.03 cmol/kg with an average of 0.01 ± 2.19E-10 cmol/kg in 2016. Similarly, in 1996 it was 0.01 ± 0.01 cmol/kg for all studied soils series (Fig. 10). These values were also perfectly close to one another. The changed of Zinc content of studied soil series were in a stable condition. The t-test value indicated that, the changes of Zinc content is not significant at 10% level. The Zinc content of studied soil samples was adequate amount. The similar observation was also made by [18].

4. CONCLUSION

The results of the analysis of thirty soil samples from ten major soil series in the Tista Floodplain showed that most of the parameter were showing positive direction towards fertility development due to farming methods, which include soil testing, crop rotation and cropping pattern based fertilizer recommendations, and integrated pest management etc. Finally it can be conclude that, the organic matter and total nitrogen content is still low in amount but increased slightly from 1996 to 2016. Others element are adequate in both 1996 and 2016 but having an increasing trend. The importance of soil testing is unquestioned and should be given priority as the Best tool for management and decision making for sustainable agriculture. Based on the crops' needs of nutrients and the size of soil nutrient reserves as learned from the soil tests, balanced fertilizer Requirement can be determined in case of maximum profit from agricultural production. The systems rely on the soil nutrient reserve and only the balanced needs should be applied. Fertilizers should be applied to supplement the nutrient elements that are in short supply in soils [2].

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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