Journal of Agriculture and Ecology Research International
5(2): 1-9, 2016; Article no.JAERI.21565
ISSN: 2394-1073

SCIENCEDOMAIN *international*
www.sciencedomain.org

Effect of Soil Physico-chemical Properties on Agriculture: A Study in Tangail District, Bangladesh

M. Rahman[1] and M. M. Mian[1,2*]

[1]School of Environmental Science, Bangladesh Agricultural University, Mymensingh, 2202, Bangladesh.
[2]School of Urban Construction and Environmental Engineering, Chongqing University, 174 Shazhengjie, Shapingba, Chongqing, 400044, China.

Authors' contributions

The research was carried out equally by both authors. Author MR conceived the main idea and plan of the study. The literature study, statistical analysis and manuscript writing were conducted by authors MMM and MR. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAERI/2016/21565
Editor(s):
(1) Abdel-Tawab H. Mossa, Environmental Toxicology Research Unit (ETRU), Pesticide Chemistry Department, National Research Centre, Egypt.
Reviewers:
(1) Mohammed Suleiman, Umaru Musa Yar'adua University, Katsina, Nigeria.
(2) Evans Ntim Amedor, Institute of Tropical Agriculture, Ghana.
Complete Peer review History: http://sciencedomain.org/review-history/11743

Original Research Article

Received 23rd August 2015
Accepted 16th September 2015
Published 8th October 2015

ABSTRACT

Aims: The economic development of Bangladesh is mainly influenced by agriculture sector, but lacks of available information regarding soil characteristics hindering the process of appropriate agricultural practice. This study tries to examine the physico-chemical characteristics of soil in Tangail district, Bangladesh, and evaluate the scope of agriculture.
Place and Duration of Study: Entire soil sample was collected from three major zones (Bhuapur, Gopalpur and Tangail Sadar Upazilla) of Tangail district, Bangladesh during the period of September, 2013 to July, 2014.
Methodology: Random quadrate methods were used to collect soil samples. Collected samples were dried at room temperature, mixed carefully, crushed and sieved by 20 mesh net and analyzed soil texture, bulk density, soil pH, organic matter, total N, available P, K, and S. Entire analysis was conducted twice and average value of results was considered for calculation.
Results: It is revealed that, the soil texture varied largely In the three study zones, Tangail Sadar soil is mainly sandy clay loam, Bhuapur and Gopalpur Upazilla are silt loam and loam texture

**Corresponding author: Email: manikmbstu@gmail.com;*

respectively. The mean bulk density is lower in Tangail Sadar (0.093) and higher in Bhuapur (5.019) and Gopalpur (4.706), which indicate soil compactness. However the pH of the three study zones were 5.70, 6.22 and 6.28, which is suitable for some crop cultivation, but the entire study area lacks soil macronutrients.

Conclusion: Adequate fertilizers are required to cultivate crops in these zones. Beside chemical fertilizer, organic fertilizer should also be used for retention of soil organic contents.

Keywords: Soil properties; nutrients; scope; agriculture; fertilizer.

1. INTRODUCTION

The economic development of Bangladesh largely depends on agricultural development. Total GDP of this country is dominated by manufacturing 17.78%, agriculture 16.11% and trade 13.41% sectors [1]. Agriculture is the second GDP earning sector, and majority of the people are associated with its practice. However, the agriculture of this country is suffering from various problems such as nutrient deficiency, toxicity in soil, natural calamities, insect and disease hazards, improper soil and crop management. For proper land use, agricultural planning and better crop production, basic data on the physical and chemical properties of soil are very important. Both climatic and physico-chemical characteristics of an area are very important to determine the type of crops to be grown [2].

Bangladesh has a wider range and greater complexity of lands. Earlier soils of Bangladesh were divided into 7 tracts, then into 20 general soil types and 530 soil series. At present, the soils of Bangladesh are divided into 30 Agro-Ecological Zones (AEZ). The soil series are classified on the basis of the characteristics of soils such as soil texture, structure, soil color, organic matter content, soil pH etc. in different layer of soils. Moreover, the chemical characteristics of soils are almost same under the same soil series and the soils are constituted by same parent materials. Evaluations of physical and chemical characteristics of soil are helpful for economic use of fertilizer and irrigation water supply and, thereby, they can be used to maximize crop production. Total area of the country is about 147570 km^2 of which about 11.3 million (79%) hectare is floodplain, 1.2 million (8.3%) hectare is terrace land and 1.8 million (12.6%) is hill area. Hilly areas occur in the north, northeast and east parts of the country [3].

Chemical characteristics of soils represent the nature of genetic process, its development and present nutrient status. For evaluating the characteristics of soil profile and present fertility status of soil, chemical analysis has got much importance. Proper fertilizer use depends on the nutrient content of the soil. As a consequence of anthropogenic activities over a long period of time, the vegetation as well as soil properties are also changed. The quality of soil refers not only its lack of degradation or contamination, but also to its overall fitness, or effectiveness for supporting plant growth, managing water and responding to environmental stresses [4]. Hence, a person dealing with soil should be acquainted with the chemical properties to decide whether the soil is suitable for plant growth.

Nowadays, the farmers of the country are desperately trying to increase the crop yield by applying more and more inorganic chemicals, mainly nitrogenous fertilizers, pesticides and by increasing cropping intensity. For these reasons, reserve of nutrient becomes depleted and available nutrient becomes unavailable. Again, excessive amount of applied fertilizers hinders the availability of other nutrients too. Our farmer do not know the inherent nutrient status of the soils and they use fertilizers blindly and uneconomically. In order to minimize these problems, it is very pertinent to evaluate the fertility status of our soils at the farmers' level [5-7].

The rigidity and supporting powers, freedom of drainage, moisture storage capacity, and ease of penetration by roots, aeration and retention of plant nutrients are all intimately related to physical and chemical condition of soil. If a soil has good physical and chemical properties, then it will be considered as an appropriate soil for agriculture [8].

Tangail is a district located in the central region of Bangladesh. Agriculture is the main occupation of the Tangail district. About 49.53% people are involved with agricultural activities. The main agricultural products are paddy, potato, jute, sugarcane, sesame, linseed, wheat, mustard seed and pulse. About 2800 km^2 cultivable lands are available in Tangail. The main fruit products are mangos, jackfruit,

bananas, litchis, and pineapples. It produces about 847309 tons of crops every year. Among 12 Upazillas of Tangail district Bhuapur, Gopalpur and Tangail Sadar are three important Upazillas in respect of agricultural production. Tangail Sadar, Bhuapur and Gopalpur Upazilla have 61594, 40125 and 47295 acres of cultivable lands respectively [9]. For successful crop production in this area, knowledge of physical and chemical properties of soil is very important. But data on physical and chemical properties in this area is not sufficient. This study tries to examine the physical and chemical properties of soil of three upazillas of Tangail district, Bangladesh, and analyze the scope of agricultural practice in these areas.

2. MATERIALS AND METHODS

2.1 Materials

Entire soil samples were collected from, Bhuapur, Gopalpur and Tangail Sadar Upazilla of Tangail district. Among 30 Agro-ecological Zones (AEZ) of Bangladesh, Bhuapur and Tangail Sadar Upazilla were located in the Old Brahmaputra Floodplain and Gopalpur Upazilla was located in Young Brahmaputra-Jamuna Floodplain. A total of 87 samples was collected from 29 locations of 3 Upazilla, particularly 27 samples were collected from Bhuapur Upazilla, 24 samples from Gopalpur Upazilla and 36 samples from Tangail Sadar Upazilla of Tangail district (Fig. 1). All the samples were collected from (0 – 30) cm depth of soil. The collected samples were dried at room temperature, mixed thoroughly, crushed, sieved with a 20-mesh sieve and preserved in plastic bags for subsequent laboratory analysis.

2.2 Methods

2.2.1 Soil texture

Soil textures were analyzed by using hydrometer method [10]. Fifty grams of oven dry soil from each sampling depth was taken separately in dispersion cup and 10 ml of 5% calgon solution was added to the sample and allowed to soak for 15 minutes. 90 ml tap water was added to the

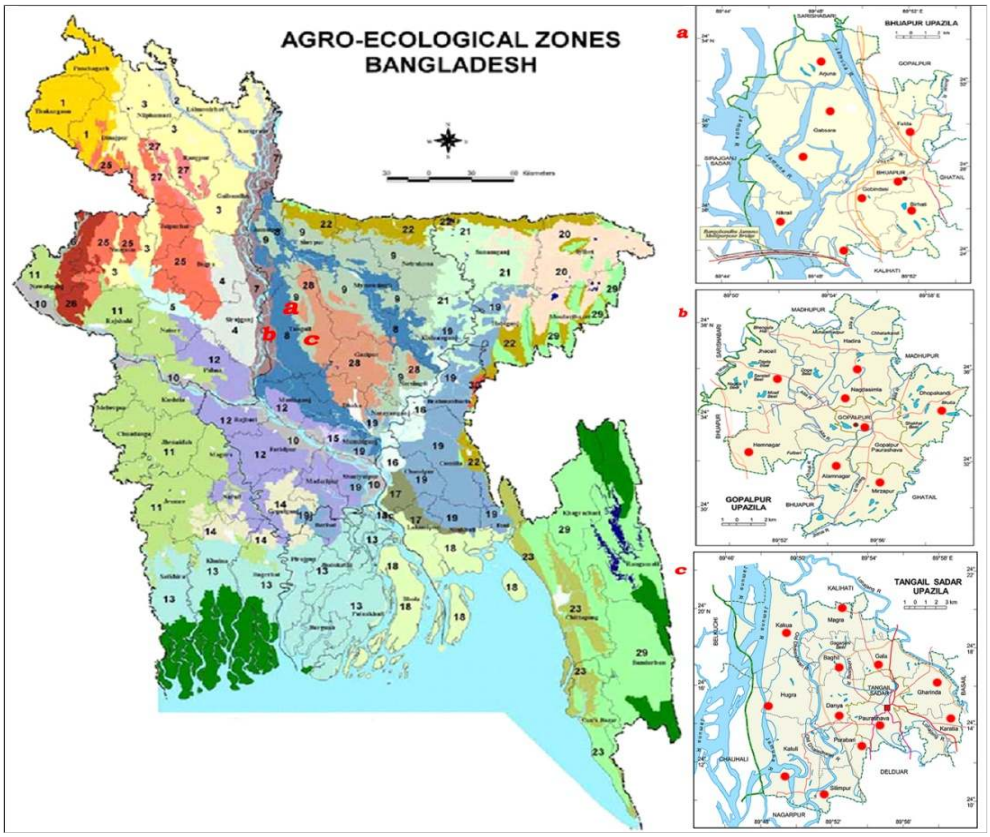

Fig. 1. Location of study area: (a) Bhuapur, (b) Gopalpur and (c) Tangail Sadar Upazilla of Tangail District, Bangladesh

dispersion cup. The suspension was then stirred with an electric stirrer for 15 minutes. The content of the dispersion cup was then transferred to one liter sedimentation cylinder and tap water was added to make the volume up to mark. A cork was placed in the mouth of the cylinder and the cylinder was inverted several times until the whole soil mass appeared in the suspension. The cylinder was set up right and the hydrometer readings were taken at 40 second and 2 hours of sedimentation. The temperature of suspension was recorded with a thermometer at 40 second and 2 hours of sedimentation. The corrections of hydrometer readings were made as the hydrometer was calibrated at 68℉.

The percentage of sand, silt and clay were calculated as follows:

% (Silt + Clay) = (Corrected hydrometer reading after 40 seconds)/(Oven dry weight of soil)×100
% (Clay) = (Corrected hydrometer reading after 2 hours)/(Oven dry weight of soil)×100
% Sand = 100 − % (Silt + Clay)
% Silt = % (Silt + Clay) − % Clay

The textural class of soil for different depths of each series was determined by plotting the results (sand, silt and clay) on triangular diagram (Fig. 2) designed by Marshall [11].

2.2.2 Bulk Density

Bulk density is a measure of a soil mass per unit volume of soil. It is used as a measure of soil wetness, volumetric water content, and porosity. Factors that influence the measurement include; organic matter content, the porosity of the soil, and the soil structure these factors will intern control hydraulic conductivity.

Bulk Density (p) = Mass of oven dried soil / Total volume

2.2.3 Soil Ph

Soil pH was determined by glass electrode pH meter [12]. Twenty grams of air dried soil from each sampling depth was taken in 50 ml beaker separately and 50 ml of distilled water added to each beaker. The suspension was stirred well for several times during the next 30 minutes and allowed to stand for about an hour. The position of the electrode was adjusted in the clamp of the electrode holder. Then the electrode was immersed into partly settled soil suspension and pH was measured. The result was reported as "soil pH measured in water" (Soil: water ratio being 1:2.5).

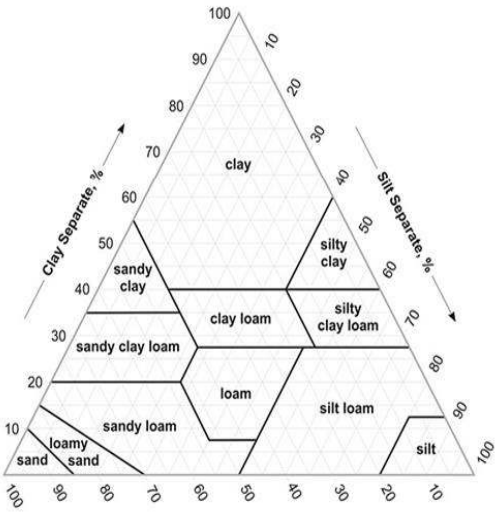

Fig. 2. Triangular diagram of textural classes of soil

2.2.4 Organic matter

The percentage of organic carbon was determined titrimetrically using Walkley and Black method with oxidation of organic matter using potassium dichromate ($K_2Cr_2O_7$). Following the procedure of previous study [13], 2g soil along with 10 ml 1N $K_2Cr_2O_7$ solution and 20 ml of Cone. H_2SO_4 was taken in a 500 ml conical flask. After 30 minutes rest, about 200 ml distilled water and 10 ml concentrated H_3PO_4 was added. 40 drops of diphenylamine indicator ($C_{12}H_{11}N$) was added and titrated against 0.2 N ferrous sulphate ($FeSO_4$. $7H_2O$) until purplish blue color was turned to green color. The organic matter was obtained by multiplying the content of organic carbon by Van Bemmelen factor of 1.73 [14].

2.2.5 Total nitrogen

Total nitrogen content in soil was determined by Semi-Micro Kjeldahl method, following concentrated sulphuric acid digestion and distillation with 40% sodium hydroxide. The ammonia evolved was collected in boric acid indicator and was titrated with 0.01 N sulphuric acid [15]. The % N in soil was calculated by the following formula:

$$\% N = [\{(R-B) \times 1.4\}/ W] \times S$$

Where, R= Reading of the sample in burette (H_2S0_4). S= Strength of H_2S0_4., B= Value of blank reading., W = Weight of the soil in mg., 1.4= Correction factor.

2.2.6 Available phosphorus

Available phosphorus present in soil was determined by Olsen's method colorimetrically, where $SnCl_2$ was used as a reductant. Extracted with 0.5 M sodium bicarbonate solution [16] and developed blue color by $SnCl_2$ reduction and measured the color colorimetrically [15], with the help of spectrophotometer at 660 nm wave length [12].

2.2.7 Available sulphur

Available sulphur (S) was determined by extracting the soil samples by calcium chloride solution (0.15%) [14]. The amount of S content in the extract was estimated turbidimetrically by spectrophotometer at 420 nm wave length.

2.2.8 Available potassium

Available potassium was determined by ammonium acetate extraction method. Soil samples were saturated with ammonium acetate (NH_4OAC) solution and the supernatant clear solution was separated and collected. Then NH_4OAC solution was added again to make the final volume up to 100 ml for each sample. For the above cation the Flame photometer was separated, adjusted and different standard curves were prepared to final out the concentration of the cation but the extracting solution used for each sample was same. The reading was recorded by flame photometer. From each reading the concentration of the ion was obtained from its standard curves.

2.3 Quality Control of Experiment

In order to ensure accurate and reliable results each experiment was done twice and the average result was taken for calculation, and a further experiment was carried out, if the difference of two results were more than 5%. Entire data were calculated using MS office 2010 and SPSS 2012.

3. RESULTS AND DISCUSSION

3.1 Physical Characteristics of Soil

3.1.1 Soil texture

The percentage of sand, silt and clay content in the three Upazilla were varied largely. The particle size distribution of soil of Tangail Sadar, Bhuapur and Gopalpur are presented in Table 1. The mechanical analysis was done for the determination of the relative percentage of the sand, silt and clay in the soils and ultimately to find out the textural classes.

In Tangail Sadar Upazilla, the soil texture was sandy loam. The sand, silt and clay fraction of the soil were varied from (36.8% - 64.43%), (9.34% – 28.08%) and (25.23% – 44.33%) respectively. The surface layer had a higher percentage of sand compare to a deeper layer and the deeper layer was dominated by high percentages of silt and clay. The soil texture of Bhuapur Upazilla was silt loam, the fraction of sand, silt and clay were varied from (9.23% - 30.64%), (58% - 76%) and (0.25% - 20.36%) respectively. In Gopalpur Upazilla, the soil textural classes were mostly loam, and some silt loam also found. The fraction of sand, silt and clay were (11% - 38.64%), (45% - 76%) and (0.25% - 14%) respectively.

Soil like silt loam has higher agricultural values being less susceptible to become loose and open [17]. Silt loam soil can easily be kept in a state good tilt, favorable for germination of seed, easy for root penetration and has considerable water holding capacity. This soil may be highly productive if managed properly.

Table 1. Particle size fractions and textural classes of selected soils

Location	Particle size fractions			Textural class
	Sand (%)	Silt (%)	Clay (%)	
Tangail Sadar	54.831	17.337	28.782	Sandy clay loam
Bhuapur	17.475	69.417	11.825	Silt loam
Gopalpur	29.271	57.124	10.958	Loam

3.1.2 Bulk density

The bulk densities of three Upazillas were quite different, the average bulk density of three Upazilla's were 0.09 g/cm^3, 5.02 g/cm^3 and 4.71 g/cm^3 respectively (Table 2). However, the bulk densities of Tangail Sadar and Bhuapur upazilla are relatively similar type, but in Gopalpur Upazilla show a wide variation throughout the area.

The average bulk density 4.71 g/cm^3 in Gopalpur Upazilla is quite high i.e. soils of this region are compacted. Hence, there would be restricted seed emergence and root growth which will affect the total plant growth and yield. The use of tractors will directly affect the soils bulk density, causing extreme compaction especially if the soil is wet. High bulk density also means that there is little pore spaces in soil to be occupied by water and air.

3.2 Chemical Characteristics of Soil

3.2.1 Soil pH

The soil pH of the three Upazilla is slightly acidic, Tangail Sadar Upazilla are mostly acidic (5.70) soil compared to other to Bhuapur Upazilla and Gopalpur Upazilla. The data on soil pH for the three Upazilla are presented in Table 3. The pH of Tangail Sadar Upazilla varied within that area, whereas Gopalpur Upazilla shows higher variation of pH throughout the area.

Table 2. Bulk density of selected soils

	Location	Mean	SD.
Bulk density (gcm-3)	Tangail Sadar	0.093	0.001
	Bhuapur Upazilla	5.019	0.436
	Gopalpur Upazilla	4.706	1.013

The pH value of this area is similar to the results of previous studies [18]. Hence it can be speculated that soil of this zone is slightly acidic in nature. So, rice, potato, tomato, rye, peanut, corn, tobacco, carrot, cauliflower and cucumber, can be cultivated in these three zones. However, the soil pH depends on kinds of basic rock or parent materials. Rainfall is also a great factor to increase soil acidity. The use of nitrogenous fertilizers without the addition of lime contributed to this decline in soil pH. Due to the acidic nature, these zones are not most nutritious soil for all kinds of plants. Fig. 3, illustrate the suitable pH range for a variety of crops [19] and mean pH of study areas.

The soil of Bhuapur Upazilla and Gopalpur Upazilla have suitable pH range for a wide variety of crops, whereas lower soil pH in Tangail Sadar is not suitable for wheat, onion, pea, soybean, sugarcane and asparagus.

Table 3. Soil reaction (pH) of the three Upazilla's of Tangail

	Location	Mean	SD.
pH	Tangail Sadar	5.70	0.322
	Bhuapur Upazilla	6.22	0.588
	Gopalpur Upazilla	6.28	0.930

3.2.2 Macronutrients

The macronutrients N, organic C %, S, P and K ppm of the study area are illustrated in Fig. 4. Among the three Upazillas of Tangail district, the total N content was highest (0.73%) at Tangail Sadar Upazilla. The amount of total N in maximum locations was very low to low. Perhaps the accelerated decomposition of organic matter, addition of less organic matter, changed in cropping systems and variations in soil characteristics affect N content of these study areas. Entire soil samples contained N below critical level. The total N content in Bhuapur and Gopalpur Upazilla were close to the findings of previous studies [5,20]. However, the N status can easily be increased by the addition of nitrogenous fertilizers for better crop production.

The number of organic carbon content in three different regions varied a little, and the percentage of organic carbons shows approximately similar pattern as N. The available S contents of soils showed wide variation among different locations. The S content was lower in Tangail Sadar Upazilla, due to oxidation and leaching or exhausted by continuous cultivation affecting lower S content of this region, which is similar to the result of previous study [21]. The highest available P was found to be 25.08 ppm in Gopalpur Upazilla, due to the addition of phosphatic fertilizer applied to previous crops. The available P in Bhuapur Upazilla was medium and in Tangail Sadar Upazilla was low. Available P is mainly affected by soil characteristics and farming practices. It might be decreased because of inadequate P fertilization and phosphate fixation in acidic terrace soils. The K is higher in Bhuapur and Gopalpur Upazilla, and very lower in Tangail Sadar Upazilla. Perhaps the presence of more primary and secondary K bearing

minerals was the reason of such variation. Soils in temperate regions that supply adequate K for crop needs often contain considerable trioctahedral mica (biotite) in their clay fractions [6]. Potassic fertilizer should be applied to maintain the K status above critical level for optimum yield. Continual K fertilization is necessary for K deficient soils [6].

3.3 Soil Assessment

The correlations of soil physical and chemical properties are well supported by the study findings (Table 4). The bulk density of soil has significant negative correlation with N and Organic C, and positive correlation with P, K, S and soil pH. The Sand and Clay soil has availability of N compounds, whereas silt dominating soil has higher P, K and S ratio. The soil pH is positively correlated with silt, comparatively higher pH can be found in Gopalpur Upazilla, where it recorded percentage of (69.417) silt.

Though the pH level of the study area is favorable for some crop, but overall macronutrients are low to very low. Fig. 5, illustrate the recommended nutrient level for a variety of plants [22].

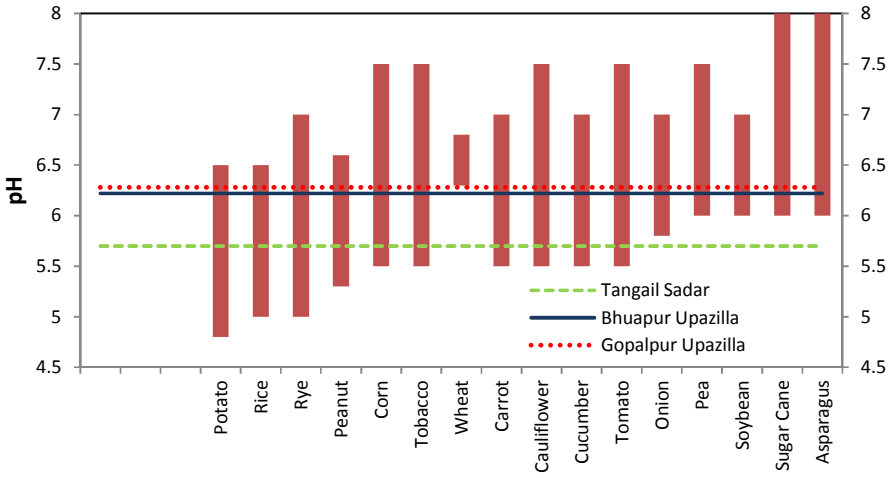

Fig. 3. The pH of the study areas and suitable range for various crops cultivation

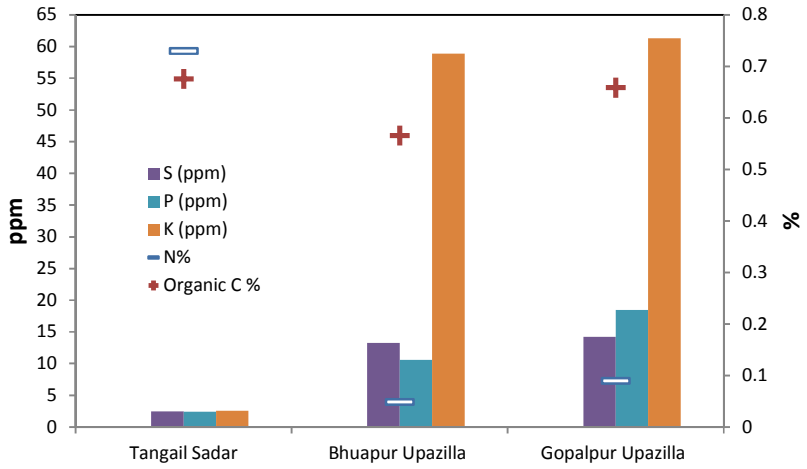

Fig. 4. Macronutrient contents in study area

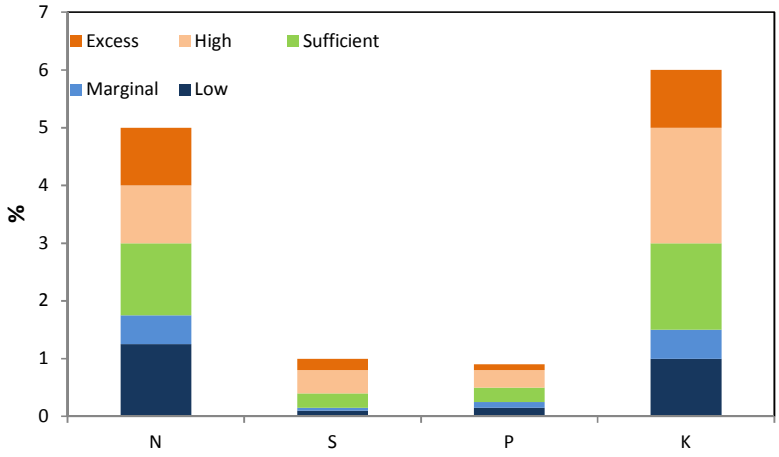

Fig. 5. The recommended level of nutrients for a variety of plants

Table 4. Correlation of soil physical and chemical properties

	N	Organic C	P	K	S	pH
Bulk density	-0.954 **	-0.177	0.600 **	0.474 **	0.698 **	0.431 **
Sand	0.843 **	0.215	-0.364 *	-0.234	-0.517 **	-0.412 *
Silt	-0.920 **	-0.171	0.462 **	0.320	0.600 **	0.485 **
Clay	0.841 **	0.067	-0.611 **	-0.446 **	-0.675 **	-0.532 **

*** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed)*

Three zones of the study area have very lower percentages of N, S, P and K. Additional fertilizer is required for the cultivation of these areas. Beside chemical fertilizer, organic fertilizer is also required for the organic retention of the soil.

4. CONCLUSION

The physical and chemical properties of soil in three major zones (Tangail Sadar, Bhuapur and Gopalpur) of Tangail District, Bangladesh were successfully investigated. The soil of Tangail Sadar is sandy clay loam and comparatively less compact, and Bhuapur and Gopalpur Upazilla soils are silt loam and loam respectively, and more compact soil. The pH of the study area is slightly acidic and sufficient for some crop cultivation, but selective areas have lack of soil micronutrients, appropriate fertilizer is required to cultivate crops in these zones.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. BBS. GDP of Bangladesh; 2013-2014. (Base: 2005-06). Bangladesh Bureau of Statistics, Bangladesh; 2014.
2. Hossain MM, Sattar MA. Physical and chemical properties of some selected soils of Bangladesh. MS Thesis Department of Soil Science BAU. Mymensingh. 2002;1-58.
3. SRDI. Land and soil resources utilization guide (in Bengali). Thana nirdeshika series- tangail sadar thana, soil resources development institute. Dhaka, Bangladesh. 2000;51-61.
4. Lewandowski A, Zumwinkle M, Fish A. Assessing the soil system: Arevies of soil quality literature. Minnesota department of agriculture, energy and sustainable agriculture program. St Paul; 1999.
5. Bhuiya ZH, Sattar MA, Islam MS. Physical and chemical studies of some soils of Bangladesh. Asiatic Society of Bangladesh. 1974;19.
6. Bhuiyan NI. Co-ordinated project on potassium studies Progress Report (1987-88). BARRI, Joydevpur, Gazipur. 1988; 1-45.
7. Ahsan E, Karim Z. Soil and management research on upland soils of Bangladesh. In: Proceeding of the international conference on the management and fertilization of upland soils in the Tropics and Sub-tropics. 1988;247-51.

8. Foth HD. Fundamentals of Soil Science. John Wiley & Sons. New York; 1990.
9. Zilla Tyatha Batayan. Available:http://www.dctangail.gov.bd/ (Accessed; 2012)
10. Bouyoucos GJ. The hydrometer as a method for the mechanical analysis of soils. Soil Science. 1927;23:343-53.
11. Marshall TJ. Mechanical composition of soils in relation to field description of texture. Common wealth of Australia. Council for Scientific and Industrial Research. Melbourne, Australia. Bull. 1947;227:20.
12. Jackson ML. Soil chemical analysis. Constable and Co Ltd. London; 1988.
13. Gosh AB, Bajaj JC, Hasan R, Singh D. Soil and soil water testing method. A laboratory manual, division of Soil Science And Agricultural Chemistry. IARI. New Delhi-110012. 1983;1-45.
14. Page AL. Methods of soil analysis. American society of agronomy and soil science society of amecica publisher. USA Part II, chemical and microbial properties, 2nd edition; 1982.
15. Black CA. Methods of soil analysis. Amer Soc Agron Inc Pub Madison, Wiscosin, USA, Part I and Part II; 1965.
16. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. US Department Agriculture 1954;929.
17. Weir WW. Soil science, its Principles and Practices. JB Lippincott CO, Philadelphis, Pa, USA; 1949.
18. Hannan MA. Structure and related physical properties of some soils of Bangladesh. M.Sc. thesis. Department of soil science. University of Dhaka. Bangladesh. 1995; 138-52.
19. SC H. Soil reaction preferences of plants. Mich. Agr. Exp. Sta. Spec. Bull. 306. East Lansing; 1941.
20. Islam MS. Soil Management in Agricultural Research in Bangladesh. BARC, Dhaka. 1983;105-9.
21. Beaton JD, Wanger RE. Sulphur a vital component of maximum economic yields systems. Sulphur in Agriculture. 1985;9: 2-7.
22. Dr. Ross McKenzie. Soil fertility/ crop nutrition alberta agriculture. Food and Rural Development Lethbridge; 1998.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/11743