



Research Paper

Physico-chemical properties of soils collected from different agricultural lands of Chittagong district of Bangladesh

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ABSTRACT

The current study was conducted in the Department of Soil Science, University of Chittagong, Bangladesh to assess the physical and chemical properties of soils of agricultural lands of Potenga Thana in Chittagong district. The results showed that the mean values of pH, Electrical conductivity, organic carbon, organic matter and Cation exchange capacity of all collected soil samples were 5.66, 1.69 mS/cm, 1.04%, 1.79% and 27.95 cmol/kg, respectively. The mean amount of clay, silt and sand were found to be 29.6, 53.1 and 17.3%, respectively. On the other hand, the average concentration of available N, P, K, S, Ca, Mg and Na were 11.29 mg/kg, 14.28 mg/kg, 0.62 cmol/kg, 99.17 mg/kg, 2.80 cmol/kg, 9.96 cmol/kg and 15.22 mg/kg, respectively, whereas the mean values of 0.22, 0.09, 3.61, 0.05, 0.23, 0.35 and 0.15%, respectively were found for total content of N, P, K, S, Ca, Mg and Na. Overall, the concentration of available and total elements among the soils differed significantly ($p < 0.05$) under examination.

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Key words: Available concentration, Bangladesh, chemical properties physical properties, sampling points, total concentration.

Abbreviations: %, Percentage; °C, degree Celsius; AAS, atomic absorption spectrometer; Ca, calcium; CEC, cation exchange capacity; cmol/kg, centimol per kilogram; DMRT, Duncan multiple range test; EC, electrical conductivity; EDTA, ethylene diamine tetraacetic acid; ESP, exchangeable sodium percentage; FRG, fertilizer recommendation guide; H₂O₂, hydrogen peroxide; H₂SO₄, sulfuric acid; HNO₃-HClO₄, nitric-perchloric acid; K, potassium; KCl, potassium chloride; LiSO₄.H₂O, lithium sulfate; m³, square kilometer; meq, milliequivalent; Mg, magnesium; mg, milligram per kilogram; mS/cm, milliSiemens per centimeter; N, nitrogen; Na, sodium; NaOH, sodium hydroxide; NH₄⁺-N, ammonium-nitrogen; NH₄OAc, ammonium acetate; OC, organic carbon; OM, organic matter; P, phosphorus; S, sulfur, SAR, sodium adsorption ratio; Se, selenium; SP, sampling point; SRDI, soil resource development institute.

INTRODUCTION

Soil is the most important natural resource on which the existence of plants and animals depend. Plants can be grown without soil in small scale but there is no alternative to soil for large scale crop production to supply food for large number of population in the world. Soils provide all sorts of requirements such as physical support, nourishment, nutrients and so on to plants for growth (Brady and Weil, 2005; Gaur, 1997). Uptake of water and nutrient by plants are mostly regulated by the physical and

chemical properties of soil. Better understanding of soil physical, chemical and biological properties ensure the production of better food and fiber along with the establishment of natural ecosystem (Griffith et al., 2010; Tewari, 2016). Bangladesh is an agrarian country with an area of 144,862 square kilometer (m²) and the area fluctuates depending on the alluvial formations within the main river channels and the Meghna estuary (Brammer, 1996). About 60% of the entire people of this country

depend on agriculture for their living. Though the country is small in area, it possess a wide variety of soil types and most crops respond to fertilizers on almost all soils because of their low fertility status. Through reconnaissance soil survey from 1965 to 1976, Soil Resource Development Institute (SRDI) identified 465 soil series of which the physical and chemical properties were determined in the laboratory and published in thirty three reconnaissance soil survey reports. Later, SRDI cumulated a large number of information on soil properties of different Upazilas through semi-detailed soil survey during the period of 1985 to 2001 which were published in three hundred twenty four Land and Soil Resource Utilization Guide popularly known as Upazila Nirdeshika (Huq and Shoaib, 2013). The analysis of soil is necessary to determine the inherent nutrient status of soil. To achieve higher crop yield, it is essential to estimate the demand of fertilizers for a specific crop as well as to ensure efficient use of fertilizer. Fertilizer recommendation can be made from accurate assessment of the soil's fertility through soil testing (Hergert, 2009). The loss of nutrients can also be reduced by regular soil testing programme which is becoming popular because of increasing cost of fertilizers (Dikinya and Mufwanzala, 2010; Hergert, 2009; Murugan and Swarnam, 2013) as well as environmental pollution (Myint, 2010). However, very little information on physical and chemical properties of cultivated soils of different agricultural lands of Patenga Thana is available. Potenga is a Thana of Chittagong district in Bangladesh which occupies an area of 32.65 km² and is bounded on the north by Chittagong Port Thana, on the east by Karnafuli Thana and the Karnafuli River, on the south by Anowara Thana and on the west by the Bay of Bengal (Banglapedia, 2015). Thus, it would be utmost importance to evaluate the physico-chemical properties of soils of different agricultural lands of Patenga Thana for economic use. This study was carried out in agricultural lands of Potenga Thana in Chittagong district, Bangladesh in 2017.

MATERIALS AND METHODS

Collection and processing of soil samples

An amount of 2-3 kg surface soil samples from 0–15 cm depth was collected on March, 2017 from nine cultivated fields of Potenga Thana of Chittagong district (Figure 1). The soil samples were mostly collected from ward No. 41 which represents almost half of the total area. The description of the locations and crops commonly grown in the areas are shown in Table 1. Soil samples were collected in replicates from each sampling sites in completely randomized way. After removing undesired plant materials, soil samples were air dried for 7 days and sieved through 2 mm stainless sieve for the determination of physical and chemical parameters.

Methods of analysis

Soil pH and EC were assessed by a pH and EC meters of 1:2.5 and 1:5 soil-water suspension, respectively immediately after collection of soil samples. Organic carbon (OC) was determined by Walkley and Black wet oxidation method (Walkley and Black, 1934) and that of organic matter (OM) by multiplying OC content with 1.724 (Van Bemmelen factor) as described in Gupta (2001). The measurement of soil separates was done using Hydrometer method and that of CEC by procedures as described by Huq and Alam, (2005). Available phosphorus content of soil samples was determined using ascorbic acid method (Murphy and Riley, 1962) following extraction by Bray and Kurtz (1945). For the determination of available NH₄⁺-N, the samples were extracted with 1N KCl at soil: Extractant ratio of 1:10, whereas the available calcium, magnesium and potassium were extracted with 1N neutral (pH- 7) NH₄OAc at soil: extractant ratio of 1:10. For total analysis of nitrogen, phosphorus, potassium, calcium, magnesium and sodium, the soil samples were heated with a digestion mixture of 350 ml H₂O₂, 0.42 g Se powder, 14 g LiSO₄·H₂O and 420 ml concentrated H₂SO₄ (Rowland and Grimshaw, 1985). For 1.0 g of soil sample, 6 ml digestion mixture was added and heated in a digestion block for 6 h after reaching the temperature finally at 350°C gradually from 50°C (Parkinson and Allen, 1975). The available sulfur in soil was extracted with calcium di-hydrogen phosphate at a ratio of 1:5, whereas the samples were digested with nitric-perchloric (HNO₃-HClO₄) acid mixture to bring total sulfur into solution. Nitrogen was determined by distilling the extracts and NaOH in a micro Kjeldahl's distilling unit to collect NH₃ in boric acid- mixed indicator solution in an Erlenmeyer flask. The distillate was then titrated against standard (0.013 N) sulphuric acid. Total phosphorus was determined by spectrophotometer at a wavelength of 490 nm wavelength, whereas total and available sulfur were determined at of 420 nm wavelength, respectively by vanadomolybdate yellow color method and turbidimetric method using Tween-80 (Huq and Alam, 2005). Total and available calcium and magnesium in extract were measured using EDTA method (Gupta, 2001). Both available and total potassium and sodium were determined by atomic absorption spectrometer (AAS), (Model: Agilent Technologies 200 Series AA). Sodium adsorption ratio (SAR) was calculated according to Equation 1:

$$\text{SAR} = \frac{\text{Na}^+}{\left[\frac{\text{Ca}^{2+} + \text{Mg}^{2+}}{2}\right]^{0.5}} \quad (1)$$

Where, Na⁺, Ca²⁺, and Mg²⁺ are exchangeable sodium, calcium, and magnesium in Cmol/kg, respectively. Exchangeable sodium percentage (ESP) which is another index to determine whether a soil is sodic or not was

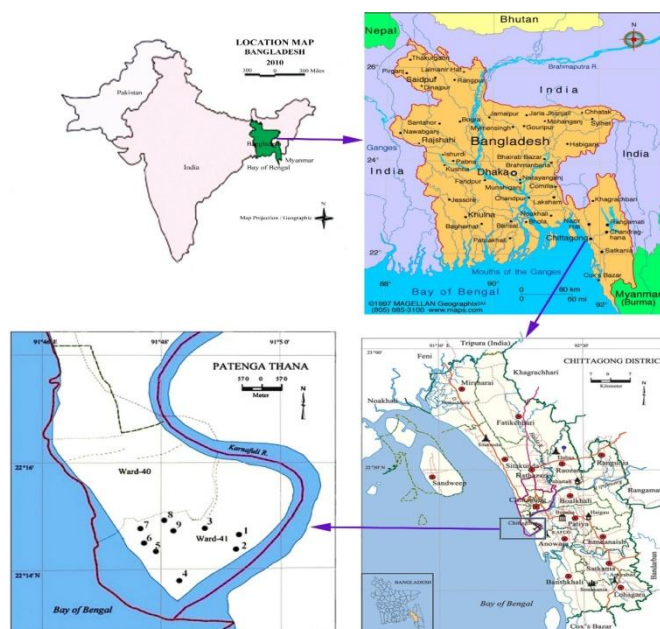


Figure 1: Geographic location of the study area and the sampling sites (Banglapedia, 2012; Huq and Shoaib, 2013).

Table 1: Description of the locations and crops grown in the study areas.

Sampling points	Description of location	Latitude and Longitude	Common crops
SP- 1	Near Shah Aman at International Airport Road (Back side of Butterfly park), South Patenga, Chittagong	22°14' 27.70" N 91°48' 55.92"E	Paddy, tomato, brinjal, bean, bottle ground
SP- 2	Near Blue Lagoon Restaurant (Near Naval Road), South Patenga, Chittagong	22°14' 17.74"N 91°48' 53.21"E	Paddy, tomato, brinjal
SP- 3	Near VIP road (Beside Jahangir Londoni Bari) South Patenga, Chittagong	22°14' 22.63" N 91°48' 24.97"E	Tomato, brinjal
SP- 4	East side of BNA boating pond (Near Naval Academy Road), South Patenga, Chittagong.	22°13' 52.00" N 91°48' 06.52"E	Paddy, tomato, brinjal, radish, chili
SP- 5	Fulcharipara, South Patenga, Chittagong	22°14' 03.45" N 91°47' 53.97"E	Paddy, tomato, bottle ground, pumpkin, bean
SP- 6	Beside Sumit Alliance Port Limited, Sea beach road, Potenga, Chittagong	22°14' 43.75" N 91°47' 28.85"E	Paddy, tomato, brinjal, yard long bean, bottle ground, chili
SP- 7	Char Para (Near Golden beach road), Potenga, Chittagong	22°14' 58.37" N 91°47' 16.09"E	Paddy, tomato, spinach, brinjal, mustard
SP- 8	Mira para (Near Mira Para Govt. Primary School), Kathgar Potenga, Chittagong	22°15' 20.88" N 91°47' 22.87"E	Paddy, tomato, spinach, mustard, red and green amaranthus
SP- 9	NazirPara, Potenga, Chittagong.	22°14' 39.73" N 91°47' 48.06" E	Paddy, tomato

calculated from the relationship proposed by Seilsepour et al. (2009) based on Equation 2:

$$ESP = 1.95 + 1.03 SAR \quad (2)$$

Microsoft Excel 2010 and 2003 was used to calculate standard deviation and correlation, whereas SPSS-16 package was used for Duncan Multiple Range Test (DMRT) of the analytical results.

RESULTS AND DISCUSSION

From Table 1, it is obvious that paddy, tomato brinjal are the most common crops cultivated in the studied area. In addition, short duration crops such as radish, amaranthus, bean, chilli, pumpkin and spinach are grown either for commercial purposes or to fulfill family demand.

Physico-chemical properties of soils

Some physico-chemical properties of collected soil samples assessed are shown in Table 2. The values of pH ranged from 4.32 to 6.69 with an average of 5.56. The maximum pH was found in SP-8 and the lowest value was found in SP- 4. The EC was found to be maximum in SP-3 (4.74 mS/cm) and minimum in SP-7 (0.21 mS/cm). The average status of EC of the samples was 1.69 mS/cm. The highest contents of OC and OM were 1.17 and 2.01% were found in SP-8, while the lowest amounts of OC and OM were 0.87 and 1.49% respectively recorded in SP-7. The mean organic carbon and organic matter contents of all soil samples were 1.04 and 1.79%, respectively. The mean cation exchange capacity of soil samples was found to be 27.95 cmol/kg with a maximum of 34.88 cmol/kg in SP-9 and a minimum of 24.16 cmol/kg in SP-1. The physico-chemical properties of the soil samples collected from different sampling sites varied at 5% level of significance.

Particle size analysis and textural classes

Table 3 shows the amounts of sand, silt and clay and textural classes of the samples. Soil samples collected from SP- 3, 4 and 7 were silt loam in texture, whereas those of SP- 1, 2, 6 and 8 represented silty clay loam. Soil samples collected from site 5 and 9 showed clay loam texture. The highest clay content was found in SP- 6 (34.5%), followed by SP- 9 (32.8 percent) and the lowest amount of 25.5% clay was found in samples SP-3, 4 and 7. The percent of sand and silt were found to be the highest in SP-5 (36.3%) and SP-3 (63.3%) and lowest in SP- 1 (9.7 percent) and SP- 5 (35.8%), respectively. The average contents of sand, silt and clay were 17.3, 53.1 and 29.6%, respectively.

Available concentration of elements

Table 4 shows the available concentrations of nitrogen,

phosphorus, potassium, sulfur, calcium, magnesium and sodium. The concentration of available ammonium-nitrogen ($\text{NH}_4^+\text{-N}$) in soil samples ranged from 8.73 mg/kg in SP-7 to 17.97 mg /kg in SP-9 with a mean concentration of 11.29 mg /kg. The mean content of phosphorus was 14.28 mg /kg with the lowest value of 7.78 mg /kg in SP-2 and the highest value of 23.47 mg/kg in SP-3. The second highest concentration of 22.08 mg phosphorus per kg soil was found in SP-8, followed by 17.12 and 14.82 mg phosphorus per kg soil samples collected from SP- 7 and SP-1, respectively. Among the sampling points, the maximum concentration of available potassium was found in SP-4 (0.84 cmol/kg), followed by SP-3 (0.80 cmol/kg) and the minimum was found in SP- 7 (0.31cmol/kg), while the mean concentration of available potassium was 0.66 cmol/kg. The concentration of available sulfur ranged from 19.04 to 205.46 mg /kg with a mean value of 99.17 mg/kg. The concentrations of available calcium and magnesium ranged from 2.17 to 4.00 cmol/kg with an average value of 2.80 and 8.32 cmol/kg to 12.98 cmol/kg with a mean value of 9.96 cmol/kg, respectively. The maximum concentration of available calcium was found in SP-1, whereas the minimum concentration was recorded in samples SP- 4, 7 and 9. On the other hand, the maximum concentration of available magnesium was detected in SP-6 and minimum in SP-7. The average concentration of available sodium was found to be 15.22 mg/kg with a highest content of 16.23 mg/kg in SP-7 and a lowest value of 14.00 mg /kg in SP-3.

Total concentration of elements

Results presented in Table 5 showed the concentration of total nitrogen, phosphorus, potassium, sulfur, calcium, magnesium and sodium in soil samples. The maximum content of total nitrogen was found in SP-6 whereas the minimum was found in SP-1. The content of total nitrogen varied from 0.18 to 0.28% with a mean of 0.22%. The concentration of total phosphorus was found to be the highest in SP-5 (0.14%) and that of the lowest in SP- 2 (0.05%). However, the mean of total concentration of phosphorus of the samples was 0.09%. The total amount of potassium was found highest in SP- 4 (4.16%) and that of the lowest in SP- 5 (2.35%) with an average of 3.61%. Total content of sulfur ranged from 0.03 to 0.08% with average content of 0.05%, where the highest amount was found in SP-3 and lowest in SP-1. Similar to available concentrations, the total contents of magnesium were found to be higher as compared with calcium in soil samples. The total concentration of calcium ranged from 0.18% (SP- 3) to 0.30% (SP-9) with an average value of 0.23%, whereas the total content of magnesium ranged from 0.21% (SP-4) to 0.66% (SP-1) with a mean concentration of 0.35%. Total sodium ranged from 0.12 % in SP-7 to 0.19% in SP-3 with a mean content of 0.15 %.

Table 2: Physico-chemical properties of collected soil samples.

Sampling points	pH	EC (mS/cm)	Organic carbon (%)	Organic matter (%)	CEC (cmol/kg)
SP- 1	6.39±0.58 ^{ab}	0.65±0.03 ^e	0.97±0.06 ^b	1.67±0.10 ^b	24.16±0.68 ^c
SP- 2	5.48±0.27 ^{bcd}	0.46±0.02 ^f	1.12±0.02 ^a	1.93±0.04 ^a	28.76±0.16 ^{bc}
SP- 3	5.96±0.94 ^{abc}	4.74±0.04 ^a	1.17±0.00 ^a	2.01±0.00 ^a	24.38±4.30 ^c
SP- 4	4.32±0.31 ^e	2.96±0.07 ^c	1.14±0.06 ^a	1.95±0.10 ^a	26.98±2.25 ^{bc}
SP- 5	5.57±0.90 ^{bcd}	1.37±0.05 ^d	0.97±0.06 ^b	1.67±0.11 ^b	30.27±3.84 ^b
SP- 6	5.54±0.43 ^{bcd}	0.49±0.08 ^f	1.11±0.05 ^a	1.91±0.09 ^a	29.52±.25 ^b
SP- 7	5.27±0.23 ^{cde}	0.21±0.02 ^g	0.87±0.06 ^c	1.49±0.10 ^c	24.27±2.91 ^c
SP- 8	6.68±0.49 ^a	0.55±0.06 ^f	1.12±0.04 ^a	1.93±0.07 ^a	28.33±0.34 ^{bc}
SP- 9	4.74±0.44 ^{de}	3.82±0.06 ^b	0.92±0.02 ^{bc}	1.58±0.03 ^{bc}	34.88±2.44 ^a
Mean	5.55	1.69	1.04	1.79	27.95

Means followed by the same letter(s) in a column do not differ significantly from each other at 5% level of significance.

Table 3: Particle size distribution (%) and textural class of collected soil samples.

Sampling points	Clay	Silt	Sand	Textural class
SP- 1	31.2±3.82 ^{ab}	59.2±3.82 ^{bc}	9.7±1.44 ^d	Silty Clay Loam
SP- 2	33.7±3.82 ^a	54.2±5.20 ^{cd}	12.2±1.44 ^d	Silty Clay Loam
SP- 3	25.3±1.44 ^c	63.3±1.44 ^{ab}	11.3±1.44 ^d	Silt Loam
SP- 4	25.3±1.44 ^c	65.0±2.50 ^a	9.7±2.89 ^d	Silt Loam
SP- 5	27.8±1.44 ^{bc}	35.8±1.44 ^e	36.3±2.89 ^a	Clay Loam
SP- 6	34.5±2.50 ^a	55.0±2.50 ^{cd}	10.5±2.50 ^d	Silty Clay Loam
SP- 7	25.3±1.44 ^c	54.2±3.82 ^{cd}	20.5±2.50 ^c	Silt Loam
SP- 8	30.3±1.44 ^{ab}	50.8±1.44 ^d	18.8±1.44 ^c	Silty Clay Loam
SP- 9	32.8±1.44 ^a	40.8±1.44 ^e	26.3±1.44 ^b	Clay Loam

Means followed by the same letter(s) in a column do not differ significantly from each other at 5% level of significance

Table 4: Concentrations of available N, P, K, S, Ca, Mg and Na in soil samples.

Sampling points	NH ₄ ⁺ -N (mg/kg)	P (mg/kg)	K (cmol/kg)	S (mg/kg)	Ca (cmol/kg)	Mg (cmol/kg)	Na (mg/kg)
SP- 1	10.78 ^c ±0.00	14.42 ^{bc} ±0.45	0.62 ^c ±0.07	34.75 ^g ±0.25	4.00 ^a ±0.50	9.32 ^{cde} ±0.76	15.49 ^{ab} ±0.28
SP- 2	9.24 ^d ±0.00	7.78 ^e ±0.40	0.59 ^c ±0.04	108.12 ^d ±0.18	2.33 ^d ±0.29	11.15 ^b ±0.50	15.45 ^{ab} ±0.59
SP- 3	10.78 ^c ±1.54	23.47 ^a ±3.89	0.80 ^{ab} ±0.09	78.24 ^e ±0.25	3.00 ^c ±0.50	9.82 ^{bcd} ±0.76	14.00 ^{bc} ±0.55
SP- 4	11.29 ^c ±0.89	8.80 ^e ±1.56	0.84 ^a ±0.01	205.46 ^a ±0.47	2.17 ^d ±0.29	10.32 ^{bcd} ±0.76	14.75 ^{bc} ±0.51
SP- 5	10.78 ^c ±0.00	12.62 ^{cd} ±1.30	0.55 ^c ±0.06	27.74 ^h ±0.35	2.33 ^d ±0.29	8.65 ^{de} ±0.50	15.41 ^{ab} ±0.17
SP- 6	12.83 ^b ±0.89	12.50 ^{cd} ±1.08	0.71 ^b ±0.02	19.04 ⁱ ±0.30	3.33 ^{bc} ±0.29	12.98 ^a ±1.61	15.50 ^{ab} ±0.29
SP- 7	8.73 ^d ±0.89	17.12 ^b ±2.30	0.31 ^d ±0.01	48.41 ^f ±0.77	2.17 ^d ±0.29	8.32 ^e ±0.76	16.23 ^a ±0.17
SP- 8	9.24 ^d ±0.00	22.08 ^a ±1.38	0.75 ^b ±0.02	196.15 ^b ±0.93	3.67 ^{ab} ±0.29	8.40 ^e ±0.25	15.23 ^b ±0.62
SP- 9	17.97 ^a ±0.89	9.73 ^{de} ±0.19	0.75 ^b ±0.04	174.61 ^c ±0.95	2.17 ^d ±0.29	10.65 ^{bc} ±1.50	14.90 ^b ±0.49
Mean	11.29	14.28	0.66	99.17	2.80	9.96	15.22

Means followed by the same letter(s) in a column do not differ significantly from each other at 5% level of significance.

SAR and ESP

SAR values of the collected soil samples ranged from 2.36 to 3.08 with average value of 2.64, whereas the range of exchangeable sodium percentage (ESP) was found to 4.38

to 5.12 with mean value of 4.66 (Table 6). The lowest content of SAR and ESP was detected in SP-4 and SP-6, respectively. On the other hand, the highest SAR and ESP were recorded in SP-7.

The pH of the present study is also in line with some

Table 5: Concentrations (%) of total N, P, K, S, Ca, Mg and Na in soil samples.

Sampling points	N	P	K	S	Ca	Mg	Na
SP- 1	0.18 ^b ±0.04	0.06 ^{de} ±0.00	3.78 ^{abc} ±0.34	0.03 ^e ±0.00	0.23 ^{bc} ±0.03	0.66 ^a ±0.02	0.14 ^{bcd} ±0.01
SP- 2	0.23 ^{ab} ±0.02	0.05 ^e ±0.00	3.92 ^{ab} ±0.10	0.05 ^c ±0.00	0.22 ^{bc} ±0.03	0.39 ^c ±0.04	0.14 ^{bcd} ±0.02
SP- 3	0.23 ^{ab} ±0.04	0.13 ^{ab} ±0.01	3.89 ^{abc} ±0.31	0.08 ^a ±0.01	0.18 ^c ±0.03	0.28 ^d ±0.02	0.19 ^a ±0.00
SP- 4	0.22 ^{ab} ±0.00	0.06 ^{de} ±0.01	4.16 ^a ±0.48	0.06 ^b ±0.00	0.19 ^c ±0.01	0.21 ^e ±0.05	0.17 ^{ab} ±0.02
SP- 5	0.20 ^b ±0.02	0.14 ^a ±0.01	2.35 ^d ±0.32	0.05 ^c ±0.00	0.23 ^{bc} ±0.03	0.29 ^d ±0.02	0.16 ^{abc} ±0.01
SP- 6	0.28 ^a ±0.03	0.12 ^b ±0.03	3.77 ^{abc} ±0.33	0.06 ^b ±0.01	0.24 ^{abc} ±0.01	0.30 ^d ±0.04	0.13 ^{cd} ±0.01
SP- 7	0.21 ^{ab} ±0.04	0.10 ^c ±0.00	3.29 ^c ±0.33	0.05 ^c ±0.01	0.23 ^{bc} ±0.03	0.26 ^{de} ±0.02	0.12 ^d ±0.01
SP- 8	0.23 ^{ab} ±0.04	0.07 ^d ±0.01	3.47 ^{bc} ±0.07	0.04 ^d ±0.00	0.27 ^{ab} ±0.06	0.46 ^b ±0.03	0.14 ^{bcd} ±0.03
SP- 9	0.20 ^b ±0.01	0.06 ^{de} ±0.00	3.89 ^{abc} ±0.38	0.05 ^c ±0.01	0.30 ^a ±0.05	0.35 ^c ±0.03	0.15 ^{bc} ±0.02
Mean	0.22	0.09	3.61	0.05	0.23	0.35	0.15

Means followed by the same letter(s) in a column do not differ significantly from each other at 5% level of significance.

Table 6: SAR and ESP of collected soil samples.

Sampling points	Sodium adsorption ratio (SAR)	Exchangeable sodium percentage (ESP)
SP- 1	2.61	4.64
SP- 2	2.58	4.61
SP- 3	2.41	4.43
SP- 4	2.56	4.59
SP- 5	2.86	4.90
SP- 6	2.36	4.38
SP- 7	3.08	5.12
SP- 8	2.69	4.72
SP- 9	2.56	4.59
Mean	2.64	4.66

other studies (Mukta, 2008; Uddin et al., 2014). Huq and Shoaib (2013) reported that the average pH of most soils of Bangladesh except Gangetic alluvium is acidic type within a range between 5.5 and 6.5. Except peat lands, most soils of Bangladesh have OM below 1% organic matter ranging between 0.05 and 0.9% and crops respond to organic matter incorporation (FRG, 2012; Huq and Shoaib, 2013). Hossain (2001) reported that the low organic matter content of soils in Bangladesh is one of the most serious threats to the sustainability of agriculture and application of organic matter improves crop growth and yield of crops. The low organic matter content in Bangladesh soils may be due to the rapid decomposition of organic matter because of tropical monsoon climate, rapid removal of mineralized products through leaching and crop removal, high cropping intensity and low return of crop residues to the soil (Bhuiya, 1987; Karim and Iqbal, 2001; Islam, 2008). Because of low organic matter content, the nitrogen status of Bangladesh soil is also low while phosphorus is considered low to medium and potassium is not deficient in most soils. On the basis of Bray and Kurtz-1 extractable phosphorus (mg kg⁻¹) in loam to clay soils, soils were grouped as very low: ≤ 5.25, low: 5.251-10.5, medium:

10.51-15.75, optimum: 15.76-21.0, high: 21.1-26.25 and very high: > 26.25 (FRG, 2012). In view of this classification, irrespective of soil texture, the phosphorus content of collected soils was in the range of medium. Because of poor organic matter content and mostly 1:1 type of clay minerals, the soils possess considerably low cation exchange capacity. Depending on cation exchange capacity, soils were grouped into five classes as very high: >30; high: 15-30; medium: 7.5-15; low: 3-7.5; and very low: <3. Thus, the level of mean cation exchange capacity of collected soils was satisfactory. Similarly, based on the total nitrogen status, soils were categorized from very low (≤0.09) to very high (≥0.45) with 0.09 intervals from one class to another. Accordingly, mean nitrogen content was below optimum level. The critical limit for phosphorus in Bangladesh soils is considered to be 10.0 mg /kg for neutral and calcareous soils and 7.0 mg /kg for acid soils. Except coastal saline areas, most soils in Bangladesh respond to potassium and sulfur. The critical limits of potassium and sulfur are 0.12 meq/100 g and 10 mg/kg though coastal soils usually have higher concentrations than the critical limit (Huq and Shoaib, 2013). The concentration of available potassium and sulfur in this study was to greater than the critical limit.

When the values of SAR and ESP in soils are greater than 13 and 15, respectively, the soils are said sodic soils and considered as problem soils (Brady and Weil, 2005; Osman, 2013). All collected soil samples were in the category of non-sodic as both the SAR and ESP were found to be less than the critical sodicity values. Highly significant positive relationship of cation exchange capacity with clay content and cation exchange capacity have already been observed by several authors (Helling, 1964; Lambooy, 1984; Wang et al., 2005). The positive relationship between clay content and exchangeable calcium and magnesium may be the resulting effects of negatively charged sites of clays which adsorb positively charged ions (McKenzie et al., 2004).

CONCLUSION

From the analyses of collected soil samples, it can be concluded that the soil pH of the study area was found to be within the range at which the nutrient availability as well as microbial activities are suitable. Considering the electrical conductivity, some sites may pose threats to crop production which need special consideration. The available nitrogen and phosphorus contents were below the optimum level while concentrations of potassium, sulfur, calcium and magnesium were satisfactory. Thus, to obtain high yield of crops, the recommended doses of nitrogen and phosphorus should be applied to soil. In addition, incorporation of organic matter along with inorganic fertilizers will be beneficial as soils were very low in organic matter content. The addition of organic matter will serve to improve soil physical condition as well as the source of slow releasing fertilizer in order to encounter the quick loss and cost as in the case of inorganic fertilizer.

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