INTERNATIONAL JOURNAL OF ENVIRONMENT

Volume-7, Issue-1, 2018 ISSN 2091-2854

Received: 8 May 2018 *Revised: 4 Sep 2018* *Accepted: 14 Sep 2018*

SEASONAL AND LAND TYPE BASED SOIL CHEMICAL AND NUTRIENT STATUS IN AGRICULTURAL LANDS OF COASTAL DISTRICT, BAGERHAT, BANGLADESH

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Abstract

The present study investigated the land type based seasonal status of agricultural topsoil chemical properties at Bagerhat district, Bangladesh. Because of relief and seasonal effect we hypothesized the changes of soil nutrient and chemical properties in topsoil. Composite soil samples were collected from fifteen purposive sampling points in pre-monsoon and post-monsoon period of 2016-2017. Soil digestion and analysis were performed following standard procedures. Topsoil pH was strongly alkaline to slightly alkaline (8.02-7.85) in pre-monsoon and post-monsoon with a significant variation. Seasonal OM status was below the optimum level (<3.4). Mean salinity status was very slightly saline in both seasons. Total nitrogen status was low in different lands in both seasons. Phosphorus status was very low (<0.06µg/g) in post-monsoon for upland and wetland crops. Sulfur status was very high (>45.0µg/g) in both seasons for upland and wetland crops. Seasonal mean status of B, Ca and Mg was very high in different lands. Status of Zinc was medium in both seasons having a deficiency (<9.0 µg/g) in some lands. Multivariate analysis showed that lowlands were rich in salinity, OM, K, Ca, total nitrogen and S comparing with medium lowland and medium highland (LL>MLL>MHL). Considering the above issues present study suggests to avoid excessive use of chemical fertilizer and encourages organic fertilizer for sustainable management of these agricultural lands.

Keywords: Relief, Season, Nutrients, Salinity

DOI: http://dx.doi.org/10.3126/ije.v7i1.21293

Introduction

Soil is a central component for sustaining life. Soil degradation is the underlying causes of natural capital loss and unhealthy ecosystem. In healthy ecosystem, soil plays a major role for a constant flow of environmental goods and production (GEF, 2004). Soil degradation by intensive agriculture and heavy reliance on agrochemical inputs is threatening the food security and livelihoods. Crop yield reductions are strongly related to soil quality degradation; particularly nutrient depletion (Roy et al., 2003; Haque et al., 2014). From the early sixties, Bangladesh has been facing essential elements deficiencies and low crop yield (Islam, 2006). Bangladesh is well known for its agricultural activity where 60% people, directly or indirectly, rely on agriculture for their livelihood. Again, in southern coastal region of Bangladesh, agriculture is considered as the major livelihood option for survival of people (BBS, 2011; GOB and UNDP, 2005). Soils in many intensively farmed areas of Bangladesh are suffering from nutrient deficiencies. Again southern coastal districts of this deltaic country have been experiencing salinity intrusion which restricts agricultural production (CCC, 2007). Gowing et al. (2015) found that in dry season, coastal agricultural lands faces severe salinity that prevented agricultural crop production.

Several studies have been carried out nationally and internationally for nutrient dynamics of agricultural land as well as seasonal effect on soil chemical properties. Hossen et al. (2015) studied nutrient status comparing with fertilizer recommendation guide (FRG) in four types of land of Brahmaputra Floodplain area. Naher et al. (2011) analyzed soil properties in coastal areas considering soil salinity effect due to sea level rice. Again Ali (2004) showed that soil quality is degrading due to land use change (Rice to Shrimp) in the southern coastal district of Bangladesh. Fatubarin and Olojugba (2014) investigated the impact of rainfall on soil chemical properties of southern guinea savanna ecosystem, Nigeria in 2011.

A study on soil nutrient status is essential to ascertain the future sustainability of soil fertility and continued rice farming. Assessment of nutrient status would be valuable not only for monitoring purposes but also for farmers to gauge the appropriate application of fertilizers. In the present study, we assessed the status of soil pH, salinity, organic matter (OM), total nitrogen (N), available phosphorus (P), exchangeable potassium (K), calcium (Ca), magnesium (Mg), available sulfur (S) and zinc (Zn) in topsoil of three different land types in pre-monsoon and post-monsoon season. In coastal areas of Bangladesh, most of the lands go under water during the monsoon season and soil is categorized as floodplain soil or fluvisols. During monsoon or logging condition soil sampling is not fruitful for agricultural betterment. It is well known that land elevation or relief and climate variability are subjected to the changes of agricultural soil physical and chemical properties. So that a study on land typed based topsoil chemical and nutrient status along with seasonal dynamics could open a new window for the sustainable agriculture. Considering the above issues, present study was designed to understand the seasonal and land type based changes of coastal soil chemical and nutrient status for the betterment of agriculture of unfavorable ecosystems at Bagerhat district, Bangladesh.

Materials and Methods

Study area

The present study was conducted at five different upazilas (upazila, sometimes called thana, is a geographical segment of Bangladesh generally used for administrative purposes) namely Mollarhat, Fakirhat, Bagerhat Sadar, Rampal and Mongla of Bagerhat district (**Figure 1**). Bagerhat geographically lies between $21^0$49' and $22^0$59' in the north latitudes again 89º32' and 89º98' in the east longitudes (BBS, 2013). Climatically coastal areas of Bangladesh enjoy tropical monsoon climate like other parts of Bangladesh. Average annual maximum temperature of Bagerhat district is 33.5^0 C whereas average minimum temperature is 12.5^0C with an annual average annual rainfall of 1710mm.The main crops are paddy, vegetable, wheat, Jute, sugar cane, potato and banana and main export items are paddy, fish (shrimp), coconut and honey (BDEP, 2014). Different areas of Bagerhat district are fall in three different agro-ecological zones namely Low Ganges River Floodplain (AEZ-12), Ganges Tidal Floodplain (AEZ-13) and Gopalganj-Khulna Bils (AEZ-14). The land elevations of these three agro-ecological zones are highland (above normal flood level), medium highland (flooded up to 90cm), medium lowland (flooded between 90-180cm), lowland (flooded between 180-300cm) and very lowland (flooded above 300cm) (SRDI, 2001; BARC, 2012). Soils of Bagerhat district are floodplain soil. In general the coastal areas of Bangladesh are categorized as less fertile lands (Moselehuddin et al., 2013).

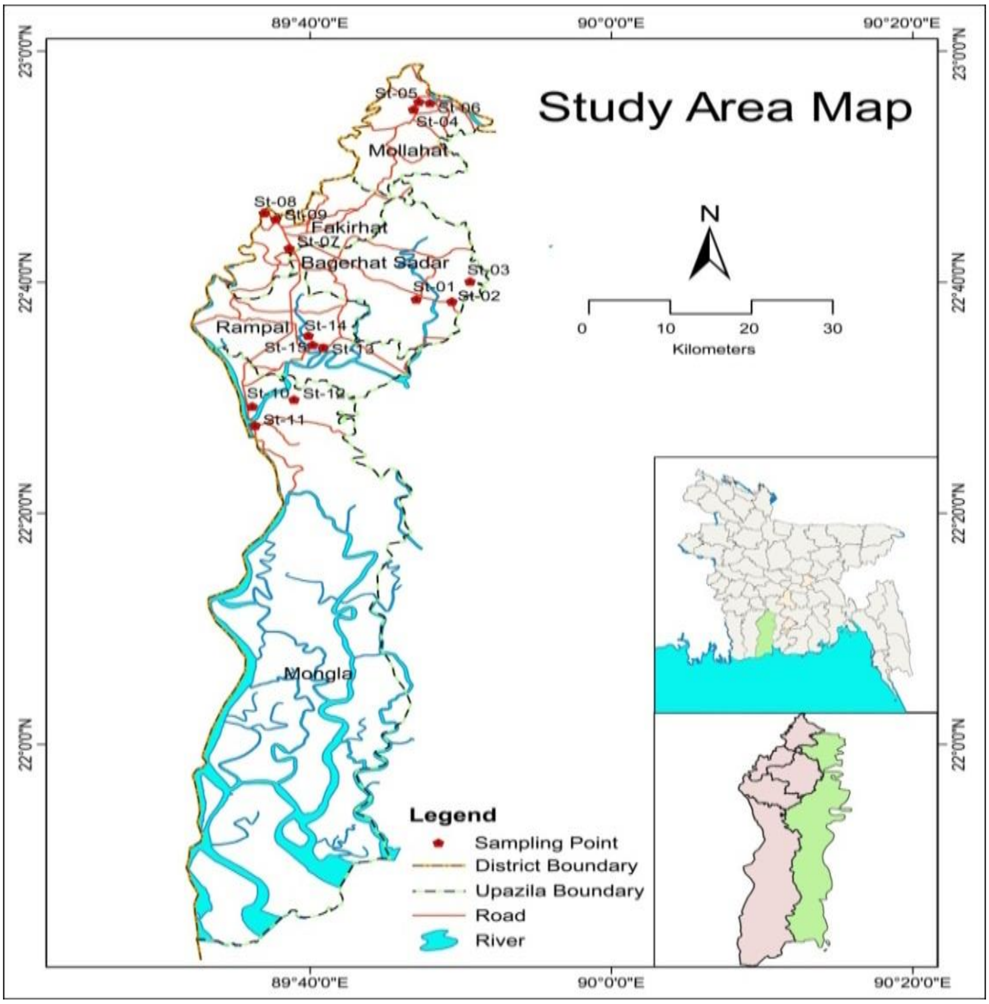

Figure 1. Soil sampling stations at Bagerhat district.

Soil sampling and analytical procedure

Soil samples were collected from medium highland, medium lowland and lowland of five different upazilas of Bagerhat district. Total thirty soil samples were collected whereas fifteen samples were in pre-monsoon season (March-May) and another fifteen samples were in post-monsoon season (October-November) respectively following the methods of composite soil sampling (SRDI, 2001). A stainless steel Ekman Grab Sampler was used for collecting top soil (10-15cm) and avoided cross-contamination for each time. After sampling (about 250-300g for each sample), soil was kept in ambient temperature and air dried for several days over pyrex petri dishes. Soil pH was examined by digital pH meter (soil: water ratio of 1:2.5) and EC of soil was examined by EC meter (soil: water ratio of 1:5) as described by Jackson (1973). Organic Matter (OM) in soil samples were analyzed by Walkley and Black's Wet Oxidation method and $K_2Cr_2O_7$ was used for oxidation of OM described by Jackson (1973).

Semi Micro Kjeldahl method was used for determining total nitrogen content of soil (Page et al., 1989). Concentrated H_2SO_4 and catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se = 10:1:0.1) were used for soil sample digestion. Nitrogen contains in digest was determined by distillation or purification with 40% NaOH. The distillate trapped in boric acid was titrated with 0.01 N H_2SO_4. Available phosphorus was analyzed by Bray and Kurtz methods shaking with 0.03M NH_4F-0.025M HCl solution and the wavelength of spectrophotometer was at 660nm. We used ammonium acetate extraction method for determining available potassium in soil samples. The Calcium and Magnesium of the soil sample were extracted by ammonium acetate extraction method. Ethylenediamene Tetra Acetic acid was used for titration (SRDI, 2001). Available sulfur content in soil was analyzed by calcium dihydrogen phosphate extraction method. Flame emission Spectrophotometer was used for detection of exchangeable K content by ammonium acetate extraction method using K filters described by Sattar and Rahman (1987). Hot-water extraction method was used for analyzing Boron (B) content in soil where calcium chloride solution was used for dilution (Wolf, 1971). Zinc was analyzed with Atomic Absorption Spectrophotometer (AAS, NOV AA-300) following the procedure developed by McLaren et al. (1984) using wavelength 213.9nm.

Statistical analysis

Paired sample t-test was used for seasonal difference. Two way ANOVA along with Tukey test was used for multiple comparisons of soil chemical parameters in different lands. The relation strength between two parameters was determined by the Karl Pearson's correlation coefficient. SPSS 20 was used for all discriminate, bivariate and multivariate analysis.

Results and Discussion

Soil reaction (pH)

Mean pH values in medium highlands were strongly alkaline (8.11±0.28; 8.02±0.24) in pre-monsoon and post-monsoon season respectively (**Figure 2**). Again mean pH value of medium lowland (8.18±.26) was strongly alkaline in pre monsoon but slightly alkaline (7.83±.30) in post-monsoon period. On the other hand, mean pH values of lowland were slightly alkaline in both seasons. In this study highest pH value 8.6(SA) was found in medium lowland at Rampal (St-14) in pre-monsoon and lowest pH value 7.2(SLA) was found in lowland at Rampal (St-15) in post-monsoon season. The mean value of pH in pre-monsoon was strongly alkaline (8.02± 0.33) whereas it was slightly alkaline (7.85±0.31) in post monsoon season. Nazmul et al. (2015) found soil pH ranged from 5.1-8.1 at Jhilwania, Cox' Bazar. Optimum pH range is 6.6-7.3 for nutrients availability (BARC, 2012). The soil of Bagerhat has some basic properties due to calcareous alluvial deposition. The basic properties of this soil will be reduced by mixing appropriate amount sulfur (Muzaale, 2014).

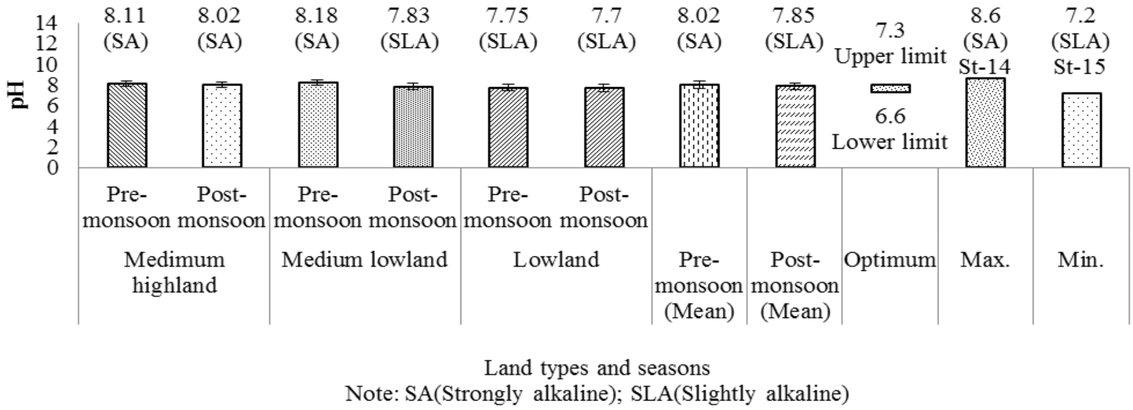

Figure 2. Land type and seasonal soil pH status at Bagerhat district.

Organic Matter (OM)

Present study revealed that, organic matter status was ranged from low to high with a mean value 2.08±0.71% and 1.91±0.61% in pre-monsoon and post monsoon period respectively (**Figure 3**). This study also revealed that medium highland, medium lowland and lowland had medium organic matter content in both seasons. Haque (2006) found that OM status was low (1.0-1.5%) in southern coastal saline soils of Bangladesh. According to BARC (2012), organic matter content in a productive soil should have at least 3.4%. Intensive uses of land and excessive use of chemical fertilizer, low microbial activity and a decrease of soil porosity might be responsible for organic matter deficiency (Olojugba, 2010). Application of organic fertilizer can reduce the organic matter deficiency at Bagerhat district.

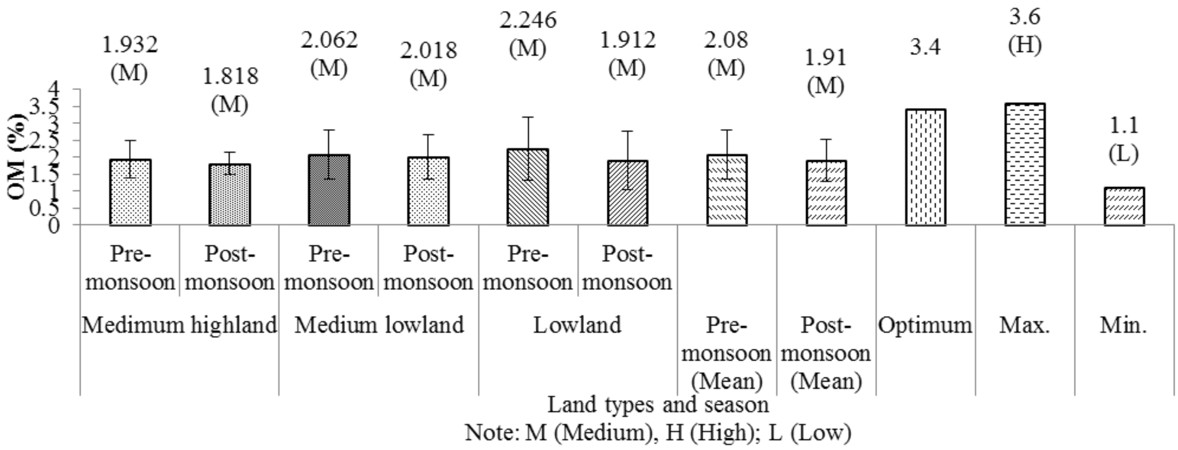

Figure 3. Land type and seasonal status of soil OM (%) at Bagerhat district.

Soil salinity

During pre-monsoon season, in medium highland, salinity ranged was non-saline (0-1.2 dS/m) and the mean status was also non-saline (0.464± 0.64dS/m). Again in post monsoon, its range was non-saline (0-1.4 dS/m) and mean salinity was also non-saline (0.518±.71 dS/m). In medium lowland, salinity range was non-saline to slightly saline in pre-monsoon (0-4.98 dS/m) and post-monsoon (0.78-5.07dS/m) respectively. On the other hand, mean status was slightly saline in pre-monsoon (2.792±2.4dS/m) and post-monsoon (3.186±2.1dS/m) respectively in medium lowland. During pre-monsoon, in lowland salinity was ranged from very slightly saline to slightly saline (3.8-7.41 dS/m) and the mean status was slightly saline (5.568±1.71 dS/m). On the contrary in post-monsoon salinity range was very slightly saline to moderately saline (2.11-8.24dS/m) and the mean value was slightly saline (5.682±2.4 dS/m). Through leaching methods very slightly salinity to moderate salinity could be managed. Salinity could also be managed trough irrigation timing. As evaporation rate is high in hot and dry day and therefore, concentration of salt become high in the plant root area. So that, night time or cool and humid weather is suitable for irrigation to manage soil salinity (Baten et al., 2015).

Total nitrogen (N)

Total nitrogen status in medium highland, in pre-monsoon season, ranged from very low to low (0.07-0.14%) and the mean status was low (0.098%). On the contrary, in post monsoon season its range was also very low to low (0.07-0.11 %) and the mean status was low (0.098 %). In pre-monsoon season, nitrogen status in medium lowland was ranged from very low to low (0.06-0.14 %) and the mean status was low (0.104%). Again in post monsoon period, its range was very low to low (0.07- 0.14%) with a low mean status (0.096%). During pre-monsoon, in lowland, total nitrogen status ranged from very low to low (0.08-0.18%) and the mean status was low (0.106 %). On the other hand, its range was very low to low (0.05-0.15 %) and mean value was low (0.097 %) in post-monsoon period (**Figure 4**).

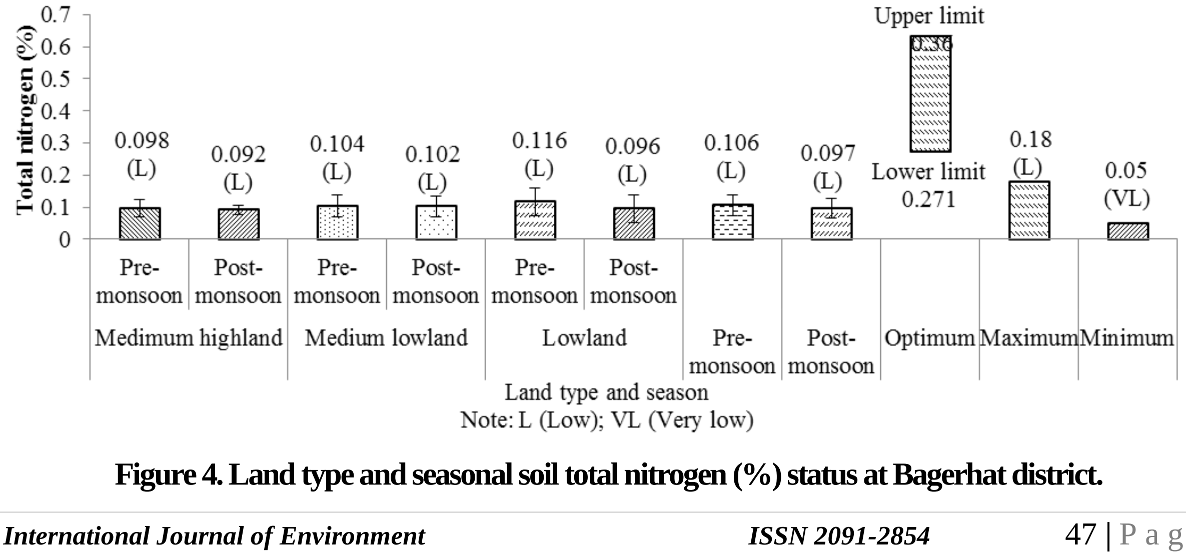

Figure 4. Land type and seasonal soil total nitrogen (%) status at Bagerhat district.

Due to low amount of nitrogen, soil of Bangladesh have long been classified as poor fertile soil as like as other tropical or subtropical agricultural soil. Nazmul et al. (2015) found total nitrogen content in paddy field soil ranging from 0.03-0.12% of Jhilwania at Cox' Bazar district that is similar to the present findings. According to BARC (2012) optimum limit for total nitrogen is 0.271-0.36 %. The low nitrogen status of salt affecting soil might be due to high cropping intensity, inadequate application of organic matter in terms of manure, compost and high volatilization of ammonium nitrogen. According to Sonko et al. (2016) the reasons behind nitrogen deficiency might be having crop residues and lack of mineralization process in the dry season. To fix nitrogen deficiency organic or inorganic fertilizer should be used.

Phosphorus (P)

During pre-monsoon, in medium highland, available P status ranged from very low to very high (2.32-293.6 µg/g) and mean status was very high (88.04 µg/g) for both upland and wetland condition. On the contrary, during post-monsoon, it was very low to medium in upland and very low to optimum (2.65-18.15 µg/g) in wetland condition and mean status was very low (7.01 µg/g) in both conditions. Again in the medium lowland, available P status ranged from very low to very high (348.8-2.96 µg/g) and mean status was very high (94.96±148.6 µg/g) for both upland and wetland condition in pre-monsoon season. Whereas, during post-monsoon, it was very low to medium in upland and very low to optimum (22.36-2.14 µg/g) in wetland condition and mean status was low (7.6±8.42µg/g) in both conditions. During pre-monsoon, in lowland, P status was ranged from very low to very high (2.87-309.2 µg/g soil) for upland and wetland conditions and mean status was very high (90.48±125.9 µg/g) for both conditions. On the other hand, during post-monsoon P range was very low (2.1- 4.79 µg/g soil) for upland and wetland crops and the mean status (3.63±1.1 µg/g soil) was also very low for both conditions. For upland condition, optimum value of available phosphorus is 30 (µg/g soil) and for wetland condition optimum value is 24 (µg/g soil) (BARC, 2012). But the mean status of available phosphorus was very low to low (6.08±5.96 µg/g) in post monsoon season which was not satisfactory for upland and wetland crops. Naher et al. (2011) found phosphorus deficiency at Asasuni (1.25 to 9.50 µg/g), Satkhira district and Kalapara (0.70 to 1.75 µg/g) at Patuakhali district respectively and these ranges were very low to low which is similar to the present status of phosphorus in post-monsoon period. Phosphorus availability and deficiency depend on the improper use of fertilizer such as TSP, DAP and SSP. The lower level of P in the post-monsoon period might be due to the huge quantities drawn by vegetation from the topsoil layer during monsoon (Fungo et al., 2011). Again the reason for high phosphorus fixation may be due to the weathered with high content of aluminum oxides (Okiror, 2017). Fungo et al. (2011) noted that the tendency of P movement is slow comparing with Ca and K because of chemical reaction of various types.

Potassium (K)

During pre-monsoon in medium highland, K range was low to very high for upland crops and medium to very high for wetland crops (0.17-0.68 meq/100g) and mean status (0.318±.21 meq/100g) was optimum for upland crops and high for wetland crops. Again in post-monsoon K range was low to high for upland crops and low to very high for wetland crops (0.10-0.44 meq/100g). Whereas in post-monsoon mean status was medium for upland and optimum for wetland condition (0.24±.12 meq/100g). In medium lowland, K range was low to very high for the upland condition but medium to very high for wetland condition (0.18-0.52 meq/100g) in pre-monsoon period. Again mean status was high (0.366±.16 meq/100g) for both conditions in pre-monsoon season. On the contrary, in post-monsoon period its range was low to very high (0.15-0.53 meq/100g) for upland and wetland crops respectively. Mean status was also high for both conditions (0.37±.17 meq/100g). During pre-monsoon season, in lowland K range was optimum to very high (0.28-0.55 meq/100g) for both upland and wetland conditions whereas; mean status was high for upland and very high for wetland condition (0.45±.11 meq/100g). Again in post-monsoon season K range was medium to very high (0.22-0.58 meq/100g) for upland and wetland crops respectively. On the other hand, mean status was high (0.37±.16 meq/100g) for both conditions. According to BARC (2012), the optimum level of K is 0.36 meq/100g for upland crops and optimum level of K is 0.30 meq/100g for wetland crops. The mean value in pre-monsoon was high for upland crops and very high for wetland crops. Again mean value in the post-monsoon season was optimum for both upland and wetland crops. Rahman et al. (2014) found K ranged from 0.3-1% in the different coastal soil of Bangladesh. Feldspar and biotite are the weatherable minerals having high potentiality to release K in soil. Besides feldspar and biotite are found in sufficient quantity in Ganges' floodplain or seasonally flooded soils (Huizing, 1971). Again high cropping intensity and inadequate application of potash fertilizer might be the cause of low potassium content in some sampling points.

Sulfur (S)

During pre-monsoon, in medium highland, S status ranged from low to very high (11.4-190.5µg/g) and the mean status was very high (90.23±69.03µg/g) both for upland and wetland crops. Again, during post-monsoon, it was also ranged from very low to very high (2.83-117µg/g) and the mean status was very high (52.4±46.71µg/g) both for upland and wetland crops. In medium lowland, sulfur range in pre-monsoon season was low to very high (10.69-121.82µg/g) with a very high mean status (62.394±51.44µg/g) both for upland and wetland crops. Whereas, in post-monsoon S range was optimum to very high for wetland crops and high to very high (30.37-193.4 µg/g) for upland crops. Again mean status was very high (107.7±79.19µg/g) for wetland and upland crops. On the other hand, in the lowland, sulfur was ranged from very low to very high (4.58-202.7µg/g) and the mean status was very high (88.01±99.66µg/g) for upland and wetland crops. On the contrary, in the post-monsoon period the range was medium to very high (18.30-205.3µg/g) for upland and optimum to very high for wetland crops but the mean status was very high (93.9±74.7µg/g) for both crops. Surface soil S status studied by Naher et al. (2011) and they found medium to high content of S. The content was higher at Kalapara at Patuakhali Bangladesh which support our study. For upland condition, the optimum value of sulfur is 22.51-30µg/g and for wetland condition, the optimum value is 27.1-36.0µg/g (BARC, 2012). Very high status of sulfur at different lands might be due to the regular inundation of tidal water in the study area. Again sulfur deficient soils in study area need sulfur fertilization for optimum yield and gypsum, elemental sulfur or zinc sulfate are the popular external sources of sulfur (Imamul and Shoaib, 2013).

Calcium (Ca)

During pre-monsoon in medium highland, calcium range was very high (8.00-16.5 meq/100g) and mean status was also very high (12.72±3.4 meq/100g). On the contrary, in post-monsoon Ca range was also very high (8.50-15.78 meq/100g) with very high (13.37±2.9 meq/100g) mean status. In the medium lowland, Ca range was very high (9.40-17.41 meq/100g) and mean status was also very high (13.56±3.2 meq/100g) during pre-monsoon.

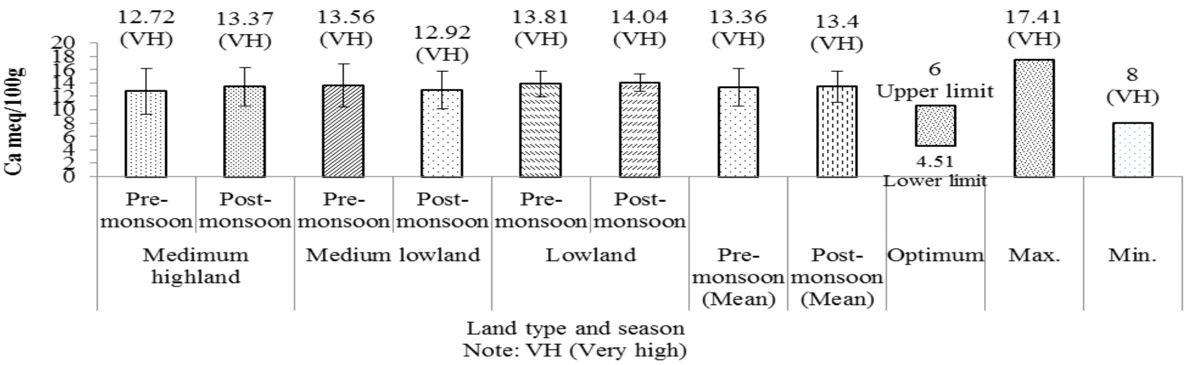

Figure 5. Land type and seasonal soil Ca status Bagerhat district.

On the contrary, in post monsoon, Ca range (9.52-16.34 meq/100g) and mean status (12.92±2.8 meq/100g) was very high in the medium lowland. In lowland, Ca range in pre-monsoon (11.24-15.76 meq/100g) and post-monsoon (12.16-15.37 meq/100g) were very high whereas, mean status in both seasons were also very high (13.81±1.9 and 14.04±1.2 meq/100g) (**Figure 5**). The optimum level of calcium in agricultural surface soil is 4.51-6.0 meq/100g (BARC, 2012). Ca participates in plant tissue synthesis during the monsoon period, therefore, their deficiency found during the rainy season. For this reason, sufficient amount of Ca might be found in pre-monsoon and post-monsoon season (Olojugba, 2010). Again regular inundation in the coastal area might be the source of high amount Ca content in Bagerhat district.

Magnesium (Mg)

The present study revealed that the mean status of Mg of pre-monsoon (2.68 meq/100g) and post-monsoon (2.35 meq/100g) at medium highland were very high. Again in medium lowland mean status was also very high in pre-monsoon (2.63 meq/100g) and post-monsoon (2.74 meq/100g) period. On the other hand in lowland, mean status was also very high in pre-monsoon (2.65 meq/100g) and post-monsoon (2.69 meq/100g) respectively (**Figure 6**). Optimum status of Mg for successful crop production is 1.126-1.5 meq/100g (BARC, 2012). Mean values 2.654±0.416 meq/100g and 2.595±0.271 meq/100g in pre-monsoon and post-monsoon period indicated that Mg was very high. In the present study, the highest Mg (3.75meq/100g) was found at medium highland at Mongla (St-10) in pre-monsoon and the lowest Mg (1.95 meq/100g) was found in the same land at Mongla in post-monsoon period. Like other exchangeable cations, Mg has great importance in plant tissue synthesis and its disappearance occurs in the rainy season due to high plant tissue synthesis. Therefore there seen the availability of Mg in pre-monsoon and post-monsoon (Olojugba, 2010).

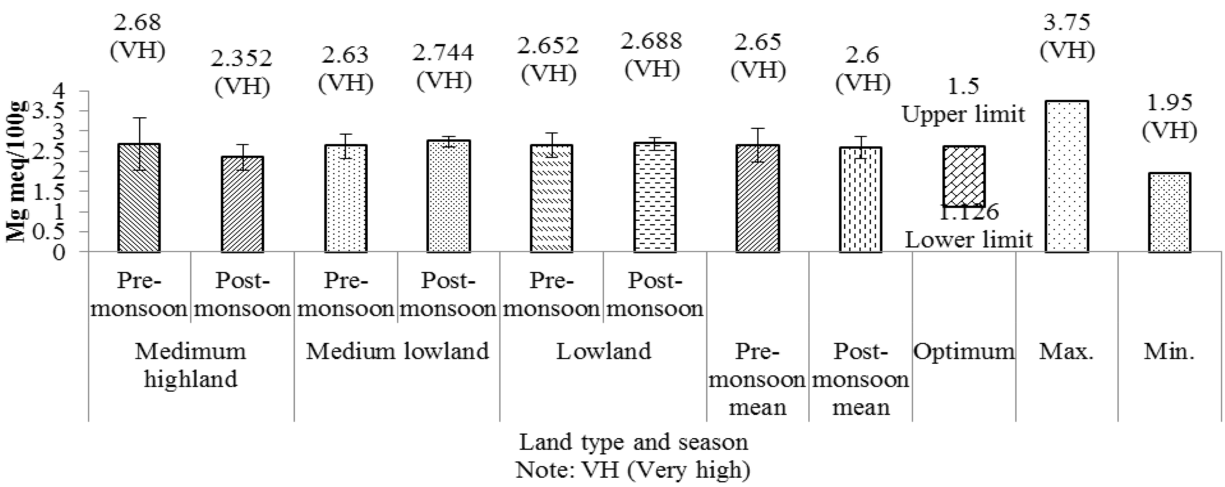

Figure 6. Land type and seasonal soil Mg status at Bagerhat district.

Zinc (Zn)

During pre-monsoon, in medium highland Zn was ranged from very low to very high (0.26-4.3µg/g) and mean status was optimum (1.67µg/g). Again in post-monsoon Zn was ranged from low to very high (0.9-3.81µg/g) and the mean status was also optimum (1.54µg/g). On the contrary, in medium lowland, its range was very low to high (0.34-2.1 µg/g) and the mean status was medium (1.05µg/g) in pre-monsoon season.

Again in the post-monsoon season, its range was medium to optimum (0.93-1.54µg/g) and the mean status was also medium (1.31µg/g) in the medium lowland. On the other hand, in the lowland, during pre-monsoon, the status of Zn was ranged from very low to medium (0.29-0.98µg/g) and the mean status was low (0.718µg/g). Again in the post-monsoon season, its range was low to optimum (0.73-1.65µg/g) and the mean value was medium (1.09µg/g). Mean status 1.15±1.016 µg/g (M) and 1.31±0.746 µg/g (M) were found respectively in pre-monsoon and post-monsoon period (**Figure 7**). Zinc deficiency was observed in Ganges floodplain and coastal saline soils in Bangladesh (BRRI, 1980; Mukhopadhayay et al., 1986). In this study, Zn deficiency might be due to high soil pH, soil submergence and interaction with phosphate ion. In the calcareous soils Zn deficiency is common. Again its deficiency is also widespread in saline soils and piedmont soils. Applying Zn fertilizer would be a solution of these deficiency problems (Imamul and Shoaib, 2013).

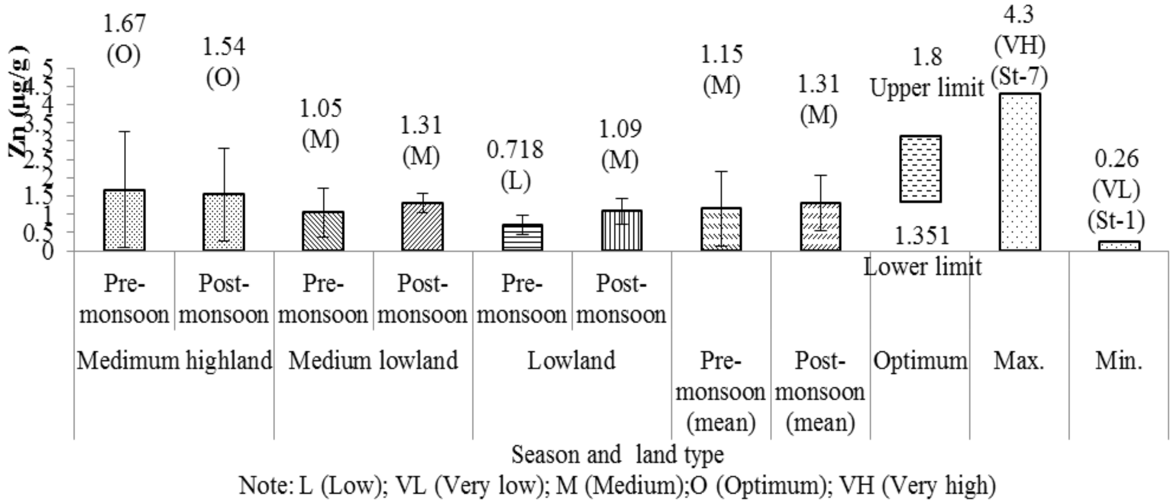

Figure 7. Land type and seasonal soil Zn status at Bagerhat district.

Boron (B)

In the medium highland status of B was ranged from very low to very high (0.1-3.46µg/g) and the mean status was very high (1.38±1.13µg/g) in pre-monsoon season. Again in post-monsoon season, boron was ranged from low to very high (0.3-2.34µg/g) with a very high mean (1.08±0.81µg/g) status in medium highland. During pre-monsoon, in the medium lowland, the status of boron ranged from high to very high (0.67-0.99µg/g) and the mean status was very high (0.83±0.15µg/g). On the contrary in post-monsoon its status was high to very high (0.68-1.02µg/g) and the mean status was also very high (0.84±0.13µg/g). Again in the lowland, boron range was very high (0.83-1.15µg/g) and mean status was also very high in pre-monsoon. On the other hand in post-monsoon its range was very high (0.85-1.6µg/g) and mean status was also very high (1.10±0.29µg/g) (**Figure 8**). Soils along the seashore or derived from mudstone and marine shale enriched parent material are usually B enriched (Waqar et al., 2012). Bagerhat district is almost free from boron deficiency due to its geographic location (SRDI, 1998). Less soil organic matter, high soil pH, sandy texture, intensive cultivation and drought might be the crucial factors for B deficiency at medium highland of Mollarhat in both seasons (Niaz et al., 2007; Rashid et al., 2005).

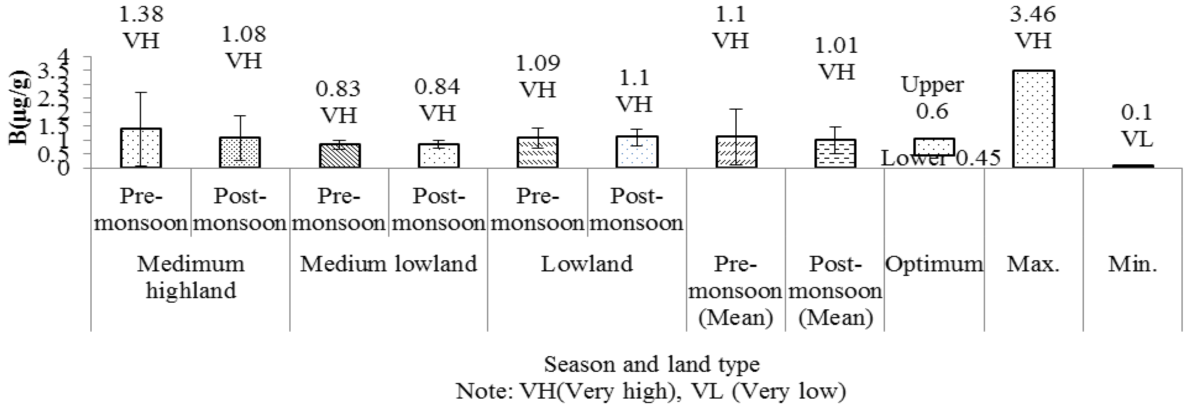

Figure 8. Land type and seasonal soil B status at Bagerhat district.

Seasonal difference of soil chemical and nutrients (Paired sample t-test)

Paired sample t-test was performed for assessment of seasonal difference in topsoil chemical and nutrients status. Soil properties (Chemical and nutrients) entered as testing variables against the grouping variables of two seasons. From the results, it was revealed that mean difference of pH between pre-monsoon and post-monsoon was significant ($p<0.05$). Positive mean difference indicated that lower pH value in post monsoon and this might be due to after heavy shower in monsoon season. No seasonal difference was found in case of OM, total nitrogen, K, Mg, B in the study area. Seasonal variation was very high for P content and it was statistically significant ($p<0.05$). Again negative mean difference of EC, S and Ca indicated that their status was higher in post-monsoon season. These may be due to the inundation by monsoon flood in the study area which brings marine water in different lands but these were not statistically significant.

Multiple comparisons of soil properties at the different type of lands

Two way analysis of variance (ANOVA) with Tukey test (5% significant level) was performed for multiple comparisons of soil chemical properties and nutrients at different type of lands. It was found that, lowlands were more affected by salinity than medium lowland and medium highland. Again highlands were more alkaline than lowlands (MHL>HLL>LL) and significant results were found for mean difference MHL-LL ($p<0.05$). Mean difference of OM, K, Ca, N, S indicated that their availability was high in lowland comparing with medium lowland and medium highland (LL>MLL>MHL). But these were not statistically significant.

In case of Zn there found availability of Zn in medium highland than medium lowland and lowland (MHL>MLL>LL). Highest mean difference was found for S but it was not statistically significant. Again S availability was high in lowland than medium lowland and medium highland. Status of B in medium highland is high comparing with medium lowland and lowland was greater (MHL>LL; MHL>MLL). But B was more available in lowland comparing with medium lowland (LL>MLL). The availability of B in lowland comparing with medium highland and medium lowland might be the regular inundation of marine water in lowland at Bagerhat.

Correlation matrix among soil salinity, pH, and soil nutrients

From the correlation matrix (**Table 1**), soil salinity had a significant positive relation with K (r=0.637), S (r=0.594) and a significant negative relation with pH (r=-0.416). Again soil pH and Ca were significantly positively correlated ($p<0.05$). Soil organic matter was showed a significant positive relation with total nitrogen (r=0.978) and a significant negative relation with Ca (r=-0.381) and S (r=-0.403). Total nitrogen content and S also showed significant negative relation (r=-0.376; $p<0.05$). Ca significantly negatively correlated with Zn (r=-0.418; $p<0.05$). Mg showed a significant positive correlation with K (r=0.775; $p<0.01$) and S

Table 1. Correlation Matrix between the soil chemical properties and soil nutrients of Bagerhat district.

Parameters	Salinity	pH	OM	Total N	Ca	Mg	K	P	S	Zn	B
Salinity	1										
pH	-0.416*	1									
OM	-0.215	-0.066	1								
Total N	-0.149	-0.099	0.978**	1							
Ca	0.066	0.409*	-0.381*	-0.343	1						
Mg	0.309	0.142	-0.220	-0.187	0.271	1					
K	0.637**	0.005	-0.252	-0.210	0.092	0.775**	1				
P	-0.247	0.202	0.359	0.338	0.107	-0.157	-0.219	1			
S	0.594**	-0.129	-0.403*	-0.376*	-0.014	0.523**	0.706**	-0.361	1		
Zn	-0.305	-0.046	-0.112	-0.139	-0.418*	-0.307	-0.180	-0.138	-0.007	1	
B	0.005	0.176	-0.243	-0.336	0.340	0.139	0.074	-0.242	0.167	-0.223	1

Note: * 5% level of significant; **1% level of significant

(r=0.523; $p<0.01$). It was found that K and S (r=0.706; $p<0.01$) had a significant positive relation. These results were in confirmatory with the findings of Naher et al. (2011). Significant positive relation of K and salinity; Mg and K with S in coastal soil indicated that marine inundation presumably their common source.

Conclusion

The study concluded that status of soil chemical and nutrient very from season to season and land to land. Soil pH was found slightly alkaline to strongly alkaline from lowland to medium highland in the entire study period. Soil salinity was higher in the lowland compared with highland. It is exposed from the study that most of the sampling stations faced organic matter and total nitrogen deficiency. All the exchangeable cations (K, Ca and Mg) were sufficient in both seasons. The present study also revealed that level of B was around very low to very high level. Zn status was medium in both seasons but lowland and medium lowland of Bagerhat showed Zn deficiency in pre-monsoon period. Considering alkalinity and salinity at Bagerhat district concern authority should manage OM, total nitrogen, B, Zn deficiency for the betterment of agriculture.

Limitations of the research

During monsoon season lowlands of Bagerhat districts remained under water that inhibited us to collect soil sample in monsoon period. Again due to budget constrains only one coastal district was chosen which might not reflect the whole coastal scenario of Bangladesh.

Acknowledgement

The authors acknowledge the Ministry of Science and Technology, Bangladesh for providing financial support. They also express sincere thanks to UAOs of Bagerhat district and scientist of Soil Resource Development Institute, Dinajpur for their kind support during study period. Special thanks to Hujaifa Ibne Murtuza, student of the Department of ESRM, MBSTU, Tangail-1902, Bangladesh and the anonymous farmers for their kind cooperation during the sample collection.

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