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SOIL PLANT NUTRIENT STATUS UNDER INTENSIVE RICE-FARMING SYSTEMS IN UNFAVORABLE ECO-SYSTEMS OF BANGLADESH

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Abstract:-
Soil fertility and crop production varies depending on ecological factors and soil parent materials. A baseline study was conducted to delineate soil nutrient status of unfavorable ecosystems under different agro-ecological zones (AEZ) of Bangladesh (Char and saline, AEZ-18; submergence and cold, AEZ-3; tidal flood ecosystem, AEZ-13; drought and cold prone, AEZ-26 and haor area, AEZ-21). A total of 125 composite soil samples (10 samples/spot) were collected at 0-20 cm depth, maintained geographical positions and data on village, union, upazila, land type, soil series and land use patterns. Soil samples were analyzed for texture, pH, electrical conductivity (EC), organic matter (OM), total nitrogen (N), available phosphorus (P), exchangeable potassium (K), calcium (Ca), magnesium (Mg), available sulfur (S) and zinc (Zn). Soil pH was slightly acidic to neutral in AEZ-18, 3 and 13. In AEZ-21, soil was strongly acidic but neutral to slightly alkaline AEZ-26. In most locations, soil OM was below critical level (1.72%) in 80 to 96% samples. Soil N was below critical level (0.12%) in almost all samples except in AEZ-21. In AEZ-21, 100% samples showed P deficiency and in AEZ-26 it was 24%. In AEZ-3, 60% samples were K deficient and in AEZ-26 it was 40%. Thirty-two and 24% samples were S deficient in AEZ-3 and 26, respectively. The highest 84% samples were Zn deficient in AEZ-18 followed by AEZ-21 (48%). About 52% samples were Ca deficient in AEZ-3 followed by AEZ-21 (4%). Nutrient status of soils was mostly low and varied among locations.

Keywords:- *Unfavorable ecosystems, soil fertility, rice production*

INTRODUCTION

Crop yield reductions are strongly related with soil quality degradation, particularly nutrient depletions (Ali et al., 1997; Roy *et al*., 2003; Haque et al., 2014), which can be attributed to either insufficient fertilizer use or imbalanced fertilization (Tan *et al*., 2005; Chaudhary et al., 2007). The common nutrients applied in Bangladesh are N as urea, P as triple super phosphate (TSP) and di-ammonium phosphate (DAP), and K as potassium chloride (KCl), S as gypsum and Zn as zinc sulfates for rice production. The use of N fertilizer in Bangladesh is increasing since 1960s and reached to 2.46 million metric tons in 2013-14. However, the consumption of P and K fertilizers has not been followed the same tends of N use. In wet land rice soils, N fertilizer has been applied at higher rates than P and K.

The rate and types of fertilizer used depend on a farmer's financial status, and the farmer's choice is often made without considering indigenous supply capacities of soils under variables AEZ of Bangladesh. Besides, being cheaper and highly visible response of N than P and K fertilizers, farmers apply more N for rice production (Biswas *et al*., 2004; Rahman et al., 2008) and thus create nutrients imbalance in many cases. The imbalanced fertilizer use in Bangladesh agriculture is speeding up nutrients depletion (Panaullah *et al*. 2006; Rijpma and Islam, 2015). So, a study on soil nutrient status is essential to ascertaining 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 pH, EC, OM, total N, available P, exchangeable K, Ca, Mg, available S and Zn in soil with the aim of better understanding of nutrients flow under current intensive rice farming systems in unfavorable eco-systems of Bangladesh.

MATERIALS AND METHODS

Description of the study site

Five locations were selected from unfavorable ecosystems, such as AEZ-18 (Char and saline area of Sonagazi); AEZ-21 (Haor area of Habiganj); AEZ-3 (Submergence and cold area of Rangpur); AEZ-13 (Tidal flood ecosystem of Barisal) and AEZ-26 (Drought prone and cold area of Rajshahi). In collecting soil samples, global positioning system (GPS) data were recorded. The GPS data were: 22.69412-22.81959ºN latitudes and 91.38613-91.38967ºE longitudes for Londonipara, Feni (AEZ-18); 24.41719-24.41889ºN latitudes and 91.42238-91.42539ºE longitudes for Nagura, Habiganj (AEZ-21); 25.86088-25.88511ºN latitudes and 89.23211-89.23856ºE longitudes for Gunnarpar, Rangpur (AEZ-3); 22.75666-22.75991ºN latitudes and 90.29867-90.30708ºE longitudes for Gozalia, Barisal (AEZ-13) and 24.5417-24.54442ºN latitudes and 88.55575-88.55886ºE longitudes for Raitanboso, Rajshahi (AEZ-26). Some basic characterizations of the study area were presented in Table 1.

In Bangladesh, coastal area covers about 2.5 million hectares, which is about 25% of total cropland (S A Haque, 2006; Rasel., 2013). About one million hectares are affected by varying intensities of salinity (Karim et al., 1990). Crop production in this area is dominated by traditional T. Aman rice with yield of 2 t ha^{-1}. Flood-prone rice ecosystem of Bangladesh covers about 2.6 million hectares (Karim, 1997). The average yield of rice under such ecosystem is very low (2.5 t ha^{-1}). Nearly 2.5 million hectares are affected by drought in the north-west parts of Bangladesh (Karim, 1997) where yield of BRRI dhan39 can vary from 0.61 to 2.8 t ha^{-1} (Mazid *et al*., 2004). The non-saline tidal flood ecosystem of Bangladesh covers about 1.9 million hectares and average yield of rice is not more than 3.0 t ha^{-1} due to lack of appropriate fertilizer management packages, etc. Haor is the wetland ecosystem in north-eastern part of Bangladesh. Total area in this ecosystem is 80,000 square kilometers. Most of this area remains under water for seven months of the year. During dry season, most of the water drains out, leaving small shallow lakes or completely dried out by the end of winter season. This exposes rich alluvial soil, extensively suitable for rice cultivation.

Sampling and laboratory analyses

A total of 125 composite soil samples (10 samples/spot) were collected from the surface layer (0-20 cm depth) from five AEZs (3, 13, 18, 21 and 26). Soil samples were collected from 25 farmers' fields at each location. The GPS reading and some basic information like village, union, upazila, land type, soil series and land use were also collected (Table 1). Soil samples were airdried, ground and passed through a 2-mm sieve and prepared for routine analyses of texture, pH, EC, OC, total N, exchangeable Ca, Mg and K, available P, S and Zn. Texture was determined by hydrometer method. Soil pH was measured using glass electrode method with a soil-to-water ratio of 1:2.5 (McLean, 1982; Jackson, 1962). The EC was measured by EC meter with a soil-to-water ratio of 1:5. Soil organic carbon (SOC) was determined by wet oxidation method (Walkley and Black, 1935; Nelson and Sommers, 1982). Soil total N was determined by micro-Kjeldahl method (Bremner and Mulvaney, 1982). The available soil P from acid soil was extracted using the Bray 2 method (Bray and Kurtz, 1945) and from neutral and calcareous soils by modified Olsen's method (Olsen and Sommers, 1982). Available soil S was extracted using calcium di-hydrogen phosphate (500 ppm of P) and determined by turbidity method. Available soil Zn was extracted using the DTPA and determined by using an atomic absorption spectrophotometer. Exchangeable Ca, Mg and K were extracted with 1 M NH_4OAc pH 7.0. Exchangeable Ca and Mg were determined by an atomic absorption spectrophotometer. Exchangeable K was determined by flame photometer (Barker and Surh, 1982).

RESULTS AND DISCUSSION

Soil Chemical properties

Summary results of chemical analyses of soil samples under study sites are presented in Table 2. Soil chemical property value was assessed using the soil fertility criterion for soils under wet land rice crops provided in FRG-2012 (BARC, 2012). Soil pH was slightly acidic to neutral in AEZ-18, 3 and 13. In AEZ-21, soil was strongly acidic and in AEZ-26 it was neutral to slightly alkaline. Soil pH changes because of management practices, which in turn influence nutrient availability. Ali *et al*. (1997) reported that mean value of soil pH for Bangladesh has been decreased by 0.23 units from 1967 to 1997 (only 27 years). This implies that corrective measures have to be taken to adjust soil pH for efficient crop production. In most locations (AEZ-18, 3, 13 and 26), the status of soil OM was 1.1-1.4%, below critical limit (1.72%) in 80 to 96% of samples. Only in AEZ-21, it was 2.4% (medium). Similar trend was also found with total soil N. Almost 100% samples were below critical level (0.12%) except AEZ-21. In AEZ-21, it was 0.14%. Good relationships were found between OM and N status of soils (Fig. 1).

In AEZ-21, 100% soil samples were P deficient (mean P was 1.8 mg kg^{-1}) and in AEZ-26 it was 24%. In AEZ-18, 3 and 13, it was only 4%, 8% and 4%, respectively. Soil available P in these sites ranged from 14.7 to 14.8 mg kg^{-1}. However, build up of soil P in Tista Flood Plain and decrease in Chittagong Flood Plain was reported by Ali *et al.* (1997). Our findings and previous results indicate variation of soil P status depending on ecological conditions. Thirty-two and 24% samples were S deficient in AEZ-3 and 26, respectively. Available soil S status in AEZ-18, 21 and 13 was 33.0, 22.9 and 21.9 mg kg^{-1} (mean value), respectively. None of the samples in these areas was below critical level (12 mg kg^{-1}). Widespread S deficiencies in Bangladesh are reported by many authors (Hossain, 1990; Islam and Hossain, 1993; Hoque and Jahiruddin, 1994). The highest soil samples (84%) were Zn deficient in AEZ-18 followed by AEZ-21 (48%). Soil available Zn ranged from 0.5 to 1.8 mg kg^{-1}. The lowest Zn value was found in AEZ-18 and the highest in AEZ-26.

The highest number of soil samples (52%) was Ca deficient in AEZ-3 followed by AEZ21 (4%). The exchangeable Mg ranged from 1.1 (AEZ-21, 26) to 3.8 cmol kg^{-1} (AEZ 18). None of the soil samples in the study areas was below critical level (0.5 cmol kg^{-1}). The exchangeable Ca ranged from 2.3 to 8.8 cmol kg^{-1}. The lowest Ca value was found in AEZ-3 and the highest in AEZ-13. In general, exchangeable Ca and Mg are declining in Bangladesh soils (Ali *et al*., 1997).

In AEZ-3, 60% soil samples were deficient in K and in AEZ-26 it was 40%. Soil exchangeable K ranged from 0.11 to 0.29 cmol kg^{-1}. The lowest K value was found in AEZ- 3 and the highest in AEZ-21. Potassium mining is widespread, although not below critical limit in many cases (Ali *et al*., 1997; Panaullah *et al*., 2006). Dobermann *et al*. (1995) also reported 25-70 kg ha^{-1} $year^{-1}$ Kmining in rice based farming system in several eastern Asian countries.

CONCLUSIONS

In most study locations, the status of soil organic matter was below critical level (1.72%) in 80 to 96% sample. Nitrogen level was below 0.12% (critical limit) in almost 100% soil samples of all AEZ except AEZ-21. In AEZ-21, 100% samples were P deficient followed by 24% in AEZ26. In AEZ-3, 60% samples were K deficient and in AEZ-26 it was 40%. Thirty-two and 24 % samples were S deficient in AEZ-3 and 26, respectively. The highest number of samples (84%) was Zn deficient in AEZ-18 followed by AEZ-21 (48%). The highest number of samples (52%) was Ca deficient in AEZ-3 followed by AEZ-21 (4%). Nutrient status of soils was mostly low and varied among locations. Initiative needs to be taken to improve soil organic matter contents in Bangladesh.

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Figure legends

Fig. 1. Soil organic matter contents and its relationships with total nitrogen in different unfavorable eco-systems of Bangladesh

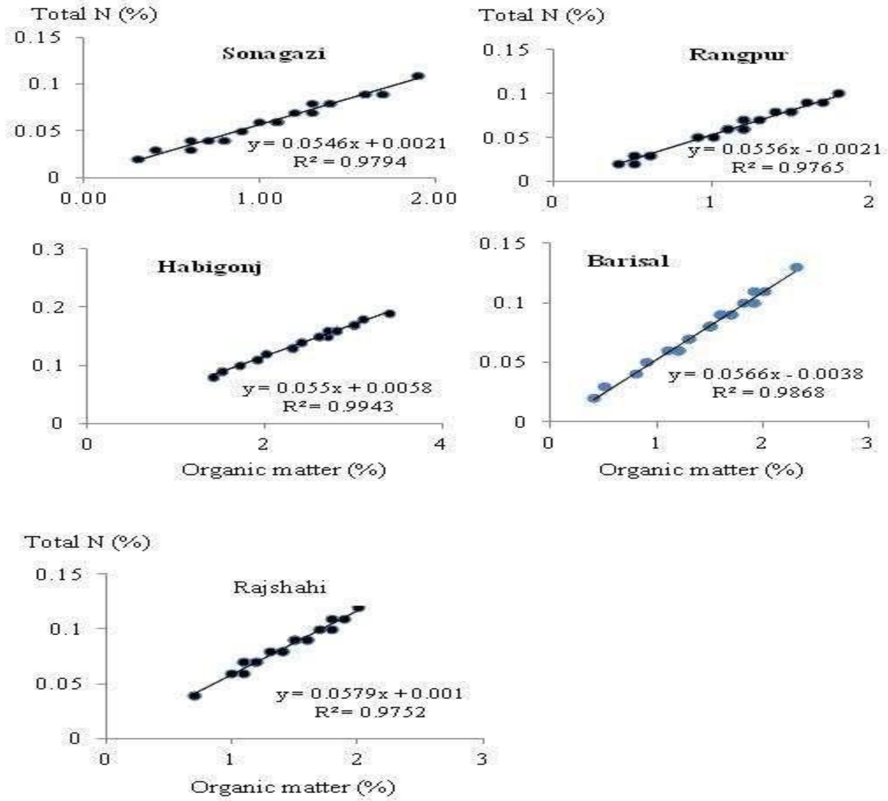

Fig. 1.