Coastal afforestation effects on soil properties at Hatiya in Bangladesh

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Abstract: An exploratory study was conducted in the coastal plantation (12- and 17-year-old Sonneratia apetala) of Char Alim and Char Piya and on their adjacent barren lands at Char Rehania and Char Nurul Islam in Hatiya of Noakhali district, in Bangladesh to determine afforestation effects on soil properties. At soil depths of 0–10, 10–30 and 30–40 cm across three different land strips viz. inland, middle and sea side in 12- and 17-year-old keora (Sonneratia apetala) plantations, soil moisture, particle density, organic matter and C, total N, pH, available P, K, Na, Ca and Mg were significantly (p≤0.05, p≤0.01, p≤0.001) higher, and soil salinity significantly (p≤0.001) lower than that in their adjacent barren lands. Soil moisture, particle density, organic matter and C, total N, pH, soil salinity, available P, K, Na, Ca and Mg of surface soil in Char Alim plantation at inland were 31.69%, 2.24 g·cm⁻³, 0.43%, 0.74%, 0.25%, 6.57, 0.09 dS·cm⁻¹, 28.06 mg·L⁻¹, 0.50 mg·L⁻¹, 11.5 mg·L⁻¹, 3.30 mg·L⁻¹ and 2.7 mmol·kg⁻¹, respectively. Their corresponding values for the same depth and land position at adjacent Char Rehania barren land were 16.69%, 1.25g·cm⁻³, 0.43%, 0.74%, 0.25%, 6.57, 0.13 dS·cm⁻¹, 13.07 mg·L⁻¹, 0.30 mg·L⁻¹, 1.4 mg·L⁻¹, 0.30 mmol·kg⁻¹ and 0.50 mg·L⁻¹, respectively. Soil moisture, particle density, organic matter and C, total N, pH, soil salinity, available P, K, Na and Mg increased from inland towards sea side in the plantations. Although soil texture did not differ in most soil depths between plantation and adjacent barren land, proportion of sand particle was significantly (p≤0.01) lower and silt particle significantly (p≤0.001) in the plantations higher than that in their adjacent barren lands. In the study, evaluation of all the parameters was also done for the other pair of lands.

Keywords: coastal afforestation; keora plantation; soil physicochemical properties; afforestation effect; soil texture; soil base cations; Sonneratia apetala; Bangladesh

Introduction

Coastal region of Bangladesh is characterized by large number of river network with huge amount of water in rainy season between July and September. Another aspect related to the hydrology of the country is the process of sedimentation. Three main rivers – the Ganges, Brahmaputra and Meghna of Bangladesh, originated in Himalayas and passing through upland countries such as India, Nepal and China, carry a tremendous amount of sediment to Bangladesh. Coastal zone is about 710 km long extending along the Bay of Bengal, comprising estuaries and offshore islands and covers 19 districts including Bagerhat, Barguna, Barisal, Bhalo, Chandpur, Chittagong, Cox’s Bazar, Feni, Gopalganj, Jessore, Jhalokati, Khulna, Lakshmipur, Narail, Noakhali, Patuakhali, Pirojpur, Satkhira and Shariatpur, out of 64 districts in the country. Natural disaster like cyclone, storm surge and flood in this areas cause massive damage of lives and properties. Plantation of coastal areas with mangrove species in Bangladesh was initiated in 1960 to mitigate disastrous effects of cyclones and storm surges, to produce timber for fuel wood and industrial use and to conserve and stabilize newly accreted lands, which ultimately transferred a large part of such lands to agriculture (Siddiqi 2001). Sundarban, the unique natural mangrove ecosystem in the world, exists in this region. Major mangrove species planted on the newly accreted lands along the coastal belt, estuaries and river banks were Sonneratia apetala, Avicennia officinalis, A. marina, A. alba, Amoora cuscullata, Bruguiera gymnorrhiza, Excoecaria agallocha, Xylocarpus mekongensis, Ceriops decandra and Nypa fruticans (Das et al. 1985). Up to 2002–2003, a total of 148 792 ha of mangrove plantations have been established through different development projects (Shamsuddin et al. 2003). Combination of natural and man-made hazards such as river-bank erosion, high concentration of arsenic in ground water, earthquake, water logging in places with salinity and climate change have adversely affected lives and livelihoods in the coastal zone and slowed down the pace of social and economic development. Mangrove reduces cyclones, enhances land maturation, stabilizes shoreline, prevents river-bank erosion, reduces soil salinity, enhances activities of heterotrophic micro organ-
isms through uplifting nutritive value of the soil, provides necessary nutrient and habitat for fish and wildlife species, and offers significant ecological services in coastal ecosystems (Rao et al. 2007). Physicochemical conditions such as salinity, oxidation status and nutrient availability directly and indirectly influence mangrove growth and reproduction, and in turn mangroves influence soil physicochemical characteristics (Hossain 2002). Coastal afforestation affects soil properties like soil texture, color, water retention capacity, pH, salinity, organic matter and total nitrogen availability (Bandyopadhyay 1995; Khan et al. 1998; Jonston et al. 1995; Pal et al. 1996; Hasan 2000; Cardona et al. 1998; Sukardjo 1978; Eswaran et al. 1993; Machiwa et al. 1998). Afforestation activities along Noakhali coast of Bangladesh with mangrove species were started from 1967. Sonneratia apetala was a pioneer species for afforestation of newly accreted land, while partially stabilized and slightly raised lands afforested with Excoecaria agallocha and Avicennia officinalis. Up to 2003–2004, about 57,433 ha of coastal lands were afforested (ICZMP 2007). Many researches were done on the effects of coastal afforestation on soil properties in global perspectives (Botao et al. 1984; Gunasekaran et al. 1992; Cardona et al. 1998; Tam et al. 1998; Matthijs et al. 1999), but in Bangladesh, only a few works done in coastal areas (Haque et al. 2000; Siddiqi 2001; Shaifullah et al. 2008). Owing to this background, the present study was an attempt to assess the effects of coastal afforestation on soil physicochemical properties in Hatiya coast in Noakhali district.

Materials and methods

Collection of soil samples

The study was conducted from October 2006 to January 2008 at two pair lands at Hatiya Island under Noakhali Coastal Forest Division in Bangladesh. First pair land was 12-year-old keora (Sonneratia apetala) plantation at Char Alim with adjacent Char Rehania barren land under Sagaria Forest Range. Second pair land was 17-year-old keora plantation at Char Piya with adjacent Char Nurul Islam barren land under Nalchira Forest Range. Char Alim plantation covered 858 ha and Char Piya 819 ha. Based on inundation depth, each of the plantations as well as barren lands was divided into three land strips: inland, middle part and sea side, each of 100 m width. In each land strip, two sample plots of 50m×50m in size were demarcated at 30 m apart. Soils were collected at three successive depths: 0–10 cm, 10–30 cm and 30–40 cm. The first depth was confined to top soil on the idea that maximum tree effect might be within 0–10 cm depth with the addition of litter as well as due to maximum root activities of planted trees and associated natural coming plant species. Effect of vegetation gradually may reduce to increased soil depth for which the second depth was wider, i.e. 10–30 cm and the third depth contained remaining portion of 40 cm core sampler. For each soil depth and each plot, 14 samples were collected randomly using core auger and mixed together to give a composite sample. Thus, 36 composite soil samples were taken from three soil depths in plantations and 36 from barren lands for analyzing the physicochemical properties in the laboratory.

Soil analysis

In the laboratory the collected moist soil samples were separated in two portions. One portion was air dried, sieved through 10-mm mesh in size to remove gravel, small stones and coarse roots. This portion was used to determine soil texture by hydrometer method, moisture content, pH (1:2 soil water ratio), soil salinity, available P (Bray and Kurtz method), available Na, K, Ca and Mg according to Hug et al. (2005) and Petersen (2002). The other portion was oven dried to determine soil organic C and organic matter by loss of ignition method (Ball 1964), particle density and total nitrogen (micro-Kjeldhal digestion method). All the data were analyzed statistically using Statistical Package SPSS.

Results and discussion

Soil texture

Although soil texture did not differ in most of the pair sites, proportion of sand particle was significantly (p≤0.01) lower and silt particle significantly (p≤0.001) higher in both the planted sites than their adjacent barren sites (Table 1). Three soil textures viz. sandy loam, loamy sand and loam were found in both the plantation sites, whereas only sandy loam texture existed in the adjacent barren char land. Sand, silt and clay contents in surface soil (0–10 cm) at Char Alim coastal plantation were 56.58%, 36.72% and 6.50% at inland; 62.08%, 33.92% and 4.00% at middle part; and 68.48%, 21.18% and 10.40% at sea side, respectively, while their corresponding values at Char Rehania barren land were 76.48%, 16.32% and 7.20% at inland; 63.28%, 24.72% and 12.00% at middle part; and 83.28%, 15.52% and 4.20% at sea side. Similar textural differences were found from soil depths of 10–30 cm and 30–40 cm between the pairs of lands. At all the three depths and land positions between other pair of sites, i.e., Char Piya plantation and Char Nurul Islam barren land showed similar differences for soil particles (Table 1). This finding indicated that coastal plantation through trapping increased silt contents on one side, and more sand particles were deposited on barren lands in absence of vegetation due to larger size and more weight of the particles on the other side. This finding was in agreement with Kabir (2005), Sukardjo (1978) and Shaifullah et al. (2008). Similar differences for soil particles under keora (Sonneratia apetala) plantation, compared to the adjacent barren land, were found by Kabir (2005) in Chittagong and by Shaifullah et al. (2008) in Lakshmipur district of Bangladesh. Sukardjo (2007) found that the mangroves had a significant role in increasing clay and silt parentage and reducing sand percentage of coastal soils in mangrove forest of Java, Indonesia.

Soil physicochemical properties

At soil depths of 0–10, 10–30 and 30–40 cm on inland, middle