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Agricultural sustainability of some low land rice soils of the Chalan Beel area under lower Atrai basin of Bangladesh

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Abstract: An investigation was carried out to study the soils of the Chalan Beel of Bangladesh with a view to evaluate the agricultural sustainability and their management options. This area is very important hydrologically, geo-morphologically and agro-climatologically in relation to its cropping pattern. The agricultural sustainability of the area particularly in respect to the soil fertility status at its present agro-climatological and hydrological conditions were studied following analysis of the soil samples collected from some selected locations. The analytical results reveal wide variations in the physico-chemical properties of the soils. Soil textural condition is very much appropriate for rice production which varied from silty clay to clay and organic matter contents varied from low to moderate status. The contents of N, P and Zn are low, whereas S, B, Cu and Fe are medium and K, Ca and Mg are high. The pH value stands near neutral which indicates the agricultural viability of the studied soils. Boro and deep water aman pattern prevails in the study area. Due to the changes in landuse, demands for nitrogen and phophorus fertilizer have increased. The soils can be high potential for the existing cropping pattern (Boro-fallow-B.Aman) if the deficiencies are taken care of through appropriate soil management. The present investigations ascertain that the study area can be economically exploited through appropriate nutrient management without any extra agro-chemical use.

Key words: Agricultural Sustainability, Chalan Beel, Lower Atrai Basin.

Introduction

Chalan Beel, the largest beel in Bangladesh comprises the low lying wetland area between the Barind tract and the Ganges river floodplains. The Chalan Beel area comprises the physiographic unit of Bangladesh that is named as “Lower Atrai basin” (FAO-UNDP, 1988). This small unit occupies a low-lying area where mixed sediments from the Atrai and Ganges rivers and from the Barind tract overlie the down-warped southern edge of the Barind tract.

The landscape north of the Atrai river is mainly smooth, but floodplain ridges and extensive basins occur to the south of the river. Seasonal flooding is deep and extensive in the Chalan Beel area of this basin remains wet throughout the year. Heavy clay soils predominate but loamy soils occur on ridge in the south and west. Chalan beel is one of the large inland depressions of marshy land and is also one of the richest wetlands areas in the northern parts of Bangladesh. It is located between $24^0 05'$ to $24^0 35'$ north latitude and 89^0 to $89^0 35'$ east longitude. The beel extends over the adjacent districts of Rajshahi, Pabna, Sirajgonj, Natore and Naogaon (Fig 1). It is the largest beel of the country and comprises a series of depressions inter-connected by various channels to form more or less one continuous cover of water in the rainy season when it covers an area of about 368 sq km (36,800 ha). A survey carried out in 1909 by the Public Works Department (PWD) about the drainage and silting up of the beel and found that the original area of the beel which was about 1,088 sq km (108,800 ha) has been reduced to about 368 sq. km (36,800 ha). The lost area had been reclaimed either for paddy cultivation or settlement (Islam, 2003). In the dry season Boro paddy is the main crop in these areas. In the rabi season, farmers can grow oilseeds, pulses, gram, lentil, kalai, khesari, pea and vegetables. Peas and wheat can also be grown together as pea to the wheat crops. Potentially, irrigated HYV Boro rice is grown on basin margins and local Boro in basin centers. Among the pulses khesari which could be grown with zero tillage and zero input in saturated soil, remain popular in the basins and become on e of the best fodders and its hey is the best feeding for the cattles in the rainy season. The area has great potentialities for increasing the production of agricultural crops and fisheries. Unfortunately, the potentialities of the area have never been explored for their optimum utilization. For this exploration, the salient features of the agro-ecological and hydrological scenario of the Chalan Beel as well as the morphological, physical and chemical characteristics of the soils will play important roles. The present study aims at evaluating the agricultural sustainability of the area with particular emphasis on the soil fertility status at its existing agro-climatic and hydrologic condition and suggesting probable soil management options.

Materials and Methods

Four representative soil series Jaonia, Halti, Taras and Digli were selected from the Chalan Beel area and a total of 8 soil samples were collected from the surface (Ap1) and subsurface (B21) of the each soil series. GPS was used to locate the position (Table 1) of the sites from where soil samples were collected for the study. Soil, land type, land use, drainage, depth of inundation data were collected from aerial photography, field survey and interviewing farmers in the study area. Soil texture studied in the field followed by standard laboratory methodology. Collected soil samples were air dried, grinded and screened through sieve. The samples were analyses for pH, organic matter, N, P, K, Ca, Mg, S, B, Cu, Zn, Fe and Mn. pH of the soils was determined by a pH meter at a soil water ratio of 1 : 2.5. Organic Carbon was determined volumetrically by wet oxidation method of Walkley and Black.

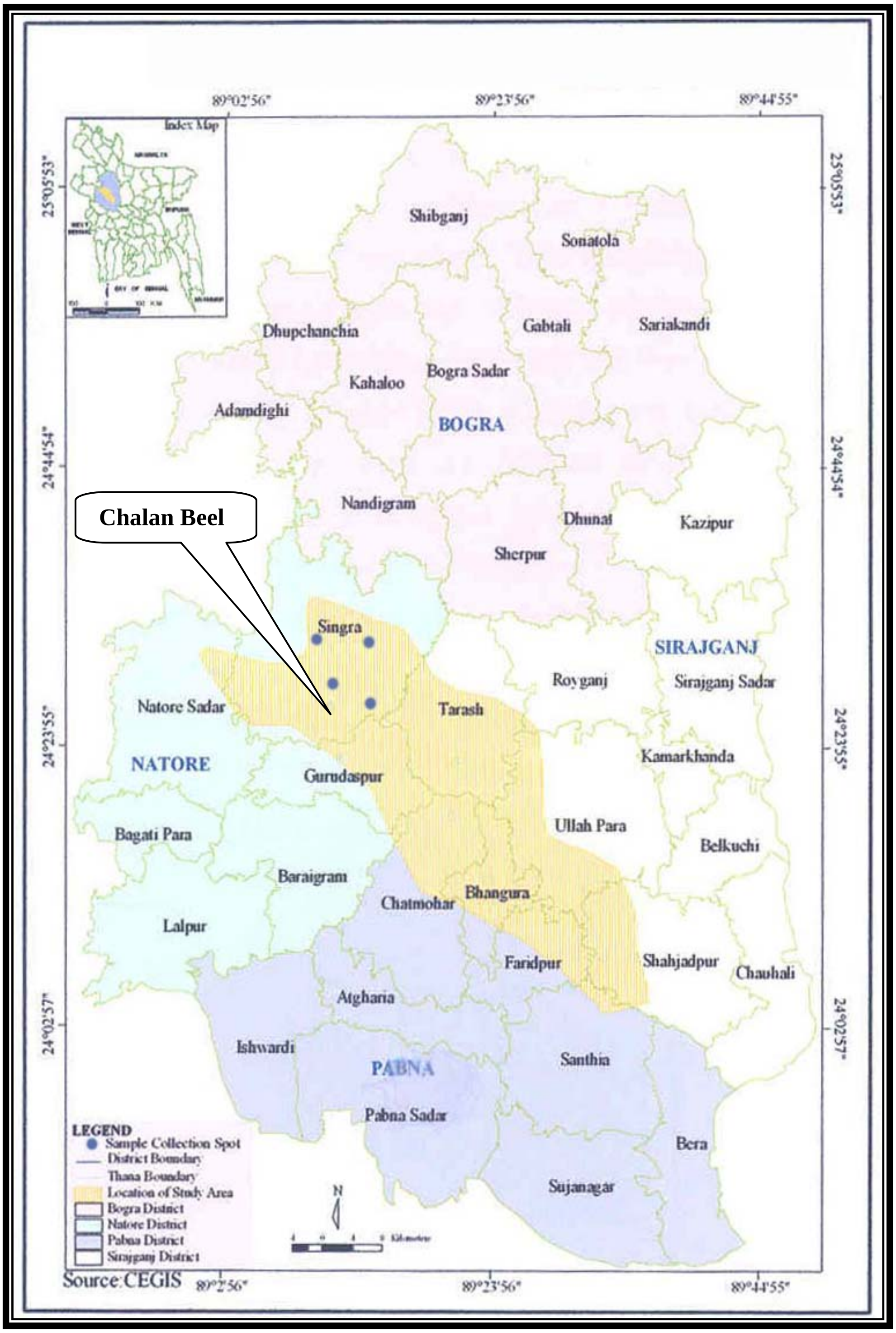

Fig. 1: Sampling location of the Chalan beel area in Bangladesh.

Total N was estimated by Kjeldahl's method and available P was determined by Olsen method, available S was determined by a spectrophotometer after developing turbidity with barium chloride (Jackson, 1996). Ammonium acetate extract was prepared and the exchangeable Ca, Mg, K were determined from the extracts (Black, 1965). Zn, Cu, Fe and Mn were extracted with DTPA solution as followed by Agro-Services International methodology. Boron was determined by Azomethine H reagent buffer solution (Hunter, 1984).

Soil descriptions: *Digli soils (Typic Endoaquepts)* are developed on the meander floodplain. They are seasonally very deeply flooded, poorly drained, grey to dark grey, clays with strong prismatic and angular blocky structure in the B horizon. They often overlie weathered Madhupur clay below about 3 feet from the surface. *Halti soils (Humi Dystrudepts)* are developed in a mixture of Atrai alluvium and Barind tract sediments. They occupy broad basins. They are seasonally deeply flooded, very poorly drained, dark grey, heavy clays with strong angular blocky , wedge shaped structure in the B horizons. They are perennially gleyed below about 2 feet from the surface. *Jaonia soils* (*Vertic Dystrudepts*) comprises seasonally very deeply flooded, poorly drained soils developed on the basins. They have dark grey, with heavey clays in the surface as well as in the subsurface. *Taras soils (Humic Dystriudepts)* are poorly drained, seasonally deeply to very deeply flooded soils developed in fine textured sediments overlying the Madhupur clay. They occur on nearly level to very gently undulating broad basins of the Barind tract. They are very dark grey heavy clays with wedge shaped peds and slickenside below about 15-20 inches.

Results and Discussion

The field textural class was silty clay in the Jaonia and Halti soil series where as Taras and Digli soil series was clay (Table 2). The best soils for agricultural crops are the silty clay and clay (ICLARM, 1988) which showed relevancy with the above textural class. Soil texture always influences the drainage conditions of the soils as well as crop performance. The drainage conditions of these soils varied from poor to very poor (Table 2).

The organic matter content of the soils varied from 0.58 to 2.40 with a mean of 1.38 percent. The pH value of the studied wetland soils ranged from 6.2 to 6.9 with a mean of 6.5 (Table 3). The decomposition and mineralization of organic matter are interrelated with successive changes in chemical reduction of the soils resulting in the lowering of redox potential and changes of pH to near neutrality (IUCN, 1993).

Total nitrogen contents in the studied soils ranged from 0.06 to 0.17 percent with a mean of 0.11 percent. The low nitrogen content of the soils may be attributed to the loss through denitrification. The denitrification was probably due to the poor drainage condition of the soils. The C/N ratio of the studied soils ranged from 5 to 9 indicating agricultural suitability of these soils. Potassium contents of the soils ranged from 0.33 to 0.64 Cmol (p^+) kg^{-1} with an average of 0.56 cmol (p^+) Kg^{-1}. Sodium contents of the soils ranges from 1.50 to 1.82 cmol $(p^+)Kg^{-1}$ with an average of 1.70 cmol (p^+) kg^{-1} (Table 3). Calcium contents ranged from 8.58 to 11.17 cmol (p^+) kg^{-1} with a mean of 9.83 cmol (p^+) kg^{-1}. Magnesium contents varied from 2.79 to 4.87 cmol (p^+) kg^{-1} with an average of 3.66 cmol (p^+) kg^{-1} and can be considered as high. The Ca/Mg ratio of the studied soils varied from 2.15 to 3.25 and the mean ratio was 2.74 (Table 3). Hence, the level of basic cations is not satisfactory as because of the non-calcareous nature of the parent materials of this area. The Mg/K ratio varied from 4.67 to 9.63 with average being 6.8. Available P contents varied from 1.90 to 4.80 μgml^{-1} with an average of 3.09 μgml^{-1} (Table 3). Here, low category of P may be due to the intensive cropping of the basin area. Slow release fertilizer can be used during land preparation or incorporated with soils prior to the transplanting of rice. Sulphur contents varied from 21.5 to 28.20 μgml^{-1} soil with an average of 24.67 μgml^{-1}. Removal or burning of the rice straw in combination with the use of sulphur free fertilizers has resulted in depletion of sulphur. It can be remedied by the supply of sulphur containing fertilizers gypsum. Boron contents varied from 0.21 to 0.34 μgml^{-1} and average 0.27 μgml^{-1}. Zinc contents varied from 0.75 to 1.4 μgml^{-1} (Table 3). Zinc deficiency was generally observed in soils with rice cultivated areas of Bangladesh (Saheed, 1984). Copper contents varied from 1.5 to 2.45 μgml^{-1} and average 1.96 μgml^{-1}. Iron content varied from 24.0 to 35.1 μgml^{-1}. Manganese contents varied from 18.3 to 25.6 μgml^{-1} and average was 21.7μgml^{-1} (Table 3). The reaction of the soil enhanced the availability of P, Mo and while depressing the toxicity of Mn, Al and Fe. Here antagonistic effect of manganese and possibly of magnesium on zinc uptake by rice plants is expected (Sakai, 1979).

To assess the agricultural potentiality of the studied soils, the nutrients were classified in to three categories as low, medium and optimum using the recommendation of (BARC, 2005). From that recommendation, the studied soils were verified (Table 4) and categorized according to their potentialities and a advisory services can be given to the farmers to use the present level of fertilizer recommendations to reduce the extra cost of fertilizers. The content of nitrogen is low and boron is medium. The application of boron and nitrogen should be advised according to its yield goal level. Probably, the denitrification process leads to the loss of nitrogen in this basin soils otherwise the other nutrients remains a balanced position for the successful growth of rice. Boro and deep water aman were introduced in the study area and irrigation facility in the dry season and shallow inundation level in the monsoon may be the main cause of such cropping pattern. There is a considerable change in landuse along with their changes in soil properties (Uddin, 2002).

Agricultural sustainability of soils depends on the organic carbon content of soils. Organic carbon is the skeletal of the soil mass and acts as a regulator of soil biochemical and physico-chemical behaviour. On the other hand, soil pH plays a very vital role in grouping the soils into different classes and has a profound influence on many factors connected with the suitability of a soil for agricultural use. It is found that soil pH stands nearly suitable for rice production. In this connection, it can be strongly advised that the studied soils will be productive in respect of their agricultural use.

Fertility level of the Chalan Beel area is moderate to optimum and is believed to be enriched by siltation during flooding. Annual siltation is a characteristic feature of these soils where from the traditional natural fertility of these soils is derived (Zaman, 1974). The land use depends on the timing and duration of flooding. With the introduction of irrigation along with HYV of rice, the cropping pattern has been changed and HYV Boro rice got preference over broadcast aman and aus as a major rice crop in the area (Zaman, 1993). Due to the changes in cropping pattern, demands for nitrogen and phophorus fertilizer have increased. There is no considerable change in organic carbon content and the pH value stands near neutral which indicates the agricultural sustainability of the studied soils. The present investigations ascertain that the Chalan Beel area can be economically exploited through appropriate nutrient management with proper cropping patterns.

Table - 1. ***Sampling location of the Chalan beel area.***

Soil series	**Duration of inundation**	**Location**				**Latitude and longitude**	**Area* (ha)**
		Village	**Union**	**Upazila**	**District**		
Digli	4 -5 Month	Rakhalgasa	Singra	Singra	Natore	24º 31′ 514″ N 89º 08′ 730″ E	17,821
Jaonia	4 -5 Month	Parshawile	Kalam	Singra	Natore	24º 29′ 049″ N 89º 09′ 495″ E	16,228
Halti	5 -6 Month	Hizoli	Italy	Singra	Natore	24º 28′ 464″ N 89º 12′ 088″ E	14,406
Taras	5 - 6 Month	Chaugram	Chaugram	Singra	Natore	24º 32′ 039″ N 89º 10′ 659″ E	44,678
Total	-	-	-	-	-	-	93,133

*Source: SRDI Staff (1965-86) and Hussain *et al*.(2003)

Table -2. ***Physical attributes of the studied Chalan beel soils.***

Soil series	**Topography**	**Drainage**	**Texture**	**Land type**	**AEZ[1]**	**Soil Tracts[2]**	**General soil type[3]**
Jaonia	Edge of beel	Poor	Silty clay	Low land	Lower Atrai basin	Gangetic Alluvium	Noncalcareous dark grey Floodplains
Halti	Broad basin	Poor	Silty clay	Lowland	Lower Atrai basin	Gangetic Alluvium	Noncalcareous dark grey Floodplains
Taras	Nearly level broad basin	Very poor	clay	Very Low land	Lower Atrai basin	Gangetic Alluvium	Noncalcareous dark grey Floodplains
Digli	Nearly level broad basin	Very poor	clay	Very Lowland	Lower Atrai basin	Gangetic Alluvium	Noncalcareous dark grey Floodplains

1= FAO – UNDP (1988) 2 Islam and Islam (1956) ; 3 = Brammer (1971)

Table 3. Chemical and Physico-chemical properties of the Chalan beel soils.

Soil series	Horizon	OM %	Total N %	C/N ratio	pH	Cmol $(p^+)Kg^{-1}$						μgml^{-1}						
						K^+	Ca^{++}	Na^+	Mg	Ca/ Mg	Mg/ K	P	S	B	Zn	Cu	Fe	Mn
Jaonia	Ap1g	1.53	0.10	9	6.8	0.33	9.07	1.50	2.79	3.25	8.45	2.90	27.30	0.32	1.13	2.45	24.0	20.5
	B21g	0.86	0.06	8	6.9	0.35	9.39	1.63	3.37	2.78	9.63	3.10	28.20	0.33	1.11	2.31	25.1	23.3
Halti	Ap1g	1.34	0.12	7	6.2	0.64	10.85	1.75	3.72	2.91	5.81	1.90	22.40	0.25	0.75	1.84	32.0	24.5
	B21g	1.06	0.09	7	6.3	0.72	10.50	1.82	4.87	2.15	6.76	2.80	23.80	0.21	0.89	1.60	30.1	25.6
Taras	Ap1g	1.92	0.13	9	6.2	0.64	11.17	1.67	3.72	3.00	5.81	2.20	21.50	0.20	1.40	2.04	29.2	21.8
	B21g	0.58	0.07	5	6.4	0.59	8.73	1.65	3.47	2.51	5.88	2.50	21.90	0.24	1.30	2.09	32.1	20.6
Digli	Ap1g	2.40	0.17	8	6.4	0.60	8.58	1.75	2.80	3.06	4.67	4.50	26.40	0.30	0.81	1.86	28.4	18.3
	B21g	1.34	0.10	8	6.8	0.60	10.31	1.82	4.57	2.25	7.62	4.80	25.90	0.31	1.10	1.50	35.1	18.9
Mean		1.38	0.11	7.63	6.5	0.56	9.83	1.70	3.66	2.74	6.80	3.09	24.67	0.27	1.06	1.96	29.5	21.7

Table 4: ***Classification of nutritional elements according to the soil properties.***

Elements	Recommended by BARC			Verified Status			Recommended fertilizer dose by BARC $(Kgha^{-1})$.	
	Low	Medium	Optimum	Low	Medium	optimum	HYG*	MYG**
N μgml^{-1}	75-76	76-150	151-300	Low			91-135	65-96
P μgml^{-1}	12-13	13-25	26-75	Low			21-30	15-21
S μgml^{-1}	12-13	13-25	26-75		Medium		15-21	11-15
B μgml^{-1}	0.20-0.21	0.21-0.50	0.51-4.00		Medium		0-0.6	0-0.3
Cu μgml^{-1}	1.0-1.1	1.1-3.0	3.11-10.0		Medium		Trace	
Feμgml^{-1}	20-21	21-40	41-200		Medium		Trace	
Mn μgml^{-1}	5.0-5.1	5.1-10.0	11-50			High	N/A	
Zn μgml^{-1}	2.0-2.1	2.1-4.0	4.1-18.0	Low			1.4 - 2.7	1.1-2.0
Ca cmol (p^+) kg^{-1}	2.0-2.1	2.1-4.0	4.11-18.0			High	N/A	
Mg cmol (p^+) kg^{-1}	0.80-0.81	0.81-2.0	2.1-9.0			High	N/A	
K cmol (p^+) kg^{-1}	0.20-0.21	0.21-0.40	0.41-1.50			High	0-25	0-18
Ca/Mg	1.2-1.3	1.3-1.7	1.8-3.1			High	N/A	
Mg/K	1.6-1.7	1.7-2.0	2.1-7.0			High	N/A	

HYG*= High yield goal; MYG**= Medium yield goal

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