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Characterization of Tal Soils of Chandan River Catchment of South-East Bihar

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ABSTRACT

Nine pedons representing Chandan river system of Banka and Bhagalpur district of south Bihar comes under Tal and upland physiography were selected for detailed investigation of the soils. In general Tal soils were light gray to dark gray in color, clay to clay loam in texture and old alluvium soils were gray to grayish yellow in color, heavy textured with wide cracking fall under the watershed of Chandan River. The upland physiography of old alluvial soils under immediate influence of the river Chandan are characterized by Yellowish brown in colour, sandy loam to sandy clay loam in texture, presence of low organic carbon, neutral reaction to slightly alkaline (pH 6.4 -7.7), very slow to slow hydraulic conductivity, lower CEC, while the soils on upland, under immediate influence of Chandan river are light olive in colour, sandy loam to sandy-clay-loam. This study was conducted to recommend soil test efficient nutrient management for improving agricultural productivity and with an objective to sustain soil health of the Chandan River System in South-East Bihar in India.

Keywords: Alfisols, CEC, Chandan River, Hydraulic Conductivity, Pedons.

INTRODUCTION

Chandan river system occupies major areas of Banka and Bhagalpur districts of South Bihar covering an area of approximately 64 thousand ha (Singh *et al.*, 2000, Diwakar and Singh, 1992 and Diwakar 1988). Soils of this region are alluvial; among the group of most fertile soils of the country. The Chandan River originates from the northern part of Deoghar hills and terminates in the river Ganga in the lower regions. The clayey texture of such soils either from the basic nature of parent materials in the mountain regions or from the sedimentation process in wide flood plains (Diwakar, 1988). The Chandan river, being the largest hill stream in south Bhagalpur, thus, this river system has a topographical variability which has contributed greater extent to soil formation in respect to soil depth, textural classes, fertility status, water retaining character and several other physical and chemical characters (Krishnamurti and Singh,1975). Present investigation has been undertaken to characterize and classify the soils of Chandan river system which is considered to be useful for improving agriculture livelihood of this area by the means of providing information about soil and its scientific management. The main factors affecting utilization of irrigation water in Chandan irrigation project are unpredictable supply of water, improper maintenance, inadequate micro-distribution system and lack of coordination (Singh *et al.*, 2000).

MATERIALS AND METHODS

This geographical location belongs to Bhagalpur and Banka districts of South Bihar and covers an area of 64,000 ha approximately. The study areas lies between 24°48′ - 25°16′ N latitudes and between $86^0$45′ - 87°4′ E longitudes situated under Chandan Command area. The minimum and maximum temperature ranges between 10.2 and 36.5^{0}C. The rainfall varies from 1135 mm to 1200 mm. The mean annual temperature (MAT) varies from 28.8 to 36.5°C. The climate of the area is sub-tropical and sub-humid with annual precipitation of around 1200 mm covering 63 to 70 per cent of the potential evapotranspiration. Natural vegetation in the study area varied considerably with altitude and aspect. The soils may remain moist in some parts of control section for more than 180

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cumulative days and dry for 60 consecutive and/or more than 90 cumulative days in a year (Table 1). Therefore, it qualifies for Ustic moisture regime and Hyperthermic temperature regime. Natural vegetation in the study varied considerably with altitude and aspect. A field investigation of the area was conducted as per procedures outlined by Anonymous (1970). Representative nine pedons (P_1 to P_9) at each site were studied for their site characteristics (upland, middle and lower areas) and morphological properties (boundary, colour (moist), texture, structure and consistence (moist/dry) (Table 1) following standard procedures and sampled depth-wise (0-100 cm) for laboratory characterization as per standard analytical techniques (Jackson, 1978). The soils were studied and described in the field for their morphology as per the soil survey manual (Soil survey staff, 1951 and 1998). Colour of the horizons was noted by using Munsell Colour Notations. The mechanical analysis of each soil layers was done by International pipette method followed (Piper, 1966) by using International textural triangle. The water stability of aggregates was workout with the wet sieving method (Tiulin, 1928).

Total porosity was calculated by determining the particle density and bulk density of soil by using the formula (Hillel, 1971). Infiltration rate (by using double ring Infiltrometers, Bertrand, 1965); and others were also determined *in situ*. Core samples were also collected for determination of hydraulic conductivity using formula of Richards, 1954 and Bulk density in lab (Biswas *et al.*, 1961). Soil pH was determined with the help of glass electrode pH meter. Electrical conductivity was determined with the help of conductivity bridge (Jackson, 1978). Free $CaCo_3$ was determined by the rapid titration method by Piper (1950). Organic carbon was determined by Walkely and Black, 1934 rapid titration method (Jackson, 1978). The total CEC of soil was determined by Schollenberger and Simon's method, 1945. Exchangeable ca^{++} and Mg^{+++} were determined by versenate titration (EDTA) method. Exchangeable Na^+ and K^+ were determined separately in the ammonium acetate leachate of the soil with the help of flame photometer (Jackson, 1978). The soils were further classified taxonomically (Soil survey staff, 1998).

RESULTS AND DISCUSSION

Soil Morphology

The data revealed (Table 2) that under moist condition, the colour of the soils from pedon I to III varied from brown to yellowish brown; pedon IV to VI, varied from dark grayish brown to light olive brown and pedon VII to IX; varied from dark yellowish brown to dark grayish brown. This difference in colour may be attributed to the organic matter, high clay content, presence of sufficient iron and manganese compounds and their hydration (Diwakar and Singh, 1992). The lower boundaries of surface horizons of these soils were clear and smooth indicated relatively well defined stratification of these soils and thus suggesting somewhat imperfect horizonation as affected solely by pedo-chemical processes, where as the lower boundaries of sub-surface horizons were generally gradual and smooth with few exceptions of the lower layers of pedon V, where they were diffused and smooth and pedon VI where they were abrupt and wavy. The structure of these soils were angular to sub-angular blocky with variable grades (moderate, week to strong) in general except in bottom layers of pedon V

Table 1: Site characteristics

Pedons	Location	Altitude (M)	Slope (%)	Natural vegetation
P_1	Khiri Pagar, 24048′N Latitude, 86048′E Longitude	70	2-3	Doob (Cynodon dactylon), Tetar (Launea pinnutifolia), Bathua (Chenopodium album), Mango (Mangifera indica)
P_2	KVK, Banka, 24055′N Latitude, 86055′E Longitude	67	1-2	Doob (Cynodon dactylon), Bathua (Chenopodium album), Babool (Acacia Arabica)
P_3	Karma, 24057′N Latitude, 86057′E Longitude	64	0-1	Doob (Cynodon dactylon), Tetar (Launea pinnutifolia), Bathua (Chenopodium album), Mango (Mangifera indica)
P_4	Baniyachak, 24048′N Latitude, 86048′E Longitude	50	0-1	Doob (Cynodon dactylon), Tetar (Launea pinnutifolia), Bathua (Chenopodium album), Mango (Mangifera indica)
P_5	Rutpai, 25003′N Latitude, 86045′E Longitude	46	0-1	Doob (Cynodon dactylon), Babool (Acacia Arabica), Neem (Melia aradirachata), Gumma (Leucas aspera), Peepal (Ficus religious)
P_6	Akarbarnagar, 25013′N Latitude, 86050′E Longitude	35	0-1	Doob (Cynodon dactylon), Gumma (Leucas aspera), Palm (Borassus flabellifer), Gorkhul (Tribulus terrestris)
P_7	Rajpur, 25014′N Latitude, 87004′E Longitude	39	0-3	Doob (cynodon dactylon), Tetar (Launea pinnutifolia), Babool (Acacia Arabica), Mango (Mangifera indica)
P_8	English Farka, 25014′N Latitude, 87004′E Longitude	37	0-1	Doob (cynodon dactylon), Babool (Acacia Arabica), Kataiya (Argemone mexicana)
P_9	Kasil Kharwa, 25016′N Latitude, 87004′E Longitude	40	0-5	Doob (Cynodon dactylon), Mango (Mangifera indica)

where it was platy (coarse). The relative distribution of cations like Ca^{2+}, Fe^{2+} etc. along with organic matter in these soils appear to be influencing the development of mostly angular blocky structures (Diwakar and Singh, 1992).The consistence of the soils were generally very hard, very sticky & plastic and very firm, under dry, wet and moist conditions with extremely hard and extremely firm in the lower layers of the pedons. All these soils have been found to be very plastic. It might be attributed to the dominance of smectite group of clay minerals along with the clayey texture of the soils.

Table 2: Morphological characteristics of soils

Pedons	Soil Depth (cm)	Boundary Boundary	Colour (Moist)	Texture	Structure	Consistence Moist/dry
P1	0-10	cs	10YR 5/3	Sandy loam	sbk	mfi
	10-21	cs	10YR 5/4	Sandy loam	sbk	mfi
	21-48	-	10YR 4/2	Sandy clay loam	sbk	mfi
	48-66	-	10YR 5/3	Sandy clay loam	sbk	mfi
	66-101	-	10YR 5/4	Sandy clay loam	sbk	mfi
P2	0-10	cs	10YR 5/3	Sandy Loam	sbk	mfi
	10-24	cs	10YR 5/4	Sandy clay loam	abk	dh, mfi
	24-36	cs	10YR 4/3	Sandy clay loam	abk	mfi
	36-52	gs	10YR 3/4	Sandy clay loam	sbk	mfi
	52-75	cs	10YR 4/3	Sandy loam	sbk	mfi
P3	0-16	cs	10YR 5/3	Sandy clay loam	m 2 abk	mfi
	16-32	cs	10YR 5/4	Sandy clay loam	abk	mvfi
	32-64	gs	10YR 3/4	Sandy clay loam	m 2 abk	mefi
	64-85	gs	10YR 3/4	Sandy clay loam	sbk	mefi
	85-130	-	10YR 5/4	Sandy clay loam	abk	mefi
P4	0-20	-	10YR 4/2	Clay	m 2 abk	mfi
	20-45	-	10YR 3/2	Clay	m 2 abk	mfi
	45-100	-	10YR 4/2	Clay	m 2 abk	mfi
	100+	-	10YR 4/2	Clay	m2abk	mfi
P5	0-20	cs	2.5Y 4/4	Clay	m 2 abk	dvh, wvs, wvp, mvfi
	20-55	gs	2.5Y 4/4	Clay	c 2 abk	deh, wvs, wvp, mefi
	55-95	gs	2.5Y 5/4	Clay	c 2 abk	deh, wvs, wv, pmefi
	95-120	ds	2.5Y 4/4	Clay	c 2 abk	deh, wvs, wvp, mefi
	120-150	-	2.5Y 4/4	Clay	c 2 pl	deh, wvs, wvp, mefi
P6	0-15	cs	2.5Y 5/2	Clay	c 3 abk	dvh, wvs, wvp, mvfi
	15-34	aw	2.5Y 4/2	Clay	m 2 abk	dvh, wvs, wvp, mvfi
	34-80	gs	2.5Y 7/4	Clay loam	f 2 sbk	dvh, wvs, wvp, mvfi
	80-115	gs	2.5Y 6/4	Clay loam	f 2 sbk	dvh, wvs, wvp, mfi
	115-150+	-	2.5Y 6/6	Clay	m 2 abk	dvh, wvs, wvp, mvfi
P7	0-30	cs	10YR 3/4	Clay	m 2 abk	dvh, wvs, wvp, mfi
	30-65	gs	10YR 3/4	Clay	m 2 abk	dvh, wvs, wvp
	65-90	cs	10YR 3/4	Clay	m 3 abk	dvh, wvs, wvp
	90-132	gs	10YR 3/3	Clay	m 3 abk	dvh, wvs, wvp
	132-172	-	10YR 3/2	Clay	m 3 abk	dvh, wvs, wvp
P8	0-20	cs	10YR 4/2	Clay	m 3 abk	dvh, wvs, wvp
	20-40	gs	10YR 4/2	Clay	m 2 3abk	dvh, wvs, wvp
	40-85	gs	10YR 4/2	Clay	f,m 2 abk	dvh, wvs, wvp, mfi
	85-125	gs	10YR 4/3	Clay	f,m 2 abk	dvh, wvs, wvp, mfi
	125-165	gs	10YR 3/2	Clay	f,m 2 abk	dvh, wvs, wvp, mfi
P9	0-20	cs	10YR 4/2	Clay	m 1 abk	dvh, wvs, wvp, mvfi
	20-54	cs	10YR 4/2	Clay	m 2 abk	dvh, wvs, wvp, mvfi
	54-100	gs	10YR 4/3	Clay	m cabk	dvh, wvs, wvp, mvfi
	100 +	-	10YR 4/2	Clay	m cabk	dvh, wvs, wvp, mvfi

Symbols as per Soil Survey Manual (Anonymous, 1970)

PHYSICAL CHARACTERISTICS

Morphological Characteristics of Soils

The particle size distribution (Table 3) indicates to have varied amount of sand and clay particles depending upon the distance of pedon from the river of Chandan. The textural classes of upper three pedons varied from sandy loam to sandy clay loam but medium to lower pedons were clay in texture. In general, the top soils (0-15 cm) were having higher sand (64.6%) as compare to the lower layers (14.17%). It might be due to canal irrigation water siltation at the nearest point and also due to sudden decrease in threshold velocity for sand particles. Similarly, the decrease in threshold velocity for silt and clay particles may result in deposition of soil separates. The movement of clay from upper layer may also be resulted in increasing the clay content in lower layers due to puddled rice cultivation. There was increase in bulk density in lower layers (Table 3) as compared to top soil. The highest bulk density in lower layers may be due to contribution of higher

Table 3: Morphological Characteristics of Soils

Pedons	Soil Depth (cm)	Particle Size Distribution (%)				Bulk Density (Mg/m^3)	Saturated Hydraulic Conductivity (cm/hr)
		Sand	Silt	Clay	Soil Texture		
P1	0-10	64.60	20.43	14.25	Sandy loam	1.50	0.260
	10-21	63.10	21.15	16.47	Sandy loam	1.52	0.270
	21-48	57.90	22.10	20.00	Sandy clay loam	1.65	0.300
	48-66	52.20	26.30	21.50	Sandy clay loam	1.64	0.280
	66-101	50.15	27.60	22.25	Sandy clay loam	1.64	0.240
P2	0-10	60.15	20.55	19.30	Sandy Loam	1.50	0.203
	10-24	56.30	21.15	22.55	Sandy clay loam	1.54	0.168
	24-36	54.10	19.40	26.50	Sandy clay loam	1.60	0.152
	36-52	60.45	12.40	27.15	Sandy clay loam	1.64	0.145
	52-75	60.10	20.40	19.50	Sandy loam	1.52	0.298
P3	0-16	60.15	20.35	19.50	Sandy clay loam	1.32	0.165
	16-32	57.10	22.15	20.75	Sandy clay loam	1.48	0.145
	32-64	53.15	24.30	22.55	Sandy clay loam	1.45	0.142
	64-85	49.15	27.30	23.55	Sandy clay loam	1.43	0.131
	85-130	45.10	27.40	27.50	Sandy clay loam	1.45	0.152
P4	0-20	22.32	24.60	53.08	Clay	1.49	0.090
	20-45	21.25	23.40	55.35	Clay	1.51	0.081
	45-100	21.10	20.25	58.65	Clay	1.53	0.080
	100+	22.10	20.55	57.25	Clay	1.45	0.080
P5	0-20	23.50	25.70	50.80	Clay	1.30	0.131
	20-55	23.50	24.10	52.40	Clay	1.41	0.086
	55-95	23.00	23.80	53.20	Clay	1.42	0.072
	95-120	23.35	24.80	51.85	Clay	1.53	0.062
	120-150	22.20	23.70	54.10	Clay	1.54	0.052
P6	0-15	25.40	22..85	51.75	Clay	1.45	0.088
	15-34	27.10	22.40	50.50	Clay	1.45	0.072
	34-80	4.60	29.40	30.00	Clay loam	1.44	0.085
	80-115	42.40	28.50	29.10	Clay loam	1.41	0.080
	115-150	33.30	24.40	42.30	Clay	1.52	0.062
P7	0-30	17.84	31.06	51.10	Clay	1.31	0.044
	30-65	16.69	28.65	54.66	Clay	1.33	0.041
	65-90	16.10	28.30	55.60	Clay	1.34	0.039
	90-132	15.90	27.82	56.28	Clay	1.40	0.035
	132-172	15.15	27.05	57.80	Clay	1.42	0.030
P8	0-20	15.32	30.06	54.62	Clay	1.30	0.031
	20-40	15.22	29.19	55.59	Clay	1.31	0.041
	40-85	15.15	27.52	57.33	Clay	1.31	0.045
	85-125	14.97	25.93	59.10	Clay	1.32	0.030
	125-165	14.71	25.69	59.60	Clay	1.30	0.035
P9	0-20	16.75	30.50	51.75	Clay	1.31	0.042
	20-54	16.45	29.14	54.41	Clay	1.34	0.034
	54-100	16.10	28.60	55.30	Clay	1.40	0.031
	100+	15.60	27.20	57.20	Clay	1.42	0.024

pH and development of sodicity in lower layers of some of the profiles. Similar result was observed by Pandey and Pathak (1975). The values of saturated hydraulic conductivity (Table 3) were in the range of very slow to slow hydraulic conductivity. It seems to be due to high bulk density, low organic matter, high pH and high clay content in lower layers. Similar result was observed by Nayer and Shukla (1943 a, b & c).

Water stable aggregates

Perusal of the data presented in table 4 revealed that there was an increase in total aggregates with depth. The depth wise variation of micro and macro aggregates was differential. The micro aggregate generally decreased whereas macro aggregates increased with soil depth. This might be accentuated that an extra pressure generated due to fracture along with the wetting front in the lower layers of the pedons, was conductive to the generation of macro-aggregate at fastest rate. The depth wise increasing of macro-aggregate was also reported by Kauraw *et al*, (1983) and Diwakar and Singh (1992). Taking all the nine pedons into consideration, it seemed that clay mineral played an important role in the aggregation. As

Table 4: Size of water stable aggregates of soils

Pedons	Soil Depth (cm)	Macro-aggregates (>0.25mm) (%)	Micro-aggregates (<0.25 mm) (%)	Total aggregates (%)	Total Pore space (%)
P1	0-10	24.72	18.92	43.64	43.12
	10-21	23.98	24.78	48.76	42.20
	21-48	25.22	29.48	54.70	37.26
	48-66	27.92	27.68	55.60	37.16
	66-101	30.65	27.34	57.99	36.92
P2	0-10	34.10	21.10	55.20	42.30
	10-24	34.24	19.32	53.56	40.99
	24-36	38.58	19.38	57.96	38.69
	36-52	32.84	19.44	52.28	37.64
	52-75	30.86	21.26	52.12	42.20
P3	0-16	21.18	16.08	37.26	50.18
	16-32	22.80	19.44	42.24	44.36
	32-64	26.85	21.25	48.10	45.48
	64-85	28.90	22.30	51.20	46.44
	85-130	30.30	26.35	56.65	45.69
P4	0-20	35.20	32.20	67.40	43.77
	20-45	32.34	27.52	59.86	43.23
	45-100	32.92	27.26	60.18	42.48
	100+	30.42	21.04	51.46	45.28
P5	0-20	33.58	19.32	52.90	50.94
	20-55	36.28	16.84	53.12	46.79
	55-95	27.36	30.12	57.48	46.82
	95-120	25.34	33.52	58.86	41.82
	120-150	28.25	31.94	60.19	41.44
P6	0-15	32.38	27.60	59.98	44.86
	15-34	30.20	21.16	51.36	45.07
	34-80	24.88	27.22	52.10	45.45
	80-115	26.62	25.04	51.66	46.79
	115-150+	30.60	29.50	60.10	42.20
P7	0-30	39.70	26.81	66.51	50.56
	30-65	36.20	20.68	56.88	50.00
	65-90	40.15	20.66	60.81	49.62
	90-132	33.90	27.16	61.06	47.56
	132-172	43.80	24.16	67.96	46.81
P8	0-20	38.90	31.00	69.90	50.94
	20-40	41.03	38.28	79.31	50.75
	40-85	40.75	28.13	68.88	50.75
	85-125	42.97	25.30	68.27	50.56
	125-165	42.78	26.72	69.50	51.31
P9	0-20	40.49	26.21	66.70	50.56
	20-54	43.77	24.45	68.22	49.62
	54-100	45.44	25.33	70.77	47.56
	100+	44.13	35.96	80.09	46.81

there was a positive significantly positive correlation of clay with total aggregate and macro- aggregate. This also confirms the findings of Krishnamurti and Singh (1975). It is evident that total porosity of top layer i.e. 0-15 cm in all profiles were having higher values (50.94%) as compared to lower layer (36.92%) of the profiles (Table 4). This might be due to the contribution of higher amount of organic carbon and organic matter content in the top layer as compared to lower layers. With the increase in depth of soil, the porosity will decrease because of compactness in the sub-soil. This may also be due to higher organic matter content of the surface soil which might have resulted in the higher rooting density, further their decay in rice-wheat cropping system in surface soil. The higher amount of per cent pore space in lower layer may be due to higher clay content of soil in lower layers. The lowest values of per cent of pore space in lower soil layers might be due to lower organic carbon content and higher clay content. Similar results were obtained by Bertrand, 1965.

Infiltration Rates of different pedon

There was a slight variation in final infiltration rate (Table 5) but all were in under low to very low class of infiltration rate which may impose salinity hazardous in due course of time. There was a tendency of compaction development in sub-soil layers.

Chemical Characteristics

The data (Table 6) revealed that the electrical conductivity varying between 0.03 to 0.17 dS/m indicated non-hazardous concentration of soluble soils in all the profiles. The soils have free $CaCo_3$ varying between 0.71 and 6.8 per cent. The medium to low organic carbon of these soils (0.64 to 0.15%) may be attributed to the oxidation loss of organic matter due to tropical climate condition (Singh *et al*., 2000). The soils are slightly acidic to neutral (pH 6.4 to 7.7) in reaction might be due to leaching of bases under well drained conditions. The higher pH in upland physiography may be due to the accumulation of soluble salts and sodium in saucer-shaped physiography under the influence of compact and hard layers formed due to high clay content. There is negative correlation with pH and organic carbon content of these soils.

Exchange properties of poils

The dominance of clay mineral being smectite appears to be responsible for higher CEC. The clay of these soils has positively significant correlation with macro, total, CEC, Ca^{2+}, Mg^{2+}, Na^{+}; whereas organic carbon has positive significant influence with Ca^{2+},Mg^{2+}, Na^{+} & CEC and negatively correlation with pH (Table 7). These results were in conformity with the findings of Diwakar (1988) in fine textured soils of Bihar. Ram and Singh (1975) also reported positive correlation of exchangeable Ca^{2+} with the clay in the soils of Uttar Pradesh. In general, soils of lower and medium pedons were rich in bases (Ca^{2+} and Mg^{2+}) whereas soils of upper pedons were comparatably poor in bases. Soils of lower pedons were found to be high CEC and dominating in 2:1 type of clay minerals. Perusal of the data (Table 7) revealed that these soils showed high base saturation ranging from 81.32% to 97.93 % indicating them to be highly base saturated. As these soils received much of water as run-off from the vast areas and enriched with the basic ions. Calcium was the most dominating cations followed by magnesium, sodium and potassium. The exchangeable Na^{+} is within the non-hazardous range (0.20 to 1.64 c mol (p^{+})/kg). It is interesting to note that exchangeable K^{+} is relatively low. This clearly indicates that most of the potassium is present in the form of primary as well as secondary minerals leading only a small fraction on the exchangeable site. The CEC varying between 11.30 to 52.22 c mol (p^{+})/kg (Table 7) ranging medium to high in CEC. The higher values of CEC in upper layers might be due to high organic matter content and soil reaction.

Soil Classification

Based on morphological, physical and chemical properties, the

Table 5: Infiltration Rates of different pedon

Time interval (Minutes)	Cumulative time (Minutes)	Infiltration Rates (cm/hr)								
5	5	Pedon I	Pedon II	edon III	Pedon IV	Pedon V	Pedon VI	Pedon VII	Pedon VIII	Pedon IX
		5.4	4.2	5.4	5.4	4.2	4.2	6.0	5.5	5.4
10	15	2.4	2.1	2.4	2.1	1.8	1.8	2.4	2.2	2.4
15	30	2.0	1.8	2.0	2.0	1.6	1.6	2.0	2.1	2.0
15	45	1.6	1.6	1.4	1.4	1.4	1.4	1.6	1.5	1.6
30	75	1.0	1.2	1.2	1.2	1.1	1.2	1.1	1.3	1.2
30	105	0.6	0.9	0.9	1.0	0.9	0.8	0.9	1.0	0.9
60	165	0.4	0.6	0.5	0.6	0.6	0.4	0.5	0.7	0.5
60	225	0.3	0.4	0.4	0.5	0.3	0.3	0.3	0.4	0.3
60	285	0.3	0.3	0.3	0.3	0.25	0.2	0.2	0.3	0.25
60	345	0.25	0.25	0.3	0.2	0.2	0.2	0.15	0.2	0.2
60	405	0.25	0.23	0.28	0.13	0.12	0.13	0.11	0.20	0.14

Table 6: Some Chemical characteristics of soils

Pedons	Soil Depth (cm)	pH	EC (dS/m)	Organic carbon (g/kg)	Free CaCO3 (%)
P1	0-10	6.6	0.16	0.55	0.80
	10-21	7.4	0.13	0.29	0.78
	21-48	7.2	0.17	0.37	0.78
	48-66	6.8	0.13	0.31	0.77
	66-101	7.2	0.11	0.25	0.77
P2	0-10	7.4	0.15	0.64	0.74
	10-24	7.0	0.13	0.56	0.74
	24-36	7.2	0.11	0.32	0.73
	36-52	7.6	0.09	0.23	0.72
	52-75	7.7	0.09	0.59	0.71
P3	0-16	7.4	0.12	0.55	0.75
	16-32	7.4	0.13	0.41	0.73
	32-64	7.5	0.15	0.42	0.73
	64-85	7.6	0.14	0.35	0.72
	85-130	7.7	0.16	0.40	0.72
P4	0-20	6.6	0.13	0.63	1.60
	20-45	7.0	0.11	0.51	1.59
	45-100	7.2	0.09	0.34	1.59
	100+	7.2	0.07	0.41	1.58
P5	0-20	7.4	0.10	0.60	1.60
	20-55	7.6	0.09	0.39	1.58
	55-95	7.5	0.09	0.42	1.56
	95-120	7.5	0.11	0.39	1.55
	120-150	7.6	0.12	0.37	1.52
P6	0-15	7.4	0.10	0.56	1.60
	15-34	7.6	0.10	0.36	1.60
	34-80	7.7	0.12	0.20	1.58
	80-115	7.5	0.14	0.17	1.56
	115-150+	7.6	0.15	0.15	1.54
P7	0-30	7.0	0.05	0.68	3.10
	30-65	7.1	0.05	0.42	2.68
	65-90	7.1	0.05	0.41	2.74
	90-132	7.1	0.04	0.41	2.58
	132-172	7.3	0.03	0.40	2.57
P8	0-20	7.5	0.13	0.70	6.82
	20-40	7.5	0.13	0.45	5.76
	40-85	7.5	0.11	0.44	5.72
	85-125	7.6	0.11	0.44	4.64
	125-165	7.6	0.11	0.38	4.68
P9	0-20	7.3	0.11	0.58	3.10
	20-54	7.3	0.11	0.46	2.59
	54-100	7.4	0.09	0.43	2.58
	100+	7.4	0.07	0.41	2.58

Pedons have been classified into different taxa and presented in Table 8.These soils have been classified as order alfisols (Pedons I to IV), udalfs at suborder level due to udic moisture regime, hapludalfs at great group level and typic hapludalfs at sub group level, argillic horizon, ochric epipedon, have clay cutans pedons V to VI , by virtue of having cambic horizon were grouped under order inceptisol, ochrepts at sub-order level and ustochrepts at great group level because of ustic moisture regime but vertic (Pedon V) and udic (Pedon VI) at sub group level respectively. By virtue of the presence of slickensides, wedge-shaped aggregates >30% clay content and cracks, Pedons VII to IX were grouped under vertisols, usterts sub order, chromusterts at great group but typic(Pedons VII to IX) and udic (Pedons VIII) sub groups respectively with very fine textural family class (Sawhney and Sehgal,1989). Pedons I to III were found to be dominant in illite and Pedons IV to IX were found to be dominant in smectitic mineralogy.

Table 7: Exchange Properties of soils

Pedons	Soil Depth (cm)	CEC (c mol (p⁺)/kg)	Exchangeable cations (c mol (p⁺)/kg)				Base Saturation (%)
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	
P_1	0-10	20.70	14.90	2.80	0.40	0.20	88.39
	10-21	24.50	16.40	3.60	0.60	0.18	84.79
	21-48	27.60	18.40	3.65	0.60	0.17	82.66
	48-66	26.70	17.30	3.70	0.55	0.17	81.32
	66-101	26.50	17.30	3.90	0.65	0.15	83.00
P_2	0-10	17.50	12.40	2.60	0.20	0.10	87.41
	10-24	15.30	11.30	2.10	0.30	0.10	90.18
	24-36	14.10	11.30	1.90	0.32	0.10	95.15
	36-52	12.60	08.00	1.80	0.32	0.16	81.56
	52-75	13.60	10.60	1.40	0.30	0.15	91.53
P_3	0-16	11.43	11.43	2.10	0.22	0.25	91.30
	16-32	12.49	12.49	2.72	0.42	0.29	88.22
	32-64	13.06	13.06	2.96	0.45	0.25	84.98
	64-85	12.08	12.08	2.70	0.50	0.22	92.95
	85-130	11.30	11.30	2.44	0.53	0.20	94.12
P_4	0-20	26.92	26.92	12.80	1.13	0.44	86.86
	20-45	24.40	24.40	13.92	1.22	0.36	87.90
	45-100	21.45	21.45	15.62	1.09	0.32	87.28
	100+	20.45	20.45	14.65	1.35	0.28	83.83
P_5	0-20	20.65	20.65	11.62	0.88	0.46	90.87
	20-55	18.80	18.80	10.44	0.96	0.38	92.71
	55-95	19.10	19.10	11.02	0.82	0.40	90.88
	95-120	19.10	19.10	9.84	0.90	0.40	87.81
	120-150	16.80	16.80	9.26	0.97	0.39	85.63
P_6	0-15	43.65	26.90	12.20	0.97	0.45	92.81
	15-34	41.63	24.28	12.78	0.96	0.38	92.22
	34-80	26.63	14.76	9.30	0.82	0.35	94.72
	80-115	27.54	15.75	8.70	0.88	0.33	93.15
	115-150+	29.54	17.18	9.30	0.95	0.29	93.82
P_7	0-30	45.44	27.90	12.86	0.71	0.90	93.23
	30-65	47.52	26.45	15.60	1.12	0.94	92.80
	65-90	46.65	26.44	15.68	1.12	0.90	94.60
	90-132	44.16	26.45	13.91	1.08	0.81	95.65
	132-172	46.75	26.45	14.70	1.35	0.79	92.56
P_8	0-20	50.45	36.40	10.64	1.51	0.86	97.93
	20-40	52.22	34.91	13.24	1.51	0.83	94.75
	40-85	51.45	33.40	13.20	1.64	0.81	95.31
	85-125	50.10	32.10	12.60	1.30	0.78	93.35
	125-165	46.75	32.88	12.60	1.64	0.77	95.56
P_9	0-20	49.47	27.67	12.67	0.73	0.81	84.64
	20-54	48.54	26.43	15.63	1.07	0.77	90.42
	54-100	48.66	26.43	15.70	1.11	0.72	90.32
	100+	46.80	26.33	13.91	1.32	0.74	90.38

CONCLUSION

Above mentioned soil characters were due to predominant influence of Chandan river system and landscape which modified basic soil characters as a consequent it influenced water regime and vegetation of these areas. Modification gradually and continuously occurring in the Chandan river system made the whole catchment area a vibrant soil system. Keeping in the view of above study, we may suggest some economically viable crops and cropping system for the above river system. Based on the soil test efficient nutrient management for improving the economic profitability and soil health is the main objective behind this soil profile study of the Chandan River System of South-East Bihar.

Table 8: Classification of soils of different Pedons

Pedons	Phygiography	Order	Sub order	Great group	Sub-group	Family
Pedon I	Medium upland	Alfisols	Udalfs	Hapludalfs	Typic Hapludalfs	Fine, mixed, hyperthermic, typic apludalfs
Pedon II	Medium lowland	Alfisols	Udalfs	Hapludalfs	Typic Hapludalfs	Fine, mixed, hyperthermic, typic apludalfs
Pedon III	Medium lowland	Alfisols	Udalfs	Hapludalfs	Typic Hapludalfs	Fine, mixed, hyperthermic, typic apludalfs
Pedon IV	Medium lowland	Alfisols	Udalfs	Hapludalfs	Typic Hapludalfs	Fine, mixed, hyperthermic, typic apludalfs
Pedon V	Medium upland	Inceptisols	Ochrepts	Ustochrepts	Vertic Ustochrepts	Fine, mixed, hyperthermic, Vertic Ustochrepts
Pedon VI	Medium upland	Inceptisols	Ochrepts	Ustochrepts	Udic Ustochrepts	Fine, mixed, hyperthermic, Udic Ustochrepts
Pedon VII	Medium upland	Vertisols	Usterts	Chromusterts	Typic Chromusterts	Very Fine, montmorillonite hyperthermic, typic Chromusterts
Pedon VIII	Medium lowland	Vertisols	Usterts	Chromusterts	Udic Chromusterts	Very Fine, montmorillonite hyperthermic, Udic Chromusterts
Pedon IX	Medium upland	Vertisols	Usterts	Chromusterts	Typic Chromusterts	Fine, hyperthermic, typic Chromusterts

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