Short communication

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Characterization of rice growing soils: A case study in Gerua farm, Assam

UTPAL BARUAH[1], T.H.DAS[2], B.P.BHASKAR[3] AND DIPAK SARKAR[3]

[1]*National Bureau of Soil Survey and Land Use Planning, NER Centre, Jorhat-785 004, India*
[2]*National Bureau of Soil Survey and Land Use Planning, Regional Centre, Kolkata-700 091, India*
[3]*National Bureau of Soil Survey and Land Use Planning, Nagpur-440 033, India*

The flood prone rice growing soils in Assam occupy 4.93 lakh hectares (ha) accounting for 17.5 % of net sown area (Statistical Hand Book 2011). The rainfed lowland rice is most often defined by the characteristics of surface flooding within 50 cm with mottles and chroma 2 or less at 50 to 75 cm (Schwertmann and Fanning 1976; IRRI 1984). In Assam, the rice grown soils in the alluvial plains of Brahmaputra and Barak valleys in Assam have been studied by various workers (Chakravarty *et al.* 1978; Chakravarty and Baruah 1984; Sen *et al*. 1997; Singh and Chamuah 1991; Walia and Chamuah, 1992). These paddy soils in the region were classified in subgroups of Entisols and Inceptisols with horizon differentiation, high water table and low permeability (Sen *et al.* 1995, 2003 and Vadivelu *et al.* 2003). The traditional paddy soils of low land regions of Gerua farm, Assam were studied with respect to morphology, physical, chemical characteristics and taxonomy.

The low land rice farm, Gerua having an area of 12.5 ha was selected for the study in Rice Research Station situated 35 km from Guwahati (26°11' N latitude and 90°47'E longitude). The soils of the farm area have been developed from an alluvium brought down by the mighty river Brahmaputra. Landforms in the farm situation were divided into highlands (2.71 ha, 21.68 % of total area), medium lands dominant with 3.52 ha (28.16% area) and lowlands of 1.15 ha (9.1% of area). The climate is humid subtropical with three seasons *viz.* summer (March to June), rainy (July to October) and winter (November to February). The mean annual maximum and minimum temperature are 25.4°C and 20.3°C respectively. The difference between mean summer soil temperature (MSST) and mean winter soil temperature (MWST) is more than 5°C and thus qualifies for hyperthermic soil temperature regime. The average annual rainfall of 1865 mm with 121 number of rainy days make soil moisture regime as 'aquic in lowlands (Soil Survey Staff 2006). Rice is cultivated in three main seasons *viz*. ahu (February-March to June-July), sali (June-July to November-December) and boro (November-December to April-May) as field trials with an objective to develop suitable high yielding cold tolerance boro variety; resistant to flood prone variety and high yielding varieties of rice for sustainable high productivity in the farm.

The detailed soil survey of Gerua farm was done on 1:2000 scale as outlined in the soil survey manual (IARI 1970). Three soils were selected depending upon the change in topography from natural levees (Gerua A and B) to back swamp (Gerua C) and the soil profiles were examined for detailed morphological properties (Schoeneberger *et al.* 2012) and classification (Soil Survey Staff 2006). Horizon-wise soil samples were collected and air dried fine earth fraction was used for the laboratory analysis as described by Black *et al.* (1965) and Sarma *et al.* (1987). The particle size analysis was done as per international pipette method with sodium hexameta phosphate as dispersion agent after removal of organic carbon by hydrogen peroxide treatment Organic carbon was determined by wet combustion (Walkey-Black procedure), pH was measured in 1:2.5 soil/water suspension using pH meter. Exchangeable bases were extracted by 1M NH_4OAc (pH 7.0). The Cation Exchange Capacity (CEC) was determined with distillation method.

The poorly drained soils on highlands (Gerua-A) have dark grey to greyish brown with silt loam to silty clay clay textures (P1) whereas midland soils (Gerua B) have dark grey (2.5Y4/1) to very dark grey(10YR3/1; 2.5Y3/1) with alternate textural variation of silty clay loam to silt loam with brown mottles with in 50 cm (Table 1). The silt loam to silty clay loam textures in A and B horizons with massive to subangular blocky structures in P1 and P2 have surface gley features whereas silt loam textures in soils of lowlands with massive to blocky structures due to puddling and subsequent drying of paddy soils (Wilding and Rehage 1985). The low land soils (Gerua-C) have dark grey (2.5Y4/1) to grey (2.5Y5/1) and greyish brown (10YR5/2) to dark grey(10YR4/1)/ dark greyish brow (10YR4/2) with silt loam textures with distinct light yellowish brown (2.5Y6/4) to light olive brown (2.5Y5/4) mottles within 31 to 78 cm. The rice soils under study exhibits grey to light olive brown matrix, chroma of 2 and value 4 or more indicating loss of iron (Walia and Chamuah 1992, Bhaskar and Sarkar 2013).

These soils are slightly acid to mildly alkaline (pH of 6.1 to 7.6) with fine silty particle size (more with than 60 per cent of silt and 25 to 32 per cent of clay in control section and stratified with inflections of silt (65 to 70 %, Table 2) and clay distribution (17 to 30 %). These soils have more than 1.2 times more clay in argillic horizons and an organic carbon more than 1 % in Ap horizons but decreases to 0.2 to 0.4 % with depth. Ca being dominant cation on exchangeable complex have weighted mean of 4.4 (Gerua-C) to 6.9cmol/kg (Gerua-B) with its maximum in B horizons (4 to 7.6 cmol/kg) as compared to Ap horizons (2.2 to 4.5 cmol/kg). The distribution of exchangeable Mg and Na is irregular with its contents varying from 0.2 to 1 cmol/kg whereas exchangeable K contents are low (<0.1 cmol/kg) in most of the horizons. These soils have CEC of 9.7 to 16.2 cmol/kg with its maximum in B horizons and base saturation more than 60 % in P1 and P2. These soils have Ca to Mg ratio of 5 to 11.7 with high values in B horizons and are in the normal range of productive soils (Landon 1991). These soils have more than 50 % of exchangeable complex dominated by Ca (Table 3) followed by Mg˜Na (7 to 24 %). The low K saturation in majority of horizons below the critical limit of 2.84 % (Cate and Nelson 1971) and an apparent CEC of 40 to 60 % indicate the dominance of illite/chloritic minerals with appreciable change in surface characteristics of clay under paddy cultivation (Dey 1999)

Table 1. Morphological properties of low land rice growing soils

Depth (cm)	Horizon	Matrix Colour(M)	Mottles	Texture	Structure	Consistence	Boundary	pH
Gerua-A								
0-22	Ap	10YR4/1		sil	massive	s,p	cs	6.1
22-49	AB	10YR4/1		sil	m2sbk	s,p	gs	7.5
49-60	Bt1	10YR5/2		sil	m2sbk	vs,p	gs	7.3
60-108	Bt2	10YR5/2		sicl	m3sbk	vs,p	gs	7.4
108-150	Bt3	10YR5/1		sil	f1bk	vs,p		7.3
Gerua-B								
0-18	Ap	2.5Y4/1		sicl	massive	ss,sp	cs	6.4
18-30	AB	2.5Y4/1		sil	m2sbk	s,p	gs	7.4
30-49	Bt1	10YR3/1	7.5YR4/3 f2d	sicl	m2sbk	s,p	gs	7.4
49-100	Btg2	2.5Y3/1		sil	m2sbk	s,p		7.4
Gerua-C								
0-16	Ap	2.5Y4/1		sil	m1sbk	so,sp	cs	6.1
16-31	AB	2.5Y5/1		sil	m2sbk	ss,sp	gs	7.4
31-53	Bt1	10YR5/2	2.5Y6/4 f1d	sil	m2sbk	s,sp	gs	7.5
53-78	Bt2	10YR4/1	2.5Y5/4 f2p	sil	m2sbk	s,p	gw	7.6
78-110	Bt3	10YR4/2		sil	m2sbk	s,p	-	7.4

Earlier, the paddy soils with argillic B horizons in Brahmaputra valley were classified in the subgroups of Alfisols (Dey and Sehgal 1997). The differentiating characteristics (such as reduced matrix and redox depletion zones) to group under the suborder of Aqualfs. These soils have aquic moisture regime in normal years as reflected in chroma of 1 or less in majority of soil horizons with in 50 cm of mineral surface but have 22 cm thick Umbric epipedon (base saturation less than 50%) and an organic carbon content of 1.2 % in Gerua A soil. This soil shows the evidence of clay illuviation in Bt layers with clay increase of 1.28 to 1.38 time more to Ap layer. These soils have particle size class of fine silty at family level with silt more than 60 % and clay of 18 to 35%. This soil had endoaquic conditions with matrix of 10 YR hue , value of 3 or more and chroma of 2 with in 75 cm below mineral soil surface to classify as Udollic Endoaqualfs. The Gerua B soil had 18 cm thick mollic epipedon with base saturation more than 50 % in Ap horizon, 50 % or more redox depletions with chroma of 2 or less in the matrix and an organic carbon of 1.1 per cent. This soil shows an increase in clay by 1.24 to 1.49 times more than eluvial AB horizon. This soil is classified as Mollic Endoaqualfs at subgroup level. Gerua –C soil had 16 cm thick Ap horizon (Umbric with less than 50 % base saturation) and an organic carbon of 1.2 %. It shows the evidence 1.2 times more clay illuviation over eluvial horizon and have 10YR hues with colour value of 3 or more and chroma of 2 or less within 75 cm of mineral surface to classify as Aeric Endoaqualfs. The characteristics of these alluvial soils are so ambiguous that emphasize on critical appraisal of soil horizons for correlation and then to classify them in appropriate suborders. These soils require fertilizer supplementation for sustainable agricultural production when transformed into intensive rice cultivation for boosting food production and the productivity

Table 2. Physico-chemical characteristics of soils

Depth (cm)	Horizon	Particle size distribution (<2mm, %)			Sand /silt	O.C. (%)	Exchangeable bases(cmol(p+)kg $^{-1}$				Sum of bases	CEC	Base saturation (%)
		Sand	Silt	Clay			Ca	Mg	Na	K	(cmol(p+)kg $^{-1}$		
Gerua-A													
0-22	Ap	4.9	74.1	21.0	0.067	1.2	2.2	1.0	1.0	0.1	4.3	10.2	42
22-49	AB	4.3	75.2	20.5	0.057	0.6	5.1	1.5	0.6	0.9	7.3	11.3	65
49-60	Bt1	2.1	68.9	29.0	0.031	0.3	6.5	1.4	1.0	0.1	9.0	13.7	65
60-108	Bt2	3.7	69.3	27.0	0.053	0.3	8.2	0.7	1.2	0.1	10.2	14.8	69
108-150	Bt3	3.6	73.4	23.0	0.049	0.5	5.7	0.9	0.8	0.1	7.5	11.6	64
(weighted mean)		3.8	72.3	23.9	0.053	0.5	5.9	1.0	0.9	0.2	7.9	12.5	63
Gerua-B													
0-18	Ap	2.4	69.6	28.0	0.034	1.1	4.5	0.6	0.5	0.1	5.7	10.2	56
18-30	AB	3.3	74.2	22.5	0.044	0.4	6.7	1.0	1.0	0.1	8.0	11.9	67
30-49	Bt1	1.8	69.7	28.5	0.026	0.4	7.3	1.1	1.1	0.1	9.0	13.7	66
49--100	Btg2	1.5	65.0	33.5	0.023	0.4	7.6	1.0	1.0	0.1	9.7	16.2	60
(weighted mean)		1.9	67.8	30.2	0.028	0.5	6.9	1.0	0.9	0.1	8.6	14.1	61
Gerua-C													
0-16	Ap	6.5	68.0	25.5	0.096	1.2	2.2	0.9	1.2	0.4	4.8	11.4	42
16-31	AB	6.5	76.2	17.3	0.085	0.9	4.1	1.0	0.9	0.7	6.8	10.9	62
31-53	Bt1	3.0	62.8	34.2	0.048	0.7	4.0	1.4	0.7	0.5	6.6	12.4	53
53-78	Bt2	3.5	69.4	27.2	0.051	0.4	6.5	1.0	0.2	0.1	7.7	14.1	55
78-110	Bt3	3.7	70.1	26.2	0.053	0.2	4.4	0.5	0.2	0.2	5.3	9.7	54
ώ(weighted mean)		4.3	69.0	26.7	0.062	0.6	4.4	0.9	0.6	0.3	6.2	11.7	54

Table 3. Saturation of exchangeable bases, Ca to Mg ratio and Clay CEC

Depth	Horizon	Exchangeable bases (% saturation)				Ex. Ca/	CEC/
		Ca	Mg	Na	K	Ex. Mg	Clay *100
Gerua-A							
0-22	Ap	51.1	23.2	23.3	2.3	2.2	48.7
22-49	AB	69.8	20.5	8.2	12.3	3.4	55.2
49-60	Bt1	72.2	15.6	11.1	1.1	4.6	47.4
60-108	Bt2	80.3	6.8	11.8	0.9	11.7	54.1
108-150	Bt3	76.0	12	10.7	1.3	6.3	50.3
(weighted mean)		72.3	14.3	12.0	3.4	5.0	51.1
Gerua-B							
0-18	Ap	78.9	10.5	8.8	1.8	7.5	36.4
18-30	AB	83.8	12.5	12.5	1.3	6.7	52.9
30-49	Bt1	81.1	12.2	12.2	1.1	6.6	48.1
49--100	Btg2	78.4	10.3	10.3	1.0	7.6	48.4
(weighted mean)		80.6	11.4	11.1	1.2	7.1	46.2
Gerua-C							
0-16	Ap	45.8	18.8	25.0	8.3	2.4	44.7
16-31	AB	60.3	14.7	13.2	10.3	4.1	63.0
31-53	Bt1	60.6	21.2	10.6	7.6	2.8	36.3
53-78	Bt2	84.4	12.9	2.6	1.3	6.5	51.8
78-110	Bt3	83.0	9.4	3.77	3.8	8.8	37.0
(weighted mean)		67.9	15.4	10.3	6.1	4.4	44.9

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