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Soil resource information for agricultural planning and development of Assam

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Abstract

An account of the nature, classification, distribution, land use limitation, potential and management of the major soils of Assam is presented based on soil resource inventory undertaken on 1:250,000 scale and other database available. These soils have been developed on sedimentary, metamorphic rocks and alluvium under the predominant influence of climate, vegetation and topography and classified into 4 orders, 9 suborders, 15 great groups and 26 subgroups. Inceptisols are the dominant soils (41%) followed by Entisols (34%), Alfisols (11%) and Ultisols (4%). Uplands soils are dominated by Ochrepts (33%) whereas Aquents (29%) and Aquepts (12%) are the major soils in valleys and flood plains. Soils are acidic, low in fertility and exchange capacity. The soils of the Central Assam range are generally well developed, moderately to strongly acidic with varying degree of aluminium saturation in sub-soils, high in organic matter and low in cation exchange capacity (CEC). The soils of Brahmaputra valley exhibit great spatial variability and are dominated by Entisols in association with Inceptisols and Alfisols at places. These soils, in general, are very deep, poorly drained to well drained, slightly acidic to neutral, low in CEC, high in organic carbon and have moderate to high base saturation. North bank soils of the valley are relatively coarse textured than those of south bank and constitute nearly 60 per cent of the total Entisols of the state. Based on limitation and potential of soils, suitable crops/agromanagements have been suggested.

Additional key words : Soils of Assam, aluminium saturation, Brahmaputra valley soils, flood plain soils.

Introduction

Assam is located along the great river Brahmaputra in the northeast region of India between 89°42' to 95°16' E longitude and 24° 08' to 28°09' N latitude and covers a geographical area of 7.85 million ha.

The state is unique in its possession of a rich bio-diversity comprising of a mosaic of soils and vegetation under humid tropical climate. The state is, however, also known for having problems associated with poor inherent soil fertility, soil erosion and flooding. The region being ecologically delicate and economically weak, a comprehensive knowledge on soil resource is imperative to assess the production potential and future research strategies not only to reap high yield but also to preserve the natural resources. This paper reports the nature, classification, distribution, land use limitations, potential and management of the major soils of Assam.

Materials and methods

Physiography, relief and drainage : The Brahmaputra valley which constitutes the major part of Assam is a large stretch of alluvial tract extending nearly 800 km from east to west with widths of 65 to 100 km. Its altitude ranges from 32 to 132 m above msl. There are few isolated hillocks. Majuli river island (929 km^2) is the largest river island in the world (Singh 1971).

The Brahmaputra river covers its bed floor with alluvium which has been defined as unconsolidated sediment of recent geologic age (Bloom 1979). The geomorphic features of the floodplains formed principally through the depositional processes of lateral and vertical accretion are the levees, backswamps, meander scroll and oxbow lakes. The Central Assam Range comprises Karbi Anglong and parts of North Cachar Hills districts, the former being the extension of Shillong plateau whereas the latter forms the western flank of Naga Barail ranges. The highest elevation of the Barails in Assam is at Haflong (1713 m), and its elevation in the North Chachar Hills ranges from 300 to 900 m above msl. The topography of the region is characterized by steep gradient. The Barak valley occupies a triangular area surrounded by high hills. The elevation of the valley in southwest is low; it gradually rises towards east to 57 m above msl. The valley is peculiarly low lying with swamps and perfectly level alluvial flats excepting some low hillocks.

Geology and climate

The geological formations in the state belong to the Archaean gneisses and schists, the Precambrian of quartzites and phyllites, the lower Tertiary shelf (Eocene) sediments of Jaintia group, the Upper Tertiary (Ligo-Mio-Pliocene) shelf and unclassified older and newer alluvium (Anonymous, 1974).

The climate of Assam is of sub-tropical type influenced by southwest tropical monsoon. The mean annual precipitation is 1900 mm, 70% of which is received during June to August. A small quantity of rainfall is also received during April - May and September

- October. Lakhimpur and Cachar districts receive the highest rainfall (>3000 mm) whereas Nagaon and Karbi Anglong the least (<1300 mm).

Soil survey and laboratory investigations

The soil survey programme and laboratory investigations were carried out following procedures reported elsewhere (Sen *et al.* 1999).

Results and discussion

The diverse physiography, climate, geology and vegetation have led to considerable variation in soils. The soils of Assam belong to 4 orders, 9 suborders, 15 great groups, 26 subgroups and 86 soil families. Amongst these, Inceptisols are the dominant ones followed by Entisols, Alfisols and Ultisols covering 41.4, 33.6, 11.3 and 5.6 per cent area respectively, remaining area occupied by miscellaneous lands. Figure 1 shows a soil map at suborder level along with the location of the selected pedons representing the dominant physiography. The soils of the major physiographic divisions of Assam are i) Hill soils of Central Assam, ii) Interhill basin soils iii) the Brahmaputra valley soils, iv) Purbanchal hill soils, and v) the Barak valley soils.

Hill soils of Central Assam

These soils are primarily derived from gneisses and schists of the Archaean group. They are very deep, fine, well drained, dark grey brown to strong brown with well developed structural and/or colour B horizons. Clay enriched subsoils are common in many of these soils. However, like other soils of the north-eastern region, identification of clay cutan was found to be difficult (Sen *et al.* 1994, Bhattacharyya *et al.* 1994). These soils are acidic with surface pH between 5.0 and 5.5 (Table 1, pedons a and b). They contain considerable amount of exchangeable aluminium. These soils were classified as Typic/Umbric Dystrochrepts, Typic Hapludalfs, Typic Hapludults and Typic Udorthents (Sen *et al.* 1999).

Interhill basin soils

These soils derived from alluvium and/or colluvium received from the surrounding Karbi Anglong and North Cachar hills are very deep, dark greyish brown to yellowish red, imperfectly drained to well drained, fine to coarse-loamy with medium to high organic carbon content, low CEC and medium to high base saturation (Pedon c). Unlike hill soils, the pH and base saturation increase down the profile. The soils do not contain exchangeable aluminium. However, they suffer from surface acidity and seasonal moisture stress. At subgroup level, the soils belong to Typic Hapludalfs, Dystric Eutrochrepts, Aquic Dystric

Table 1 : Physical and chemical properties of soils

Horizon	Depth (cm)	Clay (<0.002) (%)	Org. C (%)	pH 1:2.5 (H_2O)	Exchangeable cations					CEC NH_4OAc	Base saturation
					Ca	Mg	Na	K	Al^{3+}		
					---------- cmol (p+) kg^{-1} soil ----------						
Pedon a : Central Assam : Typic Hapludalf, District (Karbianglong)											
Al	0-23	28.0	0.98	5.5	1.72	0.68	0.41	0.13	0.0	6.2	47
Bt1	23-50	42.0	0.54	5.2	0.93	1.27	0.56	0.19	1.98	8.0	49
Bt2	50-78	47.5	0.50	5.3	2.15	1.05	0.40	0.15	1.17	8.4	44
Bt3	78-120	42.5	0.48	5.6	3.44	1.16	0.40	0.16	0.27	9.0	57
Bt4	120-160	44.5	0.18	5.5	3.18	1.10	0.30	0.14	0.33	8.1	58
Pedon b : Central Assam : Typic Hapludult, District (Karbianglong)											
Al	0-21	29.0	0.77	5.0	1.29	0.31	0.37	0.12	1.44	6.2	34
Bt1	21-48	39.5	0.62	5.0	0.86	0.55	0.37	0.15	2.88	8.7	22
Bt21	48-73	43.5	0.59	4.9	1.07	0.13	0.29	0.16	3.15	8.8	19
Bt22	73-125	43.5	0.56	4.9	0.95	0.11	0.21	0.12	3.42	8.5	16
Bt3	125-180	41.8	0.21	4.9	1.0	0.12	0.22	0.12	3.33	7.6	19
Pedon c : Interhilly basin : DystricEutrochrept; District (Nagaon)											
Ap	0-15	24.5	0.98	5.4	3.6	1.4	0.38	0.14	-	7.4	75
B21	15-40	36.5	0.59	5.9	4.4	3.2	0.43	0.15	-	9.8	83
B22	40-75	41.0	0.30	6.4	7.4	3.2	0.42	0.19	-	13.4	84
B3	75-125	39.5	0.16	7.0	9.6	5.6	0.56	0.20	-	16.0	100
Pedon d : Brahmaputra valley, North bank : Mollic Fluvaquent (District : North Lakhimpur)											
Ap	0-14	19.0	1.33	5.0	4.40	1.60	0.37	0.20	-	9.2	71
A21	14-26	32.0	0.81	6.7	4.85	2.20	0.48	0.22	-	12.0	64
A22	26-48	23.0	0.48	6.8	3.62	3.0	0.41	0.17	-	8.4	87
C1	48-66	8.5	0.19	7.0	1.78	1.85	0.25	0.08	-	4.1	96
C2	66-97	5.1	0.26	7.1	1.36	1.30	0.23	0.05	-	4.1	96
C3	97-125	2.8	0.16	7.0	1.02	0.87	0.18	0.05	-	2.7	79
Pedon e : Brahmaputra valley, North bank : Typic Haplaquept (District : Nalbari)											
Ap	0-15	20.2	1.10	6.5	2.47	1.50	0.55	0.11	-	7.2	64
B1g	15-26	30.4	0.89	6.6	2.57	2.31	0.56	0.10	-	7.6	70
B2g	26-52	31.6	0.80	6.7	3.10	1.95	0.46	0.21	-	7.8	73
B3g	52-97	31.8	0.70	6.8	3.71	2.20	0.63	0.20	-	8.6	78
BC	97-125	42.4	0.36	6.8	3.69	2.80	0.42	0.13	-	9.0	78

Cond.

Pedon f : Brahmaputra valley, South bank : Umbric Dystrochrept (District : Dibrugarh)

A1	0-18	26.0	2.23	4.9	0.60	0.17	0.43	0.07	1.6	9.2	14
B1	18-38	23.0	0.88	4.9	0.40	0.18	0.48	0.04	3.2	7.7	14
B21	38-64	24.5	0.63	4.9	0.40	0.18	0.52	0.03	3.4	6.9	16
B22	64-93	20.5	0.34	5.1	0.60	0.17	0.42	0.03	2.9	6.9	18
B3	93-125	15.0	0.19	5.4	0.80	0.16	0.39	0.02	2.1	4.6	29

Pedon g : Brahmaputra valley, South bank : Typic Dystrochrept (District : Jorhat)

Al	0-19	14.5	0.83	4.5	0.43	0.17	0.35	0.06	1.90	4.1	25
B21	19-47	17.0	0.48	4.5	0.22	0.18	0.38	0.04	1.85	3.2	23
B22	47-87	17.0	0.48	4.9	0.43	0.17	0.33	0.05	1.50	4.3	28
B31	87-112	17.0	0.48	4.9	0.43	0.17	0.34	0.04	1.90	3.5	28
B32	112-162	20.7	0.26	5.0	0.43	0.17	0.34	0.06	2.18	3.5	49

Pedon h : Brahmaputra valley, South bank : Aeric Fluvaquent (District : Goalpara)

Ap	0-12	27.0	1.76	5.5	2.49	1.59	0.56	0.06	-	8.9	53
A2	12-52	32.5	0.92	7.0	3.90	3.65	0.65	0.05	-	10.5	79
AC	52-75	15.0	0.15	7.4	4.74	1.62	0.56	0.02	-	7.4	94
Clg	75-128	9.5	0.21	7.5	5.32	1.00	0.52	0.01	-	6.1	100
C2g	128-145	13.5	0.12	7.5	6.42	1.14	0.48	0.02	-	7.2	100

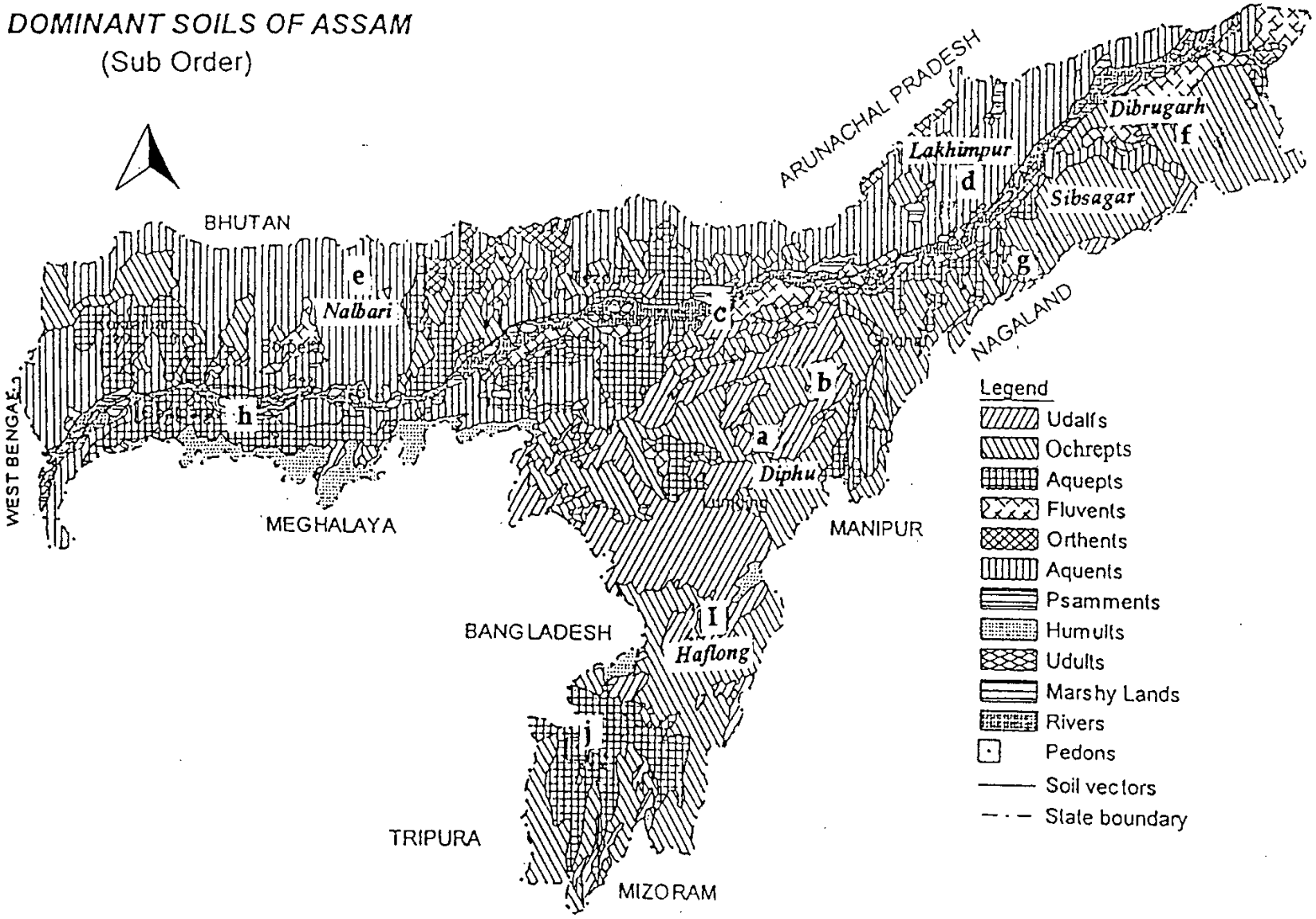
Pedon i : Pirbanchal hills: Hapludalf (District : North Cachar)

Al	0-15	21.5	1.72	6.5	3.36	0.84	0.42	0.23	-	5.3	91
Bt1	15-50	31.5	1.49	6.0	1.89	2.11	0.43	0.46	-	5.9	83
Bt2	50-69	37.0	1.45	5.5	1.47	1.53	0.39	0.56	1.43	7.7	51
Bt31	69-92	29.5	0.83	5.1	1.26	1.34	0.43	0.23	1.63	7.3	44
Bt32	92-115	31.5	0.43	5.3	1.05	1.15	0.39	0.16	1.53	6.3	43
Bt4	115-169	32.5	0.20	5.5	1.26	0.74	0.40	0.16	1.84	6.9	37

Pedon j : Barak valley : Typic Haplaquept (District Karimganj)

Ap	0-15	69.5	1.20	5.6	4.75	5.25	0.61	0.25	-	20.4	53
2B1g	15-32	65.5	0.67	5.8	4.32	6.28	0.78	0.16	-	19.86	58
2B21g	32-65	62.0	0.48	6.6	4.10	6.50	0.74	0.15	-	19.31	60
2B22g	65-125	65.0	0.38	6.9	3.89	10.11	0.91	0.16	-	20.40	74

Eutrochrepts, Aeric Haplaquepts and Aquic Udifluvents. Geogenic calcretes have been observed in parts of Nagaon and Karbi Anglong districts; the source being lime reserve near Dillai of Karbi Anglong district. Similar observations were made in the hilly soils of Tripura (Bhattahcharyya *et al.* 1996).


DOMINANT SOILS OF ASSAM
(Sub Order)
ARUNACHAL PRADESH
Dibrugarh
Lakhimpur
Sibsagar
BHUTAN
Nalbari
NAGALAND
WEST BENGAL
MEGHALAYA
MANIPUR
Diphu
BANGLADESH
Haflong
TRIPURA
MIZORAM
a
b
c
d
e
f
g
h
I
j
Legend
Udalfs
Ochrepts
Aquepts
Fluvents
Orthents
Aquents
Psamments
Humults
Udults
Marshy Lands
Rivers
Pedons
Soil vectors
State boundary

The Brahmaputra valley soils

Great spatial variability was observed with respect to texture and organic matter content in the surface and sub-soils of these valley soils. The soils of the north bank of the river are developed on both old and recent alluvium. The old alluvium derived soils are very deep, brownish to yellowish brown, imperfectly drained to well drained, fine-loamy to coarse-loamy, slightly to moderately acidic in surface with low CEC and poor base saturation. They were classified as Typic Paleudalfs, Typic Dystrochrepts, Umbric Dystrochrepts and Typic/Aeric Haplaquepts. The soils on level to nearly level plains developed in recent alluvium exhibit A-C profiles and are moderately deep to very deep, moderately well drained to well drained, coarse textured, dark grey to dark greyish brown, slightly acidic to neutral with low CEC and medium to high base saturation. The pH and base saturation of these soils increased with depth (Pedons d and e). It is also observed that the surface soils of upper Assam (North Lakhimpur, Pedon d) in the north bank are more acidic than those of lower Assam (Pedon e, Nalbari). Irregular distribution of organic carbon content, abrupt horizon boundaries and stratification are some of the common features of these soils. The majority of the north bank soils belong to Entisols which constitute nearly 60 per cent of the total Entisols. The soils were classified as Fluventic/Dystric Eutrochrepts, Aeric/Typic Haplaquepts, Aeric/Mollic/Typic Fluvaquents, Aquic/Typic Udifluvents, Typic Haplaquents and Typic Udipsamments.

The south bank soils are mostly developed on old alluvium and show cambic and at places argillic horizons. The upland soils of south bank are relatively more developed and texturally homogeneous than those of north bank soils. These soils, in general, are very deep, pale brown to reddish brown, moderately well drained to well drained, light to medium textured, rich in organic carbon with low CEC and base saturation. These soils are strongly acidic (pH, 4.1 to 5.6) and generally contain considerable amount of exchangeable aluminium (Pedons f and g). pH and base saturation of these soils show gradual increase down the profile. These soils were classified as Typic/Umbric Dystrochrepts, Typic Paleudalfs, Typic Hapludults and Typic Udorthents. Most of the tea growing soils are Typic Dystrochrepts whereas forest soils are Umbric Dystrochrepts. Soils occurring in comparatively lower topography and depressions have yellow and rusty brown mottles throughout the control section indicating seasonal fluctuations in ground water table. They are very deep, poorly to moderately well drained with low chroma, fine to coarse-loamy, rich in organic matter with high base and low CEC. The pH of the surface soils is acidic (pH 5.0 to 5.5) and increases to neutrality down the pedon. The pH and base saturation of the subsoils increases along the south bank towards lower Assam (Pedon h). These soils were classified as Aeric/Typic Haplaquepts, Aquic/Dystric Eutrochrepts and Aeric/Typic Fluvaquents.

The flood plain soils lack in profile development and are deep to very deep, grey in colour associated with brown mottles, imperfectly drained to well drained, sand to silt loam with coarse and/or fine stratification, slightly acidic to neutral surface with low CEC and moderate to high base saturation. Fe/Mn concretions are common in majority of these soils. These soils were classified as Aeric/Mollic/Typic Fluvaquents, Aquic/Typic Udifluvents and Aeric/Typic Haplaquents.

Purbanchal hill soils

These soils derived from the Lower Tertiary shelf (Eocene) sediments and the Precambrian group of rocks under predominant influence of vegetation, physiography and climate are reddish brown to pale brown, deep to very deep, well drained to somewhat excessively drained, fine to coarse-loamy with slight stoniness at places. These soils in general are highly weathered and have cambic horizon. Argillic horizons were also identified at places on stable landform. The surface soils are less acidic (pH 5.5 to 6.5) and base rich as compared to those of central hill range. The pH and base saturation showed gradual decline down the profile indicating biocycling of bases (Pedon i). Sub-soils had considerable amount of exchangeable aluminium. These soils have low CEC and low to medium base saturation with strong subsurface acidity. They were classified as Typic/Umbric/Ruptic/ Ultic Dystrochrepts, Mollic/Typic Hapludalfs, Typic Haplohumults and Typic Udorthents.

The Barak valley soils

These soils are mostly developed in recent alluvium under high rainfall, moderate temperature and high humidity. The lowland soils had yellow hue (2.5Y) and low chroma (2 or less). Upland soils developed in old alluvium are well drained with dark brown (7.5YR 3/3) to yellowish brown (10YR 5/4, 5/6 and 5/8) surface and redder subsurface (7.5YR 5/6) horizons. The lowland soils are slightly acidic to neutral and pH of the surface soils varies from 5.2 to 5.6. Sub-surface pH of the valley soils increases down the pedon (Pedon j) at Karimganj towards south of the valley. Upland soils are strongly acidic with poor base saturation and low CEC. Lowland soils were classified as Typic/Aeric Haplaquepts, Typic/Aeric/Aquic Haplaquents and Typic/Aeric Fluvaquents whereas upland soils belong to Aeric/Typic/Ruptic/Ultic Dystrochrepts and Typic Udorthents. The soils of valley are finer in texture.

The well drained, humus rich hill and upland soils are suitable for tea, coffee, pineapple, rubber and other crops tolerant to high level of aluminum saturation. The Alfisols and Ultisols of similar characteristics of the adjoining North Eastern Region (Sen *et al.* 1994; Bhattacharyya *et al.* 1994, 1996) show that tea, native spices and horticultural crops could be a meaningful landuse option in Assam. Rubber has been a success story in Tripura. However, similar success is not so far in Assam.

Some varieties of rice, maize, wheat, beans and soybeans will perform well in lower reaches of hill slope under proper soil and water conservation measures, liming and fertilizer applications. Soils of low lying areas with relatively high nutrient reserve are suitable for a large variety of agricultural and horticultural crops. The soils of warm humid agro-ecological subregion covering North Cachar hill around Haflong extending towards central to south-eastern region of the district have immense potential for plantation and horticultural crops like Jackfruit, pineapple, orange etc.

Constraints of the major soils : Despite favourable agro-climate and good physical conditions, the soils of Assam, in general, have inadequate quantity of plant nutrients to sustain food production. Soil reaction is the most serious limitation resulting in fast weathering of minerals under humid climate. As a result, many of these soils contain large quantities of exchangeable aluminium throughout the control section (sub-soil acidity) limiting the growth of many field crops. Furthermore, there is a concern that the severity of soil acidity may increase because of poor management. The soils of valley regions suffer from surface acidity, nutrient loss through water erosion, waterlogging and flooding along the river courses. Soils occurring on side slopes of hills, undulating and rolling uplands suffer from moisture stress. Shifting cultivation is a potential threat for ecological balance. Soil erodibility was found to be alarming in Jorhat and Sibsagar districts in the Brahmaputra valley as the soil erodibility factor 'K' varied from 0.184 to 0.562 for Jorhat and 0.205 to 0.404 for Sibsagar districts(Sen *et al.* 2001).

Except few exceptions the major soils of Assam are acidic. Most of the plantation crops, native horticultural fruit crops and spices are known for their sustenance in acid soils from time immemorial. As a matter of fact Assam tea is one of the most important foreign revenue earning crop of the country. The valley soils, the bread basket of Assam, on many occasions are kept fallow during rabi season. Proper management guidance is necessary to convince the farmers that these soils are productive and can therefore be utilized profitably to increase the cropping intensity. The soil information of Assam state can thus serve as a true resource inventory for perspective crop farming in different difficult zones of this state.

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