PROCEEDINGS OF THE CARIBBEAN FOOD CROPS SOCIETY

SIXTH ANNUAL MEETING
ST. AUGUSTINE, TRINIDAD
JULY 7-13, 1968

VOLUME VI

SOILS OF FRENCH GUIANA

By J. F. Turenne*

INTRODUCTION

Natural Conditions

The French "Department" of Guiana is located between the 2nd and 6th North parallel, and between the 54th and 56th West longitude. This part of South America is under the influence of a tropical rain climate (Koeppen); the rainfall varies from the coastal zone (80–120 inches) to the interior of the country (137 inches and more). The annual meau temperature is about 26° C (79° F). Two small dry seasons (March and September—October and November) with a rainfall less than 100 mm, more or less marked, are characteristic of this climate. Regular winds (trade winds) blow at the coastal region but there are no hurricanes or storms. All conditions are present for a maximum intensity of bed rock weathering.

Different vegetational landscapes are in correlation with geological formations:

The lowlands (3,700 sq. km.) are formed out of marine clay deposits from the holocene up to the present. A mangrove vegetation ("Avicennia" and "Rhizophora") grows on the parts flooded by marine waters; behind the mangrove there are swamps which are flooded almost all the year round by brackish or fresh water (wet savannas).

The emerged savannas (1,500 sq. km.) form a narrow strip, parallel to the coast, behind the swamps: They are covered with grass vegetation, forest ridges or wet gallery forest running through the landscape. These savannas are growing on fine sorted sands (median about 110 microns) representing old shores; this deposit originates from the upper Pleistocene. Clays of the Medium and Lower Pleistocene can be found, mixed with the sands.

Behind these regions we find the Pre-Cambrian shield, part of the large Guiana shield (84,800 sq. km.), composed of crystalline metamorphous rocks and some lavas. The mantle of weathered rocks is very deep (several scores of meters). The landscape shows numerous hills separated by small valleys and sometimes by swamps. A sheet of detrital sands forms the border between this part and the emerged savannas. This landscape is covered by Tropical Rain Forest.

THE DIFFERENT SOILS

According to the French Classification (Aubert 1967) 5 soil-classes can be distinguished:

Classe des sols mineraux bruts ...	(Usda entisols)
Classe des sols peu evolues	(Usda inceptisols)
Classe des Podzola et sols podzoliques ...	(Usda spodosol)
Classe des sols ferrallitiques	(Usda typic or plinthic Udothox, ochric or plinthic tropudult (Latosols)).
Classe des sols hydromorphes	

*Office de la Recherche Scientifique et Technique Outre-Mer Centre Orstom de Cayenne.

I. Sols mineraux bruts: These soils are represented in French Guiana by the "sols mineraux bruts d'apport marin" which consist of recent clay deposits, under mangrove (*Avicennia* or *Rhizophora*). These marine clays (clay 60 per cent, fine silt 30 per cent) show 40 per cent kaolinite, 20 per cent montmorillonite, 20 per cent illite and 20 per cent quartz. In these soils, the upper 30 centimeters are marked by oxidation, aeration, biological distribution and accumulation of small amounts of organic matter. Chemically these clays are salty clays (pH 7); magnesium and sodium are predominating. The stability of structure in the upper horizon is low. A very important character is that these deposits do not contain calcium carbonate. Among those "sols mineraux bruts", soils also exist which are formed on eroded areas of ironstone or on granitic hills in the interior of the "department".

II. Soils peu evolues: These are the soils of the best part of the lowlands; swamp vegetation takes the place of the mangrove. Such soils are formed by marine clay soils showing a beginning of evolution by a fairly thorough aeration of the profile accompanied by loss of salt and structuration.

Among several groups of soils two can be distinguished: poorly developed hydromorphic soils and poorly developed salty ones.

Poorly developed hydromorphic soils cover a large surface East of Cayenne and offer interesting development possibilities when they do not contain any pyrites. They show a clay texture (60 per cent clay) and desaturation is rather marked attaining about 50 per cent of the absorbing complex. The capacity of this complex is about 30 milliequivalents. Permeability is variable, depending on internal structure after drying and on oxidised iron tubes originating from fossil roots. A series containing pyrites exists within this group; such soils show acidity by oxidation.

Poorly developed salty soils are as well represented; in most cases salt is leaving the upper horizon, and deeper down, the total amount of salt rises. The pH values vary from 5.6–6.4 in the upper horizons to pH 7–8 in lower layers of the profile.

There is also a series with pyrites where, iu spite of salt pH can decrease to 4 because of oxidation.

On sandy ridges (old shores) among marine clays, we also find poorly developed soils on sandy material (90–95 per cent sand); the layer containing organic matter is fairly thick and the Amerindian population went there to establish their plantations. Such soils are submitted to the varying level of ground water which is related to the water level in adjacent marine clay. Podzolic profiles can appear if the water reaches the organic horizon.

III. Podozolics soils and podzols: These soils are located on well-drained sandy material of old sandy ridges or on detritic sands (95 per cent sand) bordering the precambrian shield. A hard pan of humic and ferric material can be distinguished under a bleached horizon. A ground water level often exists in the soil; especially in savannas on fine sorted sands, where the varying level maintains the migration of elements.

IV. Les sols ferrallitiques (latosols): The greater part of French Guiana is covered by these soils, either on pre-Cambrian rocks or on material resulting from erosion of the Guianese shield. These soils show profiles A (B) C or A B C, (AUBERT and SEGALEN, 1967), often deep, displaying an accentuated decomposition of organic matter, strongly bound to minerals. Weathering of minerals is very strong, and separation of iron, manganese and aluminium sesquioxides can be observed. The clay mineral is most often composed of kaolinite, sometime illite, not counting aluminum and iron sesquioxydes.

According to the French Classification, which considers desaturation of the complex first of all, the most represented soils among ferralitie ones are the vary strongly desaturated ferralitic soils, where exchangeable bases are lower than 1 meq., saturation less than 20 per cent of the complex, sometimes only 10 per cent, and exchange capacity of the order of 5–10 milliequivalent according to the amount of clay. Organic matter increases this exchange capacity in the upper horizon; and is the only way to modify the chemical poverty of these soils. The carbon ratio in the surface layer varies from 1 to 8 per cent, C/N ratio being between 12 and 15. The low differences in chemical status which are noted between different soils are not so important as to be considered as a fertility test. In such cases, one tries to define physical properties, particularly texture and structural stability: for this purpose the composition of the soil with respect to particle size distribution and amount of coarse elements (given by concretions or dismantling of iron stone) are to be considered.

Leaching is generally not well marked in the Pre-Cambrian shield; the amount of clay increases progressively following depth, and texture changes at the level of weathered rock. This change is well marked by a larger amount of silt. Important leaching can only be seen in fine sorted sands of quaternary deposits with a moving ground water level.

Texture depends on the type of parent-rock (BRUGIERE-MARIUS, 1967).

Clay Texture: (0–20 microns: 60–80 per cent) : on Paramaca lavas Gabbros, Paramaca schists, Orapu schists, Amphibolites.

Sand-clay Texture : (0–20 microns: 40–60 per cent): alluvions from Bonidoro and Orapu schists, alluvions from granite.

Clay-sand Texture: (0–20 microns: 20–40 per cent): on granites and quartzites of the Pre-Cambrian shield and on fine sorted sands of the coastal plain.

Sand Texture : (0–20 microns : 0–10 per cent): detritic sands.

The amount of coarse elements can be due either to iron stone formation (this phenomenon being located on table-lands and terraciform deposits), or to dismantling of old iron-stones. These elements can be found as follows:

Iron-stone or remains of iron stone (thin soils); on table-land summits of Orapu and Paramaca schists, on Paramaca lavas, amphibolites and down the slopes on schists and Amphibolites.

Abundant coarse elements; slopes and at the base of slopes on schists and amphibolites.

Fairly abundant coarse elements: on steep schist-slopes.

Few coarse elements: on top of slopes on gabbros, on alluvions from schists and from amphibolites.

Soils without coarse elements: alluvions and colluvions or soils on granite and gneiss.

V. Hydromorphic soils: These soils are well represented. Peat is frequent and shows large surfaces on flooded marine clay or in inland depressions. Clay soils are present on the bottom of depressions in wet gallery forest and in quaternary depressions of the coastal plain.

The soils on alluvial terraces fairly often show a pseudo-gley surmounting a gley.

Problems of fertility and development: Marine clays ("sols mineraux bruts" and "sols peu evolues") have a high chemical fertility but the amelioration of physical properties correlated to clay texture needs important consideration. Land improvement is possible by empoldering accompanied by severe control of water level and drainage/irrigation—equilibrium. This equilibrium can be modified during the dry season; in the coastal plain 2 or 3 months with less rain than one inch are frequent. The possibilities of irrigation with fresh water during this period require serious survey. Mechanisation would be necessary, though supplementary expenses of road construction would have to be considered.

The ferralitic soils of the Pre-Cambrian shield could yield important surfaces for land improvement; the physical properties are fair to well developed but these are chemically very poor. Forest-clearing modifies the equilibrium between soil and vegetation; so that care should be taken to preserve the layer of organic matter located in the first 10 or 20 centimeters. After clearing, covering of the soil is necessary. The structural stability is good in the upper layer but decreases rapidly in lower horizons. Soil management is necessary to prevent the top soil from being eroded (anti-erosive systems). Soils on steep slopes (schists, dolerites) cannot be used; soils on granites or on gabbros with gentle slopes and without coarse elements present some advantages (good physical properties in particular). Mechanisation is easier on such slopes, manuring is necessary.

Land Use. The population of French Guiana is actually gathered along the coastal plain where their houses are generally situated on sandy ridges or along the estuaries. The agricultural production, barely sufficient for home consumption is the result of shifting cultivation, practised on a wide range of soils. Around the houses there are small orchards. Extensive breeding is restricted to the savannas.

Pedological studies actually give an idea of developmental possibilities and define the vocation of the soil; citrus plantations are thought of today, and soils on granite are prospected. In the coastal plain, there is a grouping of cattle-breeders. On leached ferralitic soils (fine sorted sands) and hydromorphic soils with pseudo-gley, fodder-grass may be grown.

We can distinguish:

Land of medium quality: For its improvement one does not need anti-erosive systems but medium or high manuring is necessary (grass land). In this category we find leached ferralitic soils on fine sorted sands (savannas) or soils with a pseudo-gley and gley in the lower horizons.

Land of poor or medium quality: Land improvement should be undertaken when clearing the forest (protection of organic layer, covering of the soil, improvement of anti-erosive systems) and manuring in medium or high quantity is necessary.

In this category we find soils on granites, soils on lavas and soils on schists, but the last ones posing problems due to steep slopes and the abundance of coarse elements.

Land with good chemical properties but needing very intensive management: On this land we find marine clay soils, the best among them being those on fresh clays.

Land without any development possibilities: Gley soils, salty soils, soils containing pyrites, podsolic soils.

According to onr knowledge of natural environment, tropical cultures could be promoted from a technical point of view. But the main problem owing to the small population density (35,000 h.) is the lack of agricultural labour.

The local market is limited and labour is high-priced. The cost price is therefore, rather high and dispositions aiming at maximum mechanisation are the only means to arrive at a system of competitive production; these methods would raise the question of the international market. During the present period of difficult openings in this market the economic aspect of agricultural development would be among the most important problems.

REFERENCES

1. AUBERT G. Classification des sols Cah. ORSTOM Ser. Ped. 1965 No. 3 269—288 modification G. AUBERT—P. SEGALEN 8.11.1966.
2. BRUGIERE (J–M.) 1965 Etudes pedologiques et mise en valour agricole de la Guyane Francaise in Compte-rendu du congres des Recherches agricoles dans les Guyanes 27 Nov.—3 Dec. 1963 Landbouwproefstation in Suriname Paramaribo pp. 107—111.
3. BRUGIERE (J–M) et MARIUS (Cl.) 1967 Relation sol substrat geologique Centre ORSTOM de Cayanne 10 p. multigr. 1 diagr.
4. LEVEQUE (A.) 1962 Memoire explicatif de la carte des sols des terres basses de Guyane Francaise O.R.S.T.O.M. PARIS 85 p. 2 cart.
5. LEVEQUE (A.) 1967 Los Sols ferrallitiques de Guyane Francaise O.R.S.T.O.M. PARIS 168 p. graph.
6. MARIUS (Cl.) 1966 Carte pedologique au 1/50 000 et notice explicative Feuille de Cayenne Centre ORSTOM de Cayenne 57p. multigr. 1 carte.
7. MARIUS (Cl.) TURENNE (J–F.) 1967 Problemes de classification et de caracterisation des sols formes sur alluvions marines recentes dans les Guyanes Centre ORSTOM de Cayenne 62 p. multigr.
8. SORDGILLET COLMET-DAAGE (F.) SUBRA (P.) 1958 Mission agro-economique dans les Guyanes. Etude des possibilites de la mise en valeur des terres basses guyanaises. Credit Social Antilles Guyane Cayenne 206 p. multigr.
9. SOURDAT (M.) 1965 Notice de la carte provisoire au 1/50.000 des sols du littoral Guyanais entre KOUROU et SINNAMARY Guyane Francaise Centre ORSTOM de Cayenne 90 p. multigr. cart. photos.
10. TURENNE (J–F.) 1966 Conservation du sol et culture par abattis Centre ORSTOM de Cayenne 11 p. multigr.
11. VAN AMSON (F.W.) 1967 Soils of Surinam Caribbean Food Crops Society 5th Annual Meeting July 24—31, 1967 Paramaribo—Suriname 4 p. multigr.

Soil	Depth cm	hori-zon	Course elem. >2mm	Clay <2u	Silt 2—20u	Fine sand 20—200u	Course sand 0,2—2mm	C o/oo	N o/oo	C/N	pH H20	Ca	Mg	K	Na	Total cation	CEC	Fe libre %	Fe total %
												milliequivalents							
Sol mineral brut ...	0—30	(A)C	.6	53.5	34.	1.5	1.5	17.4	1.47	11	7.3	5.4	11.80	2.12	21.2	—	38.4	—	3.6
d'apport marin ...	50—90	C	.3	56.	34.	0.5	0.3	15.2	1.36	11	7.	5.18	11.95	2.74	22.	—	36.4	—	3.2
(TURENNE)																			
Sol peu evolue ...	0—5	A1	1.3	3.	0.5	38.	55.7	12.2	1.08	12	5.7	0.69	0.13	0.09	0.08	—	3.	—	1.4
d'apport sableux ...	30—40	C	.1	4.5	2.	46.5	45.1	—	—	—	5.6	0.19	0.02	0.04	—		2.1	—	3.5
(cordon)	40—130	C	.01	2.	0.5	45.5	52.1	—	—	—	5.5	0.19	0.02	0.02	0.01	—	1.4	—	3.8
(TURENNE)																			
Sol peu evolue ...	0—15	Aoo	—	59.	31.	0.1	0.1	14.1	1.8	7.8	4.9	1.02	12.96	0.08	1.41	15.35	33.18	—	—
d'apport marin ...	15—35	A1	—	56.	33.	0.3	0.1	14.1	1.3	4.8	5.	1.61	16.4	0.15	0.8	18.99	26.92	—	—
hydromorphe ...	55—75	C	—	52.	38.	0.4	0.15	5.2	1.	5.2	5.4	2.35	18.28	0.12	2.53	23.28	25.44	—	—
(LEVEQUE) ...	95—115	C	—	46.	40.	0.5	0.39	13.3	1.7	11.	5.	1.94	15.37	0.46	0.43	18.20	30.08	—	—
Sol peu evolue ...	10—45	A1	0.01	62.	25.	0.5	0.5	40.	2.48	16.2	5.1	11.	20.15	2.93	36.23	70.	28.	—	—
sale	45—90	C	0.01	56.	21.	2.5	1.	7.7	0.7	9.9	6.8	10.3	21.18	3.23	40.24	74.	25.	—	—
(MISSET)																			
Sol peu evolue ...	0—20	A1	4.2	49.	35.	2.	1.	24.7	2.6	10.	4.2	4.52	6.43	9.6	0.6	13.	13.	40.	3.2
d'apport a pyrites...	70—90	C	3.3	43.	44.	3.2	3.2	12.6	1.83	8.	2.7	3.72	7.55	0.1	0.28	11.	33.	—	3.3
(MISSET)																			
Podzols sur sables ...	0—7	Aoo	2.7	2.	0.5	6.	88.	2.2	0.15	14.	—	0.26	0.25	0.12	0.09	0.7	4.2	—	—
grossiers	20—30	A1	4.2	1.	1.	9.	89.	0.2	0.05	5.5	—	0.06	0.01	0.02	0.02	0.12	0.12	2.7	—
(TURENNE) ...	45—55	A2	6.8	2.	0.1	16.	82.	0.4	0.04	9.9	—	0.06	0.01	0.02	0.02	0.12	2.2	—	—
	90—110	Bh	4.6	3.	0.01	5.	87.	2.76	0.8	34.	—	0.06	0.02	0.04	0.06	0.18	11.6	—	—

Soil	Depth em	hori-zon	Course elem. >2mm	Clay <ud2	Silt 2–20u	Fine and 20–200u	Coarse sand 0,2–2mm	C o/oo	N o/oo	C/N	oH H20	Ca	Mg milliequivalents	K	Na	Total cations	CEC	Fe libre %	Fe total %
Ferrallitique ... fortement dessature	1—7	A1	2.6	27.	6.5	10.5	42.	76.	4.3	17.	4.5	0.11	0.11	0.15	0.07	0.58	9.9	2.2	1.9
appauvri sur ...	20—40	AB	2.7	32.	11.	11.	39.	43.	2.8	15.	5.2	0.06	0.06	0.02	0.01	0.15	5.3	3.9	2.8
granite	120—140	(B)	4.5	39.	11.5	6.5	37.5	—	—	—	5.2	0.09	0.06	0.02	0.01	0.18	3.5	4.8	3.5
Weathered rock granito gneiss ...	780—840	(C)	1.	6.5	37.	8.5	48.	—	—	—	5.	0.04	0.01	0.02	0.02	.14	5.6	7.5	5.
Ferrallitique ... fortement dessature	0—20	A—1	36.7	42.	15.	12.5	16.	58.	3.6	16.1	4.9	0.19	0.10	0.24	0.28	0.81	12.7	10.	26.6
sur schistes Paramaca (MARIUS) ...	30—50	(B)	38.8	51.	14.	8.	17.5	38.5	2.4	16.	4.9	0.06	0.01	0.12	0.11	0.30	8.6	10.3	28.9
	100—120	(B)	28.2	48.5	48.2	13.5	22.5	—	—	—	5.1	0.09	0.09	0.06	0.06	0.22	3	13.4	18.4
ferrallitiqu forte-ment dessature sur	0—15	A1	12.2	35	18	16.	16.	61.4	3.95	15.5	—	0.94	0.15	0.19	0.111	1.39	16.6	12.2	19.8
schistes Bonidoro ...	30—50	(B)	38.	61	9.5	13.	9.5	19.5	1.50	13.	—	0.06	0.01	0.06	0.05	0.18	8.9	11.5	21.3
(MARIUS) ...	100—120	(B)	13.8	63	12.	11.	9.	—	—	—	—	0.06	0.01	0.04	0.02	0.13	4.3	12.5	23.
	200	—	.0	16.5	34.	34.	24.	—	—	—	—	0.06	0.01	0.04	0.02	0.13	4.8	16.8	25.1
Ferrallitique ... fortement dessature	0—5	A1	2.6	10.	2.	63.5	10.5	18.5	1.15	16.1	—	0.96	0.50	0.10	0.13	1.73	8.2	0.9	1.2
lessive	15—25	AB	1.7	12.5	4.	70.	10.5	11.3	.77	14.	—	0.54	0.22	0.13	0.07	.06	5.2	1.6	1.8
(Fine sorted sands)	50—70	B	1.1	20.5	5.5	61.	10.5	—	—	—	—	0.54	0.40	0.06	1.07	1.07	4.2	2.2	3.7
(TURENNE)	175—185	BC	22	15.5	6.5	2.	14.	—	—	—	—	0.49	0.08	0.4	0.03	0.64	2.4	3.	3.9