ACID SOILS OF FRENCH GUIANA

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INTRODUCTION

This report presents the main types of acid soils of French Guiana that have been surveyed and on which crops have been cultivated so far. These soils mainly occur along the coast, as the sparsely populated interior is not at present included in the development plans.

Although the knowledge on the morphology and other profile characteristics of the soils of this coastal strip is quite advanced, little is known as yet about their agricultural potential. The morphology and variability of the different soil mantles in this area will be described, followed by a brief account of the climate. The agricultural uses will then be discussed along with the main agronomic problems that slow further development.

SOIL TYPES, THEIR EXTENT AND PROPERTIES

The acid soils on sandy to sandy clay, sedimentary formations that have been surveyed so far in French Guiana, are found on the Zanderij formation, the Lelydorp formation and the sandy formations on recent coastal ridges.

Soils of the Zanderij formation

The Zanderij formation, known in French Guiana as the Detrital Basement Series, is found in the northwest of the country. Its present known extent as shown in Figure 1, covers over 53 000 ha. Figure 2 shows the position of the Zanderij formation relative to the surrounding formations. This formation rests unconformably on the crystalline basement rock. It is located between the basement and the formations of the old coastal plain, covering areas ranging from stretches of a few hectares to plateaus of over 5 000 ha.

Morphological observations made in the field during soil surveys have enabled us to reconstruct in great lines the pedological history of the area since the Zanderij formation was formed. This history will be briefly discussed as it explains the distribution of the soils, the types of profile development and the soil forming processes encountered. It may

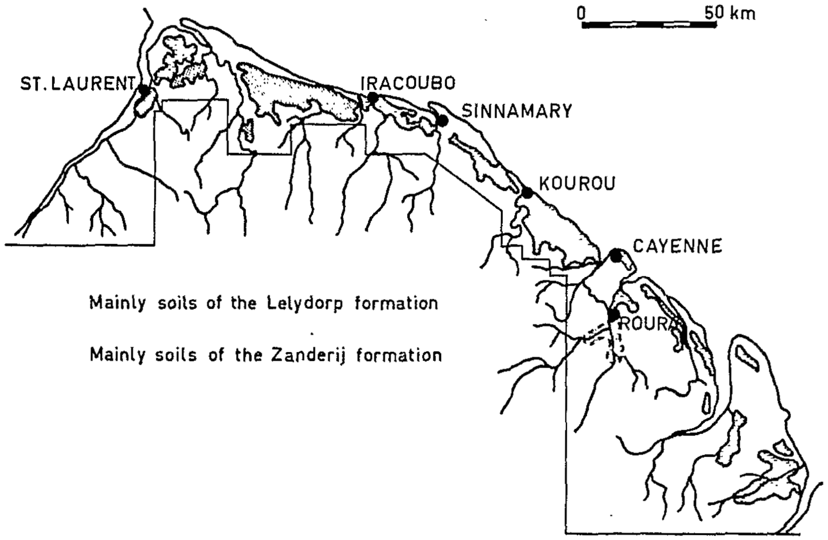


Fig. 1. Extent of Lelydorp and Zanderij formations in French Guiana.

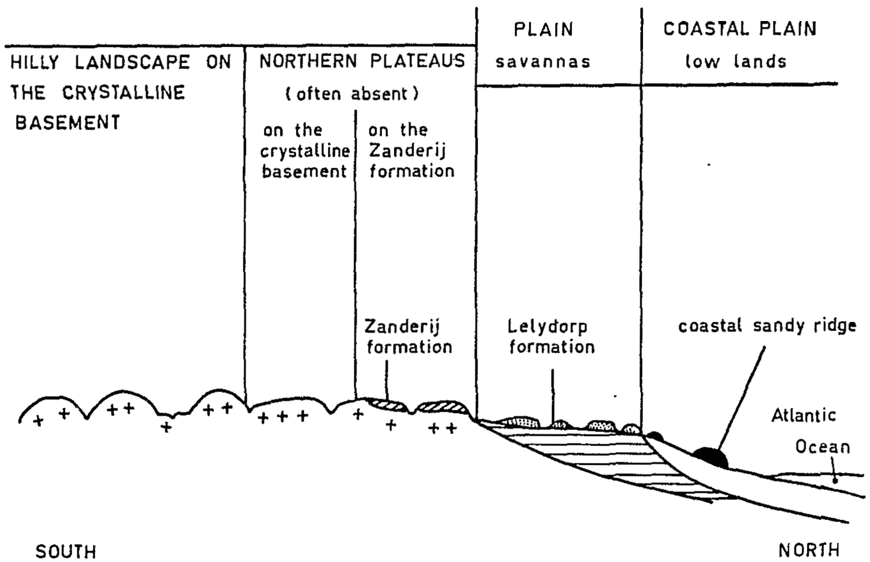


Fig. 2. Location of the sand and sandy clay sedimentary deposits relative to the *crystalline basement.*

be divided into four stages, outlined in Figure 3.

1) Initial formation, on the crystalline basement rock, of a soil mantle with the same horizon differentiation as presently found in soils on this rock.
2) During an undetermined period - most probably antequaternary - truncation of this soil mantle as a result of increased erosion.
3) Simultaneously, or a little later, deposition of sedimentary material of what is now called the Zanderij formation. From what we know of present-day sediments, it most probably is a matter of continental spreading related to shifting rivers. The base of these sediments is consistently marked by a thin bed (5 cm) of smooth quartz pebbles. Thicker beds mark the position of larger water courses.

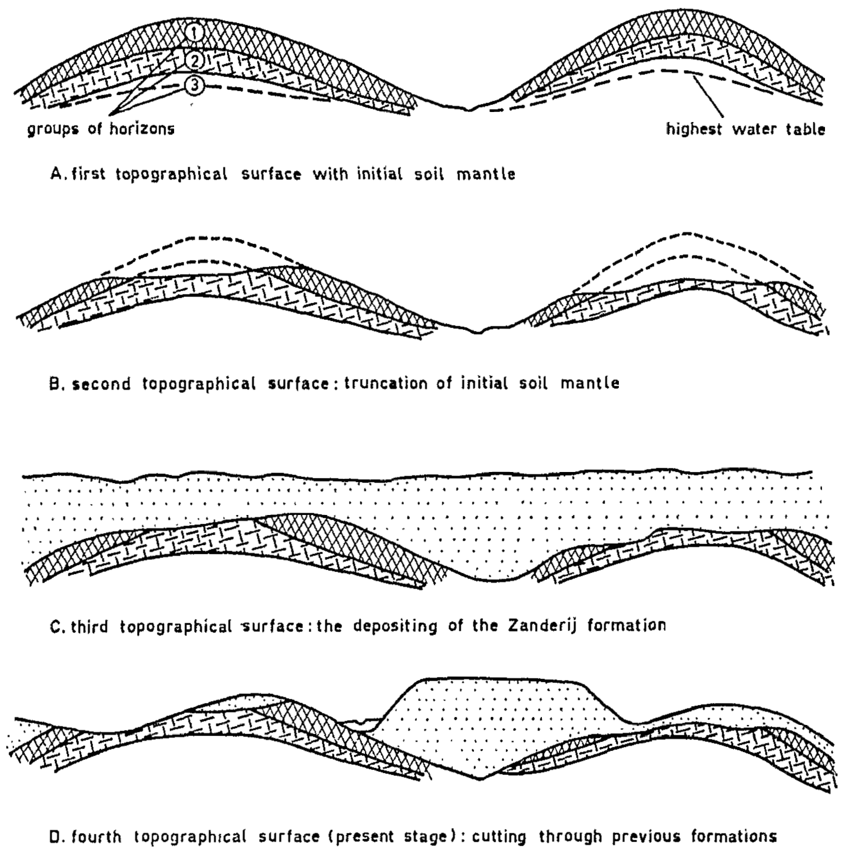


Fig. 3. The different stages of landscape and soil formation in the French Guiana Zanderij formation.

4) During the Quaternary, erosion lowered the surface of this sedimentary formation, sometimes reaching the base.

It is therefore the intersection of three seemingly independent, topographical surfaces which determines the complex distribution of the various soil materials. This complexity (see Fig. 3) has the important consequence that it is impossible to predict the distribution of materials from a limited number of observations made in particular sites. Instead, a systematic survey has to be made in these regions at a scale depending on the precision required.

In fact, it is essential that one should be able to differentiate between soils on sufficiently thick Zanderij formation, soils on a shallow Zanderij formation overlying horizons derived from weathering products of the crystalline basement rock, and soils directly formed from this rock. If certain horizon types that were formed on the basement rock (e.g. horizon groups 2 and 3 in Fig. 3) are present near the surface (about 1 metre deep), the water flow in the soil is essentially superficial and lateral, contrary to soils with a deep percolation. This difference in water movement is of great agronomic importance and should therefore be used as a criterion in soil surveys.

Where the Zanderij formation is sufficiently thick, the soils are either brightly coloured or white sandy or a combination of both. The brightly coloured soils represent the least weathered part of the Zanderij formation. These soils have a strong brown colour (7.5YR 5/6-5/8); their texture below 20 cm varies from sandy loam to sandy clay loam. The clay content increases with depth reaching a maximum of 30 to 40 percent at 110 cm depth. This clay content remains constant at about 30 percent in a thick, strong brown horizon with a massive, microaggregated structure (aggregate diameter about 0.2 mm). These soils may represent variations in the eluviation process and the decolourizing of the surface horizons. The A horizon overlies a brown to yellowish brown, sandy horizon (10YR 5/4-5/3), with a distinct transition between 30 and 80 cm depth, to strong brown, more clayey horizons. In such cases, between 40 and 60 cm a horizon of greater bulk density may be present which is associated with a temporary perched water table during the rainy season.

The white sands represent the most strongly weathered soils of the Zanderij formation. The profiles have a dark grey surface horizon which gradually changes into white sand at 30 cm depth. The texture is very sandy, clay content being less than 1 percent. Water infiltrates rapidly, and is not retained because of the soil's very low water-holding capacity. This water feeds a water table which fluctuates rapidly and, in places, reaches the surface either at the foot of a slope or in the centre of a plateau.

The strong brown coloured soils and the white sands are the

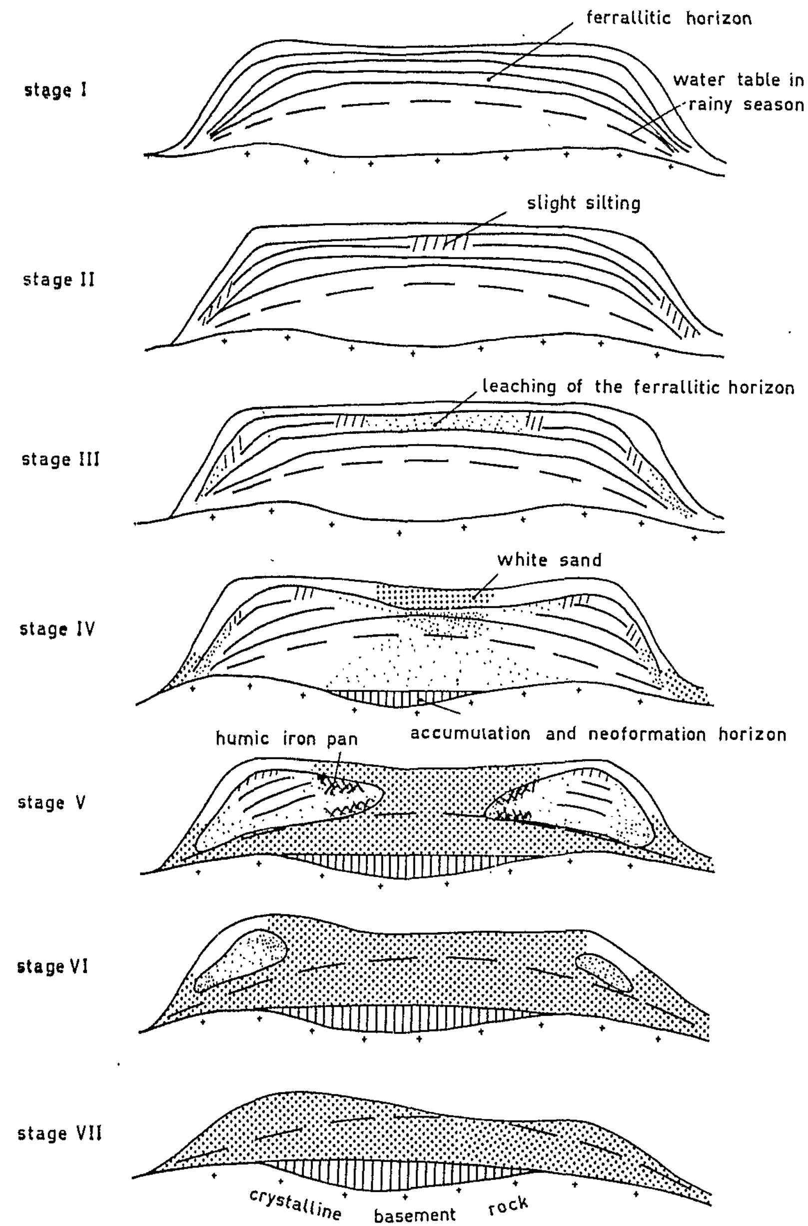


Fig. 4. Schematized stages of transformation from a sandy clay mantle of the Zanderij formation into a white sand mantle.

extremes in the process of soil formation. Turenne (1975) and Boulet et al. (1979) studied these systems on the basis of many observations in the field. The various weathering stages are outlined in Figure 4. The clay fraction gradually disappears from the centre and from the boundaries of the landscape units - which may cover a few kilometres - without decolourizing the soil. When the clay content becomes less than 3 percent, the sandy material becomes white, a phenomenon which is frequently associated with the presence of horizons with an accumulation of organic matter and iron (Bhir). These horizons are situated at the interface between the upper and lower weathering fronts. This weathering process, which in fact is a podzolization process, will continue until only white sand remains.

The strong brown coloured, least weathered soils of the Zanderij formation are among the soils of the French Guiana uplands with the least limitations. They are therefore the first to be surveyed. At present the Iracoubo - Saut Sabbat region is being studied.

Soils of the Lelydorp formation

The Lelydorp formation also has varied soils that constitute a weathering sequence. This formation was originally deposited as offshore ridges which run more or less parallel to the coast. These ridges are 1 to 10 m high, 200 m long, 5 to 800 m wide. At present they are found in the coastal plain, up to about 20 kilometres inland. Their distribution is shown in Figure 1; they cover an area of about 100 000 ha and are associated with the Para formation.

On these ridges the least weathered soils have sandy textures and brown colours near the surface, changing into strong brown sandy loamy to loamy fine sand (grain diameter less than 0.1 mm; 20 percent clay) below 40 cm depth, while also some violet-reddish spots or nodules occur. The thickness of the profile depends on the depth at which the Para clay is found. The most weathered stage has a white sand profile abruptly overlying Para clay. Intermediate stages occur between these two extremes. The sand becomes white if the clay content of the surface horizons of these intergrades has decreased to a value of 3 - 5 percent, a stage which is accompanied by a temporary and discontinuous Bhir horizon. This weathering pattern is both centripetal, i.e. beginning at the centre of the ridges, and centrifugal, i.e. beginning at their boundaries.

Soils of recent coastal ridges

The recent coastal ridges with medium to coarse sand, can also be differentiated in yellow sandy well-drained soils and white sands that have a water table near the surface during the rainy season. These soils are limited to narrow strips parallel to the coast.

Acid soils on material from the crystalline basement rock

Certain soils on the crystalline basement rock have properties and a morphology that closely resemble those of the least weathered soils of the Zanderij formation. They occur immediately south of the Zanderij formation. Their profile is conformable with the topography. Underneath brown to yellow-brown surface horizons, a thick (over 1 m), yellow-red clay to sandy clay horizon occurs which is porous, containing numerous microaggregates and changing into a more compact redder horizon at lower depths. Rainwater passes vertically through the whole profile. These soils are called "free vertical drainage" soils. They also are an initial stage of a weathering sequence, but one that differs considerably from the Zanderij formation sequence.

Various studies have shown that this weathering sequence was initiated by a relative subsidence of the base level. The topographical surface then lowered which caused originally deeper horizons to appear higher in the soil profile. This entire process was due to a tectonic lifting of French Guiana between two subsident, sedimentary basins, i.e. Guyana-Suriname to the northwest and the Amazon basin to the southeast.

Where the compact red horizon or the deeper horizons appear near the surface, i.e. within about 1 metre, they cause the water flow to become essentially superficial and lateral. These soils are called "blocked vertical drainage" soils. This differentiation of the water flow is at present an important limitation for agricultural development and use. Technology must be developed to eliminate these drawbacks as these soils cover considerable areas of the uplands.

CLIMATIC CONDITIONS (Godon, 1980)

The equatorial climate of French Guiana is marked by two seasons, i.e. a dry season from mid-August to mid-November, and a rainy season from mid-November to mid-August. The rainy season can be divided into two intensive rainy periods, the 1st and 2nd crop cycles, with - between these two - a period with statistically less rain, the so-called "little March summer". The rainfall regime is dependent on the intertropical convergence zone. The amount of annual rainfall varies considerably but there also is considerable variation in the monthly averages, as shown in Figure 5. Average annual rainfall can vary by 100 percent, e.g. extreme values for Cayenne are 1 500 and 4 200 mm.

Rains are sometimes heavy and of long duration. Rainfall decreases towards the interior and to the coast.

The annual mean temperature is high, i.e. 25.5°C at Rochambeau. Relative humidity is high all year round and wind speeds are low.

Variations in daily sunshine are considerable. Potential evapotranspiration is high.

From an agro-climatic point of view the following can be noted:

- The long rainy season favours perennial crops or crops with a long growing cycle (over 10 months).
- Annual crops with a short growing cycle, i.e. a few months, could be grown twice a year. However, there are restrictions. During the first period difficulties with ripening and harvesting (occasional dry February) and during the second period, difficulties with tillage and sowing - with risks of water excess in May and June - may be encountered.

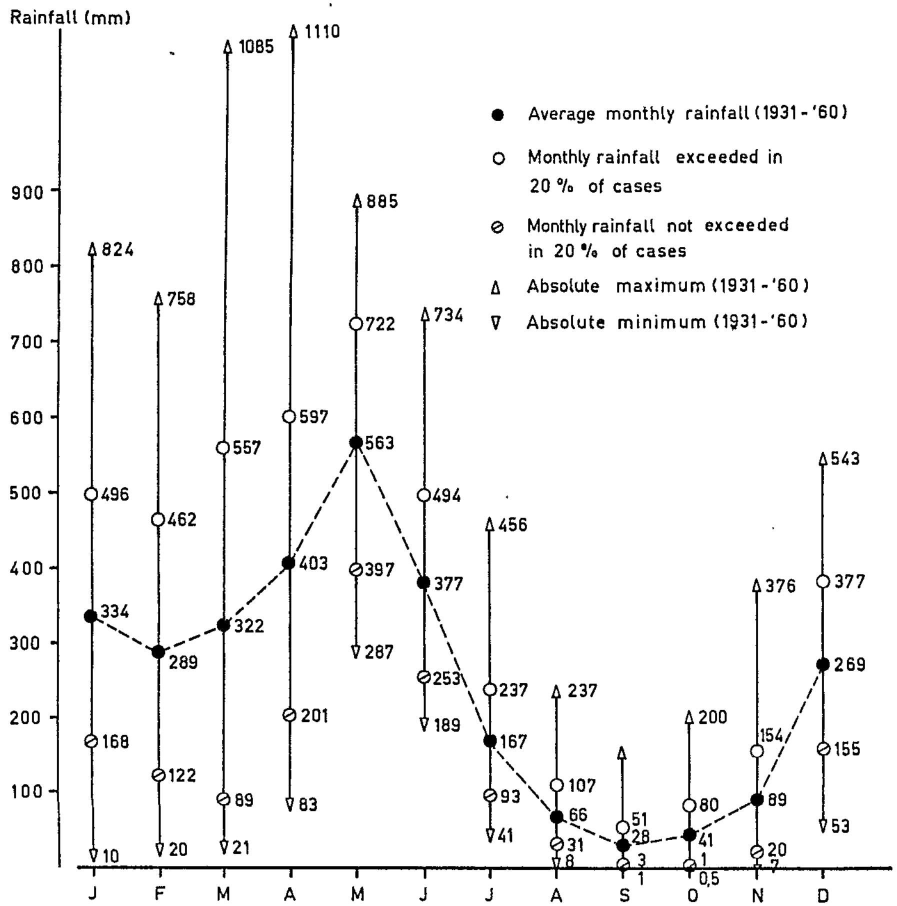
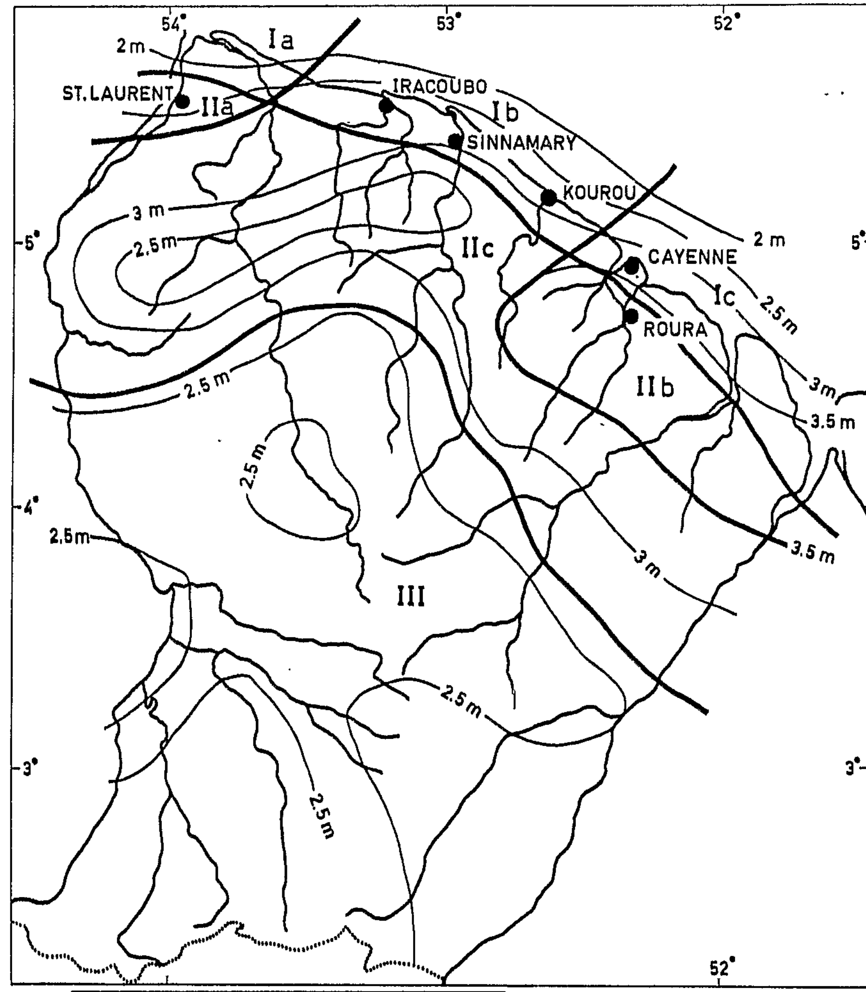


Fig. 5. Distribution of monthly rainfall for Cayenne, French Guiana. Source: Godon (1980).



	annual rainfall (1956-'75)	length of dry season	ratio rainfall/pot. evapotransp. in March
	m	weeks	
Ia	< 2	18	< 1.5
Ib	2.5 — 3	16 — 17	1.5 — 2
Ic	3 — 3.5	15 — 17	2.5 — 3
IIa	2.5	14	1.5
IIb	> 3 5	14 — 15	> 2.5
IIc	> 3	15	1.5 — 2
III	< 2.5	15 — 16	1.5 — 2

Fig. 6. Agro-climatic zones in French Guiana.

All crops may be subject to a lack of sunlight during certain periods or to water excess at other times.

Figure 6 gives an agro-climatic zoning of the area under consideration. Criteria used are annual rainfall, length of dry season and the ratio between rainfall and potential evapotranspiration in March.

PRESENT USE OF THE FORMATIONS DISCUSSED

Figure 7 shows the various agricultural enterprises established or being established. It is striking how small the total cultivated area is, i.e. about 4 500 ha, concentrated in the coastal region.

On the Zanderij formation, mainly stock farms (about 900 ha) and annual crops (about 450 ha) have been set up in the Saint Jean and Acarouany regions, and some silviculture around St. Laurent. The rest of the formation is covered by forest.

The Lelydorp formation, which is always associated with Para formation, is being used for stock farming (about 1 100 ha), annual crops and orchards. The rest of the formation is covered by forest or savannas.

The agricultural potential of the soils of the various formations discussed, i.e. Zanderij, Lelydorp and crystalline basement rock, is far from known. In fact, without sufficient agronomic trials one cannot relate advanced knowledge of the soils' morphology and other proper-

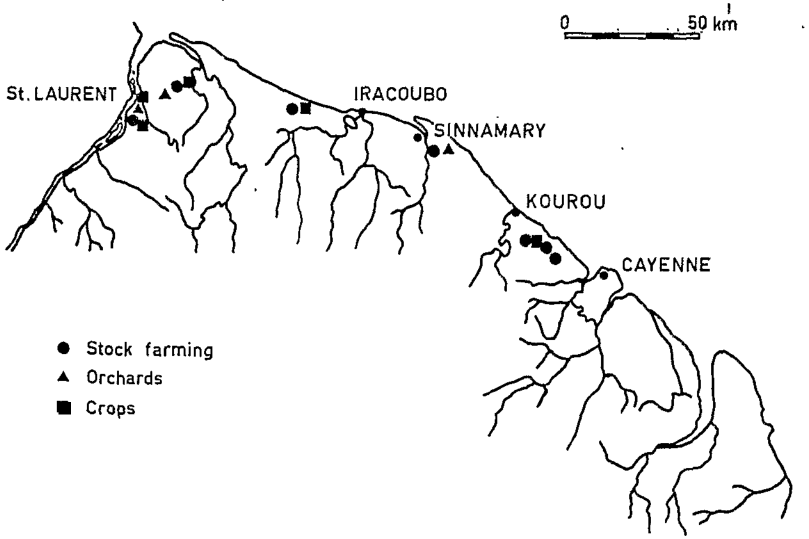


Fig. 7. Present agricultural enterprises on the Zanderij and Lelydorp formations in French Guiana.

ties to technology for intensive agriculture. However, quite a few problems can be noted.

- In areas on slightly weathered soils of the Zanderij formation, the infiltration rate varies extremely, locally leading to boggy patches. IRAT's observations at Acarouany show that these boggy patches have an important, negative effect on the growth of sugarcane. Moreover, areas where water stagnates at the surface, have a low mechanical resistance and low workability.
- The water infiltration rate and the finer textured subsurface horizons pose problems (perched water tables) on weathered soils of the Lelydorp formation.
- For pastures on the Lelydorp formation or on "blocked vertical drainage" soils on crystalline basement rock, weed invasion (especially *Carex*) becomes a serious problem.
- Citrus orchards on the Leydorp formation or on soils on the crystalline basement rock show a large variation in tree growth, which is

Sugarcane yields in tons / ha

	Cayenne	St. Laurent
Year and cut	Soils with vertical free drainage on crystalline basement rock	Soils on slightly weathered material of the Lelydorp formation
1976 2nd cut	65	56
1977 1st, 2nd 3rd cuts	80	73
	Acarouany	
	Soils with blocked vertical drainage on crystalline basement rock	Soils on slightly weathered material of the Zanderij formation
1977-78 2nd cut	74	114
1978 1st cut	80	102

directly related to the type of profile development.

Several agronomic trials are presently being carried out by IRAT, ORSTOM and INRA. These trials, however, are quite insufficient to be able to define the agricultural potential of the various soil types or to indicate a technology to be adapted for their development and use. However, the data on page 47 may give some idea. They have been obtained from trials by IRAT, the results of which are in press now.

The relatively high yields for the Acarouany Zanderij formation soils are due to recent clearing (1st year of cultivation); surface water infiltration problems have not yet shown up.

The response of the sugarcane (leaf analysis) to the chemical status of the soils of the Zanderij formation shows deficiencies, firstly in potassium and secondly in phosphate. No nitrogen deficiency has been observed. Trace elements seem to cause some problems.

CONCLUSIONS

The acid soils of French Guiana, situated on uplands or on the ancient coastal plain, show considerable pedological variation. These soils fit in a weathering sequence by which a soil mantle with favourable physical properties is changed into one marked by unfavourable physical characteristics, i.e. excessively drained, sandy profiles or a deficient internal drainage. These soil variations have important agronomic consequences. Although in French Guiana the morphology, physico-chemical features, and the dynamics of the soils of the Zanderij formation, Lelydorp formation and crystalline basement rock, are now well understood, information from agronomic trials still is insufficient for any sound forecast as to their cultivation.

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WORKSHOP ON THE

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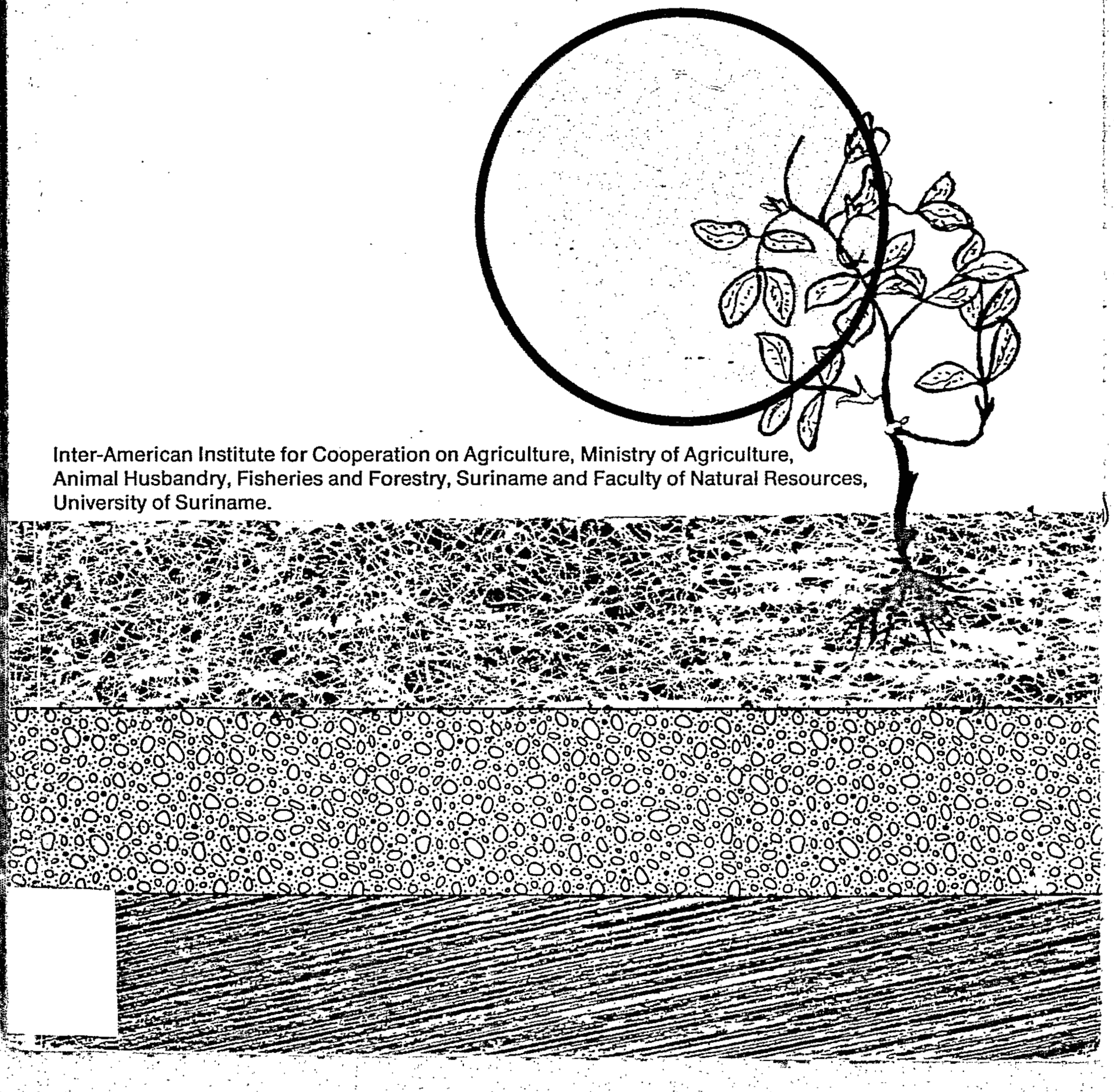

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