Tropeptic Haplustox: Major soils of the plains of Riberalta-Guayaramerín in northeastern Bolivia[1,2]

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ABSTRACT

Major soils of the plains of the Riberalta-Guayaramerín region in northeastern Bolivia are probably Tropeptic Haplustox. They are highly weathered, leached, very deep, well drained and porous, and have strong structural stability. Colors are yellow to red. Iron concretions and plinthite are an evident feature in some B horizons. The soils are strongly acid and low in CEC and bases. Inherent fertility is extremely low, but physical properties and topography favor the development of an intensive, permanent agriculture, if the soils are adequately managed.

INTRODUCTION

The Department of Beni, in eastern Bolivia, with 21 million hectares of land and fewer than 250,000 inhabitants, offers a vast potential for agricultural development (3, 6). The great natural resources of Beni, apart from possible mineral resources, are its climate and soils. The tropical and subtropical climate would permit continuous year round cultivation if floods during the rainy season could be controlled and irrigation provided during the dry season.

In the Riberalta-Guayaramerín area, in the northeast, Oxisols prevail. Even with fertility handicaps, if properly managed, they could be productive and contribute positively to the development of the economy of the region.

This paper describes major soils of the region and provides some quantitative data on soil properties in an attempt to classify the soils on the basis of U.S. Soil Taxonomy (7, 8).

PHYSICAL GEOGRAPHY

The Riberalta-Guayaramerín area is located in northeastern Bolivia within the Yata Canton, province of Vaca Diez, Department of Beni (fig.

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1). It lies approximately at lat. 10°48′ S. and long. 65°22′ W. Altitude ranges from 170 to 190 m. Mean rainfall is around 1434 mm. The rainy season extends from October to April, with 85% of the total rainfall in that period. Rains of 49 to 105 mm in 24 h have been registered from December to March. The dry season extends from May to September; the driest months are June, July and August. Relative humidity is 80 to 85% in the rainy season; 61 to 76% in the dry season. Mean annual temperature is around 25.7° C. Mean minimum temperature ranges from 16 to 20° C; mean maximum from 33 to 37° C. Potential evapotranspiration has been estimated to be 14.39 m^3/ha/yr (2).

Parent materials are Quaternary sediments, mostly unconsolidated, of gravel, sand and clay; also with coarse conglomerates of sandstone and quartzite bound by iron oxides.

In general, the area can be considered as part of an ancient alluvial plain that is strongly dissected with smoothly sloping terraces, slightly irregular topography covered with trees. The San Fernando and El Tigre creeks and the deep and large Beni, Madre de Dios and Mamoré Rivers are the natural drainage outlets of the area.

Natural vegetation is typical of lowlands. It is either humid, subtropical forest or humid tropical forest. There is pioneer forest on the river banks, "bajío"[4] forest on depressions, old secondary forest on the highest parts of the terraces and wetland forests (4).

Most of the land is virgin with only a few "chacos"[5] under shifting cultivation, mostly cassava, corn, rice and beans.

MATERIALS AND METHODS

Soil profiles were examined at various locations both in pits dug for the purpose and from roadcuts. They were described following USDA Soil Conservation Service guidelines. Mechanical analyses were made by the Boyoucus method (5). The pH was determined electrometrically in a 1:5 solution; P by the modified Olsen method; organic matter by potassium dichromate titration; CEC, Ca, Mg, Na and K by leaching with NH_4OAc and by atomic absorption; exchangeable Al by extraction with 1*N*KCl and titration (1); electrical conductivity in a 1:5 solution with a standard solubridge.

RESULTS

MORPHOLOGICAL PROPERTIES OF THE SOILS

Eight soil profiles were examined at various sites. Complete descriptions of two typical profiles are included in this section.

[4] Low spots on the forest land typical of the Bolivian plains.

[5] Relatively small areas where forest trees are cut and burnt and the land is cropped for 1 or 2 years and the regrowth allowed to develop.

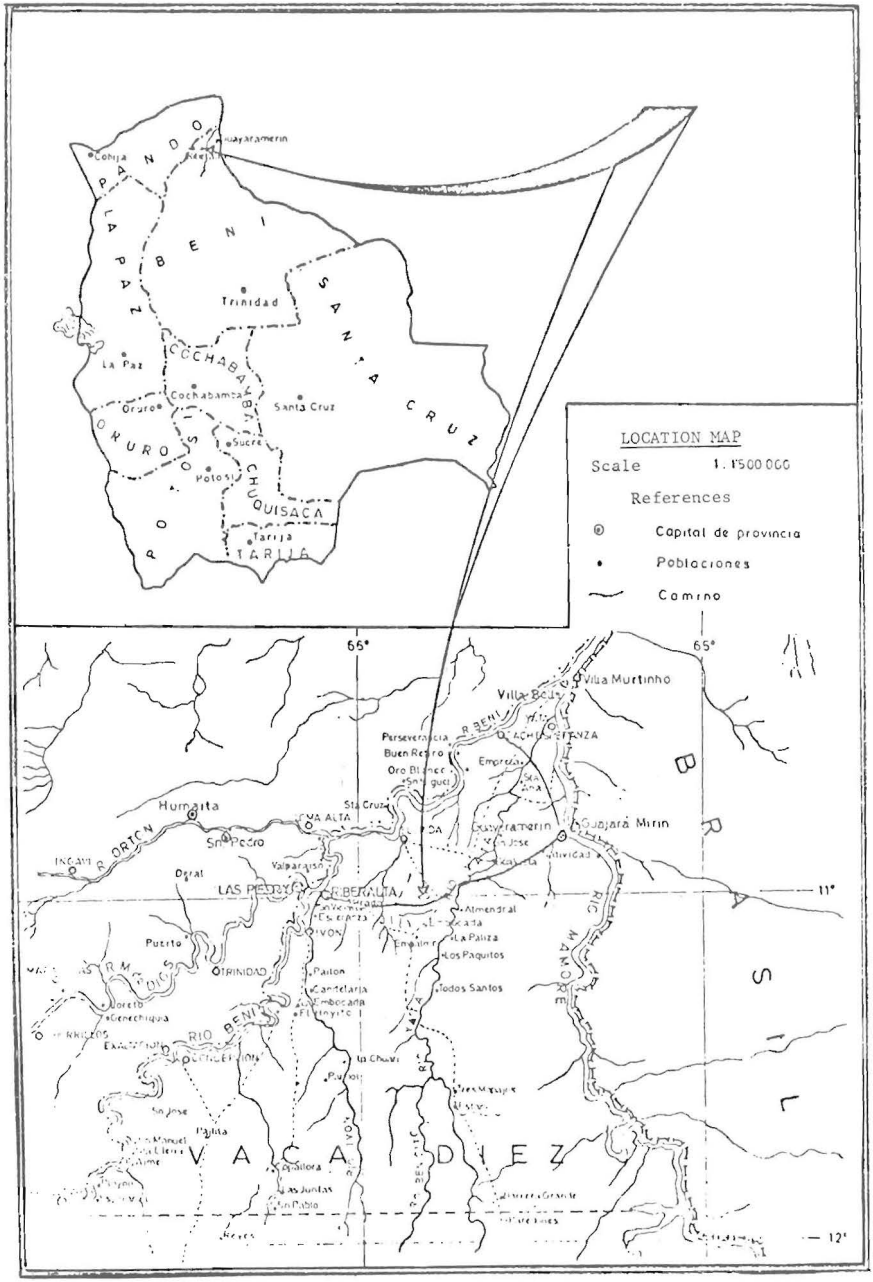

FIG. 1.—Sketch map showing location of the Riberalta-Guayaramerín region in northeastern Bolivia.

A soil profile was examined on the grounds of the new experiment station farm on Riberalta. It was identified as El Maral series. Slopes were not greater than 2%. The soil was formed on old sediments, it was deep with hardly any horizonation. Native vegetation is forest. The profile (No. 1) is as follows:

Horizon	*Depth, cm*	*Description*
A_{00}	0–2	Undecomposed forest litter.
A	2–10	Yellowish red (5YR 5/8) when dry and (5YR 5/6) when wet; sandy clay loam; subangular blocky structure, medium, moderate; friable, slightly firm; many fine and medium pores; insect and rodent nests; abundant fine and medium roots; very strongly acid; boundary gradual and smooth.
A_2	10–45	Yellowish red (5YR 5/8) when dry and (5YR 5/6) when wet; sandy clay loam; subangular blocky structure, fine, firm; friable, slightly firm; frequent fine and very fine pores; insect nests; common, fine roots; strongly acid; boundary gradual and smooth.
B_2	45–150	Red (2.5YR 5/8 when wet and 2.5Y5 5/6) when dry; sandy clay loam; subangular blocky structure, fine, moderate; friable, firm, very fine frequent pores; rounded, discontinuous iron nodules, vesicular; few fine roots; moderately acid; boundary gradual and smooth.

Variations in the series include sandy loam A_2 horizons and others caused by moderate erosion where slopes are steeper than 2%.

A second profile was described and identified as El Tigre. It occurs in terraces at a lower level than the previously described series. The land is mostly level with occasional depressions. Native vegetation is mainly herbaceous in association with scant forest trees.

The profile (No. 2) is as follows:

Horizon	*Depth, cm*	*Description*
A_{00}	0–3	Undecomposed forest litter.
A_2	3–20	Light yellowish brown (10YR 6/4) when dry, dark brown (7.5YR 5/6) when

Horizon	*Depth, cm*	*Description*
		wet; sandy loam; subangular blocky structure, medium, moderately developed; slightly firm; many fine and medium pores; insect nests; abundant fine and medium roots; very strongly acid; boundary gradual and smooth.
A_2	20–45	Reddish yellow (7.5YR 6/8) when dry, brownish yellow (10YR 6/8) when wet; loamy sand; subangular blocky structure, medium, moderate; very slightly sticky, friable, slightly firm; frequent pores; insect nests; common fine roots; strongly acid; boundary gradual and smooth.
B_2	45–150	Yellow (10YR 7/8) when dry, reddish yellow (7.5YR 6/8) when wet; sandy loam; blocky subangular structure, medium, moderate; slightly sticky, slightly plastic, friable, slightly firm; very fine frequent pores; few fine roots; moderately acid.

Variations of the series include some soils with externally and internally restricted drainage.

Six other profiles examined at the old Riberalta Station site and along the Riberalta-Guayaramerín road show only slight variations from the two typical profiles described previously. In one case, the 0–10 cm A horizon consists of dark reddish brown clay, but the rest of the profile conforms to the description of profile 1. Another profile along the Riberalta-Guayaramerín road has a 14–50 cm sandy clay light yellow horizon. Still a third profile 15 km north of Riberalta is mostly clayey throughout the 0–58 cm depth with predominantly yellow colors. In others plinthite was observed, while still in others a hard iron crust was a predominant feature.

PHYSICAL PROPERTIES

Table 1 gives data on particle size distribution of some of the soils of the Riberalta-Guayaramerín area. They range from 18 to 24% clay which increased only slightly with depth. Sand was over 60% in all layers of El Maral series; over 70% in El Tigre. Silt content was twice as high in El Maral as in El Tigre soils. On the basis of these values and the nature of the soils, it is to be expected that bulk density values will be above 1.4 or 1.5 g/cm^3. Water retention values, at various tensions, are likely to be

TABLE 1.—*Particle-size distribution of soils of the Riberalta-Guayaramerín region in northeastern Bolivia*

Soil series	Horizon	Depth	Sand	Silt	Clay
		Cm		%	
El Maral	A_1	0–10	65	14	21
	A_2	10–45	63	14	23
	B_2	45–150	63	13	24
El Tigre	A_1	0–20	76	6	18
	A_2	20–45	73	7	20
	B_2	45–150	73	7	20

similar to those measured for the Bayamón sandy loam of northern Puerto Rico (9, 10).

CHEMICAL PROPERTIES

Table 2 gives data on CEC; exchangeable Ca, Mg, K, Na and Al; available P, pH, and organic matter levels. Data from the A horizon of La Pampa, Guayaramerín, Tomichucua, Cachuela, Esperanza, and Florida series can be summarized as follows:

Parameter	*Range of values*
CEC	1.29–4.28 meq
Exchangeable Ca	.2–2.8 meq
Exchangeable Mg	.1–.6 meq
Exchangeable Na	.13–.16 meq
Exchangeable K	.06–.43 meq
Exchangeable Al	.3–2.5 meq
Acidity	.3–3.0 meq
Base saturation	15–43%
P	.3–4.5 p/m
Organic matter	1.20–4.14%
pH	3.5–5.5

In general, typical soils of the Riberalta-Guayaramerín region of northeastern Bolivia have a very low CEC. Values range from less than 2 to 4.3 meq in El Maral; from 2.2 to 2.8 meq in El Tigre. Exchangeable Ca, Mg, K and Na are extremely low in all cases. Sum of bases is thus very low: less than 1. Exchangeable acidity is high. Values reported for exchangeable Al are rather high; i.e., in El Maral it is 1.1 meq out of a CEC of 4.28 meq. Predominantly low pH values indicate extremely high acidity. Organic matter levels are around 2% in the A horizon decreasing to 1.2% in the A_2. Available P is 0.5 p/m or less for all depths in El Maral and El Tigre soils. It ranges from 0.3 to 4.5 p/m in other surface soils.

TABLE 2.—*CEC, exchangeable Ca, Mg, Na, K, and Al, available P and electrical conductivity, pH, and organic matter of soils of the Riberalta-Guayaramerín region in northeastern Bolivia*

Soil series	Horizon	Depth	CEC	Ca	Mg.	Na	K	Al	P	Electrical conductivity	pH	Organic matter
					meq/100 g of soil							
		Cm			*Meq.*				*P/m*	*Mmhos/cm.*		%
El Maral	A_1	0–10	4.28	0.6	0.1	0.06	0.12	3.4	0.5	27	4.3	2.0
	A_2	10–45	3.13	0.7	0.1	0.06	0.07	2.2	0.3	15	4.6	1.2
	B_2	45–150	1.91	0.6	0.1	0.06	0.05	1.1	0.5	13	5.4	—
El Tigre	A_1	0–20	2.81	0.6	0.1	0.06	0.05	2.0	0.5	25	4.7	2.6
	A_2	20–45	2.71	0.6	0.1	0.06	0.05	1.9	0.5	13	4.8	1.2
	B_2	45–150	2.21	0.7	0.1	0.08	0.04	1.2	0.5	18	5.5	—

DISCUSSION

The soils of the Riberalta-Guayaramerín area can be classified as Oxisols in terms of U.S. Soil Taxonomy. The morphological, physical, chemical and climatic data allow them to be included in the Ustox. They are probably Tropeptic Haplustox (7, 8).

The influence of climatic factors on these soils must be intense resulting in very deep soils from Quaternary sediments, possibly from ancient metamorphic rocks. Colors range from yellow to red. Aggregates tend uniformly to form medium sized subangular blocks. The structural development is moderate but becomes stronger with depth. Texture is mostly sandy clay loam. Clay is not dominant throughout the profile.

Accentuated in these soils is porosity which provides for adequate air and water diffusion. Soil consistency does not impede root penetration.

In some cases, there are iron concretions in the B horizon that do not quite yet form a hard crust. In some of the profiles, other than El Maral and El Tigre series, plinthite was present. In some profiles a hard iron crust was observed.

It was not possible to measure the content of Fe and Al oxides, but it can be safely assumed on the basis of prevailing climatic conditions, soil colors and friability that Fe and Al oxides are high. On the same basis, because of the low CEC, it can be assumed that kaolinite is predominant in the clay fraction.

The soils are strongly acid; salts are absent; organic matter levels are low and CEC and exchangeable bases are low. Therefore, these soils must be strongly weathered and leached. Inherent fertility is extremely low. Physical properties appear to be favorable with rapid apparent infiltration and hydraulic conductivity. The topography will allow full mechanization.

Soil conditions can be improved markedly through liming and rational fertilization. Then, the soils will be suitable for a variety of crops in addition to the traditional rubber and Brazil nuts now grown extensively. If properly managed, good crops of corn and cassava are feasible. The soils are also suitable for intensive forage crop production.

The production of vegetable crops at the Riberalta-Guayaramerín region offers distinct possibilities. Such crops as watermelons, tomatoes and peppers can do well. The possibilities of pineapples, acerolas, grapefruits, oranges and peanuts should be evaluated if marketing problems can be solved.

RESUMEN

En la región de Riberalta-Guayaramerín, en el Departamento de Beni, noreste de Bolivia, predominan los Oxisols. A base de sus características morfológicas, químicas y físicas, estos suelos pueden clasificarse siguiendo las normas del Sistema de Taxonomía de Suelos de los Estados Unidos,

como Ustox; muy probablemente son Tropeptic Haplustox. Son suelos bien profundos, de buen desagüe, muy meteorizados y lavados, porosos, con una fuerte estabilidad estructural. Predominan los colores amarillos a rojos. En algunos perfiles, las concreciones de hierro o la plintita son características del horizonte B. Los suelos son muy ácidos y bajos en capacidad de cambio y en bases cambiables. La fertilidad inherente es muy baja, pero las características físicas y la topografía favorecen el desarrollo de una agricultura intensiva y permanente si los suelos se tratan adecuadamente.

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