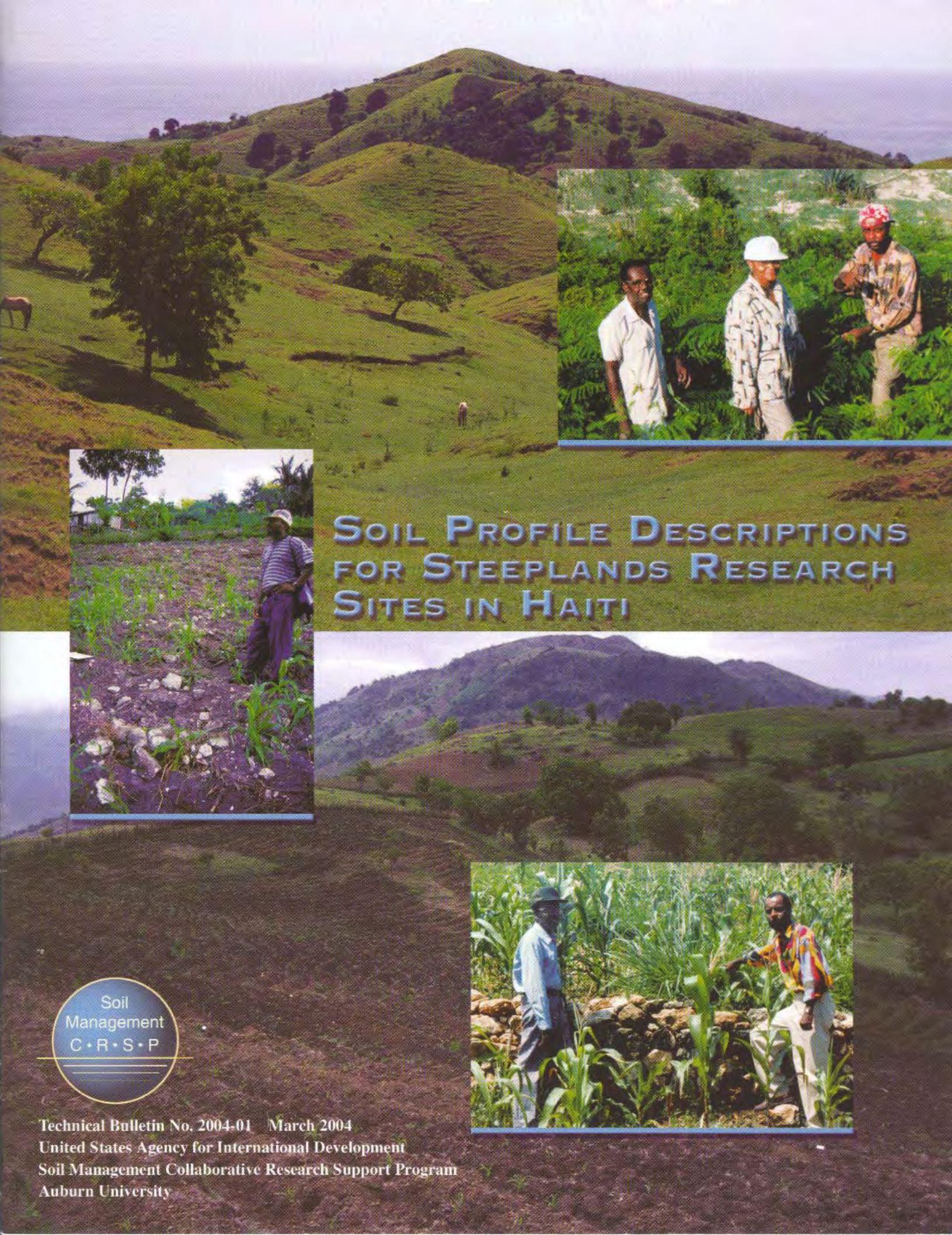

Soil Profile Descriptions for Steeplands Research Sites in Haiti

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SOIL PROFILE DESCRIPTIONS FOR STEEPLANDS RESEARCH SITES IN HAITI

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COVER. Top: Landscape at Saint Georges, southern Haiti. These soils, formed over basalt, are prone to sloughing. They have poor water-holding capacity and are infertile in their native state. They respond well to fertilizer and can be productive if properly managed. Bottom: Site of phosphorus and potassium fertilizer study at St. Georges. Insets, clockwise from top right: Gérard Alexis, Carine Bernard, and Lionel Isaac in hedgerow species study at Saint Georges. Gérard Alexis and Lionel Isaac in front of rock wall soil conservation barrier at Pernier, Haiti. Lithic Hapludoll over limestone bedrock at Bergeau, southern Haiti, site of phosphorus and potassium fertilizer response study. Shown is Delva Josène.

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SOIL PROFILE DESCRIPTIONS FOR STEEPLANDS RESEARCH SITES IN HAITI

INTRODUCTION

Research data must be examined in relation to accurate descriptions of the environment to provide for consistent interpretation and to make sound recommendations for specific sites. The information provided here can be used as a reference to characterize soils for the research sites of the Soil Management CRSP Project **Soil Management Practices for Sustainable Production on Densely Populated Tropical Steeplands**, herewith referred to as the "Steeplands Project." The Steeplands project began its activities in Haiti in 1997. Those activities include trials initiated in 1991 under the USAID/Haiti Agroforestry II Project (AFII) and continued under the Productive Land Use Systems (PLUS) Project, as well as new trials established in 1997 and 1998. The Pernier site was selected to represent low elevation upland sites; Saint Georges was selected to represent low elevation basaltic soils; Bergeau was selected to represent low elevation calcareous soils; and Fort Jacques and Salagnac were selected to represent mid- to high-elevation soils associated with limestone. The Fort Jacques site averages around 1,160 millimeters (mm) rainfall annually, while Salagnac averages are double that amount. The Titanyen site was selected to represent low elevation semi-arid conditions.

The trials located at the sites described below were designed to study the use of the agroforestry practice known as alley cropping as a means to sustain or improve soil productivity in hillside agriculture. One study compared biomass productivity of different hedgerow species under a regular pruning regime under different conditions of elevation (temperature), rainfall, and soil characteristic. The sites for this trial were Fort Jacques, Bergeau, Saint Georges, and Titanyen. Studies comparing in situ decomposition rates of most productive species were conducted at Fort Jacques and Bergeau, and in vitro decomposition studies were conducted with soils from these two locations and also from Saint Georges. This trial was followed by a second high-elevation hedgerow species trial currently underway at Salagnac and on-farm trials at Gaïta and Bannate. Data on physical and chemical properties and soil descriptions are not available for Gaïta and Bannate.

A trial located at Pernier was designed to determine appropriate management of leucaena hedgerows in order to sustain crop yields in an alley cropping system. The trial also is used to study nitrogen (N) cycling in alley cropping. A second trial at Pernier compares alley cropping with other soil conservation practices in terms of sustained crop production. Instrumentation was installed to determine the effectiveness of alley cropping at reducing runoff and soil loss from these plots.

A series of trials was initiated in 1998 to study phosphorus (P) and potassium (K) response in relation to biomass applications from alley cropping and in relation to soil properties. Sites selected for these trials were Pernier and Bergeau (limestone-based soils), Saint Georges (basalt), and Salagnac (high elevation highly weathered soils).

The soil descriptions and site information included in this report may be used to relate the results of the Steeplands trials to research carried out under the SECID/Auburn University PLUS Project, as well as the Steeplands Project. Five reports have been published on data from the PLUS Project (Shannon and Isaac, 1993; Isaac *et al.*, 1994; Isaac *et al.*, 1995; Isaac *et al.* 1996, Shannon *et al.*, 2001). Additional data is published in Shannon *et al.* (2003), Isaac *et al.* (2003 a, b), Isaac 2001, Isaac *et al.* (2000), Shannon *et al.* (1997) as well as in numerous abstracts published by the American Society of Agronomy. The SECID/Auburn Agroforestry Report No. 16 (Guthrie *et al.*, 1990) provides soil descriptions from a number of sites throughout Haiti. Some of the current descriptions were included in SECID/Auburn PLUS Report No. 29 (Guthrie *et al.*, 1995).

METHODS

The soils examined were described using soil description sheets from the Natural Resources Conservation Service of the U.S. Department of Agriculture. This form was adapted to fit the conditions in Haiti. Some of the items that were irrelevant were eliminated while other information was added. For example, because information on ***soil characteristics*** is not available, we replaced it with data from the geological map units taken from the Organization of American Studies Geology Map for Haiti (Geologie, Republique d'Haiti, 1972). For ***area***, we indicated the name of a major town or village, followed by the department (state) name. The date the soil was described was recorded. A preliminary classification of the soil was made in the field. Soil samples were taken by horizon for physical and chemical analyses. In a few instances, the tentative ***soil classification*** conducted in the field was revised according to the results of the laboratory analyses. ***Location*** includes the locality where the field is situated and the distance from a known landmark. Natural vegetation, crops, and crop association were described. The ***parent material*** refers to the geological material from which the soil developed. If parent material is known, it is often possible to have an indication of the fertility constraints that are present or which may occur. The following physiographic data were recorded: description of landform, slope, altitude, and aspect. ***Slope*** is important in predicting the intensity of the runoff. ***Aspect*** indicates the direction the slope faces and is a measure of how exposed or protected the landform is from solar radiation, dominant winds, and rain. These last two factors are important when evaluating risks for erosion.

Relevant information regarding soil properties specific for each site are also given. ***Drainage***, ***moisture***, and ***permeability*** will be used to assess the soil moisture regime. ***Stoniness*** and ***soil texture*** of the surface, as well as ***root distribution*** and the depth of the soil to a root-restrictive soil layer, are used to identify constraints to land preparation and cultivation. An estimate of the degree of soil erosion is also given and will help assess the urgency of needed soil conservation measures.

After the general site description was completed, a soil profile description by horizon was made from a soil pit. Pits were dug one meter deep, or until the parent material or the bedrock was reached. The horizons were named using standard horizon nomenclature and their thickness was measured. The color is defined as being either "dry" or "moist" using the Munsell soil color chart. The Munsell system includes three variables: the ***hue***, ***value***, and ***chroma***. The hue indicates the relation of the color to red, yellow, green, blue, and purple (Munsell color chart manual) and is generally linked to the form of the iron in the soil. Within each hue, the value indicates its lightness and the chroma its strength. For practical purposes, the lower the chroma and the value, the higher the organic matter content. ***Texture*** (particle size distribution) is estimated in the field, but soil samples taken in the field were also analyzed in the laboratory for their content of clay, silt, and sand. Based on these results the exact textural classes can be defined. ***Structure*** is described by grade, or distinctness, size, and type of soil aggregates. ***Consistence*** is a measure of a soil's ability to adhere or cohere, that is, to resist deformation or rupture. These last three properties combined provide a good estimate of the soil moisture regime, which is very important when considering plant vulnerability to moisture stress and drought. Structure and consistence also affect root penetration, which will affect tree establishment and growth as well as efficiency in conserving soil.

The reaction of the soil to hydrochloric acid tests the presence of free calcium carbonate, an indicator of high pH. This is a very important aspect of site specific tree selection because some plants are extremely sensitive to nutrient deficiencies resulting from high pH, whereas others are tolerant. This test is very simple and can be performed in the field by extension personnel.

Laboratory Procedures

Particle size distribution was determined by the pipette method and dry sieving (Soil Survey Staff, 1991). Cation exchange capacity (CEC) of whole soil (less than two mm) was determined by extraction with pH 7.0, 1 M NH4 OAc, replacement with 1 M KCl and titration (Soil Survey Staff, 1991). Soil solutions were obtained by extraction with the Mississippi solution and analyzed for P, K, calcium (Ca), and magnesium (Mg) according to standard procedures of the Auburn University Soil Testing Laboratory (Hue and Evans, 1986). Organic matter was determined by the Walkley and Black method (Black, C.A., *et al.*, 1965). Available water capacity was determined gravimetrically for the soils sampled in 1995, but was not determined for the soils sampled in 1998. X-ray diffraction analyses were used to identify the mineralogical basis for the high CEC values at Fort Jacques, Saint Georges, and Pernier.

Presented below are the analyses for each site. These data will be used in relation to production data in the future. This analysis will provide generalizations about the best soil and tree species combinations. Most measurements are presented in metric units and are abbreviated as follows: meter (m), centimeter (cm), millimeter (mm), and kilometer (km). "Département," when used in reference to the area, is the equivalent of a state. "O.M" listed in the tables is organic matter and "nm" represents not measured.

SOIL DESCRIPTIONS

Fort Jacques, Département de l'Ouest
Hedgerow Species Trial, Mid-elevation Site

SITE DESCRIPTION

Soil Series: Fort Jacques
Map Unit, Symbol: Omc Name: Formations Madame Joie et La Crete
Classification: Typic Hapludalfs, clayey-skeletal, kaolinitic, isohyperthermic
Area: Fort Jacques - Département de L'Ouest, Commune de Kenscoff
Location: Greffin - 3.7 miles (6.0 km) from Baptist Mission, Fermathe
Latitude: 18° 29'N Longitude: 72°15'W
Climate: Humid tropical
Use and Vegetation: Low elevation mountain humid forest; PLUS Project hedgerow species trials
Parent Material: Colluvium from siliceous limestones and argillaceous shales
Landform: Mountain
Topography, Percent Slope: Very steep, 30-45% slope
Elevation: 1,150-1,200 m Aspect: North
Drainage: Well drained Permeability: Moderate
Moisture: Udic Stoniness: Class 0
Depth to Root-restrictive Layer: 125 cm
Degree of Erosion: Very severe
Sampled and Described by: Richard Guthrie, Gerard Alexis, Lionel Isaac, Marguerite Blemur, Carine Bernard
Date: 3/8/95
Comments: Alley-cropping research site. In the year before the trials, this site was planted to beans, cassava, and sweet potatoes. Annual rainfall averages about 1,142 mm.

PROFILE DESCRIPTION

Ap1 - 0 to 17 cm; dark reddish brown (5YR 3/2) clay; moderate fine granular structure; friable; common fine roots; less than 15% coarse fragments; neutral; abrupt smooth boundary.

Ap2 - 17 to 28 cm; dark red (2.5YR 3/6) clay; strong fine subangular blocky structure; friable; common fine roots; less than 15% coarse fragments; mildly alkaline; abrupt smooth boundary.

Bt1 - 28 to 42 cm; dark red (2.5YR 3/6) gravelly clay; strong fine subangular blocky structure; friable; many coarse roots; 25% coarse fragments <7.5 cm in diameter; neutral; abrupt wavy boundary.

Bt2 - 42 to 64 cm; red (2.5YR 4/8) very gravelly clay; strong fine subangular blocky structure; friable; common fine roots; 40% coarse fragments <7.5 cm in diameter; moderately alkaline; abrupt wavy boundary.

Bt3 - 64 to 125 cm; red (2.5YR 4/8) very gravelly clay; moderate fine subangular blocky structure; friable; 50% coarse fragments <7.5 cm in diameter; moderately alkaline.

PARTICLE SIZE ANALYSIS

Horizon	Particle Size			Textural Class	H_2O Avail.
	Sand	Silt	Clay		
		%			cm/cm
Ap1	11.25	33.75	55.00	Clay	0.22
Ap2	6.25	26.25	67.50	Clay	0.23
Bt1	3.75	18.75	77.50	Clay	0.24
Bt2	8.75	6.25	85.00	Clay	0.22
Bt3	25.00	7.50	67.50	Clay	0.18

SOIL TEST RESULTS[1]

Horizon	pH	Phosphorus	Potassium	Magnesium	Calcium	CEC	O.M.
		Mg ha^{-1}				$cmol_c$ kg^{-1}	%
Ap1	6.8	.0146	.2324	.4872	14.3248	49.03	8.9
Ap2	6.8	.0090	.1859	.2106	9.3968	37.73	5.0
Bt1	7.0	.0056	.2106	.1187	9.8000	37.63	3.6
Bt2	7.7	.0045	.2815	.0974	19.4272	39.83	2.5
Bt3	8.0	.0090	.2531	.1322	15.0528	29.93	2.1

[1] Previous reports (Guthrie *et al.*, 1990) reported cations in parts per million (ppm). To convert ppm to tonnes per hectare (Mg ha^{-1}), multiply by 0.00224.
To convert cations to $cmol_c$ kg^{-1}:
Ca: divide Mg ha^{-1} by 0.224
Mg: divide Mg ha^{-1} by 0.134
K: divide Mg ha^{-1} by 0.437
The difference between the sum of K, Mg, and Ca and the CEC is largely due to free Ca in the form of $CaCO_3$. Approximate values for exchangeable Ca may be obtained by differences.

Bois Greffin, Pernier, Département de l'Ouest
Site of Hedgerow Management and Soil Conservation Barrier Studies

SITE DESCRIPTION

Soil Series: Bois Greffin, Pernier
Map Unit, Symbol: Tm Name: Miocene, sables, gres, conglomerates
Classification: Lithic Eutropepts, fine, mixed, isohyperthermic
Area: Commune de Pétion Ville
Location: 4.9 miles (7.9 km) northeast of Petionville
Latitude: 18°N Longitude: 72°30'W
Climate: Humid tropical
Use and Vegetation: Low Elevation Mountain Forest; PLUS Project soil conservation trials
Parent Material: Limestone
Landform: Mountain
Topography, Percent Slope: Steep, 25% slope
Elevation: 250 m Aspect: North
Drainage: Well drained Permeability: Moderate
Moisture: Udic Stoniness: Class 0
Depth to Root-restrictive Layer: 40 cm
Degree of Erosion: Severe
Sampled and Described by: Richard Guthrie, Lionel Isaac, Gerard Alexis, Carine Bernard
Date: 5/11/95
Comments: In previous years, maize, cassava, and pigeon pea had been planted in the first rainy season followed by carrots and sweetpotato in the second season. During the last three years prior to establishing the trials, carrots and lima bean had been planted in the second rainy season followed by a fallow period with pasture. Average(mean) annual temperature is 27.5°C and mean annual rainfall is 1,318 mm.

PROFILE DESCRIPTION

Ap - 0 to 24 cm; dark brown (7.5YR 3/2) gravelly clay; weak fine granular structure; very friable; more than 15% coarse fragments; many fine roots; moderately alkaline; abrupt wavy boundary.
B - 24 to 40 cm; dusky red (2.5YR 3/2) gravelly clay; weak very fine subangular blocky structure; friable; more than 15% coarse fragments >7.5 cm in diameter; common fine roots; moderately alkaline; abrupt wavy boundary.
R - 40+ cm; white (10YR 8/1).

PARTICLE SIZE ANALYSIS

Horizon	Particle Size			Textural Class	H_2O Avail.
	Sand	Silt	Clay		
		%			cm/cm
Ap	22.50	37.50	40.00	Clay loam	0.19
B	28.75	26.25	45.00	Clay	0.17
R	——	——	——	——	——

SOIL TEST RESULTS

Horizon	Ph	Phosphorus	Potassium	Magnesium	Calcium	CEC	O.M
			Mg ha^{-1}			$cmol_c$ kg^{-1}	%
Ap	8.0	.0157	.5163	.8411	111.9888	58.05	10.0
B	8.1	.0157	.4514	.6037	17.3376	45.17	7.7
R	——	——	——	——	——	——	——

Bois Greffin, Pernier, Département de l'Ouest
Study of Effects of P, K, Zinc (Zn), and Leucaena Biomass on Maize Yields, Reps 1, 2

SITE DESCRIPTION

Soil Series: Bossa Trial 1:
Map Unit, Symbol: Tm Name: Miocene, sables, gres, conglomerates
Classification: Lithic Hapludolls, loamy, carbonatic, superactive, isohyperthermic
Area: Commune de Pétion Ville
Location: Pernier - 4.9 miles (7.9 km) northeast of Petion Ville
Latitude: 18° N Longitude: 72° 30' W
Climate: Humid tropical
Topographic Quadrangle Name: Joint Operations Ground (Graphic)
Use and Vegetation: Low Elevation Mountain Forest; Soil Management CRSP trials-corn
Parent Material: Limestone
Landform: Mountain
Topography, Percent Slope: Steeply sloping, 35% slope
Elevation: 250 m Aspect: N
Drainage: Well Permeability: Moderate
Moisture: Udic
Depth to Root-restrictive Layer: 15 cm
Degree of Erosion: Severe
Sampled and Described by: R. Guthrie and Jean Rene Bossa
Date: 12/12/98
Comments: Depth to hard bedrock ranges from 10 to 20 cm; this pedon represents replicates 1 and 2 in Bossa Trial 1; the soil contains more than 35% coarse fragments throughout.

PROFILE DESCRIPTION

Ap - 0 to 15 cm; very dark grayish brown (10YR 3/2) clay loam; moderate fine subangular blocky structure; friable; many fine roots; >35% coarse fragments <7.5 cm; violent effervescence; 7.3-7.8; abrupt wavy boundary.

PARTICLE SIZE ANALYSIS

Horizon	Particle Size			Textural Class
	Sand	Silt	Clay	
		%		
Ap	1.51	53.88	44.61	Clay Loam

SOIL TEST RESULTS

Horizon	pH	Phosphorus	Potassium	Magnesium	Calcium	CEC	O.M.
			Mg ha^{-1}			$cmol_c$ kg^{-1}	%
Ap	7.90	.0067	.7179	.9519	nm	49.84	12.3

Bois Greffin, Pernier, Département de l'Ouest
Study of Effects of P, K, Zinc (Zn) and Leucaena Biomass on Maize Yields, Reps 3, 4

SITE DESCRIPTION

Soil Series: Bossa Trial 2:
Map Unit, Symbol: Tm Name: Miocene, sables, gres, conglomerates
Classification: Cumulic Hapludolls, loamy-skeletal, mixed, superactive, isohyperthermic
Area: Commune de Pétion Ville
Location: 4.9 miles (7.9 km) northeast of Petionville - Pernier - Bossa Trial 2
Latitude: 18° N Longitude: 72° 30' W
Climate: Humid tropical
Topographic Quadrangle Name: Joint Operations Ground (Graphic)
Use and Vegetation: Low Elevation Mountain Forest; Soil Management CRSP trials - corn
Parent Material: Limestone
Landform: Alluvial fan
Topography, Percent Slope: Gently sloping, 6% slope
Elevation: 250 m Aspect: N
Drainage: Well Permeability: Moderate
Moisture: Udic
Depth to Seasonal High Water Table: > 1.5 m
Depth to Root-restrictive Layer: >1.5 m
Degree of Erosion: Slight
Sampled and Described by: Richard Guthrie and Jean René Bossa
Date: 12/12/98

PROFILE DESCRIPTION

Ap - 0 to 25 cm; very dark gray (10YR 3/1) clay loam; weak fine subangular blocky structure; friable; contains >15% coarse fragments; many fine roots; violent effervescence; mildly alkaline; clear wavy boundary.

IIApb - 25 to 55 cm; very dark grayish brown (10YR 3/2) loam; weak fine subangular blocky structure; friable; contains >35% cobbles; violent effervescence; common fine roots; mildly alkaline; clear wavy boundary.

IIIC1 - 55 to 90 cm; dark brown (10YR 4/3) clay loam; massive; firm; contains 15-35% coarse fragments; violent effervescence; few fine roots; mildly alkaline; clear smooth boundary.

IIIC2 - 90 to 150 cm; dark yellowish brown (10YR 4/4) clay loam; massive; firm; contains 15 - 35% coarse fragments; >15% calcium nodules; violent effervescence; mildly alkaline.

PARTICLE SIZE ANALYSIS

Horizon	Particle Size			Textural Class
	Sand	Silt	Clay	
		%		
Ap	16.27	65.70	18.03	Loam
IIApb	18.33	62.72	18.95	Loam
IIIC1	15.39	66.10	18.51	Loam
IIIC2	16.86	64.65	18.49	Loam

SOIL TEST RESULTS

Horizon	pH	Phosphorus	Potassium	Magnesium	Calcium	CEC	O.M.
		Mg ha^{-1}				$cmol_c$ kg^{-1}	%
Ap	8.02	.0647	.1839	.5373	nm	22.06	5.3
IIApb	8.01	.0318	.1926	.3109	nm	21.21	5.0
IIIC1	8.06	.0264	.1663	.2209	nm	20.67	4.8
IIIC2	7.99	.0235	.1576	.1964	nm	19.76	4.7

Titanyen, Département de l'Ouest
Hedgerow Species Trial, Semi-arid Site

SITE DESCRIPTION

Soil Series: Titanyen
Map Unit, Symbol: Tm Name: Miocene; sables, gres, conglomerates
Classification: Lithic Petrocalcic Calciustolls, loamy, mixed, isohyperthermic
Area: Département de L'Ouest, Commune de Cabarêt
Location: On the grounds of the Baptist mission camp
Latitude: 18°41'N N Longitude: 73°W
Climate: Semi-arid tropical
Use and Vegetation: Native grasses and shrubs; PLUS Project hedgerow species trials
Parent Material: Limestone colluvium
Landform: Alluvial terrace
Topography, Percent Slope: Gently sloping, 10%
Elevation: 87 m Aspect: West
Drainage: Well drained Permeability: Moderate
Moisture: Moist Stoniness: Class 0
Depth to Root-restrictive Layer: 40 cm
Degree of Erosion: Slight
Sampled and Described by: Richard Guthrie, Lionel Isaac, Gerard Alexis, Carine Bernard
Date: 5/7/95
Comments: The site has not been cultivated in recent history and had a sparse cover of shrubs and grasses. Average annual temperature is estimated to be 28.50C and average annual rainfall is estimated to be 780 mm.

PROFILE DESCRIPTION

A1 - 0 to 8 cm; very dark gray (10YR 3/1) loam; weak very fine granular structure; very friable; common coarse roots; many fine roots; few pebbles; moderately alkaline; abrupt smooth boundary.

A2 - 8 to 40 cm; very dark brown (10YR 2/2) loam; weak very fine granular structure; very friable; Many fine roots; more than 35% coarse fragments <7.5 cm in diameter; moderately alkaline; abrupt wavy boundary.

Bkm - 40 to 60 cm; white (10YR 8/1); massive structure; very hard; fragments are coated with secondary carbonates; cemented; strongly alkaline.

PARTICLE SIZE ANALYSIS

Horizon	Particle Size			Textural Class	H_2O Avail.
	Sand	Silt	Clay		
		%			cm/cm
A1	33.75	41.25	25.00	Loam	0.16
A2	35.00	37.50	27.50	Clay loam	0.16
Bkm	—	—	—	—	—

SOIL TEST RESULTS

Horizon	pH	Phosphorus	Potassium	Magnesium	Calcium	CEC	O.M.
		Mg ha^{-1}				$cmol_c$ kg^{-1}	%
A1	8.1	.0538	.5163	.9867	111.9888	28.04	9.0
A2	8.1	.0403	.3170	.8411	111.7648	28.63	8.6
Bkm	—	—	—	—	—	—	—

Bergeau, Département du Sud
Hedgerow Species Trial, Calcareous Site

SITE DESCRIPTION

Soil Series: Bergeau
Map Unit, Symbol: Te Name: Eocene-Calcaires massiff
Classification: Typic Troporthents, loamy, mixed (calcareous), iso-hyperthermic
Area: Cayes - Département du Sud
Location: About 4.5 miles (7.2 km) East of Les Cayes
Latitude: 18°13'N Longitude: 73°W
Climate: Humid tropical
Use and Vegetation: Low Elevation Humid Mountain Forest; PLUS hedgerow species trials
Parent Material: Limestone
Landform: Upland
Topography, Percent Slope: Steep, 32% slope
Elevation: 70 m Aspect: East
Drainage: Well drained Permeability: Moderately slow
Moisture: Udic Stoniness: Class 0
Depth to Root-restrictive Layer: 22 cm
Degree of Erosion: Severe
Sampled and Described by: Richard Guthrie, Lionel Isaac, Gerard Alexis, Carine Bernard
Date: 5/9/95
Comments: Site was in unimproved pasture for the previous four or five years. Previous to that, sorghum was cultivated in rotation with maize and beans. Average annual temperature is 26.5°C and average (mean) annual rainfall is 1,792 mm.

PROFILE DESCRIPTION

Ap1 - 0 to 7 cm; dark brown (10YR 3/3) clay loam; moderate very fine subangular blocky structure; friable; common fine roots; less than 15 % coarse fragments; moderately alkaline; abrupt smooth boundary.
Ap2 - 7 to 22 cm; dark grayish brown (10YR 4/2) clay loam; moderate fine subangular blocky structure; friable; common fine roots; less than 15 % coarse fragments; moderately alkaline; abrupt wavy boundary.
C - 22 to 72 cm; very pale brown (10YR 8/3); structureless massive; very firm; soft limestone; moderately alkaline.

PARTICLE SIZE ANALYSIS

Horizon	Particle Size			Textural	H_2O
	Sand	Silt	Clay	Class	Avail.
		%			cm/cm
Ap1	33.75	48.75	17.50	Loam	0.16
Ap2	28.75	51.25	20.00	Silt loam	0.17
C	30.00	47.50	22.50	Loam	0.17

SOIL TEST RESULTS

Horizon	pH	Phosphorus	Potassium	Magnesium	Calcium	CEC	O.M.
		Mg ha^{-1}				$cmol_c$ kg^{-1}	%
Ap1	8.0	.0224	.1859	.4637	17.5728	21.09	6.8
Ap2	8.1	.0202	.1422	.3382	17.8864	20.31	5.5
C	8.3	.0134	.0515	.1277	111.9888	6.20	1.9

Bergeau, Département du Sud
Study of P, K, and Leucaena Biomass Effects on Maize

SITE DESCRIPTION

Soil Series: Bossa trials - Bergeau
Map Unit, Symbol: TE Name: Eocene-Calcaires, massiff
Classification: Lithic Hapludolls, loamy, carbonatic, superactive, isohyperthermic
Area: Cayes, Département du Sud
Location: About 4.5 miles (7.2 km) east of Les Cayes
Latitude: 18° 13'N Longitude: 73° W
Climate: Humid tropical
Topographic Quadrangle Name: Joint Operations Ground (Graphic)
Use and Vegetation: Low Elevation Humid Mountain Forest; Soil Management trials, corn
Parent Material: Limestone
Landform: Upland
Topography, Percent Slope: Steeply sloping, 25% slope
Elevation: 70 m Aspect: N
Degree of Erosion: Severe
Sampled and Described by: Jean René Bossa, Greg Mullins, Jean Pierre Roswold Villefranche, Richard Guthrie
Date: 12/15/98
Comments: This research site is near Bergeau Hedgerow Species Trial. A few rock outcrops are present in the field; the soil contains >35% coarse fragments throughout; the soil is violently effervescent throughout.

PROFILE DESCRIPTION

Ap - 0 to 30 cm; very dark grayish brown (10YR 3/2) gravelly clay; moderate finesubangular blocky structure; friable; many fine roots; violent effervescence; mildly alkaline; abrupt, smooth boundary.
R - 30+ cm; Hard limestone.

PARTICLE SIZE ANALYSIS

Horizon	Particle Size			Textural Class
	Sand	Silt	Clay	
		%		
Ap	16.24	68.30	15.46	Silt Loam

SOIL TEST RESULTS

Horizon	pH	Phosphorus	Potassium	Magnesium	Calcium	CEC	O.M.
		Mg ha^{-1}				$cmol_c$ kg^{-1}	%
Ap	7.85	0.0242	.1138	.2291	nm	19.03	5.5

Saint Georges, Département du Sud Hedgerow Species Study, Basaltic Site; Study of P, K, and Leucaena Biomass Effects on Maize

SITE DESCRIPTION

Soil Series: Saint Georges
Map Unit, Symbol: Cb Name: Basaltes, Dolerites et Roches Basique metamorphisees, Cretacee
Classification: Typic Hapludalfs, fine, mixed, isohyperthermic
Area: Cayes - Département du Sud, Commune d'Aquin/Commune de Cavaillon
Location: 26.7 miles (43.0 km) East of Les Cayes
Latitude: 18°15' N Longitude: 73°W
Climate: Humid tropical
Topographic Quadrangle Name: Joint Operations Ground (Graphic)
Use and Vegetation: Low Elevation Humid Mountain Forest, PLUS hedgerow species trials
Parent Material: Basalt
Landform: Mountain
Topography, Percent Slope: Steep, 53% slope
Elevation: 80 m Aspect: North
Drainage: Well drained Permeability: Moderately slow
Moisture: Udic
Depth to Root-restrictive Layer: 90 cm
Degree of Erosion: Very severe
Sampled and Described by: Richard Guthrie, Lionel Isaac, Gerard Alexis, Carine Bernard
Date: 5/10/95
Comments: The site was previously in pasture into which had been planted hedgerows of *Erythrina indica* and *L. leucocephala*. Average annual temperature is 26°C and average annual rainfall is about 1,600 mm.

PROFILE DESCRIPTION

Ap - 0 to 13 cm; dark brown (7.5 YR 4/2) clay loam; moderate very fine subangular blocky structure; friable; many fine roots; few stones; neutral; abrupt wavy boundary.

Bt1 - 13 to 38 cm; very dark grayish brown (10YR 3/2) clay; moderate fine subangular blocky structure; friable; common fine roots; neutral; abrupt irregular boundary.

Bt2 - 38 to 59 cm; dark reddish brown (5YR 3/4) gravelly clay; weak fine subangular blocky structure; friable; more than 15% coarse fragments; more than 50% weathered basalt; neutral; abrupt irregular boundary.

Bt3 - 59 to 90 cm; dark brown (10YR 4/3) clay loam; weak very fine subangular blocky structure; friable; neutral; abrupt wavy boundary.

R - 90+ cm; Basalt rock.

PARTICLE SIZE ANALYSIS

Horizon	Particle Size			Textural	H_2O
	Sand	Silt	Clay	Class	Avail.
		%			cm/cm
Ap	68.75	23.75	7.50	Sandy loam	0.07
Bt1	71.25	18.75	10.00	Sandy loam	0.07
Bt2	76.25	18.75	5.00	Loamy sand	0.05
Bt3	51.25	36.25	12.50	Loam	0.12
R	——	——	——	——	——

SOIL TEST RESULTS

Horizon	pH	Phosphorus	Potassium	Magnesium	Calcium	CEC	O.M.
		Mg ha^{-1}				$cmol_c$ kg^{-1}	%
Ap	7.3	.0034	.1534	10.8102	7.2910	30.44	1.4
Bt1	7.2	.0034	.0515	10.9581	7.4700	37.96	1.5
Bt2	7.3	.0034	.0302	11.1765	6.8100	33.58	0.7
Bt3	7.2	.0022	.0280	11.0880	8.1540	40.26	0.6
R	——	——	——	——	——	——	——

Salagnac, Département de la Grande Anse
Study of P, K, and Leucaena Biomass Effects on Maize
(Note: Hedgerow species trial has similar properties.)

SITE DESCRIPTION

Soil Series: Bossa trial, Salagnac
Map Unit, Symbol: ? Name: ?
Classification: Typic Rhodudalfs, fine, kaolinitic, isohyperthermic
Area: Salagnac, Département de la Grande Anse
Location: Salagnac Research Station; 1.6 miles (2.5 km) W of station
Latitude: 18° 25'N Longitude: 73°14'W
Climate: Humid tropical
Topographic Quadrangle Name: Joint Operations Ground (Graphic)
Use and Vegetation: Low Elevation Humid Mountain Forest; Soil Management CRSP trial, corn
Parent Material: Limestone
Landform: Upland
Topography, Percent Slope: Gently sloping, 5% slope
Elevation: 850 m Aspect: N
Drainage: Well Permeability: Moderate
Moisture: Udic
Depth to Seasonal High Water Table: >100 cm
Depth to Root-restrictive Layer: >100 cm
Degree of Erosion: Slight
Sampled and Described by: Jean René Bossa, Greg Mullins, Jean Pierre Roswald Villefranche, Richard Guthrie
Date: 12/15/98

PROFILE DESCRIPTION

Ap - 0 to 31 cm; dark red (10R 3/6) clay loam; weak very fine subangular blocky structure; friable; neutral; gradual smooth boundary.

Bt1 - 31 to 45 cm; 10R 3/6 clay; weak very fine subangular blocky structure; friable; mildly alkaline; gradual wavy boundary.

Bt2 - 45 to 100 cm; dark red (10R 3/6) clay; weak fine subangular blocky structure; friable; mildly alkaline; gradual wavy boundary.

Bt3 - 100 to 150 cm; dark red (10R 3/6) clay; friable; mildly alkaline.

PARTICLE SIZE ANALYSIS

Horizon	Particle Size			Textural
	Sand	Silt	Clay	Class
		%		
Ap	42.86	25.46	31.68	Clay loam
Bt1	29.64	4.75	65.62	Clay
Bt2	15.88	41.77	42.35	Clay
Bt3	nm	nm	nm	nm

SOIL TEST RESULTS

Horizon	pH	Phosphorus	Potassium	Magnesium	Calcium	CEC	O.M.
		Mg ha^{-1}				$cmol_c$ kg^{-1}	%
Ap	7.55	.007	.0613	.1691	nm	19.36	9.91
Bt1	7.74	.008	.0525	.0545	nm	10.79	5.21
Bt2	7.99	.010	.0262	.0573	nm	6.57	2.96
Bt3	nm	nm	nm	nm	nm	nm	nm

Photo 1. Site of hedgerow species trial, Ft. Jacques.

Photo 2. Soil profile at Ft. Jacques.

Photo 3. Hedgerow management and soil conservation barrier studies in Bois Greffin, Pernier. Shown are pedologist Gérard Alexis and agronomist Lionel Isaac.

Photo 4.Soil profile at Bois Greffin, Pernier, site of hedgerow management and soil conservation barrier studies.

Photo 5. Site of fertilizer and leucaena biomass study, Bois Greffin, Pernier, reps 1 and 2.

Photo 6. Site of fertilizer and leucaena biomass study, Bois Greffin, Pernier, reps 3 and 4.

Photo 7. Site of hedgerow species study, Titanyen.

Photo 8. Soil profile at Titanyen.

Photo 9. Hedgerow species study, Bergeau, after pruning.

Photo 10. Soil profile at Bergeau, site of hedgerow species trial.

Photo 11. Roadcut at Bergeau, showing petrocalcic horizon at surface of limestone bedrock. This is caused by precipitation of dissolved calcium carbonate onto bedrock, rendering it impervious to water. Petrocalacic horizons were also observed at Pernier and Titanyen.

Photo 12. Site of P, K, biomass study at Bergeau.

Photo 13. Site of hedgerow species trial at Saint Georges.

Photo 14. Soil profile at Saint Georges, site of hedgerow species trial.

Photo 15. Site of P, K, biomass study at Saint Georges. The soil was similar to that at the hedgerow species site.

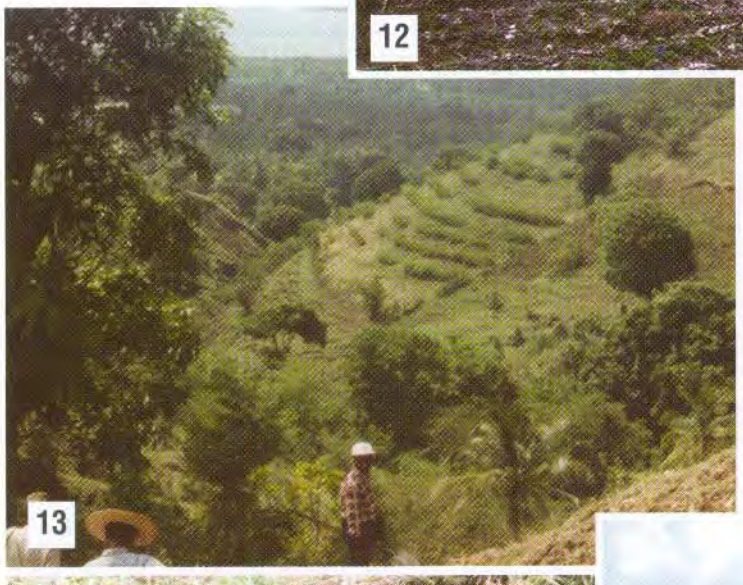


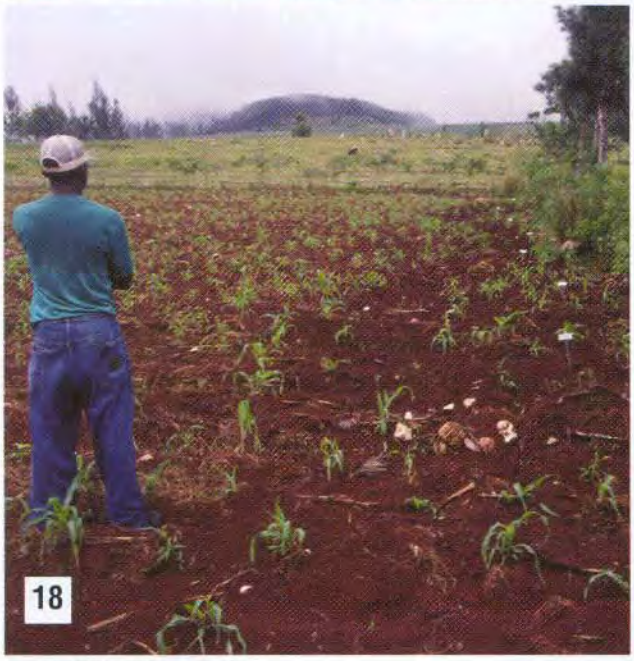
Photo 16. Site of P, K, biomass study at Saint Georges.

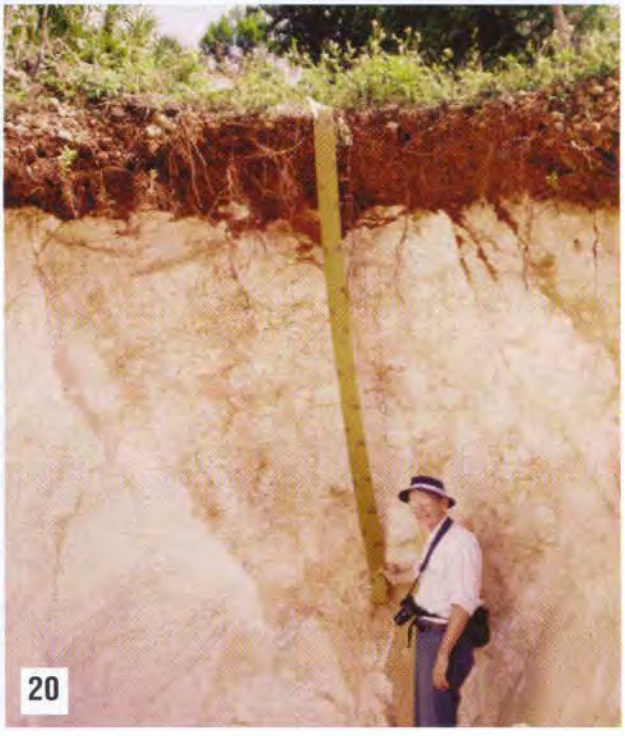
Photo 17. The soils at Saint Georges, formed over basalt, show evidence of sloughing. They are heavily grazed, making them vulnerable to erosion.

Photo 18. Site of P, K, leucaena biomass study at Salagnac.

Photo 19. Site of hedgerow species trial at Salagnac. Agronomists Carine Bernard and Jean René Bossa examine hedgerow of *Calliandra calothyrsus*.

Photo 20. The soils near Salagnac are typically dark red over limestone bedrock. They are high in aluminum and iron oxides. Bauxite was once mined nearby. Shown is Dr. Keith Cassel, soil scientist at North Carolina State University.





SUMMARY AND CONCLUSIONS

Because limestone is the parent material associated with a majority of soils of the Steeplands studies, pH is frequently above neutral and most of the soils are calcareous throughout. Calcium was determined to dominate the soil exchange complex. High pH values lead to induced low soil fertility through nutrient imbalances. In particular, phosphorus and micronutrients are locked into insoluble forms and thus not available to plants. Low available phosphorus prevents adequate growth and micronutrient deficiencies often affect photosynthetic and physiological activity, which are indicated by chlorosis. In addition, the amount of available magnesium and potassium, even though they may be in adequate supply, are in imbalance compared to the very large amounts of calcium. A response to potassium is often observed in these situations. Organic matter content is high for all soils, especially considering the fact that these soils have been subjected to extensive erosion. All of the Steeplands soils have high CEC values and high organic matter content; therefore, these soils should be very responsive to applications of fertilizers containing phosphorus and minor elements. Three sites, Fort Jacques, Saint Georges, and Pernier, have exceptionally high CEC values. X-ray diffraction reveals a high proportion of 2:1 clay minerals (see figures in Appendix). This indicates a high capacity to retain nutrients. However only at the St. George and Fort Jacques sites is soil pH low enough to predict a good response to fertilizer.

The major limitations for the soils described in this report are low inherent fertility, poor physical properties, and low available water. Also, the fact that most of them are on very steep slopes makes most land preparation, cultural practices, and mechanization difficult. Heavy fertilizer inputs would be required to achieve maximum production on these soils. The introduction of intensive cropping techniques is impossible in most of the sites studied because of steep slopes or inadequate moisture. Fertilization of low-value crops or trees may not be economical. However, improved well-adapted crop varieties and improved cropping practices can increase food production. The planting of well-developed and healthy tree seedlings will result in a better survival rate. Thus the use of phosphorus-based fertilizers in nurseries is encouraged.

The soil developed from basalt at Saint Georges is generally chemically better balanced than the other soils. Available P is very low, available K is low, and Mg is high. In addition to P, a response to K can be expected because of the inadequate balance between Ca, Mg, and K.

The soil at Fort Jacques also has a near-neutral pH and very low available phosphorus, but medium available potassium. This soil is less likely than the soils at Titanyen, Bergeau, and Bois Greffin to have micronutrient deficiencies and is more likely to respond to phosphate fertilizer.

The soil at Salagnac has a near-neutral pH, very high P and K, and very high Mg. This soil is highly productive, although deficiencies of micronutrients are likely. On the day of sampling, however, no chlorosis was evident in a growing crop of corn.

The soils at Bergeau, Titanyen, and Bois Greffin (Pernier) have calcareous surface horizons, very low available P, and low available K. All are likely to have micronutrient deficiencies and to be unresponsive to phosphate fertilizer. Also, all three are shallow, resulting in low available water. In addition, the Titanyen site receives little rainfall and is, therefore, unsuited for food crop and tree production without supplemental irrigation.

As a general conclusion of this study, both chemical and physical limitations are affecting crop yields and tree production. Special attention needs to be given to the introduction of crop or tree species that are tolerant of high pH. Crop production should be focused on the better land that has the greatest potential. Practices aimed at sustaining the relatively high percentages of organic matter in all soils should be given special emphasis in order to minimize nutrient imbalance and enhance moisture retention.

A previous study (Guthrie *et al.*, 1990) presented descriptions and data for soils in areas mostly in the northern half of Haiti. Utilizing the taxonomic classification and comparing the properties of soils in this and the previous study, the transfer of technologies from research sites to extension and on-farm research sites should be improved.

REFERENCES

Black, C.A., *et al.* (Ed.). 1965. Methods of Soil Analysis, Part 2. Agronomy 9. American Society of Agronomy, Madison, Wisconsin.

Guthrie, R.L., L. Isaac, G. Alexis, C. Bernard, and M. Blémur. 1995. Soil Profile Descriptions for Research Sites in Haiti. SECID/Auburn PLUS Report No. 29. USAID/Haiti Economic Growth Office. 28 pp.

Guthrie, R.L., P.M. Rosseau, A.G. Hunter, and M.P. Enilorac. 1990. Soil Profile Description for Selected Sites in Haiti. SECID/Auburn Agroforestry Report No. 16. USAID/Haiti 72 pp.

Hue, N.V., and C.E. Evans. 1986. Procedures Used by the Agronomy University Soil Testing Laboratory. Dept. Series No. 106. Department of Agronomy and Soils. Auburn University, Alabama.

Isaac, L. 2001. Carbon and Nitrogen Cycling in Alley Cropping Systems in Haiti. Ph.D. Thesis, Auburn University, Alabama.

Isaac, L., D.A. Shannon, and F.E. Brockman. 1994. Evaluation of Tree Species Adaptation for Alley Cropping in Four Environments in Haiti. B. First Year of Pruning. SECID/Auburn PLUS Report No. 15. 56 pp.

Isaac, L., D.A. Shannon, F.E. Brockman, and C.R. Bernard. 1995. The Effects of Leucaena Hedgerow Management in Alley Cropping on Maize (*Zea mays*) and Hedgerow Biomass Yields over Two Years of Cropping. SECID/Auburn PLUS Report No. 69 pp.

Isaac, L., D.A. Shannon, F.E. Brockman, and C.R. Bernard. 1996. The Effects of Alley Cropping and Other Soil Conservation Practices on Maize (*Zea mays*) Yields Over Two Years of Cropping. SECID/Auburn PLUS Report No. 30. 54 pp.

Isaac, L., C.W. Wood, and D.A. Shannon. 2003. "Pruning management effects on soil carbon and nitrogen in contour-hedgerow cropping with *Leucaena leucocephala* (Lam.) De Wit on sloping land in Haiti." Nutrient Cycling in Agroecosystems 65:253-263.

Isaac, L., C.W. Wood, and D.A. Shannon. 2003. "Hedgerow species and environmental conditions effects on soil total C and N and C and N mineralization patterns of soils amended with their prunings." Nutrient Cycling in Agroecosystems 65: 73-87.

Isaac, L., C.W. Wood, and D.A. Shannon. 2000. "Decomposition and nitrogen release of prunings from hedgerow species assessed for alley cropping in Haiti." Agronomy Journal 92:501-511.

Shannon, D.A., and L. Isaac. 1993. Evaluation of Tree Species Adaptation for Alley Cropping in Four Environments in Haiti. A. Establishment Phase. SECID/Auburn PLUS Report No. 6. 90 pp.

Shannon, D.A., L. Isaac, C.R.Bernard, and C.W. Wood. 2003. Long-term Effects of Soil Conservation Barriers on Crop Yield on a Tropical Steepland in Haiti. United States Agency for International Development, Soil Management Collaborative Research Support Program, Auburn University Technical Bulletin 2003-01. 40 pp.

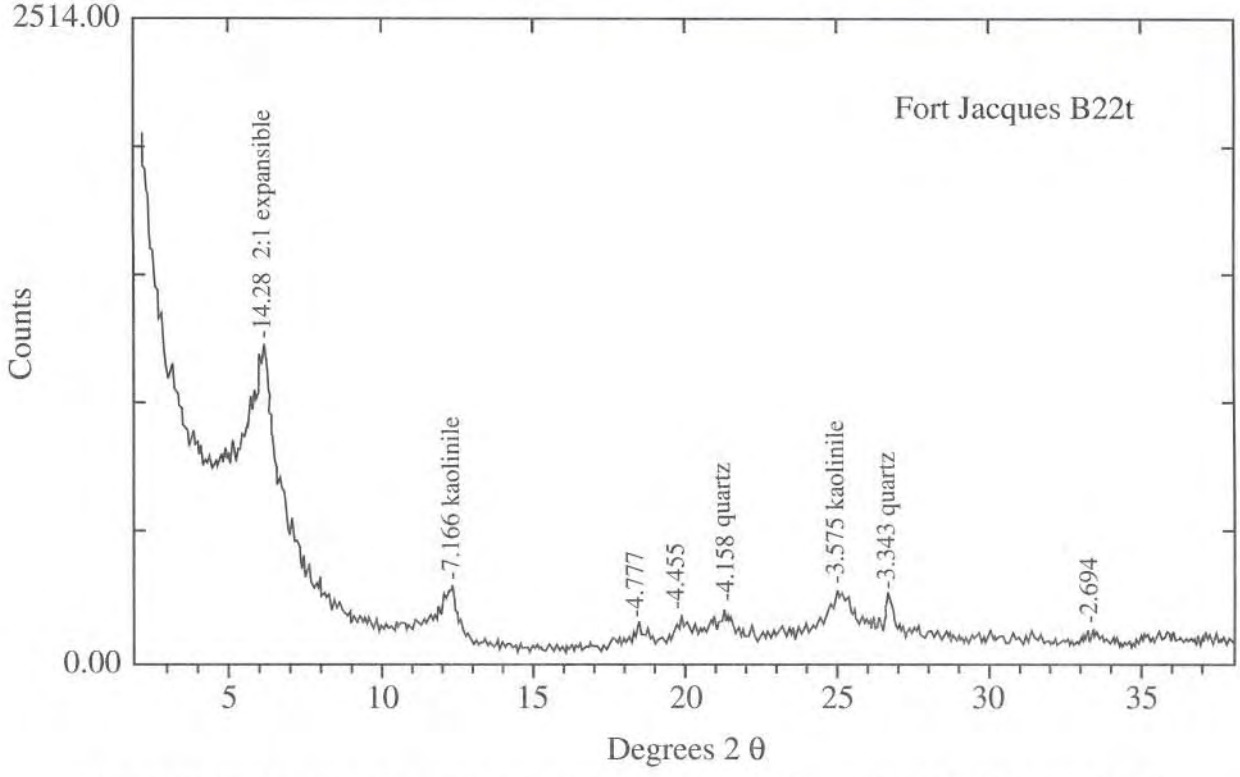
Shannon, D.A., L. Isaac, and F.E. Brockman. 1997. "Assessment of hedgerow species for seed size, stand establishment and seedling height." Agroforestry Systems 35: 95-110.

Shannon, D.A., J.D. (Zach) Lea, L. Isaac, and S. Belfort. 2001. Technical Assistance to the PLUS Project: Final Report of the South-East Consortium for International Development (SECID) and Auburn University. South-East Consortium for International Development. 125 pp.

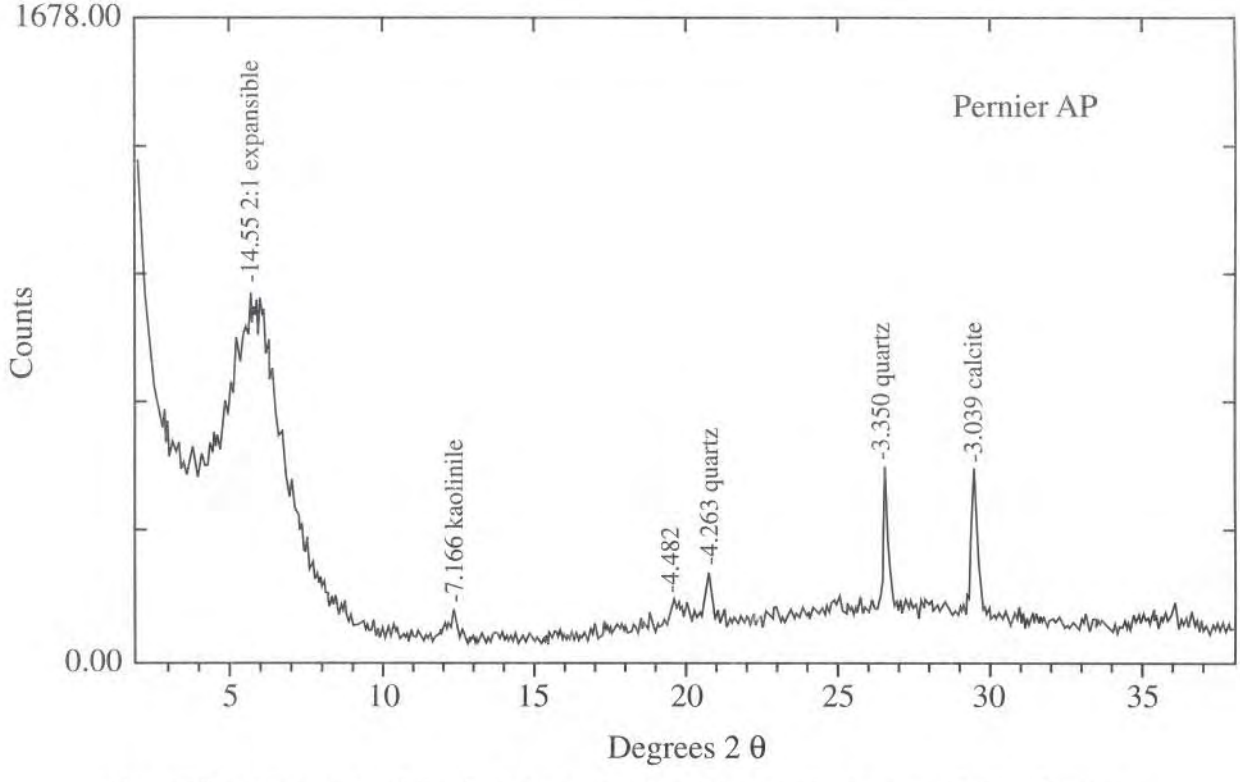
Soil Survey Staff. 1991. "Procedures for collecting soil samples and methods of analysis for soil survey." USDA-SCS Soil Survey Investigations Report No. 42, version 1. Washington, D.C.

APPENDIX

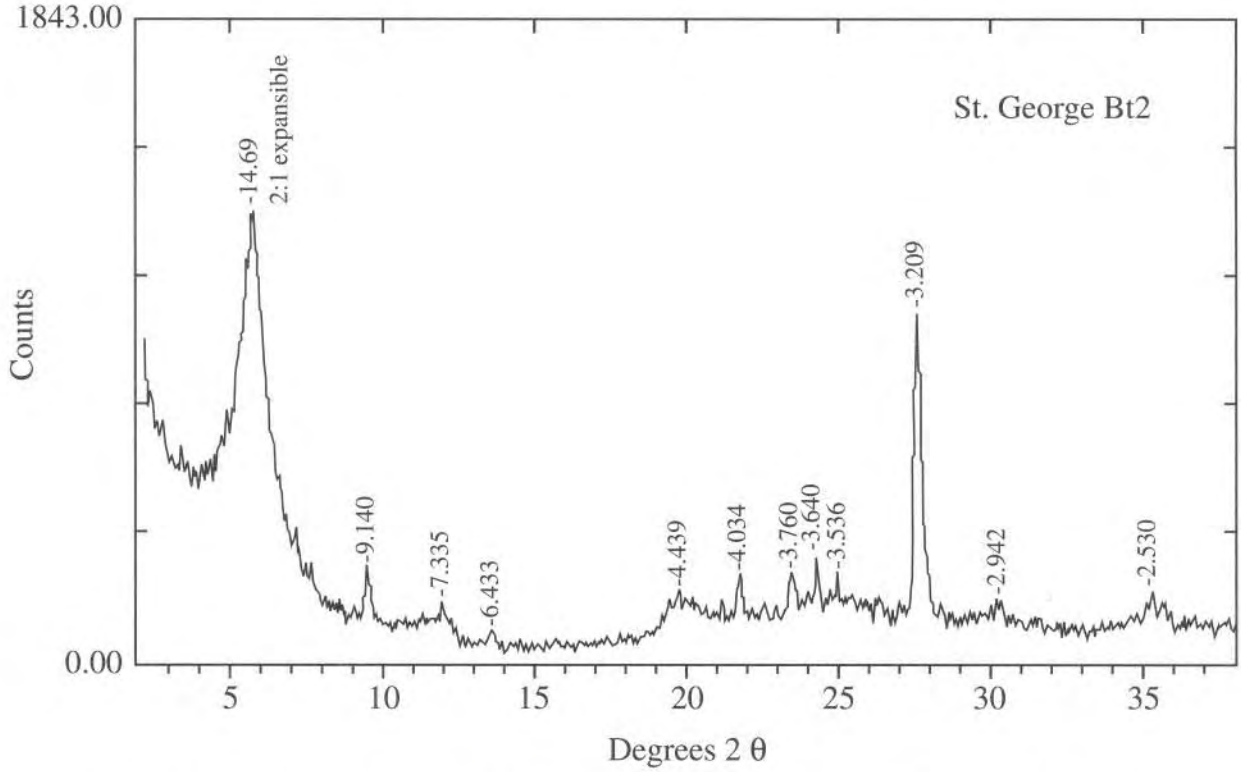
CLAY MINERALS DETERMINED BY X-RAY DIFFRACTION



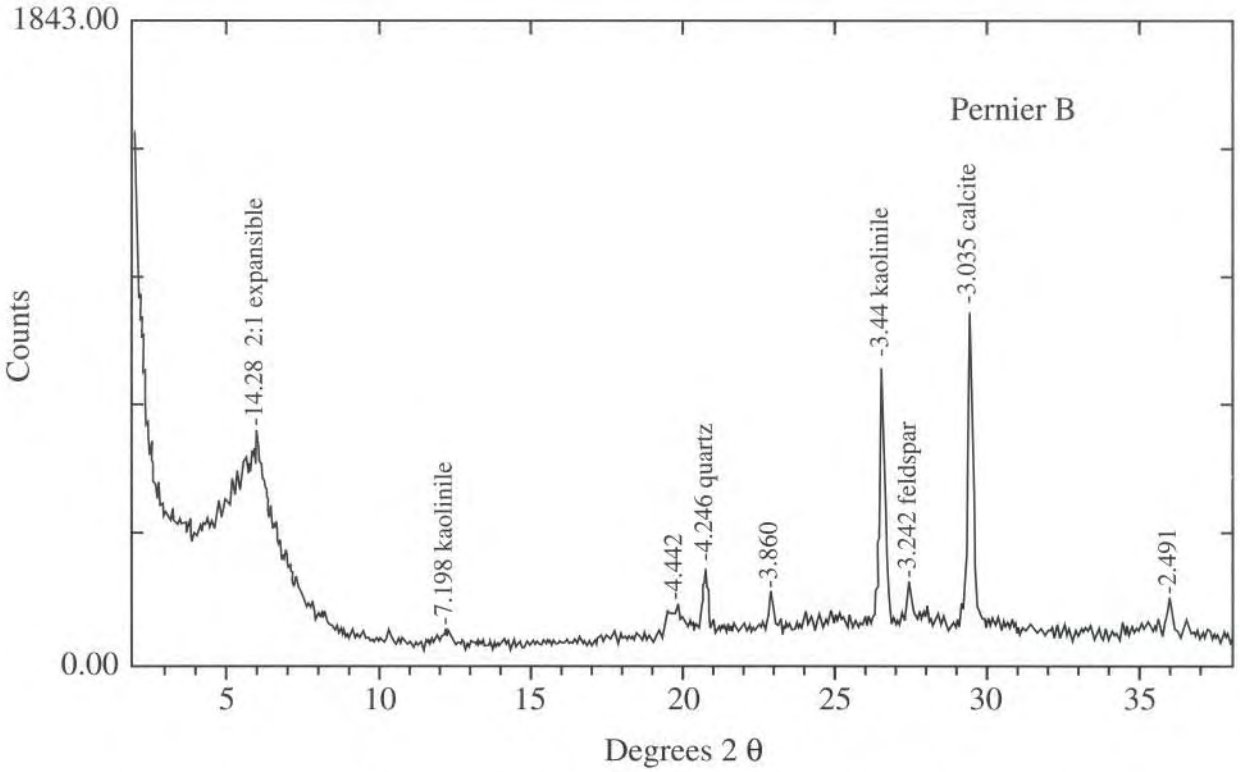
X-ray diffraction pattern of clay (less than two micron) fraction for horizon B22t from Fort Jacques.



X-ray diffraction pattern of clay (less than two micron) fraction for horizon AP from Pernier.



X-ray diffraction pattern of clay (less than two micron) fraction for horizon Bt2 from St. Georges.



X-ray diffraction pattern of clay (less than two micron) fraction for horizon B from Pernier.