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SOILS OF THE SAVANNA GUABATICO--DOMINICAN REPUBLIC

J. B. Collins, et al

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TEXAS

Soils of the Savanna Guabatico - Dominican Republic

J. B. Collins
J. C. Polanco
J. I. Kirkwood

AGRICULTURE

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Attention is focussed upon an area of acid savanna soils (Savanna Guabatico) in the Dominican Republic. Topography of this area is nearly level to gently rolling. The soils are residual and developed in calcareous marine sediments of the pleistocene age. Vegetation consists of tall grass, sugar cane, rice, and improved pasture. Results of the study indicate that the soils contain suitable field texture, structure and natural drainage, and organic matter for the growth of agricultural plants. Its topography permits easy mechanization. New land areas to produce food and fiber for the increasing population needs to be found. However, further study is needed to over-come the limitations and deficiencies of the area. The limitations include (1) low levels of available plant nutrients, (2) acid soils that are high in exchangeable aluminum-phosphorous fixation, and (3) soil erosion. The high temperature and precipitation of the area along with modern technology points to great agricultural potential.

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THE FIRST REPORT ON SOILS OF THE SAVANNA GUABATICO - DOMINICAN REPUBLIC

J. B. Collins[1], J. C. Polanco[2] and J. I. Kirkwood[1]

INTRODUCTION

In January of 1972, an area of acid savanna soils (Savanna Guabatico) in the Dominican Republic was sampled. This study is part of Prairie View's commitment to the University Consortium On Soils Of The Tropics, and is financed by Prairie View A&M College AID Grant 211 (d).

This area is located east of Santo Domingo, the capital, in what is known as the Southern Coastal Plain Agricultural Region of the Dominican Republic (3 & 4). Topography of this area is nearly level to gently rolling. The soils of the area are residual and have developed in calcareous marine sediments of pleistocene age (3 & 4). The orginal vegetation of the area was tall grass (4). Sugar cane (30%), rice and improved pasture (10%), and unimproved pasture (60%) are the major agricultural activities and nearly all of the land is in large holdings. Average rainfall is about 70 inches/year (3 & 4). The average temperature is 25°C during the Winter months, 29°C during the Summer and 27°C during the Spring and Fall (3 & 4). Temperature changes from day to night can be quite drastic. The dry season is from December through March (3 & 4). The Savanna Guabatico consists of approximately 400,000 acres, and the population density is about 10 persons / Km^2 (3).

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[2]Formerly Graduate Research Assistant, now Soils Specialist, Dominican Republic

METHODS OF ANALYSIS

All analyses were made on air dry samples that had been crushed and sieved through a two millimeter screen, except where otherwise indicated.

Soil Reaction

Hydrogen ion activity was determined on air dry samples with the Helige-Troug colorimetric kit and with a Coleman pH meter using a 1:1 soil - H_2O ratio and a 1:2 soil-1.0NKCl ratio (Agronomy No. 9, part 2, 1965).

Organic Matter

Organic matter contents were determined by use of the Walkley-Black chromic acid method (Jackson, 1958).

Aluminum

Aluminum was extracted by use of a 1.0NKCl extraction solution. The concentration of Al was measured by the Aluminon method and the percent transmission was read at 530 mu (Soil Survey Investigation Report No. 1, 1967).

Phosphorus

The Bray extraction solution (0.03NH_4F, 0.1NCCl - 1.5 soil solution ratio) was employed for the extraction of phosphorus. Phosphorus was analyzed by the reduced phosphomolybdate method and the percent transmission was read at 660 mu (Agronomy No. 9, part 2, 1965).

Calcium and Potassium

Calcium and potassium were extracted by use of a 1.0N NH_4Ac solution.

The extract was analyzed for K and Ca by use of a Coleman Flame Photometer (Jackson, 1964).

Soil Sampling and Soil Profile Description

Seven soil pits (representative of the range in properties of the soils in the area) were excavated to a depth of five to six feet. These seven pedons were described by use of standard soil profile description forms (SCS 232A - Soil Description - Rev. 7-15-56). Soil samples were collected from each horizon of each of the seven profiles.

RESULTS AND DISCUSSION

Seven pedons representing the major soils in the area were described and sampled for laboratory studies of their physical, chemical and mineralogical compositions at Prairie View A&M College and at Texas A&M University. The results of the field and laboratory studies of these seven profiles are presented in the discussion which follows.

Soil Profile Descriptions

Poorly to somewhat poorly drained soils occur on the flat to nearly level portions of the landscape (profiles No. 1, 2, 3, and 6), and moderately well to well drained soils occur on the gently rolling portions of the landscape (profiles No. 4, 5, and 7). The poorly to somewhat poorly drained soils have dark colored, loan textured (field grading) surface horizons that are at least five inches thick. The surface horizons of the better drained soils are lighter in color and finner in texture than the less well drained soils (this is due in part to greater erosion by water on the more gently sloping better drained sites). All profiles show significant

accumulation of clay in the B horizons. The field texture of the B horizons ranges from clay loam to clay. Browns, reds, whites, grays, and yellows are the subsoil colors with the reds and whites being dominant in the better drained profiles.

Many plant roots were observed in the surface horizons, but few were observed in the lower portions of the profiles. This suggest that the structure and consistence of the surface horizons of these soils are favorable for the growth of the roots of common agricultural crops. However, field observations in the area indicate that the B horizon will become harden or cemented when at the surface (exposed by erosion) and not covered by vegetation. In addition, concretions were observed through out the profile of the better drained sites.

Many small earthworms (3" long) were observed in the surface horizons of two of the less well drained profile (numbers 3 and 6).

PROFILE NO. 1

Horizon	Depth	Description
AP	0-8'	Very dark brown (10YR 2/2) with strong brown (7.5YR 5/6) stains or coatings on roots and root channels; loam to clay loam texture; granular to weak, fine to medium, subangular blocky structure; friable to firm consistence; clear, smooth boundary.
AB	8-15"	Red (2.5YR 4/8) with common, fine to medium, distinct, yellow (10YR 7/8) mottles; clay loam texture; moderate, fine to medium, subangular blocky structure-dark brown (10YR 4/3) coatings on ped faces; firm consistence; gradual, wavy boundary.
B21	15-23"	Dark red (2.5YR 3/6) and pinkish gray (5YR 7/2) with common to many fine to medium, distinct, yellow (10YR 7/8) mottles clay loam texture; moderate, medium, subangular blocky structure; very firm consistence; gradual, irregular boundary.
B22t	23-65"	Pale brown (10YR 6/3) and light gray (10 YR 7/2) with many, medium, distinct, yellow (10YR 7/8) mottles, clay loam to clay texture; moderate, medium, subangular, blocky structure; very firm consistence.

ADDITIONAL NOTES

1. The pedon described above is located near Los Llanos.
2. Nearly level with an A slope of 1%.
3. Southern aspect with slight erosion.
4. Moist through out the profile.
5. Water table - below 65".
6. Poorly to somewhat poorly drained.
7. Many, fine to medium roots in surface horizon and few in lower profile.
8. Savanna prairie (native vegetation) - range pasture.

PROFILE NO. 2

Horizon	Depth	Description
AP	0-12"	Very dark grayish brown (10YR 3/2); clay loam texture; moderate, medium subangular blocky structure; firm consistence; clear wavy boundary.
B21t	12-25"	Dark yellowish brown (10YR 3/4) with common to many, prominent, red (2.5YR 4.8) mottles; clay texture; moderate, medium, subangular blocky structure; very firm consistence; clear smooth boundary.
B22t	25-60"	Yellowish brown (10YR 5/8); clay texture; massive to weak, medium, subangular blocky structure; plastic consistence; free carbonates.

ADDITIONAL NOTES

1. Few, medium, distinct concretions in B22t horizon.
2. Few, poorly developed pressure faces in lower B22t horizon.
3. Variable depth to free carbonates.
4. This profile is located near Guerra.
5. Savanna Prairie (native vegetation) - slightly improved pasture.
6. Poorly to somewhat poorly drained.
7. Ground water table - below 60". Moisture to wet through out the profile.
8. Nearly level with a slope of 1 1/2%.
9. Southeastern aspect with slight erosion.
10. Many, fine to medium roots in surface horizon and few in lower profile.

PROFILE NO. 3

Horizon	Depth	Description
AP	0-5"	Dark brown (10YR 3/3); loam to sandy loa texture; granular to weak, fine, subangular blocky structure; friable consistence; abrupt smooth boundary.
A2	5-12"	Yellowish brown (10YR 5/6) with many fine, distinct red (2.5YR 4/8) mottles; sandy loam texture; granular to weak, medium subangular blocky structure; very friable consistence; clear, wavy boundary.
B21	12-20"	Yellowish brown (10YR 5/6) with many, coarse, prominent red (2.5YR 4/8) mottles; sandy loa texture; granular to weak fine, subangular blocky structure; friable consistence; gradual, irregular boundary.
B22t	20-32"	Gray (10YR 6/1) and yellowish brown (10YR 5/6) with many red (2.5YR 4/8) concretions (up to 1" in diameter); sandy clay loam texture; massive to strong, coarse, sub-angular blocky structure; very to extremely firm consistence; clear, wavy boundary.
B23t	32-60"	llow (10YR 7/8); clay loam to clay text ure; ssive structure; plastic consistence.

ADDITIONAL NOTES

1. Many small (3" long) earth-worms in surface horizon.
2. Yellowish red (5YR 4/8) stains or coating on roots and in root channels and worm channels of surface horizon.
3. The B22t horizon shows evidence of weak cementation.
4. Few, fine concretions in B23t horizon.
5. Many, fine to medium roots in surface horizon, but most roots stop at the B22t horizon.
6. Somewhat poorly drained.
7. Ground water table-below 65".

8. Moist to wet through out the profile.

9. This profile is located northwest of Guerra on the Reyes Farm.

10. Gently sloping with a 4% slope and slight erosion.

11. Southwestern aspect.

12. Savanna prairie (native vegetation) - range pasture.

PROFILE NO. 4

Horizon	Depth	Description
AP	0-7"	Brown (7.5YR 5/4 to 7.5YR 4/4); loam texture; granular to weak, medium, subangular blocky structure; friable consistence; abrupt smooth boundary.
B21t	7-15"	Dark red (2.5YR 3/6); clay loam texture; moderate, medium subangular blocky structure; firm consistence; gradual irregular boundary.
B22t	15-22"	Light brownish gray (10YR 6/2) and dark red (2.5YR 3/6); clay loam to clay texture; moderate, medium to coarse, subangular blocky structure; very firm consistence; gradual, wavy boundary.
B23t	22-60"	Light brownish gray to white (10YR 6/2 to 10YR 8/2) and dark red (2.5YR 3/6); clay loam to clay texture; massive to weak, coarse subangular blocky structure; very firm consistence.

ADDITIONAL NOTES

1. The amount of the grayish color in the B23t horizon increases with increasing depth.

2. Concretions (up to and larger than 1" in diameter) occur through out the profile, even at the surface.

3. Few roots in the surface horizon and almost none in the lower profile.

4. Gently sloping with a slope of 3%.

5. Northeastern aspect.

6. Slight erosion.

7. Savanna prairie (native vegetation) - very short grass in range pasture.

8. Moderately well drained.

9. Ground water table - below 65"

10. Moist through out the profile.

11. A near-by eroded area indicates that the B horizon may become harden (cemented) when it is at the surface and not covered with vegetation.

12. The soil described above is located northeast of Site No. 3 on the Reyes Farm (north of Guerra).

PROFILE NO. 5

Horizon	Depth	Description
A1	0 - 1 1/2"	Dark brown (10YR 3/3); soft, platy organic mat; abrupt, smooth boundary.
A2	1 1/2-6"	Red (2.5YR 4/6); clay loam; granular to moderate medium, subangular structure; hard consistence; clear, smooth boundary.
B21t	6-19"	Red (10YR 4/8); clay loam to clay texture; moderate, medium to coarse subangular blocky structure; hard consistence; gradual irregular boundary.
B22t	19-60"	Red (10YR 4/6) and pinkish white (5YR 8/2) with many, medium to coarse, prominent mottles; moderate, medium to coarse, subangular blocky structure; very firm consistence.

ADDITIONAL NOTES

1. Erosion along drain-ways indicates that the B horizon may harden when exposed.

2. Lime and manure (cattle) has been applied-Dairy Farm, most of the A1 appeared to be manure and grass roots.

3. Many fine to medium gravel in 0-6" depth.

4. Moderate erosion.

5. Three percent slope with southern aspect.

6. Gently sloping relief on dissected plain-about one mile from mountains.

7. Moderately well drained.

8. Dry in upper 20" and moist in lower profile.

9. Many roots in upper 22" and few in lower profile.

10. Good response has been observed due to manuring.

11. Pasture grass (pingola grass).

12. This soil was described on the Amelia Ricart dairy farm.

PROFILE NO. 6

Horizon	Depth	Description
AP	0-10"	Dark brown (10YR 3/3): loam texture; granular to weak, medium subangular blocky structure; friable consistence; abrupt smooth boundary.
A2	10-18"	Very pale brown (10YR 7/3) and red (10YR 4/8) with few, fine to medium yellow (10YR 7/8) mottles; clay loam texture; moderate, fine to medium subangular blocky structure; friable to firm consistence; gradual wavy boundary.
B22t	18-55"	Red (10YR 4/6) and light gray (5YR 7/1 with many, medium, prominent, yellow (10YR 7/8 mottles, clay to clay loam texture; moderate to strong; medium, subangular blocky structure; firm consistence; gradual irregular boundary.
B23t	55-65"	Dark red (2.5YR 3/6) and light gray (10YR 7/1) with many, medium, distince yellow mottles (10YR 7/8); clay texture; moderate to strong, medium subangular blocky structure; firm consistence.

ADDITIONAL NOTES

1. Few, fine, harden concretions in A2 horizon.

2. Fertilized and limed in about 1965.

3. Earth worms in upper 20".

4. Moist through out profile.

5. Cultivated field.

6. Southern aspect with 1% slope.

7. Nearly level with slight erosion.

8. Ground H_2O at 73". Not saturated or wet at 65", but after 5 to 30 minutes water table comes to 48 to 60".

9. Poorly to somewhat poorly drained.

10. Some tounging of A2.

11. Located close to secretary of agriculture (Australia).

PROFILE NO. 7

Horizon	Depth	Description
AP	0-7"	Dark yellowish brown (10YR 4/4); clay loam; granular to weak, medium, subangular blocky structure; hard consistence; clear wavy boundary.
B21	7-21"	Yellowish brown (10YR 5/8) and strong brown (7.5YR 5/6); clay loam; moderate to strong medium, subangular blocky structure; hard consistency; clear irregular boundary.
B22t	21-72"	Red (10YR 4/6), brownish yellow (10YR 6/8) and white (10YR 8/2); clay loam to clay; moderate to strong, medium, subangular blocky structure; very firm consistency.

ADDITIONAL NOTES

1. Many small concretions in AP horizon.

2. Moderately well to well drained.

3. H_2O table below 85".

4. Dry in upper 21", moist in lower profile.

5. Slight erosion.

6. Gently sloping with 4% slope.

7. Southwestern aspect.

8. Below 85", texture appeared to be loam to clay loam.

9. This soil was described and sampled near Monte Plata in the Ginebra Farm.

10. Vegetation-pasture.

Soil Reaction

These fine-textured soils have developed in calcareous marine sediments, and they have been subjected to considerable leaching during their formation. Except for profile number two which is calcareous at 25 inches, the pH's measured in water with the glass electrode show that these soils range from strongly acid to slightly acid throughout their profiles (Table 1). Excluding profile number two, the differences in pH with increasing depths in the soil profiles range from 0.3 - 1.4 pH units, 0.2 - 1.2 pH units and 0.5 - 1.5 pH units when measured in H_2O, in KCl and with the Trough Kit, respectively. The KCl pH's generally tend to increase or remain about the same with increasing depths. Hence, soil pH's measured in KCl appear to reflect an intrinsic characteristic of the soil.

There are little differences in the pH's as measured in water and in KCl with the glass electrode. In fact, using water as the standard, the KCl pH's are on the average only 0.4 pH unit lower. However, the pH's measured in 1.0NKCl and in H_2O with the glass electrode are on the average 1.0 pH unit and 0.6 pH unit lower than those measured with the Troug kit, respectively. These adjustments, plus the adaptability of the Troug kit for field work and quick pH determinations make it a satisfactory field kit for the determination of the pH's of these and similar soils.

Table 1. Soil pH's, determined on air-dry samples with the Troug Kit and with the Glass Electrode, for each of the seven profiles.

Depth (inches)	Horizon	pH Troug Kit	Glass Electrode KCl	Glass Electrode H_2O
		PROFILE NO. 1		
0 - 8	AP	6.5	4.6	5.7
8 - 15	AB	6.0	4.9	5.0
15-23	B21	6.0	5.1	5.2
23-65	B22t	5.5	5.1	5.1
		PROFILE NO. 2		
0 - 12	AP	6.5	4.7	5.4
12-25	B21t	6.5	4.9	5.6
25-60	B22t	calc	calc	calc
		PROFILE NO. 3		
0 - 5	AP	6.5	5.1	6.1
5 - 12	A2	6.0	5.3	6.1
12-20	B21	7.0	5.7	5.6
20-32	B22t	7.5	6.1	6.5
32-60	B23t	7.5	6.3	7.0

Table 1--Continued

PROFILE NO. 4				
0-7	AP	5.5	4.9	5.3
7-15	B21t	5.5	5.0	5.1
15-22	B22t	5.5	4.9	5.0
22-60	B23t	6.0	4.7	5.0
PROFILE NO. 5				
1 1/2-6	A2	6.5	5.3	5.6
6-19	B21t	6.0	5.1	5.1
19-60	B22t	6.0	5.1	5.4
PROFILE NO. 6				
0-10	AP	6.0	4.8	5.2
10-18	A2	6.0	4.8	5.1
18-55	B22t	5.5	5.1	5.2
55-65	B23t	5.0	5.2	5.5
PROFILE NO. 7				
0-7	AP	6.5	5.1	5.7
7-22	B21	5.5	5.2	5.2
22-72	B22t	5.5	4.7	4.7

Organic Matter

Organic matter percentages are highest in the surface horizons and generally decrease with increasing depths in the soil profiles (Table 2). The differences in organic matter contents with depth vary from 0.35% to 4.91%. The average percentage of organic matter in the surface horizons of the less well drained profiles (numbers 1,2,3, & 6) is 3.65% while that of the surface horizons of the better drained profiles (numbers 4,5 & 7) is 2.28%.

The relatively high content of organic matter in these soils helps to explain the excellent physical structure of the surface horizons. In addition, with good management, the structure of these soils will probably not detriorate readily under sustained cultivation.

Exchangeable Potassium and Calcium

Exchangeable potassium and calcium values in these seven soil profiles are low and range from 12.5 to 117.5 ppm and 15.0 to 970.0 ppm, respectively (Table 2). Except for profile number three, these values are highest in the surface horizons and generally tend to decrease or remain about the same with increasing depths in the soil profiles. Exchangeable potassium and calcium values for profile number three increase in the lower B horizons. (This can best be explained by the fact that the lower portion of this profile is less altered than the upper horizons).

These data show evidence of nutrient cycling where bases are returned to the soil surface by the vegetation, enriching the surface horizons.

These soils would need to be fertilized with calcium and potassium to obtain good growth and yield of most agricultural crops.

Table 2. Organic matter (O.M), exchangeable potassium (K) and calcium (Ca), and extractable aluminum (Al) and phosphorus (P) for each of the seven profiles.

Depth (inches)	Horizon	O.M %	K ppm	Ca ppm	Al ppm	P ppm
			PROFILE NO. 1			
0-8	AP	4.34	50.0	70.0	495.5	4.35
8-15	AB	1.50	20.0	40.0	550.0	7.50
15-23	B21	0.80	27.5	20.0	1013.0	3.52
25-65	B22t	0.51	35.0	15.0	1100.0	4.75
			PROFILE NO. 2			
0-12	AP	4.91	95.0	-	67.8	2.00
12-25	B21t	1.40	45.0	-	250.0	1.00
25-60	B22t	0.35	50.0	-	3.6	2.66
			PROFILE NO. 3			
0-5	AP	2.38	25.0	240.0	49.3	0.64
5-12	A2	0.52	12.5	60.0	112.5	1.08
12-20	B21	0.41	12.5	65.0	56.3	1.36
20-32	B22t	0.59	12.5	295.0	6.8	3.00
32-60	B23t	0.47	57.5	970.0	5.9	3.88
			PROFILE NO. 4			
0-7	AP	2.12	35.0	40.0	198.0	[illegible].61
7-15	B21t	1.02	25.0	20.0	901.4	2.35
15-22	B22t	0.54	27.5	20.0	981.0	.32
22-60	B23t	0.51	27.5	20.0	395.5	1.08

Table 2--Continued

PROFILE NO. 5						
0-6	A2	2.20	70.0	150.0	45.6	7.32
6-19	B21t	0.85	25.0	40.0	303.2	0.64
19-60	B22t	0.56	54.0	30.0	337.5	0.32
PROFILE NO. 6						
0-10	AP	3.00	60.0	200.0	122.5	5.88
10-18	A2	0.95	27.5	20.0	556.0	9.48
18-55	B22t	0.79	25.0	40.0	900.6	0.32
55-65	B23t	0.42	30.0	20.0	1100.0	3.00
PROFILE NO.7						
0-7	AP	2.45	117.5	310.0	47.5	3.88
7-21	B21	0.80	32.5	30.0	468.5	8.32
21-72	B22t	1.03	30.0	20.0	975.0	9.00

Extractable Aluminum and Phosphorus

Extractable phosphorus is quite low and varies from 0.32 to 9.48 ppm within these seven soil profiles (Table 2). Extractable aluminum values are generally high and vary from 3.6 to 1100.0 ppm within the seven profiles. However, it is interesting to note that the aluminum values in the surface horizons are less than 70 ppm for four of the profiles (numbers 2, 3, 5, & 7), less than 200 ppm for two of the profiles (numbers 4 & 6) and less than 500 ppm for profile number one. Hence, the acidity of the surface horizon (plow layer) can probably be neutralized by the application of reasonable amounts of a liming material. However, deep plowing (below 6") will likely increase soil acidity due to the high content of aluminum in the lower horizons.

The amount and distribution of organic matter, phosphorus and aluminum in these soils suggest that much of the phosphorus is comming from the organic fraction and that phosphorus is being fixed by aluminum. Phosphorus fixation is probably the bottle-neck to the agricultural potential of these soils.

Current Laboratory Analyses

Other analyses of the soil samples are presently being made. These analyses will provide additional information on the physical, chemical and mineralogical characteristics of these soils. This information will be useful in making recommendation on the use and management of these soils. In addition, this data will also be used in classifying these soils according to the current U.S.D.A. Soil Classification System (Soil Taxonomy).

SUMMARY AND CONCLUSION

The results of this study indicate that the soils of the Savanna Guabatico have suitable physical conditions (field texture, structure and natural drainage) and organic matter contents for the growth of common agricultural plants. The topography of the area is nearly level to gently rolling which permits easy mechanization. These factors, plus the high temperature and precipitation of the area, along with modern technology give these tropical Savanna soils an interesting agricultural potential.

In the Dominican Republic, new land areas to produce food and fiber for the rising population need to be found. The Savanna Guabatico may have this potential. However, further study is needed to over-come the limitations or deficiencies of the area. Such limitations include (1) low levels of available plant nutrients, (2) acid soils that are high in exchangeable aluminum-phosphorus fixation, and (3) soil erosion.

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