The pH of Puerto Rican Soils Used for Principal Crops[1]

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INTRODUCTION

The factors responsible for soil development: Climate, native vegetation, relief, age, and parent material, are extremely varied within short distances in Puerto Rico and therefore a large number of soil types may be expected. The variation in soil types has also produced variation in the pH of the soil. The pH (degree of acidity or alkalinity) of the soils of Puerto Rico presents an interesting study because of the large variation encountered in an area smaller than that of some of the western counties in Continental United States.

Aside from any theoretical interest in determining the pH of the soils of Puerto Rico, there is great practical need. Many soils are at such low pH levels that proper growth of crops is being limited. The majority of Puerto Rican soils are acid (below pH 7). From the standpoint of formation and classification many of these soils were acid even before man began to cultivate them. The heavy rains that occur in most of the Island have been leaching out of the soil great quantities of plant bases such as calcium, magnesium, sodium, and potassium, and thus lowering the soil pH. Man has helped to lower soil pH by the use of residual acid fertilizers such as ammonium sulfate for fertilizing his crops. These factors have combined to produce soils of such intense acidity (below pH 4) that normal crop growth often cannot be maintained.

Although many tropical crops such as sugarcane show adaptability to varied soil conditions, they do not grow well in soils which are very acid (below pH 5). The availability of nutrients to a plant is restricted when a soil becomes too acid. In acid soils, nitrate formation is markedly reduced below pH 5.5 (*2*)[3]; hence organic matter in the soil and added nitrogen sources cannot be used as efficiently by the growing plant. Phosphates,

[1] The data from which this paper was developed were derived from a cooperative study carried out by the Agricultural Experiment Station and the Agricultural Extension Service of the University of Puerto Rico. The author wishes to acknowledge the efforts of those individuals who helped gather the data, especially Francisco Miranda, Soil Specialist of Extension, who supervised the soil sampling, and F. González-Vélez and E. González-Tejera, Research Assistants of the Agronomy and Horticulture Department of the Station, who aided in preparing the maps and tables.

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[3] Italic numbers in parentheses refer to Literature Cited p. 119.

calcium, and magnesium become less available, whereas, aluminum and manganese become available in such quantities as to be toxic to plant growth.

Recently samplings made by the Experiment Station of sugarcane soils at Fajardo and San Sebastián, and of pineapple soils at Manatí, where poor growth and yields have been obtained, showed values of below pH 4. These soils have never received lime and have been heavily treated with fertilizers leaving acid residues.

Because of such indications of a rapidly developing acidity in our agricultural soils, a survey of their pH status was undertaken of the soil pH. This paper reports the results on the pH values obtained for the soils of Puerto Rico.

PROCEDURES

Soil samples for pH determinations were taken of the entire area of Puerto Rico, using as a guide the maps of land use developed under the Program of Rural Land Classification of the Department of Agriculture and Commerce of Puerto Rico. The scale of the map was 1:10,000. Equidistant gridlines were superimposed on each map so that each section to be sampled represented an area of 466 acres.

One composite sample of 0 to 8 inches of the topsoil was taken at the center of each 466 acre area. The major crop growing in the area where the soil sample was taken was also noted.

The Extension Agents of the Agricultural Extension Service of the University of Puerto Rico took the soil samples and determined their pH values, using Lamotte pH testing kits. The pH and the crops growing were recorded at each pH site on the map. The soil series and texture were determined from the Soil Survey Map of Puerto Rico (*3*). These data were transferred to IBM punch cards and tabulated. A total of 5,035 pH samples was taken.

Lime groups for the various soils encountered were designated by the Soil Department of this Station, who also gathered special soil samples and developed lime-requirement curves for the various soil groups.[4]

It should be remembered that, because the data reported herein are based on a field survey, certain assumptions must be made in their interpretation. The results of more intensive sampling or research may confirm conclusions reached or show that they were incorrect.

[4] A complete description of the methods employed and the various lime-requirement curves developed will be made available in a forthcoming publication by members of the Soil Department of the Station.

RESULTS

pH BY CROPS

The distribution of the pH values encountered in soils used for the various crops in Puerto Rico is given in table 1. The distribution is expressed as the

TABLE 1.—*The percentage distribution of soil pH values for the agricultural crops of Puerto Rico*

Crop	Percentage of the acreage of a soil within the following pH groupings—					
	Below pH 4	pH 4.0–4.9	pH 5.0–5.9	pH 6.0–6.9	pH 7.0–7.9	Above pH 8.0
Bananas	0	11	33	33	22	0
Brushland	1	7	32	21	29	9
Coconuts	0	0	12	40	31	17
Coffee	1	13	49	27	7	[1]
Corn	0	10	10	60	0	20
Cotton	0	0	100	0	0	0
Grapefruit	0	57	29	0	14	0
Pasture, improved	[1]	13	26	44	15	2
Pasture, natural	8	38	29	17	4	0
Pasture, rotation	0	10	10	60	0	20
Pineapples	8	38	29	17	4	0
Plantains	0	21	47	26	6	0
Root crops	2	12	35	37	12	2
Soilage (cut grass)	0	8	19	27	42	4
Sugarcane	1	17	25	32	24	1
Tobacco	1	11	49	26	12	1
Vegetables	0	0	50	38	12	0
Woodland	0	10	29	27	29	4
Average	1	15	34	30	15	5

[1] Less than 1 percent.

percentage of the total acreage of the crop found within the pH range specified.

If we use the classical definition of acid soils as those below a pH 7, then 80 percent of the soils of Puerto Rico now in agricultural usage are acid. If we choose to use the more practical definition that all soils below pH 6 are acid enough to receive lime, then 50 percent of the cropland falls into this grouping.

Better to appreciate the distribution of the soil acidity in respect to particular crops, each crop will be discussed separately.

Bananas

Most of the banana acreage is found in soils of pH 6 and above, which generally are best for it. The 33 percent at pH 5.0 to 5.9 and especially the 11 percent at pH 4.0 to 4.9 (table 1), probably represent small plantings in the acid soils of the mountainous interior of Puerto Rico associated with the coffee areas.

Brushland

Land in brush is usually abandoned farmland or land which cannot be farmed economically at present. The pH range is as wide as the distribution of these lands which are scattered throughout the Island from the salty mangrove swamps and the rolling and dry alkaline foothills of the southern coast to the heavily leached ridges and foothills of the north.

Coconuts

Coconuts are found in plantations along the coastal shores of Puerto Rico. The finding that over 80 percent of the coconut soils have pH 6 and above reflects the fact that coconuts are grown in well-drained, fairly fertile, loose sandy neutral or calcareous soils.

Coffee

Coffee is normally associated with acid soils in Puerto Rico as in many coffee-growing areas of the world (*5*). Coffee here is grown at high elevations where rainfall is normally above 80 inches per year. For countless years the high rainfall has leached the bases from the soil, so we find 63 percent of the coffee soils with a pH below 6, of which 49 percent run pH 5.0 to 5.9, and 13 percent are in the very acid range of pH 4.0 to 4.9. The 34 percent of the coffee soils with pH 6.0 and above are found mostly on the southern slopes of our central mountain range where the soils have a higher pH attributable both to parent material and a somewhat lower rainfall.

The distribution of the soils devoted to coffee and their pH values are shown in a map in figure 1.

Corn

Corn is grown extensively in Puerto Rico. Nearly every rural dwelling has a small corn patch nearby. In the tobacco area it is a part of the rotation following tobacco. It is difficult to assess the pH of all soils cropped to corn, because the time at which the survey was conducted was not in the normal planting period for the small plots devoted to a tobacco-corn-beans rotation.

The 20 percent of the acreage above pH 8 represents the southwestern portion of the Island, with its alkaline soils, where corn is grown on larger acreages and some machinery is used.

Cotton

The growing of cotton is limited to a very small acreage on the sandy soils in the semiarid northwestern part of the Island in the vicinity of Isabela. The pH 5.0 to 5.9 range is normal for the sandy soils in this area.

Grapefruit

In the 1920's Puerto Rico had quite a large number of commercial grapefruit orchards on the north coast from Bayamón to Arecibo. The orchards were planted mostly on acid sandy-textured soils with some on well-aerated neutral or calcareous sands to sandy loam types. Today the orchards have largely been abandoned. What few orchards remain reflect their distribu-

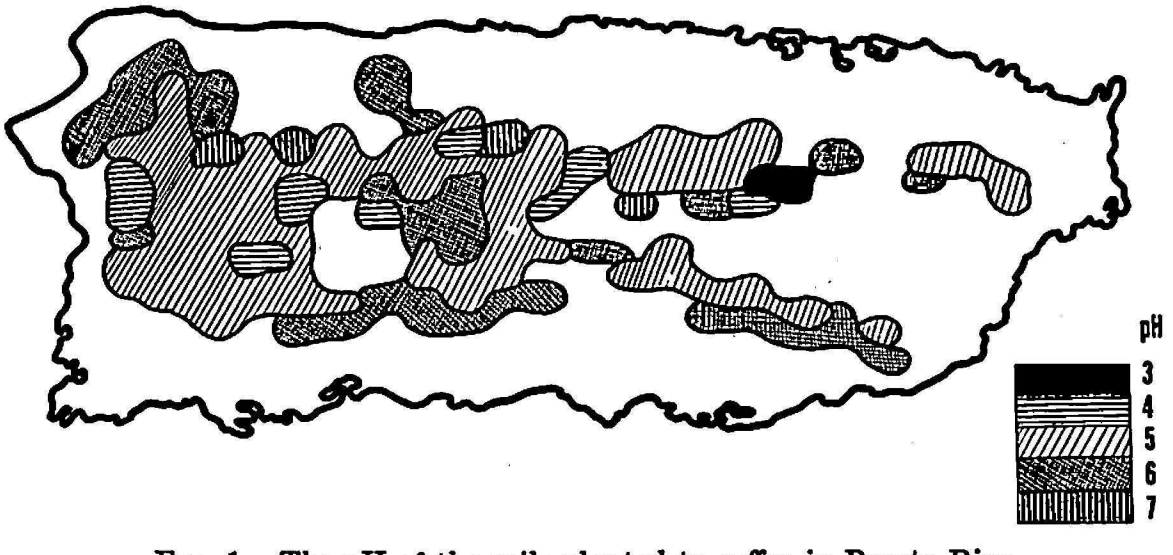

FIG. 1.—The pH of the soils planted to coffee in Puerto Rico.

tion in these acid sandy soils with 57 percent of their acreage at pH 4.0 to 4.9 and 29 percent at pH 5.0 to 5.9 (table 1).

Pastures

The natural pastures cover a wide range of soils and are found scattered throughout the Island. The bulk of the natural pastures, 75 percent, are found on acid soils below pH 6, with 8 percent in the extremely acid range of below pH 4 (table 1).

Improved pastures tend to shift to the nearly neutral pH soils, with 44 percent in the pH 6.0 to 6.9 range and only 39 percent below pH 6.

Rotational pastureland follows the same pattern as the improved pastures in pH distribution of the soils.

Pineapples

The pineapple soils are acid, well-drained, and permeable, and located in the Vega Baja-Manatí-Arecibo area. The location of pineapple farming in

acid soils is well reflected in the fact that 75 percent of the soils planted to pineapples have a pH below 6.

Pennock found that the Red Spanish pineapples gave their highest yields in soils at about pH 5, with yields diminishing at pH levels above this (*1*). However, the acidity of some of the soils in pineapples is too extreme, with 8 percent falling below pH 4 (table 1).

Plantains

The majority, 68 percent, of the plantains are found growing in acid soils below pH 6. This contrasts with bananas, the majority of the crop being planted in soils above pH 6.

Much of the acreage devoted to plantains was found intercropped with coffee as temporary shade, or, in the tobacco and mountain areas, a food crop. The soils in these areas are predominantly acid.

Root Crops

Root crops are planted on nearly every soil type, and nearly every rural dwelling has a small patch. Thus, the planting of root crops shows a systematic distribution through the range of pH from below 4 to above 8, with the majority in the range of pH 5.0 to 6.9.

Soilage (Cut Grass)

The cutting of grass for feeding animals has been a practice in Puerto Rico for many years. The majority of soils used are found with a pH above 6. The 46 percent above pH 7 (table 1) reflect the great use of this practice in the neutral to alkaline soils of the southern part of the Island, rather than in the acid soils of the mountains or on northern coast.

Sugarcane

Sugarcane is grown in almost all areas of Puerto Rico, and thus the distribution of pH is wide. We found 43 percent of the cane-acreage soil below pH 6, and 57 percent above this. Eighty-one percent of the acreage planted to sugarcane is in soil in the range of 5 to 8.

Most of the sugarcane acreage is planted in soils with a pH above 6 and requires no liming. Most of these soils are found in the southern part of the Island in the alluvial irrigated areas and in the rolling nonirrigated foothills.

In a special study devoted to the pH values of sugarcane soils (*4*), 36 percent were within a range of pH 3.8 to 5.4 and needed liming. The total area below pH 5.5 was approximately 123,000 acres.

The distribution of the soils devoted to sugarcane and their pH values is present in a map in figure 2.

Tobacco

Tobacco is grown primarily on acid soils in Puerto Rico with a majority of 61 percent of the acreage having a pH below 6 (table 1).

As compared with citrus or sugarcane, tobacco is a shallow-rooted crop. Therefore, it will grow and produce fair to good yields on shallow soil or even on steep hillsides. The heart of the tobacco area is the rolling to steep hills in the vicinity of Cayey, Comerío, Utuado, and San Lorenzo. Many of the soils were the once neutral friable Juncos and Múcara soils, but intensive use of residually acid ammonium sulfate fertilizer has reduced the pH. We now find 49 percent of the acreage in the 5.0 to 5.9 range and only 26 percent in the near-neutral pH 6.0 to 6.9 range.

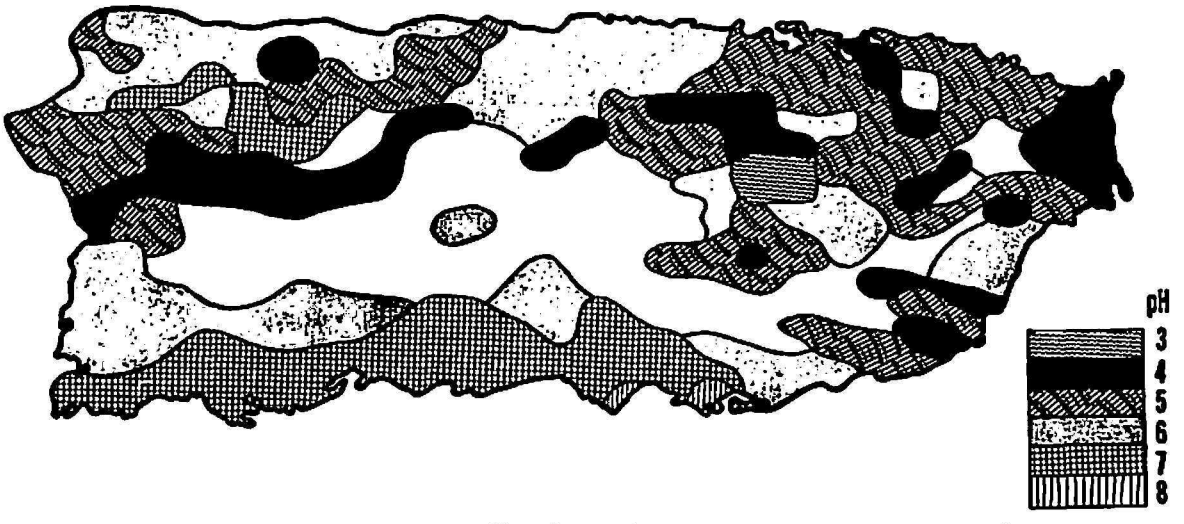

FIG. 2.—The pH of the soils planted to sugarcane in Puerto Rico.

A portion of the tobacco acreage is planted in the vicinty of Isabela and Sabana Grande for use as chewing tobacco. This is made apparent by the 12 percent of the acreage above a pH 7, which is normal for the neutral soils in these areas.

Vegetables

Vegetables such as tomatoes, cabbage, beans, and peppers are grown in small plots throughout the Island. However, the more fertile lands are normally devoted to these crops. None of the vegetable crops was found growing in soils with a pH below 5 (table 1). Fifty percent of the acreage was planted in soil with a pH range of 5.0 to 5.9 and the other 50 percent in soil above pH 6 where liming is not usually needed.

Woodland

Scattered throughout the mountain areas of Puerto Rico is woodland. Hardly any of this can be considered virgin timberland, nor are the trees of

TABLE 2.—*The average*[1] *and range of pH for the soils of Puerto Rico*

Soils	Average pH	pH range	Soils	Average pH	pH range
Jayuya	5.0	4.2–6.4	Aguadilla	6.1	4.8–7.6
Talante	5.0	4.2-5.4	Almirante	6.1	3.8–7.4
Fajardo	5.1	4.4–6.4	Guayama	6.1	5.2–6.2
Lares	5.2	4.0–6.6	St. Lucie	6.1	4.8–8.0
Mayo	5.2	5.2	Josefa	6.2	5.2–7.2
Vía	5.2	3.8–6.8	Sabana Seca	6.2	4.0–8.0
Alonso	5.3	5.1–6.6	Teja	6.2	4.2–7.8
Catalina	5.3	4.0–8.2	Tiburones Muck	6.2	4.6–8.0
Ciales	5.3	4.4–6.8	Vega Alta	6.2	4.6–7.8
Estación	5.3	4.2–7.8	Algarrobo	6.3	5.4–8.0
Maunabo	5.3	4.6–6.6	Martín Peña	6.3	4.2–7.8
Torres	5.3	3.8–6.8	Saladar muck	6.3	5.4–7.4
Cayaguá	5.4	4.2–7.4	Utuado	6.3	3.8–7.6
Cialitos	5.4	3.8–8.2	Vives	6.3	5.0–7.6
Juncos	5.4	3.8–7.2	Cabo Rojo	6.4	5.0–7.3
Vega Baja	5.4	4.4–6.8	Caguas	6.4	4.8–7.8
Yabucoa	5.4	5.1–5.8	Colinas	6.4	4.0–8.2
Fortuna	5.5	4.2–6.8	Guayabo	6.4	5.2–6.2
Mariana	5.5	4.6–6.4	Humacao	6.4	6.0–6.8
Pandura	5.5	4.2–8.2	Lajas	6.4	4.6–7.0
Río Arriba	5.5	5.0–6.2	Maleza	6.4	6.0–6.6
Viví	5.5	5.0–7.6	Nipe	6.4	5.2–7.2
Espinosa	5.6	3.8–7.4	Plata	6.4	6.4
Los Guineos	5.6	4.6–7.6	Tanamá	6.4	3.8–8.2
Palmas Altas	5.6	4.2–8.0	Camagüey	6.5	4.6–7.8
Picacho	5.6	4.4–7.6	Machete	6.5	5.9–8.2
Rough stony land	5.6	4.6–6.8	Palm Beach	6.5	5.0–7.2
Sabana	5.6	4.0–8.0	Riverwash	6.5	4.9–7.8
Bayamón	5.7	4.2–7.8	Coamo	6.6	4.2–7.8
Daguao	5.7	4.2–7.2	Descalabrado	6.6	4.8–8.2
Mabí	5.7	3.8–7.8	Santa Clara	6.6	4.8–7.8
Múcara	5.7	3.8–8.0	Coto	6.7	4.8–7.8
Naranjito	5.7	3.8–7.0	Cataño	6.8	5.4–7.4
Yunes	5.7	4.0–7.2	Juana Díaz	6.8	5.2–7.4
Corozo	5.8	5.6–6.0	Peat	6.8	5.4–8.0
Toa	5.8	4.0–7.8	Ponceña	6.8	6.4–7.2
Candelero	5.9	4.5–6.8	Soller	6.8	3.8–8.2
Coastal Beach	5.9	4.4–7.4	Paso Seco	6.9	4.8–8.0
Coloso	5.9	3.8–7.8	Fraternidad	7.0	5.1–8.2
Malaya	5.9	4.4–7.3	San Antón	7.0	5.0–8.0
Moca	5.9	4.2–7.7	Aguilita	7.1	5.2–8.2
Rosario	5.9	4.6–7.2	Islote	7.1	5.4–8.4
Córcega	6.0	4.2–7.6	Vayas	7.1	6.3–7.6
Matanza	6.0	4.8–7.4	Amelia	7.2	6.3–8.2
Piñones	6.0	6.4–7.8	Pozo Blanco	7.2	7.2
Río Lajas	6.0	4.0–7.0	Santa Isabel	7.2	5.6–7.8

TABLE 2.—*Continued*

Soils	Average pH	pH range	Soils	Average pH	pH range
Yauco	7.2	6.2–8.0	Mercedita	7.5	7.4–7.6
Altura	7.3	6.8–7.4	Serrano	7.5	5.8–8.2
Barrancas	7.3	6.3–8.2	Teresa	7.5	6.6–7.8
Portugués	7.3	7.3	Río Cañas	7.6	6.6–8.2
San Germán	7.3	6.4–8.2	Fe	7.7	6.6–8.2
Aguirre	7.4	6.0–8.4	Meros	7.7	7.2–8.2
Dominguito	7.4	7.4	Jaucas	7.8	7.8
Guánica	7.4	5.9–8.4	Reparada	7.9	7.4–8.2
Citrona	7.5	7.2–7.7	Ursula	7.9	7.9
Ensenada	7.5	7.2–7.8			

[1] Weighted average based on acreage sampled at each pH.

great economic importance for such quality lumber as mahogany, cedar, or other hardwoods. Most of the forests are on steep mountain slopes not suitable for farming.

The range for woodlands is distributed rather evenly from pH 5.0 to 7.9 with lesser percentages found at pH 4.0 to 4.9 and above pH 8 (table 1).

pH BY SOILS

The large number of soils (115 soil series) make it difficult to present a condensed development of the pH by soils for Puerto Rico. The average and range of pH values encountered in the survey for the soils of Puerto Rico are given in table 2 by series. The series have not been divided into groups or physiographic divisions because such a complex discussion would be voluminous. For an authoritative work on the soils of Puerto Rico arranged in physiographic divisions the Soil Survey of Puerto Rico (*3*) will be of value to use in conjunction with the pH values of table 2. However, several examples will be discussed to illustrate the interesting relationship found between soil pH and the soil series.

The pH range may be very wide within a soil series. For example, the Catalina series has an average pH 5.3, but it has a range of pH from 4 to pH 8.2. The Catalina soil series consists primarily of the Catalina clay, a deep permeable clay, high in iron and aluminum, red or purplish red, and acid in pH. The values near pH 4 are readily understandable, because of erosion exposing the more acid subsoil and man using residually acid fertilizers. The high pH values above 7 are more difficult to explain, but it is probable that some soil samples were taken in recently limed fields.

The large variation in pH range is found not only for the acid soils (pH below 7), but many series with an average pH of 7 or above have values

in their pH range which swing to the acid side. As an example, the San Antón series has an average pH 7.0, but its pH range is from 5.0 to 8.0. The soils of the San Antón series are well-drained river flood-plain soils on the southern coast of Puerto Rico. These soils, the textures of which range from loams to clays, are usually found planted to sugarcane with irrigation. Normally the soils are neutral in pH. Many of these San Antón sugarcane soils, however, have been heavily fertilized for over 50 years with ammonium sulfate, and after many years of application this residually acid fertilizer has lowered the pH of the lighter textured San Antón loams.

The climate, especially rainfall, has had a great influence on the soil pH. The medium-friable soils of the terraces and alluvial fans occur in both the humid (80 inches of rain annually) and arid and semiarid (below 45 inches of rain annually) sections of the Island. The soils of the humid section comprise the Torres, Vía, Lares, Fajardo, Mayo, and Humacao series. These soils which have been heavily leached by rains have average pH values from 5.1 to 5.3 except the Humacao series with a soil pH of 6.4. The soils of the arid and semiarid section are formed by the Coamo, Machete, and Vives series, and they have higher average pH values from 6.3 to 6.6 because less bases are leached from the soil in this lower rainfall section.

The medium-deep soils of the uplands provide an interesting example of the influence of the original parent material on soil pH. The soil series Colinas, Soller, and Tanamá are derived from Tertiary limestones, and have a near-neutral average pH value of 6.5. On the other hand, Daguao, Múcara, Juncos, Sabana, and Naranjito series are derived from massive tuffs and have a more acid average pH value of 5.6. The last of the medium-deep soils of the uplands are the series Pandura, Cayaguá, Ciales, Utuado, and Teja which are derived from igneous rocks, mostly granite. The average pH for this group is 5.7.

A map showing the distribution of the pH of the soils of Puerto Rico appears as figure 3.

SUMMARY

The pH values of the soils of Puerto Rico were determined with the following results:

1. About 80 percent of the soils were acid (below pH 7) and 50 percent were below pH 6, which was acid enough to require liming.
2. Most of the soils planted to bananas were pH 6 and above.
3. The pH range for brushland was wide, extending from acid to alkaline.
4. Eighty percent of the soils of the coconut plantations were above pH 6.
5. Coffee soils, in general, were acid, with 63 percent below pH 6, of

which 49 percent were in the range pH 5.0 to 5.9 and 13 percent in the very acid range of pH 4.0 to 4.9.

6. The pH of soils planted to corn varied widely.

7. The small cotton acreage had a pH range of 5.0 to 5.9.

8. The soils planted to grapefruit had 57 percent of their acreage at pH 4.0 to 4.9 and 29 percent in the range pH 5.0 to 5.9.

9. The natural pastures had 75 percent of their soil at pH below 6, whereas improved and rotational pastures had only 39 percent below pH 6.

10. Pineapples were planted in acid soils, 75 percent of which were below pH 6.

11. The majority, 68 percent, of the plantains were grown in acid soils below pH 6.

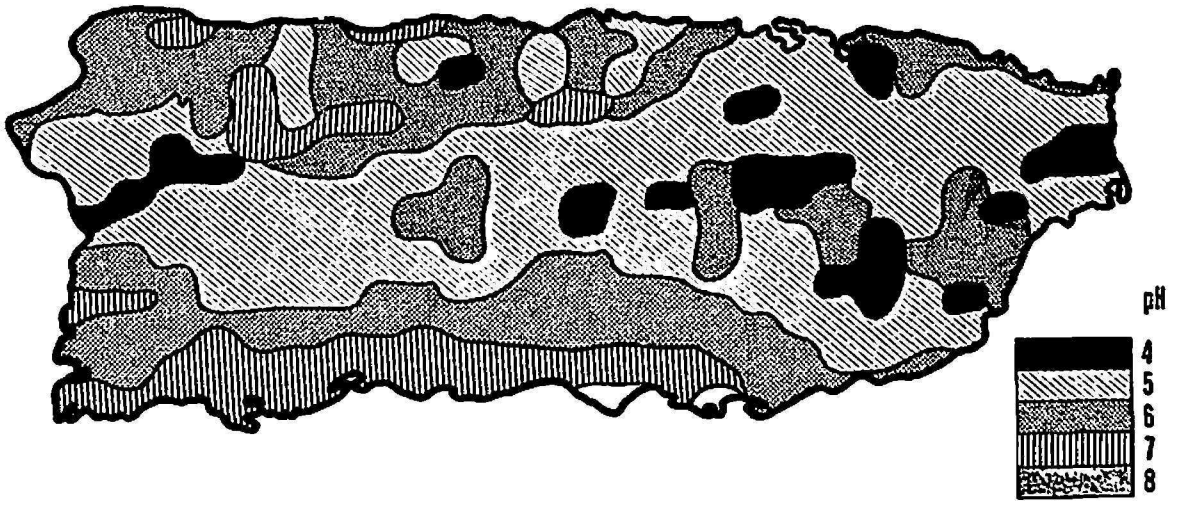

FIG. 3.—The pH of the soils of Puerto Rico.

12. Root-crop soils had a systematic distribution throughout the range of pH from below 4 to above 8.

13. Most soils used for soilage (cut grass) had a pH above 6.

14. Eighty-one percent of the sugarcane acreage was found to be in the range of pH 5 to 8. About 36 percent of the cane acreage was below pH 5.5 and in need of liming.

15. Tobacco was grown primarily on acid soils, with 61 percent of its acreage on those below pH 6.

16. No vegetables were found in soils with a pH below 5, and 50 percent were planted in soils with a pH above 6.

17. The pH range for woodland soil was distributed rather evenly from a pH 5 to 7.9.

18. The average pH and range of pH of the soils of Puerto Rico are presented, by soil series, and several examples are given of the relationship between soil pH and soil series.

RESUMEN

Se determinó el valor pH de los suelos de Puerto Rico con los siguientes resultados:

1. Alrededor del 80 por ciento de los suelos resultaron ácidos con un pH menor de 7; el 50 por ciento resultó con un pH menor de 6, lo cual significa que necesitan encalarse.
2. La mayoría de los suelos sembrados de guineos tenían un pH de 6 ó más.
3. El área de distribución de pH de los terrenos en matorrales cubría desde ácido hasta alcalino.
4. Las plantaciones de coco tenían el 80 por ciento de sus suelos sobre un pH de 6.
5. En términos generales, los suelos en café resultaron ácidos con un 63 por ciento que tenía un pH menor de 6, de cuyo porcentaje el 49 por ciento tenía un pH desde 5.0 hasta 5.9 y el 13 por ciento un área de distribución de pH desde 4.0 hasta pH 4.9.
6. El valor pH de los suelos sembrados de maíz varió ampliamente.
7. Los suelos de la limitada zona donde se cultiva el algodón tuvo un área de distribución de pH desde 5.0 hasta 5.9.
8. El 57 por ciento de los suelos sembrados de toronjas tuvieron un área de distribución de pH desde 4.0 hasta 4.9 y el 29 por ciento desde 5.0 hasta 5.9.
9. El 75 por ciento de los suelos en pastos naturales tuvieron un pH menor de 6, mientras que los pastos mejorados y en rotación sólo el 39 por ciento tuvo un pH menor de 6.
10. Se encontró que la mayoría de las siembras de piña estaba en suelos ácidos. El 75 por ciento de estos suelos indicaron tener un pH menor de 6.
11. La mayoría de las siembras de plátanos, esto es el 68 por ciento, se encontró que estaba en suelos con un pH menor de 6.
12. Los suelos ocupados con cosechas de raíces comestibles farináceas demostraron tener una distribución sistemática cuya área de distribución de pH fue menor de 4 hasta más de 8.
13. Los suelos usados para yerbas de corte en su mayoría tenían un pH sobre 6.
14. El 81 por ciento del área dedicada al cultivo de la caña de azúcar comprendió un área de distribución de pH desde 5 hasta 8. Alrededor del 36 por ciento de estos suelos indicó tener un pH menor de 5.5, lo cual significa que necesitan encalarse.
15. El tabaco se siembra en suelos ácidos; el 65 por ciento de estos suelos resultó con un pH menor de 6.
16. No se encontraron hortalizas sembradas en suelos con un pH menor

de 5; el 50 por ciento de los suelos dedicados a estas cosechas tenían un pH mayor de 6.

17. El área de distribución de pH para los suelos en bosques resultó estar distribuida casi uniformemente desde un pH de 5.0 hasta uno de 7.9.

18. Se presentaron en este estudio el promedio del valor pH y el área de distribución de pH para los suelos de Puerto Rico según sus series, y se señalaron varios ejemplos en cuanto a la reacción entre el pH y las series de suelos.

LITERATURE CITED

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