



CHARACTERISTICS OF SOIL AND ITS LIMITING FACTORS OF REGIONAL MURGAS, HAVANA PROVINCE

Características de los suelos y sus factores limitantes de la región de Murgas, provincia La Habana

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ABSTRACT. In this work the study of 897,22 ha in the region Murgas, Havana province is performed to characterize soils in relation to agricultural use for planting herbs (*Moringa oleifera*). In conjunction with this analysis of some of the physical and chemical properties as drainage conditions, pH and organic matter content, to assess the agricultural productive soil limiting factors under study. This region its characterize by various terrains of high plains and cumulative denudation lowlands with karst phenomena of sinkholes in the lowlands; under a subhumid tropical climate with 1400 mm annual rainfall and average annual temperature of 24-25 °C, which shows that the soil limitations are given by drainage problems, which is insufficient in the lower parts of the relief and much of the area.

Key words: soil fertility, soil, organic matter, soil pH

INTRODUCTION

The study of soils is essential to attain an efficient agriculture. By means of this work, using cartographic and characterization people can know what kinds of soil are present; the area occupied by each of them and also soil factors that may be limiting for agricultural production or agroproductive limiting factors (1), which is one of the most important elements for achieving a sustainable agriculture.

In Cuba these studies began to do systematically since 1960s¹, with the first soil chart to medium-scale, 1:250 000^A and later in scale 1:25 000^B. In recent years these studies are made in detailed scale through

RESUMEN. En este trabajo se realiza el estudio de 897,22 ha en la región de Murgas, provincia La Habana para caracterizar los suelos en relación con su uso agrícola para la siembra de plantas medicinales (*Moringa oleifera*). Conjuntamente con esto se realiza un análisis de algunas de las propiedades físicas y químicas como condiciones de drenaje, niveles de pH y contenido de materia orgánica, para evaluar los factores limitantes agroproductivos de los suelos en estudio. Esta región, se caracteriza por un relieve variado de llanuras altas denudativas y llanuras bajas acumulativas con fenómenos cársicos de dolinas en las partes bajas; bajo un clima tropical subhúmedo con 1400 mm de lluvia anual y temperatura media anual de 24-25 °C, donde se observa que las limitaciones de los suelos están dadas por problemas de drenaje, que resulta insuficiente en las partes bajas del relieve y en gran parte del área.

Palabras clave: fertilidad del suelo, suelo, materia orgánica, pH del suelo

Reference sectors such as soil study in the farm "La Rosita", located before arriving at the popular council Campo Florido, Guanabacoa municipality, Havana province (2). These technologies have been carried out to others country like Ecuador^C (3).

Another important aspect in determining soil properties is the characterization for profile taken by landscape elements. In Cuba, in the last 10 years, many works have been developed in different soil type

^A Instituto de Suelos. Mapa genético escala 1:250 000 de los suelos de Cuba. 19 hojas cartográficas a color. Instituto de Geodesia y Cartografía de Cuba, La Habana. 1970.

^B Dirección Nacional de Suelos y Fertilizantes. Mapa genético de los suelos de Cuba, escala 1.25 000. Ministerio de Agricultura, 1990. La Habana, Cuba.

^C Vera, L. Estudio de los suelos y su fertilidad como base para el manejo sostenible del Campus de la escuela Superior Politécnica Agropecuaria de Manabí, Ecuador. [Tesis de Maestría]. INCA, Mayabeque, 2013, 62 pp.

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in which using this methodology can be demonstrated as the land use, in this case intensive cultivation or continued monocropping example by rice cultivation; the soil structural state is degraded, also it reduces biodiversity, organic matter content and carbon reserves (4, 5, 6, 7, 8, 9, 10).

Considering the importance of this work implementation, in 2012 the update on the mapping and soil characteristics of the Murgas region was conducted in an area of 897,22 ha to determine its limitations for growing moringa.

In the past, for many years, this area was planted with sugar cane belonging SM (sugar mill) "Manuel Martínez Prieto" but about 10-15 years ago this region passed to the Fauna and Flora Department and pasture system was established based on guinea (*Panicum maximum*) and forages, with some small cultivation areas of the entity and some individual farmers, especially around Murgas zone. Due to the change of vegetation cover, and in light of new findings in the field of soil classification, mapping and characterization of soils were updated with its limiting factors.

MATERIALS AND METHODS

The selected area comes from the town of Murgas road towards Havana-San Antonio de los Baños Highway to the west and out to the Wajay the east (between coordinates N: 349 000 and 352 000; E: 350 000 and 353 000, of Cuba North System, Lambert Conformal Conic projection). To the south taking part in the Murgas depression, arriving until Zaldívar and La Coca lagoons, located in the Boyeros municipality, Havana province.

The terrain is generally flat, except for the descent to the south where there is a slope of 3-4 %. The source material of the soil at the top is hard limestone (Miocene) and parts with soft limestone or coco (marls from the Oligocene) and southward into depression, it is texturally different sediments, with part constituted by an impermeable lower clay layer, red, yellow and gray, and the upper sediments with a loamy texture, approximately 20-25 % clayey.

This entire region is dominated by carsic phenomena of sinkholes formation, some very large that form El Coca and Zaldívar lagoons and some smaller ones. This system of sinkholes and more underlying layers of clay soils, influence strongly hydric regime in the same. The climate is subhumid tropical, taking as reference rainfall data from the meteorological station at the INIFAT (Institute of Fundamental Research in Tropical Agriculture) in Santiago de las Vegas (at less than 15 km away), where between 1500-1600 mm annual rainfall and 24.2 °C mean annual temperature are reported.

The study was conducted with routes where contours were separated, following genetic-geographic principles. About 60 points with auger, 20 sampling of agrochemical plots and 15 soil profiles were taken, opening holes up to 30-40 cm deep and then reaching up to 100-120 cm with soil auger.

To soil samples, were done general characterization analysis in the INCA soil laboratory. Analyzes done were:

- ♦ PH, by potentiometry soil-water relation 2,5: 1
- ♦ Organic matter by the Walkley Black method
- ♦ Exchangeable cations (except sodium and potassium), by extraction with ammonium acetate and assessing EDTA
- ♦ The assimilable phosphorus by Machiguin method.
- ♦ Mechanical analysis by the Bouyoucos method with sodium pyrophosphate and sodium hexametaphosphate

A soil map was drawn to scale 1:10 000 based on the soil map 1:25 000^B and map sheets 1: 2 500 of Boyeros municipality where the New Version of Genetic Classification of Cuba Soils was applied (11) and a correlation was made using at the same time the World Reference Base (12) and the Soil Taxonomy classifications (13)

For this map, Cuba^D cartographic standards were followed, also taking into account previous work results in this region^B (14) with the characterization of 15 new soil profiles.

Considering soil characteristics, following drainage types are established according to the manual soil description of Cuba^D and Guide for soil description (15).

TYPES OF DRAINAGE

Very poorly drained. Water is removed from the soil so slowly and the water table remains in the surface or on it, most of the time. Soils of this kind generally occupy flat or depressed places and they are often flooded.

Poor drained. Water is removed so slowly that the soil remains wet for long periods of time.

Imperfectly drained. Water is removed from the soil sufficiently slowly to keep wet the soil for very significant periods, but not all the time.

Moderately well drained. The water is eliminated rather slowly, so that the profile remains wet for some notable time periods.

^D Hernández, A.; Paneque, J.; Pérez, J. M.; Mesa, A.; Bosch, D. y Fuentes, E. Metodología para la cartografía detallada y evaluación integral de los suelos. Instituto de Suelos y Dirección Nacional de Suelos y Fertilizantes, La Habana, 1995. 53 pp.

Well drained. Water is easily removed from the soil, but not quickly. Optimal amounts generally retain moisture for plant growth after rainfall or irrigation. *Something excessively drained.* Water is removed from the soil quickly. Many of these soils have little differentiation in their horizons and are sandy and very porous. *Excessively drained.* water is removed very quickly from the soil. These soils are generally lithosols and can be steep, very porous or both.

The program (software) for managing geographic information ILWIS 3,4 in mapping soil subtypes and some of the limiting factors of the area (drainage, pH and organic matter) was used.

RESULTS AND DISCUSSION

After separate and distinct contours soil, following genetic-geographical principles (Figure 1, Table I) Ferruginous Nodular Gley and Fersialitic reddish brown soils were observed ,prevailing among others although Lixiviated Ferralitic Red, Beige Ferralitic Lixiviated Brown and Eslithosol soils are present too.

The complexity of the soil cover layer is due to differences in formation factors, which vary considerably in a relatively small region.

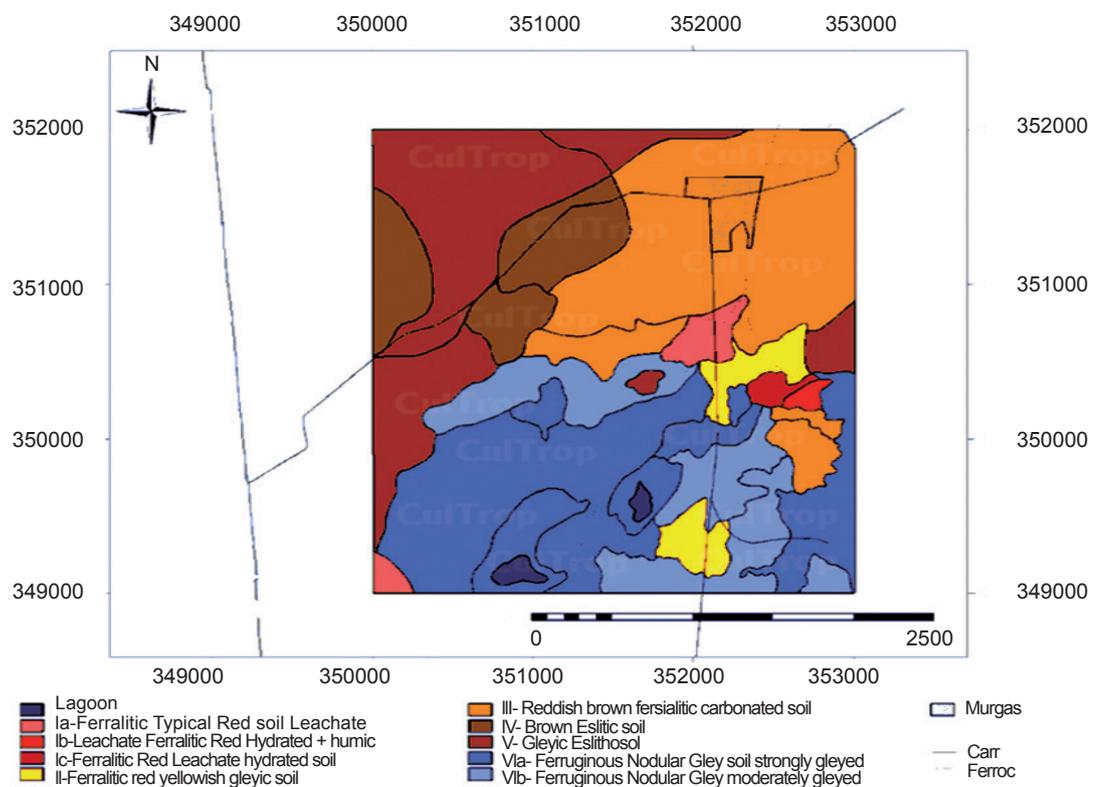


Figure 1. Soil map of the studied region

Table I. Predominant types of soils and area occupied

Soil types	Variants	Area (ha)	Area (%)
Red Ferralitic lixiviate	typical	17,26	1,92
	humic-hydrated	3,47	0,39
	hydrated	5,70	0,64
Yellowish ferralitic lixiviate	gleyic	31,86	3,55
Fersialitic reddish brown	carbonated	229,62	25,59
Brown	eslitic	83,77	9,34
Eslithosol	gleyic	175,76	19,59
Ferruginous Nodular Gley	Strongly gleyic	231,76	25,83
	Mederately gleyic	111,71	12,45
Lagoons		6,31	0,7
Total		897,22	100

On the other hand, the relief presents denudation plains in highland and cumulative ones in depressions, with a well clear system of sinkholes besides the relief evolution in time, since the lower and current sinkholes in the ancient quaternary; they must have been under the influence of more intense hydromorphic processes. Moreover, the variability of the source material on the one hand consists of hard limestone, marl and especially transported materials, with a clay, gleyed, ferralitic layer in depressions.

CHARACTERISTICS OF REGION SOILS

Ferruginous Nodular Gley soils

Most of these soils have an underlying clay ferralitic layer (with a higher clay percentage 50 %) of red, yellow and gray color, formed under the influence of a temporary water table, which led to oxidation processes and iron reduction ; this process is called gleying and leads to Gley soil formation. When this layer occurs within 50 cm deep, soil is classified as Gley or Gleysol, but when it is below 50 cm is set as gleyic subtype reference land and represents an indicator of poor drainage in the soil (11). This diagnostic Gleysol classification coincide to the World Reference Base classification (12) and the Aquult or Aquent suborder in Soil Taxonomy soil classification (13).

These soils in the studied area are presented in the lowlands, in the "Murgas depression", formed from sediments texturally different. In the zone two areas differ, one with strong gleyed soils (with the manifestation of the process between 0 and 30 cm deep) and another moderately gleyed (when it appears between 30 and 50 cm deep), which apply in the soil classification to separate in more detail for this study, in a relatively small area.

The ground surface has a horizon of light brownish gray, grayish brown to dark grayish brown (10YR6 / 2-10YR5 / 2-10YR4 / 2) of loam texture, passing a yellowish brown horizon (10YR5 / 4-5 / 8), sometimes pale yellow 2,5YR7 / 3-7 / 4), with black spots (10YR2 / 1) and below, before 50 cm an impermeable clay layer reticulated gray color (10YR5 / 1) appears , red (2,5YR4 / 6-4 / 8) and yellow (2,5Y7 / 6-7 / 8), with some black spots (10YR2 / 1), with iron and manganese. You can have ferruginous concretions (pellets), both round and oval-hard and soft.

Gleyed strongly Gley soil is the worst drainage, very acidic, with values that can be between 4,5 and 5,0 and high contents of exchangeable aluminium^D, which is very toxic to crops and which, in time in humid conditions generates more acidity, besides having high fixing power soil phosphorus. The medium gleyed Gley soil presents a faster drainage above the ground, with a pH that comes to have values of 6,5-7,0.

Reddish Brown Fersialitic soils

The Ferralitic soils occupy the highest part of the relief, in large smaller contour soil around this village and other contour, lower part of the relief. These soils in the studied area, are generally rich in organic matter (except very cultivated variants) and in carbonates from the surface, increasing in depth. Therefore they are classified as humic and carbonated (11). These soils classification matches the classification of the World Reference Base (12) as ferralitic Cambisol and correlate with Inceptisol Order, Udept Suborder, Eutrudept Group on soil classification Soil Taxonomy (13).

They are moderately deep soils, reddish brown (5YR5 / 3-5 / 4) to red (2,5YR4 / 6-4 / 8), formed of hard or semi-hard limestone, clay, surface structure, the granular- nuciform type, but they have no deeper than 40-50 cm. They have a pH around 7.0, sometimes slightly higher, with a suitable cation retention and high in organic matter, where the only limiting factor is the depth of soil.

Eslithosol soils

This soil is not in the current version of soil classification of Cuba, it was separated in the first version, applied to the soil map 1: 250 000 under the guidance of specialists from the Republic of China^B, classified as Tropical soft Gley and moderately gleyed, which there is not correlation with other classification systems (12, 13).

Eslitosols soils are formed in plains, they are very clayey, deep, very plastic when wet, and with structure of large aggregates mainly prismatic structures. In Cuba they are widely distributed in the lower parts of relief and particularly quaternary clayey plains.

In this soil, clay of type 2: 1 abounds, dilatible, with high retention of cations. In the studied area it was observed that these soils appear in depressional parts between Brown and Ferralitic soils, mainly from Murgas to the Highway and another boundary in the southeast part attached to solid of fersialitic soil.

They are affected by gleying but it is less intense one than in Gley soil case mainly because black spots are reflected in manganese composition. When reduction processes begin, manganese reduces first than iron due to; it needs less Redox potential for mobilization and concentration.

In Eslitosol soil, stains appear on 40-50 cm or deeper and therefore is classified as gleyic subtype and not as Gleysol. They are deep, rich in organic matter soils, although the pH is a little acidic, mostly 5-6. The fundamental limitation in these soils for its productivity is drainage resulting particularly clayey, so when they dry much, can be very compact.

Brown soils

They are soils that are characterized by a sialic B horizon and just like the fersialitic are moderately deep, formed on soft limestone, which allows despite its medium depth; root crops do not have a limitation for development in depth. On the A horizon they are brown (10YR4 / 3-5 / 3) to dark brown (10YR3 / 3), and very plastic clay. Surface soil structure is not thin, rather prismatic, possibly under the influence of growing sugar cane before. They have a pH between 6-7 good organic matters present, with soils that have higher nutrient exchange capacity. Regarding classifications World Reference Base (12) and Soil Taxonomy (13) these soils are classified as Cambisol Order, Inceptisol Suborder: Ustept Group: Haplustept respectively.

The classified subtype is eslitic, which means they are heavy clay soils, with a predominance of dilatible clays and prismatic structure, compact and hard when dry and very plastic when wet, usually with low porosity (1).

Ferralitic Red Lixiviate soils

In the studied region they are hardly extensive, with small areas of typical Red Ferralitic soil to the outside of the region, towards the highway and Red Ferralitic humic and hydrated soil in small highland areas. For climatic conditions of the region to continue the process of washing bases and silica in time and space (1), the soil reaction becomes more acid, which influences the structures of primary minerals and alterites that are where the weathering process on the structure of 2: 1 type side aluminosilicates intensifies, leading to the formation of clay minerals of the 1: 1 type and releasing aluminum.

These soils, with ferralitic B horizon red (2,5YR4/6), which in turn is argillite, are characterized by clayey deep, well drained and suitable pH between 6,0 and 7,0. In the past, a profile studied under sugarcane, had an organic matter content of 2,6 % in the 0-20 cm depth, and now in these areas under pasture has a content of 4,18 % matter organic. They present a drainage and Ca / Mg appropriate ratio, with a holding capacity cations between 15 and 20 cmol kg⁻¹ clay. These soils are the most optimal for the study region conditions but

are less extensive. These soils are classified by the World Reference Base (12) and Soil Taxonomy (13) as Nitisols and Alfisol or Ultisol, respectively.

Lixiviate Yellowish Ferralitic gleyic soils

Soils are ferralitic B horizon with yellowish brown (10YR5 / 4-5 / 8) to brownish yellow (10YR6 / 6-6 / 8), too deep, but less than the clay surface and with Red Ferralitic Lixiviate ones, pH around 6.0, sometimes between 5.5 and 6.0 demonstrating these features in gleyic subtype. They are clay soils in the middle of the profile, gleying below 50 cm, which are not as well drained as Ferralitic and fersialitic, but better drained soils Gley. These soils are classified by the World Reference Base (12) and Soil Taxonomy (13) as Lixisols and Aquic Kandiuustalf respectively. Under pastures it has a higher organic matter content of 4.0 and Ca / Mg proper (2 to 6). They are not extensive soil and presented in an intermediate area between the upper and lower part.

LIMITING FACTORS

When we talk about limiting factors refer to factors and soil properties that influence their productivity and yield potential of the soil to either crop. That is, they are those properties and environmental or geographical characteristics affect negatively the crop development in a given time (1). From the results of this work show that the limiting factors that affect the most productivity are, drainage, pH and organic matter content; which are discussed below.

DRAINAGE

It is called internal drainage to capacity of permeabilizing excessive water. When the permeable capacity is very low, downward movement is too slow or stopped; it says that its internal drainage is poor.

Clay soils tend to be more deficient than loamy or sandy texture drainage. Also, if the type of clayey mineral is of the smectite, clayey soils in flat relief, drainage is not the best; As with Vertisols, Eslitosols and clayey Gleysol ones. In Cuba, it has been determined that about 40 % of its soils have some drainage problems (16), this is because 4/5 of the Cuban territory is plains, most of the time with clay soils. As sampling was conducted in the dry season, in the February month, these soils maintain good moisture, especially under 30-50 cm deep.

By the soil map prepared for the studied area behavior subtypes draining soils (Table II) is shown. According to the Mapping Manual Detailed and Soil Integral Evaluation areas are represented by the type of drain region (Figure 2).

Table II. Type of drain according to soil subtypes

	Types of drain	Soil subtypes	Area (ha)	Area (%)
Type 0	Very poorly drained	Ferruginous Nodular Gley strongly gleyic	30,13	3,38
Type 1	Poorly drained	Ferruginous Nodular Gley moderately gleyed	201,63	22,63
Type 2	Imperfectly drained			
Type 2		Ferruginous Nodular Gley moderately gleyed	319,33	35,84
Type 3	Moderately drained	Ferruginous Nodular Gley moderately gleyed		
Type 3		Ferruginous Nodular Gley moderately gleyed	89,47	10,04
Type 4	Well drained	Ferruginous Nodular Gley moderately gleyed		
Type 4		Ferruginous Nodular Gley moderately gleyed	250,35	28,10
		Ferruginous Nodular Gley moderately gleyed		
	Total		890,91	100

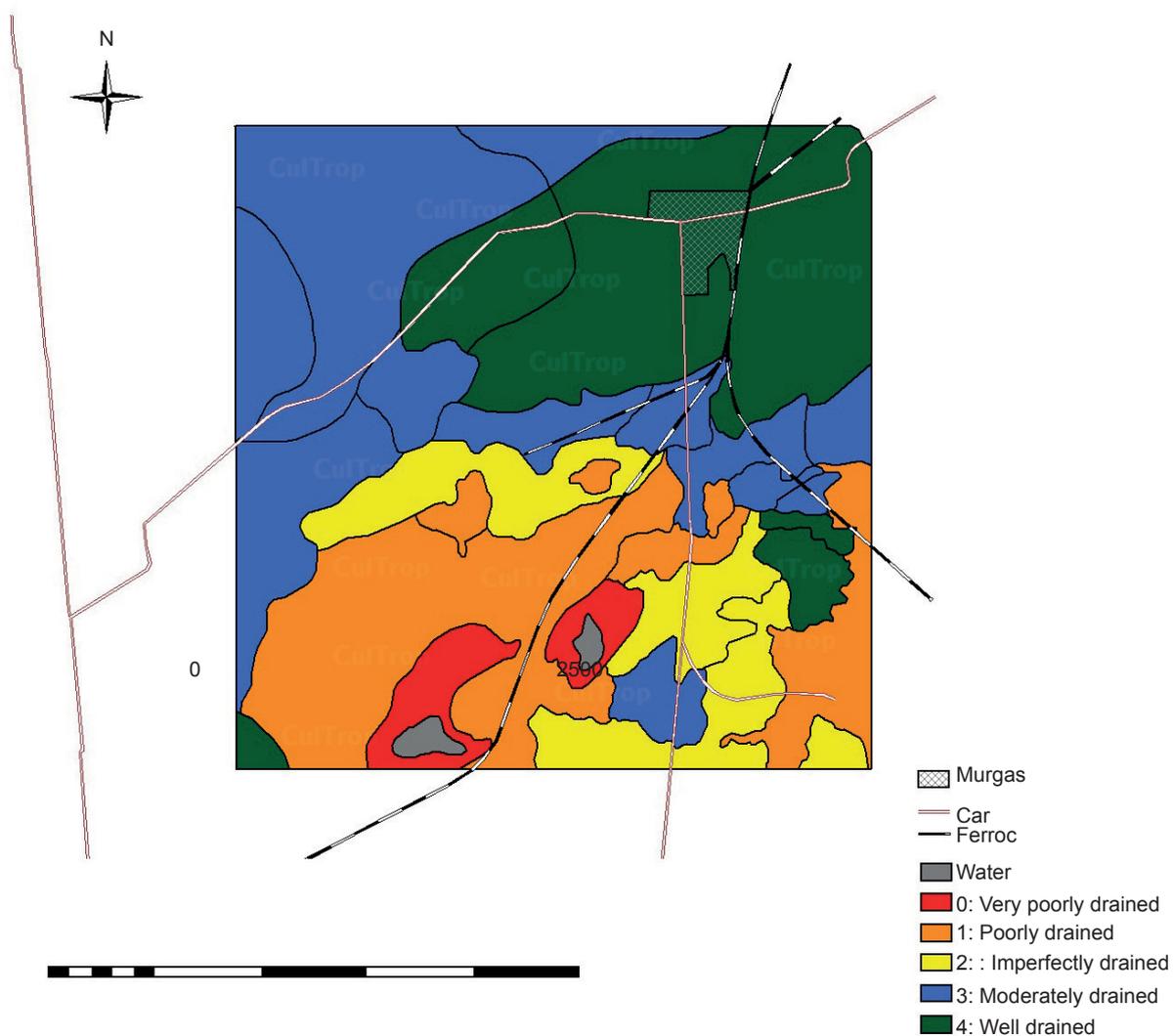


Figure 2. Map of drain types

Considering the suitability of soil drainage types may establish recommendations for use them in the *Moringa* cultivation. Type soil 0, very poorly drained should not be used in medicinal plants such as *Moringa* or other crops that are susceptible to excess moisture, as in times of rain; a water table is established throughout the area, which prevents the development of these crops.

Type soil 1, poorly drained, moisture present in the rainy season above field capacity at the profile top and in the depressions should have a water table. It is not recommended for moringa cultivation or agriculture, except for specific crops.

Type soil 2, imperfectly drained, may have high moisture content in the rainy period, but in the 30-50 cm layer. They are not suitable for use in root crops penetrate below 50 cm, such as citrus. Its use in agriculture must be done carefully, can be preliminary tests hectares a year in reference and monitoring of soil moisture every month, to a depth of one meter. In the case of the moringa use, it is not recommended because it is a culture that does not tolerate poorly drained soils (17).

Type soil 3, moderately drained, can be used in the moringa cultivation and agriculture, given that in years of atmospheric events (water seasons, cyclones) may be flooding in these areas, with crops affectations.

Type soil 4, well drained, have no limitations for use, but must take into account the soil depth, as they can be moderately deep with limitations due to the presence of rocks relatively close to the soil surface.

REACTION OF SOILS, pH VALUES

The pH soil is a very important feature, because it depends on a number of functions that have relation to crops, such as nutrient assimilation by crops, microflora development and generating of ions can be toxic to plants, such as aluminium.

Soil having a pH between 6 and 7 is ideal, since in this pH range assimilation of most all nutrients by plants takes place and also the greatest biological activity occurs.

Also at very low pH values is present large amount of exchangeable aluminium, toxic to crops and very high values, predominantly sodium cation, which is harmful too.

The map of pH in water of the A horizon was prepared by applying pH ranges for Mapping Manual Detailed and Integrated Assessment of Soil^D. On this map the areas of soil with different pH values found are obtained (Figure 3).

From the results shown (Table III), it is observed that there are slight prevalence study of soils in the region with proper pH (between 6,1 and 7,5), with 56,34 % of the area. Below 6,0 are acidic soils, with four intensities of acidity; occupying pH variant very acidic almost with 20 % of the territory, which is worrying for the proper development of crops in this case.

In connection with the pH values and different soils it should be taken into consideration the Ferralitic red, brown and Ferralitic soils have a suitable pH neutral to slightly acid, the Eslithosol ones, slightly acidic, the Ferralitic Yellowish and Gley moderately gleyed ones it is moderately acid while Gley strongly gleyed presents acid and very acidic pH values.

That is, in the upper parts of the relief, where well-drained soils predominate, an appropriate pH occurs, while in the lower parts, with increasing of gleying intensity the pH is acidic.

This is related to the gleying process in a ferralitic medium (the mineralogical chemical composition of sediments forming the underlying clay layer soil of Gley Nodular Ferruginous soil), because iron when reduces most of the time it creates acidity and also released aluminium, which in a medium rich in moisture tends to create acidity, resulting in what is known as alteration soil process very represented in humid tropical regions.

CONTENT OF SOIL ORGANIC MATTER (SOM)

The content of organic matter depends on the vegetation, biology and climate. It accumulates in the soil by plant residues, which are decomposed by biological activity. So depending on the vegetation type and the intensity of macroorganisms and microorganisms activity, will be decomposed organic matter content; although in anaerobic environments biological activity is inhibited and therefore organic matter does not decompose and accumulates in crude form, resulting in histosols.

The climate is concerned, in the humid and sub-tropical climates decomposition of plant residues is more intense than in temperate and cold climates. The soil organic matter content is important not only for fertility but also, that from this depends other properties such as bulk density, total porosity and aeration, the soil capacity to retain cations, moisture, dispersion coefficient of particles, biological activity, nutrient content especially nitrogen, etc.

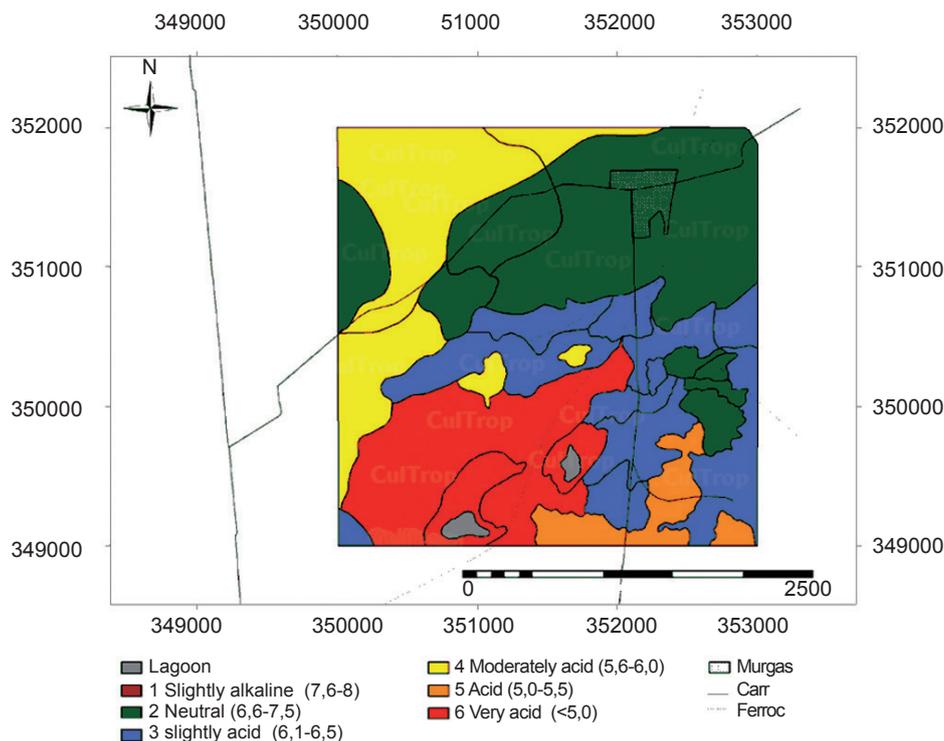


Figure 3. Thematic map of pH

Table III. pH values in the studied area

pH values in water	Denomination	Area (ha)	Area (%)
1 > 8,5	Alkaline	0	0
2 8,1 – 8,5	Mildly alkaline	0	0
3 7,6 – 8,0	Slightly alkaline	0	0
4 6,6 – 7,5	Neutral	303,27	34,04
5 6,1 – 6,5	Slightly acid	198,66	22,30
6 5,6 – 6,0	Moderately acid	171,74	19,27
7 5,0 – 5,5	Acid	43,9	4,93
8 < 5,0	Very acid	173,34	19,46
Total		890,91	100,0

One of the main features of soil quality is the structure and it depends on the content of organic matter (18). Organic matter also has a protective function in pollutants fixing both organic such as pesticides or heavy metals as minerals. The content of organic matter and therefore soil carbon depends not only on the natural conditions in which it is formed but also the handling has been subjected to (8).

In tropical regions, due to cultivation, soils quickly lose their organic matter content (5, 19) and over a period of 20-30 years may be reduced 5-6% under forest vegetation 1-2 % under intensive cultivation. In the studied region agrochemical sampling results show the organic matter content in soils (Table IV), as well as area representation for matter content areas

according to the Manual for Detailed Mapping and Integral assessment of Soil^D (Figure 4).

In the studied region, under a subhumid and tropical climate, the organic matter accumulation in soils will be depending on the contribution of plant residues to the soil. Until 10-15 years ago studied soils were under intensive activity sugarcane agriculture, mechanization, irrigation and fertilizer application; the contribution of this organic debris was very low, reducing the carbon content of the soils (19, 20).

Previous studies showed the organic matter content of Gleysol soils was 2,0-2,5 %, while t Fersialitic and Ferralitic ones was between 2,5-3,0 %; showing that the organic matter content of soils under sugarcane did not exceed 3 % (14), but with the change of land use to pastures, this percentage has increased, indicating an improving soil properties (21, 22, 23, 24, 25).

Table IV. Content of SOM per area

Range	SOM (%)	Category	Area (ha)	Area (%)
1	> 5,0	Extremely high	47,17	5,29
2	4,5 - 5	Very high	466,9	52,41
3	4,0 – 4,4	High	176,15	19,77
4	3,0 – 3,9	Medium	200,69	22,53
5	2,0 – 2,9	Low	0	0
Total			890,91	100

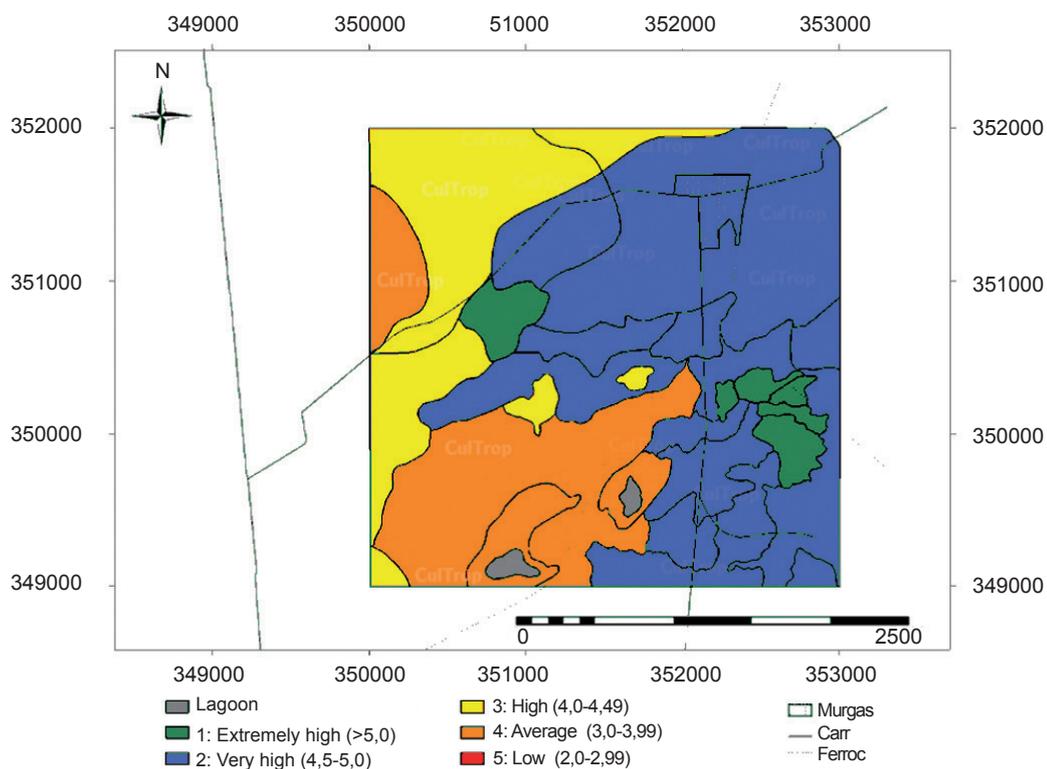


Figure 4. Thematic map of SOM content

In all samples the average organic matter content was in 4,40 % in 34 agrochemical samples. With the establishment of pastures for almost 10 years, region soils increased organic matter content, which is manifested in the current soil color and structure, which in many cases was granular and nutty.

CONCLUSIONS

- ◆ In the studied region of Murgas soil variation occurs, with six different types.
- ◆ The main soil limitations for moringa are given, first by draining, which is insufficient in the relief lower parts to the Murgas depression. However for established drainage types, there can be differentiation in agricultural use.
- ◆ Besides drainage there is a high acidity in poorly drained areas, with pH below 5,0-5,5 and changeable high contents in aluminum, which can be detrimental to this cultivation development.
- ◆ In the highlands where Fersialitic soils predominate, the limitation for the moringa is given by the depth, as they are fairly deep soils, which affects the root system functioning.
- ◆ The organic matter content of the soil, do not represent a serious limitation right now, however the evolution of organic matter when soils are cultivated should be monitored because these can reduce if not handled well.

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