




## Soil Fertility: Definition and some properties

### Fertilidad del suelo: definición y algunas propiedades

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**ABSTRACT:** Various definitions have been established on soil fertility; however, the definition is broad and complex since it depends on the supply of nutrients and other edaphic, environmental factors and the management to which this medium is subjected. The aim of this review has been to integrate various considerations that have been taken regarding the definition of soil fertility in a spread way and present in a broad way results that characterize the fertility of the main Cuban soils. The definition of soil fertility must be broad and complex, since it depends on the supply of nutrients and edaphic, environmental factors, and the management to which this medium is subjected. Based on what has been expressed and considering the complexity of the system where the soil is inserted, the definition of soil fertility is proposed as “the result of the interaction between the plant, the properties of the soil, the environment, the socio-economic phenomena and anthropogenic activity, which give it the ability to serve as a support and supply nutrients in the forms, quantities and proportions that plants require to achieve their growth and development”. In the work, chemical, physical-chemical, morphological, physical, biological properties are presented, as well as the impact of socio-economic activities and anthropogenic activity that characterize the fertility of the main Cuban soils.

**Key words:** acidity, phosphorus, structure, aggregates.

**RESUMEN:** Diversas definiciones se han establecido sobre la fertilidad del suelo; sin embargo, la definición resulta amplia y compleja ya que depende del suministro de nutrientes y de otros factores edáficos, ambientales y del manejo a que este medio esté sometido. El objetivo de esta revisión ha sido integrar diversas consideraciones que se han tenido respecto a la definición de fertilidad de manera dispersa y presentar de una manera amplia resultados que caracterizan la fertilidad de los principales suelos cubanos. La definición de fertilidad del suelo debe ser amplia y compleja, pues depende del suministro de nutrientes y de factores edáficos, ambientales, y del manejo a que este medio esté sometido. Sobre la base de lo expresado y considerando la complejidad del sistema donde se inserta el suelo, se propone como definición de fertilidad del suelo a “la resultante de la interacción entre la planta, las propiedades del suelo, el ambiente, los fenómenos socio - económicos y la actividad antrópica, que le confieren la capacidad para servir como sostén y suministrar nutrientes en las formas, cantidades y proporciones, que las plantas requieren para lograr su crecimiento y desarrollo”. En el trabajo se presentan propiedades químicas, físico químico, morfológico, físico, biológico, el impacto de actividades socio económicas y de la actividad antropogénica que caracterizan a la fertilidad de los principales suelos cubanos.

**Palabras clave:** acidez, fósforo, estructura, agregados.

## INTRODUCTION

The term soil fertility has had several definitions, which have generally been directed to consider it as the capacity of the edaphic medium to supply the nutrients that plants require for adequate growth and development.

Some authors have defined soil fertility as the practice of supplying plants with nutrients with very low amounts of losses through leaching (1).

Other authors have described soil fertility as the ability of the medium to support and sustain plant growth, including

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making available N, P, S, and other nutrients for plant uptake. In general, soil fertility and soil functioning depend on interactions between the soil mineral matrix, plants, and microbes (2).

Whatever the definition used, the characterization of soil fertility generally refers to chemical properties, which most consider to be more related to the supply of soil nutrients. In this regard, it was pointed out that soil fertility assessment is aimed at providing an adequate supply of essential nutrients to the plant to ensure optimum productivity while maximizing economic benefit and minimizing environmental degradation (3).

The objective of this review has been to integrate diverse considerations that have been had regarding the definition of fertility in a dispersed way and to present in a wide way results that characterize the fertility of soils, with emphasis on the main Cuban soils.

## DEVELOPMENT

### Definition of soil fertility

Soil fertility definition must be broad and complex, since it depends on the supply of nutrients and on edaphic and environmental factors, as well as on the management to which this environment is subjected.

Based on the above and considering the complexity of the system in which the soil is inserted, the definition of soil fertility is proposed as "the result of the interaction between the plant, soil properties, the environment, socio-economic phenomena and anthropic activity, which give it the capacity to serve as a support and supply nutrients in the forms, quantities and proportions that plants require to achieve their growth and development".

### Chemical and physical-chemical properties of the soil

#### Organic matter and nitrogen content

Table 1 shows the contents of organic matter and related properties of various soils.

The average OM and total N contents do not vary markedly between groupings; the highest values are found in the sialitic brown soils, where there are carbonate soils, in which the quantity and distribution of humus are related to the formation of the soil under secondary savannas, which contributes to relatively high values of organic matter. Ferrallitic and ferralic soils have the highest contents of hydrolyzable or assimilable N and the lowest C/N ratios; this last property generally performs adequately.

### Exchange complex and acidity

There is great variability in the particularities of the exchange complex and acidity of soils (Table 2).

The highest concentrations of exchangeable bases are found in the Vertisols and the lowest in the Ferrallitic and Ferrallic soils, indicative of the relative youth and lesser evolution of the former. The Sialitic and Fersialitic Browns occupy an intermediate position, although the latter show a greater washout of their bases, suggesting a progressive process of Ferrallitization.

The predominant cation in the adsorption complex is  $\text{Ca}^{2+}$ . The other base that has a wide participation is  $\text{Mg}^{2+}$ , being found in some Ferrallitic soils deficiencies of this nutrient (5).

The average  $\text{K}^+$  values of Ferrallitic, Sialitic Brown and Vertisols soils are above the critical level of  $0.38 \text{ cmol kg}^{-1}$  established (6).  $\text{Na}^+$  is the basis for the greatest variation, sometimes caused by the marked influence of irrigation with water of inadequate quality and by the deficient drainage of some areas.

Vertisols have the highest base and cation exchange capacity, as well as the highest base saturation. The Ferrallitic and Ferrallic soils have a lower exchange capacity and base saturation, but it should be noted that they are high when compared to similar soils in other regions and even in the tropical area, which is one of the reasons that give these soils great fertility (5), which is motivated by the presence of smectite, smectite-like compounds and kaolinite-smectite interstratification in some

**Table 1.** Average contents and variation of organic matter, nitrogen and C/N ratio of the arable horizon of the main soils of Cuba

Characteristic	Measurement unit	Magnitude	Soil grouping			
			Ferrallic and Ferrallitic	Fersialitic	Sialitic brown	Vertisol
Organic matter (OM)	$\text{g kg}^{-1} \text{ g kg}^{-1}$	mean	32.0	31.5	37.5	33.5
		minimum	12.8	15.7	3.1	8.6
		Maximum	60.3	48.1	75.9	69.3
Total N		mean	1.84	1.80	2.06	1.54
		minimum	0.62	0.90	0.24	0.50
		Maximum	5.07	2.41	3.85	3.30
Hydrolyzable N	$\text{Mg kg}^{-1}$	mean	126.23	92.09	89.22	83.47
		minimum	25.60	23.44	30.80	37.45
		Maximum	310.20	146.00	163.02	137.10
C/N ratio	dimensionless	mean	10.33	10.47	11.30	13.16
		minimum	6.70	6.60	4.36	4.47
		Maximum	17.40	27.00	35.42	34.80

Organic matter: Walkley-Black; total N: digestion with  $\text{H}_2\text{SO}_4$  conc. + Se; hydrolyzable N: Tiurin-Kononova. All analytical techniques are listed in the manual (4). N = 1 400 samples

**Table 2.** The exchange complex and the acidity of the arable horizon of the main soils of Cuba

Characteristic	Measurement unit	Magnitude	Soil grouping			
			Ferralic and Ferrallitic	Fersialitic	Sialitic brown	Vertisol
Ca <sup>2+</sup> exchangeable	cmol <sub>(+)</sub> .kg <sup>-1</sup>	mean	11.48	21.24	37.06	41.11
		minimum	2.65	5.89	3.89	17.92
		Maximum	39.40	37.03	80.60	70.60
Mg <sup>2+</sup> exchangeable		mean	3.35	6.69	9.09	17.99
		minimum	0.21	0.30	1.47	1.43
		Maximum	10.16	13.16	41.10	54.47
Na <sup>+</sup> exchangeable		mean	0.197	0.265	0.514	1.28
		minimum	0.020	0.070	0.030	0.16
		Maximum	1.980	0.550	7.880	24.66
K <sup>+</sup> exchangeable		mean	0.348	0.524	0.526	0.890
		minimum	0.040	0.160	0.100	0.140
		Maximum	1.680	1.560	2.020	3.480
CCB		mean	15.26	29.36	47.13	61.41
		minimum	3.91	21.66	6.95	23.24
		Maximum	42.88	45.53	86.84	104.77
CIC		mean	18.97	29.90	49.57	67.54
		minimum	6.45	22.92	7.67	32.15
		Maximum	44.60	47.61	87.28	105.65
Al <sup>3+</sup> exchangeable		mean	0.054	No determined	No determined	No determined
		minimum	0.008			
		Maximum	0.372			
H <sup>+</sup> exchangeable		mean	3.54	1.39	2.43	1.18
		minimum	0.34	0.28	0.07	0.24
		Maximum	7.40	3.08	8.14	6.69
Base Saturation	g.kg <sup>-1</sup>	mean	781.2	952.7	934.7	976.8
		minimum	489.1	878.4	688.3	864.3
		Maximum	980.4	990.5	998.7	996.3
pH - KCl	-log [H <sup>+</sup> ]	mean	5.40	6.05	5.63	6.22
		minimum	3.35	5.00	3.50	4.60
		Maximum	7.00	7.10	7.90	7.85

Exchangeable cations: Ammonium acetate 1 mol L<sup>-1</sup> pH 7; pH: potentiometric ratio 1:2.5 in KCl 1 mol L<sup>-1</sup>; exchangeable Al<sup>3+</sup> and H<sup>+</sup>: KCl 1 mol L<sup>-1</sup> and titration with NaOH 0.02 1 mol L<sup>-1</sup>. All analytical techniques are given in the manual in (4). N = 1 400 samples

of these soils (7), as well as by the notable increase in the base adsorption capacity of kaolinite in a neutral or alkaline medium (8).

The Ferrallitic and Ferralic soils present an acid pH and, sometimes, close to neutrality, emphasizing that in general, in the acidity of Cuban soils, the role of exchangeable Al<sup>3+</sup> is insignificant.

### Phosphoric regime

It is characterized by the highest total contents in the Fersialitic, Ferrallitic and Ferralic soils (Table 3), which is related to the calcic material from which these soils originate. The assimilable P in Fersialitic, Sialitic Brown and Vertisol soils stands out, where the average content is higher than the critical level of 7 mg kg<sup>-1</sup> of P established (9).

The Fe-bonded mineral fraction (P-Fe) predominates in the Fersialitic, Ferrallitic and Ferralic soils, while in the Vertisols it is the Ca-bonded one (P-Ca), indicative of a relative youth and less weathering of the latter. In the Sialitic Brown soils, sometimes the P-Fe fraction predominates, due to the fact that in the carbonates, free Fe reaches 14 - 51 % of the total Fe in the upper part of the profile (10).

A particularity of Cuban soils is the low retention power of phosphorus applied with the fertilizers they present, which guarantees that the required nutrient is supplied to the plant with relatively low doses (11).

It should be mentioned that, at present, the results presented in Tables 1, 2 and 3, could have been modified by the use and management given to the soil in time, being able to find lower values (indicative of fertility degradation), or higher (indicative of an irrational use of fertilization), than those shown.

### Morphological and physical properties

#### Texture

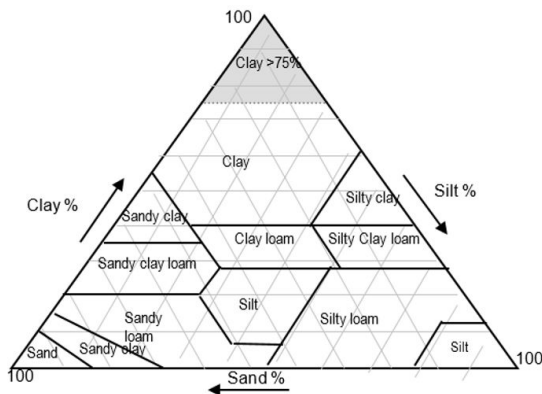
The texture of a soil is determined by the relative proportion of particles of the mineral part that have different diameters, and is classified according to the Textural Triangle (Figure 1), where each fraction has a percentage expression (12).

The importance of texture is given by the influence that this property exerts on the physical and hydrophysical behavior of a soil and with other properties associated with fertility, such as cation exchange capacity.

**Table 3.** Phosphoric regime in the arable horizon of the main soils of Cuba

Characteristic	Magnitude	Grouping soil			
		Ferrallic and Ferrallitic	Fersialitic	Sialitic brown	Vertisol
-----P, mg kg <sup>-1</sup> of soil-----					
total P	Mean	1 845	2 290	910	763
	Minimum	300	930	340	300
	Maximum	4 830	4 340	2 810	2 400
P assimilable	Mean	6.75	35.34	9.39	18.31
	Minimum	tr	0.96	tr	tr
	Maximum	43.49	420.00	73.71	144.02
P-Al	Mean	37.74	47.45	6.80	14.56
	Minimum	tr	9.82	1.00	tr
	Maximum	385.00	232.00	36.10	92.93
P-Fe	Mean	137.34	164.93	10.91	19.46
	Minimum	3.39	41.08	tr	tr
	Maximum	692.57	675.67	30.56	71.88
P-Ca	Mean	35.67	90.16	8.91	68.59
	Minimum	tr	10.00	0.57	2.18
	Maximum	245.00	300.00	55.28	289.61

Total P: Digestion with perchloric acid and colorimetry; Assimilable P: Bray-Kurtz No.2; P fractions: Chang and Jackson. tr: traces. All analytical techniques are listed in the manual of (4). N = 1 400 samples



**Figure 1.** Textural triangle for classifying soil texture based on particle size ratio and distribution

**Structure**

When soil particles are arranged and grouped together through a cementation process, soil aggregation occurs and a secondary unit or aggregate is formed that varies in size, shape and sharpness (13). It results from the development of biological, chemical, physical and mechanical processes.

According to other criteria (14,15), these aggregates are formed from the disintegration of the soil mass into separations of different shapes and sizes.

Between one aggregate and another there is a separation formed by pores or empty spaces.

The structure is related to porosity and compaction, two fundamental indices for crop development.

In the arable horizon, organic matter is the main responsible for the cementation of the particles; while, in the subsoil, this responsibility falls on Fe and Al oxides; in both cases, the clay composition plays a relevant role.

Some structures of Cuban soils are shown in the following photos (Photo 1-6), courtesy of (15).



**Photo 1.** Granular structure. Ferrallitic Red Leached Soil. San José de las Lajas, Mayabeque, Cuba



**Photo 2.** Alitic soil of low clay activity. La Palma, Pinar del Río, Cuba



**Photo 3.** Subangular block structure. Horizon Bt, Ferrallitic Red Leached soil. San José de las Lajas, Mayabeque, Cuba



**Photo 5.** Prismatic block with sliding faces of the B horizon. Pelic Vertisol. Farm La Rosita, Campo Florido, Havana



**Photo 4.** Angular block structure. Horizon Bt, Red Ferrallitic Leached soil. San José de las Lajas, Mayabeque, Cuba



**Photo 6.** Coarse polyhedral structure. Compacted Ferrallitic Red soil. Batabanó region, Mayabeque, Cuba

### Structural stability

It determines the resistance of the soil to the loss of its structure and to erosion, makes possible the movement of air and water (16,17) and reduces the potential of erosion and the formation of hard armor (16,18). It is used as an indicator of soil quality (19), since it influences the productivity of crops and responds quickly to changes in management practices (20,21).

Various agents modify soil structure, such as rain, Na, inadequate moisture conditions, unfavorable colloidal state, mechanization and plant species, among others.

Table 4 presents results that illustrate the effect of soil management on soil structural stability.

Within the same soil type, the increase in *Keh*, which corresponds to a decrease in *Ie*, indicates soil degradation as the soil becomes more tilled; the protection offered to structural stability by grass cover is highlighted.

### Bulk density

This property, also known as bulk density or simply soil density, is an estimator of compaction and is calculated

**Table 4.** Structural stability in the first 20 cm depth of Cuban soils, subjected to different management methods

Locality	Soil	Management	<i>Keh</i>	<i>Ie</i>
Mayabeque	Red Ferrallitic Leached	Wood	0.33	0.74
		Fruit trees	0.57	0.65
		Intensive cultivation	0.74	0.62
Artemisa	Ferrallitic Red Leached	Pasture	0.12	0.92
		Tobacco	0.77	0.65
Cienfuegos	Brown Agrogenic Vertic brown	Pasture	0.28	0.79
		Intensive cultivation	1.20	0.51

*Keh*: Coefficient of wet sieved stability; *Ie*: Stability index. Both indicators determined (22)

considering the existing pore spaces, always at a given moisture content.

The increase in bulk density indicates the degradation of the soil structure by compaction or loss of organic matter.

The most commonly used method for determining bulk density is known as the "cylinder method".

$$D_a = \frac{M}{V} \quad (\text{Mg m}^{-3}) \quad (1)$$

where:

$D_a$ : bulk density, expressed in  $\text{Mg m}^{-3}$ .

M: mass of dry soil, expressed in g

V: volume of the soil mass, expressed in  $\text{cm}^3$

Bulk density values of some Cuban soils are presented in Table 5, where it is observed that as the soil is cultivated,  $D_a$  increases, indicative of a compaction process.

**Table 5.** Bulk density values present in the cultivable horizon of the soils depending on the management to which they are submitted

Soil	Horizon depth, cm	Management	$D_a$ , $\text{Mg m}^{-3}$
Ferrallitic Red humic eutric leachate	6-16	Grove of more than 45 years old	0.90
Ferrallitic Red typical eutric leachate	0-12	Agricultural crops	1.12
	0-17	Agricultural crops including rice ( <i>Oriza sativa</i> L.)	1.20
	0-31	Cultivation of pasture and King Grass ( <i>Pennisetum</i> )	1.21

In general, and according to soil texture, bulk density is considered to be between  $0.90 \text{ Mg m}^{-3}$ - $1.20 \text{ Mg m}^{-3}$  for clay soils and  $1.20 \text{ Mg m}^{-3}$ - $1.60 \text{ Mg m}^{-3}$  for sandy soils.

### True density

It is the mass of soil contained in a known volume, but unlike bulk density, pore spaces are not considered, so its value is higher than the value of bulk density.

One method used for the determination of the true density is the "pycnometer method". The principle of the method is to displace the air contained in the soil pores by the occupation of the pores by water.

An equation similar to equation 1 is used for its calculation, except that the variable to be estimated is  $D_r$ :

$$D_r = \frac{M}{V} \quad (\text{Mg m}^{-3}) \quad (2)$$

where:

$D_r$ : actual density, expressed in  $\text{Mg m}^{-3}$ .

M: mass of dry soil, expressed in g

V: volume of soil mass, expressed in  $\text{cm}^3$

For practical purposes, in mineral soils, an adequate average value of real density is assumed to be between  $2.50 \text{ Mg m}^{-3}$  and  $2.65 \text{ Mg m}^{-3}$ .

### Porosity

Constitutes the existing spaces between the mechanical elements and the soil aggregates, in which water, water vapor, air, microorganisms and plant roots are found.

Porosity is thus the total volume of pores in a unit volume of soil.

Three types of porosity are classified, total porosity, pores occupied by water and aeration pores, and their calculations are made with the values of the real density, bulk density and natural moisture of the soil.

It is accepted as a good total porosity in the soil in the vicinity of 50 %. In a more detailed way, it is considered that when the total porosity expressed in % is  $> 70$ , it is excessive, when it is between 55 - 70 it is excellent, between 50 - 55 it is satisfactory, already between 40 - 50 it is low and when it reaches a value  $< 40$  it is very low (22).

## Biological properties

### Micro biota

The highest concentration of soil microbiota is established in the rhizosphere, which is characterized by a high amount of available carbon (23,24).

Bacteria are the most numerous and smallest soil microorganisms; most are heterotrophic and are important organisms in the processes of decomposition of organic matter and in the recycling of energy and nutrients such as N, P, K, S, Fe and Mn.

Some bacteria are capable of utilizing atmospheric  $\text{N}_2$  (25), others are solubilizers of P such as *Azotobacter vinelandii*, *Bacillus cereus*, *Bacillus licheniformis* and *Pseudomonas fluorescens* (26), K such as *Bacillus* sp. INCA-FRc7 and *Bacillus* sp. INCA-FRc19x (27) and other nutrients. There are bacteria with oxidizing capacity and others with reducing capacity, which cause changes in the nutritional and mineralogical conditions of the soil. There are also species that produce antibiotics and toxins for other soil organisms, as well as animal and plant pathogens.

Fungi are efficient heterotrophic organisms in the decomposition of compounds resistant to bacteria, such as cellulose, hemicellulose, lignin, fats and starches (24). Fungi play an important role in plant nutrition, since they form mycorrhizae, especially arbuscular mycorrhizal fungi (28).

Algae are important photoautotrophic organisms in the process of colonization of the parent material. In addition, in soils already formed, they are an important source of organic matter (29).

### Meso and macro biota

The main groups are annelids and arthropods. Among the former are earthworms and among the latter are those animals that have an external skeleton like a shell and are articulated. The main representatives of arthropods are insects, arachnids, myriapods and crustaceans; other groups that stand out are nematodes, mollusks and some rodent vertebrates and small mammals.

Most of the soil meso- and macrofauna, with the exception of annelids, predominate in the arable horizon.

Soil meso- and macrobiotic organisms play a fundamental role in the fragmentation, transformation and translocation of organic materials; they also contribute considerable amounts of biomass to the soil and improve some of its physical properties.

## Socio-economic phenomena

### Deforestation

The need to produce more food to satisfy the needs of a growing population has led to the development of cultivated areas through deforestation, which has modified soil fertility (30-32).

Even nowadays, this behavior is still evident and sometimes the profound changes that the deforestation process causes in the soil and its fertility are not foreseen, as shown in Table 6 Modified from (33), where it is observed that when a forested area is transformed into an agrosystem, the organic matter content decreases, the soil acidifies and the cation exchange capacity decreases due to the leaching of exchangeable bases.

### Changing agriculture

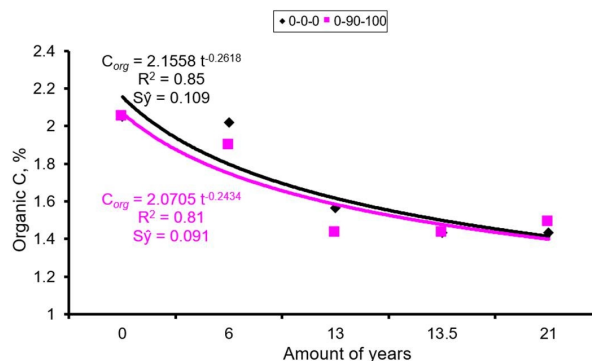
In order to satisfy their food requirements, the communities, with a certain nomadic character, developed agricultural areas from deforestation and burning of the fallen material. For some time, the new areas supplied food to these communities, but at some point, production declined, the area was abandoned and they went in search of a new one. The cycle was repeated repeatedly in time and space. All this resulted in the degradation of soil fertility, conditioned fundamentally by the depletion of the nutrient supply.

### Anthropogenic activity

Man modifies soil fertility because he uses this resource in various ways and for many purposes. The most outstanding effects that some of man's activities have on the soil and its fertility are summarized in Table 7.

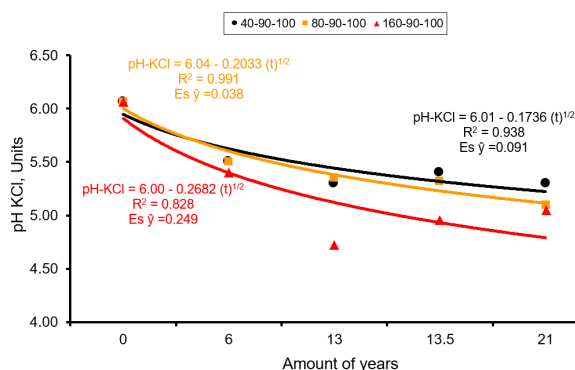
Results that illustrate the effects of human activity on the agrosystem are presented in Figures 2 and 3.

Figure 2 shows how the use of burning to harvest sugarcane causes a decrease in soil organic C over time, which is accentuated when mineral fertilizers are applied (34).



**Figure 2.** Variation of soil organic C over time using burning to harvest sugarcane with no mineral fertilizer applied and P and K applied. Each point is the average of four replicates

Another example shows how the application of nitrogen fertilizers acidifies the soil over time, a manifestation that becomes more acute as the dose of fertilizer increases, which speaks of the damage that can be caused by irrational and excessive fertilization (Figure 3) (35).



**Figure 3.** Soil acidification over time caused by mineral fertilization. Each point is the average of four replicates

**Table 6.** Modification of soil fertility caused by the change of ecosystems

Soil property	Measurement unit	Wood area with more than 20 years	Wood area changed into sugar cane area
Organic matter	g.kg <sup>-1</sup>	43.9	28.7
pH-KCl	-log [H <sup>+</sup> ]	4.4	3.9
pH-Water		5.4	4.8
Hydrolytic acidity	cmol <sub>(c)</sub> .kg <sup>-1</sup>	1.43	8.75
K <sup>+</sup>		0.41	0.38
Ca <sup>2+</sup>		20.80	4.60
Mg <sup>2+</sup>		0.60	0.20
CIC		23.25	14.33

CEC: Cationic exchange capacity

Mechanization alone compacts the soil and this damaging effect can be reversed with subsoiling, but when mechanized tillage is inadequately managed, it causes such compaction that the solution to the problem can be complex due to the considerable consumption of resources it imposes (Photo 7) (36).

**Table 7.** Consequences caused by human activities on the agrosystem

Anthropic activity	Effect or manifestation	
	Adequate management	Inadequate management
Mineral fertilization	<p>Increases:</p> <ul style="list-style-type: none"> <li>• yields</li> <li>• biomass production</li> <li>• quantity and activity of microorganisms</li> <li>• organic matter</li> <li>• nutrient supply</li> </ul> <p>Improvement:</p> <ul style="list-style-type: none"> <li>• the physical and chemical properties of the soil</li> <li>• gas exchange</li> <li>• carbon sequestration</li> <li>• agrosystem functioning</li> </ul>	<p>Decreases:</p> <ul style="list-style-type: none"> <li>• yields</li> <li>• biomass production</li> <li>• quantity and activity of micro and meso biotata materia orgánica</li> <li>• causes inter-nutrient antagonisms</li> </ul> <p>Causes:</p> <ul style="list-style-type: none"> <li>• toxicity</li> <li>• contamination</li> <li>• acidification</li> <li>• alkalization</li> <li>• deterioration of physical properties</li> <li>• eutrophication</li> <li>• malfunctioning of the agrosystem</li> </ul>
Organic fertilization	Similar to chemical fertilization, although nutrient supply is more limited.	Depending on the origin, composition and quality, it may behave like mineral fertilization, although the organic matter content is increased and the physical properties may not deteriorate.
Irrigation	<ul style="list-style-type: none"> <li>• Modifies the water regime in the agrosystem.</li> <li>• Enhances solubilization, hydration, hydrolysis, mineral weathering and mineralization of organic matter</li> <li>• Improves yields</li> </ul>	<p>Provokes:</p> <ul style="list-style-type: none"> <li>• salinity or sodicity</li> <li>• deterioration of physical and chemical properties</li> <li>• erosion</li> </ul>
Mechanization	<ul style="list-style-type: none"> <li>• Improves aeration with all its benefits</li> <li>• The plant performs a greater exploration of the soil</li> <li>• Increases organic matter supply</li> <li>• Improved nutrient recycling</li> </ul>	<ul style="list-style-type: none"> <li>• Deterioration of soil structure</li> <li>• Soil becomes compacted</li> <li>• Erosion is promoted</li> </ul>
Use of burning	SHOULD NOT BE CARRIED OUT, EVEN THOUGH IN LOW-LYING AREAS WITH POOR DRAINAGE, THIS PRACTICE IS CONSIDERED ALMOST INEVITABLE.	<p>Causes:</p> <ul style="list-style-type: none"> <li>• Losses of agrosystem nutrients, especially N, S and C.</li> <li>• Decrease in soil moisture</li> <li>• Decrease in the concentration and activity of microorganisms.</li> <li>• Short-term increase and medium- and long-term decrease in soil pH.</li> <li>• Emission of greenhouse gases into the atmosphere.</li> </ul>



**Photo 7.** Ploughing floor formed in the soil due to mechanization

## CONCLUSIONS

- Soil fertility is a reflection of the formation processes and factors that are modified over time by socioeconomic elements and human activity.
- The definition of soil fertility is broad and complex because it depends not only on the supply of nutrients but also on edaphic and environmental factors and the management to which this environment is subjected.
- The fertility of Cuban soils is, in general, favorable for agricultural development.

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