Acta Agron. (2017) 66 (4) p 457-465 ISSN 0120-2812 | e-ISSN 2323-0118 *https://doi.org/10.15446/acag.v66n4.61271*

Soil quality index in conventional and semi-ecological farms producing plantain (*Musa AAB* Simmonds cv. Dominic Harton) in Anolaima-Cundinamarca, Colombia

Índice de calidad del suelo en fincas convencionales y semi-ecológicas productoras de plátano *(Musa AAB* simmonds cv. Dominic Harton) en Anolaima-Cundinamarca, Colombia

Roberth Alberto Herrera Culma, Lina Isabel Calderón Rodríguez and Álvaro Martín Gutiérrez Malaxechebarría*

Facultad del Medio Ambiente y Recursos Naturales. Universidad Distrital Francisco José de Caldas, Cundinamarca, Colombia. Author for correspondence: amgutierrezm@udistrital.edu.co

Rec.:26.11.2016 Accep.: 06.06.2017

Abstract

This research aimed to generate a soil quality index which have allowed to compare the effect of conventional and semi-ecological plantain farming systems. For its construction, we considered biometric data of near-to-harvest plants, physical, chemical and biological indicators which were evaluated using a principal components analysis; the weight of each indicator was calculated, and so were the response curves, establishing a minimum set of data which includes: sand percentage, sheet of water, pH, Nitrogen, organic carbon percentage, potassium, biodiversity conservation and microbial respiration, respectively. In fact, this index was validated in areas cultivated with plantain cv. Dominic Harton in farms located in the same taxonomic unit in Anolaima-Cundinamarca, Colombia. Results indicate that farms with semi-ecological practices had achieved a better soil quality than those with conventional practices.

Key words: agriculture, alternative agriculture, indexes, agricultural practices, soil.

Resumen

El objetivo de esta investigación es generar un índice de calidad del suelo que permita comparar el efecto de sistemas de producción de plátano convencionales y semi-ecológicos. Para su construcción se consideraron datos biométricos de plantas cercanas a la cosecha, indicadores físicos, químicos y biológicos que fueron evaluados a través de un análisis de componentes principales; se calculó el peso de cada indicador y además se establecieron las curvas de respuesta, estableciendo un Conjunto Mínimo de Datos, del cual hacen parte: porcentaje de arena, lámina de agua, pH, Nitrógeno, porcentaje de carbono orgánico, Potasio, conservación de la biodiversidad y la respiración microbiana. Este índice se validó en áreas cultivadas con plátano Dominico Hartón en fincas ubicadas en la misma unidad taxonómica en Anolaima, Colombia. Los resultados indican que las fincas que realizan prácticas semi-ecológicas presentan una mejor calidad de suelo que aquellas cuyo manejo es de tipo convencional.

Palabras clave: Agricultura, agricultura alternativa, indicadores, prácticas agrícolas, suelo.

Introduction

Current (conventional) agricultural models have been acting as soil degradation accelerators due to the implementation of inappropriate practices as follows: excessive soil tillage, monoculture, mechanization, among others, respectively, seeking to maximize crop yield and optimize space throughout technological packages, which demand high cost inputs and an intensive use of agrochemicals (Sofi, Bhat, Kirmai, Wani, Aabid, Ganie & Dar, 2016).

Hence, recent approaches to agriculture emerge as a response to environmental degradation by focusing on the relationships between organisms and their environment, and integrating practices, which have allowed a protection in biological activity by recognizing their importance in soil processes (Bulluck, Brosius, Evanylo, & Ristaino, 2002; Ponge, Pérès, Guernion, Ruiz, Cortet, Pernin, Villenave, Chaussod, Martin, Bishop & Cluzeau, 2013).

Plantain (*Musa* spp.) crop is a prominent source of food for a large part of world population and constitutes an important source of income for peasants and small producers. However, plantain cultivation requires soils with special physical characteristics such as absence of rocks, good drainage, deep soils with good aeration and good capacity of water retention (Villarreal, Pla, Agudo, Villaláz, Rosales & Pocasangre, 2013).

In addition, plantain has a root system sensitive to low content of organic matter, which in turn, is highly influenced by soil depth and irrigation. For instance, in superficial systems, 80% of the roots tend to be between 0 and 30 cm (Vargas, Serrano & Vargas, 2011).

The most consumed elements in plantain cultivation are nitrogen and potassium, their deficiency affects the cluster as follows: number of hands and cluster total weight, respectively (Furcal-Beriguete & Barquero-Badilla, 2014).

The aim of the present research was to generate a soil quality index (SQI) that reflects the influence of conventional and semi-ecological agricultural practices on soils dedicated to the production of plantain(*Musa AAB* Simmonds cv. Dominic Harton) in Anolaima, Cundinamarca.

Materials and methods

Study area

The field research was carried out in the rural area of the municipality of Anolaima-Cundinamarca, Colombia during the first half of 2015, in six farms under semi-ecological and conventional systems with an approximate extension of 1 ha, exclusively dedicated to plantain cv. Dominic Harton.

The area is located at the western flank of the eastern mountain range, at 1650 m.a.s.l., in temperate climate with temperatures ranged from 18-22°C, average annual rainfall of 1232 mm and relative humidity of 75 to 85%. The soils of the study area belong to the soil unit MQBe (Dystric Eutrudepts and Humic Eutrudepdts), characterized by the presence of high contents of expandable clays. The slopes can vary between 25-50% and form a heavily broken hill relief within a mountain landscape (Córdoba Vargas & León Sicard, 2013). It should be noted that plantain production was recently received in the area due to a commercial agreement that facilitated the inputs acquisition for this crop. In fact, there are basically two types of production as follows: conventional, which is based on the use of synthetic inputs; semi-ecological, which is involved with the use of practices that favor the soil care.

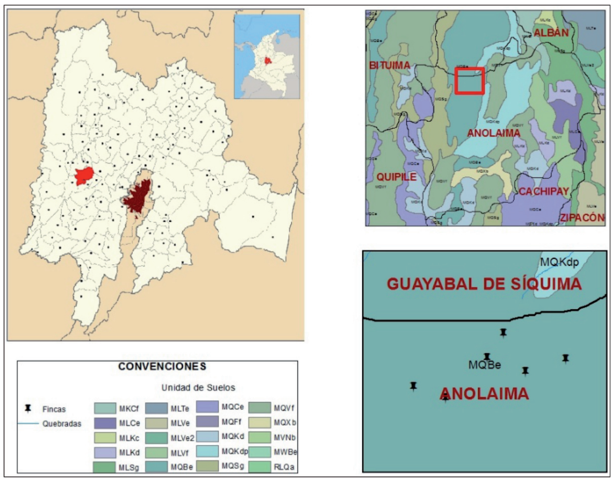

Figure 1. Geographical location of the study area. Adapted from: IGAC (2000).

Experimental design

In order to minimize the experimental error and obtain the grouping of homogeneous experimental units, a randomized complete block design, was designed. In this sense, each of the farms, which belongs to the commercial agreement will be analyzed as a block, since each one individually has homogeneous conditions in its interior. However, factors such as the treatment (semi-ecological or conventional) confers them unique characteristics which modify the soil properties and the block analysis, favors the obtaining of conclusive data per treatment.

The choice of farms group, which is object of study was based on three criteria as follows: farms which had achieved commercial agreement and are established in the study area (60 farms); farms with same soil taxonomic unit, since each unit has unique soil characteristics and have allowed comparison among them; within the farms group with at least one of the treatments needs to be analyzed (conventional and semi-ecological), respectively. Under these criteria, 24 farms located in the "Chiniata" sector, belonging to the MQEb complex, were selected, ascribed to the agreement and with at least one of the treatments will be evaluated.

Therefore, farms were grouped according to the implemented treatment obtaining a group of 14 farms under a conventional system and another group of 10 farms under semi-ecological system. Finally, three farms from each of these groups were randomly selected to obtain a total of 6 farms, which were constituted as the study area of this research. Additionally, this last reduction was established based on the evaluation guide of soil quality and soil health taking a minimum 3 measurements per each soil management (Rosales, Pocasangre, Trejos, Serrano, Acuña, Segura, Delgado, Pattison, Rodriguez & Staver, 2015). The type of treatment and description practices in each evaluated farms are listed in Table1.

Table 1. Farm characteristics under evaluation

Characteristic /Practice	Production System SOM					
	Semi-ecological			Conventional		
	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6
Soil conservation	Yes	Yes	Yes	No	No	No
Use of chemical fertilization	No	No	No	Yes	Yes	Yes
Weed management	Yes	Yes	Yes	No	Yes	No
Use of herbicides	No	No	No	Yes	Yes	Yes
Presence of pests	Low	Low	Low	Medium	Low	Low
Use of pesticides	No	No	No	High	High	Medium
Purchase of inputs	High	Low	Low	High	High	Medium

* Farm 1: Los Ocobos; Farm 2: El Laurel; Farm 3: Nuestros Sueños; Farm 4: El Paraíso; Farm 5: La Cajita; Farm 6: La Alcancía.

The soil sampling method in the judgment of an expert was used for the selection of sampling sites, in which, throughout the producer experience, the most representative area of the farm was chosen, which in all cases was the one performed growth heterogeneity.

Therefore, two plots of 20 x 50 meters each (1000 m) were delimited and 20 plantain plants with a cluster between 13 and 16 weeks were selected with the aim to measure the biometric productivity parameters as follows: circumference diameter of the mother plant and number of hands, respectively.

Subsequently, were identified 1 plant per plot based on foliage, number of hands and cluster height. In front of each plot, a mini-calicata of 60*60*30 cm was established where soil samples were extracted for soil physical analysis. In fact, soil samples for chemical analysis were taken on the same experimental unit and throughout zig-zag path method seeking the greater data representativeness.

In this sense, ten soil subsamples were taken at soil depth of approximately 30 cm comparable in variability and based on the results obtained by Vargas, Serrano & Vargas (2011), where is concluded that most of the plant root system is in the first 30cm of soil depth, given the type of irrigation practiced on the evaluated farms. In fact, soil samples were then homogenized in a vessel and 1 kg of soil samples were extracted from the resulting mixture.

It was observed that all soil samples taken at field conditions, were packed in airtight, labeled and sealed bags, which were subsequently refrigerated in cold-storage boxes with a temperature of approximately 4°C. Finally, a portion of the samples was sent to the IGAC (Instituto Geogràfico Agustin Codazzi) soil laboratory, where soil physical (texture) and chemical indicators (K, N, CO, pH), were evaluated.

The remaining portion was used to calculate soil bulk density and soil water depth (Castaño, Aristizábal, & González, 2011) (Table 2)

Data analysis

The statistical analysis was carried out through SPSS Software ®. For the selection of the most significant indicators, linear regressions were applied to soil physical, chemical and biological indicators with respect to the biometric indicators. Subsequently, correlation among variables and indicators were determined with the productivity indicator. Therefore, the selected indicators have allowed an explanation of the biometric variables behaviour related to soil quality (CMD). For instance, it was determined the independence among indicators, which carried out CMD throughout correlation analysis.

Table 2. Evaluated soil indicators

Soil indicator	Method
Soil physical indicators	
Texture	Bouyoucos and touch texture at field conditions
Apparent Density	Waxed Lump
Available sheet of water	Gravimetric setting the field capacity and wilting point of each farm.
Soil chemical indicators	
Potassium	Acetate – NH4 1M Ph: EAA
Nitrogen	Kjeldahl
Total Soil Organic Carbon	Walkley Black, Colorimetric
pH	Suspension in water 1:1; Potentiometric
Soil biological indicators	
Microbial respiration	CO_2 release
Biodiversity conservation	Macrofauna and invasive species identification
Productivity Indicators (Biometric)	
Circumference of the mother plant (pseudostem)	Measurement of the diameter of the pseudostem of 20 plants to 1 m of the ground
Number of hands	Count of produced hands

In addition, an analysis was applied for principal components in order to determine a relative importance of each indicator. Therefore, the indicators commonality was calculated to determine the weight of each agricultural soil and the corresponding response curve, obtaining the soil quality index for plantain cv. Dominic Harton using the soil quality index equation (Equation 1).

$$Index = \sum_{i-l}^{n} Weight\ i\ f_i(x_i) \quad \text{Equation 1}$$

Where:

Weight i: weight of indicator; fi: response curve corresponding to indicator i

xi: value of indicator i of the place to be evaluated.

Conversely, for each indicators value x1, x2, ..., xn of the MDS, there is a value between 0 and 1 of the soil index, from which the closer to 1, can be translated into a better soil quality and how much closer to 0 or worse, indicates soil production (Villarreal *et al.*, 2013). Finally, soil indicators were subjected to Mann-Whitney U analysis to determine whether or not, there was a significant difference among treatments.

Results

The circumference diameter of the mother plant presented significant differences, according to the Turkey test using p= 0.05 among treatments, showing that blocks with semi-ecological management (T1), with a pseudostem vigor value of 46.93 (cm). The number of hands did not reflect significant differences per treatment, however, the average in T2 blocks, had achieved a decreasing in vigor value compared to the average recorded by T1.

Given these concerns, standard deviation of the soil samples, indicates little variability among them, this could happen due to farms are not only under the same soil unit, which bring similar properties, even they are covered under the same production target, for all of which, present the same level of technical assistance.

Table 3. Physical, chemical and biological results.

Practice	Farm	Granulometry			Apparent Density g.mL^{-1})	Sheet of Water (mm)	pH	S.O.C. (%)	N.Total (%)	K Cmol(+) (Kg)	Biodiversity conservation	Microbial respiration
		Sand	Silt	Clay			.					
Semi-ecological	1	11.8	24.6	63.6	1.67	7.77	5	2.6	0.36	0.28	6	63.4
		7.8	24.6	67.6	1.66	8.08	5	2.3	0.31	0.31	7	62.7
	2	26.1	20.5	53.4	1.76	7.15	5	2.7	0.33	0.31	6	58.7
		9.7	18.5	71.8	1.5	7.47	5	2.3	0.29	0.33	7	67.8
	3	24.2	24.6	5.12	1.71	6.89	5	2.5	0.3	0.31	6	60.3
		7.9	23.9	68.2	1.56	7.6	5	2.6	0.31	0.28	7	53.6
Conventional	4	7.7	30.7	61.6	1.73	8.03	5	3.1	0.37	0.21	4	62.5
		3.7	26	70.3	1.57	7.89	4	2.1	0.27	0.41	5	43.4
	5	7.9	28.6	63.5	1.66	7.84	4	2	0.25	0.91	4	40.7
		13.9	32.8	53.3	1.61	6.85	5	3	0.35	0.23	5	65.8
	6	20.3	22.5	57.2	1.79	7.71	5	1.9	0.27	0.54	5	34.3
		16.1	24.6	59.3	1.72	7.61	5	1.5	0.22	0.61	5	26.3

Physical results

The soil apparent density does not present significant differences. However, T1 records are lowest than soils with greater porosity and infiltration. Conversely, all treatments, had achieved higher values than the one desired for plantain cultivation.

Chemical results

pH and K in farms with T2, performed averaged values of 4.58 and 0.49, respectively. In fact, T1 reached on average a pH of 5.03, ratifying what was mentioned by Bulluck *et al.* (2002), who found soils with ecological practices where have allowed a decreasing in pH compared to evaluated areas under the influence of chemical fertilizers. Alternatively, potassium (K) reached a value of 0.30, which exposes a more balanced soil according to the general considerations from soil interpretation of the IGAC-soil national laboratory, where the average value oscillates between 0.2 and 0.4, respectively. In fact, SOC, and N, reached the highest registers in T1.

Biological results

The highest percentage of SOM- soil organic matter, indicates the presence of microbial activity and an increasing in root development in T1 (Askari & Holden, 2015). Therefore, microbial respiration had achieved a significant difference (p = 0.0418).

The biodiversity conservation indicator, have allowed significant differences among treatments (p = 0.001), based mainly on a greater richness in terms of macrofauna species which favors the soil organic matter biodegradation and a greater diversity of natural species that protect the structure and agroecosystem functioning (Amezaga, Elustondo, Crespo, Hortala, & Sierra, 2016; Garbisu, 2014).

Minimum set of data

Throughout linear regressions, soil indicators with highest significance for pseudostem were identified as follows: sand percentage, soil water depth, percentage of soil organic carbon (SOC), total nitrogen, K, biodiversity conservation and microbial respiration, respectively. For instance, the soil indicators for number of hands variables were as follows: percentage of sand, percentage of clay, apparent density, soil water sheet, pH, K and biodiversity conservation, respectively. The importance of soil indicators was determined according to parameters listed in Table 4.

Table 4. Regression coefficients for soil indicators

Indicator	Beta Value Circumference of the mother plant	Beta Value (Number of hands)
Sand (%)	-6.551	-1.126
Clay (%)	-4.547	-7.129
Apparent Density (g.mL^{-1})	-7.490	-4.686
Sheet of water	8.193	5.502
pH	-0.995	-1.379
Soil organic carbon (SOC)	1.066	0.976
Total Nitrogen	2.099	0.925
K (cmol(+)/Kg)	0.528	0.812
Biodiversity conservation	2.111	1.540
Microbial respiration (mgCO$_2$.kg^{-1})	1.809	0.927

In Table 5, is shown the matrix correlation where is highlighted several relationships, which refers to the relationship between soil porosity and its ability to absorb water. Like sand, soil organic carbon (S.O.C.) and total nitrogen with positive correlation among them.

Table 5. Coefficients matrix

	Circumference	Number of hands	sand(%)	Clay(%)	Apparent density (g.mL^{-1})	Sheet of water (mm)	pH	S.O.C.(%)	Total N(%)	K(cmol(+)/Kg)	Biodiversity conservation	Microbial Respiration (mgCO$_2$.Kg^{-1})
Circumference	1	0.21	0.99	0.61	0.54	0.9	0.2	0.07	0.06	0.1	0.16	9.30E-04
N. of hands	0.39	1	0.36	0.06	0.08	0.63	0.4	0.61	0.78	0.61	0.12	0.49
Sand(%)	-3.60E-03	-0.29	1	6.40E-04	0.02	0.02	0.5	0.99	0.99	0.86	0.84	0.85
Clay(%)	0.16	0.56	-0.84	1	0.01	0.01	0.8	0.51	0.62	0.88	0.32	0.9
Apparent density (g.mL^{-1})	-0.2	-0.53	0.64	-0.69	1	0.99	0.6	0.76	0.99	0.56	0.17	0.27
Sheet of water (mm)	-0.04	0.16	-0.68	0.68	0.01	1	0.3	0.36	0.62	0.42	0.63	0.4
pH	0.36	0.27	0.19	-0.1	-0.16	-0.33	1	0.19	0.12	0.04	-3.30E-03	0.04
S.O.C.(%)	0.53	-0.17	-3.30E-03	-0.21	-0.1	-0.29	0.4	1	4.60E-06	4.90E-03	0.82	8.90E-04
Total N(%)	0.56	-0.09	-3.30E-03	-0.16	-3.30E-03	-0.14	0.5	0.94	1	2.20E-03	0.68	1.00E-03
K(cmol($^+$)/Kg)	-0.5	0.16	-0.06	0.05	0.19	0.26	-0.6	-0.8	0.79	1	0.12	4.50E-03
Biodiversity conservation	0.43	0.48	0.07	0.31	-0.42	-0.16	0.8	0.08	0.13	-0.47	1	1.40E-01
Microbial respiration (mgCO$_2$.Kg^{-1})	0.83	0.22	-0.06	0.04	-0.35	-0.27	0.6	0.83	0.82	-0.76	0.46	1

In addition, the matrix have allowed to distinguish fundamental relationships for vital soil components formation such as soil organic matter (positive correlation between soil organic carbon and total nitrogen). It also highlights the high correlation between biological activity and soil organic matter, which indicates a greater ability to decompose and helps to the nutrient absorption. In fact, sand content presents a high correlation with total nitrogen due to an increasing mineralization.

The main components analysis (PCA), have allowed to determine soil indicators set, which had achieved the greatest influence on the productivity variables behavior, as well as the first three components (pH, CO%, total N, K, biodiversity conservation and microbial respiration, respectively) may account for 86.4% of total variability.

Table 6, summarizes the results and defines the soil indicators that best explain the biometric characteristics throughout the counting of occurrences in each of the statistical techniques used (linear regressions for the circumference of the mother plant, linear regressions for the number of hands and ACP), choosing those that appeared in 2 of the 3 evaluated techniques.

Finally, the minimum data set (CMD) consisted of two soil physical indicators (% sand, water sheet), four chemical indicators (pH, percentage of soil Organic Carbon, Total Nitrogen, K, respectively) and two biological indicators (Biodiversity Conservation and microbial respiration).

Table 6. Set of minimum selection data

Indicator	Circumference of the mother plant	(Number of hands)	ACP	Total
Sand (%)	1	1		2
Clay (%)			1	1
Apparent density (g. mL^{-1})			1	1
Sheet of water	1	1		2
pH		1	1	2
% Organic Carbon	1		1	2
Total Nitrogen	1		1	2
K	1	1	1	3
Biodiversity conservation	1	1	1	3
Microbial respiration ($mgCO_2/kg^{-1}$)	1		1	2

It was observed that a decreasing in values were obtained when is demonstrated a considerably high independence. The positive correlation between microbial respiration- soil organic carbon and microbial respiration-total nitrogen is highlighted, as it reflects a close relationship among constituent elements of soil organic matter and microbial activity, as well as the relevance of the biological indicators for a proper development of the agricultural soils (Ponge *et al.,* 2013). It is worth noting the negative correlation between potassium-soil organic carbon and total potassium-nitrogen content.

Soil quality index

In the PCA of the selected indicators, three main components with a variance greater than 1 were obtained, which accumulated 89.224% of cumulative inertia (Table 7).

Table 7. Proper core values of component analysis

	Component 1	Component 2	Component 3
Own Value	4.169	1.686	1.283
Variability (%)	52.111	21.074	16.040
Accumulated Inertia (%)	52.111	73.185	89.224

In the calculation of commonality for each CMD indicators, the relative importance of each soil indicator is demonstrated with respect to the three major components, these communalities helped to define the weights of each soil indicator within the construction of soil quality index (Table 8).

Table 8. Weight obtaining for each indicator

Soil index	Component 1	Component 2	Component 3	Communality	Total Weight (%)
% Sand	0.078	0.044	0.926	1.048	11,13
Sheet of water	0.193	0.121	0.893	1.207	12,81
pH	0.381	0.826	0.204	1.1411	14,98
Soil Organic Carbon %	0.979	0.001	0.097	1.077	11,43
Total Nitrogen (N)	0.969	0.081	0.01	1.06	11,25
Potassium (k)	0.795	0.417	0.083	1.295	13,75
Biodiversity conservation	0.068	0.976	0.022	1.066	11,32
Microbial respiration	0.851	0.383	0.017	1.251	13,28
				9.415	100%

As indicated in Table 8, soil indicators with the greatest weight were as follows: pH, K, microbial respiration and sheet of water, respectively. In addition, it was found that the soil physical factor affects 23.94%, the soil chemical in 51.41% and the soil biological in 24.6%.

Although the supremacy of the influence percentage for soil chemical factor is obvious, the idea that a single factor provides a complete information since in the soil multiple variables obey to more than one factor interaction.

Table 9. Results of soil quality index

Treatment	Farm	Plot Index	Farm Index	Treatment index
Semi-ecological (T_1)	Farm 1	0.648	0.655	**0.652**
		0.662		
	Farm 2	0.645	0.655	
		0.664		
	Farm 3	0.649	0.647	
		0.646		
Conventional (T_2)	Farm 4	0.589	0.586	**0.571**
		0.583		
	Farm 5	0.550	0.590	
	Farm 6	0.565	0.538	
		0.510		

At first sight, the soil index for each treatment, shows an acceptable soil quality index and is comparable in variability to the report by Rosales *et al*., (2015). However, when submitting data to the Mann-Whitney U analysis, a significant difference can be observed among farms according to the type of treatment (bilateral asymptotic significance p=<0.05), although shows a better soil quality for T1, both per plot and farm, respectively.

Discussion

The results indicate that pseudostem diameters of T1 could present a higher resistance to winds, diseases and also reflect a stable and strong root system, highly linked to soil physical properties and microbial activity (Pérez, Francesena, Espinosa, & Castellanos, 2014; Segura *et al.,* 2015). In addition, the number of hands would reflect a nutrient imbalance in T2, which could affect the growth potential and fructification stage in conventional crops (Villarreal-Núñez *et al.,* 2013).

The circumference diameter of the mother plant, sand and sheet of water, respectively, presented high correlations among them, demonstrating the relevance of the textural factor for the correct air circulation, water, nutrients and root penetration of plantain crop (Villarreal-Núñez *et al*., 2013). However, the high percentage of expandable clays had achieved drastic aggregation changes under the same soil unit, weakening root development and decreasing water content, affecting the air movement between soil pores (Sağlam, Selvi, Dengiz, & Gürsoy, 2014). Therefore, an increasing in microbial respiration in T1 soils, could be explained by the greater physical protection due to bacteria which interacts with the negative clay loads, since the high correlation was performed between clay content and the microbial activity.

The high percentage of soil organic matter is influenced by the use of organic fertilizers (Mazur & Mazur, 2015), since the inclusion of techniques such as polyculture, favors the plant association, which benefits the soil stability and also can lead to a generation in average of 1.7 (Askari & Holden, 2015), which is coupled with the use of synthetic fertilizers, can lead to a reduction of soil organic carbon and Total N of 28 and 25%, respectively (Ponge *et al.,* 2013).

The soil characteristics accentuate water stress in the plant by limiting nutrient uptake and a low photosynthetic activity affecting the fructification stage, rachis, pseudostem and plant root system (Barrera, Combatt & Ramírez, 2011; Furcal-Beriguete & Barquero -Badilla, 2014). In addition, the high slopes present in the study area could prevent natural absorption, limiting water flow only for the first soil horizon (Reinaldo & López, 2014).

According to Bulluck *et al.* (2002), the high percentage of soil organic matter, indicates an increasing in the density of propagules of Trichoderma species, thermophilic microorganisms, enteric bacteria, and a decreasing in the amount of plant pathogenic microorganisms due to organic fertilizer treatment.

However, high values of this indicator in the presence of a considerable percentage of fine particles are often associated with stress and low efficiency of microorganisms (González, Atencio, Cubillán, Almendrales, Ramírez & Barrios, 2014), due to a decreasing in soil macroporosity, which limits the water hydraulic flow, reducing the leaching of nutrients.

As a result, it has long been thought that this increasing aeration, favors the mineralization process of soil organic matter (González *et al.,* 2014). Humus and soil organic carbon linked to the soil particles in soil aggregates (sand, silt and clay particles grouped into units of different sizes, respectively) forming their main structure.

A low variance among collected data was mainly caused by a high relation among obtained values per farm. The inclusion of soil indicators related to the soil biological activity became in the first analysis component (SOC%, total N, biodiversity conservation, microbial respiration, respectively) is highlighted, and remarks the importance of these soil indicators for the performance of productive characteristics for plantain crop.

According to Verhulst, François, & Govaerts (2015), the semi-ecological practices modify the soil quality. However, these changes depend heavily on the environmental context, such as temperature and rainfall. Phenomenon that would explain why the significant difference among treatments is low, due to the similarities of the above conditions among farms.

The positive incidence of T1 is argued by Amezaga *et al.* (2016), since this type of management practices have allowed an increasing in the macrofauna diversity in the soil and had achieved an improvement in the soil quality. On the other hand, Pérez *et al.*, 2014, state that the conventional plantain management had a negative effect on soil quality due to the high levels of toxicity caused by chemical fertilizers, as well as significantly reducing the amount of organic material.

Nevertheless, applying the soil quality index, the results show there is good soil quality for both treatments when comparing them, a significant difference is verified, thus confirming that farms with T1 present a better soil quality than those with T2.

The greatest limitation for research is the economic capacity of researchers since they did not have any external funding, which hindered the obtaining of resources and the ability to evaluate a wider range of farms. Given these concerns, the proposed methodology could be replicated in different timing evaluation and to establish a verification of the different soil treatments influence.

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