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The organic matter accumulation improves the soil in an agroforestry system

La acumulación de materia orgánica mejora el suelo en un sistema agroforestal

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ABSTRACT

The study consisted of analyzing the content of organic matter (OM) in the soil and changes that occurred in some physical properties. Soil properties such as hydrophysical properties, moisture, bulk density (Bd), total porosity and field capacity (FC) were evaluated. During years (2012 to 2021), samples were described in the field as the color and type of structure in the laboratory, the mechanical composition was determined presenting a sandy clay loam texture (sand 48.5%, silt 25.1% and clay 26.4%), pH 6.4, OM 1.4%, Bd 1.4 g cm^{-3} and FC 22.3%. The soil was classified as Anthrosols, and samples were taken at a depth of 0 to 20 cm. Thirty samples were analyzed, and the results show a poorly defined A horizon that presents large to medium blocks characteristic of a B horizon, this soil was hosted more than 23 years ago, with prolonged agricultural use and later with agroforestry use at present as an organic orchard, which has a low carbon content of 0.84%, these soils have been preserved with vegetation cover, concluding that the carbon content has not led to soil improvement in 10 years of implantation of the agroforestry system.

Keywords: soils, carbon, physical properties.

RESUMEN

El estudio consistió en analizar el contenido de materia orgánica (MO) en el suelo y los cambios ocurridos en algunas propiedades físicas. Se evaluaron propiedades del suelo, como son: propiedades hidrofísicas, humedad, densidad aparente (Da), porosidad total y la capacidad de campo (CC). En los años 2012 y 2021 se describieron muestras en campo como el color y el tipo de estructura; en laboratorio se determinó la composición mecánica presentando una textura franco arcilloso arenoso (arena 48.5%, limo 25.1% y arcilla 26.4%), pH 6.4, MO 1.4%, Da 1.4 g cm^{-3} y CC 22.3%. Las muestras se tomaron a una profundidad de 0 a 20 cm. Se analizaron 30 muestras, el suelo se clasificó como Antrosoles y los resultados presentan un horizonte A poco definido que presenta bloques de grandes a medianos característicos de un horizonte B; ese suelo fue alojado hace más de 23 años, con uso agrícola prolongado y posteriormente con uso agroforestal y en la actualidad como huerto orgánico, el cual presenta un contenido de Carbono de 0.84% que representa un bajo contenido en carbono. Estos suelos se han conservado con una cobertura, concluyendo que el contenido de carbono no aumento en 10 años de implantado el sistema agroforestal.

Palabras clave: suelos, carbono, propiedades físicas.

INTRODUCTION

Soil is fundamental in the agroforestry ecosystem with chemical, physical, and biological characteristics which intervene in its fertility, and determine its properties, and the changes that occur through the influence of land use change. The intensive use of soils causes changes in their physical properties, affecting the productive capacity of vegetation and their intensive agricultural use (Hernández *et al*., 2004, 2006).
The physical characteristics that intervene on soil structure are the depth of rooting space, useful water capacity, drainage and air content in the pores; these properties, in similar climatic situations, are the main causes of the change in the composition of agroforestry vegetation (Murray *et al*., 2011).

The objective of agroforestry is to regenerate the soil, maintain productivity through planned management, systematizing the impact on the environment (Shibu, 2009). In this context, knowing the attribution of tree species through the accumulation of leaf litter on soil structure is important for its use in projects of recovery of degraded areas or in the management of agroforestry systems tending to the sustainability of the environment (Castellanos & León 2011). The relationship between organic matter and bulk density is manifested in the soil structure, which is improved to the extent that the soil has a significant litter cover, enough to transform some chemical, physical and biological properties of the soil by increasing the organic matter on the surface and enough to reach the subsoil (Murray *et al*., 2011).

Considering that soil organic matter content and some physical properties are useful in detecting changes in texture, structure, and mechanical composition of Anthrosol soils (Murray *et al.,* 2014 b), transformed to an agroforestry system and now with an agricultural system, this work aims to investigate the organic matter (OM) content of a soil under an agricultural system and the changes occurred in the physical properties.

MATERIAL AND METHODS

The area selected for this work is located on the campus of the Autonomous University of Nayarit. This site is located in a morphological environment characterized by slopes of San Juan volcano, grouped by complexes associated with volcanoes and reliefs of the Pre-San Juan hill, in addition to hillsides covered by pyroclastic materials, volcanic breccia and acid tuff associated with the previous volcanic structures. The environment is characterized by two depositional landscapes: the piedmont is associated with the volcanic structures of the San Juan and mixed colluvial-alluvial processes; in the plains, accumulation processes dominate.

To determine the content of organic matter (MO); the mechanical composition (texture) of the soil was by the Bouyoucos method and soil pH (measured in water), for these methods mentioned were based on the Mexican official standard NOM 021 RECNAT 2000; real density (Rd), bulk density (Bd), pycnometer; by the cylinder technique; total porosity (Pt), by the formula Pt=(1-(Bd/Rd)x100) and field capacity (FC), aeration porosity (Pa), by calculation from total porosity (Pt), minus field capacity (FC), infiltration by the double ring method, for soil classification IUSS Workin Group WRB (2014) was used.

In relation to the analysis, 30 soil samples were used, three samples per year (2012 to 2021), the Bd was made at a depth of 0 to 30 cm to coincide with the first horizons of the soil, and to consider the first layers of the thickness of the diagnostic A horizon, also because the most influenced horizon as a result of the accumulation of leaf litter that is deposited on the soil (Murray *et al*., 2011, 2014). The experimental design considered was completely randomized, the data were studied using the standard ANOVA procedure for the statistical design of study with the variables MO and Bd; a correlation and comparison of means $p<0.05$ was made. In the analysis of variance, the SAS package was used to show if there are statistical differences between treatments; the mean experiment was performed by Tukey's method.

RESULTS AND DISCUSSION

The results obtained in the first year of the experiment (2012) are presented in Table 1. It is observed that the mechanical composition (MC) of the experimental site, presents a sandy clay loam texture (sand 48.4%, silt 25.2% and clay 26.3%) in 2021, presents the same MC results, taking into account (Murray *et al.,* 2014) that the texture requires many years to be able to be modified, and a short period of years have elapsed to see changes, with a pH (6.4). The soil is classified as Anthrosols, according to IUSS Workin Group WRB (2014).

Table 1. Mechanical composition and textural class of the studied profile from 2012 to 2021

Horizon	Depth cm	Sand %	Silt %	Clay %	Textural class
A_1p	0 – 3	48.5	25.1	26.4	Sandy-clay loam
B_1p	3 – 20	48.5	25.1	26.4	Sandy-clay loam

The values obtained for the real density of the soil showed no variation in the 10 years studied, an average value of 2.60 g·cm-3 was obtained. The soil presents a MO content 1.4% and values of 0.84 CO that can be considered as low based on Nom 021 RECNAT 2000, Bd 1.4 g cm $^{-3}$ and FC 22.3%, (Table 2).

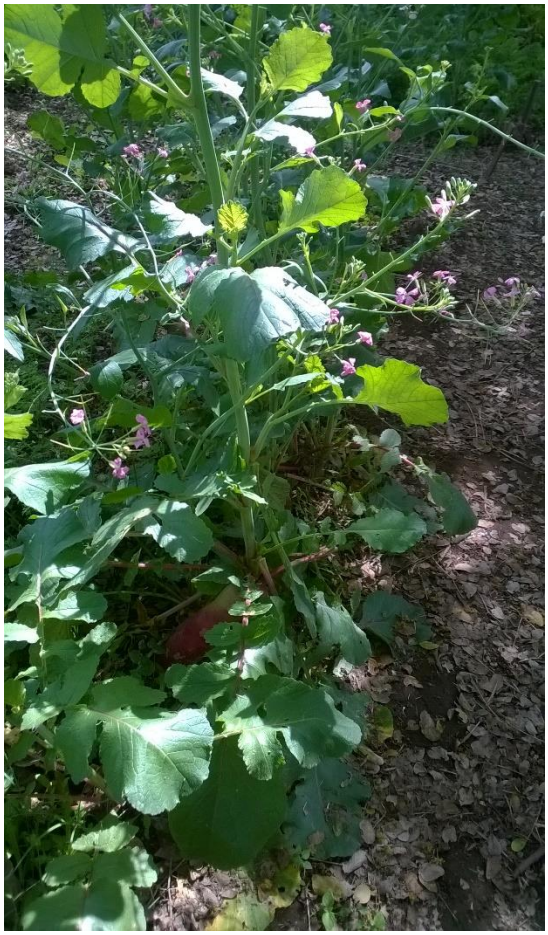

Figure 1. Radish plant

Figure 2. Broccoli plant

Figures 1 and 2 show the poor development of vegetables, as the soil is pruned in OM, presenting compact blocks.

Table 2. Physical determination of the soil studied in the first 20 cm from 2012 to 2021

Year	OM %	Bd·cm^{-3}	Pt%	FC %	Pa%	Infiltration mm/h
2012-2021	1.4	1.4	45	22.3	20.8	12.0

MO=organic matter; Bd= bulk density; Pt=total porosity; FC=field capacity; Pa=aeration porosity.

Consequently, the OM content obtained from the soil of the A horizon had very little influence on bulk density, including air space, since its measurements are related to total porosity and to the soil structure of medium to large subangular blocks. This is also in agreement with Murray *et al.,* (2010) who found a correlation between edaphic OM content and Bd.

Moisture equivalent to FC was determined, giving values of 22.3% as well as infiltration rate of 12.0 mm/h, which can be considered as good, but at the same time, presenting very low values of microporosity, exhibiting a clay layer that does not allow water to filter to deeper layers of the subsoil.

Figure 3. Blocks are observed

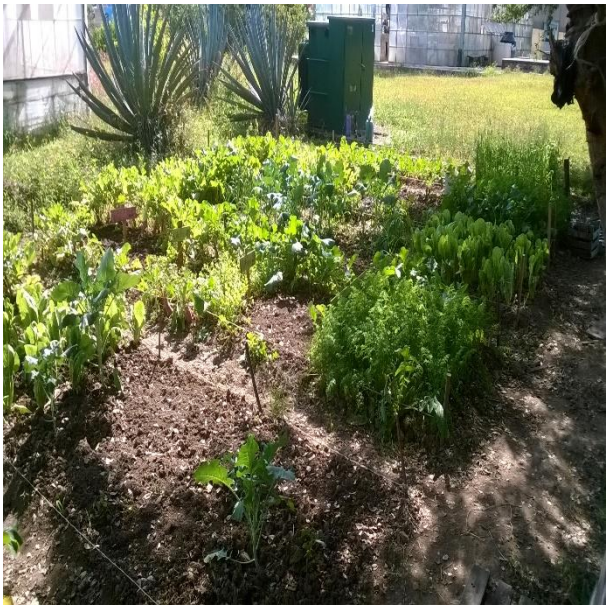

Figure 4. Vegetables of the experiment

The experimental system presents large to medium blocks characteristic of a B horizon, presenting an A horizon, poorly defined, this Anthrosol was hosted more than 23 years ago and now with an agroforestry system, which does not present an organic carbon content that can modify soil structures, C content of 0.84% which is considered low in carbon, these are soils that were conserved with a pasture cover within the agroforestry system, see figures 3 and 4.

CONCLUSION

With the values obtained, it is shown that the soil structure was not modified, it presents a little developed A horizon after the agroforestry system was implemented, with more than 10 years, especially if they are transferred soils, and these were housed as fillers (Anthrosols), the soil presents a B horizon (0 to 30) cm. On the surface, it can be seen that an organic horizon was not developed, and this causes that an A horizon does not develop in the medium term, and the contribution of organic matter is too little to modify the physical properties of the soil, the physical degradation of the soil occurs in soils with a lot of sand and silt and little organic carbon, with a B horizon of medium to large angular blocks, the carbon content did not increase in these years of implantation of the

agroforestry system, which means that this soil was stabilized with the little organic matter that it retained. In summary, the contribution of organic matter and nutrients derived from the decomposition of leaf litter has not led to soil improvement in the agroforestry system.

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