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Conservation agriculture, an option for carbon sequestration in soil. Case study in Guantánamo, Cuba.

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Abstract

During 3 years, a demonstrative area was monitored in the southwest part of Guantánamo province, Cuba, for the implementation of Conservation Agriculture technology, with the objective of validating the technology transfer to the country. Laboratory analysis were used to evaluate soil moisture, organic matter content, pH, electrical conductivity and bulk density; in order to corroborate the results obtained by the Visual Evaluation of Soils (VES). An increase of moisture retention in the soil profile of 20% was achieved, up to a depth of 60 cm. The decrease of the bulk density was verified in 10%, which reflects the decrease of the compaction and benefit of other properties. The organic matter in the soil showed improvement in 30%, increasing in turn, the carbon sequestration. Improvement in soil structuring and increase in soil biological activity were verified. These results are still within the ranges determined at the beginning of the system, but show signs of ecosystem recovery and the feasibility of technology transfer as a measure to Climate Change adaptation.
Keywords: Conservation agriculture, climate change.

Introduction

Global warming is due, to a large extent, to the high concentrations of CO_2 in the atmosphere; and soil is naturally, a large reservoir of organic carbon. It must therefore to be considered as a way of retaining carbon to prevent it from being released into the atmosphere. The production of organic materials varies according to the ecology of the specific medium. In general, management practices that increase soil organic carbon also reduce erosion, increase production, and improve natural resources. (Espinoza, 2005)

Just as the soil is over, provides a medium in which the plants grow, in turn, they protect the soil from erosion. Human activity is breaking this relationship. At some point in the last century, with the intensification of agricultural activity, soil erosion began to exceed the rate of soil formation in large areas. The secret to avoid soil erosion is to not allow it to be unprotected, ensuring that the surface is always covered with plants or with a mulch of those same plants.

Conservation Agriculture (CA) is based on three fundamental principles: crop rotation, permanent land cover and minimum or zero tillage and is a technology widely recognized as a viable concept for the practice of sustainable agriculture, increasing the levels of soil matter and with it, the available organic carbon as an energy source, adding or releasing N to or from the soil through the symbiotic fixation of the N_2 of the atmosphere, breaking the cycle of some pests and diseases that can appear in the crop systems, improving the structure of the soil, retaining soil moisture, and reducing the energy needed for cultivation, among other benefits.

Methodology

The experience was developed during 3 years in the Malabé farm, of 4 ha, belonging to the CCS Enrique Campos of Guantánamo municipality, southwest of the province of the same name, in Cuba, on a typical Salinized Fluvisol soil (Hernández et al., 1999), Typical Ustifluvent (USDA, 1992) loamy clay texture, located between the coordinates North 156.450 - 156.650 and East 667.400 - 667.500. In order to perform this work, was used the basic soil map 1:25 000. Periodic soil samples were taken at a scale of 1: 5000 for the determination of chemical analyzes: (pH in H2O by the potentiometric method (Soils Institute, 1985), percentage of organic matter by Walkley - Black method (Soils Institute, 1985) and electrical conductivity in automated paste to determine soil salinity which became saturation extract from the conversion factor for light soils (Rivero et al., 1998)) and physical analysis (soil moisture up to 60 cm in depth and apparent density). In addition, Visual Evaluation of Soils (VES) (Shepherd et al., 2006) was used to corroborate the analytical results obtained.

Results and Discussion

Initially the study area was under the technology of traditional agriculture, being carried out all the corresponding agricultural activities like, for example, tillage, furrow, pass of step, crossing and seeding. In cultivated soils, the greatest contribution of carbon comes from harvest residues, hence the need for technological change that favors adaptation and / or mitigation of the effects of climate change, through CA. The term organic matter refers to the total amount of all the organic carbon contained in the soil. The main chemical element of all that content is carbon, hence the terms organic matter and carbon are used indiscriminately. (Goddard et al., 2008)

In the initial physical - chemical characterization of the soil the pH values varied between 7.70 and 8.80, from slightly to medium alkaline, obtaining, as average, 8.18, medium alkaline; Organic matter averaged 1.9%, classified as low; and the electrical conductivity in the saturation extract ranged from 0.88 to 1.31 $dS.m^{-1}$, with mean values of 1.05 $dS.m^{-1}$, which classified the soil as No Saline. The apparent density was determined, with a value of 1.35 $g.cm^{-3}$, classified as medium to high. The values of humidity were between 12 and 17%, the average being 14.5%, to a depth of 60 cm.

Considering international experience accumulated on the implementation of CA system that proposes to obtain positive results between the 3 and 5 years after introduction, the demonstration area was monitored and these parameters were monitored during 3 years, maintaining a rotation in the system with crops like sorghum, beans, maize and squash, fundamentally.

The average values of pH obtained were kept within the initial range, that is, from slightly to medium alkaline, but with a slight decrease to 7.7; an average of 2.5% of organic matter was obtained, showing an approximate increase of 30% with respect to the initial values, although it remains classified as low. Martínez et al. (2008) refer that organic matter in the soil affects the pH of the soil due to the various active groups that contribute acidity levels, to the cation exchange capacity and the nitrogen content present in the organic residues contributed to the soil. The electrical conductivity showed similar behavior, maintaining the classification of soil as No Saline.

The apparent density decreased 10% (1.22 $g.cm^{-3}$) classified as medium to high, showing a decrease in compaction and a benefit of other important physical properties (structural stability, porosity, infiltration velocity), which ratifies the thesis that the recovery of a soil is much slower than its destruction. Carter (2002) cited by Martínez et al. (2008) argues that the maintenance of adequate levels of organic matter in the soil contributes to decrease the apparent density and resistance to soil compaction.

Cairo (1982), showed that the increase of organic matter increases notably the stability of the aggregates, the porosity and consequently the permeability of the soil.

An increase in moisture retention in the soil profile of 20% was observed, allowing a more rational use of irrigation throughout the cycle. Karenski (1975), Geigel (1977) and Goddard et al. (2008), pointed out that the annual biomass contribution, besides protecting the soil from surface runoff with the layer that forms, increases water retention 3.15 times, which implies a considerable increase in infiltration capacity and decrease the loss of soil by trawling.

Through the VES, the soil structure was improved, with the presence of macro and micro pores, increased biological activity of the soil with the presence of earthworms in the first 20 cm of the soil and the formation of galleries. In the same way a better development of the root system could be appreciated. This corroborates the fact of the increase of the organic carbon in the soil, essential for the biological activity of the soil. The presence of these soil organisms allows the decomposition of organic residues actively participating in the cycles of many elements used by plants; in addition, they participate in the formation and stabilization of soil structure and porosity (Martínez et al., 2008).
There is also sufficient evidence in the literature that traditional agriculture lowers soil carbon and supports the increase of new and improved forms, such as CA, to preserve or increase the storage of organic matter in the soil, which allow better control of the carbon balance on the planet.

Conclusions

Soil, although the monitored properties present non-significant improvements, because their evaluation remains in the ranks characterized at the beginning of the system, showed signs of recovery in a fragile, difficult to manage ecosystem and the feasibility of Conservation Agriculture technology transfer. It is important to note that the increase of organic content in the soil, understood as organic carbon, favored the chemical, physical and biological properties evaluated in the demonstration area by means of Conservation Agriculture.

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