HILL PUBLISHING

International Journal of Food Science and Agriculture, 2022, 6(3), 320-326
https://www.hillpublisher.com/journals/jsfa/
ISSN Online: 2578-3475
ISSN Print: 2578-3467

Influence of Conservation Agriculture on Some Physical Properties of a Red Ferralitic Soil

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How to cite this paper: Amaury Rodríguez González, Javier Arcia Porrúa, José Antonio Martínez Cañizares, Calixto Domínguez Vento, Julian Herrera Puebla, Alexander Miranda Caballero. (2022) Influence of Conservation Agriculture on Some Physical Properties of a Red Ferralitic Soil. *International Journal of Food Science and Agriculture*, 6(3), 320-326.
DOI: 10.26855/ijfsa.2022.09.012

Received: July 29, 2022
Accepted: August 25, 2022
Published: September 13, 2022

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Abstract

In recent years, it has become aware that the factors that limit the agro-productive capacity of soils are derived from the phenomenon of physical degradation that they have experienced, which has been a consequence of intensive tillage with highly productive conventional tillage technologies. In Cuba, despite the advances in tillage, conventional tillage based on the use of plows and disk harrows still prevails, which adversely affect the physical, chemical and biological properties of the soil, hence the importance of looking for alternatives that mitigate such effects. The present work was developed in the "Pulido" Science and Technical Unit belonging to the Agricultural Engineering Research Institute with the aim of evaluating the behavior of the physical and hydrophysical properties of the soil under the influence of two technologies of soil preparation, (Conventional Tillage and Conservation Agriculture) the first based on the use of disc implements, the second on the application of the three principles of Conservation Agriculture (minimum soil mobilization, permanent coverage and crop rotation). To evaluate the changes, two plots were established, in which 9 sampling points were taken with three repetitions, for a total of 27 for each area at depths of 0-10, 11-20, 21-30. The results indicate favorable changes in favor of conservation tillage, since a decrease in apparent density and compaction superior to 7%.

Keywords

Intensive Application, Degradation, Alternatives

1. Introduction

One of the most effective methods against soil degradation is Conservation Agriculture(AC), a revolutionary technique cultivation in which the soils are not tilled, this practice defines it as a model that points towards a sustainable and profitable agriculture, with the consequent increase in the income of the farmers who implement it [1].

There are several international studies on the effect of agricultural practices on the physical and chemical properties of the soil and its impact on crop yields [2-5].

In Cuba, research related to the change in the physical and chemical properties of the soil under Conservation Agriculture systems are scarce, the objective of this work being to evaluate the changes on some physical properties of a compacted Red Ferralitic soil under Conventional Tillage and Agriculture of Conservation.

2. Materials and Methods

The study was carried out in areas of the “Pulido” Science and Technical Unit (UCTB) belonging to the Agricultural Engineering Research Institute (IAgric), located at the coordinates (Latitude 220, 4649.2″ N and Longitude 820, 36′

06 , 69″ W), located in the Municipality of Alquizar, Artemisa Province (Figure 1). An area that has been dedicated to various crops for more than 20 years under conventional tillage was selected, which was divided into plots in plots of 1.5 ha (Conservation Agriculture) and 0.5 ha (Conventional Tillage). The soil is compacted Ferralitic Red [6].

Two tillage systems were established, the first based on the use of conventional tillage technology based on disk implements (Plow and disk harrow) and the second (Conservation Agriculture), which is characterized in the lodging of the cover with roller. knife, herbicide application and direct seeding with minimal mobilization (Table 1).

To evaluate the possible changes produced in the physical properties of the soil with the use of the systems of the tillage systems under study, three replicas were established in each plot, in which three permanent sampling points were carried out, taking a total of 27 samples distributed in nine points, they were taken before and after the harvest of each crop cycle. In all cases, soil samples were taken at depths of 0-10, 11-20 and 21-30 cm.

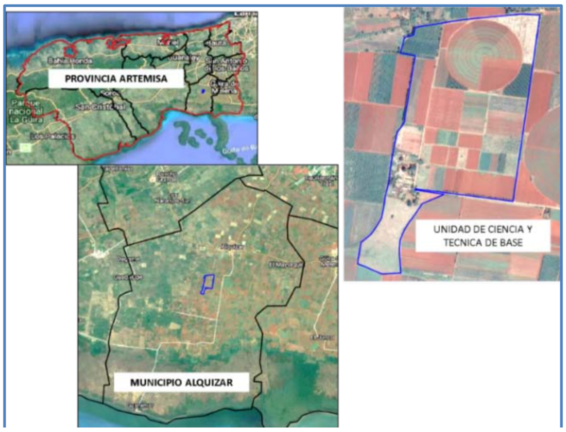

Figure 1. Geographical location of UCTB, Alquizar Municipality, Artemisa Province.

Table 1. Tillage systems used

Energy source	Conventional Tillage		Conservation Agriculture	
	Implement	Work	Implement	Work
Tractor 20 KN	4 disc plow	Break	Rolo blade	Finishing the coverage
	28 disc harrow	Fluffy	Sprinkler	Herbicide application
	4 disc plow	Crossing	Coarse grain seeder	Sowing
	28 disc harrow	Fluffy		

Soil analysis performed. Methods used

- ***Humidity of floor***

Stainless steel cylinders with a volume of 100 cm^3 were used, which were weighed at the time of taking the sample with an electronic balance with 0.1 g precision, once weighed they were subjected to the drying process at 105 ^{o}C for 24 hours, then they were weighed again to obtain the dry weight and proceed to the calculation, using the following expression:

$$HS = \frac{PSH - PSS}{PSS - PA} \times 100$$

Where:

HS: Soil moisture, %
PSH: Wet soil weight, g
PSS: Weight of dry soil, g
PA: Ring weight, g

- ***Apparent density***

It was determined by the method of rings with a known volume of 100 cm^3, using the same points and procedure used to determine soil moisture. Its calculation was carried out using expression [7].

- ***Porosity***

It was determined from the density of the solid phase and the apparent density of the soil [8], by means of the expression:

$$Pt = [1 - (Da \div Dr)] \times 100 ,$$

Where:

Pt: Total porosity,%
Da: Apparent density, g.cm^{-3}
Dr: real density g.cm-3 or specific weight.

- ***Water infiltration into the soil***

Infiltration was determined by the concentric ring method [9]. In each treatment, the tests were carried out using in each case three pairs of concentric rings with diameters of 28/53 cm, 30/55 cm and 32/57 cm and height of 25 cm, with a beveled edge for better introduction into the soil. Each ring was introduced into the soil to a depth of 10 cm and leveled [9]. The data obtained from the field tests were adjusted according to the model proposed by Kostiakov [9] and whose mathematical expression for the accumulated infiltration is:

$$Z = Kt^{n} (1)$$

Where:
Z = cumulative infiltration (L t-1)
t = infiltration time
K and n = empirical constants that vary with each type of soil

- ***Soil organic matter (SOM)***

It was carried out using the Walkley-Black method to determine organic carbon. According to the procedures manual of the laboratory of the Sugarcane Research Institute.

Statistical processing of the experimental results.

The statistical package STATGRAPHICS PLUS, Version 5.1, was used for the exploratory analysis and the t-contrast test was performed to determine if there were significant differences between the means.

3. Discussion

Different properties, over time, are capable of detecting alterations in the quality of the soil due to the way of handling it [10-11]. The data shown in Table 2 are the result of the analysis of the physical and chemical properties survey before establishing the evaluated tillage systems with a view to determining the variations produced by the traditional and conservation tillage systems.

Table 2. Physical and hydrophysical properties that characterize the experimental área

Depth (cm)	Mos (%)	Field capacity (cm3. Cm-3)	Gives (g / cm3)	Porosity (%)	Sand (%)	Slime (%)	Clay (%)
0-10	2.23	23.2	1.18	54.78	20.9	57.4	21.7
11-20	2.19	22.4	1.28	50.72	17.7	61.8	20.5
21-30	2.06	23.8	1.20	55.61	28.9	62.8	14.3

SOM- Soil organic matter, Da- Apparent density, RP- Penetration resistance.

When evaluating the influence of the evaluated tillage systems, a slight increase in the content of SOM stands out, as the soil is prepared with the Conservation Agriculture system, this behavior presumably motivated by the decomposition of root systems of crops and permanent coverage of the ground.

Figure 2 shows the content of soil organic matter (SOM) when comparing the influence of the two tillage systems evaluated (Conventional and Conservation Agriculture). A trend is observed, mainly in the surface layers, to an increase in the content of SOM when prepared with the Conservation Agriculture system with respect to conventional tillage, associated with the non-inversion of the prism, which, although not statistically significant, may indicate a potential benefit of this type of system for carbon sequestration in the soil [12]. Other authors consider that SOM constitutes an important indicator of soil quality, given its sensitivity to management practices and have shown changes in this parameter when different tillage systems are used, noting that the turning of the soil caused by tillage Conventional CO2 flux into the atmosphere increases, and as a consequence decreases the CO2 content [9-13].

Figure 3 shows the behavior of the apparent density (Da) of the soil under the two tillage systems under study, observing statistically significant changes of this variable in the systems evaluated in favor of Conservation Agriculture, with a decrease in the Da of 7% on average, it is also observed that the highest values were found in the depth of 11-20 cm, which may be given by intensive tillage over the years with implements and disc harrows creating a compacted layer at this depth, this type of degradation is common in soils where agricultural machinery is used intensively [12, 14-15].

Table 3 shows the results obtained in the total porosity (Pt), results that allow corroborating the above stated about the effect of the decrease in apparent density on the increase in porosity, which for the evaluated areas presents increases of 4% on average in favor of Conservation Agriculture. However, these increases will be more noticeable in a longer period of application of the technology evaluated and should gradually increase with the continued use of the same. Similar studies also report favorable changes in porosity in favor of reduced tillage [16].

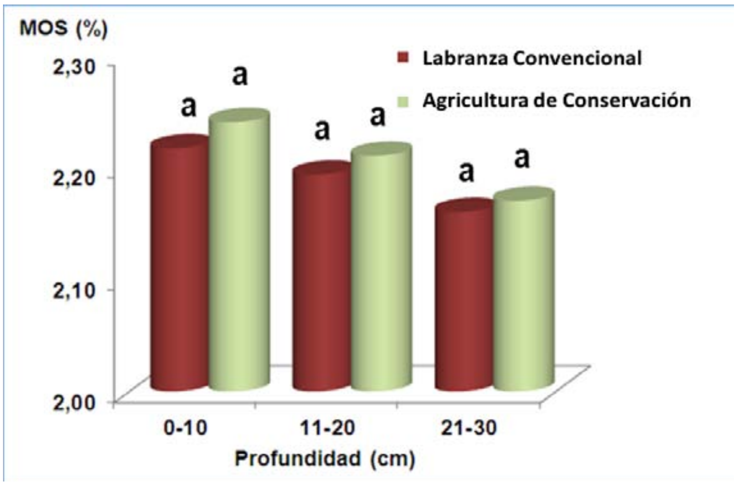

Figure 2. Influence of the tillage systems evaluated on the content of organic matter up to a depth of 30 cm in a compacted Red Ferralitic soil.

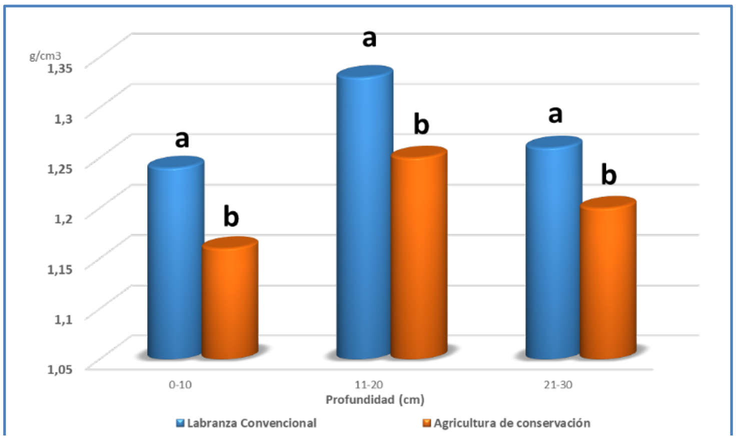

Figure 3. Influence of the tillage systems evaluated on the apparent density up to a depth of 30 cm in a compacted Red Ferralitic soil.

Table 3. Influence of the tillage systems evaluated on porosity up to a depth of 30 cm.

Depth (cm)	Technology	
	Traditional	Conservationist
	Porosity (%)	
0-10	51.28	54.47
11-20	48.52	53.93
21-30	51.19	54.06

The variation in soil moisture content has been one of the parameters that is most emphasized in studies of conservation tillage systems, attributing advantages when conditions of water stress occur [14], fundamentally in systems under agriculture of conservation.

Figure 4 shows the moisture content in the soil at the time of sampling the different properties under study, showing no significant differences for the areas evaluated with the two tillage systems, however, a slight increase can be estimated. of this property in conservation tillage. Several authors [16-17] attribute a greater availability of soil water to the effect of stubble and crop residue on the surface in systems under conservation agriculture, with minimal or no tillage. Similar results were found [10-11] when comparing cropping systems under conservationist and conventional tillage.

Figure 5 shows the behavior of the instantaneous infiltration and Figure 6 the accumulated infiltration for the two treatments studied. According to Figures 5 and 6, the Conservation Agriculture treatment exceeds the instantaneous and accumulated infiltration in relation to the conventional preparation.

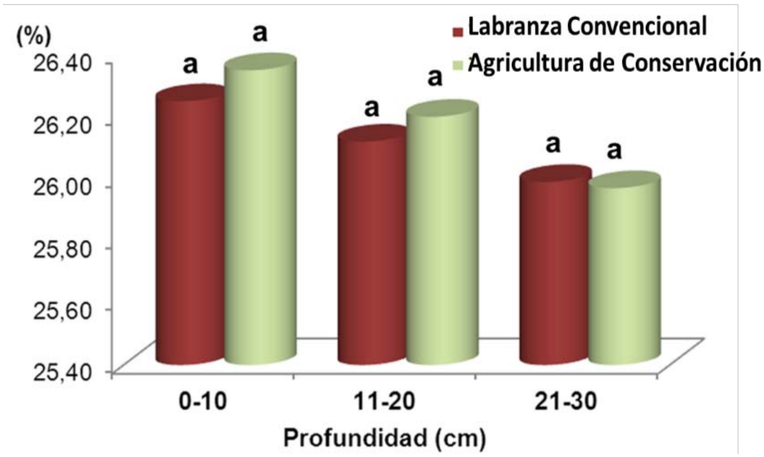

Figure 4. Influence of the evaluated tillage systems on humidity up to a depth of 30 cm in a compacted Red Ferralitic soil.

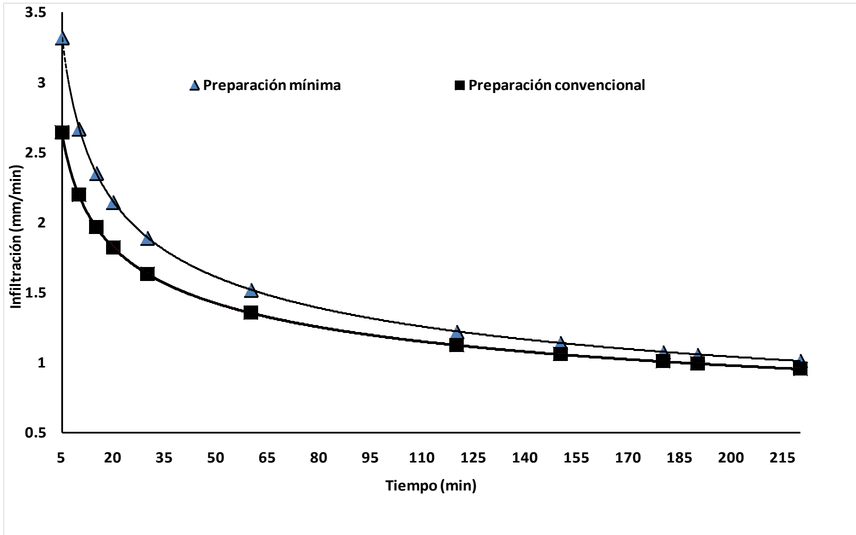

Figure 5. Influence of the tillage systems evaluated on the instantaneous infiltration in compacted Red Ferralitic soil.

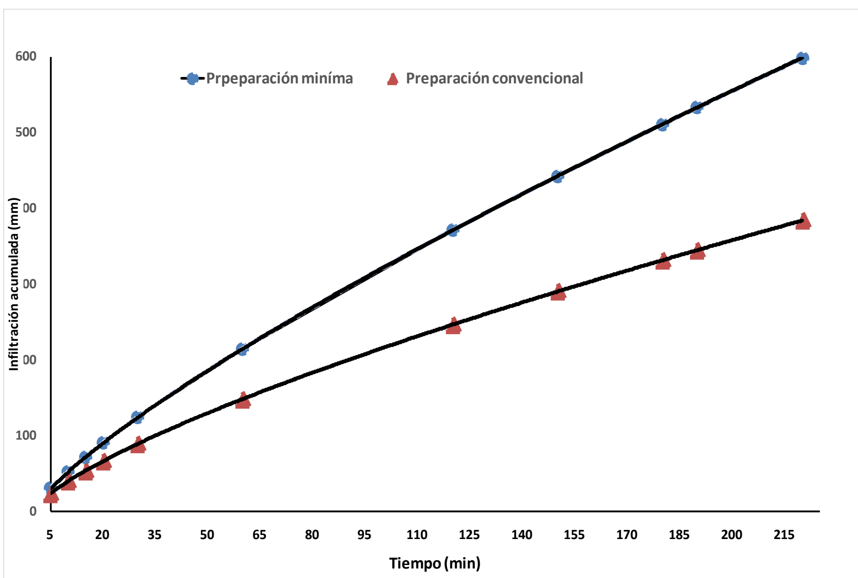

Figure 6. Influence of the tillage systems evaluated on the accumulated infiltration in compacted Red Ferralitic soil.

The above is congruent with the average increase in apparent density from 1.21% to 3.8% (Figure 3) in the profile from 0 to 30 cm of conventionally prepared soil in relation to Conservation Agriculture.

In this sense [18-20] when studying different infiltration calculation models for an Oxisol from Colombia and relating their parameters with Da, they found an inverse correlation between this property and the different parameters, which for the authors previously mentioned, this behavior confirms that the higher the apparent density, the infiltration speed decreases; [21-23], on the other hand, found that a surface pressure in the range of 200-250 kPa reduced water infiltration into the soil by more than 80% compared to unsaturated soil. The main soil degradation problems associated with agricultural activities and their effect on water infiltration, concluded that the infiltration capacity of soils was diminished for all uses due to excessive tillage.

4. Conclusions

The evaluation of conservation tillage with respect to conventional tillage did not present significant differences in the change of most of the properties of the soil under study, except for the apparent density, which presented a significant average decrease of 7%. However, the tendency to improve the properties evaluated indicates a potential benefit of this type of tillage.

When determining the instantaneous and accumulated infiltration in both treatments, an increase in water infiltration in the soil of 20% was observed in favor of Conservation Agriculture.

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