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Research Article

Effect of Soil Compaction on the use of Water in Areas of Forage Irrigation

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Abstract

Introduction: The animal tramples produce the soil compaction, which finishes affecting the roots. The subsolation of the areas for forage with irrigation before its seedtime can contribute to improve the physical characteristics of the floors and to elevate the productive results of the grasses. Studies carried out in others cultivars have demonstrated effectiveness in the physical characteristics of the soil, with some farm types, however data are not reported for the cattle areas.

Objective: The objective of this work was to evaluate the effect of the compaction in the use of the water in areas of forage irrigation.

Methodology: The study was carried out in the property La Victoria of the municipality Jimaguayú, province Camaguey, Cuba; for this were compared it the compaction levels in areas of forage low irrigation with and without subsolation and in shepherding areas, and it carried out samplings of humidity to determine the irrigation programming keeping in mind the precipitations.

Results: The results showed bigger compaction levels in the area without subsoiled in relation to the area subsoiled, with apparent density of 1,44 g/cm3 and 1,30 g/cm3 respectively. The reading of the humidity and the precipitations allowed designing an irrigation programming chord with the characteristics of the grass, the soil and the climatic conditions. The effectiveness of the subsolation the yields of the forage it were measured being 33 t/ha of green mass in a cut in the area subsoiled vs. 11 t/ha in the area without subsoiled.

Conclusions: The improvement of the physical conditions of the soil by means of the subsolación allowed a more efficient use of the water, that which together to the control of the soil humidity and the precipitations was reflected in the increment of the yields

Keywords: Forage; Cattle Raising; Humidity; Subsolation

Introduction

The population of cattle in the world grows with the increase of the human population; this behavior constitutes a threat to livestock areas, so that today the degraded pastures in the world reach 650 million hectares. If one takes into account that practically 4/5 of the world production of the goat bovine-sheep mass (52 million tons) comes from animals that feed on pastures, it is a necessity to know the causes of grassland degradation, as well as possible solutions to this problem [1].

Although livestock is an important productive activity, its negative effects on the soil are becoming more evident; for this reason, one of the main challenges facing dairy farming is the need to develop a viable system with forages that are capable of ensuring an increased and sustainable production with a minimum of degradation of the soil resource [2].

Current fertility without the restitution of soil nutrients is insufficient; its conservation has been based on a balance of nutrients, which includes the amount present in the soil, the amount extracted by forages for an expected production and the efficiency of the absorption of nutrients by plants applied as broader terms that include in addition to chemical, physical, biological and environmental variables [3].

Animal trampling has as a final result its effect on soil compaction, which ends up affecting the habitat of roots, microorganisms and the productivity of pastures, since the soil reduces its ability to retain water and supply oxygen. [4] and [5].

[6] Suggest that measuring penetration resistance in a soil is better measured than apparent density (Da) for determining the degree of root development in a soil and that the penetrometer is more accurate in measuring the resistance of the roots to enter the soil.

The fact that there are soils with poor drainage reflects compaction problems, with few studies being carried out in this regard. Livestock areas, once planted, receive very little cultural attention, while irrigation activity is scarce and adequate programming is not taken into account according to compaction levels, so inadequate use of water is made [7].

The subsolation of the areas mainly for forage with irrigation before planting can contribute to improving the physical characteristics of the soils and raising the productive results of the pastures, so the objective of this work is to evaluate the effect of soil compaction on the use of water in areas of forage irrigation.

Materials and Methods

This work was carried out on the farm "La Victoria", belonging to the Credit and Services Cooperative (CCS) "Evelio Rodríguez", located in areas adjacent to the town of El Guayabo, in the municipality of Jimaguayú, province of Camagüey, Cuba, which occupies a total area of 144.01 ha [8]. Its social purpose is cattle ranching, especially milk production, although it also reports production of various crops for self-consumption and sale to the state. Table 1 lists the composition of the farm's soils and some of their physical properties.

Type of Soils	Total Area	%	Dr (g/cm^3)	Da (g/cm^3)	DC (%)	Infilt rate (mm/h)
Brown without carbonates	113,82	79,04	2,56	1,27	31,19	21,89
Brown grizzly	27,36	19,00	1,43	2,46	24,12	30,00
Reddish brown Fersialítico	2,83	1,96	2,49	1,24	30,07	21,06

Table 1: Composition of the soils of the farm La Victoria and some physical properties.

Dr: Real Density; Da: Apparent Density; DC: Field Capacity; V inf: Infiltration Rate

Source: Institute of Soil and Fertilizers (2019).

In the area evaluated the predominant soil is of the brown type without carbonates, the crop evaluated was the Panicum maximum cv Mombasa.

For the irrigation of the area there is a semi-stationary sprinkler irrigation system of medium pressure of 1 ha, supplied from a source of ground water. The rain was controlled with the use of a standard rain gauge, making the readings in the early hours of the morning.

To carry out the study, the subsolation of the area was carried out. The initial irrigation was developed according to the schedule used on the farm (irrigation every 7 days and 2 hours per position). Subsolation was applied in part of the area destined for forage, the compaction effect was measured by Eikelkamp brand penetrometer of 0-1000 Newton with precision of 20 Newton, performing three evaluations and comparing the results between the areas with and without subsolation (Figure 1).

Figure 1: Scheme grazing and forage.

The apparent density was determined by the method suggested by [9] which consists of taking apparently unaltered samples with the help of a beveled cylinder at the end that is introduced into the ground [10].

To evaluate irrigation programming, two parameters were considered.

- **Soil moisture control:** these evaluations were carried out at different points of the irrigated areas, the readings were carried out in the early hours of the morning and the results were used to check the behavior of soil moisture and its relationship with rainfall and irrigation, as a basis for possible adjustments in the interval and time of irrigation, for this purpose a portable TDR combined meter brand TF48.1000 was used with registration of soil moisture, pH and luminosity (Figure 2).

Figure 2: Sampling of the moisture sampling.

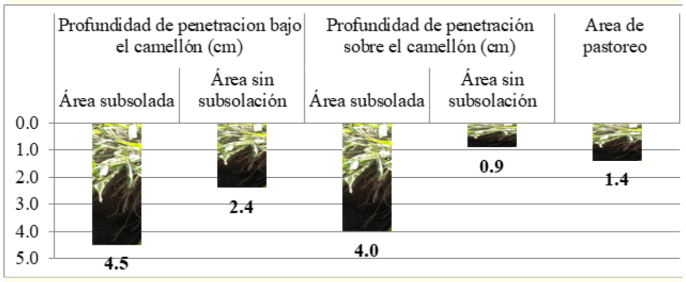

Figure 3: Average depth reached by the penetrometers.

- **Pasture yields:** for this purpose, 2 sampling points of, 25 m^2 were selected, which were used for yield control and measurement of leaf length. A variant of the proposal of [11] was applied, sampling was carried out during the period evaluated. The effectiveness of the adjusted irrigation schedule and its influence on soil moisture was verified from the growth of the plants and the yield, the control was carried out at the ninth month of the subsolation and the irrigation was rescheduled.

Results and Discussion

In general, the trampling of animals compacts the soil in the first 15 cm, causing a severe decrease in the internal movement of water and an increase in apparent density, this results in a decrease in porosity and unfavorable changes in the soil-water-air relationship that affects the development of plant roots and their productivity [12].

The results of the compaction evaluations when applying the penetrometer indicate a greater penetration of the same in the subsolate area both on the groove and below it, this coincides with [13] that explains that this influence of trampling is mainly of a physical-mechanical type, since it affects the state of compaction of the first centimeters of the soil (Figure 3). Compaction in the grazing area was even greater than in the area without subsolation.

It is observed that in the evaluations carried out in the forage areas both on and under the ridge, the greatest results were obtained in the sub-floored area, although these are still small, which is attributed to the fact that there was only one subsolation pass, so an increase in depth should be expected in successive passes of the subsoiled. In relation to the grazing area, the results are also lower in relation to the forage area with subsolation.

The use of subsolation as a method to remedy compaction in areas of pastures for fodder in order to make better use of water has been pointed out by [12], who has expressed that to break the compacted layers robust tools may be necessary in order to create larger pores through which roots and water can penetrate. In this research the subsolation was carried out in an area already sown when the ideal would be before planting, but observing the results and with the aim of making irrigation more efficient in forage areas this could be done when cutting. Figure 4 shows the behavior of the depth of penetration under the ridge in relation to the behavior of humidity in 3 repetitions performed.

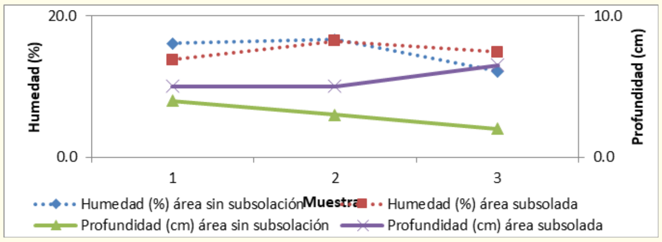

Figure 4: Depth and humidity in areas with and without subsolation.

Taking into account the effect that compaction has on the apparent density of the soil; we proceeded to the analysis of the humidity based on dry soil and the depth reached by the penetrometer, after three months of the subsolation activity. [12] Refers to the importance of assessing physical analyses of soils to determine whether soils are degrading, due to compaction at different depths, or whether the arable layer is being lost; criteria coinciding with those applied in this study, whose results will allow establishing parameters of irrigation organization to achieve an efficient use of water.

The results show similar humidity levels for both areas, however, the depth levels differ, this indicates a lower penetration of water in depth in the area without subsolation and therefore a greater permanence of moisture near the soil surface, as a consequence of which it is expected greater evaporation and faster process of soil drying. These conclusions justify subsolation as a measure for the improvement of soil characteristics, coinciding with [14] who states that compaction with the footsteps of animals in the soil is like 1 or 2 centimeters in soils with good coverage, creates rooting problems in plants, but insists that this affectation comes to be generated to a greater extent when the paddocks have little vegetation cover, because the grazing of animals with poor management, ends up harming the soil.

As shown in table 1, in [8] apparent density values of 1,27 g/cm^3 are reported for this type of soil on the La Victoria farm, which were taken as a reference in this research, it is observed that this value is higher than those studied by [15] who indicate that extensive livestock and intensive dairy farming were categorized among the systems with average densities between 0, 98 and 1,05 g/cm^3. The results are shown in figure 5.

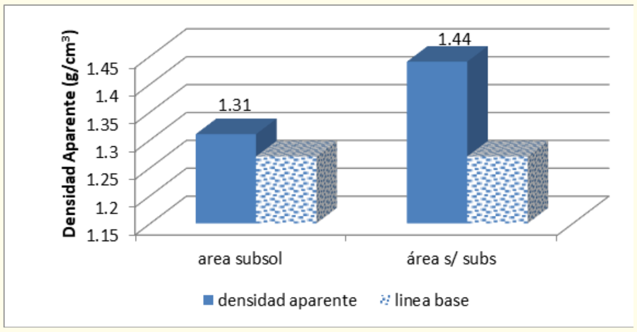

Figure 5: Values of apparent density of the study area.

As you can see the average value of Da in the subsolated area is lower than in the area without subsoleo which means that the subsolation performed yielded fruits despite the short time of effect. They explain [16]. That apparent density varies with soil texture and organic matter content can vary seasonally due to tillage and soil moisture. The values found coincide with what [9] states that for the soils of the brown grouping the values of Da fluctuate between 1.41 and 1.01 g/cm^3.

The reduction of the Da should be interpreted as an improvement of the physical properties of the soil, in this regard [17] they point out that normally the variation in the data of the Da are due, for the most part, to differences in the total volume of pores, the lower the Da the greater the porous space that is, it is less compact soils, when a soil is compacted due to the trampling of animals, the number of pores decreases, which increases the weight per unit volume.

The research shows that the trampling of cattle during the time that the farm has been on the livestock area has had an impact on the Da, (from 1,27 g/cm^3 as a baseline to 1,44 g/cm^3 in the area without subsoleo), on the behavior of the soil without animal trampling; [18] indicated that for many soils, 7 or 8 years of pastures restore the physical properties to almost the levels they had when virgin with the passage of agricultural machinery in the inters weaving.

To optimize water consumption and achieve better yields, it is necessary to make measurements of soil moisture in real time, having this information can regulate the standard and frequency of irrigation to be applied.

It is stated in [19] that measuring equipment brings a generic calibration curve but if more precise measurements are desired, such as those required for irrigation control, it is necessary to construct calibration curves for each soil. The results of the calibration of the portable TDR are shown in table 2, where the appropriate values for working are highlighted.

Reading (adimensional)	%CC	Reading (adimensional)	%CC
1	Very dry	6	98
2	Dry	7	102
3	74	8	Very humid
4	84	9	Saturated
5	92	10	Saturated

Table 2: Curve of calibration of the TDR for the studied soils.

The reading values corresponding to scale 3 and 6 were taken as reference as indicators of the minimum and maximum (74 and 98% CC respectively) for irrigation programming.

[20] States that two golden rules for establishing an irrigation system on a farm are: knowledge of the rainfall of the place and the water requirements of the soil according to its analysis. To adjust the irrigation schedule, moisture measurements taken with the TDR showed higher averages in the subsolated area, the same behavior was obtained in terms of the depth reached, with 5,5 cm and 3,0 cm on average in the subsolated and non-subsolated area

respectively, so it is inferred a better aeration, water use and root growth; results that coincide with what was expressed by [21] who obtained favorable results by applying tillage without reversing the prism up to 20 cm deep with increases in total porosity and aeration.

To check the behavior of soil moisture according to the irrigation and rainfall regime, a pilot control was carried out over a period of three months; figure 6 shows the results obtained, which show that during it there were 17 rainfall events with values between 10 and 50 mm and 4 irrigations were carried out; the 9 TDR readings performed in the subsolated area indicate that the humidity was managed to remain within the expected limits.

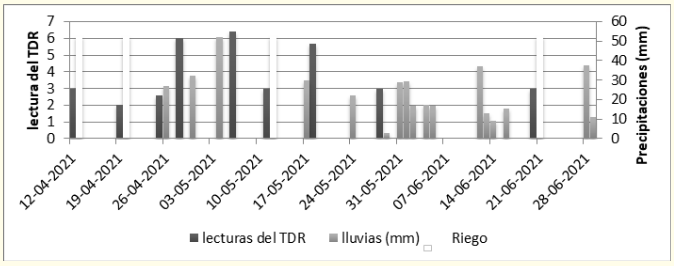

Figure 6: Measurement of humidity, irrigation and rainfall.

It was possible to verify that for the local conditions, the planned irrigation schedule is adjusted to the needs of the crop, the soil conditions and the characteristics of the irrigation system, being effective in the sub-floored area, while in the area without subsolation the soil moisture fell below the desired values before the seven days of irrigation interval established.

The control of rainfall together with the measurement of soil moisture allowed an efficient use of water for the irrigation of forages; during the period evaluated if the behavior of soil moisture had not been considered for irrigation programming according to the pre-established program, a total of 12 irrigations would have been carried out with a consumption of 1000 m^3/ha of water more than necessary.

With regard to irrigation and its more efficient use in pastures, [22] he states that in livestock farms strategies can be used to save liquid while protecting pastures for livestock, noting that to harvest fodder or maintain sowing made months ago the sprinkler system can be used, but it should not be done at the same times of the day or in the same amount, similar result in terms of the amount of water to be used is obtained if rainfall measurements are used to program irrigation.

Citing other authors [23] he has proposed that the objective of irrigation is to supply crops and pastures, efficiently and without altering soil fertility, with the additional water to the precipitation they need for optimal growth and to cover the needs, so as to avoid their accumulation in the soil profile, ensuring the sustainability of irrigation.

Based on the results obtained, for practical purposes it was recommended to maintain the planned irrigation schedule, and in case of rain to make the corresponding adjustments

- If the rains are greater than 50 mm, the last precipitation can be irrigated after 15 days of fall.
- If the rainfall is less than 20 mm, the irrigation interval cannot exceed 10 days.

The measurement of rainfall is a prerequisite and must be carried out as accurately as possible. The control of soil moisture is important for decision making, considering that the producer does not have the necessary instrument, it is recommended to use a practical method based on touch, which can be applied with permissible reliability depending on the experience and possibilities of observation and interpretation of the producer.

In relation to crop productivity, [24] he has stated that Mombasa Guinea grows in different types of soils and can fully survive a long period of drought, but only show its best conditions under a humid environment; its highest productivity occurs in loam-clay soils.

They found [25] in Brazil heights of 59,9 and 53,9 cm in the rainy period at 35 days of regrowth of The Guinea Mombasa, results lower than those obtained in this work, where 75 days after the second regrowth, heights of 167 cm and 148 cm were reported in the subsolated and non-subsolated area respectively (Table 3).

Show	Subsoiled area	Without Subsoleo area
M1	1,65	1,28
M2	1,64	1,48
M3	1,68	1,59
M4	1,68	1,47
M5	1,71	1,56
Average	1,67	1,48

Table 3: Results of samplings of the long one of the leaves (m).

Explains [24] that in the production of forage with Guinea Mombasa under natural conditions and in relatively fertile soils, 60 to 75 t/ha of green mass can be obtained per year by cutting every 7 to 9 weeks, in this research, the cut was made at 9 months after subsolation, a period during which the irrigation was reprogrammed, obtaining yields between 33 and 11 t/ha of green mass for the subsolated and non-subsolated area respectively, which indicates the possibility of achieving potential yields.

Conclusions

- The improvement of the physical conditions of the soil through subsolation allowed a more efficient use of the water available for cultivation, which together with the control of soil moisture and rainfall was reflected in the increase in the yields of the Mombasa from 11 t/ha to 33 t/ha of green mass in a cut.
- This result has an environmental impact by helping to avoid soil degradation.
- The control of soil moisture and rainfall allowed to adjust the irrigation schedule.

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