PHYSICAL ATTRIBUTES OF A CHERNOSOL ON THE WEST BORDER OF RIO GRANDE DO SUL CULTIVATED WITH RICE IN TWO CULTIVATION AND IRRIGATION SYSTEMS.

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Abstract

Rio Grande do Sul is the largest rice producer in Brazil. In most areas, planting is conventional and irrigation is done by continuous flooding. This irrigation method has high water consumption, therefore a production alternative that has been used by some producers and which has been shown to be economically viable with meaningful water savings in rice cultivation is the sprinkler irrigation method. The use of the sprinkler irrigation technology also presents other advantages, such as the adoption of no-till farming as the cropping system. This work aimed to evaluate the effect of conventional and no-till systems in rice areas over the soil physical attributes. Soil samples preserved in the layer of 0.00-0.15m in two rice producing areas in the municipality of Uruguaiana were collected. The collections were made in an area where crop irrigation is done by spraying and where no-till farming has been used for about ten years, as well as in another where rice is irrigated by flooding and conventional tillage is performed. The physical soil attributes were evaluated: bulk density, macroporosity, microporosity, distribution of aggregates by size class and mean weight diameter of aggregates. Soil bulk density was greater in the no-tillage area, and in consequence the total porosity, micro and macroporosity were lower here. However, the no-tillage area had a higher concentration of aggregates in the classes of largest size and largest mean diameter, which means that in no-tillage systems the soil is better structured.

Keywords: soil management, density, porosity and aggregation.

Introduction

The planting of irrigated rice is preferably performed in flat, mildly hilly areas that usually occur in poorly drained lowlands in reason of the easy management of flood irrigation for the crop. These soils can be found in different regions of Brazil and, in Rio Grande do Sul, account for approximately 25% of the total area of this state (1).

Rio Grande do Sul is the largest rice producer in Brazil and uses a cropping system under continuous flood irrigation (2). This method has high irrigation water consumption mainly in the rice production regions of the state, where the terrain is mildly hilly, a feature most often found in the region known as West Frontier.

An alternative production recently adopted is the sprinkler irrigation method, which has proven to be economically viable with significant water savings in rice cultivation. The average volumes of water applied to two flood irrigation systems (conventional and pre-germinated) was approximately three times higher than that applied to sprinkler irrigation (3).

The use of the sprinkler irrigation method in rice crop has other additional advantages, like the adoption of no-till farming as the cropping system in crop rotation. In areas of rice cultivation under flooding conditions, the adoption of both systems of crop rotation and no-till farming are seriously limited (4). This is due to the need to implement systems that allow efficient drainage of the areas in years when rice is not grown and the need to remove remaining mud walls of the previous crop (5).

Soil cultivation modifies some of its physical attributes. The most pronounced changes can be more often seen in conventional tillage systems than in conservational ones, generally affecting bulk density, volume and pore size distribution, and stability of soil aggregates, influencing the infiltration of water, water erosion and plant growth (6).

This study aimed to evaluate the soil physical attributes in two areas of rice cultivation with distinct soil management and irrigation systems.

Materials and Methods

For this study, it was selected two areas of rice cultivation in the municipality of Uruguaiana, on the western border of Rio Grande do Sul. The soil of both areas was classified as Chernosol (7). In the first area the rice cultivar is sprinkler-irrigated and no-till farming has been performed (Pivot + NT) for ten years. The second area has flood-irrigated rice under conventional tillage (Flood + CT).

In each area 30 intact core samples were collected from the 5-10 cm soil layer (to represent the 0 - 15 cm soil layer), using steel cylinders 5.0 cm high and 4.7 cm in diameter in order to determine Soil Bulk Density (BD), Soil Total Porosity (TotPor), Macroporosity (Macro) and Microporosity (Micro), (8). From both areas were also collected 30 soil samples from the 0-15 cm soil layer to determine water stable aggregate size distribution and Aggregate Mean Weight Diameter (AMWD), (9). Stable aggregate size distribution was obtained using the wet sieving method. Aggregates were classified in six different size ranges: C1 = 9.52 to 4.76 mm; C2 = 4.76 to 2.00 mm; C3 = 2.00 to 1.00 mm; C4 = 1.00 to 0.25 mm; C5 = 0.25 to 0.105 mm and C6 < 0.105 mm.

To assess the effect of tillage systems on the soil physical attributes, paired t-tests were performed. For normal data distributions the hypothesis of the applied test was parametric (t statistics) and for non-normal distributions the test was non-parametric (Mann-Whitney), (10). Analysis was done with Sigmaplot software.

Results

In figure 1 it is observed that bulk density was higher in Pivot + NT areas. This result is associated to the fact that in this area no-till farming is performed. The higher bulk density values in no-till soils, result from less machine disturbance in this kind of management system, implying coalescence of aggregates and, therefore, a thicker matrix. The lower soil bunk density values found in conventional farming can be related to soil revolving and the incorporation of crop residues (11).

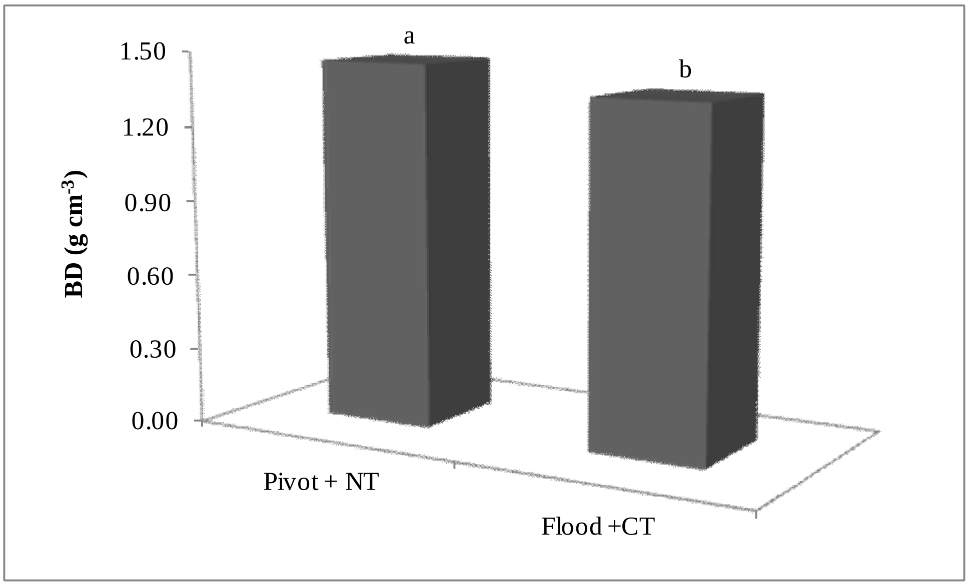

Figura 1- Mean values of soil bulk density (BD) in two rice irrigation and cultivation systems: sprinkler with no tillage (Pivot + NT) and flood with conventional tillage (Flood + CT). Different letters represent significant difference between mean values (t test, $p<0.05$).

Soil porosity was also affected by the irrigation systems adopted and the kind of soil management associated to them (Figure 2). In the Flood + CT area it was found the highest values of Macro, Micro and TotPor, which were significantly higher when compared to the values found in the Pivot +NT area. This is due to the fact that in conventional tillage soil revolving enables higher porosity values when comparing to no-till farming. The highest porosity and macroporosity values in the systems using soil revolving, were associated with the persistence of tillage effects, resulting in the fracturing of aggregates and in the development of pores, mainly macropores (12).

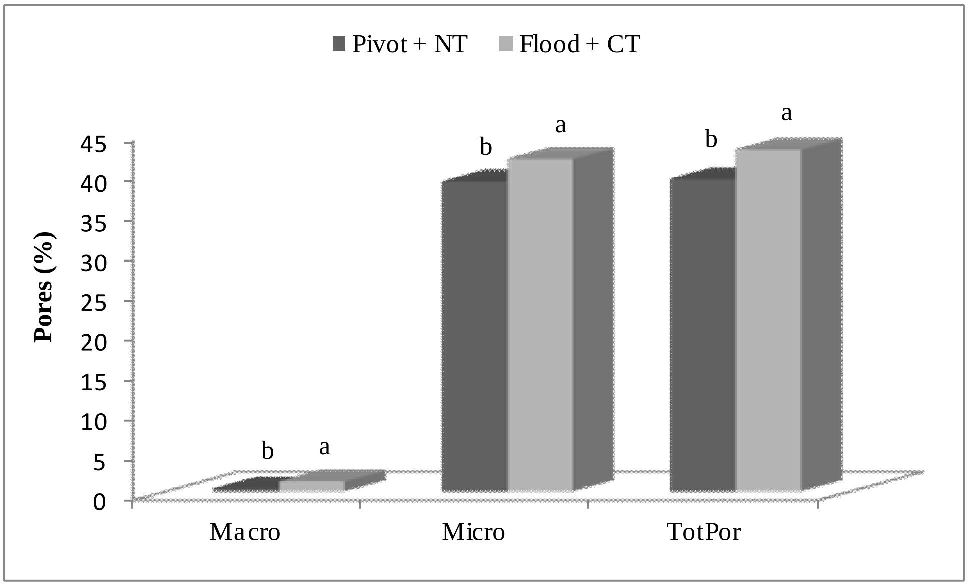

Figure 2- Mean values of macroporosity (Macro), microporosity (Micro) and soil total porosity (TotPor) in two rice irrigation and cultivation systems: sprinkler with no tillage (Pivot + NT) and flood with conventional tillage (Flood + CT). Different letters represent significant difference between mean values (Mann-Whitney test, $p<0.05$).

Soil BD and TotPor are inversely related variables, as it was confirmed by this work. The Pivot + NT area had the highest BD values and the lowest TotPor values; macroporosity has proved to be the most affected variable, as in the Pivot + NT area its value (0.44%) was three times lower in relation to the Flood + CT area (1.33%). The no-till farming not only decreases total porosity, but also changes pore size distribution, reducing the largest-sized pores (13).

Figure 3 shows the values of water stable aggregates distribution by class of size. In the Pivot + NT area it was found the highest percentages of water stable aggregates in the largest-sized classes C1 and C2, while in the FLOOD + CT area the highest percentage of aggregates is in the smallest-sized classes. Because of no-tilage, the Pivot + NT area presents a greater input of organic matter, which is a very important agent for soil aggregation. Moreover, in this kind of system there is no soil revolving and therefore no fracturing of aggregates either.

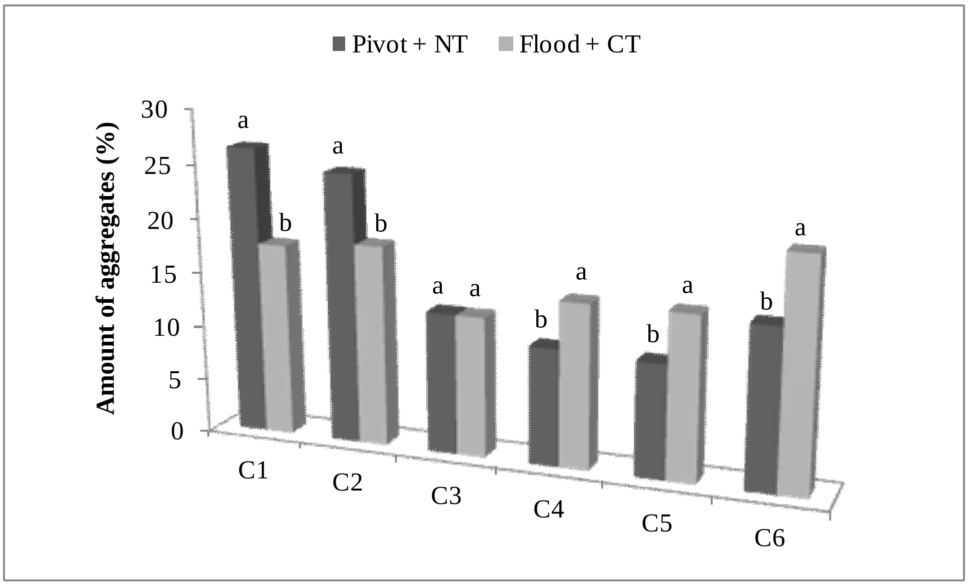

Figure 3 ï Mean values of six aggregate size distribution classes obtained by wet sieving from two rice irrigation and cultivation systems: sprinkler with no tillage (Pivot + NT) and flood with conventional tillage (Flood + CT), where C1 (9.52 ï 4.76 mm), C2 (4.76 ï 2.00 mm), C3 (2.00 ï 1.00 mm), C4 (1.00 ï 0.50 mm), C5 (0.50-0.25) and C6 (<0.25). Different letters represent significant difference between mean values (Mann-Whitney test, $p<0.05$).

In Figure 4 it can be observed that the values of Aggregate Mean Weight Diameter (AMWD) were significantly higher in the pivot + NT area, whose result is associated to the no-till system. The no-till farming generates bigger-sized stable aggregates when compared to conventional tillage, possibly due to non-mechanical destruction of aggregates by tillage implements and the protection offered by straw to the soil surface (15). Analyzing cropping systems, the performing of no-tillage for two years was responsible for the highest value of AMWD (16). The no-till farming favored the increase of 39.6% in AMWD compared to conventional management, and also that soils with largest-sized stable aggregates are considered structurally better and more resistant to erosion as aggregation favors soil aeration, gas exchange and water infiltration (17).

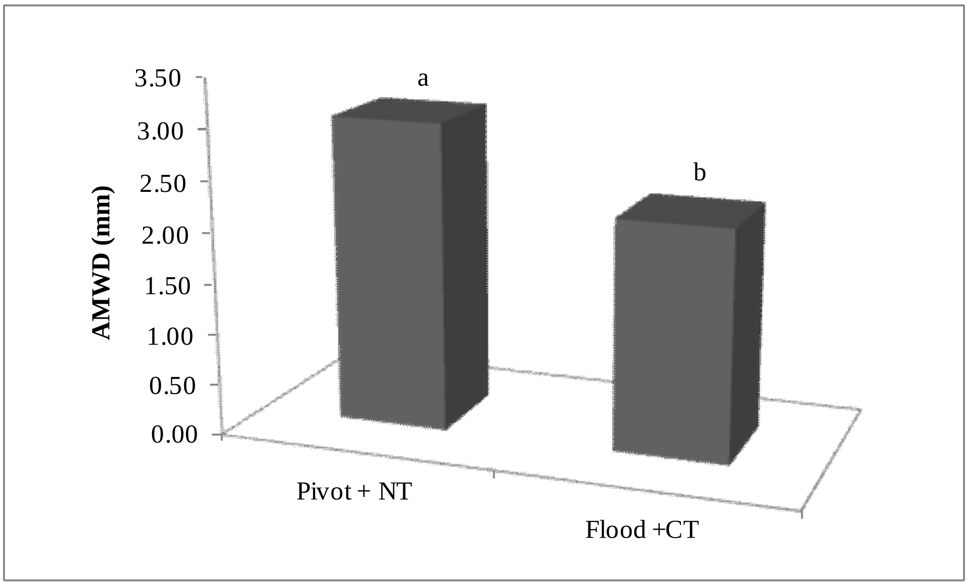

Figure 4 ï Mean values of Aggregate Mean Weight Diameter (AMWD) in two rice irrigation and cultivation systems: sprinkler with no tillage (Pivot + NT) and flood with conventional tillage (Flood + CT). Different letters represent significant difference between mean values (t test, $p<0.05$).

Conclusions

In the area where rice was flooded and conventional farming was performed, soil bulk density was lower and total porosity was higher.

The aggregate mean weight diameter was higher in the area where rice was sprinkler-irrigated and no-till farming was adopted.

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