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PHYSICAL PROPERTIES AND SOIL DEGRATION INDEX IN THE "PLATEAU OF GUADALUPE IRRIGATION DISTRICT", PIAUI STATE, BRAZIL

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ABSTRACT: The management of water and soil is an important aspect of sustainable agricultural production. Knowledge of the physical properties of the soil is essential for the characterization of the soil-water-plant interactions and also for the establishment of irrigation management, in accordance with soil and crop requirements. The objective of this study was to evaluate the physical properties i.e. that pertain to water content, granulometry, bulk density, along with the water retention curve and soil physical degradation index of the "Plateaus of Guadalupe Irrigation District", Piaui State, Brazil. Undisturbed and disturbed soil samples were collected in plots, randomly chosen, as well as in areas of initial preparation, at depths of 0 to 0.2 m and 0.2 to 0.4 m. The water retention curves were molded with suction pressure of -6, -10, -30, -100, -300, -500 and -1500 kPa and adjusted by the Genucthen model. There was an increase in clay levels of the soil depth. The bulk density showed lower values in the areas of initial preparation. The average available soil water was higher in the layer 0 to 0.2 m. Three plots presented problems with the soil physical degradation index, but in general, the soil had good physical conditions for cultivation.

KEYWORDS: soil properties, irrigation management, agricultural planning.

INTRODUCTION: The "Plateaus of Guadalupe Irrigation District" is situated in the mid-southern region of Piaui State, Brazil. The Parnaíba River is the main water resource for this region. It has great potential of use for irrigated agriculture, with an area of 3,186 ha in operation. Currently, the main productive activity is in irrigated orchards, with predominance in the cultivation of watermelon, guava, banana, cashew, passion fruit and coconut, but also presenting favorable conditions for grain crops. Productivity and sustainable agriculture is strongly dependant on the physical conditions of the soil. Knowledge of these conditions is essential for proper irrigation management; therefore the physical quality of the soil becomes indicative. The crops need a porous system for aeration (macroporosity) and in order to supply water and nutrients through the soil solution (microporosity), an appropriate relationship between macro and microporosity is consequential. Soil water retention is explained, basically, by two processes: i) thought capillarity pores of less than or equal to 30 μm; ii) by absorption on the surface of solid soil such as film caught on it (LIBARDI, 1995). These processes depend, mainly on soil texture, which directly determines the area of contact between solid particles and water, setting the proportions of pores of different sizes. GAVANDE (1972) and ARRUDA et al. (1987) emphasize that the nature of clay also influences the water retention, so that a soil with a high content of 2:1 clay type, as montmorilonita, retains more water than a sandy soils. DEXTER (2004) proposed the index S as an indicative of the physical quality of soil. This is based on the soil water retention curve (CRA), which express the distribution of soil pore size. The objective of this research was to evaluate the physical properties of soil such as granulometry, bulk density, along with the water retention curve and the soil physical degradation index in "Plateaus of Guadalupe Irrigation District", Piaui State, Brazil.

METHODOLOGY: This study was carried out in "Plateaus of Guadalupe Irrigation District", in Guadalupe, Piaui State, Brazil. The predominant soil in the region is sandy loam Oxisol (EMBRAPA/SUDENE, 1983). We selected 11 plots within the four sectors that make up the Irrigation District. Disturbed soil samples were collected to determine the granulometry and organic matter content, according to the methodology described in EMBRAPA (1997). Undisturbed samples were gathered in order to determine the water retention curve (SWRC) and bulk density (Ds), within the depths of 0 to 0.2 m and 0.2 to 0.4 m samples. For undisturbed samples, the Uhland sampler for collection of cylindrical rings was used (0.05 m in height and 0.05 m in diameter) and the layer being studied was represented by the midpoint. The SWRC was determined in the soil through the Richards chamber pressure applying suction pressure of -6, -10, -30, -100, -300, -500 and -1500 kPa. The SWRC's were adjusted by the GENUTCHEN (1980) model described by DOURADO NETO et al. (1990). After the attainment of the SWRC, the samples were submitted to drying at 105 °C, for 48 h, in order to determine the bulk density. The soil water available (SWA) to the crops was obtained by the upper (-10 kPa) and lower limit (-1,500 kPa) corresponding to the field of capacity and permanent wilting point, respectively. The physical soil degradation index (S) was calculated using the parameters (Θs, Θr, n and m) from the GENUTCHEN (1980) model, obtained with the use of the program Soil Water Retention Curve - SWRC (DOURADO NETO et al., 2000) in accordance to the equation proposed by DEXTER (2004).

$$S = n(\theta s - \theta r).\left[1+\frac{1}{m}\right]^{-(1+m)} \quad (1)$$

The negative signal that accompanies parameter n, originally described by DEXTER (2004) in the previous equation, was removed because of the CRA adjustments made with the module of the matric potential, or soil water tension. The value of index S corresponds to the inclination of the curve of retention in its point of inflection (DEXTER, 2004). The scale of "S" values proposed by DEXTER (2004) provides that, for soil physical conditions, root growth does not occur for S values < 0.020; partial development of the roots for values between 0.020 < S < 0.030 and adequate root growth, normally requires S values > 0.030.

RESULTS AND DISCUSSION: The physical properties of the soil, referring to the layers of each plot selected in the study, are presented in Table 1. For all plots, the total sand content was higher in the 0 to 0.2 m layer. The silt average levels almost did not vary between the layers, 3.54 and 3.57% of 0 to 0.2 m and 0.2 to 0.4 m, respectively. For 0.2 to 0.4 m layer, higher levels of clay were observed, which can be explained due to the process of displacement of clay from upper to lower layers because of the conventional tillage and intensive soil management. Similar results were found by SANTOS & RIBEIRO (2000) that characterized the process of transport of the clay by continuous preparation of the soil and irrigation water excess. However, it is noteworthy that even in the initial preparation areas this behavior was observed. The organic matter (O.M), of the two studied layers presented relatively similar content, with averages of 1.50 and 1.22%, 0 to 0.2 m and 0.2 to 0.4 m, respectively. These levels are characteristic of the soil texture of sandy loam clay, predominant in studied plots, in which the mineral fraction confers low physical protection of organic matter, to microbial decomposition (SILVA et al. 2005). In general there was little variation in the bulk density (Ds), in average values, 1.41 and 1.42 Mg cm^{-3} from 0 to 0.2 m and 0.2 to 0.4 m layers, respectively. Note the decrease in Ds, mainly in 0 to 0.2 m layer, in the initial preparation areas when compared with the majority of the cultivated plots. These values are below the critical limit of 1.70 to 1.75 Mg m^{-3}, for sandy clay textured soil that could restrict the root growth of the crops (ARSHAD et al., 1996). The soil water retention curves demonstrated higher water contents in the soil, in general, in the 0.2 to 0.4 m layer, both in the upper limit (-10 kPa) as in the lower limit (-1500 kPa) of the crop water available. This can be explained by the fact that this layer has a higher content of fine granulometry fractions (silt + clay), providing smaller sized pores thus increasing content moisture.

TABLE 1 - Physical properties and soil degradation index (S) in "Plateaus of Guadalupe Irrigation District", Piaui State, Brazil, 2007.

Sector	Plot	Crops	Total Sandy	Silt	Clay	O.M	Ds	Θfc	Θpwp	WA	S*
			......%			......	$Mg\ m^{-3}$	......volume	%	......	
					Layer 0 a 0.2 m						
2	10	Banana	81.95	2.45	15.60	0.91	1.44	15.24	9.14	6.10	0.029
2	16	Coconut	90.60	0.80	8.60	1.11	1.52	11.50	4.47	7.03	0.019
2	17	Banana	84.05	1.35	14.60	1.77	1.67	20.59	11.73	8.86	0.023
3	4	Passion fruit	62.50	4.90	32.60	1.72	1.23	19.17	11.92	7.25	0.027
3	26	Guava	75.15	4.25	20.60	1.08	1.57	15.13	7.73	7.40	0.023
4	12	Banana	56.35	6.05	37.60	1.93	1.16	21.03	12.92	8.11	0.132
4	18	Banana	80.75	3.65	15.60	1.43	1.55	12.99	7.84	5.15	0.046
4	19	Passion fruit	60.70	5.70	33.60	1.59	1.53	26.98	16.80	10.18	0.024
5	1	IP**	76.70	1.70	21.60	1.55	1.26	16.21	10.93	5.28	0.047
5	14	IP**	68.50	3.90	27.60	1.85	1.36	20.15	12.62	7.53	0.055
5	27	IP**	69.90	4.50	25.60	1.55	1.24	16.87	10.79	6.08	0.041
Maximum			90.60	6.05	37.60	1.93	1.67	26.98	16.80	10.18	0.132
Minimum			56.35	0.80	8.60	0.91	1.16	11.50	4.47	5.15	0.019
Average			73.38	3.57	23.05	1.50	1.41	17.81	10.63	7.18	0.042
Median			75.15	3.90	21.60	1.55	1.44	16.87	10.93	7.25	0.030
					Layer 0.2 a 0.4 m						
2	10	Banana	75.95	1.45	22.60	1.16	1.31	17.32	10.90	6.42	0.021
2	16	Coconut	89.85	0.55	9.60	0.92	1.60	12.42	4.93	7.49	0.024
2	17	Banana	73.70	0.70	25.60	1.61	1.34	19.17	13.28	5.89	0.053
3	4	Passion fruit	57.00	5.40	37.60	1.02	1.19	20.19	14.19	6.00	0.022
3	26	Guava	57.50	3.90	38.60	0.90	1.58	15.91	9.72	6.19	0.016
4	12	Banana	51.25	5.15	43.60	1.86	1.18	23.32	17.27	6.05	0.053
4	18	Banana	72.20	5.20	22.60	1.32	1.62	15.44	10.23	5.21	0.029
4	19	Passion fruit	53.45	4.95	41.60	1.36	1.47	28.75	21.66	7.09	0.017
5	1	IP**	63.15	1.25	35.60	1.01	1.57	22.77	16.56	6.21	0.034
5	14	IP**	63.00	4.40	32.60	1.16	1.34	20.01	13.30	6.71	0.038
5	27	IP**	63.40	6.00	30.60	1.05	1.38	18.85	11.95	6.90	0.048
Maximum			89.85	6.00	43.60	1.86	1.62	28.75	21.66	7.49	0.053
Minimum			51.25	0.55	9.60	0.90	1.18	12.42	4.93	5.21	0.016
Average			65.50	3.54	30.96	1.22	1.42	19.47	13.09	6.38	0.032
Median			63.15	4.40	32.60	1.16	1.38	19.17	13.28	6.21	0.030

O.M - Organic matter; Ds - Bulk density; Θfc – Soil water content at the field capacity (-10 kPa); Θpwp – Soil water content at the permanent wilting point (-1500 kPa). * Soil physical degradation index proposed by DEXTER (2004). **Initial preparation areas.

The S index values, for 0 to 0.2 m layer, presented critical values ($S<0.020$) for sector 2, plot 16, may present restrictions for the root growth of crops (DEXTER, 2004). Note also, that the plots that are not yet cultivated (initial preparation), presented the highest values of S, which can be explained because the intensely cultivated soil is subject to the loss of physical quality due to the traffic of machinery and tools. In average terms, in 0 to 0.2 m layer, the index S, presented a value that guarantees good conditions for the development of crop roots ($S > 0.030$). For layer 0.2 to 0.4 m it is worth emphasizing attention to sector 3, plot 26, and sector 4, plot 19, which presented values of S < 0.020. In terms of average values, the layer 0.2 to 0.4 m obtained satisfactory S index.

CONCLUSIONS: Differences in the content of the granulometry fractions resulted in variation of the soil water content on the field capacity and permanent wilting point of the sampled points. The soil of the initial preparation areas had better physical conditions in relation to the cultivated soil. In average terms, in 0 to 0.2 m layer, the index S, presented values that guarantees good conditions for the development of crop roots.

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