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CHANGES IN SOIL PROPERTIES IN FUNCTION OF DIFFERENT SOIL USES IN THE IRRIGATED PERIMETER OF ICO-MANDANTES IN THE SEMIARID REGION OF PERNAMBUCO, BRAZIL

MUDANÇAS NAS PROPRIEDADES DO SOLO EM FUNÇÃO DE DIFERENTES USOS DO SOLO NO PERÍMETRO IRRIGADO DE ICÓ-MANDANTES NA REGIÃO SEMIÁRIDA DE PERNAMBUCO, BRASIL

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ABSTRACT

The aim of this study is to evaluate land uses, using physical and chemical attributes in the irrigated perimeter Ico-Mandantes, between Petrolândia and Floresta, in the semiarid region of Pernambuco, Brazil. The identified uses of the land are as follows: short cycle crops (C), fruit (F), pasture (P), abandoned areas (D), and native vegetation (V). This study evaluated the uses C, F, D, P and V. In both places, samples were collected from deformed soil at 0–10, 10–30, and 30–60 cm, as well as non-deformed soil from the first two layers to the physical determinations and chemical properties. The data of physical and chemical analyses were subjected to descriptive linear analysis and multivariate analysis, the technique of principal component analysis, and clustering by the Tocher method. The use of the native vegetation differed from all other uses among the analyzed layers, thereby indicating that the productive uses which were evaluated, promote in fact changes in the physical and chemical layers studied. The analysis of the physical and chemical attributes do not differentiate any of the productive uses systematically analyzed in all layers.

Keywords: soil quality; soil management; native vegetation; land use; São Francisco; semi-arid.

RESUMO

Este trabalho teve como objetivo avaliar usos do solo utilizando atributos físicos e químicos no perímetro irrigado Icó-Mandantes, entre Petrolândia e Floresta, semiárido de Pernambuco. Foram identificados os usos do solo: culturas de ciclo curto (C), fruticultura (F), pastagem (P), áreas descartadas (D) e vegetação nativa (V). Neste estudo avaliaram-se os usos C, F, D, P e V. Para tanto, coletaram-se amostras de solo deformadas nas camadas de 0–10, 10–30 e 30–60 cm, e indeformadas nas duas primeiras camadas para as determinações físicas e químicas. Os dados das análises físicas e químicas foram submetidos à análise descritiva e à análise multivariada, pela técnica de análise de componentes principais, e agrupamento pelo método Tocher. O uso vegetação nativa diferenciou-se dos demais usos em todas as camadas analisadas, indicando que os usos produtivos avaliados promoveram alterações nos atributos físicos e químicos nas camadas estudadas. A análise conjunta dos atributos físicos e químicos não diferenciou nenhum uso produtivo sistematicamente em todas as camadas analisadas.

Palavras-chave: qualidade do solo; manejo do solo; vegetação nativa; uso do solo; São Francisco; semiárido.

INTRODUCTION

The inclusion of areas in agriculture in the semiarid region of Northeastern Brazil must ensure, through irrigation, the environmental sustainability of the region without which there would be no economic feasibility of the project. The sustainability of an irrigation district determines, among other things, the maintenance of soil productivity that undergoes physical and chemical changes in its biological attributes within the production systems by the application of fertilizers and pesticides, machinery transit, and a change in the water regime of the river basins and the removal of vegetation thus exposing the soil to the weather.

After the removal of natural vegetation, the soil has often seen changes in its chemical attributes, which are dependent on the weather, the type of culture and cultural practices adopted. In the semiarid region, some authors (TIESSEN *et al.,* 1992, 1998; FRAGA & SALCEDO, 2004) observed that the replacement of native vegetation, Caatinga, for agricultural crops caused significant decrease: from 40 to 50% in the levels of soil organic carbon.

Assessments of agricultural uses of soils using soil attributes as indicators are a constant work in evaluating production systems, in order to adapt systems or propose more sustainable land uses. Accordingly, Carpenedo & Mielniczuk (1990) observed that soil cultivation would bring about some physical changes, with more pronounced changes in the conventional tillage than in the conservation which is manifested usually in soil density, volume, and size distribution pores and soil aggregate stability, thereby influencing water infiltration, water erosion, and plant development.

The changes caused by the different land uses in the semiarid region, and which have characteristics like peculiar soil and climate, should be studied for the proposition of sustainable models maximizing production and avoiding degradation of natural resources. This study aimed to evaluate land uses in an irrigated perimeter in the semiarid region of Northeastern Brazil using physical and chemical attributes of the soil.

MATERIAL AND METHODS

The site of the study was the irrigated perimeter of Ico-Mandantes, Block 3, located in the municipality of Petrolândia, Pernambuco, on the shores of the Itaparica Reservoir, São Francisco River, which is a part of the resettlement conducted by the Hydroelectric Company of San Francisco (CHESF). They are areas of soils developed from sedimentary rocks, mainly sandstones and shales of the cretaceous calciferous. The climate, according to the Köppen classification, is characterized as BSw'h', semi-arid climate with a short rainy season (average of 460 mm), and the native vegetation of the region is the Hiperxerophilic Caatinga (THEMAG, 1986).

All plots visited for the identification of land uses, were irrigated. In agricultural lots, there were landmarked area for each use and information as the type(s), of the crop(s), the irrigation system, the batch production situation, and when necessary the location of the various uses within the batch. The Hydroelectric Company of São Francisco River (CHESF) in some cases discarded some lots considered unfit for cultivation and agricultural uses.

It was then possible to classify the uses in the following manner:

1. short cycle (C): areas cultivated with annual crops, the most representative pumpkin, watermelon, cilantro, corn, and beans;
2. fruit (F): the cultivated areas were predominantly with banana, coconut, guava, and mango. The movement of the soil by plowing and disking is only the deployment of crops, without the use of machinery in harvesting and treatment plant;
3. pasture (P): these areas are continually used as native pasture in some cases and in others, between periods of cultivation of short cycle more widely spaced, with an intermediate soil movement between uses C and F, where, in general, to maintain the pasture, it is practiced over irrigation;
4. abandoned areas (D): areas as identified by CHESF not recommended for agricultural practices, as well as areas with regeneration of the native vegetation;
5. native vegetation (V): original areas of Caatinga, without human intervention or historical agricultural crop.

It is noteworthy that the uses related to agricultural systems, i.e. C, F, P, and D, were conducted with the practice of irrigation, except use D when it was observed that there were signs of the vegetation regeneration.

After the identification of uses in the area, using the map of soils classification, it was selected as the area for the study with sandy texture. These soils are more representative of the perimeter, with approximately 50% of the area irrigated.

Along with the definition of the total area of each use in sandy soils, was taken into consideration the possibility of an homogeneity in the attributes of soils under different land uses, and it was adopted as stratified random sampling (MEUNIER *et al.*, 2001). The sampling unit was set to 0.5 hectare, submultiple of the area of lots (1.5, 3.0, 4.5, and 6.0 ha). Each sample unit was located on the map and received an identification code to draw.

For each use, single soil samples were collected in 15 randomly selected points at 0–10, 10–30, and 30–60 cm, making the use of repetitions, totaling 225 samples, and holding the collection of soil samples in layers 0–10 and 10–30 cm for the determination of bulk density.

For the physical properties, the following were determined: the granulometric composition and clay dispersed in water (ADA) by the method of the densitometer, the bulk density (BD) by the method of volumetric cylinder (sample un deformed), the particle density with the volumetric flask and saturated hydraulic conductivity of the permeated vertical column and constant load (EMBRAPA, 1997). With the data of particles and bulk density, it was calculated as total porosity (TP), and with a total clay and clay dispersed in water, it was calculated as the degree of clay flocculation (DCF).

The following chemical attributes in the samples were determined: pH and electrical conductivity (CE) of the soil and soil saturation extract (pHes, CEes) (Richards, 1954). In soil, the pH in water (1:2.5) is available at P with Mehlich-1 (EMBRAPA, 1997) and assayed by colorimetric (BRAGA & DEFELIPO, 1974), total organic carbon (TOC) by the Walkley-Black (MENDONÇA & MATOS, 2005), Ca, Mg, K, Na, and CTC (RICHARDS, 1954). After, it was calculated as the sum of bases (SB), the percentage of base saturation (V%) and the exchangeable sodium percentage (ESP). The carbon stock (CS) in a certain depth (Mg ha^{-1}) was calculated by CS = (TOC).(Ds).(e)/10, where TOC is the total organic carbon content ($g.kg^{-1}$), Ds is the average density of the soil depth ($kg.dm^{-3}$) and the layer thickness (cm).

After calculating descriptive statistical data, it was used as the principal components analysis (PCA) to evaluate the characteristics of soils in sets of physical and chemical attributes (SOUZA, 2001). It was adopted as the minimum PCA involving at least 80% of the total variation (CRUZ *et al.,* 2004). The Tocher method for the cluster analysis was held from scores of PCA retained for interpretation according to the criterion adopted, applying as a measure of dissimilarity, the mean Euclidean distance (RAO, 1952).

RESULTS

Physical attributes

The descriptive statistics for the different land uses are shown in Table 1.

Land use D showed the highest average density of particles in three layers, followed by using C, other uses had values considerably smaller and similar.

The average values of Sd and TP were similar for use in the V layer. For other uses there was an increase of mean values of Sd and a decrease in PT 10–30 cm layer in comparison to the 0–10 cm. In the 10–30 cm layer uses, the C and D values were observed slightly larger than that observed Sd for use V. The CDW in the surface layer of uses P and F showed average values, while the use of higher value has been in use D. By observing the results of CDW in depth there were increases in the subsoil layers, especially in the use D, from 7.94% in the 0–10 cm layer to a value exceeding 11% of the total clay in the lower layers.

The FD had an inverse relationship with the CDW values, was consistent with the CDW data, observing the highest values of FD uses for P and F, an intermediate value for the use of V and lower values for the uses D and C.

Table 1 – Mean and standard deviation (s) of physical attributes of the land uses corresponding to short cycle (C), discarded area (D), fruit (F), pasture (P) and native vegetation (V).

Atributes	Layer (cm)	Soil uses									
		C		D		F		P		V	
		Ȳ	s	Ȳ	s	Ȳ	s	Ȳ	s	Ȳ	s
Pd ($kg.dm^{-3}$)	0–10	2.56	0.10	2.60	0.08	2.48	0.08	2.50	0.08	2.50	0.08
	10–30	2.57	0.10	2.62	0.09	2.48	0.09	2.51	0.09	2.49	0.07
	30–60	2.56	0.13	2.59	0.10	2.52	0.11	2.52	0.10	2.49	0.13
Sd ($kg.dm^{-3}$)	0–10	1.65	0.07	1.69	0.07	1.62	0.06	1.60	0.14	1.69	0.08
	10–30	1.76	0.16	1.80	0.10	1.72	0.10	1.70	0.14	1.69	0.15
TP	0–10	0.36	0.04	0.35	0.03	0.35	0.04	0.36	0.06	0.33	0.05
	10–30	0.32	0.07	0.31	0.05	0.31	0.05	0.32	0.06	0.32	0.07
Sand ($g.kg^{-1}$)	0–10	860.1	45.7	848.0	32.1	881.0	69.7	891.6	27.7	876.9	34.0
	10–30	844.5	32.6	820.5	55.7	877.9	24.0	869.3	29.1	873.2	28.8
	30–60	825.7	50.5	813.1	62.4	861.7	21.5	840.3	48.6	866.5	19.1
Silt ($g.kg^{-1}$)	0–10	40.1	22.2	37.6	13.7	42.2	67.1	24.6	17.2	25.2	16.8
	10–30	33.1	17.1	33.1	10.5	20.2	7.5	21.4	9.7	18.9	11.0
	30–60	36.0	19.0	33.2	11.8	25.1	10.1	26.8	14.8	21.9	9.6
Clay ($g\ kg^{-1}$)	0–10	99.9	29.6	114.4	22.5	76.8	11.4	83.8	19.7	98.0	20.0
	10–30	122.4	24.1	146.4	56.7	101.9	22.8	109.3	25.5	107.9	21.0
	30–60	138.2	36.4	153.7	55.9	113.3	19.4	132.9	39.1	111.6	10.7
CDW ($g.kg^{-1}$)	0–10	73.2	29.1	79.4	28.1	49.7	16.0	48.1	25.4	63.3	11.7
	10–30	90.3	21.7	118.4	569	76.1	23.1	76.3	34.0	68.2	13.5
	30–60	87.0	42.8	110.3	66.2	77.1	29.5	86.8	54.7	72.6	16.7
DCF (%)	0–10	29.65	11.1	31.46	16.4	36.56	18.5	45.80	25.3	34.95	7.44
	10–30	26.58	6.3	20.46	9.59	26.24	8.19	32.48	23.7	36.61	5.31
	30–60	37.40	20.5	29.91	23.4	32.48	20.8	36.50	28.1	35.23	11.9
SHC ($cm.h^{-1}$)	0–10	25.89	15.8	21.99	9.90	38.86	16.7	30.30	12.2	17.75	9.4
	10–30	18.68	7.9	16.98	8.97	30.81	14.2	26.18	12.5	20.24	17.6
	30–60	19.56	13.6	16.59	11.1	28.40	12.2	17.86	12.1	13.41	5.9
Depth (m)		1.81	0.52	1.11	0.66	2.11	0.25	1.96	0.51	1.93	0.5

Ȳ: mean; s: standard deviation; Pd: particle density; Sd: soil density; TP: total porosity; CDW: clay dispersed in water; DCF: degree of clay flocculation; SHC: saturated hydraulic conductivity.

While valuating the depth of the layer for soil prevention were observed in the uses of high average values M, C, P and V, while in the use of the average depth D was 1.11 m (Table 1).

CHEMICAL ATTRIBUTES

The descriptive statistics for the different land uses are shown in Table 2.

Observe pHs and pHse with values close to zero. Considering the use BS as the standard, inserting a cultivation system in raise of pHs, particularly in the surface layer of the soil. The PHse showed higher values, even surpassing the value of 7.0, characteristic of neutral ground reaction.

ECse increased in all uses compared to soils under native vegetation. These increases, although not sufficient to classify soils as saline, demonstrate the significant increase of salts on the surface. Regarding the use of BS with ECse 0.23 dS.m^{-1} at 0–10 cm was observed for the uses C, D, and P values CEes of 0.91, 0.80, and 0.76 dS m-1, respectively, significantly higher than V using reference. Using F presented for the 0–10 cm CEes of 0.38 dS.m^{-1}, the use value greater than V, but significantly lower than those recorded for other uses.

The mean values of the ESP for all uses layers evaluated were low, not exceeding 3.5%, except use P at 0-10 cm, which showed 5.6% ESP.

Observing the values of CEC, it was found that the low values are justified by the low clay soils found in the

Table 2 – Mean and standard deviation (s) of the chemical properties of soils corresponding to the uses: short cycle (C), discarded area (D), fruit (F), pasture (P) and native vegetation (V).

Atribute	Layer (cm)	Soil uses									
		C		D		F		P		V	
		Ȳ	s	Ȳ	s	Ȳ	S	Ȳ	s	Ȳ	s
pHs	0 – 10	6.01	0.62	6.31	0.64	6.73	0.66	6.27	0.57	5.15	0.69
	10 – 30	5.51	0.84	5.96	0.95	5.98	0.66	5.91	0.96	4.69	0.37
	30 – 60	4.98	0.81	5.57	0.79	5.27	0.81	5.53	1.20	4.66	0.41
pHse	0 – 10	6.75	0.48	7.28	0.58	7.10	0.64	6.79	0.59	5.58	1.04
	10 – 30	6.12	0.96	6.77	0.86	6.51	0.69	6.62	0.58	5.45	0.79
	30 – 60	6.04	0.92	6.80	0.88	5.84	0.93	6.38	1.00	5.42	0.71
ECse (dS.m^{-1})	0 – 10	0.91	0.85	0.80	0.79	0.38	0.11	0.76	0.51	0.23	0.11
	10 – 30	0.48	0.33	0.49	0.47	0.20	0.11	0.47	0.38	0.12	0.04
	30 – 60	0.45	0.43	0.40	0.22	0.21	0.17	0.34	0.17	0.10	0.05
Na (cmol$_c$.dm^{-3})	0 – 10	0.05	0.09	0.08	0.07	0.03	0.04	0.09	0.11	0.07	0.16
	10 – 30	0.07	0.12	0.09	0.19	0.07	0.12	0.08	0.06	0.06	0.10
	30 – 60	0.08	0.13	0.09	0.14	0.09	0.09	0.06	0.05	0.04	0.04
CEC (cmol$_c$.dm^{-3})	0 – 10	3.06	2.43	3.32	1.47	2.08	0.59	2.16	1.35	2.78	1.08
	10 – 30	3.49	2.31	4.51	4.15	2.25	0.92	2.80	1.58	2.40	0.86
	30 – 60	4.02	2.87	4.48	3.35	2.73	1.30	3.88	2.68	1.95	0.60

Continue...

Table 2 – Continuation.

Atribute	Layer (cm)	Soil uses									
		C		D		F		P		V	
		Ȳ	s	Ȳ	s	Ȳ	S	Ȳ	s	Ȳ	s
ESP (%)	0 – 10	0.98	1.28	2.52	2.47	1.22	2.24	5.61	11.61	1.87	3.28
	10 – 30	1.39	1.25	1.33	1.32	2.62	3.95	3.00	2.82	2.04	3.36
	30 – 60	1.93	2.34	1.33	1.17	3.38	3.94	1.91	1.41	1.96	1.96
Ca ($cmol_c.dm^{-3}$)	0 – 10	2.29	1.05	2.44	0.74	1.82	0.41	1.97	0.77	1.33	0.59
	10 – 30	2.12	0.96	3.16	1.80	1.42	0.49	1.93	1.30	1.18	0.43
	30 – 60	1.75	0.96	2.66	1.67	1.20	0.43	1.76	1.21	0.86	0.32
Mg ($cmol_c.dm^{-3}$)	0 – 10	0.34	0.23	0.38	0.13	0.24	0.05	0.24	0.14	0.12	0.08
	10 – 30	0.34	0.33	0.67	0.93	0.19	0.06	0.28	0.21	0.09	0.08
	30 – 60	0.32	0.43	0.62	0.56	0.13	0.04	0.26	0.27	0.07	0.07
K ($cmol_c.dm^{-3}$)	0 – 10	0.28	0.16	0.43	0.16	0.14	0.09	0.28	0.19	0.23	0.07
	10 – 30	0.27	0.11	0.31	0.11	0.14	0.08	0.21	0.17	0.17	0.07
	30 – 60	0.22	0.12	0.23	0.15	0.16	0.10	0.24	0.13	0.15	0.04
SB ($cmol_c.dm^{-3}$)	0 – 10	2.93	1.40	3.33	0.92	2.08	0.71	2.57	1.00	1.75	0.74
	10 – 30	2.77	1.41	4.23	2.78	1.82	0.54	2.50	1.47	1.50	0.45
	30 – 60	2.37	1.43	3.59	2.42	1.58	0.41	2.33	1.53	1.13	0.35
BS (%)	0 – 10	91.06	12.53	89.23	16.54	93.15	10.88	94.98	7.77	64.43	22.44
	10 – 30	81.36	17.59	87.63	14.38	77.61	22.06	93.51	65.67	67.19	25.47
	30 – 60	64.27	21.93	76.27	22.60	63.73	24.24	64.82	24.58	62.41	26.50
P ($mg.dm^{-3}$)	0 – 10	42.08	22.64	39.68	28.07	28.52	25.39	35.18	27.24	7.40	2.69
	10 – 30	25.68	17.46	23.90	27.75	15.23	15.05	13.79	9.12	4.62	1.05
	30 – 60	7.31	4.04	13.20	15.15	5.92	2.89	9.72	8.53	4.10	0.94
OC ($dag.kg^{-1}$)	0 – 10	0.55	0.11	0.52	0.15	0.45	0.08	0.47	0.11	0.56	0.10
	10 – 30	0.33	0.09	0.38	0.15	0.29	0.05	0.31	0.10	0.41	0.13
	30 – 60	0.31	0.09	0.32	0.15	0.24	0.05	0.29	0.10	0.31	0.07
CS ($Mg.ha^{-1}$)	0 – 10	9.24	1.82	8.81	2.41	7.36	1.37	7.26	1.85	9.36	1.70
	10 – 30	11.54	3.75	13.87	5.42	9.98	1.98	10.63	3.65	13.82	5.02

pHs: pH of soil; PHse: pH of the saturation extract; ECse: electrical conductivity of the saturation extract; CEC: cation exchange capacity; ESP: exchangeable sodium percentage; SB: sum of bases; SB: base saturation; OC: total organic carbon; CS: carbon stock.

study (Table 1). This also contributed to the results obtained in base saturation, in which small amounts of exchangeable bases occupy almost all the electrical charges of the colloids.

It was observed that the base saturation was high for all uses and it was observed between productive uses similar and higher values in the 0–10 and 10–30 cm. In the 30–60 cm layer only use D showed a value considerably higher than that using V and it showed similar values of base saturation in all layers and lower than those observed for other uses in the 0–10 and 10–30 cm, although correspond to values around 65%.

Similar values were observed for the SB, between uses V and F in all layers, and the other productive uses showed average values of SB higher than that observed in the use V at 0–10 and 10–30 cm layer of 30–60 cm using D had the highest value for this variable.

The average values of phosphorus concentration were higher in the uses related to production systems at the 0–10 cm layer in the middle of 10–30 and lows in the 30–60 cm layer. Using V showed low mean values (CAVALCANTI *et al.,* 1998), the highest values were observed in the use related to production systems which possibly occurred due to the application of fertilizers on adopted crops.

The average values of OC were low for all uses. Using V showed the highest average values in all layers evaluated. Among the cultivated soils related to uses C and D had higher levels of OC, while the F and P uses the ones presented below.

The average values of the SHC confirmed the results of the OC accumulation of uses. Using V presented the highest value of the sum of the values of SHC layer 0–10 cm and 10–30 cm, 23.18 Mg ha^{-1}, uses D and C had 22.68 and 20.78 Mg ha^{-1}, respectively, and uses P and F showed 17.89 and 17.34 Mg ha^{-1}, respectively.

Principal component analysis applied in conjunction with physical and chemical attributes

Figure 1 shows the dispersion of the physical and chemical attributes of the soil layer.

The principal component analysis applied to physical and chemical variables, to the joint analysis in the 0–10 cm which retained the first three PCA that together explained 95.64% of the total variation of the data. The PC1 explained 45.31% of the total variation. The uses C and D differed from other uses in this component, they had the greatest influence of the variables calcium, magnesium, potassium, CEC, SB (all negatively related to axis) and physical Pd, clay content, CDW (negatively related axis) and content of sand and soil depth, positively related to the axis, with all correlation with the variable component in modulus greater than 0.77.

The PCA2 gathered 35.50% of the total variation, the most influential variables in this component were pHs, pHse, P, V, hydraulic conductivity, and porosity (positively related to axis) and organic C, SHC, and soil density negatively related to the axis. Analyzing the PCA2, it was found that using V presented in relation to other uses, slightly higher values of organic C, SHC, and bulk density and lower pHs, PHes, K, SB, K, and total porosity, an interpretation confirmed by the observation of mean values in Tables 1 and 2.

The PCA3 gathered 14.83% of the total variation, and the most influential variables in this component were sodium and ESP (positively related to axis) silt and negatively related to the axis, all variables with value in module, with a correlation between the variable and component greater than 0.79. The analysis of PCA3 (Table 1) revealed that using P values were slightly higher sodium, ESP and lower values of silt, which possibly led to this use were not similar to uses F, C and D, interpretation confirmed by analysis of mean values of variables in Tables 1 and 2.

The cluster analysis identifies three groups. Use V was isolated in a group in the same manner using P, and the other group involved the use D, C, and F. All uses related to production systems distanced themselves from the use V.

In the 10–30 cm layer, the analysis of PCA applied to the physical and chemical attributes jointly identified to PCA. The PC1 explained 66.48% of the total variation and PC2 accounted for 22.91%, together gathered 89.39% of the total variation.

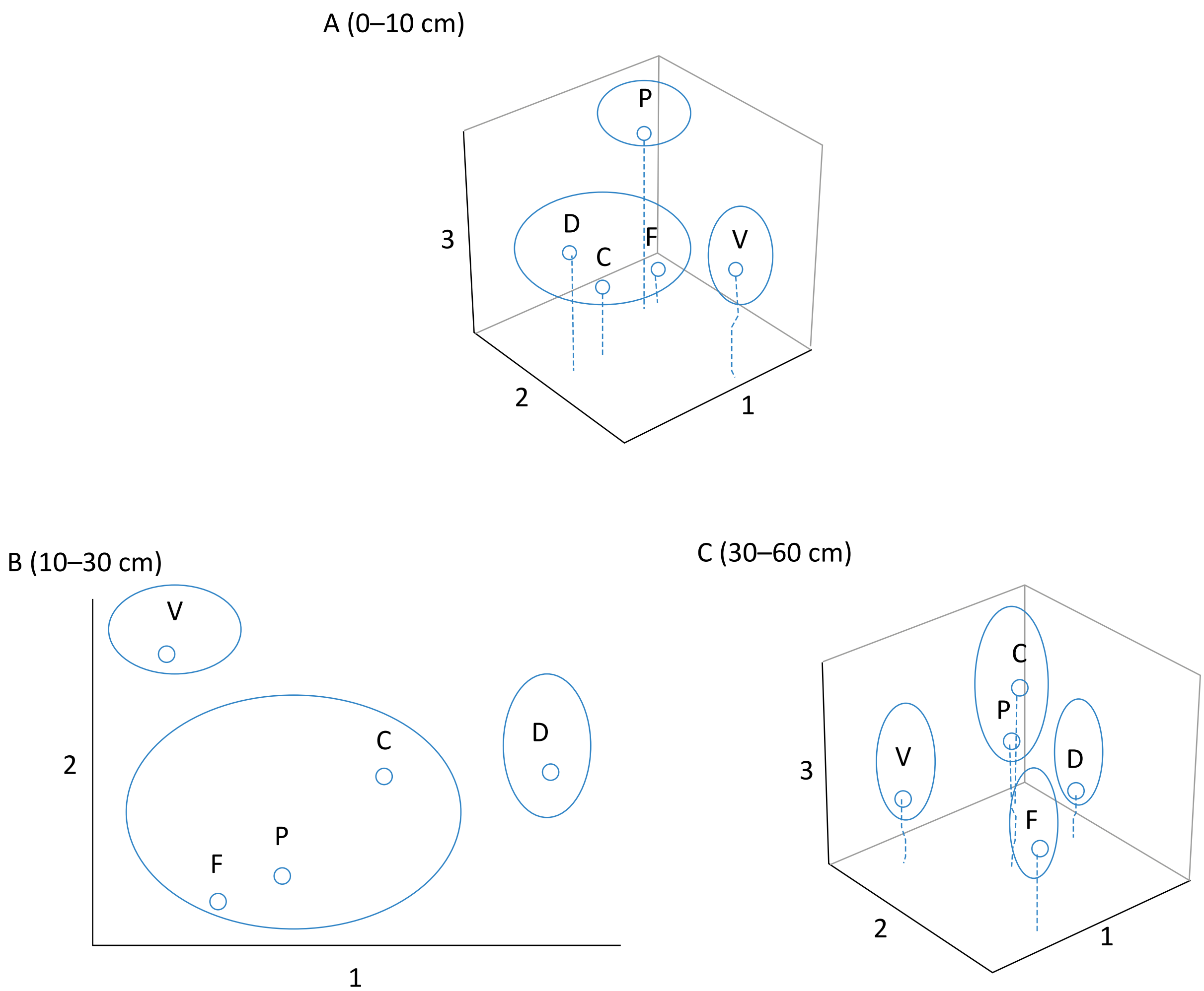

Figure 1 – Dispersion of the physical and chemical attributes of the soil layer in relation to major components (1, 2, and 3) grouped by the Tocher method (circles and ellipses) for the uses short cycle (C), discarded area (D), fruit (F), pasture (P), and native vegetation (V).

The variables most effective in PCA1 were CEse, content of Ca, Mg, K, Na, and P, CTC, SB, Pd, silt, clay, CDW, and Ds (positively related to axis) and sand, soil depth, and GF negatively related to the axis. The main component 2 presented as the most effective variables: pH, PHes, OC, SHC, hydraulic conductivity, and porosity, all with correlation values between the variable component and in module, above 0.74.

Cluster analysis identified three groups according to the similarities of their physical and chemical properties, one of the uses formed with C, P, and F, and the other using V, which also happened to use D.

Three PCAs were retained in the analysis of the physical and chemical attributes jointly layer of 30–60 cm, explaining 95.26% of total variation distributed at 69.62, 16.25, and 9.40%, respectively, in the PC1, 2, and 3. The PCA1 showed greater intensity of the variations in the 15 attributes: PHES, CEes, calcium, magnesium, potassium, CEC, phosphorus, SB, V, Pd, silt, clay, and ADA (positively related to axis) and sand and soil depth negatively related to the axis, all variables correlated with the component, module, greater than 0.79. In PCA2 the most important factors in the total variation were hydraulic conductivity, organic C, sodium and ESP, correlating to the largest component in module, which in PCA3 0.75 and the most influential variable was correlated positively to GF with a component of 0.84. Analyzing the PCA2, we found that using V had the lowest sodium, CTC, hydraulic conductivity (Tables 1 and 2). These results away from the use of V F, both presented themselves isolated in the cluster analysis (Figure 1) with great influence of PCA2.

Cluster analysis has identified four groups: were stranded together forming unit uses V, D, and F, the other group was formed by the uses C and P.

DISCUSSION

Possibly, every day practices in the region as plowing and harrowing decreased soil density and increased porosity in the surface layer of 0–10 cm of uses D, C, F, and P. In the 10–30 cm layer uses, the C and D values were observed slightly higher bulk density than that observed for using V (Table 1). As these uses have suffered greater movement of the soil (plowing and harrowing) according to the adopted production management in the region, probably been a soil compaction due to traffic engineer or densification of this layer, the migration of colloidal particles of soil.

The influence of soil management on physical attributes was observed by Silva *et al.* (2005), the authors evaluated the effect of long term (17 years) of conventional tillage, reduced tillage and no-tillage on soil physical properties of an Ultisol, with medium texture in Rio Grande do Sul. Additionally, it was incorporated into the study of an area of native grass as a reference to the natural condition of the soil. The samples were collected in layers of 0–2.5, 2.5–7.5, 7.5–12.5, and 12.5–17.5 cm in a succession vetch/corn. These authors observed that the total porosity varied more with depth than with tillage systems. Regarding depth, porosity was highest in surface than in subsurface. These results were similar to those observed in this study.

With the aim of studying the changes in soil properties for different uses, Su *et al.* (2004) evaluated the pasture system, the transformation of this area into cultivation of short cycle fallow for three years and a grazing area for five years. The pasture area of study had degraded and was part of the sandy soils in semi-arid region of Horgin, China. The fallow for five years has resulted in significant improvements in soil properties in the 0–7.5 cm layer of depth. Soil bulk density was significantly lower in fallow relative to short-cycle crops and grazing area in the layer 0–2.5 cm and 0–7.5 cm layer was second only to the cultivation of short cycle. From 7.5 cm occurred not influence the uses of soil density and soil organic carbon. This result was similar to that obtained in this study, where use C showed a value of bulk density higher than that observed for the use of P (Table 1). However, changes in soil density were observed in layers deeper than 7.5 cm, and discrete changes in soil density in the layer of 10–30 cm for the uses C and D with respect to use V (Table 1), which possibly occurred due to soil management practices.

This analysis showed that the change in agricultural practice has caused the soil's physical properties under native vegetation when they were incorporated into production systems. Similar results were observed by other authors who found significant modifications of the physical characteristics of soils after the incorporation in agricultural systems. According to Rosa Junior *et al.* (2006), values of flocculation were influenced by land use, which was significantly lower for the conditions under annual crops than for soils under pasture and native vegetation, which showed no significant difference between them. Souza *et al.* (2005) evaluated physical attributes in a Quartz Neosol under different uses: corn, soybeans, pasture, crop–livestock integration and anthropic savannah. These authors noted that this soil was a reduction in total porosity and macroporosity and increase in soil density in all areas were observed, when compared with native vegetation, with the exception of anthropogenic savanna. Possibly the mechanization of soil and cattle trampling contributed to the decline in soil quality.

The increase of CDW values with depth may be indicative of a migration of colloids in the soil profile, more pronounced in the uses related to production systems, with increased dispersion in depth and decreased concentration of clay in the topsoil already presented low values of this colloid great importance in physical and chemical reactions. In use D shallow soil, clay migration, due to the proximity, preventing layer may further hinder the movement of water in this layer. Maia *et al.* (2006) observed an increase in the depth of the CDW, realizing the existence of a direct relationship between increased CDW and decreased COT, similar results were observed in this study (Tables 1 and 2).

Silva *et al.* (2006) found that management systems with cane sugar influenced the physical properties of the soil, resulting in increased water dispersible clay and reduction in water aggregate stability of cultivated soils in relation to forest soil. Similar results were observed in this work at the 0–10 cm, with respect to use V, uses C and D had slightly higher values of CDW (Table 1), possibly due to the effect of soil disturbance. In the work it was found a different result observed by Silva *et al.* (2006) uses the P and F, in such a smaller movement of the soil by plowing and harrowing practical as compared with practices C and D, plus the highest concentration of calcium and magnesium flocculants, with respect to use possibly afforded V, CDW uses these values lower than those observed in native vegetation (Tables 1 and 2).

The low soil depth D hinders the use of soil drainage and leaching of salts and sets the groundwater near the surface potentiating the capillary rise of salts that accumulate on the surface layer over time may reach levels that limit the full development of crops. This was not observed probably due to the short period of operation the perimeter nine. Additionally, the proximity of the surface of the water table impairs growth of plants by oxygen deficiency and reduced layer of soil explored.

In the range 6.0 to 6.5, it was observed pHs values for the uses C, D and P; the ground reaction for these uses is therefore favorable to full production plant, this evaluation can also be applied to use F for presenting a pH value slightly above 6.5 (pH of 6.7 in the use F). The use of V that never received the application of correctives resulted in pH acid, which was an expected result.

The ECse values observed in C, D and P uses do not classify soils as saline, but deserve special attention because they are significantly higher than using V despite the sandy texture of the soil and the quality of water used for irrigation classified as C1S1, without the risk of salinization and sodification soil, according to Richards (1954). Special focus should be on using D due to its shallower limiting the leaching of salts, and to facilitate the rise of salts dissolved in the water by capillarity, promoting soil salinization. The use of F presented smaller ECse values compared to other productive uses possibly due to better irrigation management.

The average values for phosphorus concentration in the 30–60 cm layer, observed in uses relating to production systems, still showed considerably greater than that observed for the use of V, except for using F (Table 2), possibly occurred a movement of this element of the surface layer of 0–20 cm, where usually occurs the application of fertilizers. The low clay content, which operates in the phosphorus fixation, and water movement in the soil profile due to irrigation probably contributed to the greater movement of this element, usually slightly mobile in soil. The use of F, possibly the best irrigation management, resulted in less movement of phosphorus in the soil.

The uses of F and P presented lower values of total organic carbon (Table 2), contrary to the expected result, since the soil management normally associated with these uses has a smaller disturbance. The most significant reductions were observed between the V and F uses with reduced values of total organic carbon content of approximately 19, 28 and 21%, respectively, in the layers of 0–10, 10–30 and 30–60 cm. Sandy soils usually with good aeration possibly were little influenced by aeration increase caused by soil management by plowing and harrowing. The use of V for not being irrigated has low soil moisture for most of the year, probably, presented reduced rate of decomposition of organic matter which must be contributed to that use presents the higher C-organic content. It is noteworthy that the low depth average of the D use may have contributed to the saturation of water from the surface layers of these soils, especially in the rainy season, normally with high intensity, turned the environment less oxidative, allowing more organic C accumulation.

Other authors observed the influence of soil management on the total organic carbon content. Maia *et al*. (2006) evaluated the impact of agroforestry and conventional systems on soil quality, compared to the natural condition (native savanna) after five years of use in Ceará semiarid region. The treatments were: agrosilvopastoral (AGP); silvipastoral (SILV); traditional cultivation in 1998 and 1999 (TR98); traditional cultivation in 2002 (TR02); and intensive cultivation (CI) and two areas of native forest (MN-1 and MN-2) that were used as reference of equilibrium sites. The AGP treatments, TR98 and CI promoted greater soil disturbance, causing a reduction in the total organic carbon (TOC). The AGP treatment was efficient in nutrient cycling, however soil disturbance and the concomitant reduction in OC content also led to decrease in aggregate stability. A similar result was observed in this study, in which different land uses provided considerable differences in the TOC content and the carbon stock (Table 2).

Changes in physical and chemical properties were characterized on the analysis since the use V was isolated in the cluster analysis performed in scores of principal components, observed in the three evaluated layers. A similar result was observed by Leonardo (2003).

CONCLUSIONS

Use native vegetation differed from other uses in all analyzed layers, indicating that the productive uses evaluated promoted changes in physical and chemical properties in the soil layer.

The analysis of the physical and chemical attributes did not differentiate any productive use systematically in all analyzed layers.

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REFERENCES

BRAGA, J.M. & DEFELIPO, B.V. Determinação espectrofotométrica de fósforo em extratos de solo e material vegetal. *Revista Ceres*, Viçosa, MG, v. 21, p. 73-85, 1974.

CARPENEDO, V. & MIELNICZUK, J. Estado de agregação e qualidade de agregados de Latossolos Roxos, submetidos a diferentes sistemas de manejo. *Revista Brasileira de Ciência do Solo*, Campinas, v. 14, p. 99-105, 1990.

CAVALCANTI, F.J.A. (Org.) *Recomendações de adubação para o estado de Pernambuco (2° aproximação).* Recife: IPA, 1998. 198p.

CRUZ, C.D.; REGAZZI, A.J.; CARNEIRO, P.C.S. *Modelos biométricos aplicados ao melhoramento genético*. 3.ed. Viçosa: Universidade Federal de Viçosa, 2004. 480p.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA – EMBRAPA. Centro Nacional de Pesquisa de Solos. *Manual de métodos de análises de solo*. Rio de Janeiro, 1997. 212 p.

FRAGA, V.S. & SALCEDO, I.H. Declines of organic nutrient pools in tropical semi-arid soils under subsistence farming. *Soil Science Society American Journal*, Madison, v. 68, p. 215-224, 2004.

LEONARDO, H.C.L. *Indicadores de qualidade de solo e água para a avaliação do uso sustentável da microbacia hidrográfica do rio Passo Cue, região oeste do estado do Paraná*. 2003. 131f. (Mestrado em Recursos Florestais) – Escola Superior de Agricultura Luiz de Queiroz, Universidade de São Paulo, Piracicaba.

MAIA, S.M.F.*;* XAVIER, F.A.S.; OLIVEIRA, T.S.; MENDONÇA, E.S.; ARAÚJO FILHO, J.A. Impactos de sistemas agroflorestais e convencional sobre a qualidade do solo no semi-árido cearense. *Revista Árvore*, Viçosa, MG, v. 30, n. 5, p. 837-848, 2006.

MENDONÇA, E.S. & MATOS, E.S. *Matéria orgânica do solo:* métodos de análises. Viçosa, MG: UFV, 2005. 107 p.

MEUNIER, I.M.J.; SILVA, J.A.A.; FERREIRA, R.L.C. *Inventário florestal:* programas de estudo. Recife: Impressa Universitária da UFRPE, 2001. 189 p.

RAO, C.R. *Advanced statistical methods in biometric research.* New York: John Wiley & Sons, 1952. 390 p.

RICHARDS, L.A. *Diagnosis and improvement of saline and alkali soils.* United States Department of Agriculture, 1954. 160 p. (Agriculture Handbook – n.· 60).

ROSA JUNIOR, E.J.; MARTINS, R.M.G.; ROSA, Y.B.C.J.; CREMON, C. Calcário e gesso como condicionantes físico e químico de um solo de cerrado sob três sistemas de manejo. *Pesquisa Agropecuária Tropical*, v. 36, n. 1, p 37-44, 2006.

SILVA, M.A.S.; MAFRA, A.L.; ALBUQUERQUE, J.A.; BAYER, C.; MIELNICZUK, J. Atributos físicos do solo relacionados ao armazenamento de água em um Argissolo Vermelho sob diferentes sistemas de preparo. *Ciência. Rural*, Santa Maria, v. 35, n. 3, p. 544-552, 2005.

SILVA, A.J.N.; CABEDA, M.S.V.; CARVALHO, F.G.; LIMA, J.F.W.F. Alterações físicas e químicas de um Argissolo amarelo sob diferentes sistemas de uso e manejo. *Revista Brasileira de Engenharia Agrícola e Ambiental*, Campina Grande, v. 10, n. 1, p. 76-83, 2006.

SOUZA, E.D.; CARNEIRO, M.A.C.; PAULINO, H.B. Atributos físicos de um Neossolo Quartzarênico e um Latossolo Vermelho sob diferentes sistemas de manejo. *Pesquisa Agropecuária Brasileira*, Brasília, DF, v. 40, n. 11, p. 1135-1139, nov. 2005.

SOUZA, G.S. *Introdução aos modelos de regressão linear e não-linear*. EMBRAPA, 2001. 489 p.

SU, Y.Z.; Zhao, H.L. ; Zhang, T.H. ; Zhao, X.Y. Soil properties following cultivation and non-grazing of a semi-arid sandy grassland in northern China. *Soil & Tillage Research,* Madison, v. 75, p. 27-36, 2004.

TIESSEN, H.; SALCEDO, I.H.; SAMPAIO, E.V.S.B. Nutrient and soil organic matter dynamics under shifting cultivation in semi-arid northeastern Brazil. *Agriculture Ecosystems Environment,* Amsterdam, v. 38, p. 139-151, 1992.

TIESSEN, H.; FELLER, C.; SAMPAIO, E.V.S.B. Carbon sequestration and turnover in semiarid savannas and dry forest. *Climatic Change,* v. 40, p. 105-117, 1998.

THEMAG. *Relatório de estudos edafoclimáticos dos projetos Chesf da Borda do Lago de Itaparica – margem esquerda*. Recife, 1986. 214 p.