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EVALUATION OF SOIL FERTILITY ON A FARM OWNED BY PORTO SEGURO SUSTAINABLE DEVELOPMENT PROJECT

ABSTRACT: The objective of this study was to evaluate the soil fertility in the topsoil in different production ecosystems to support the sustainable management of the soil in family farms of the Porto Seguro Sustainable Development Project, Marabá, state of Pará. For the execution of this experiment, the areas were divided into four tracts or agro-ecosystems, denominated throughout the work of G1, G2, G3, G4. The G1 is cropped with cassava (Manihot esculenta Crantz); G2, with banana (Musa spp), G3 with Agroforestry System (AFS), and G4 with cowpea (Vigna unguiculata (L.) Walp.). Soil samples were collected from each area, and the soils of the assessed crops showed levels of pH, Al2+, P, Ca2+, Mg2+, H+, Al, SB, V%, N, and OM below the ideal values for adequate crop management. The systems under cultivation in the areas cause significant changes in soil fertility. The modifications may be related to the soil management practices of the crops under study.

KEYWORDS: Agro-ecosystems, Crops, Soil management.

AVALIAÇÃO DA FERTILIDADE DO SOLO EM UMA PROPRIEDADE AGRÍCIOLA DO PROJETO DE DESENVOLVIMENTO SUSTENTÁVEL PORTO SEGURO

RESUMO: O presente trabalho objetivou avaliar a fertilidade do solo na camada superficial em diferentes ecossistemas de produção para subsidiar o manejo sustentável do solo em uma propriedade agrícola familiar do Projeto de Desenvolvimento Sustentável Porto Seguro, Marabá-PA. Para a realização desse estudo as áreas foram divididas em quatro glebas ou agroecossistemas, denominados ao longo do trabalho de G1, G2, G3, G4. A G1 contém o plano de plantio de mandioca (*Manihot esculenta* Crantz), G2 a banana (*Musa* spp), G3 o Sistema Agroflorestal (SAF's) e a G4 o feijão de corda (*Vigna unguiculata* (L.) Walp.). Foram coletadas amostras de solo de cada área, sendo que os solos dos cultivos em estudo apresentaram teores de pH, Al^{2+}, P, Ca^{2+}, Mg^{2+}, H^{+}, Al, SB, V%, N e MO abaixo dos valores ideais para manejo adequado das culturas. Os sistemas em cultivo nas áreas provocam alterações significativas na fertilidade do solo. As modificações podem estar ligadas às práticas de manejo do solo das culturas em estudo.

PALAVRAS-CHAVE: Agroecossistemas, Cultivos, Manejo do solo.

EVALUACIÓN DE LA FERTILIDAD DEL SUELO EN UNA PROPIEDAD AGRÍCOLA DEL PROYECTO DE DESARROLLO SOSTENIBLE PORTO SEGURO

RESUMEN: El presente trabajo tuvo como objetivo evaluar la fertilidad del suelo en la capa superficial en diferentes ecosistemas de producción para apoyar el manejo sostenible del suelo en una granja familiar del Proyecto de Desarrollo Sostenible Porto Seguro, Marabá-PA. Para la realización de este estudio, las actividades se dividieron en cuatro parcelas o agroecosistemas, denominadas a lo largo del trabajo de G1, G2, G3, G4. G1 contiene el plan de siembra de yuca (*Manihot esculenta* Crantz), G2 el plátano (*Musa* spp), G3 el Sistema Agroforestal (SAF) y G4 el frijol (*Vigna unguiculata* (L.) Walp.). Se recolectaron muestras de suelo de cada área, siendo que los suelos de los cultivos estudiados presentaron niveles de pH, Al^{2+}, P, Ca^{2+}, Mg^{2+}, H^{+}, Al, SB, V%, N y OM por debajo de los valores ideales para el manejo adecuado del cultivo. Los sistemas de cultivo en las áreas causan cambios significativos en la fertilidad del suelo. Las modificaciones pueden estar vinculadas a las prácticas de manejo del suelo de los cultivos en estudio.

PALABRAS CLAVES: Agroecosistemas Manejo de suelos, Cultivos.

INTRODUCTION

The Amazon has been disorderly occupied, where crops and pastures have been replacing forests, leading to the degradation of large areas and contributing to an increase in deforestation. One way of such occupation has been through family farming. As farming has been developed and animals domesticated, we have progressively converted natural ecosystems into agro-ecosystems, to increase food production (BUG, 2019). It is common in Amazonian family farming the alteration in the natural environment to create agricultural areas, from which we can highlight the formation of pastures resulting from the felling and burning of the forest (FERREIRA; OELHO, 2015).

The farming practices adopted, according to Morais et al. (2015), are often harmful to the soil, cause a continuous decrease in its quality, resulting in low yields and losses in its sustainability. Such negative reflexes have caused degenerative impacts on the chemical properties of the soil, such as loss of biodiversity, fertility, and the capacity to sustain and enable the root development of the plants.

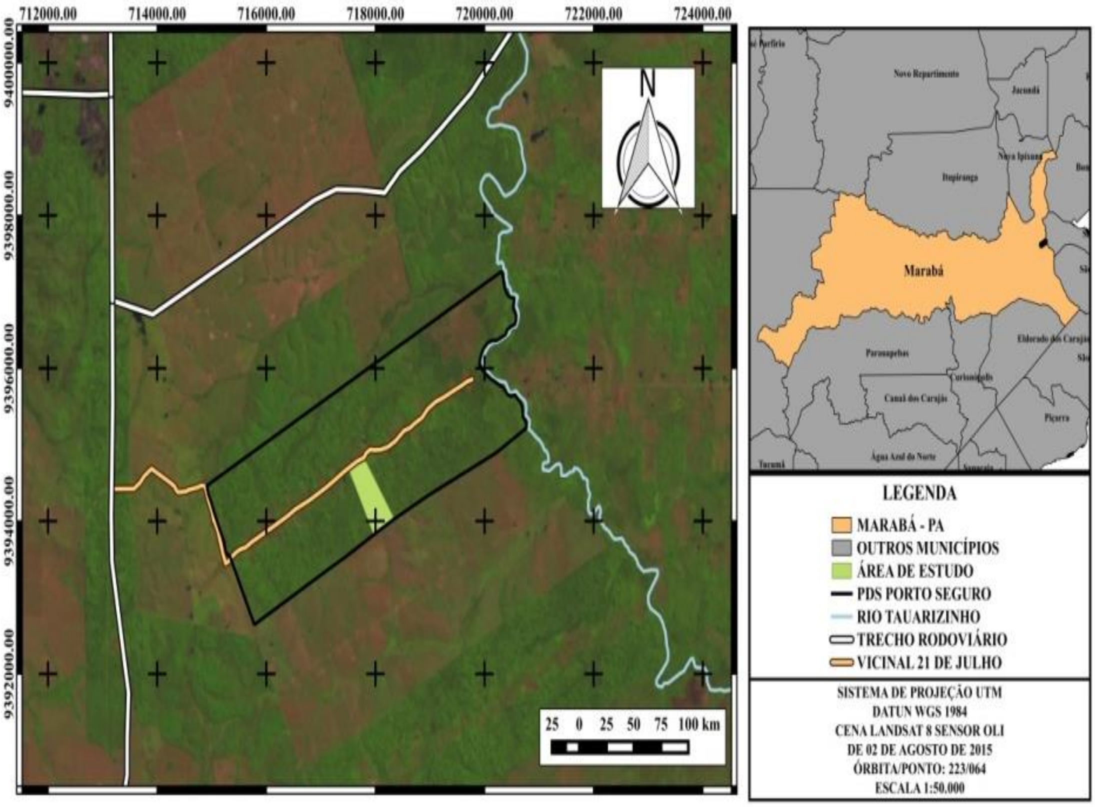
Some studies have shown that harmony between production and preservation in a sustainable manner is possible, even if it is through reforestation, after the economic exploitation of the farm or the sustainable use of conservation units in a sustainable manner (PINHEIRO et al., 2019; GUERREIRO et al., 2018, CRUZ et al., 2020).

In this context, this work evaluates soil fertility in the topsoil in different production ecosystems, in order to support the sustainable management of the soil on a farm owned by Porto Seguro Sustainable Development Project in Marabá, state of Pará.

MATERIAL AND METHODS

The family farm assessed in this experiment is located on the Sustainable Development Project - Porto Seguro located in the municipality of Marabá, state of Pará. The farm area is split into annual crops, agroforest garden area, and legal reserve (Figure 1). Soil sampling collection was performed following the procedures established by (2006), consisting in dividing the farm activities into four areas or agrosystems denominated G1, G2, G3, and G4, and a Legal Reserve area. Cassava, (Manihot esculenta Crantz), banana (Musa spp), Agroforest System (AFS), and cowpea bean (Vigna unguiculata (L.) Walp.) were determined in G1, G2, G3, and G4, respectively. Both conditions did not receive any kind of chemical and organic fertilization neither liming.

Figura 1. Location of SDP and the farm under study Marabá, Pará state.



Source: Elaborated by the author.

Soil samples were collected in March 2018. Collection points were determined at random where 10 points were established in each area where simple sample collections were carried out in each point. It was necessary to dig the soil with a shovel or hoe up to a depth of 20 cm, removing part of the terrain from which only the "middle" was used, throwing away the parts from the sides.

In each point of the area, samples were placed in an identified bucket, where 10 simple samples were later homogenized, resulting in only one 500-g composite sample. The samples were sent to Soil Fertility Analysis Laboratory – Field Laboratory for determination of the following characteristics: pH, O.M. (organic matter), V (base saturation), P (phosphorus), K (potassium), Ca (calcium), Mg(Magnesium), Al (Aluminum), H+Al (hydrogen and aluminon rate), SB (sum of bases) and CEC (cation exchange capacity).

Analysis of chemical characterization was carried out according to the methodology described by (2009).

RESULTS AND DISCUSSION

The results of the analysis for the determination of the soil chemical characteristics in the assessed agrosystems at the 0-20 cm layer can be seen in Table 1. According to the values described by Gama et al (2007), the pH of all soils of the assessed agro-ecosystems – including those of the Legal Reserve I – are considered high acidity (pH from 4.4 – 5). The balance between hydrogen ions (H+) and hydroxyls (OH-), which represent pH, results in the acidity or alkalinity of the soil ecosystem the reason for this consideration is likely to be related to the organic matter decomposition and the release of organic acid in the soil; in the Legal Reserve area is shown the highest pH value, close to the value regarded as normal for this characteristic (pH value of 7) showing the importance of these environmental protection areas, as it shows characteristics close to the natural.

In relation to the results of exchangeable aluminum (Al^{2+}), the soils in the cassava, AFS, and Legal Reserve (RL) area showed values ranging from 0 and 0.8 cmolc/dm^3, therefore representing the low harmful potential to the plants. However, the soils cropped with banana and cowpea bean had values of 1 cmol$_c$/dm^3 respectively, representing toxicity risks to the plants as exchangeable aluminum or exchangeable acidity corresponds to the amount of Al retained by the soil negative loads (OLIVEIRA, 2014).

Calcium contents in the four assessed agro-ecosystems were considered low, corroborated by Ribeiro et al. (1999a), ranging from (0.41 – 1.3 cmolc / dm^3). For the contents of magnesium in the assessed soils (four areas), the values were also low, ranging from (0.3 – 0.5). Calcium is an essential macronutrient for plants (Funk *et al.*, 2013), and is found in the cytoplasmatic membrane and the cell wall of the plant cells.

Mg plays a large number of key functions in the metabolism of plants. Its deficiency affects several biochemical and physiological processes, leading to reductions in crop growth and yield (DIAS, 2015).

Table 1. Characterization of chemical attributes as a function of the areas in SDP Porto Seguro– Marabá –Pa.

Areas	Chemical attributes *												
		(%)			(mg/dm^3)		(cmol$_c$/dm^3)						
	pH	O.M.	V	N	P	CO	K	Ca	Mg	Al	H+Al	SB	CEC
G1	4.7	1.3	34	11	1	10	0.12	1.3	0.5	1	3.7	1.92	5.6
G2	5	1.8	29	9	6	12	0.15	1.1	0.4	0,8	3.9	1.65	5.5
G3	4.6	1.5	25	9	5	12	0.09	0.9	0.3	0,7	4	1.29	5.3
G4	4.7	1.1	28	13	2	10	0.12	1	0.5	1	4.2	1.62	5.8
RL	5.75	1.8	63.75	17	5.08	3.92	0.58	4.68	2.28	0	4.33	7.53	11.86

Where: *Organic matter (OM), base saturation index (V%), Phosphorus (P), Potassium (K+), Calcium (Ca+2), Magnesium (Mg), Aluminum (Al+3), potential acidity = (H+Al), sum of bases (SB), cation exchange capacity (CEC).

Potassium showed very low levels in all assessed agro-ecosystems and LR. The values ranged from (0.12 – 0.58 cmol$_c$ / dm^3). Nutrient availability is related to rainfall (CAVALIERI et al., 2011). Plants require a large amount of potassium, after only nitrogen. This nutrient takes part in several essential processes in plant growth such as enzyme activation, photosynthesis, plant water regime, formation of amino acids, and protein synthesis (MEURER, 2006).

The P found in the four assessed areas was classified as very low (0 – 6 mg/dm^3) based on Raij et al. (1996) particularly in Areas 1 and 4 where it was found in the lowest contents, 1mg/dm^3, and 2mg/dm^3. Higher contents of P were found in Areas 2 and 3 with contents of 6 mg/dm^3 and 5 mg/dm^3, respectively. The phosphorus index in the Legal Reserve was higher than the contents set in the agro-ecosystems previously cited, with values of 5.08 mg/dm³.

Dent and Boincean (2019) claim that the biodiversity above ground is related to the soil food web. The higher the diversity within the soil food web, the greater its functionality.

The lower N contents were found in Areas 2 and 3, both with 9%. The agro-ecosystem with the highest N percentage was Area 4, with 13%. And the treatment with the highest index was LR with 17%. Nitrogen is a significantly important nutrient for plant life as it is comprised of the structures of the cell protoplasm, chlorophyll molecule, amino acids, protein, and several vitamins. In addition, it affects the metabolic reactions of the plant and intensifies the vegetative growth and crop yield (TEMÓTEO et al., 2010).

The soil in the LR had a V% higher than those found in the assessed agro-ecosystem, with an index of 64%. All the soils with a base saturation value of less than 50% are considered soils with poor fertility (RAIJ et al., 1996). The soil in the AFS in particular showed a lower value (25 %) of base saturation, which was considered the soil with the poorest fertility. Liming is significantly needed for rising base saturation (V%) of this soil. The low levels of base saturation of the soils in the assessed areas are directly related to the characteristics of Amazon soil which are greatly exposed to high rainfall indexes in particular months of the year. The leaching process of the exchangeable bases is intense, aggravating the loss of nutrients (COLLIER; ARAÚJO, 2010).

Levels of OM were considered low in all areas, classified between (1–1.9) according to Ribeiro et al. (1999b). The highest OM index was found in the LR soil with 3.92 dag/kg. Areas 1 and 4 showed the lowest OM percentage with contents of 1.3% and 1.1%, respectively. Area 2 had the highest organic matter content in comparison to the other agro-ecosystems.

The low levels of organic matter found in the assessed agro-ecosystem may be related to the low decomposition rate of the litter or indicatory of degradation of the experimental area. Therefore, soil fertility in the agro-ecosystem areas as well the continuity of the biogeochemical cycles that rule the local life of the ecosystem directly depends on the maintenance and recovery of the vegetation (CAMARGO; MARQUES JÚNIOR; PEREIRA, 2010). Consequently, it is vital to raise the contents of the main chemical attributes of the assessed soils by applying conservationists practices.

CONCLUSION

The Legal Reserve had satisfactory indexes for pH, Al, P, Ca, Mg, H, Al, SB, and OM, showing that the natural sustainability of its resources provides chemical quality to the soils. In cropping systems, significant alternations in soil chemical characteristics are reported.

The alteration in the fertility of the soils in the areas can be seen through the reduction in the contents of the macronutrients. Therefore, in the assessed agro-ecosystems, it can be seen the need in management, applied in an integrated manner for the maintenance of soil quality. To compensate for the soil chemical quality, it can be cited conservationist practices such as no-tillage and crop rotation as a source of biomass and protection of the soil fertility characteristics.

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