International Journal of Advanced Engineering Research and Science (IJAERS)
ISSN: 2349-6495(P) | 2456-1908(O)
Vol-8, Issue-3; Mar, 2021
Journal Home Page Available: https://ijaers.com/
Journal DOI: 10.22161/ijaers
Article DOI: https://dx.doi.org/10.22161/ijaers.83.37

Agricultural Suitability of a Sandy Soil in an Agrarian Reform Settlement

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Received: 03 Dec 2020;

Received in revised form:

07 Feb 2021;

Accepted: 28 Feb 2021;

Available online: 28 Mar 2021

***Keywords*— Soil degradation, Family agriculture, Entisol.**

Abstract*— The soil classification is the systematic arrangement of soils into groups or categories based on attributes and diagnostic horizons. They can be structures that enable the conservation of soil, allowing infer through them the best use and management for a particular soil class. The aim of this work was to perform the taxonomic classification of a soil, through the Brazilian Soil Classification System (SiBCS), in an agrarian reform settlement in the city of Baliza - GO. It was also carry, for the purpose of soil conservation, the interpretation of its attributes for the soil classification within the Soil Agricultural Aptitude Assessment System. The soil of this study was classify as typical Orthic Quartzarenic Neosol, with severe limitations to agricultural use and that the current soil management is causing its erosion.

I. INTRODUCTION

Soil classification deals with the systematic arranging of soils into groups or categories based on attributes and diagnostic horizons (OLIVEIRA, 2008). The objective of classifying the soil is to organize our knowledge about it, so that its properties can be recollect, and its relationships understood more easily.

Classifications are structures with compartments logically delimited and organized, in order to allow the grouping of similar individuals, according to determined criteria. There are, therefore, taxonomic classifications, which group soils based on similar genetic processes, however, without aiming at a practical objective, and the technical or interpretative classifications, which have a practical objective and can be obtained through the interpretation of the results of the taxonomic classification (FREIRE, 2006).

Soil classification can be natural/taxonomic or technical/interpretive, being able to infer the limitations, potentials, and feasibility and (better use) of the land. The agricultural aptitude system have been use in the interpretation of pedological surveys, with different levels (from exploratory level to detailed level) (PEREIRA and LOMBARDI NETO, 2004). This tool enables the evaluation of the potential of Brazilian soils and subsidizes projects and programs concerned with sustainable development.

In Brazil, the most used interpretative classifications are the Soil Agricultural Aptitude Assessment System (RAMALHO FILHO and BEEK, 1995) and the Capacity of Use System (LEPSCH et al., 1991). The Agricultural

Aptitude Assessment System is based on the qualities of the land, its type of use and the management levels considered. Guides proper land use, avoiding sub- or over-use of the soil. Suitable for assessing aptitude of large tracts of land (regional and/or national planning). It consists of an interpretative process, of ephemeral character, which varies with technological evolution (RAMALHO FILHO and BEEK, 1995).

Its favorable aspects are: i) it is the most used system in Brazil because it considers, in its structure, different levels of management; ii) allows modifications or incorporation of other parameters and limitation factors, following technological advances or the requirement of the level of study; iii) accepts adaptations and applications at different mapping scales; iv) considers the viability of reducing limitations, by the use of capital and technology, distinguishing the high-level technological farmer from the low technological level (PEREIRA and LOMBARDI NETO, 2004). Its unfavorable aspects are the scarcity of socioeconomic variables (IBGE, 2007).

Soil classifications can therefore be tools that enable soil conservation, which allow inferring the best uses and managements for a given soil class. Thus, the objective of this work was to perform the taxonomic classification of a soil, by the Brazilian Soil Classification System (SiBCS) (EMBRAPA, 2006), in a plot of an agrarian reform settlement in the municipality of Baliza - GO. For the conservationist purpose of the soil, the interpretation of its attributes for classification within the Soil Agricultural Aptitude Assessment System (RAMALHO FILHO and BEEK, 1995) was also carried out.

II. MATERIAL AND METHODS

The study site is a plot of an agrarian reform settlement (P.A. Oziel Alves Pereira) located in the municipality of Baliza - GO, with coordinates 160 30’36.38” S and 520 22’33.15” W. The total area of the settlement is 46.595,65 ha, consisting of Alic Dark Red Latosols (21,48%); Alic Red-Yellow Latosols (32%); Quartzarenic Neosols (7,30%) Cambisols (31,53%); Humic Gley and Low Humic Gley (7,46%) and Litholics (0,23%). The average altitude of the lot is 577 m, with mild local relief, Aw type (Köppen), rainy tropical climate, with concentrated rains in the summer, from October to April, and dry period from May to September with average annual precipitation 1450 mm.

Erosive grooves and gullies are frequent throughout the settlement region, including the occurrence of a gully at the study site. The owner of this lot uses the soil with pasture formed by Brachiaria brizantha in consortium with Stylosanthes guianensis, of which is degraded. There is a frequent presence of erosive grooves in this pasture, originated by the cattle walking through the pasture, forming depressions, called ‘trilheiros’, which provide the concentration of water from surface runoff along the slope.

For soil classification purposes, a morphological description of a profile was performed, with the collection of samples and soil probes to determine if there were soil variations in the studied area. The morphological description of the profile was performed on the talude of a gully located within the lot where the study was carried out. A 1 m portion of soil was scraped towards its interior, to avoid describing and collecting a pedon that had been altered by exposure to insolation and oxidation. The morphological description in the field, with the delimitation and identification of horizons, determination of color, texture, structure and consistency followed the methodology described by SANTOS et al. (2005).

In the profile described, soil samples with deformed and not deformable structure were collected for all identified horizons. The deformed samples were used for the determination of texture, fertility, particle density, and sulfuric attack to determine the Ki and Kr indexes and for mineralogical analysis of the soil. Not deformed samples were collected through monoliths, for analysis of aggregate stability by a wet sieving. Volumetric rings were used to determine soil density, total pore volume, macro and microporosity, calculation of available water in the soil and saturated hydraulic conductivity. Based on morphological description and analytical results, the taxonomic classification of this soil was carried out according to the Brazilian Soil Classification System (EMBRAPA, 2006), as well as its classification in the Soil Agricultural Aptitude Assessment System (RAMALHO FILHO and BEEK, 1995), according to the following limiting factors: fertility deficiency, susceptibility to erosion, water deficiency, oxygen deficiency (excess water) and impediments to mechanization.

The granulometric analyses were performed by the Bouyoucos densimeter method, described in EMBRAPA (1997), using NaOH 0,1 N and water as dispersant to determine natural clay and degree of flocculation, calculated using equation (1):

$$GF = \left(\frac{(AT - AN)}{AT} \right) * 100 \quad (1)$$

Where, AT = total clay (dispersed in NaOH), AN = natural clay (dispersed in water).

The soil was separated into very coarse sand (2 - 1 mm), coarse sand (1 - 0,5 mm), medium sand (0,5 – 0,25 mm), fine sand (0,25 – 0,1 mm), very fine sand (0,1 – 0,05 mm), silt (0,05-0,002 mm) and clay (> 0,002 mm), the sand fraction being separated by manual dry sizing. The particle density was obtain using the volumetric flask method, using ethyl alcohol to measure the particle volume (EMBRAPA, 1997).

To determine the percentage of aggregates and to calculate DMP (weighted average diameter) and DMG (geometric mean diameter), the monoliths were carefully loosened, sieved in a 4 mm and 2 mm sieve, and the aggregates that were retained in this last sieve were used for analysis. For wet sieving, the Yoder oscillation apparatus was used, with sieves with diameters of 2; 1; 0,5; 0,25 and 0,103 mm of opening. The samples of ten grams of soil were moisten for 10 minutes and oscillated in the apparatus (40 rpm) for 15 minutes.

The material retained in each sieve was taken to the oven, dried and weighed, and the percentage of aggregates by diameter class, the DMP and DMG, were calculated using equations (2) and (3), respectively:

$$DMP = \sum_{i=1}^{n} x_i w_i \quad (2)$$

$$DMG = \exp\left[\left(\frac{\sum w_i \log w_i}{\sum w_i}\right)\right] \quad (3)$$

Where xi is the average diameter of any size range of aggregates separated by sieving and wi is the weight of the aggregates in that size range as a fraction of the total dry weight of the sample analyzed.

For the determination of soil density, total pore volume, macroporosity, microporosity and volumetric soil moisture content in field capacity (CC), the volumetric rings were placed on the tension table and subjected to a tension of 60 cm (or 6 kPa). For the volumetric humidity corresponding to the permanent wilting point (PMP), these rings were subject to a voltage of 1515 kPa in the Richards pressure chamber.

Still using the volumetric rings, a test was perform to obtain the saturated hydraulic conductivity for each soil horizon, adapting a constant load permeameter for each ring, with a ring of diameter and height similar to the ring containing the soil sample, embedded, and sealed at the last.

The analysis of soil fertility, as well as obtaining the molecular relationships Ki, Kr and Al2O3 / Fe2O3 followed the methodology recommended by Embrapa (1997).

The determination of erodibility (K), used to determine the susceptibility of the soil to erosion, was performed for each horizon of the soil profile, using the model proposed by WISCHMEIER et al. (1971), described by equation (4):

$$K = \left\{\frac{\left[2,1\left(10^{-4}\right)\left(1,2 - MO\right)M^{1,14} + 3,25\left(EST - 2\right) + 2,5\left(PER - 3\right)\right]}{100}\right\} \times 0,1317 \quad (4)$$

Where: K = soil erodibility, Mg h MJ-1 mm-1; M = sum of the % of silt and very fine sand, multiplied by 100 minus the % of clay; MO = % of organic matter; EST = codes corresponding to structure (1 = very small granular, 2 = small granular, 3 = medium to large granular and 4 = blocks, laminar or mass); PER = codes corresponding to soil permeability (1 = fast, 2 = moderate to fast, 3 = moderate, 4 = moderate to slow and 5 = slow).

III. RESULTS AND DISCUSSION

1. Taxonomic Classification

By adopting the Brazilian Soil Classification System (SiBCS), this soil was classify at the fourth categorical level (subgroup) as a typical Orthic Quartzarenic Neosol (RQo). Neossolos are young soils, whose Greek radical neo, means new, giving a connotation of young soil, in the process of formation due to little action of the pedogenetic processes or for the characteristics inherent to the original material.

According to SiBCS, this soil class has as a criterion for its distinction the absence of subsurface diagnostic horizons, a low differentiation of horizons, with horizon A followed by C or R and with a predominance of characteristics inherited from the original material, which in the case of this soil is the product of the micaceous feldspar sandstone weathering of the Furnas Formation. The absence of a subsurface diagnostic horizon was corroborate by the morphological examination of the soil profile, as shown in Table 1. In the subsurface, there was no great differentiation of pedogenetic attributes such as color, texture, and structure, which would indicate the existence of horizon B.

The lack of a subsurface diagnostic horizon indicates the great resistance of the source material to undergo the decomposition process. Therefore, there is a preponderance of the sand fraction to the detriment of the other granulometric fractions.

Table 1. Morphological description of the profile described.

Horizon	Description
A	0 - 30 cm, bruno - dark reddish (5YR 3/2, wet), gray - dark reddish (5YR 4/2, dry); sand; weak, small, simple grain; soft, very friable, slightly plastic and non-sticky; smooth and clear transition.
AC	30 – 50/57 cm, bruno - yellowish (10YR 5/4, damp), bruno - light yellowish (10YR 6/4, dry); sand; weak, small, simple grain; loose, loose, non-plastic and non-sticky; wavy and clear transition.
C	50/57 + cm, brown - yellowish (10YR 5/8, wet), yellow - browned (10YR 6/6, dry); sand; weak, small, simple grains; loose, loose, non-plastic and non-sticky; wavy and gradual transition.

ROOTS: abundant on horizon A, being of the fasciculate type belonging to pasture; Below horizon A, infrequent occurrence of pivoting roots, and belonging to tree species.

The studied soil had its horizons classified in the sandy-sand textural classes, for the A and AC horizons, and the sandy-clay-sand horizons, for the C horizon (Table 2). In this way, these textural classes are insert in the medium textural group (Embrapa, 2006; Santos et al., 2005).

The typical value of the soil density (DS) of sandy soils is 1,6 kg dm-3. However, the DS values of the soil horizons are lower than the value found in the literature, which may indicate greater porosity of this soil. According to FAO (2006), which recommends pore percentage values above 40% as high porosity, this soil presented high porosity in all horizons.

Table 2. Average values of soil physical characteristics.

Horizon	A	AC	C	Measurement unit
Clay	160,00	195,00	210,00	g kg-1
Silt	60,00	60,00	65,00	
Sand	780,00	745,00	725,00	
AMG	5,33	7,50	10,60	
AG	20,66	24,71	20,84	
AM	251,05	230,26	199,62	
AF	447,70	437,15	423,63	
AMF	55,27	45,38	70,31	
Dp	2,61	2,60	2,59	g cm^{-3}
DS	1,47	1,46	1,48	
VTP	43,59	44,08	42,86	%

AMG = very coarse sand; AG = coarse sand; AM = medium sand; AF = fine sand; AMF = very fine sand; Dp = particle density; DS = soil density; VTP = total pore volume.

The texture, besides being a stable characteristic of the soil, influences the physical behavior of the soil and its fertility. Sandy soils, which contain more than 70% sand, are loose, friable, have no plasticity, or stickiness. Retain little water, have good permeability and aeration. The fertility of these soils is, however, low (FREIRE, 2006).

It is noteworthy that the textural evaluation in the field indicated a sandy texture, due to the tactile sensation of roughness, friction and the tiny plasticity and stickiness of this soil, but in the mechanical analysis, it presented a higher proportion of clay than expected. Such discrepancies may arise not only due to the subjective nature of the field examination, but also due to the action of clay minerals, exchangeable cations, organic matter and cementing agents that influence the texture estimate in the field by the touch method (MARSHALL et al., 1999). Field texture descriptions reflect soil behavior. The sensation that the soil offers to the touch is an inherent characteristic of the soil and serves as a criterion to differentiate it in the field, so the textural class estimated in the morphological description should not be corrected based on mechanical analysis (SCHNEIDER et al., 2007).

In the mechanical analysis with dispersant, there was an increment of clay in depth, with horizon C presenting the highest amount of this textural fraction. The sand content followed the opposite trend to that of clay, with a decrease in depth. The textural ratio of this soil was low, for example, the AC / A ratio, for clay, equivalent to 1,22, which indicates the absence of an abrupt textural gradient.

For the mechanical analysis in water, there was a reduction in the clay and sand content in depth, and an increase in the silt fraction with the increase in depth (Table 3). This fact evidences the importance of chemical dispersion (addition of sodium hydroxide) in the determination of more exact amounts of each textural fraction of a soil. When there was no addition of sodium hydroxide in the mechanical analysis, the clay behaved as silt, as it was not properly deflocculated.

Table 3. Average values of total clay (AT), natural clay (AN) and degree of soil flocculation (GF).

Horizon	Texture with dispersant (g kg-1)			Texture in water (g kg-1)			GF
	AT	Silt	Sand	AN	Silt	Sand	(%)
A	160	60	780	70	55	875	56,25
AC	195	60	745	50	80	870	74,36
C	210	65	725	35	130	835	83,33

Natural clay, dispersed in water, represents the portion of the total clay that is naturally dispersed in the presence of water. Thus, it can be used to indicate: i) erodibility, as it is related to the stability of stable aggregates in water, ii) the activity of the clay fraction, assuming that the more active the clay fraction, the greater the adsorption of water and, therefore, of clay dispersed in water (FERREIRA, 2010).

Analyzing the natural clay contents of this soil it is perceive its decrease in depth and an increase in the degree of in-depth flocculation. This means that the reduction of clay dispersion in depth can have a positive impact on the stability of aggregates in subsurface, as well as a reduction in the activity of this fraction in depth.

Ferreira (2010) points out that in a given soil profile, surface horizons have higher levels of natural clay when compared to subsurface horizons. However, contradicting this statement, the reduction of clay dispersion in depth had no positive impact on the stability of subsurface aggregates in the present study, in which a reduction in subsurface aggregate sizes was verified (Table 4). This indicates that the surface aggregates were more stable in relation to the subsurface aggregates, with a decrease in the percentage of stable aggregates in water with increasing depth. This trend can have a negative impact in cases of the occurrence of linear erosive processes such as ravines and gullies because such erosive features when reaching the subsurface horizons will progress more rapidly, potentiating the erosive process.

Table 4. Average values of the percentage of stable aggregates per diameter class.

Horizon	A	AC	C
Depth (cm)	0-30	30-57	57-100+
% Aggregates			
4-2 mm	86,48	79,77	77,12
2-1 mm	5,65	7,42	3,98
1-0.5 mm	0,95	2,12	2,18
0.5-0.25 mm	2,50	4,57	6,86
0.2-0.1 mm	2,10	3,67	7,29
DMG (mm)			
-	2,54	2,26	2,02
DMP (mm)			
-	2,70	2,54	2,43

DMG = Geometric average diameter, DMP = Pondered average diameter.

The values of the Ki index of this RQo ranged from 0,96 (horizon AC) to 1,02 (horizons A and C), with an average value equal to 1,00, which reflects the high silicon content in its composition (Table 5). This fact shows the origin of this soil, derived from the sandstone weathering product (Furnas Formation) rich in quartz, mineral rich in silicon and which presents high resistance to chemical weathering, that is, it is difficult to decompose its mineral structure. Therefore, there is a large participation of SiO2 in this soil, making its Ki ratio low.

Table 5. Average values of silicon oxides (SiO_2) iron (Fe_2O_3) and aluminum (Al_2O_3).

Horizons	A	AC	C
Attribute	(%)		
SiO_2	3,60	4,00	4,80
Fe_2O_3	0,60	0,64	0,70
Al_2O_3	6,00	7,10	8,00
TiO_2	0,14	0,20	0,21
Ki	1,02	0,96	1,02
Kr	0,96	0,91	0,97
Al_2O_3/Fe_2O_3	15,96	17,4	17,93

It is noteworthy that the Brazilian Soil Classification System (SiBCS) uses the Ki index as a characteristic attribute of the subsurface diagnostic horizon B Latossolic. According to the system, the Latossolic B horizon must have a molecular ratio Ki equal to or less than 2,2, being normally less than 2,0.

In this study, the Ki indices found are lower than the values recommended by the SiBCS (Embrapa, 2006) for the classification of Latosols. However, the interpretation of low values for the Ki index of the RQo's should not denote a high degree of weathering, as occurs for the interpretation of Ki indexes below 2,0 for the Latosols. The reduced Ki values for this RQo indicate a relevant presence of Si in this soil, a fact that occurs not by the high degree of weathering, but by the high Si content that this RQo inherited from its source material and associated with the high degree of resistance to decomposition. The Ki index, which for the Latosols indicate maturity or senility, for Quartzarenic Neosols, young soils, do not.

The Kr relationship, since it involves the levels of the oxides of Si, Fe and Al, is indicative of kaolinite soils (Kr > 0,75) and oxidic soils (Kr < 0,75) (Embrapa, 2006; IBGE, 2007). Adopting these Kr values, we would classify this Neosol as a kaolinite soil. However, it is necessary to consider the origin of this soil, which is rich in quartz, a material that is difficult to weather, before concluding about its mineralogy. Thus, this index is inconclusive in the determination of mineralogy of this soil. Therefore, this Kr index, as well as the Ki index, are indicative of the prevalence of Si in this soil.

The ratio Al2O3/Fe2O3 is considered high for values greater than 3,15, expressing the small presence of iron in the soil (IBGE, 2007). Considering the values of the ratio Al2O3/Fe2O3 for the soil under study, there were high values of this ratio for all horizons, demonstrating the prevalence of Al oxide over Fe oxide for this soil.

Neosols occupy an area of 1.246.898,89 km², or 14,57% of the Brazilian territory. Of this area, 54% is of occurrence of Litholic Neosols, 42% of Quartzarenics and 2% for Fluvic and Regolithics (IBGE, 2001). Quartzarenic Neosols have a significant occurrence in the Midwest region of Brazil, encompassing approximately 15% of its total area. This soil class presents serious limitations to agricultural use, due to its excessively sandy texture, low fertility, low water retention capacity and high erodibility with severe linear erosion processes (Coelho et al., 2002).

2. Technical Classification

2.1 Type of Use and Level of Management adopted in the land

The type of land use in this lot is with planted pasture, which is under extensive management system, without any form of grazing rotation, no type of fertilization or reform. Thus, it constitutes a type of soil exploration that is almost extractive, in which nutrients are exported via grazing and are not replaced by fertilization. Furthermore, aggravating this scenario, excessive grazing, caused by lack of cattle management, creates conditions for soil compaction and erosion. Thus, it is perceived that the level of management adopted in this plot of agrarian reform is level A, considered primitive and characterized by the reduced technological level used in soil cultivation and conservation practices.

At the management level A there is no type of soil improvement compatible with this technological condition: the soil is used according to its natural conditions, without any alteration or improvement, which is worrisome when soils of low natural fertility and high erodibility are managed. Therefore, it is expected, in this scenario, a reduced production, productivity and high rate of soil erosion.

It should also be noted that the Soil Agricultural Aptitude Assessment System relates the use of planted pasture, which is the current use of this lot, with the management level B (poorly developed). Management level B is characterized by presenting an intermediate technological level that makes use of such practices: liming and fertilization with NPK and some mechanized practice. Therefore, the current level of management under which the soil is being used falls short of the need for its use. For this specific type of use (planted pasture), it would be necessary to raise the technological level and capital spent on the management of this soil.

2.2 Agricultural Condition of the Land

2.2.1 Fertility Deficiency

According to the analytical results, this soil can be classified as dystrophic, with base saturation (V) below 50%, or even subtrophic (V<35%) and mesoalic, with the content of Al > 0,4 cmolc/dm3 and aluminum saturation (m) higher than 50% (Table 6). The soil reaction class is extremely acidic, with pH below 4,3 (EMBRAPA, 2006; Prado, 2008). Reduced pH and ‘V’, and elevated ‘m’ characterize the acid reaction of this soil. ‘V’ varies inversely with the pH and the H+ and Al3+ ions are responsible for the acidity, as they replace the K+, Ca2+, Mg2+ bases of the soil exchange complex.

The most suitable soil pH, 'V' and 'm' for most crops is between 5,5 and 6,5; 40 to 70; and 10 to 20, respectively (Malavolta, 2006). It is noticed, therefore, that this soil presents values much lower than those recommended by the literature, with averages for the parameters pH, ‘V’ and ‘m’ of 4,03, 10,69% and 58,89%, respectively. Thus, this soil falls into the degree of strong limitation for the agricultural fertility deficiency condition.

Table 6. Soil fertility - average values.

Horizons	A	AC	C	Measurement unit
MO	1,40	0,65	0,50	%
pH	4,00	4,00	4,05	$CaCl_2$
P(Mehl)	0,30	0,30	0,30	mg/dm^3
K	39,50	35,50	34,00	

Ca	0,30	0,30	0,30	
Mg	0,10	0,10	0,10	
H+Al	5,90	4,55	3,30	
Al	0,85	0,70	0,60	$cmolc/dm^3$
CTC	6,40	5,05	3,80	
m	62,85	58,80	55,20	%
V	7,80	9,75	12,90	

2.2.2 Susceptibility to erosion

Soil erosion is a function of rainfall erosivity, soil erodibility, relief, and vegetation cover. The average erodibility of the soil profile was generally low (Tables 7 and 8). By associating the average values of erodibility with the local relief, this soil can be classify as having a slight degree of susceptibility to erosion. However, it is emphasized the local condition of degraded pasture, with reduced vegetation cover of the soil, associated with a topography characterized by long and flat ramps that provide an increase in volume and speed of runoff, which potentiate soil erosion. Therefore, the erodibility value of a soil is not absolute and much less constant over time to predict its susceptibility to erosion. Soil management and use are key parameters in determining how much soil is susceptible to being eroded.

Adopting only the parameters erodibility and relief in the determination of the degree of susceptibility to erosion, this soil presents a slight degree of limitation for this agricultural factor. However, considering also that this soil is under a degraded pasture, which provides reduced protection against rain and runoff, the degree of soil limitation becomes strong for susceptibility to erosion.

Table 7. Soil erodibility (model of Wischmeier et al., 1971).

Horizon	Erodibility ($Mg\ h\ MJ^{-1}mm^{-1}$)
A	0,0018
AC	0,0024
C	0,0060

Table 8. Erodibility value for each degree of limitation (Adapted from Giboshi (1999) apud Pereira and Lombardi Neto, 2004).

Degree of limitation	Erodibility ($Mg\ h\ MJ^{-1}\ mm^{-1}$)
Null	<0,01
Slight	0,01 a 0,02
Moderate	0,02 a 0,03
Strong	0,03 a 0,04
Very Strong	>0,04

2.2.3 Water Deficiency

The volume of water that the soil can retain depends on its edaphic properties, such as texture, porosity, organic matter content. Thus, the preponderance of sand fraction, large volume of macropores and reduced organic matter content, condition a limited water retention capacity in the soil, reflected by the reduced amount of water available to plants. This amount is determine by the difference in the water content in the soil between the moisture in the field capacity (CC) and the permanent wilting point (PMP) (Table 9). By relating the physical characteristics of this soil to the climate in which it is insert, with two distinct seasons of rainy summer and dry winter, a moderate degree of limitation was obtain for water deficiency.

Table 9. Volumetric humidity and water available for each soil horizon.

Horizon	A	AC	C	Measurement unit
Depth	0-30	30-57	57-100+	cm
Volumetric Humidity				
Saturated	0,39	0,39	0,41	
CC	0,25	0,23	0,24	cm^3/cm^3
PMP	0,11	0,08	0,07	
Available Water				
CC	7,65	6,20	5,93	
PMP	3,30	2,17	1,86	mm
AD				
-	4,35	4,03	4,06	

CC = field capacity, PMP = permanent wilting point and AD = available water

2.2.4 Excess Water (Oxygen Deficiency)

The position of this soil in the local relief is in the middle of the slope, that is, away from watercourses, which restricts the occurrence of floods, since it is a typical Orthic Quartzarenic Neosol, a soil class that is not formed by alluvial and hydromorphic processes. If this soil was influenced by such processes, this Neosol would be classified, at a second categorical level, as Fluvic. This soil was classified as excessively drained, with values of fast saturated hydraulic conductivity in all horizons of its profile (Table 10). Thus, its degree of limitation for excess water is Null.

Table 10. Saturated hydraulic conductivity values (Ko).

Horizon	Ko ($cm\ h^{-1}$)	Classification (Forsythe, 1975)	
		Classes	Ko ($cm\ h^{-1}$)
A	22,44	Slow	< 0,13 - 0,5
		Moderately Slow	0,5 - 2
AC	23,77	Moderate	2 – 6,3
		Moderately Fast	6,3 – 12,7
C	16,09	Fast	12,7 – 25,4
		Very fast	> 25,4

2.2.5 Impediments to Mechanization

This agricultural factor is more relevant in the management level C, which is based on mechanized systems, than for the other management levels. The absence of pebbles and boulders on both the surface and subsurface, as well as the non-occurrence of rocky outcrops and boulders, characterize this soil as non-stony and non-rocky. In addition to the absence of stony / rocky soil, its smooth relief, with long ramps, favors mechanization, as well as its depth, classified as very deep, with fragmentary lithic or lithic contact below 2m. For being a soil with a sandy texture, good drainage and absence of hydromorphic conditions, favor mechanization. Thus, this soil presents a slight degree of limitation for the impediment to mechanization. However, the occurrence of ravines and gullies can negatively influence soil mechanization.

2.3 Viability of Improvements in Agricultural Land Condition

The soil of the present study went through a gully recovery / stabilization process using vegetative, edaphic and mechanical soil conservation techniques. The degradation was triggered by the lack of soil conservation practices. The recovery of this environmental liability was characterized as a type of intervention in the land of technological level and of capital contribution far beyond the capacity of the settlers in that area. It is demonstrated, therefore, that these settlers would not be able to recover this environmental liability with the level of management they adopt and that this same management is leading to soil depletion and its consequent degradation. If there was no intervention by the government in the recovery of this liability, the erosive process would have become worse.

The viability of land improvement is conditioned to the levels of management B and C. The current level of management (level A) under which the land is exploited, does not foresee any possibility of improvement in the management and conservation of this soil. Thus, for this soil to be explored in a sustainable way, it is necessary to increase the contribution of technology and capital, that is, that the management of this soil migrates from level A to at least level B.

Among the agricultural factors that most affects the agricultural condition of the land are fertility deficiency and water deficiency. When considering fertility at the current level of soil management, it is assume that there is no possibility of improvement of this factor. Therefore, the farmer depends on the reduced natural fertility of the soil, which in this case, requires the improvement of this agricultural factor.

By adopting improvement class 1 (RAMALHO FILHO and BEEK, 1995), which relates to management level B, the following techniques could be adopted to overcome the deficiency of fertility of this soil. Liming and plaster to reduce acidity on the surface, subsurface and 'm', as well as raising CTC and 'V'; green, organic fertilization (use of manure) to raise organic matter; maintenance fertilization with formulated fertilizers; crop rotation, with crop-livestock integration, adoption of agroforestry systems and grazing rotation systems.

To improve water deficiency, disregarding irrigation practices that are not within the scope of the Agricultural Aptitude System, practices that recommend the supply of organic matter in the soil, as well as providing its coverage and retaining water are indicated, such as: level planting, cords of permanent vegetation, addition of organic matter, dead cover and direct planting. The use of a level terrace as a water conservation mechanism is a practice of management level C, therefore, above the capacity of technology, investment and maintenance of these settlers.

Even if the Agricultural Aptitude Assessment System has indicated reduced susceptibility to erosion by this soil, care is needed to prevent it from being eroded. The RQo, because they are soils of high sand content, have low aggregation, which predisposes them to erosion. In addition to this fact, the local relief consists of flat relief with long ramps, which enhances the speed of surface runoff. As the soil is under degraded pasture, with frequent grooves and reduced vegetation cover, the risk of erosion is increased. Thus, in addition to the aforementioned conservation practices, the following practices can be used to reduce or control erosion: reduced soil tillage, strip cultivation, contour cultivation, bands of permanent vegetation, controlled grazing (paddocks with water tanks).

2.4 Agricultural Aptitude Class

The soil was in subgroup 4p (Table 11), which characterizes as land with regular aptitude for planted pastures. However, if the way in which the soil has been managed continues, the process of degradation and erosion will continue. In this way, this soil may have its classification changed to a class with more restricted use, because with the increase of degradation, the use restrictions will also increase, and it can be reclassified to the class restricted to planted pasture (4 (p)) or become unfit for agricultural use.

Table 11. Soil Agricultural Aptitude Class.

Group	4
Subgroup	4p
Class	Regular
Fertility deficiency	Strong
Water Deficiency	Moderate
Excess water	Null
Susceptibility to erosion	Strong
Impediment to mechanization	Slight
Indicated use	Planted pasture

Just as the classification of this soil may change due to the increase in its degradation, it may also be altered if the soil undergoes management and investment of technology and capital that allows the improvement of its edaphic conditions. Thus, with the reduction of its restrictions, this soil may have a classification changed to a good fitness class for planted pasture (4P), or even to a restricted fitness class (3 (abc)) for crops in the three management levels considered by the Agricultural Aptitude Assessment System.

IV. CONCLUSION

1. Soil classification, mainly technical / interpretive, is an important tool in determining the limitations of a soil for its agricultural use, as well as in determining its best use and management.

2. The soil classified as a typical Orthic Quartzarenic Neosol presented severe limitations for agricultural use under low technological level management.

3. The erosive and degradation processes that this soil goes through are more influenced by its use and management than by its physical-chemical properties, indicating that the current exploration is not sustainable, leading to degradation.

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