A Review of Soybean Cultivation On Stony Soils in Tocantins, Brazil

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Abstract: ***With the expansion and opening of new areas, these stony soils are having agricultural use, contrary to the recommendation of the agricultural aptitude system. The objective of this work is to present some results obtained about the use and management of this soil in the Legal Amazon region, state of Tocantins, Brazil. For the present study, the dialectical method of an exploratory qualitative approach was used. Plintosols yields are quite similar to Latosols, just adjusting management and conservation practices. However, it is known that we still have a long way to go to answer all the questions about growing on these soils.***

Keywords: Petric Plintosols, agriculture, land use, productivity, management

1.Introduction

Plinthosols represent 3% of the territorial surface of Latin America and the Caribbean, and about 7% of the national territory (GARDI, 2015), almost entirely contained in the Legal Amazon. According to the Atlas of Tocantins SEPLAN (2005), in the state of Tocantins the territory is composed of Latosol (22%), concretionary soils (22.8%) and Plintosols (11.1%), but due to the classification system the Concretionary Petric Plintosols end up associating and adding up to about 34% of the territory, making it the most predominant soil class in the state. Among these there are the concretionary Petrisols, which present variable proportions of petroplinthite immersed in an equally variable matrix of fine earth, demonstrating their importance in the State, precisely in areas of recent agricultural expansion (SANTANA, 2008).

These soils present strong limitations to the use of machinery, mainly due to the excessive amount of gravel and pebbles (petroplinthite) and therefore, are better suited for uses that do not require the use of implements, such as pasture (FRANCESCHETTE et al, 2013; SPERA, 2002). They commonly have limited use for agricultural activities and, in this way, criteria can be created that guide the recommendation of use of these soils, for the elaboration of management strategies, which guarantee increased productivity and less environmental impact on these soils (MOURA, 2015).

In addition to the limitation for the use of machines, other problems such as low natural fertility, high acidity, poor water drainage and, above all, the presence of stones, which normally have more than 50% of their volume. This last characteristic has been considered the most limiting, since physical-hydric, biological and chemical studies of horizons that almost do not present the fine earth fraction are unknown. (LUMBERAS, 2015). Understanding the physico-hydric processes of this class of soils is a necessity for producers and technicians who work with this type of soil.

In this way, it is possible to propose management techniques that are more suitable for the soil conditions in which the work is carried out (QUEIROZ et al., 2012). Therefore, in view of all the problems presented, it is evident the need for further studies on the pedological relationships and agronomic aspects of the soybean crop to explain their influence within the diversity of soils present in the region where they occur. The objective of this work is to present some results obtained about the use and management of this soil in the Legal Amazon region, state of Tocantins, Brazil.

2.Material and Methods

For the present study, the dialectical method was used. The choice of this method is indicated because it is a bibliographic study, it is necessary to have an exploratory qualitative approach at the time of interpretation.

The qualitative approach is based on the interpretation of phenomena and the attribution of meanings. It does not require the use of statistical methods and techniques. The natural environment is the direct source for data collection and the researcher is the key instrument (SILVA; MENEZES 2001).

The literature review is the critical, thorough and comprehensive analysis of current publications in a given area of knowledge. In this way, bibliographic research seeks to explain and discuss a topic based on theoretical references published in books, magazines, periodicals and others, in addition to knowing and analyzing scientific content on a given topic (Martins and Pinto 2001).

According to Santos et al, (2018) Plintosols are divided into three suborders: pedric, clayey and haplic. The first presents the concretionary horizon (consisting of 50% or more of its volume by coarse material - petroplinthite) or lithoplinthic (consisting of continuous or practically continuous petroplinthites). The second presents a plinthic horizon and textural gradient between the horizons and the last one does not fit into either of the two options above. In this work, we will only address the first one, which deals with soils that present petroplinthites in the size of gravel and pebbles, whether fragmented or in their consolidated form, concrecinary and litholinthic respectively. Based on the selected works, it was possible to discuss the limitations and potential of concretionary Petric Plintosols.

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3.Results and Discussion

It is estimated that 35% of the soil cover in the State of Tocantins is composed of stony textured soils (Figure 1). The so-called Plintosols that can present themselves in several ways; formed by loose gravel and pebbles; formed by a continuous layer of stones, that is, not fragmented.

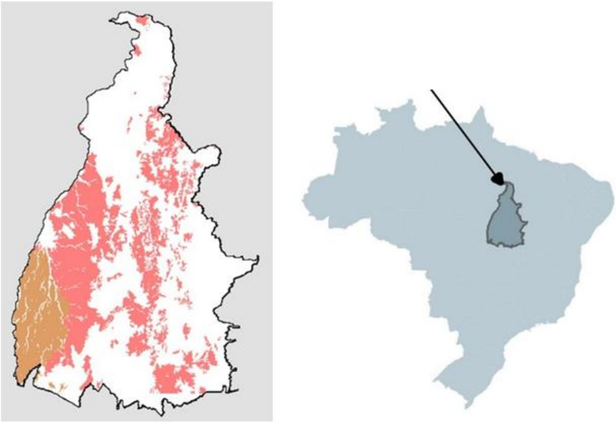

Figure 1: Distribution of Plintosols in the State of Tocantins - Source: INDE, 2018.

Finally, its last version, which is composed of a material we call plinthite (Photo 1), "an unhardened stone" (soft) with an intermediate form of hardened petroplinthite. This soil still presents an irregular distribution of clay content, where it is more concentrated in the subsurface horizon. This characteristic denotes susceptibility to erosion. A soil that has a sandy surface horizon followed by a lower horizon, enriched with clay, promotes a discontinuity in the infiltration of water in these soils and, consequently, erosion.

Photo 1: Michele Ramos, 2019 - Plinthite present in Argiluvic Plintosols, municipality of Lagoa da Confusion - TO.

In addition, it is worth mentioning that these soils occur diffusely in the landscape, in some regions of the state in the upper third of the landscape (tops of areas) and in others in the lower third of the landscape (lower/rough parts), sometimes associated to steep reliefs where the presence of water is of fundamental importance for their perpetuation in the place. They can also occur associated with drainage headwaters within rural properties. All these characteristics make it important when we realize that agriculture in Tocantins is currently developing on these soils.

Farmers from different regions cultivate in these areas one of the most important crops for the State, soybean (glycine max). It is also noteworthy that these soils, according to the agricultural suitability system, are not suitable for agricultural crops, but only for pasture, due to the presence of all these "fragility".

However, what has been noticed is the entry of agriculture in these areas, and as incredible as it may seem, contrary to all expectations, these theoretically unviable soils for agriculture are showing yields very close to the Latosol, which does have productive potential and is recognized as suitable. for the development of agricultural crops.

Research on this very peculiar soil is very recent, it is known that the presence of gravel and pebbles reduces the volume of fine earth (part of the soil, composed of sand, silt and clay), that is, the fraction that is analyzed in the routine soil analysis laboratories. But after all, what does this mean to us? Simply, when the producer collects the soil sample for analysis to recommend fertilization and liming, all material that does not pass through the 2mm sieve is discarded, that is, the analysis is performed only on the sand, silt and clay fraction. As these soils have predominantly gravel and pebbles, it means that the entire recommendation for fertilization and liming is overestimated for a volume of soil that does not represent the sample that the producer collected, since part of it is discarded because it does not pass the 2mm sieve.

A recent survey (Figure 2) (Castro & Ramos, 2020) with Petri Plintosols in different municipalities in the State of Tocantins, proved the great variability of this soil in the State. The proportion of gravel in relation to fine earth varied from 20% to 77% within the same soil class, that is, in extreme cases, more than 70% of the soil volume is not soil, it is gravel.

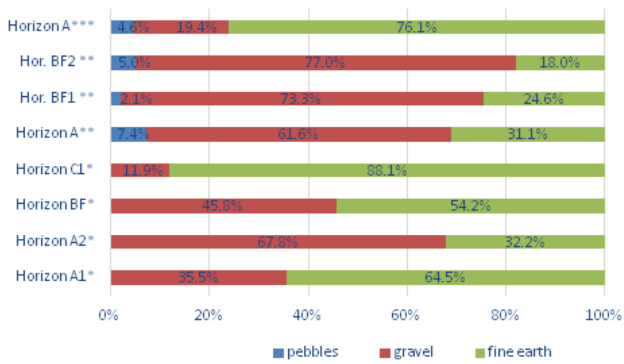

Figure 2: Percentages of soil fractions pebble, gravel and fine earth in relation to the total mass of samples collected in the horizons of the three Petri Plintosols in the State of Tocantins - Source: Castro & Ramos 2020. *municipality 1= Brejinho de Nazaré, ** municipality 2 = Santa Tereza do Tocantins, *** municipality 3 = Porto Nacional.

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Does this mean a loss of inputs (fertilizer and limestone)? Or is it that these soils can only produce because they are super fertilized and super limestone?

Another research recently carried out in a greenhouse (Tables 1 and 2 - Da Silva & Ramos, 2019), using the sieved concrete concretionary Plintosol (without the gravel) and the same soil without passing through the sieve, showed that there is a residual of nutrients from the sieve. fertilization and liming, in non-sifted soil, that is, there is evidence that the same recommendation for stony and non-stony soils, the remaining contents in the soil are higher in soils that had gravel. This is due to the fact that the reactive fraction of Plintosols is much smaller, due to the presence of gravel. The Petric Plinthosol of the study had 73% of the gravel.

Table 1: Chemical analysis of unsieved Plintosol soil after cultivation

P(meh)	K	$Ca^2 + Mg^2$	Al^3	H + Al	SB*	C.T.C.* a pH 7.0	V*	m*	pH	S.O.M*	C*
-----mg/dm^3 -----		----cmolc/dm^3------				-----%-------		água	----g/dm^3------		
18,73	0,41	2,74	0,0	3,30	3,15	6,45	48,84	0,0	6,22	17,60	10,21

Table 2: Chemical analysis of Plintosol soil sieved after cultivation

P(meh)	K	$Ca^2 + Mg^2$	Al^3	H + Al	SB*	C.T.C*. a pH 7.0	V*	m*	pH	S.O.M*	C*
-----mg/dm^3 -------		-------------------cmolc/dm^3------					-----%-------		water	----g/dm^3-----	
2,55	0,50	1,44	0,0	3,40	1,94	5,34	36,33	0,0	5,84	20,87	12,11

*SOM:soil orgânica matter, C:carbono; CTC:cation exchange capacity SB:sum of bases, V:base saturation, m:aluminum saturation
Source: Da Silva & Ramos, 2019

To answer these questions, we need to carry out more research to understand the nutrient dynamics in these soils, find a correction factor to improve the fertilization and liming recommendation when cuttings contents are high, etc. Today what we know is that there is an excess of inputs applied to these soils. In the vast majority of rural properties in the State, the management applied in Plintosols is exactly the same used in Latosols, this is due to the fact that they occur side by side within the plots, not compensating for the producer to make exclusive adjustments for stony soils.

In any case, in informal conversations, most producers are not interested in customizing production on these soils, but only in obtaining yields that justify the permanence of crops in these areas. However, if we manage to demonstrate that it is possible to reduce the amount of fertilizer and limestone and obtain the same productivity, we will take one more step towards more sustainable production in these areas, through resource savings.

Another point worth mentioning is that despite all these difficulties, the yields that some producers have achieved are impressive. In a recent survey (Dal Santo & Ramos, 2020), in a 4-year area with no-till soybean/millet, the average productivity in Latosols was approximately 3.3 tons/ha and in Plintosols 3 tons/ha (Photo two). Although the difference seems little, 0.3 tons per hectare can represent a good amount when considering the entire area. On the other hand, as it is a soil not suitable for agricultural crops, this productivity is alarmingly high, considering that the same management was applied in both areas.

Photo: Dal Santo, 2020 - Soybean planting in the Municipality of Porto Nacional - TO

In another agricultural area, a recently carried out research comparing soybean productivity in neighboring areas of Latosols and Plintosols, obtained 4.5 and 4.3 tons/ha respectively, with a 5-year history of soybean/safrinha corn/millet, with the same management in both soils (Do Carmo & Ramos, 2020).

When we evaluate areas with different crop succession managements, yields reach levels of 2.3 tons/ha when using the harrow, and when succession with other species, yields reach 3.4 tons/ha. This result shows that these soils can even be productive as long as some conservationist practices are adopted, such as crop succession, green manure such as millet (Panicum miliaceum), brachiaria (Urochloa sp.) (Photo 3) in the off-season.

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Photo 3: Michele Ramos 2019 - Brachiaria: Urochloa sp. cultivated in concretionary Petric Plinthosol in the municipality of Palmas - TO

This is because it has been noted that the presence of living or dead cover in these areas is essential to improve soil structure (aggregation mainly), promote an increase in organic matter content, improve water storage, and decrease surface temperature. The increase in temperature has caused losses in crops in this region, from failures in germination (smaller final stand) and scalding (death of the plant by heating the plant neck close to the surface) (Photo 4).

Photo 4: Gustavo Marquadt, 2020. Effect of increasing temperature on the soil surface.

Recent research has shown that the amount of gravel affects soil temperature. The study evaluated the temperature at different times of the day in Plintosols with different percentages of gravel and pebbles. Soils with the highest percentages of this fraction (> 70%) even recorded a temperature above 40ºC at 2 pm, with a daily average of 35ºC (LEITE et al., 2020). In this way, the use of cover crops becomes of fundamental importance for the use of these soils in agriculture. Being decisive in the production process.

4.Conclusion

Studies on Petri Plinthosols are far from having a definitive answer about their use and management, however, it is possible to verify that with the adequacy of soil management associated with conservationist practices it seems possible to obtain good yields for soybean cultivation in the region of Tocantins.

5.Future Scope

Research should continue to be carried out to understand the physical-hydric and chemical behavior, with regard to the availability of nutrients, super fertilization and super liming, as well as studies related to the biological properties of these soils, which have very peculiar characteristics, which at this stage last agricultural expansion are being occupied by soy plantations.

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