IMPROVEMENT OF COMPACTED LAYERS OF LATOSOLS UNDER DIFFERENT PLOWING SYSTEMS

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Introduction

In the Cerrado region, the Latosols (Oxisols), accounting for about 46% of the soils in the area (1), show adequate intrinsic and physical properties due to the proper developing of aggregate structure. In spite of these favorable properties, a compacted layer is formed which increases soil hardness, reduces soil aeration and water infiltration, hence the restriction to the elongation of crop roots.

Normally, fields are plowed using heavy disk harrow instead of a disk or moldboard, which reduces the soil macroporosity through the formation of a compacted layer at a 10 to 20 cm depth in the soil profile.

Generally, the compacted layer is formed just below the cultivated layer and it shows a bulk density (about 1.2 to 1.3 g/cm3) higher than the other layers. However, it has been observed that hard layers are also formed without significant changes in the soil bulk density. Changes in the bulk volumetric properties may not be as important for plant growth as the associated increased strength and the reduction of conductivity, permeability and diffusivity of water and air through the soil pore system (8). Some treatments to alleviate the effects of the compacted or hard layers are needed.

Therefore this experiment was conducted to compare (ways) of improving soil physical properties affecting crop growth in a Dark-Red Latosol, using different implements.

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Materials and Methods

Field:

The experimental field consisted of a Clayey Dark-Red Latosol (45% of clay, textural class sandy clay) at CPAC. In this field, wheat had been grown for about ten years followed by a fallow period of two years.

The chemical properties of the soil were as follows: pH(H_2O), 5.3-5.5, 5.4-5.6, exch-Al content, 0.04-0.05, 0.25-0.39 meq/100ml, exch-Ca content, 3.19-3.65, 1.05-1.35 meq/100 ml, ext-P content, 10.7-13.1, 0.8-1.7 μg/mg and organic matter content, 2.2.-2.8, 1.3-1.8% in the surface layer (0-5 cm) and sublayer (45-60 cm), respectively.

The following treatments were applied five months prior to the experiment.

heavy disk harrowing ---- * no organic compound applied

* organic compound applied (compost) (20 t/ha)

disk plowing ------------ * no organic compound applied

* organic compound applied (compost) (20 t/ha) fallow plot (control plot)

The experimental plot size was 9 x 12m for each treatment with two replications.

Measurements:

1 Soil water retention curve (for 3 or 4 layers/plot)

2 Soil hardness vs. soil moisture tension (θo) Soil hardness was measured by using a cone penetrometer in the field in relation to the soil moisture tension. In general, the soil hardness increased with drying. It is generally recognized that the crop roots cannot penetrate in soils with a soil hardness value above 15 kg/cm² (2,7).

3 Soil-gas diffusion vs. soil moisture tension (θo) Soil aeration occurs mainly by gas diffusion. Gas diffusion coefficient in soil was measured in relation to the soil moisture tension (5). It is generally recognized that the roots cannot respire in soils with a relative gas diffusion coefficient (D/DO) value below 0.02 (3,9).

4 CO_2 concentration and CO_2 flux (for 3 of above 5 treatments) Respiration activity of soil microorganisms leads to CO_2 evolution in upland fields. In general, the high respiration activity of soil microorganisms reflects a high decomposition rate of soil organic matter which affects the soil physical properties.

5 Available (Non-Limiting) water range (for 3 or 4 layers/plot) From the results of (1)-(3), Non Limiting Water Range (4) can be obtained: 1. Moisture range in which crop can absorb water easily; 2. Water quantity which a crop can absorb easily.

Results and Discussion

There was no significant difference in the water retention capacity of undisturbed soils between the treatments and layers. One set of the soil water retention curves is shown in Figure 1. The true density of the solid particles and bulk density did not differ significantly between the treatments and layers (the former ranged from 2.64 to 2.70 g/cm3, the latter ranged from 0.93 to 1.03 g/cm3).

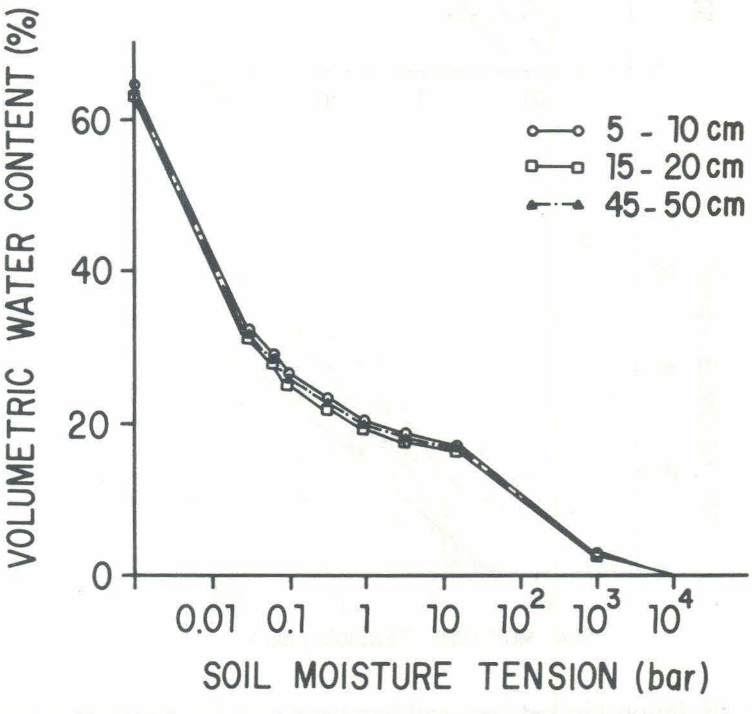

FIG. 1 - Soil water retention curves. (heavy disk harrow plot)

Examples of the relationship between the soil hardness and soil moisture tension are shown in Figure 2. The fallow plot clearly displayed a compacted layer below the surface layer. Heavy disk harrowing without organic matter application did not improve appreciably the compacted layers. Addition of organic compounds decreased the soil hardness, especially in the disk plowing plot.

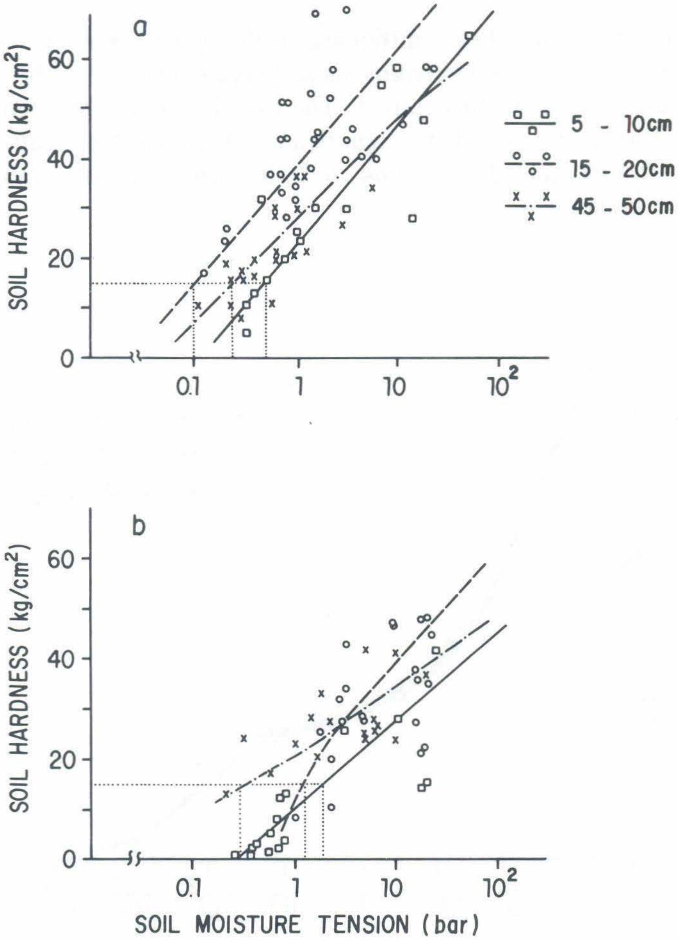

FIG. 2 - Relationship between soil hardness and soil moisture tension. a: fallow plot; b: disk plow + organic compound plot.

Examples of the relationship between the relative gas diffusion coefficient (D/DO) and soil moisture tension are shown in Figure 3. In the experiment field, gas diffusion was satisfactory in comparison with some soils in Japan (Gray Lowland soils, Yellow soils, etc.) (6). Addition of organic compounds still improved the gas diffusion in soil.

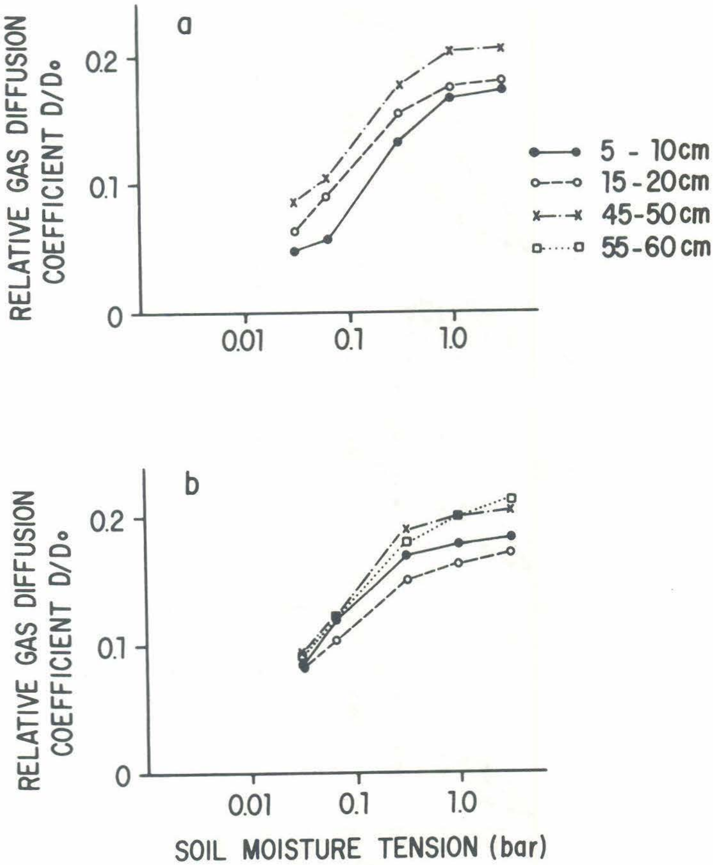

FIG. 3 - Relationship between relative gas diffusion coefficient and soil moisture tension. a: fallow plot; b: disk plow + organic compound plot.

Compacted layers showed CO_2 concentrations higher than those in adjacent layers as shown in Figure 4, revealing the presence of a CO_2 flux both upward and downward in the compacted layers. The above phenomenon seemed to disappear by disk plowing with organic compound application due to the no existence of the compacted layer.

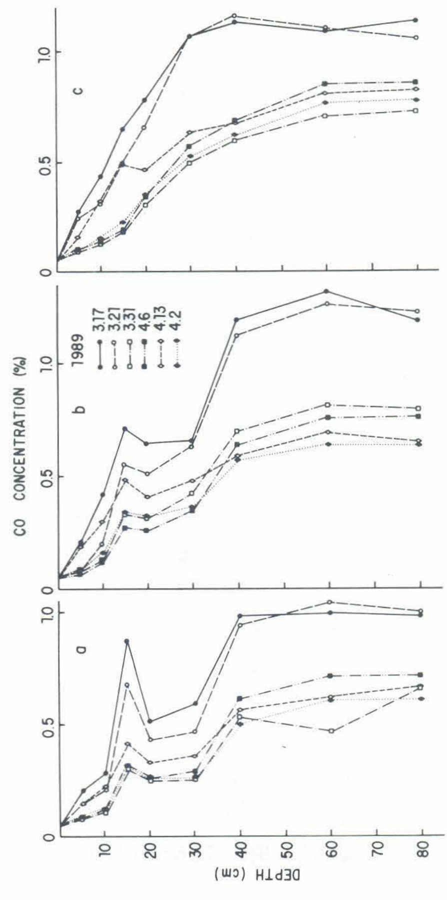

FIG. 4 - CO_2 profile in dark-red Latosol. a: fallow plot; b: disk plow + organic compound plot; c: disk plow + organic compound plot.

Available non-limiting water range (NLWR) is shown in Figure 5. In such a range, crop roots appeared to absorb water without restriction associated with the poor soil aeration and/or high value of soil hardness. In the compacted layer the available non-limiting water (2.6 vol %) did not increase too much neither with heavy disk harrow (3,0 vol %) nor with heavy disk harrow + organic compound (4,7 vol %) wich was comparable to the disk alone (4,7 vol %), but had a 170% of improvement over that compacted layer (fallow plot).

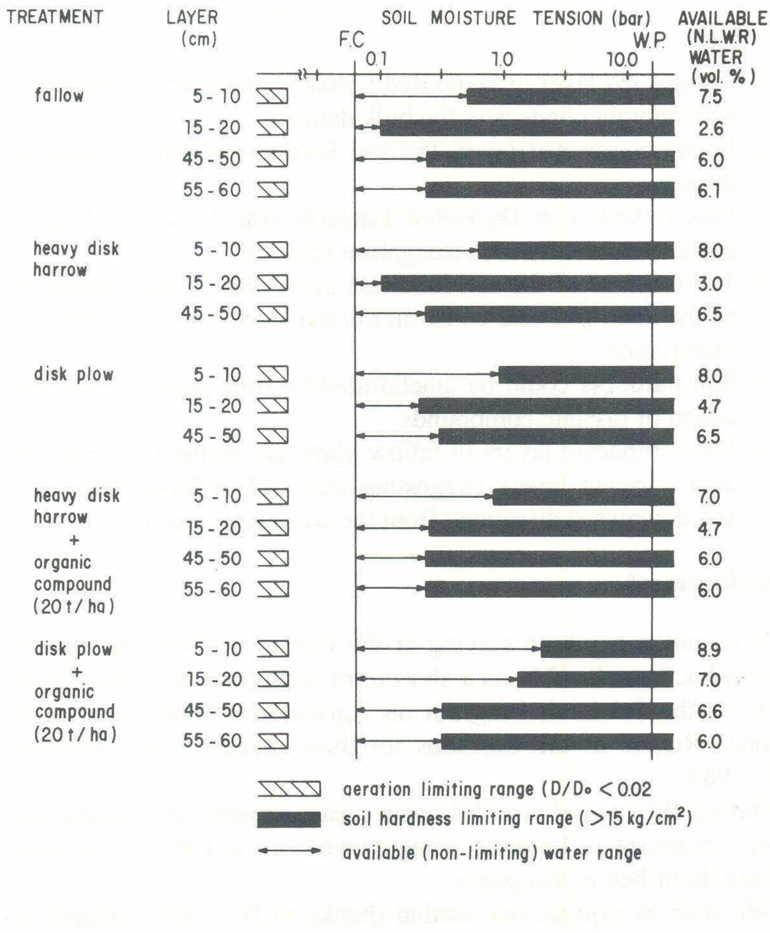

FIG. 5 - Available water ranges in Dark-Red Latosols.

Concerning the mechanism of soil compaction, the moisture conditions of the soil have been found to be an important factor in addition to the seasonal changes in the soil moisture content. In the Latosols, since the cohesion of the soil particles significantly increases during the drying process, soil hardness increases. In the Cerrados, soil wet and dry conditions alternate several times throughout the year. The increase of soil hardness under drying process either in the dry season or during the dry spells in the rainy season could be the most important factor involved in soil compaction, suggesting changes on the hydration degree at the mineralogical level.

Conclusions

1. Compacted layer in Dark-Red Latosols seemed to be formed without concomitant changes in the bulk density.
2. In the compacted layer, the soil hardness markedly increased with drying.
3. Gas diffusion in Dark-Red Latosols was fairly good and did not appear to resctrict root elongation into soil.
4. The increase of the soil hardness under the drying process seems to be the main physical constraint in the Dark-Red Latosols in the Cerrado region.
5. Soil hardness could be ameliorated by disk plowing with the application of organic compounds.
6. The compacted layers in fallow plots had higher CO_2 concentrations than adjacent layers suggesting that CO_2 diffused both in upward and downward directions from the compacted layer.

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During this period, we did some measurements on ongoing soil compaction experiment in Latosols being carried out at CPAC. The results obtained are described in this paper.

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References

ADAMOLI, J.; MACEDO, J.; AZEVEDO, L.G.; NETO, J.M. **Caracterização da região dos Cerrados**. In: GOEDERT, W.J., ed. Solos dos Cerrados: estratégias. (Planaltina): EMBRAPA-Centro de Pesquisa Agropecuária dos Cerrados São Paulo: Nobel, 1986. p.33-74.

BOONE, F.R.; VEEN, B.W. The influence of mechanical resistance and phosphate supply on morphology and function of maize roots. **Neth. J.Agric.Sci.**, v. 30, p.179-192, 1982.

GRADWELL, M.W. Soil physical conditions of winter and the growth of ryegrass plants. I. Effects of compaction and puddling. New Zeland **Journal of Agricultural Research**, v. 8, p.238-269, 1965.

LETEY: adv. in soil Sci., 1.

OSOZAWA, S.; KUBOTA, T. A simple method to determine gas diffusion coefficient in soils. **Japan Journal Soil Science Plant Nutrition**, v. 58, p.528-535, 1987.

OSOZAWA, S. Measurement of soil-gas diffusion coefficient for soil diagnosis. **Soil Physical Conditions and Plant Growth of Japan**, v. 55, p.53-60, 1987.

SHIERLAW, J.; ALSTON, A.M. Effect of soil compaction on root growth and uptake of phosphorus. **Plant and Soil**, v. 77, p.15-28, 1984.

SOANE, B.D.; BLACKWELL, P.S.; DICKSON, J.W.; PAINTER, D.J. Compaction by agricultural vehicles: A review I. Soil and wheel characteristics. **Soil & Tillage Research**, v. 1, p.207-237, 1980-81.

STEPNIEWSKI, W. Oxygen diffusion and strength as related to soil compaction. 2. Oxygen diffusion coefficient. **Pol. J. Soil Sci.**, v. 14, p.3-13, 1981.