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SHORT-TERM EFFECTS OF DIFFERENT TILLAGE PRACTICES ON SOIL PENETRATION RESISTANCE IN A TROPICAL SOIL

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ABSTRACT

Despite the increase of non-tillage systems in Brazilian agriculture, tillage systems are still largely using in Brazilian farms as well as around the world. These type of systems uses mechanical tools (implements) to turn over the soil, that process impact diverse soil properties as bulk density, pores distribution etc. The aim of this research is to determine the effects of different soil tillage practices on soil penetration resistance in a short-term period. The experiment compared four tillage methods (no-till, NT; conventional tillage, CT; reduced tillage, RT and minimum tillage, MT). Soil penetration resistance (Pr) were measured four months after set the plots in each 0.05 m until 0.3 m of depth. There were significant differences between treatments. Although, this difference was not significant in some soil layers. Overall, inmost soil layers, tillage practice affected Pr in the order: RT < CT < MT < NT. Regardless of the observation period, results shown that soils under RT and CT treatments usually resulted in lower Pr.

KEYWORDS: Soil physics; Soil compaction; Soil management.

EFEITOS A CURTO PRAZO NA RESISTÊNCIA A PENETRAÇÃO DO SOLO SOB DIFERENTES TIPOS DE PREPARO PERIÓDICO EM UM SOLO TRÓPICAL

RESUMO

Apesar do aumento de sistemas de plantio direto na agricultura brasileira, o preparo periodio do solo ainda é amplamente utilizados nas fazendas brasileiras, bem como em todo o mundo. Este tipo de sistema utiliza ferramentas mecânicas (implementos) para revolver o solo, impactando diversas propriedades do solo como densidade aparente, distribuição de poros etc. O objetivo desta pesquisa é determinar os efeitos de diferentes práticas de preparo do solo na resistência do solo à penetração em um curto periodo de tempo. O experimento comparou quatro métodos de preparo (sem revolvimento, NT; preparo convencional, CT; preparo reduzido, RT e preparo mínimo, MT). A resistência do solo à penetração (Pr) foi medida quatro meses após o assentamento das parcelas, a cada 0,05 m até 0,3 m de profundidade. Houveram diferenças significativas entre os tratamentos. Porém, essa diferença não foi significativa em algumas camadas do solo. No geral, nas camadas mais internas do solo, a prática de preparo do solo afetou Pr na ordem: RT < CT < MT < NT. Independentemente do período de observação, os resultados mostraram que os solos sob os tratamentos RT e CT geralmente resultaram em menor Pr.

PALAVRAS-CHAVE: Física do solo; Compactação do solo; Manejo do solo.

1. INTRODUCTION

The world agriculture is based on soil, almost 95% of food production is dependent of that resource as habitat for plant growth (FAO, 2020). The modern agriculture is constantly improving its practices worldwide, seeking for a more sustainable model to produce food and energy.

There are several soil management systems used in farmlands and its uses is determined due to different factors as plant species, environment (temperature, rainfall, soil type) and culture. Overall, there are two different approaches in these systems: conservative (zero, minimum/reduced till) and conventional (tillage) (WEIL & BRADY, 2017).

The main objective of tillage is to improve soil characteristics to build a "seedbed" for sowing, allowing seed germination and plant growth as well. Others tillage aims are: weed control, incorporate fertilizers and limestone, soil diseases control and increase soil temperature (BALASTREIRE, 1987; FURLANI *et al*, 2005).

During last decades soil researchers find out correlation between soil degradation and tillage practices, at a long-term period soil property as aggregation, water hold capacity, penetration resistance, bulk density and others get degraded due to tillage. In Brazil nearly 45% of its agricultural is under non-till systems, although, conventional and minimum tillage together represents the 55% left (IBGE, 2017).

Initiate a no-till farming system need satisfy some requisites as there is no compaction layers ("hardpan") in soil because after started it cannot be disturbing by implement. Thus, in particular cases, tillage is not only reliable but needed to give an adequate starting to the system (CAVALCANTI et al., 2019). Hence, it requires the uses of compaction control tools as subsoilers or deep plowing (> 0.25 m) which are needed prior to set the system.

The aim of this research is to determine the effects of different soil tillage practices on soil penetration resistance in a short-term period. Our hypothesis was that different tillage methods affect that soil physical property in different levels. Therefore, it can carry us to understand whether there are or not a better method to improve that properties to enable a well starting to non-till systems and soil recovery in tropical soils.

2. MATERIAL AND METHODS

This study was conducted at Machinery Research Field of the Agricultural Engineering Department (DENA-UFC), Fortaleza, Ceará, Brazil (3°44'47.16"S, 38°34'52.20" W). The climate is Aw' according to the Köppen climate classification (KOPPEN & GEINGER, 1923). A rainy tropical climate, very hot with a predominance of rains in the summer and autumn and an average temperature in all months above 18 ºC, it is situated at 23 m above sea level.

The soil of experimental site was a sandy-loamy, classified as Argissolo Vermelho-Amarelo by Brazilian System of Soil Classification (EMBRAPA, 2018). The area was under a continuous machinery experimental field, that provides a high-level compaction to the soil due to heavy machine traffic and successive plowing during the year, it had caused compaction into a layer of the soil (0.20 - 0.30 m). For more site descriptions see Cavalcante (2017).

The experiment was set up in four randomized blocks with repetitions laid in the blocks (i.e. 4 repetitions by treatment), each treatment plots of 5 m width and 20 m length (i.e. 100 m² and 16 experimental plots) that were arranged parallel to the slope to cover heterogeneity in soil surface. The four soil tillage methods (treatments) were:

- No-till (NT): Prior to the setting of experimental plots, the area was no-disturbed for 5 months.
- Reduced till (RT): Subsoiling with a 5-shank subsoiler (0.70 m shank length) mounted on a front wheel assist tractor (83 kW), with a working depth of 0.35 – 0.40 m and after disking with a 28-disc harrow (0.50 m disc diameter) working to a depth of 0.15 m.
- Minimum till (MT): Subsoiling as in RT.
- Conventional till (CT): Plowing with a disc plow (0.9 m disc diameter) working to a depth of 0.3 m and after as in RT.

Penetration resistance were measured on field with a Stolf impact penetrometer (STOLF, 1991) at same depths but in each 0.05 m. These samples were collected four months after the treatments were set on the experimental plots.

The data were subjected to analysis of variance (ANOVA), the software R version 3.6.0 (R-CRAB=N, 2019) were used to running tests and create graphics. Treatment means were separated by Tukey Test at 5% level of significance ($p < 0.05$).

3. RESULTS AND DISCUSSION

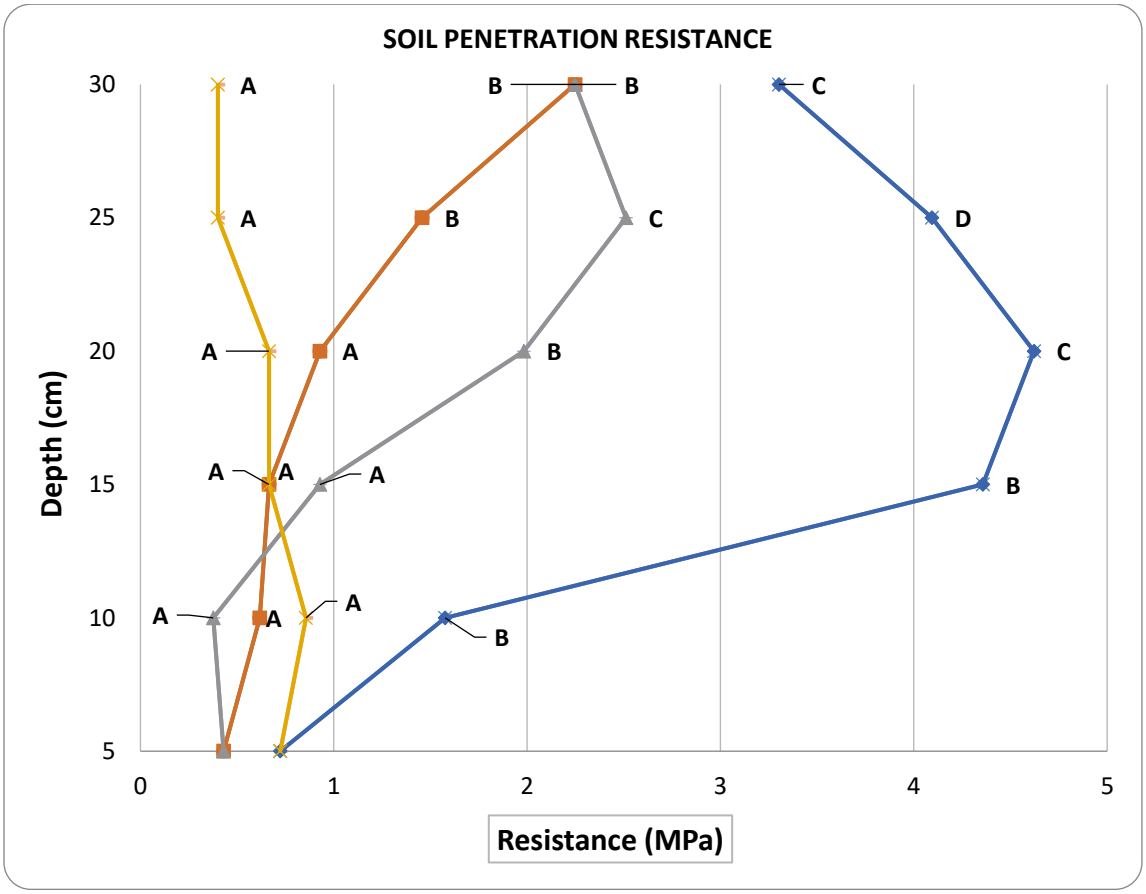
At 0-5 cm layer there was no statistical difference, similar results were found in other studies that used this methodology (ALAOUI; DISERENS, 2018). Possible reasons for that result is due to the weather conditions that the layer is exposed as the impact of rain droplets and wind erosion, which result in successive changes in the structure, hiding the effects of the treatments.

At 5-10 cm and 10-15 cm layers, was observe that only the control treatment (NT) differed from the others. A possible explanation for this phenomenon can be attributed to the level of turning that the implements used in such a layer, the active organs of both harrows and plows in more superficial layers (0-15 cm) perform the soil turning in an analogous way (CASTELLINI; VENTRELLA, 2012).

The 15-20 cm layer shows a difference in the PR of the treatments NT and CT with the others. We can see that the 20-25 cm layer was where all treatments differed, this layer, together with the previous one, is the most affected by the compaction in the area,

In the last layer (25-30 cm), the same average of treatments CT and RT was observed, while treatments NT and MT differed from the last two. The last two layers above 20 cm in depth are the layers where the treatments using the subsoiler carried out the effective work.

Figure 1 – Soil penetration resistance in the 0-30 cm layer under the different treatments



Blue line = NT; Grey line = CT; Orange Line = MT and Yellow line = RT. Same letters in the same depth does not differ by the test of Tukey ($p < 0.05$).

Generally, values of Pr above 2 MPa causes negative impact to roots development, reducing plant root uptake, thereafter impact negatively crops yield (JABRO *et al.*, 2020). Treatments NT, CT and MT reach that value in some layers.

The different types of soil disturbance caused by shanks and discs can explain the results, while the discs cutting and turning the soil, shank forces apply to soil result in shear fractures to the compaction layers (ROSA, 2007).

4. CONCLUSION

- The application of treatments RT and CT shown most effective to solve the problem of compaction in the area.
- The only treatment that do not exceed the value of 2 MPa at any layer was RT.

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