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REGRESSÃO QUADRÁTICA PARA TEORES DE ÁGUA EM FUNÇÃO DA COMPACTAÇÃO DO SOLO

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1 RESUMO

O trabalho teve por objetivo avaliar a influência do teor de água na avaliação de resistência mecânica a penetração do solo, medida através do índice de cone. O experimento foi realizado na UNESP/FCA, Botucatu-SP, sendo selecionadas duas classes de solo: o Nitossolo Vermelho distroférrico e o Latossolo Vermelho. Utilizou-se o delineamento inteiramente casualizado, com os seguintes tratamentos de compactação: T0 = 0; T1 = 1; T2 = 2; T3 = 3; T4=5 e T5 = 10 passadas consecutivas de um trator agrícola. Utilizou-se um penetrômetro hidráulico-eletrônico para a amostragem da resistência mecânica do solo à penetração nas camadas de: 0,00 - 0,10; 0,10 - 0,20; 0,20 - 0,30; 0,30 - 0,40 m em quatro condições de teor de água. Com o aumento do tráfego, maior foi a compactação. Porém para o solo argiloso, a partir de uma passada do trator, os valores de resistência à penetração tiveram pouco aumento, não diferindo estatisticamente para a camada mais superficial (0-0,20 m) e para a camada de 0,20-0,40 m a partir de duas passadas. Para o solo de textura média, este comportamento foi observado a partir de uma passada para a camada mais superficial (0-0,20 m) e de cinco passadas para a camada de 0,20-0,40m.

Palavras-chave: resistência do solo, umidade, agregação.

FERNANDES, B. B.; MARASCA, I.; MARTINS, M. B.; SANDI, J.; LANÇAS, K. P. QUADRACTIC REGRESSION FOR WATER CONTENTS IN THE FUNCTION OF SOIL COMPACTION

2 ABSTRACT

The objective of this work was to evaluate the influence of water content in the evaluation of mechanical resistance to soil penetration, measured through the cone index. The experiment was conducted at UNESP/FCA, Botucatu - SP, being selected two classes of soil: a Nitossolo Vermelho distroférrico and a Latosolo Vermelho. A completely randomized design was used,

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with the following compaction treatments: T0 = 0; T1 = 1; T2 = 2; T3 = 3; T4 = 5 and T5 = 10 consecutive passes of an agricultural tractor. A hydraulic-electronic penetrometer was used to sample the mechanical resistance of the soil to penetrate the layers; 0.00 – 0.10; 0.10 - 0.20; 0.20 - 0.30; 0.30 - 0.40 m in four water content conditions. With the increase in traffic, greater was the compression. However, for the clayey soil, from a tractor pass, the penetration resistance values had a small increase, not differing statistically for the most superficial layer (0 - 0.20m) and for the 0.20 - 0.40 m layer from two passes. For medium textured soil, this behavior was observed from one pass to the most superficial layer (0 - 0.20 m) and five passes to the 0.20 - 0.40 m layer.

Keywords: soil resistance; moisture; aggregation.

3 INTRODUCTION

The increase in the size and load of agricultural machinery, associated with the reduced time for carrying out agricultural activities, has led farmers to carry out agricultural activities without respecting ideal soil moisture conditions, resulting in soil compaction (TREIN et al. 2009).

Soil compaction due to inadequate management can result in soil erosion, which is considered one of the main causes of environmental degradation (TRETIN et al., 2018).

Rossetti and Centurion (2017) noted that the type of soil also directly influences its susceptibility to compaction, resulting in the conclusion that the Dystrophic Red Latosol is more susceptible to compaction than the Eutroferric Red Latosol, regardless of the pressures exerted by the tractors studied, due to the low values of critical compaction moisture.

Thus, given that compaction occurs with greater or lesser severity in areas managed with the aid of mechanization, it is interesting to use methods that can identify the presence of compacted soil layers and their depth. Soil resistance to penetration, measured via a penetrometer, is capable of quantifying the opposing force exerted by the soil as a function of the penetration of a conical and standardized metal tip that seeks to simulate the resistance that the soil offers to root penetration (MOLIN et al., 2012; LIMA et al., 2013). However, when this type of equipment is used, caution is necessary because, according to Ferrari et al. (2018), soil moisture influences the resistance of the surface layers of the soil.

Water in soil plays a prominent role as a lubricant, facilitating the rearrangement of soil particles when forces are applied to them, aiding in compaction. However, repeated cycles of soil contraction and expansion caused by water, combined with the absence of external forces, can gradually decrease the soil density and thus reverse the compaction process, restoring the structure of compacted soils (GUBIANI et al., 2015).

Torres et al. (2015) did not observe soil compaction at the surface but found compacted areas with rates above 2 MPa at depths between 0.30 and 0.40 m in all the treatments evaluated. This type of scenario is undesirable for farmers, as soil decompression at greater depths presents high operational costs due to the high energy demand (CORTEZ, 2013).

This work aimed to evaluate the influence of water content on the evaluation of mechanical resistance to soil penetration, as measured through the cone index.

4 MATERIALS AND METHODS

The experiment was carried out in two areas, the first being called “Soil 1” and the second as “Soil 2” at the Lageado

Experimental Farm, belonging to São Paulo State University “Júlio de Mesquita Filho”, Faculty of Agricultural Sciences, located in the municipality of Botucatu, in the state of São Paulo.

Soil 1 was classified as a dystroferric Red Nitosol (NVd) with a clayey texture and 50% clay content, and Soil 2 was classified, according to the Soil Classification of the Brazilian Agricultural Research Corporation (EMBRAPA, 2013), as a Red Latosol (LV), with a medium texture, a clay content between 15 and 35%, and a high degree of weathering, according to the criteria of the Brazilian Soil Classification System of Embrapa (2013). Both soils remained fallow during the two years prior to the experiment.

The experimental design was completely randomized, with compaction treatments performed after soil preparation in 150 m² (5x30 m) plots when the soil water content was close to field capacity (2 days after rainfall). The treatments were constituted according to traffic intensity: T0 = control (no tractor traffic); T1 = 1; T2 = 2; T3 = 3; T4 = 5; and T5 = 10 consecutive tractor passes in unidirectional movement at the same location.

In the first penetration resistance assessment, the soil had a water content of 23.5%, the second had a water content of 17.07%, the third had a water content of 21.53%, and the fourth had a water content of 19.14%.

Resistant (RP) samples were collected via a hydraulic-electronic penetrometer according to the American Society of Agricultural and Biological Engineers (ASABE, 2012) and mounted on the Mobile Soil Sampling Unit (UMAS), which was developed by NEMPA - Agricultural Machinery and Tire Testing Center according to the methodology described by Lanças and Santos Filho (1998).

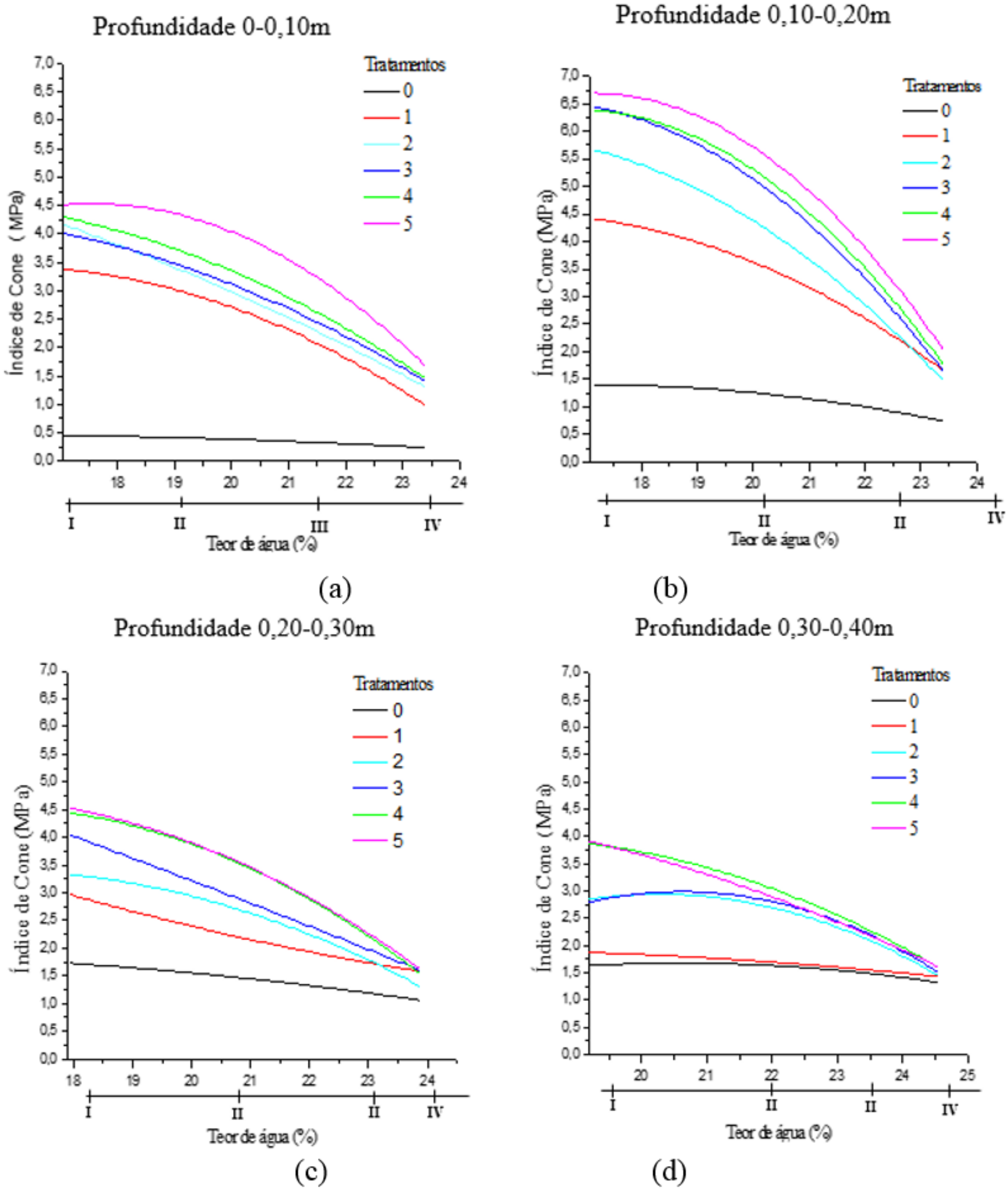
The two areas (clayey soil and medium-textured soil) were analyzed according to the soil water content at different sampling depths (0.00 - 0.10; 0.10 - 0.20; 0.20 - 0.30; 0.30 - 0.40 m) (EMBRAPA, 1997).

The data were tabulated and subjected to analysis of variance via the statistical program "MINITAB", version 16.0 (MINITAB®, 2010). In analysis of variance, Minitab separates the sequential sums of squares into different components that describe the variation due to different sources. The sequential sum of squares for the model is the difference between the total sum of squares and the error sum of squares. It is the sum of all the sums of squares for terms in the proposed models.

5 RESULTS AND DISCUSSION

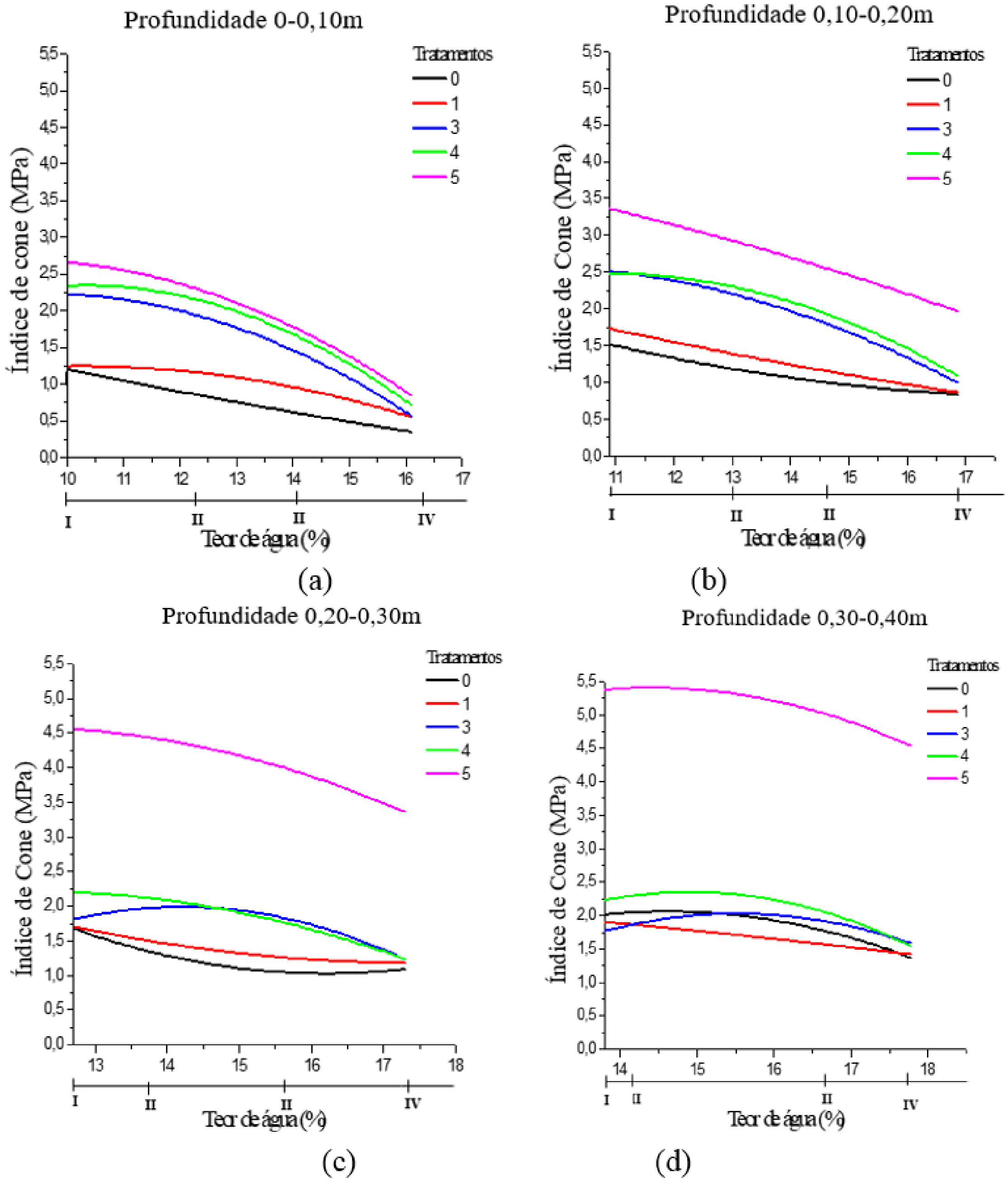
Regressions were performed to evaluate the behavior of the IC (cone index) as a function of the variation in the soil water content. The second-order polynomial fits of the soil water content (%) and IC (MPa) as a function of the number of tractor passes at depths of 0–0.10, 0.10–0.20, 0.20–0.30 and 0.30–0.40 m are represented in Figures 1 (Soil 1) and 2 (Soil 2).

Figure 1. Quadratic regression of the different IC × water content samples for the depths of 0–0.10 (a), 0.10–0.20 (b), 0.20–0.30 (c) and 0.30–0.40 (d) m for Soil 1.



The numbers I, II, III and IV refer to the different IC samples.

Figure 2. Quadratic regression of the different IC × water content samples for depths of 0–0.10 (a), 0.10–0.20 (b), 0.20–0.30 (c) and 0.30–0.40 (d) m in Soil 2.



The numbers I, II, III and IV refer to the different IC samples (2017).

The regression equations represented the variation in penetration resistance as a function of the soil water content for the different treatments and depths and are presented in Tables 1 (Soil 1) and 2 (Soil 2).

Table 1. Estimated functions by treatment at depths of 0–0.10, 0.10–0.20, 0.20–0.30 and 0.30–0.40 m for Soil 1

Layers (m)	Treatment	Function	R^2 (%)
0-0.10	0	IC: -0.31237 +0.10264U -0.00338U²	47.95
	1	IC: -7.83477 + 1.41251U -0.04427U²	87.39
	2	IC: 6.05424 +0.13735U -0.01456U²	78.15
	3	IC: -1.27879 +0.8367U -0.03086U²	68.8
	4	IC: -2.83348 +1.04844U -0.03698U²	75.87
	5	IC: -21.44113 + 2.95688U -0.08415U²	69.45
0.10-0.20	0	IC: -3.09329 + 0.53316U -0.01579U²	45.81
	1	IC: -7.33028 + 1.50836U -0.04805U²	78.33
	2	IC: -8.31406 + 1.90357U -0.06347U²	76.89
	3	IC: -16.80766 + 2.91349U -0.09083U²	87.19
	4	IC: -23.41032 +3.55154U -0.1058U²	83.42
	5	IC: -27.75573 + 4.02649U -0.11766U²	86.78
0.20-0.30	0	IC: 0.69422 + 0.18565U -0.00714U²	45.76
	1	IC: 11.7922 -0.68711U + 0.01086U²	58.76
	2	IC: -7.09111 +1.2726U -0.03856U²	57.04
	3	IC: 10.113 - 0.28405U -0.00304U²	80
	4	IC: -10.57885 + 1.83247U -0.05549U²	73.31
	5	IC: -7.17661 +1.5091U -0.04777U²	68.08
0.30-0.40	0	IC: -7.95871 +0.93538U -0.02271U²	10.48
	1	IC: -0.13233 +0.25096U -0.00763U²	20.97
	2	IC: -30.39873 +3.29243U -0.08129U²	43.00
	3	IC: -37.75024 +3.95219U -0.09586U²	55.5
	4	IC: -11.92302 +1.79815U -0.05083U²	56.53
	5	IC: -0.07385 + 0.70751U -0.02605U²	67.67

Table 2. Estimated functions by treatment at depths of 0–0.10, 0.10–0.20, 0.20–0.30 and 0.30–0.40 m for Soil 2

Layer (m)	Treatment	Function	R^2 (%)
0-0.10	0	IC: $3.1255 – 0.22392U + 0.00318U^2$	57.05
	1	IC: $-0.87411 + 0.41141U – 0.02004U^2$	65.75
	3	IC: $-1.31098 + 0.74005U – 0.03868U^2$	74.13
	4	IC: $-2.92306 + 1.01514U – 0.04897U^2$	83.9
	5	IC: $-0.36856 + 0.67382U – 0.03712U^2$	66.34
0.10-0.20	0	IC: $4.84987 – 0.43034U + 0.0114U^2$	48.75
	1	IC: $4.17342 – 0.27445U + 0.00464U^2$	52.25
	3	IC: $0.14057 + 0.52184U – 0.02792U^2$	68.75
	4	IC: $-2.0846 + 0.83809 – 0.03851U^2$	67.02
	5	IC: $4.64767 – 0.0436U – 0.00682U^2$	56.63
0.20-0.30	0	IC: $15.09738 –1.73656U + 0.05356U^2$	33.83
	1	IC: $8.19907 – 0.80126U + 0.02284U^2$	13.07
	3	IC: $-13.8382 + 2.22566U – 0.07828U^2$	54.49
	4	IC: $-3.06975 + 0.87126U – 0.03597U^2$	70.29
	5	IC: $-1.22382 + 0.9774U – 0.04118U^2$	23.5
0.30-0.40	0	IC: $-12.58147 + 2.00116U –$	23.06
	1	IC: $2.84025 – 0.02626U – 0.00303U^2$	4.69
	3	IC: $-18.73504 +2.67272U – 0.08604U^2$	14.47
	4	IC: $-19.40942 +2.91656U – 0.09775U^2$	51.7
	5	IC: $-10.16914 +2.1611U – 0.07501U^2$	27.12

When the different depths were analyzed, the variation in penetration resistance values was noted as a function of the variation in the soil water content. These results corroborate those reported by Assis et al. (2009).

When the different depths were analyzed, the intensity of the penetration resistance varied depending on the variation in the soil water content. These results are similar to those reported by Pereira et al. (2002), who reported higher soil penetration resistance values when the soil had a lower water content, which tended to decrease linearly with increasing water content.

There is a need to reformulate the ASABE (2009) EP542 standard because the negative correlation between the water content and the IC (cone index) affects the soil compaction values.

This study made it possible to understand the relationship between changes in IC as a function of the soil water content. A specific behavior was observed in this relationship. Therefore, there is the possibility of developing models for this behavior for different conditions and soil types. This approach allows standardizing the water content in soil penetration-resistant samples. Thus, real values of root development impediment in the soil can be estimated.

6 CONCLUSIONS

As traffic increased, soil compaction increased, and the water content decreased. However, for clayey soil, the penetration resistance values increased slightly after one tractor passed, with no significant difference for the most superficial layer (0–0.20 m) or the 0.20–0.40 m layer after two passes, regardless of the water content analyzed. For medium-textured soil, this occurred after one pass for the most superficial layer (0–

0.20 m) and after five passes for the 0.20–0.40 m layer.

Soils with high water contents have increased soil plasticity, reducing compaction.

Controlled traffic is an alternative to ensure that the compaction recorded with multiple passes is in a single space.

The highest values of soil penetration resistance were observed when the water content in the soil was lower, which tended to decrease linearly with increasing water content.

The values found in the experiment presented different behaviors from those obtained from the ASABE (2009) EP542 standard, since, owing to the negative correlation of water content and IC, this modified the soil compaction values.

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