SOIL COMPACTION AND THE EFFECTS ON INITIAL CORN GROWTH

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ABSTRACT: Soil compaction determines, in a way, the relationships between air, water and temperature, which influence practically all stages of plant development. In this sense, the aim of this work was to evaluate the effect of different soil compaction levels on initial corn growth. The experiment was carried out in the experimental area of the Aurora Seedling Production Unit (UPMA), belonging to the University of Afro-Brazilian Lusophony International Integration (UNILAB), municipality of Redenção, Ceará. The experimental design used was completely randomized blocks, with five treatments (0, 25, 50, 75 and 100% soil compaction) and five replicates, totaling 25 experimental units. These experimental units were represented by 17 cm polypropylene pots with volume of 6.5 dm^3. At 40 days after sowing (DAS), plant height in centimeters (AP), number of leaves (NF), stem diameter (DC), shoot dry matter (MSPA) and root dry matter (MSR) were evaluated. Results were submitted to analysis of variance and regression test at 5% probability using the ASSISTAT version 7.7 beta software. The results confirmed that shoot development, plant root growth, number of leaves and shoot and root dry matter are affected by soil compaction.

KEYWORDS: *Zea mays*; Soil density; Resistance to penetration

A COMPACTAÇÃO DO SOLO E OS EFEITOS NO CRESCIMENTO INICIAL DO MILHO

RESUMO: A compactação do solo determina, de certa maneira, as relações entre ar, água e temperatura, e estas influenciam praticamente em todas as fases do desenvolvimento vegetal. Nesse sentido, o objetivo do trabalho foi avaliar o efeito de diferentes níveis de compactação no crescimento inicial do milho. O experimento foi realizado na área experimental da Unidade de Produção de Mudas Auroras (UPMA), pertencente Universidade da Integração Internacional da Lusofonia Afro-Brasileira (UNILAB), Redenção, Ceará. O delineamento experimental utilizado foi o de blocos inteiramente casualizado, com cinco tratamentos (0, 25, 50, 75 e 100% de compactação) e cinco repetições totalizando 25 unidades experimentais. Essas unidades experimentais foram representadas por vasos de polipropileno com 17 cm de altura e volume de 6,5 dm^3. Aos 40 dias após semeadura (DAS) avaliou-se altura de plantas em centímetros (AP), O número de folhas (NF), o diâmetro do colmo (DC), a matéria da parte aérea. (MSPA) e a massa seca das raízes (MSR). Os resultados obtidos foram submetidos à análise de variância e teste de regressão a 5% de probabilidade pelo programa ASSISTAT versão 7.7 beta. Os resultados corroboraram que o desenvolvimento da parte aérea, crescimento das raízes das plantas, número de folhas e matéria seca da parte área e das raízes do milho são prejudicados pela compactação do solo.

PALAVRAS CHAVES: *Zea mays;* Densidade do solo; Resistência para penetração

INTRODUCTION

Moisture, temperature and soil aeration are among the primary factors related to soil for germination; however, these factors are directly influenced by the state of soil compaction around the seed (Modolo et al., 2011). As compaction is a serious problem for agricultural soils, its study is intense, as well as the search for measures that allow the comparison between different soils (Almeida et al., 2008).

Soil compaction can be defined as an increase in soil density caused by humans or animals, resulting from the arrangement of soil particles (Reichert et al., 2010). The optimum water content for soil compaction would be the range of soil friability, and under this condition of soil water content, agricultural mechanization operations are carried out. According to (Silva et al., 2010), this finding is worrying because this could be one of the causes for the increase in the physical degradation of many agricultural soils.

Due to the influence of compaction on the morphological characteristics of plants, studies are carried out to guide the management and prevent productivity losses in agricultural crops. Currently, it is known that the magnitude of problems caused by soil compaction depends on the type of soil, species used and compaction level (Rodrigues et al., 2011).

In corn (*Zea mays* L.) crops in compacted Red Latosol (Oxisol), for example, the diameter is increased and the length of roots is reduced, which become tortuous (Bergamin et al., 2010), reducing the volume of soil explored for obtaining water and nutrients, and consequently, productivity (Freddi et al., 2009a).

Given the above, the aim of this work was to evaluate the effect of different soil compaction levels on initial corn growth.

MATERIAL AND METHODS

The experiment was carried out in the experimental area of the Aurora Seedling Production Unit (UPMA), belonging to the University of Afro-Brazilian Lusophony International Integration (UNILAB), municipality of Redenção, Ceará. The experiment was conducted from January to March 2019. The soil used was a Dystrophic Red Yellow Latosol (EMBRAPA, 2013), which chemical characteristics are presented in Table 1.

Table 1. Chemical soil characteristics in the experimental area.

Depth	pH*	OM	N	H + Al	Al^{3+}	Ca^{2+}	Mg^{2+}	K^+	Na^+	CEC	P**	V
(cm)	---		gkg^1	----------------------$cmol_c$ kg^{-1}	-------------------------						$mgkg^1$	%
0.00-0.20	6.6	4.03	0.24	0.33	0.00	2.50	0.30	0.06	0.57	3.76	21	91

*pH in water; OM= Organic Matter; CEC= Cation exchange capacity; V = Percentage of base saturation and **Mehlich^{-1}

The experimental design used was completely randomized, with five treatments (0, 25, 50, 75 and 100% soil compaction) and five replicates, totaling 25 experimental units. These experimental units were represented by 17 cm polypropylene pots with volume of 6.5 dm³. In the first treatment (0%), pots were filled with soil without any compaction.

The other treatments were compacted with density of 1.4 kg dm^{-3}, and treatments (25%, 50% and 75%) were compacted, respectively, 25, 50 and 75% of their volume at the base (1.4) of pots. In the 100% treatment, the pot volume was completely compacted.

Soil samples that had natural apparent density of 1.0 kg dm^{-3} were collected in the 0-20 cm soil layer. Then, they passed through 4 mm mesh sieve and air dried, adding 13% of weight in water in order to facilitate the compaction process, which had the aid of a wooden mallet so that it reached the desired density.

Corn planting followed crop recommendations for cultivation in pots, five seeds per pot with three centimeters in depth, thinning was carried out at 15 DAS leaving only the most vigorous plant per pot. At 40 DAS, plant height (AP) was evaluated with the aid of a graduated ruler. Stem diameter (DC) was measured with the aid of digital caliper. The number of leaves (NF) was determined by counting them.

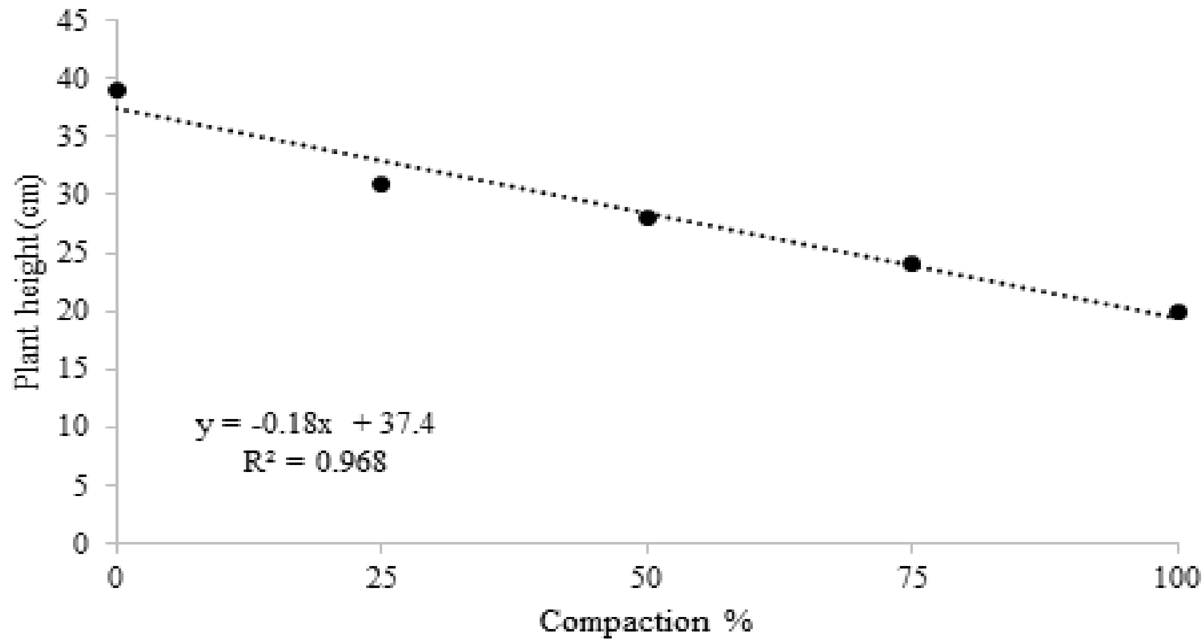
Shoot matter was evaluated according to methodology of (Oliveira et al., 2015); the corn plant was cut close to the ground and the material was placed in an oven at 65 ºC for 72 h to determine the shoot dry matter (DMPA), by weighing.

Pots were disassembled and roots were collected and separated from the soil by washing in running water and dried on paper towels. Roots were dried in an oven at 65 ºC for 72 h and the root dry matter (DMR) production was determined. Results were submitted to analysis of variance and regression test at 5% probability by the ASSISTAT 7.7 beta software.

RESULTS AND DISCUSSION

Plant height (Figure 1) showed linear behavior, decreasing with higher compaction values. In treatment with 100% compaction, value was 20.0 cm. This factor may be related to the poor development of the root system, which resulted in reduced water and nutrient absorption.

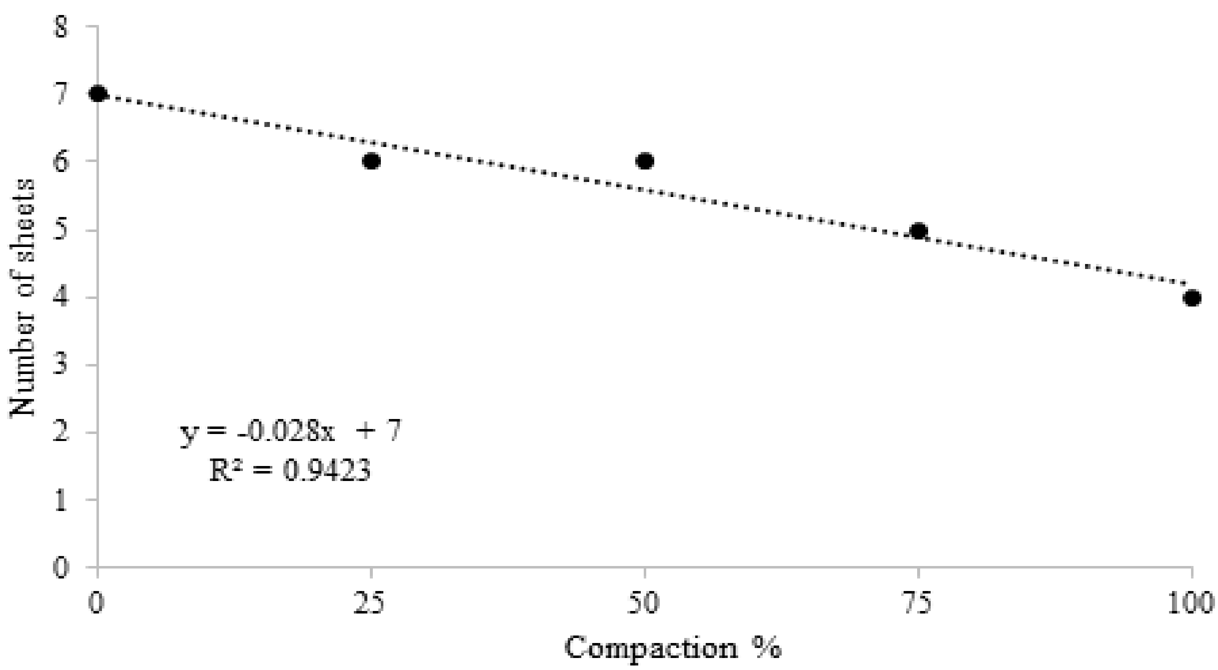
Figure 1. Height of corn seedlings under the effects of different compaction depths, Redenção/CE, 2020.



In terms of plant height (Guimarães et al., 2013), there was reduction in millet cultivars with increasing soil density due to the fact that in compacted soils, plants do not adequately absorb nutrients and water, which impairs the development of new roots. (Piffer et al., 2010) found in a study with millet cv. ‘BN2’, reduction in plant height with increase in soil compaction of 73% between densities of 1.21 and 1.51 Mg m^{-3}, results that corroborate those obtained in the present study.

The number of leaves (Figure 2) presented a linear behavior, with lower values in more compacted soils. The plant’s root and shoot development suffers from compaction, which ultimately reduces porosity and soil aeration, affecting plant shoot and, finally, the number of leaves.

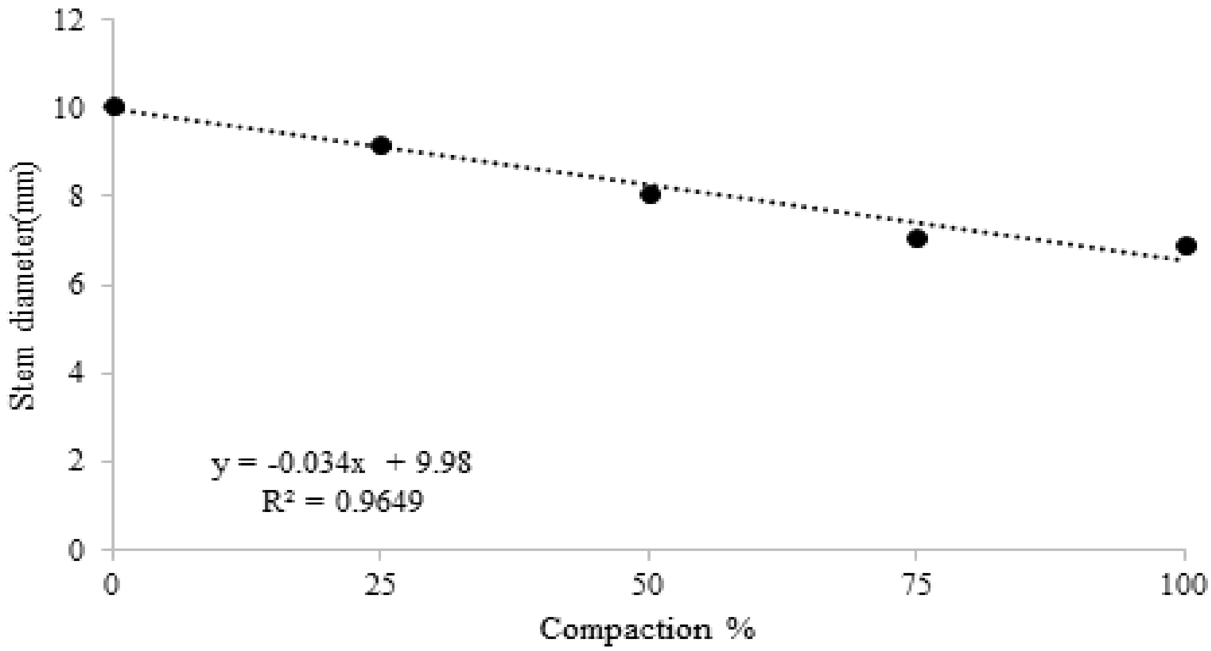
Figure 2. Number of leaves of corn seedlings under the effect of different compaction depths, Redenção/CE, 2020.



In similar results for jatropha curcas, (Ohland et al., 2014) observed that with increasing soil density, the number of leaves was affected. (Medeiros et al., 2005) worked with rice crop and observed a linear reduction in the number of tillers with increasing compaction levels, justified by the reduction in soil aeration and organic matter mineralization.

For stem diameter (Figure 3), results showed a linear behavior, with lower values in more compacted soils. This result may be linked to the formation of this compacted layer, which promoted increase in penetration resistance, leading to lower occupation of soil roots, and consequently smaller plants. The smaller stem diameter can lead to plant lodging, especially in regions with strong winds.

Figure 3. Stem diameter of corn plants under the effect of different compaction depths, Redenção/CE, 2020.



With similar conditions, (Farias et al., 2013) worked with pigeon pea testing different potted soil densities and observed that the stem diameter also had a slight decrease among treatments with increasing density. (Rosa et al., 2019), working with linseed with different soil densities, verified that the stem diameter also decreases as density increases.

For shoot dry matter (Figure 4), compaction level of 100% resulted in lower shoot dry matter accumulation (Figure 3), with 4.2 g, which is lower than value presented in treatment without compaction.

This result is similar to that obtained by (Bonelli et al., 2011), who observed reduction in MSPA whenever soil density increased in mombaça grasses. These results corroborate those obtained by (Foloni et al., 2006), who concluded that the MSPA of black mucuna and lablab forages showed reduction in production as a function of the increase in soil compaction with adjustment to a linear regression model.

Root dry matter values (Figure 5) showed linear behavior. Soil compaction reduces MSR. Thus, it appears that the compacted layer can affect root development, resulting in increase in the shoot/root ratio.

The decrease in the volume of macropores and micropores, limiting infiltration and soil water redistribution, reducing gas exchange and oxygen availability, limit growth. The reduction in dry matter production affects the economic potential of the crop, considering that this variable is correlated with productivity (Freddi et al., 2009b).

The increase in compaction resulted in lower plant development. These results indicate the negative effect of soil compaction on plant growth. Thus, during initial corn growth, shoot growth, number of leaves, root and shoot dry matter are equally affected by soil compaction at levels from 25% to 100%.

Figure 4. Shoot dry matter of corn plants under the effect of different compaction depths, Redenção/CE, 2020.

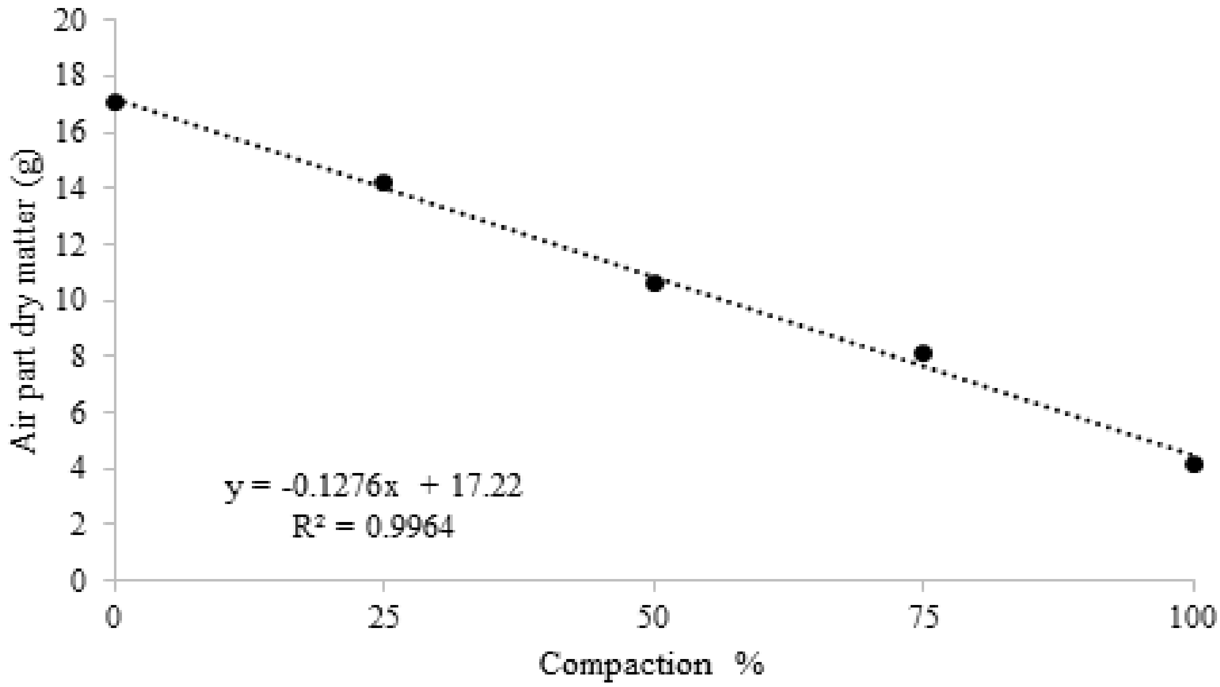
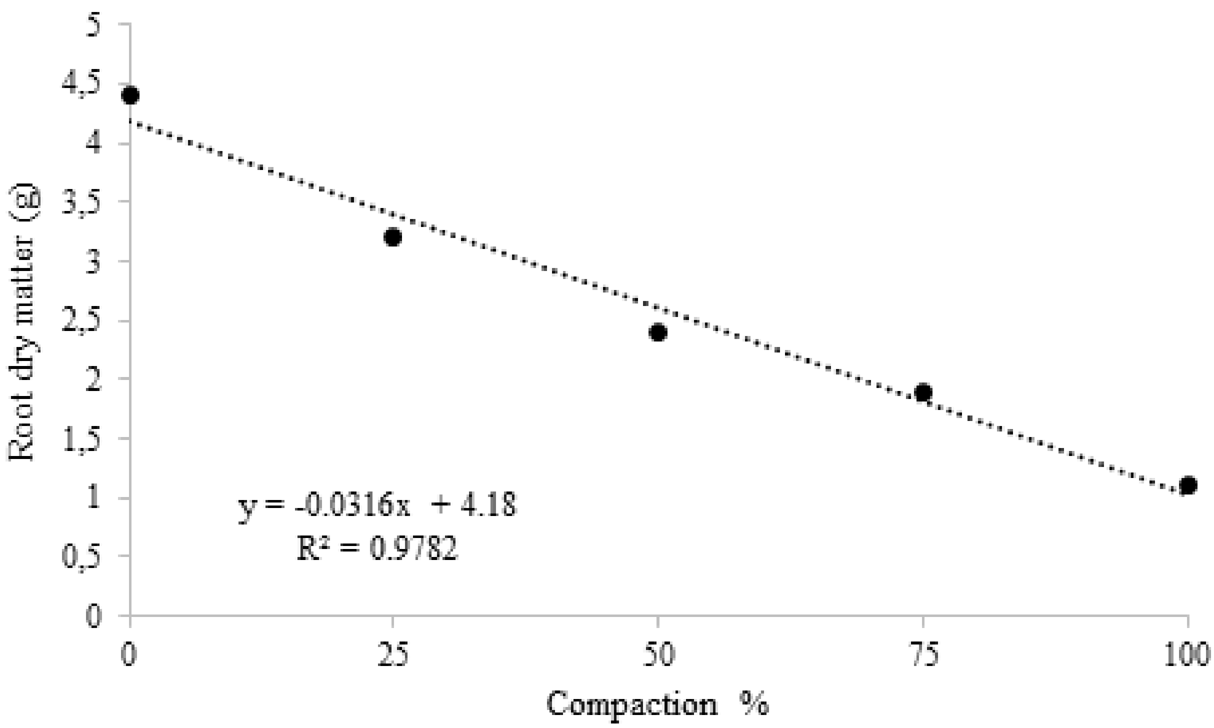


Figure 5. Root dry matter of corn plants under the effect of different compaction depths, Redenção/CE, 2020.



REFERENCES

Almeida, C. X.; Centurion, J. F.; Freddi, O. S.; Jorge, R. F.; Barbosa, J. C. Funções de pedotransferência para a curva de resistência do solo à penetração. *Revista Brasileira de Ciência do Solo*, **2008**, 32, 2235-2243

Bergamin, A.C.; Vitorino, A.C.T.; Franchini, J.C.; Souza, C.M.A.; Souza, F.R. Compactaçãoem um Latossolo Vermelho distroférrico e suas relações com o crescimento radicular do milho. *Revista Brasileira de Ciência do Solo*, **2010**, 34,.681-691.

Bonelli, E. A., Bonfim-Silva, E. M., Cabral, C. E., Campos, J. J., Scaramuzza, W. L., & Polizel, A. C. Compactação do solo: Efeitos nas características produtivas e morfológicas dos capins Piatã e Mombaça. *Revista Brasileira de Engenharia Agrícola e Ambiental*, **2011**, 15, 264-269.

Farias, L. D. N., Bonfim-Silva, E. M., Pietro-Souza, W., Vilarinho, M. K., Da Silva, T. J., & Guimarães, S. L. Farias, Lorraine Do N. Características morfológicas e produtivas de feijão guandu anão cultivado em solo compactado. *Revista Brasileira de Engenharia Agrícola e Ambiental*, **2013**, 17, 497-503.

Foloni, J. S. S., Calonego, J. C., & Lima, S. L. D. Efeito da compactação do solo no desenvolvimento aéreo e radicular de cultivares de milho. *Pesquisa agropecuária brasileira*, **2003**, 38, 947-953.

Freddi, O.S, Centurion, J. F., Duarte, A. P., & Leonel, C. L. Da Silva. Compactação do solo e produção de cultivares de milho em Latossolo Vermelho. I-Características de planta, solo e índice S. *Revista Brasileira de Ciência do Solo*, **2009**, 33, 793-803.

Guimarães, C. V., De Assis, R. L., Simon, G. A., Pires, F. R., Ferreira, R. L., & Dos Santos, D. C. Desempenho de cultivares e híbridos de milheto em solo submetido a compactação. *Revista Brasileira de Engenharia Agricola e Ambiental,* **2013**, 17, 1189-1194.

Medeiros, R. D. D., Soares, A. A., & Guimarães, R. M. Compactação do solo e manejo da água. I: Efeitos sobre a absorção de N, P, K, massa seca de raízes e parte aérea de plantas de arroz. *Ciência e Agrotecnologia*, **2005**, 29, 940-947.

Modolo, A. J.; Trogello, E.; Nunes, A. L.; Silveira, J. C. M.; Kolling, E. M. Efeito da compactação do solo sobre a semente no desenvolvimento da cultura do feijão. *Acta Scientiarum Agronomy*, **2011**, 33, 89-95,

Oliveira, J. A. M., De Macedo, A. D. B., Raulino, J. L. C., Raulino, A. D. M. D., De Santana, R. A. C., & Campos, A. R. N. Determinação do teor de água de cactáceas pelos métodos padrão em estufa e micro-ondas. *Blucher Chemistry Proceedings*, **2015**, 3, 1027-1037.

Piffer, C. R., Benez, S. H., Bertolini, E. V., Cominetti, F. R., & Silva, P. R. A. Crescimento radicular de três espécies de cobertura vegetal em camadas de solo compactadas artificialmente. *Varia Scientia Agrárias,* **2010**, 1, 31-43.

Rodrigues, J. G. L.; Fernandes, J. C.; Nascimento, F. M.; Gamero, C. A.; Bicudo, S. J. Caracterização física do solo e desempenho operacional de máquinas agrícolas na implantação da cultura do sorgo forrageiro. *Semina: Ciências Agrárias*, **2011**, 32, 1813-1824

Rosa, H. A., Neto, S., Lavratti, M., & De Souza Pinto, J. Efeito da compactação do solo no desenvolvimento inicial da cultura da linhaça. *Revista Técnico-Científica*, **2019**, 1, 1-10.