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Effect of soil compaction on the initial development of corn

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***Abstract*— *Corn is one of the oldest crops of great economic and social importance, used in human and animal food and in various industries. In 2022/2023, world production was 1,155.6 million tons, with a forecast of 1,235.7 million for 2023/2024. Brazil, the third largest producer in the world, with around 130 million, is also the largest exporter. Corn productivity faces challenges such as soil compaction, especially in the cerrado, which reduces root growth and nutrient absorption, negatively impacting production. The research sought management practices to mitigate these effects, varying according to the type of soil, species and level of compaction. The research was carried out with the objective of evaluating the effect of soil compaction in the initial phase of corn cultivation. This is a descriptive, explanatory research, experimental and field study, carried out in Porto Nacional – TO, through four treatments and five replications, with soil subjected to different compactions (0, 50, 100 and 150kg) by hydraulic press. For compaction, a hydraulic press was used, subjected to weights of 50 kg for Treatment A, 100 kg for Treatment B and 150 kg for Treatment C and Treatment D test 0 kg, The TD treatment presented the highest average values for plant height (AP), shoot dry matter (MSPA) and mean root dry matter (RMS), reaching 40%, 17% and 4.2%, respectively, these results indicate that the Proper management of soil compaction conditions is essential to optimize plant development.*

I. INTRODUCTION

Probably originating in Mexico, the Southwest of the United States or Central America, corn is a crop of great commercial importance in the Americas. Considered one of the oldest crops in the world, it has enormous economic and social importance due to its diverse forms of use, ranging from human and animal food to high-tech industry (Duarte and Garcia, 2021).

Corn (Zea mays) stands out as one of the most nutritious foods and one of the agricultural crops most widely cultivated by man, providing an essential source of nutrients for both humans and animals. Furthermore, it is a rich source of carbohydrates, proteins, vitamins and minerals (Labegalini et al., 2016).

When correlating human consumption with animal consumption and, additionally, when considering the increased use of corn in industrial applications, the increase in its relevance within the scope of cereal production on a global scale is evident. It is a cereal of utmost importance in human nutrition (both as a grain and in the production of starch, cooking oil and others), in the production of alcohol, sweeteners, animal feed and others (Duarte and Garcia, 2021).

Due to its importance, corn is produced on a large scale, with a global production of 1,155.6 million tons for the 2022/2023 harvest and an estimated production of 1,235.7 million tons for the 2023/2024 harvest. representing an increase of 6.9% (USDA, 2023). Brazil is the third largest corn product in the world, with 11% of global production in the 2022/2023 harvest, behind only the United States and China. Furthermore, it is the largest corn exporter in the world (USDA, 2024).

Given its importance and high production, it is important to identify issues related to crop productivity. Barriers to the productive potential of corn have been observed, especially in cerrado areas, such as soil compaction (Azevedo, 2018).

In a compacted soil, there is a change in the total porosity of the soil, as well as in the balance between macro and micropores, which influences the space dedicated to the plant's root growth and the area of soil explored by the roots. Thus, their development is negatively affected due to the increased soil resistance to penetration, causing a reduction in crop productivity (Bergamin et al., 2010; Azevedo, 2018).

In corn (Zea mays L.) crops grown in compacted soil, an increase in root diameter is observed, while their length decreases, resulting in tortuous roots, resulting in a reduction in the volume of soil explored to capture water and nutrients, and, consequently, reduces productivity (Freddi et al., 2009; Bergamin et al., 2010).

Research is conducted to guide management practices and mitigate productivity losses in agricultural crops due to the influence of compaction on the morphological characteristics of plants. It is currently recognized that the extent of problems resulting from soil compaction varies according to the type of soil, cultivated species and level of compaction (Rodrigues et al., 2009).

II. OBJECTIVES

2.1. GENERAL OBJECTIVE

Assessment of the effect of soil compaction in the initial phase of corn cultivation.

2.2. SPECIFIC OBJECTIVES

• Identification of the consequences of soil compaction on the roots of corn plants;

• Identification of the consequences of soil compaction on corn plants, including stems and leaves;

• Verification of what level of compaction it is possible to obtain good results in the development of the corn plant.

III. THEORETICAL FRAMEWORK

3.1. CORN CULTURE

Corn, belonging to the Poaceae family (formerly known as the grass family), is classified as Zea mays L., and is a species that reproduces annually, growing during the summer, in a bushy and erect form, with a low tillering. It is classified as a monoecious-monocline plant and is categorized in the C-4 plant group (Pereira, 2021).

Studies indicate that corn has the ability to adapt to a variety of environmental conditions. However, the ideal conditions for growing this crop include temperatures between 24 and 30°C, exposure to high levels of solar radiation and adequate availability of water in the soil (Cruz et al., 2006).

Corn stands out as one of the most effective plants in nature in storing energy, due to its remarkable ability to accumulate photoassimilates (Baldo, 2007). From a seed weighing just over 0.3 g, a plant generally over 2.0 m tall emerges in approximately nine weeks. In the following months, this plant is capable of producing around 600 to 1,000 seeds similar to the one from which it originated (Aldrich et al., 1982).

Corn cultivation is of great economic and social importance. Economically, it stands out for the high nutritional value of grains, their wide application in human and animal nutrition, and as an essential raw material for various industries. Socially, it is valued for its low cost as a food, for its adaptability to different scales of agricultural properties and for being fundamental for several agro-industrial chains, including meat production (Azevedo, 2018).

It stands out as one of the most nutritious and globally cultivated foods, being crucial as a source of nutrients for humans and animals. Rich in carbohydrates, proteins, vitamins and minerals, its versatile applications in human and animal nutrition play an essential role in the socioeconomic context. Furthermore, corn is a fundamental raw material to drive several agro-industrial complexes (Dourado Neto; Fancelli, 2004).

There are three farming systems widely used in the production of corn and other food crops. The conventional system includes plowing, harrowing, sowing and subsequent cultivation. Minimum tillage or reduced tillage reduces the number of conventional soil disturbance operations. Finally, direct planting is characterized by minimal soil movement to ensure adequate plant germination and growth (Cruz et al., 2008).

3.2. CORN MORPHOLOGY

The high production and productivity of corn begins with dedicated soil care, followed by the crucial stage of sowing, the efficiency of which has a direct influence on the results. Choosing the appropriate machinery to carry out sowing is a determining factor in the success of the harvest (Pereira, 2021).

It is crucial to understand thermal needs throughout the corn growth cycle, from seeding to maturity, to predict developmental stages. Understanding the phenology of the crop is essential for planning the sowing time, choosing inputs such as fertilizers and pesticides, and deciding the ideal time for harvesting (Silva et al., 2006).

Corn is a plant with monoecious characteristics and distinct morphology, the result of the modification and multiplication of parts of the basic anatomy of grasses. Environmental factors influence their vegetative and reproductive development. Natural selection and domestication transformed corn into an annual, erect and robust plant, adapted for grain production at heights ranging from one to four meters (Embrapa, 2015).

Corn has a varied vegetative cycle, ranging from extremely early genotypes, with pollination occurring after 30 days of emergence, to those with vital cycles of up to 300 days. In Brazil, the corn cycle varies between 110 and 160 days, depending on the genotypes (super early, early and late), from sowing to physiological maturity (Fancelli, 2015).

The development of corn plants follows a variable pattern of time between stages and number of leaves, influenced by factors such as the hybrid, year, planting time and location. This process is divided into vegetative (V) and reproductive (R) stages. The vegetative stages are numbered from V1 to VN, where (n) is the last leaf emitted before bolting (VT). The first stage is emergence (VE), and the last is bolting (VT) (Embrapa, 2015).

Corn culture follows a cycle with 11 stages of development, as defined by Fancelli (1986). Before the emergence of tassels, the stages are determined by the number of fully developed leaves, considering a leaf as fully expanded when the "collar" is visible, except for the seminal leaf, which has a rounded end. After flowering, the stages are identified by the presence of reproductive structures and grain development (Fancelli, 2015).

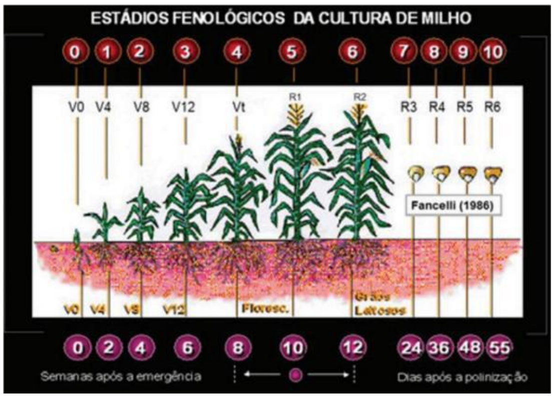

Fig. 1: Corn crop cycle: phenological stages of development. Source: Fancelli (1986).

In a more visual way, Procedi (2020) explains that the potentials of the corn plant are defined in accordance with Fig. 2.

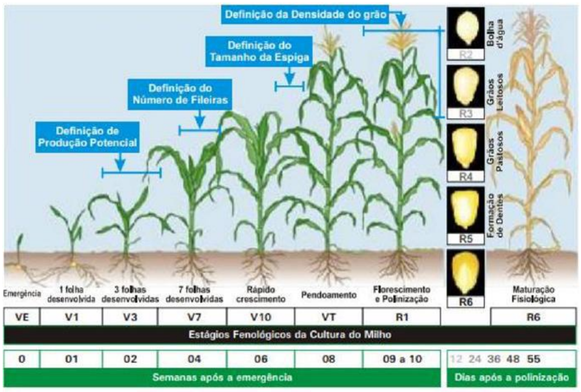

Fig. 2: Phenological stages of corn. Source: Procedi (2020).

Corn development follows distinct stages after sowing: seed germination, initial growth of roots until the VE stage (plant emergence), growth of nodal roots until V3 (formation of definitive roots and leaves), and growth until V8 (tassel formation). From stages V9 to V12, ears develop, with V15 being critical for yield, and V18 a week before flowering. VT marks pollination, followed by R1 (fertilization of ovules). R2 to R6 are for grain development, with starch accumulation and quality determination. R6 indicates physiological maturity, ideal for harvesting, influencing the destination in the consumption chain (Magalhães; Durães, 2021).

With regard to reproductive stages, Procedi (2020) points to 6 stages, from R1 to R6 (Fig. 3 and 4), where:

• Stage R1: refers to flowering;

• Stage R2: appearance of the milky grain, 10 to 14 days after flowering;

• Stage R3: appearance of the pasty grain, 18 to 22 days after flowering;

• Stage R4: appearance of the mealy grain, 24 to 28 days after flowering;

• Stage R5: mealy-hard grain, 35 to 42 days after flowering;

• Stage R6: physiological maturity, 55 to 65 days after flowering.

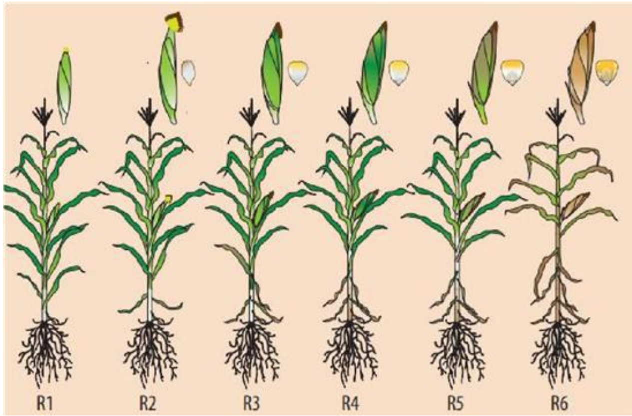

Fig. 3: Maize reproductive stages. Source: Procedi (2020).

Fig. 4: Primary spikes of the plant from R1 to R6, with and without embryo.

3.3. CORN PRODUCTION IN BRAZIL AND THE WORLD

Corn production in Brazil is marked by two harvests, which occur at different planting times. The first harvest, known as the Summer Harvest, begins planting between August and September, concluding its cycle in the months of January and February. The second crop, called Safrinha, is planted in the months of February and March, mainly in the states of the Southeast and Central-West regions, after the harvest of the soybean crop (Dutra, 2013).

Until the year 2000, corn production in Brazil was mainly aimed at meeting domestic demand. From 2001 onwards, this dynamic changed due to the reduction in domestic prices, leading Brazilian producers to explore more profitable opportunities in the foreign market through grain exports (Favro et al., 2015). This change was driven by the increase in consumption, especially due to the importance of corn as a crucial input for poultry and pig farming, sectors that contribute significantly to the country's revenues through exports (Pinazza, 2007).

Corn cultivation is widespread throughout all microregions of Brazil, often associated with the raising of poultry, pigs and cattle. The majority of production is destined for the commercial market and is not consumed directly on farms. Throughout the corn production chain, there are significant changes, from adaptations in agricultural systems to marketing processes, including price formation (Barros; Alves, 2015).

The possibilities for using corn are expanding beyond animal feed, which has historically been the main demand driving the growth of animal production sectors, with an estimated increase of more than 30% in the next 10 years. The industry is increasingly incorporating corn as a raw material in the manufacture of products such as lysine, biodegradable items, isoglucose, ethanol, among others (Barros; Alves, 2015).

Corn is a versatile resource with diverse applications. In addition to being essential in animal and human nutrition, it is a fundamental raw material for a wide range of industrial products, such as cornmeal, flour, glucose syrup, maltodextrins, dyes, corrugated cardboard, adhesives and ethanol. In the United States, it is a main source of bioenergy, while in Brazil, it stands out in the production of animal feed. This versatility and economic importance make corn an essential resource in several industries around the world (Sologuren, 2015).

According to data released in April/2024 by the United States Department of Agriculture (USDA), world corn production is expected to be 1,227.9 million tons for the 2023/2024 harvest, representing an increase of 6.1% compared to the 2022/2023 harvest, with 1,157.7 million tons. The three largest producers in the world are the United States, with 389.7 million tons, China with 288 million tons and Brazil in third place with around 130 million tons (USDA, 2024).

In the 2022/2023 harvest, the country produced 131.9 million tons of corn, representing an increase of 16.6% compared to the previous harvest (CONAB, 2023a). And although the largest grain producers in the country are Mato Grosso, Paraná and Goiás, what is observed is a considerable growth in the region known as MATOPIBA (Maranhão, Tocantins, Piauí and Bahia), both in the production of corn and soybeans. and cotton. This is a region with a growth of 92% in the last 10 years in grain cultivation (CONAB, 2023b).

3.4. SOIL MANAGEMENT FOR CORN CULTURE

Ensuring proper soil and water management is essential when establishing sustainable farming systems. When cultivating the soil, it is important to consider that it can suffer degradation in its physical, chemical and biological aspects, losing its original characteristics. The intensity of this process varies depending on management conditions and local characteristics (Viana et al., 2006).

In intensive cropping systems such as irrigated agriculture or double cropping, soil is often cultivated two or even three times a year, which increases the risk of degradation compared to traditional systems of a single annual crop. Operations such as machine traffic and soil preparation are often carried out in inadequate humidity conditions, leading to cumulative damage that accelerates soil degradation (Viana et al., 2006).

As mentioned by Azevedo (2018), the agricultural exploitation system has contributed to an accelerated process of soil degradation. This occurs due to the removal of native vegetation through intensive mechanization and inadequate management practices, resulting in changes in soil attributes.

Despite the increase in production and exports, corn cultivation, like Brazilian agriculture, faces limitations in its production chain, which undermines the sector's potential. Among these limitations are low average productivity, lack of diffusion of technology among producers, opacity in price formation in both the domestic and foreign markets, breaches of contracts, deficient infrastructure and logistical problems (Caldarelli; Bacchi, 2012).

Planning a production system must reconcile economic profitability, social demands for quantity and quality of products, and the preservation of natural resources. Considering environmental, economic, technical and social limitations, as well as legal and individual restrictions, is fundamental. Balancing conflicting interests, such as environmental conservation and maximizing production, is a crucial challenge. When developing management, it is essential to avoid degradation factors such as erosion, compaction and contamination, which can cause irreversible losses in production systems (Viana et al., 2006).

3.5. SOIL COMPACTION

According to the Soil Science Society of America (SSSA), compaction is the process in which soil grains are rearranged to reduce the void space between them, resulting in closer contact and, consequently, an increase in bulk density (SSSA, 2008).

Compaction refers to the densification and distortion of soil, resulting in reduced total porosity and air porosity (Gregory et al., 2015). This process changes the spatial arrangement, size and shape of soil clods, eventually decreasing the pore space in and around these clods and soil aggregates (Defossez; Richard, 2002).

Soil compaction occurs due to the action of mechanical forces caused by machinery traffic during sowing, cultural treatments, harvesting and transport, as well as by animal trampling in pasture areas, and also due to water percolation in the soil profile. The intensive use of areas for agricultural production, together with inadequate soil management practices, has led to the deterioration of soil structure, negatively affecting plant development and increasing soil vulnerability to degradation (Azevedo, 2018).

Soil compaction can be the result of both natural and anthropogenic practices. Natural causes include the formation of dense soil layers, soil properties inherited from rocks and minerals, the presence of a higher clay content, environmental variations such as wet and dry periods, soil shrinkage due to drying, trampling by animals and movement of soil. soil by air currents (Kirby, 2007).

On the other hand, anthropogenic or human-induced causes include the impact of wheels and tracks of agricultural machinery and soil management tools, the use of heavy machinery, intensive cultivation practices, implementation of injudicious soil management techniques, and manipulation soil under high humidity conditions (Shaheb et al., 2021).

There are two forms of compaction that are important in the study and management of soil: surface compaction and subsoil compaction. Surface compaction refers to the compression of layers close to the soil surface, generally caused by agricultural activities and human trampling. Subsoil compaction occurs in deeper layers, due to intense machine traffic and gravity on the moist soil. Both are fundamental to understanding soil degradation processes and are equally important for developing sustainable soil management practices (Shaheb et al., 2021).

According to Kirby (2007), the compaction of the surface soil is linked to the tensions exerted by the tire, track or animal hoof on the soil surface, while the compaction of the subsoil is associated with the excessive tensions induced by the vehicle load.

Subsoil compaction is widely recognized as a persistent problem that causes deterioration of soil physical properties. This deterioration has significant consequences for soil ecosystem functions and services. Such undesirable changes in soil structure have an additional negative effect on crop growth and development, as well as soil yield and productivity (Lamandé; Schjønning, 2018).

Compaction on the soil surface makes it difficult for plant roots to develop, which results in challenges in the absorption of water and nutrients, impairing gas exchange with the environment. This, in turn, can lead to a possible reduction in productivity. Essential factors for germination, such as soil humidity, temperature and aeration, are directly affected by the state of soil compaction around the seed (Modolo et al., 2011).

Soil susceptibility to compaction varies depending on its properties, such as water content and texture. The texture of the soil influences its response to external pressures, as it affects the friction between particles and the type of connection between them. In general, soils with larger particles tend to have lower compressibility and greater aggregation (Macedo et al., 2010).

Soils, especially those of medium and fine texture, are susceptible to compaction when they are at or near field capacity. This point is reached when the pore space around the soil particles is completely filled with water, acting as a lubricant between the soil aggregates. When heavy machinery applies pressure to soils at field capacity, aggregates undergo intense compaction (Bayer, 2021).

The resulting compacted soil has fewer large pores, a reduced pore volume, and a higher bulk density. This creates difficulties for the aeration of the roots of plants that grow in this environment. Additionally, water is retained rather than infiltrating through the soil profile. Soil compaction is a global problem that has been attributed to the increasing weight of agricultural machinery over the decades since the 1950s. This soil compaction causes soil degradation on a global scale (Bayer, 2021).

Soil compaction varies considerably between different agricultural fields. The main factors that influence soil compaction include soil texture, moisture levels, soil strength, type and weight of agricultural equipment, depth of tillage, tire type and inflation pressure. as well as the number of vehicle passes over the ground (Shaheb et al., 2021).

Soil compaction has a significant influence on the reduction and reorientation of pores, particularly affecting macroporosity, with agricultural machinery traffic being one of the main causes of this effect, which can persist for up to two years (Soracco et al., 2015). This modification in soil porosity often results in decreases in infiltration rate, water retention and availability, gas exchange and nutrient availability, as well as microbial activity, negatively impacting the growth and development of the root system (Freddi et al ., 2009; Miransari, 2013; Klein, 2014; Souza et al., 2018).

Soil compaction reduces drainage, aeration and productivity, compromising root growth and the ability of plants to recover from damage, increases surface runoff and erosion. In moist, clayey soils, compaction is more severe, especially when heavy machinery is used during planting and harvesting in high humidity conditions. Conventional tillage, such as moldboard or chisel plowing, often creates a compacted layer close to the soil surface (Kumar et al., 2019).

In addition to changes in soil structure, compaction also results in a decrease in pore space and an increase in soil strength. This, in turn, impairs root growth and reduces the rate of root elongation, negatively impacting the absorption of water and nutrients by crops (Sadras et al., 2016; Colombi; Keller, 2019).

Due to the impact of compaction on the morphological characteristics of plants, studies are conducted to guide management and prevent productivity losses in agricultural crops. Currently, it is understood that the severity of problems caused by soil compaction varies according to the type of soil, the species cultivated and the level of compaction (Rodrigues et al., 2009).

For example, in corn (Zea mays L.) crops in compacted Red Oxisol, an increase in the diameter and a decrease in the length of the roots is observed, which become tortuous, thus reducing the volume of soil explored to obtain water and nutrients, and consequently, productivity (Freddi et al., 2009; Bergamin et al., 2010).

The first paragraph under each heading or subheading should be flush left, and subsequent paragraphs should have a five-space indentation. A colon is inserted before an equation is presented, but there is no punctuation following the equation. All equations are numbered and referred to in the text solely by a number enclosed in a round bracket (i.e., (3) reads as "equation 3"). Ensure that any miscellaneous numbering system you use in your paper cannot be confused with a reference [4] or an equation (3) designation.

IV. METHODOLOGY

4.1. TYPE OF RESEARCH

The research is characterized as descriptive, explanatory, experimental and field study, with a qualitative-quantitative approach.

4.2. STUDY OBJECTIVE

The experimental study carried out in the city of Porto Nacional – TO, more specifically at ITPAC Porto, by planting a corn cultivar BRS 3042, a triple corn hybrid, in compacted soil, in the Agronomia greenhouse.

The city of Porto Nacional – TO is located approximately 64km from Palmas, capital of Tocantins. The municipality has an extensive area of 4,449.917 km² as shown in fig. 5 (Prefeitura de Porto Nacional – TO, 2018).

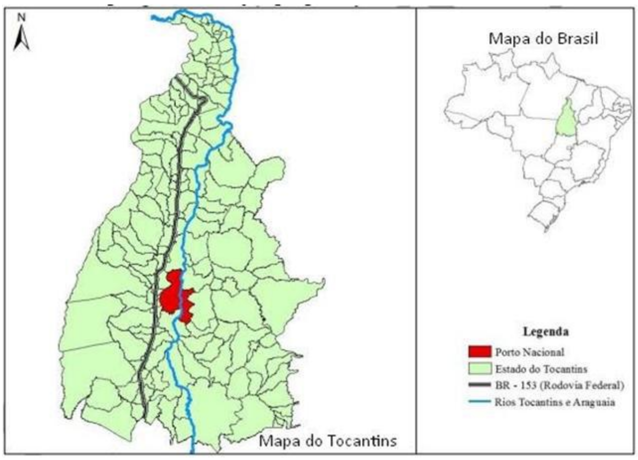

Fig. 5: Geographic location of Porto Nacional – TO, Source: Porto Nacional City Hall – TO (2018).

The study was carried out on the premises of the ITPAC Porto college, in a greenhouse. This is located as shown in Fig. 6.

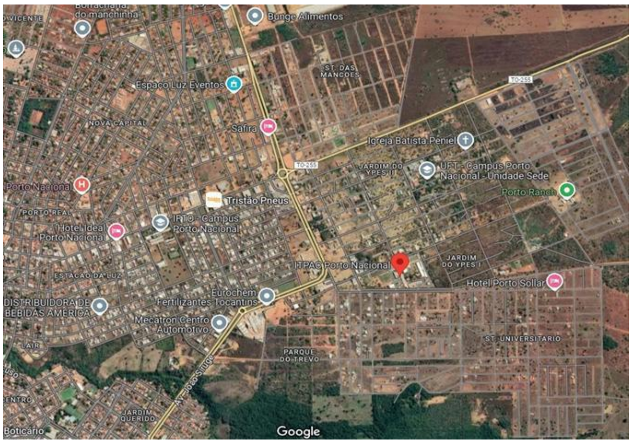

Fig. 6: Location of ITPAC Porto, Source: Google Maps (2023).

4.3. RESEARCH OPERATIONALIZATION

The experimental design used consisted of four treatments and five replications, totaling 20 experimental units. These units are represented by polypropylene pots, 21 cm wide (mouth), 18 cm wide (bottom) and 20 cm high, totaling 5.5 liters in total volume.

The soil used, found in the region, without any treatment, so as not to have any influence on the results. This was collected in samples in a layer 0-20cm deep, air-dried and passed through a sieve with a 2mm mesh.

The soil underwent chemical and physical characterization, in order to determine the following chemical parameters: pH in water, organic matter content, and exchangeable contents of Na+, K+, Ca2+, Mg2+, Al3+ and H+Al. And the following physical parameters: amount of sand, clay and silt, total porosity, textural class, soil density, particle density. All analyzes carried out according to the methodology proposed by Donagema et al. (2011), following the research of Carneiro et al. (2018).

The soil is inserted into 5.5 liter pots, with 13% of water added to facilitate the process. For compaction, a hydraulic press was used, subjected to weights of 50 kg for Treatment A, 100 kg for Treatment B and 150 kg for Treatment C, according to the study proposed and carried out by Azevedo (2018). For comparative purposes, Treatment D was used as a control, without compaction, obtained by filling the vessels without any pressing.

Five BRS 3042 corn seeds were sown per pot and five days after emergence (DAE) thinning was carried out, leaving only the two most vigorous plants in each pot.

The cultivated plants evaluated the humidity daily. At 15 and 30 days after planting (DAP), the following parameters were evaluated and verified: plant height (AP), stem diameter (DC), stem length (CC), number of leaves (NF).

The roots and aerial parts were separated, removing the plants from the soil and washing the roots in running water. Subsequently, evaluating the fresh mass of roots developed in the compacted layer (MFRC), fresh mass of roots developed without compaction (MFRSC), root volume (VR), in addition to evaluating the area mass by obtaining the fresh mass of the aerial part (MFPA). Also determined the absolute growth rate (TCA) and relative growth rate (TCR).

The set (roots and aerial part) were placed in a forced ventilation oven at 65ºC for 48 hours and from there the parameters were determined: dry mass of roots developed in the compacted layer (MSRC), dry mass of roots developed without compaction (MSRSC) and shoot dry mass (MSPA).

The data obtained are tabulated and subjected to analysis of variance and test of means using the Tukey test at 5% probability. A regression test was also carried out using the SISVAR program, considering the equations significant at 5% using the F test, using the highest coefficient of determination.

V. RESULTS AND DISCUSSIONS

The analysis of the treatments performed (Table 1) highlighted the superior performance of the TD treatment in relation to the others. The TD treatment presented the highest average values for plant height (AP), shoot dry matter (MSPA) and mean root dry matter (RMS), reaching 40%, 17% and 4.2%, respectively. These results show that, under the conditions tested, the TD treatment promoted a more favorable environment for plant development, overcoming the negative effects observed in other treatments with higher levels of compaction. The overall average of treatments also reflects the significant impact of compaction on the evaluated parameters.

Table. 1: Average test for plant height (AP) in centimeters, shoot dry matter (MSPA) in grams, root dry matter (RMS) in grams, under the effect of different percentages of soil compaction.

TREATMENTS	AP(cm)	MSPA(g)	RMS(g)
TA	29%a	11%a	3%a
TB	20%b	5%b	1,5%b
TC	10%c	2,5%c	0,5%c
TD	40%a	17%a	4,2%a
AVERAGE	20%	8,5%	2,1%

Means followed by the same letter do not differ statistically from each other using the Tukey test at the 5% probability level.

Plant height (Fig. 7) showed linear behavior, leading to increasing compaction values. In the treatment with 150% compaction, the value was 10.0 cm. This factor may be related to the poor development of the root system, which resulted in a reduction in water and nutrient absorption.

Plant height in treatments (50%, 100%, 150%) was reduced, respectively, when compared to the treatment without compaction (0%). Therefore, in the treatment with 150% compaction in relation to the treatments (50% and 100%), less plant development was observed in the culture.

Regarding plant height, Guimarães et al. (2013) observed that as soil density increases, the number of millet varieties decreases because in compacted soil plants are unable to absorb nutrients and water, thus affecting root development. Pifer et al. (2010) observed in a study with millet cv. When comparing densities of 1.21 and 1.51 Mg m3, the plant height of 'BN2' was reduced by 73%, corroborating the results obtained in this study.

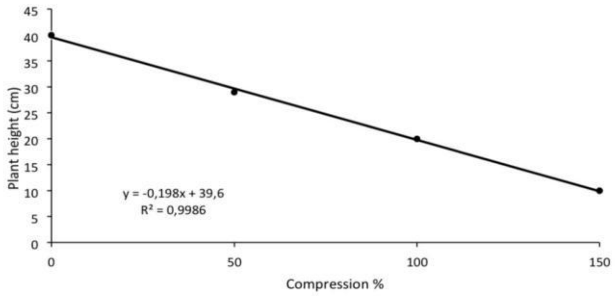

Fig. 7: Height of corn seedlings under the effect of different levels of soil compaction, Porto Nacional/TO, 2024.

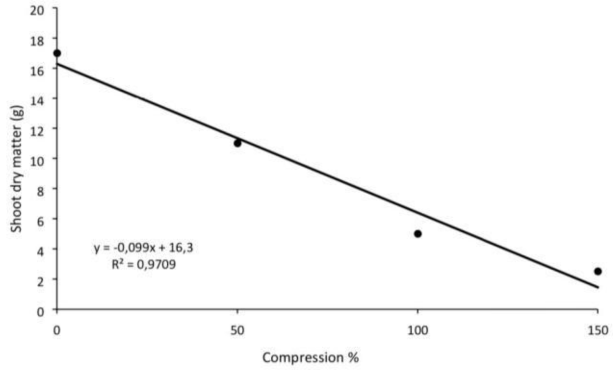

Fig. 8: Dry mass of the aerial part of corn plants under the effect of different levels of soil compaction, Porto Nacional/TO, 2024.

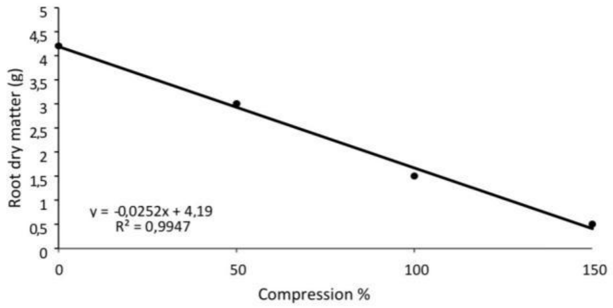

Fig. 9: Dry mass of roots of corn plants under the effect of different levels of soil compaction, Porto Nacional/TO, 2024.

For aerial dry matter (Fig. 8), the 150% compaction level resulted in a lower accumulation of dry matter above the ground, 2.5 g, a value lower than the value of the non-compacted treatment. This result is similar to that obtained by Bonelli et al. (2011), who observed a decrease in MSPA in mombaça grass with increasing soil density.

These results confirm those obtained by Foloni et al. (2006), who concluded that the MSPA of black Mucuna pruriens and jack beans decreased with increasing soil compaction, fitted a linear regression model.

Os valores de matéria seca da raiz (Fig. 9) são mostrados linear, indicando que a compactação do solo reduz a MSR. Portanto, a camada compactada parece afetar o desenvolvimento radicular, levando a um aumento na relação parte aérea/raiz.

The reduced volume of macropores and micropores limits the penetration and redistribution of water in the soil, reducing gas exchange and oxygen availability, thus limiting growth. Considering that this variable is related to productivity, the reduction in dry matter productivity affects the economic potential of the crop (Freddi et al., 2009).

Increased compaction results in reduced plant development. These results indicate the negative impact of soil compaction on plant growth. Therefore, during early corn growth, shoot growth, leaf number, and shoot and root dry matter are also affected by compaction levels of (50% to 150%).

VI. CONCLUSION

Based on the results obtained, it is concluded that the TD treatment, which was the control, presented superior performance in the evaluated parameters, showing greater plant height and greater accumulation of dry matter in the aerial part and roots, compared to the other treatments. These results indicate that adequate management of soil compaction conditions is essential to optimize plant development. On the other hand, treatments with higher levels of compaction significantly compromised plant growth and biomass, reinforcing the importance of agricultural practices that minimize the effects of compaction on the soil.

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