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Effect of the organic matter from crop residues on the structuration of an Oxisol, at semi-arid region

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Abstract

Crop residues can either be incorporated into the soil or left on the soil surface as a mulch producing soil organic matter in different quantities, having many potential benefits such as reducing soil compaction caused by passage of agricultural machines. The aim of this study is to evaluate the effect of crop residues such as maize and bean straw on the dynamic properties of a sandy soil incorporated in the laboratory condition. The experiment was carried out in laboratory. Air-dried maize (*Zea mays* L.) and cowpea (*Vigna Unguiculata* L. Walp) straw with an average size of 35 mm were incorporated into the soil in proportions of 2%, 4%, 6% and 8% in trays. Sample of each soil was collected to determine the organic matter after 120 days in wet conditions. An isolated design was carried out for each soil from maize and bean straw, consisting of two soil densities (1.2 and 1.4 g/cm3), 4 carbon contents and 4 water contents from tensions of 20, 40, 60 and 80 kPa (2x4x4) with 3 repetitions. The soil compression curves of the soil samples were determined adjusted in cylinders with 70 mm diameter and 24 mm in height using the oedometric test. The structural voids index as a function of applied pressure, as well as the soil compression index and pre-compression stresses as a function of water content and carbon content were evaluated using linear regression models with coefficient of determination at 95% confidence. The soil compression index showed a strong positive correlation with organic matter (carbon) derived from bean (r = 0.905) and maize straw (r = 0.787) at 95% confidence. The soil density was 1.2 g cm^{-3}, which was explained by a simple linear regression model.

Keywords: organic matter**,** soil compaction, pre-compression stress.

Abbreviations:

r_d	soil bulk density	g/cm^3
r_s	Soil particle density	g/cm^3
e	total void ratio	%
e_t	Textural void ratio	%
e_s	Structural void ratio	%
m2, m4, m6 and m8	Percentage of maize straw in the soil	2, 4, 6 and 8 g/100g
b2, b4, b6 and b8	Percentage of bean straw in the soil	2, 4, 6 and 8 g/100g
m16, m21, m26 and m31	Soil carbon quantity from respective maize straw percentages	g/kg
b18, b24, b29 and b34	Soil carbon quantity from respective bean straw percentages	g/kg
w	Water content	%

example: b18w7	Treatment whose soil with bean straw contains 18 g/kg of carbon and 7% of water content	
OC	Organic carbon	g/kg
Cc	Soil compression index	
Pc	Soil precompression stress	kPa

Introduction

The impact of soil water content on soil compaction is well-known. The control of agricultural machinery traffic for farmers in rainy season is concentrated in a short period of time because the producer has little time to perform all stages of the operating cycle on the agricultural production system. During this period, the soil water content cannot be controlled by the farmer because rainfall depends on natural factors such as weather conditions, relative humidity, and temperature.

Crop residues can either be incorporated into the soil (tillage) or left on the soil surface as a mulch (no-tillage) with both the systems producing soil organic matter with potential benefits in the presence of soil water content. This organic matter reduces compaction by the dynamic loads in the passage of agricultural machines. These benefits can be influenced by the farmer by providing crop residues in quantity and quality on the ground cover in function of the tillage system.

The positive effect of organic matter on the physical and dynamic soil conditions is undeniable, making the agricultural production system more productive. This beneficial influence of organic matter on soil physical conditions for plant growth is generally assumed due to its contribution on stability of aggregates (Zhang and Hartge, 1995).

Concerns about the soil compaction due to agricultural machinery traffic and increasing soil erosion by the abuse of soil resources accentuates the need for researches relating the effect of the organic matter on the soil structuration (Gupta et al., 1987, Soane 1990, Guérif 1990).

In the last 20 years, research on the machine-soil-plant system has given attention to the advancement of soil methods and conditions, where objective has been to reduce stress induced by agricultural vehicles and maintaining the porous structural state of soil. This allows a better transmission of water and air which is required for the plant growth.

Among the several factors affecting soil porosity and its dynamics, plants play a major role (Tommaso et al., 2009). They positively affect soil structure by shedding and exuding large amounts of organic matter and exert direct mechanical effects reinforcing the soil by their root systems (Greenway, 1987), thus stabilizing soil structure.

However, limited number of research has evaluated the changes in soil structure after addition of organic matter from plant straws left on the soil surface after harvest. Also, few studies have evaluated the change in organic matter in function of the quality and quantity of straw incorporated into the soil to understand beneficial changes in the structural porosity of agricultural soils. According to Kay and VandenBygaart (2002), these different forms of organic matter collectively represent a reservoir of nutrients that are critical to plant growth. Information on the rates of changes occurring over soil structure could allow for better management of the soils to obtain a more efficient control of soil compaction, improving the productivity of agricultural production systems. According to Kay and Vanden Bygaart (2002), different forms of organic matter stabilize pores of different size and; therefore, increase the persistence of these pores when soil is exposed to different stresses. Pore characteristics in turn influence the organic matter dynamics through their impact on the habitat of organisms (e.g., the balance between air- and water-filled pores, protection from predation and accessibility of substrates) that are involved in the decomposition of organic matter. Guerif (1990) found that soil aggregation could be related to the effect due to the interaction of agents such as organic matter and clay content. Khalid et al. (2019) conducted an experiment with maize and cowpea mulch incorporated into the soil with a hoe to evaluate the effect of these residues on soil properties, They found that bean straw produced higher total porosity than corn (49.28% against 47.95%). However, the difference was not significant. Reinforcing our hypothesis, some research has indicated that crop residue removal is correlated with structural soil degradation due to lower soil organic carbon formation (Blanco-Canqui and Lal, 2009, and Tormena et al., 2016) and low soil resistance to mechanical loading caused by wheelsets during the traffic on field (Braida et al., 2006), leading to the reduction of macroaggregates (Johnson et al., 2016) and consequently the decrease of soil macroporosity (Osborne et al., 2014).

The aim of this study is to evaluate the effect of residues from maize and bean straw incorporated on soil dynamic properties of a sandy soil in the laboratory.

Results and discussion

Soil organic matter

The particle density of the soil was 2.64 g cm^{-3} using both maize and bean straw. Figure 1 shows the development of organic matter as a function of the amount of maize and bean straw incorporated into the soil in the laboratory for mineralization during 120

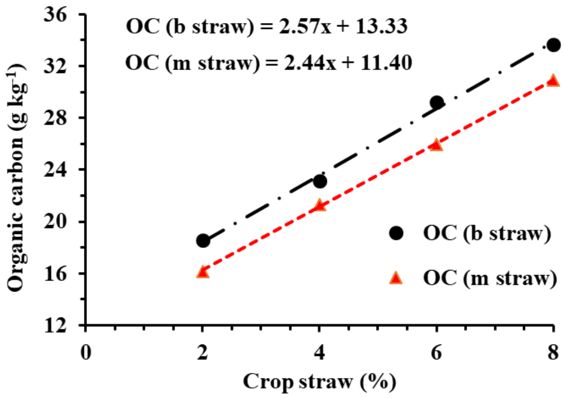


Fig 1. Soil organic carbon as a function of the amount of maize and bean straw incorporated into the soil

days. All compositions (maize-straw soil, bean-straw soil) increased the organic matter levels with the increase in the amount of incorporated straw. Bean straw produced an average increase of 11% in organic matter in relation to the organic matter produced by maize straw in all analyzed percentages, indicating a linear increase in organic matter with the increase of straw incorporation in the soil.

Soil structural voids ratio (e_s)

Figure 2 shows the structural voids ratio of the soil as a function of the vertical pressure applied to the soil with organic matter formed by the addition of maize straw and beans in four proportions in the soil densities of 1.2 g cm^{-3} and 1.4 g cm^{-3}. The effect of the organic matter formed by each crop was analyzed on the variation of the structural voids index, considering the same water content or very close levels. At the density of 1.2 g.cm^{-3}, the soil structural void ratio decreased with the amounts of organic matter of 18, 24 and 29 g/kg constituted by the bean straw with the water content of 7% and 8% (Figure 2A). The amount of organic matter of 34 g / kg obtained from the highest percentage of bean straw produced water retention greater than 8% in all tensions studied. For this reason, the water content of 10% was analyzed as being the closest. In this sense, it appears that the water content had a more important effect than the organic matter, reducing the structural voids ratio with increasing water content. In the same soil density, the results obtained with the carbon produced by maize straw revealed that there was an increase in the soil structural voids ratio when there was an increase in carbon from 16 to 21 g/kg and from 26 to 31 g/kg (Fig 2A on the right). Therefore, we verified that in the soil density of 1.2 g cm^{-3}, although the maize straw produced less carbon than the bean in all the incorporated amounts, but the results showed better effect on the reduction of the soil compaction (Fig 2A). We observed that increase of organic matter in the applied pressures may increase the soil structural voids, considering the same water content. For the analysis of this study, a greater increase in the structural voids index produces a beneficial effect in reducing soil compaction.

The soil compression test with a density of 1.4 g cm^{-3} (figure 2B) revealed greater increase on the soil structural void ratio with an organic carbon content of 31 g/kg from maize straw compared to the content of carbon of 34 g/kg produced by bean straw with a water content of 11% at vertical pressures up to 100 kPa.

The soil structural voids ratio in the soil with 29 g/kg of mineralized organic material from bean straw was higher than that produced with 24 g/kg (b29w8 > b24w8) at all applied pressures. Similar results of the structural voids ratio were revealed by compressing the soil with an organic matter content of 26 g/kg mineralized from maize straw compared to that of 21 g/kg (m26w8> m21w7, Figure 2B) in the applied pressures greater than 50 kPa with a water content of 8%. Therefore, differences among oedometric curves regarding the structural void ratio were more pronounced after mixing maize straw organic matter, when considering soil density from 1.2 and 1.4 g cm^{-3}. This particularly hapenes for the larger organic carbon contents, such as organic carbon from the maize straw providing a higher structural void ratio in the soil compared to that produced with the carbon from the bean straw at the same water content and applied pressure. With these results, it can be inferred that the carbon derived from maize straw has a greater potential for resistance to external forces, compared to that derived from bean straw under similar water content conditions. The explanation of this observation is that the maize straw residues have properties with very strong elastic characteristics that may have contributed to the formation of greater structural voids in the soil during the relaxation between an applied pressure and the following. During the sieving of the soil, residual particles smaller than 2.00 mm were observed that passed through the sieve meshes. This could have caused an additional effect to the organic matter linked to mineral constituents. Gupta et al. (1987) studied the incorporation of four percentages of corn residues in Solo Zimmerman Sand and found that the soil density decreased with the addition of residue at a given applied pressure. In other words, the voids ratio increases with the addition of maize residue, showing that the addition of maize residues in this soil slightly increased the slope of the virgin compression curve. Guerif and Faure (1979) studied the role of organic matter on the behavior of a soil compaction. They concluded separation of the specific role of the organic matter linked to the mineral phase from the free organic matter is vital.

Among the quantities of organic carbon produced by the residue of the same crop such as maize or bean

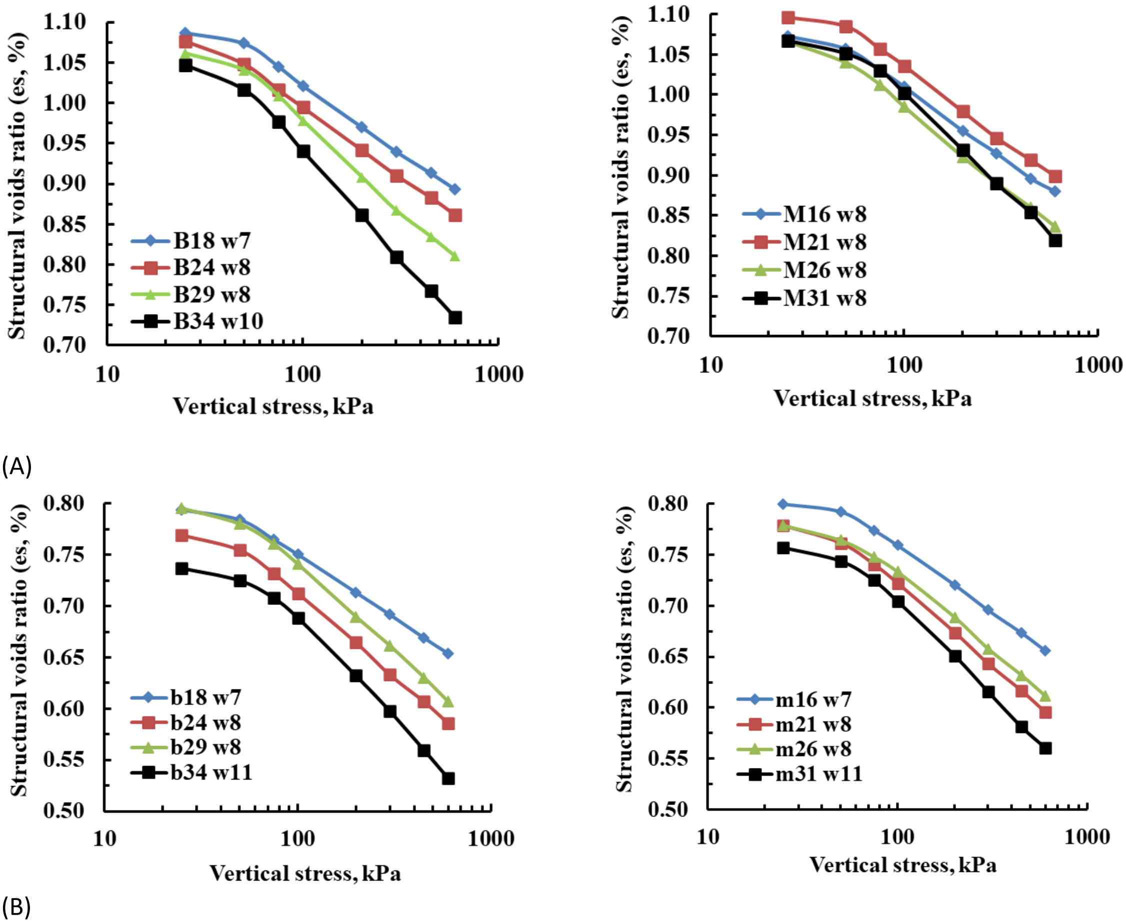
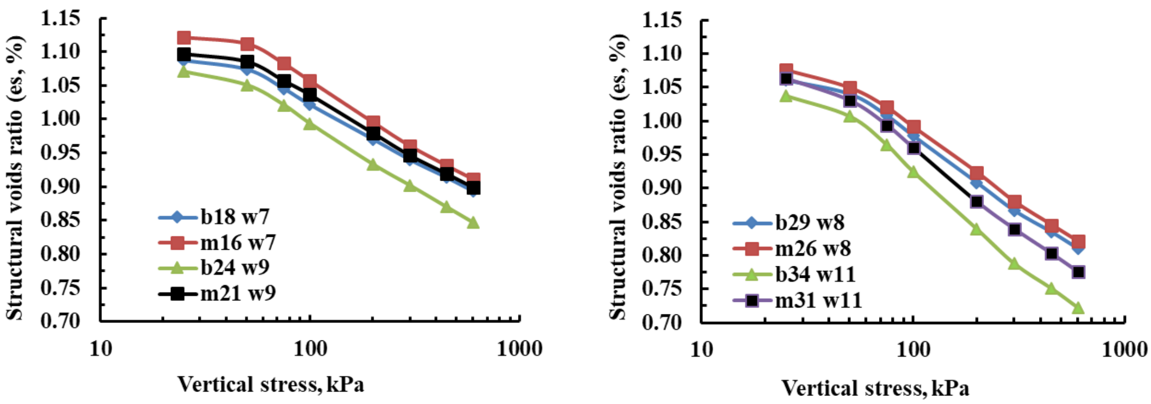


Fig 2. Structural void ratio curves as a function of applied vertical stress, in soil samples with variation of organic matter and water content, with A) density from 1.2 g/cm^3, B) density from 1.4 g/cm^3.

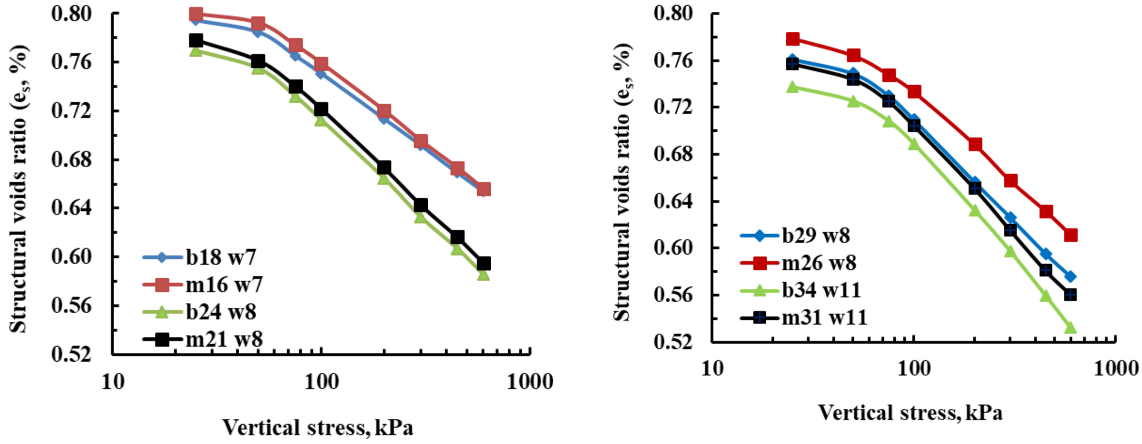
straw, there is a stronger effect among the percentages of the bean residue by the oedometric curves, mainly in the density of 1.4 g cm^{-3} (Figure 2B), evidenced by spacing among the curves. It is important to note that most of the work was developed to understand the effect of free organic matter (cultural residues in different quantities) on soil compaction in the laboratory. In our study, the effect of organic matter from maize and bean residues was linked to the mineral constituents of a sandy soil. The results showed a slight similarity with the works of Gupta et al. (1987) and Guerif and Faure (1979), but differed from those obtained by Khalid et al. (2019). However, they studied total porosity in a field experiment.

Figure 3 shows the comparison of the effect of organic carbon levels from maize and bean straw on the structural voids ratio at a given water content and pressure applied with soil samples at the soil densities of 1.2 g cm^{-3} (A) and 1.4 g cm^{-3} (B).

It can be seen that, in general, the organic carbon from maize straw provided a higher structural void ratio than bean straw in all water contents under study and all pressures applied both in the soil density of 1.2 g cm^{-3} as in the density of 1.4 g cm^{-3}. The differences were stronger between the curves **m21w9** and **b24w9**, and between **m31w11** and **b34w11**, with carbon from the maize and bean residues, respectively, at the soil density of 1.2 g cm^{-3} (Figure 3A, respectively left and right). A similar result was also obtained at the soil density of 1.4 g cm-3 between curves **m21w8** and **b24w8** and between **m31w11** and **b34w11** (Figure 3B, respectively, left and right). Note that, the structural void ratio increases as the curve moves to the right (**m31w11**, treatment whose soil with maize straw contains 31 g/kg of carbon and 11% of water content, same to **b34w11**, treatment whose soil with bean straw contains 34 g/kg of carbon and 11% of water content). Furthermore, the data has shown the potential of organic matter produced by corn residues in reducing soil compaction (increasing the structural void index), even considering that in this study, 1 g of maize straw the carbon production was, approximately, 12% less than in 1 g of bean straw as can be seen in Figure 1. The compression curves of the oedometric test with a soil density of 1.4 g cm^{-3} reveal that the differences in the increase in the structural voids index between maize and bean residues grew with the increase in organic carbon (Figure 3B right). The explanation for these results could be supported by the high C/N correlation available in maize residues considering that grasses are characterized by having a high C/N ratio in plant residues (Borkert et al., 2003) related to the higher content of recalcitrant



(A)



(B)

Fig 3. Structural void ratio curves as a function of applied vertical stress, in soil samples comparing the variation in the quantity of organic matter in the same water content with. A) density from 1.2 g/cm^3, B) density from 1.4 g/cm^3.

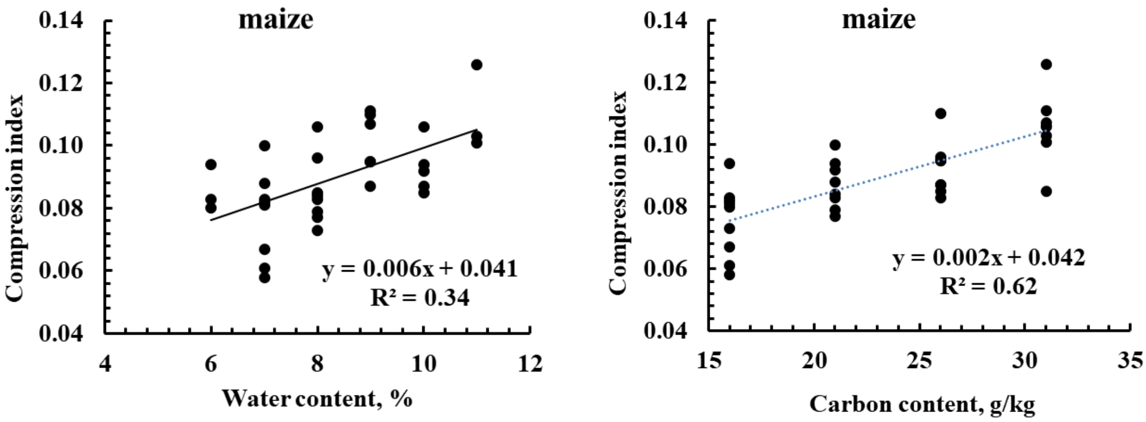
substances, such as cellulose and lignin in tissue structures since waste with a higher C/N ratio and less soluble molecules are more persistent in the soil (Barbosa et al., 2012). This hypothesis is supported only on the basis of the literature, since the nitrogen, lignin and cellulose factors were not determined in this study. Gupta et al. (1987) reported that the sandy soils have small surface area, the particles of the residues are more effective in separating particles from single grains, reducing the frictional force of the mineral fraction and resisting the compression of the soil. All of these observations corroborate our results, indicating that maize residues provided greater soil structure than bean residues.

Soil compression index (Cc) at densities from A) 1.2 g/cm^3 and B) 1.4 g/cm^3 as a function of water and organic matter content

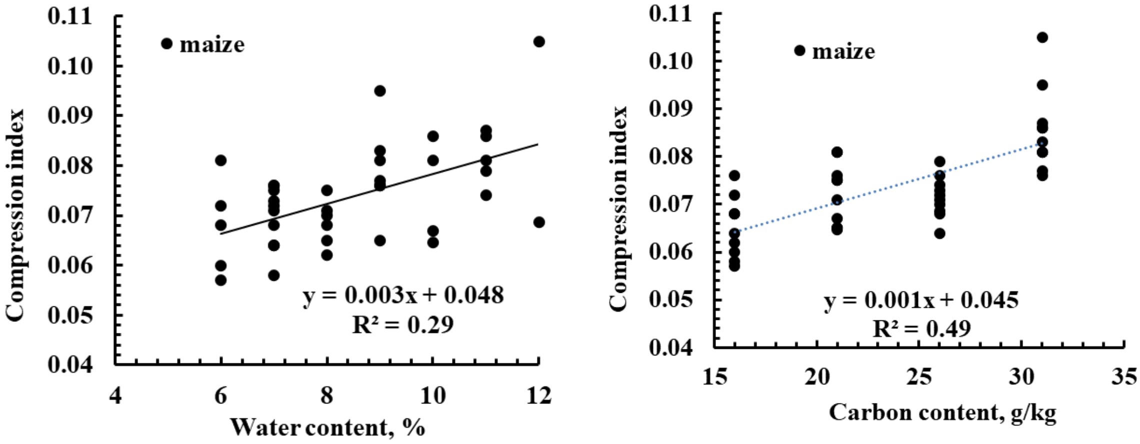
In this study, the isolated effect of organic carbon produced by maize and bean straw combined with water content on the variation of the soil compression index was evaluated using linear regression model with coefficient of determination (R^2) at 95% confidence (Figure 4 and 5).

The soil compression index showed a greater positive correlation with organic matter than water content from the compression test of soil samples composed of corn straw residues at density of 1.2 g/cm3 and at density of 1.4 g/cm3 (Figure 4 A and B). The results show that there is a positive, strong correlation between the variables soil compression index and organic carbon content and between water content, respectively, r = 0.787 and r = 0.583 ($p < 0.05$), indicating that the two variables covary proportionally for samples with soil density of 1.2 g cm^{-3}. The model also indicates that 62% of the increase in soil compression index is explained by the increase in carbon content while 34% is explained by the water content in this soil density. For the density of 1.4 g cm-3, the compression index indicated a lower correlation with both the organic carbon and the water content, revealing a strong positive correlation between the compression index and the organic carbon content and correlation moderate positive between the compression index and the water content, respectively, r = 0.70 and r = 0.539 ($p<0.05$).

Figure 5 shows the simple linear regression model of the soil compression index as a function of water content and organic carbon for the soil structured with bean straw, at density of 1.2 g cm^{-3} (A) and 1.4 g cm^{-3} (B). For both densities, the results reveal that there is positive, strong correlation between the variables soil compression index and organic carbon content and between soil compression index and water content, respectively, r = 0.906 and r = 0.742 ($p < 0.05$) at soil density of 1.2 g cm^{-3}, and r = 0.854 and 0.693 for a



(A)



(B)

Fig 4. Soil compression index as a function of water content and carbon content from maize straw in soil samples to density of 1.2 g cm^{-3} and 1.4 g cm^{-3}.

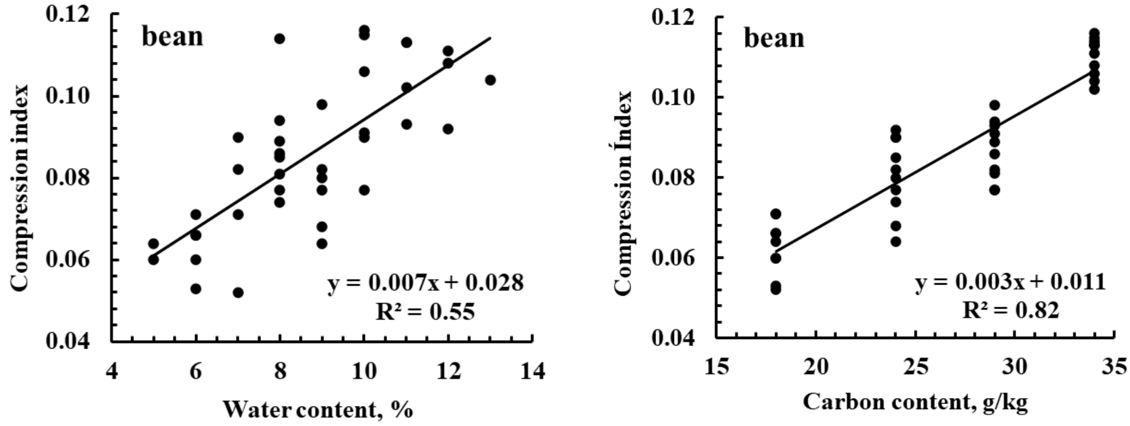
density of 1.4 g cm^{-3}, indicating that the two variables covary proportionally (Figure 5A and B). The simple linear regression model indicates that 82% of the increase in the soil compression index is explained by the variation in the quantity of organic carbon in the soil with a density of 1.2 g cm^{-3}, while in the density of 1.4 g cm^{-3} only 73% of this variable explains the proportionality of the compression index.

Comparing the results of soil samples structured by organic matter from corn and bean straw, it can be inferred that for both densities, the compression index indicated a greater correlation with water content and organic matter than the soil structured with maize straw, at the soil structure formed by bean straw. According to Dias et al. (2003), the good effects achieved with bean straw allow us to conclude that this residue can be a powerful source of enrichment for other agricultural residues. Correlation values were higher for the density of 1.2 g/cm^3, (Figure 4A and 5A) than for the density of 1.4 g/cm^3 (Figure 4B and 5B). The samples with organic matter from the maize straw showed less compressibility (slope of the compression curve decreased), varying according to the voids ratio. The samples with a density of 1.2 g/cm3 had a soil compression index (virgin compression line - vcl) higher than those used with a density of 1.4 g cm^{-3}.

This shows that the influence of water and organic matter content on the soil compression behavior is slightly dependent on the initial structural state. The interpretation for this is that more compacted soil shows much less dependence on the moisture status. The correlation among the compression index behavior and water and organic matter content in this study agree well with results reported by Larson et al. (1980), Gupta et al. (1987), Stone and Ekwue (1995), Zhang and Hartge (1995) and Pereira et al. (2007).

Pre-compression stress (Pc) at densities from A) 1.2 g/cm3 and B) 1.4 g/cm3 as a function of water and organic matter content

The pre-compression stress determined according to the method used by Dias Junior and Pierce (1995) and Arvidsson and Keller (2004) showed a moderate tendency to decrease with increasing water and organic matter content in soil samples structured with the decomposition of corn straw to density from 1.2 g cm^{-3}, revealing a negative correlationof 53% and 49%, respectively (Figure 6A) at the 95% confidence (Cohen, 1988). However, for a density of 1.4 g/cm3, the inverse process was occurred. The precompression stress increased with the increase in water and organic matter content, indicating a positive correlation



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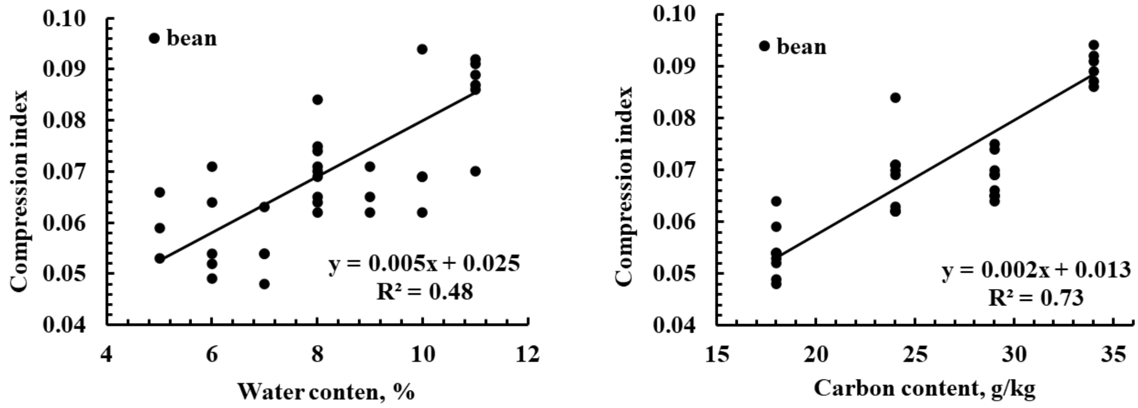


(B)

Fig 5. Soil compression index as a function of water content and carbon content from bean straw in soil samples to density of 1.2 g cm-3 and 1.4 g cm-3.

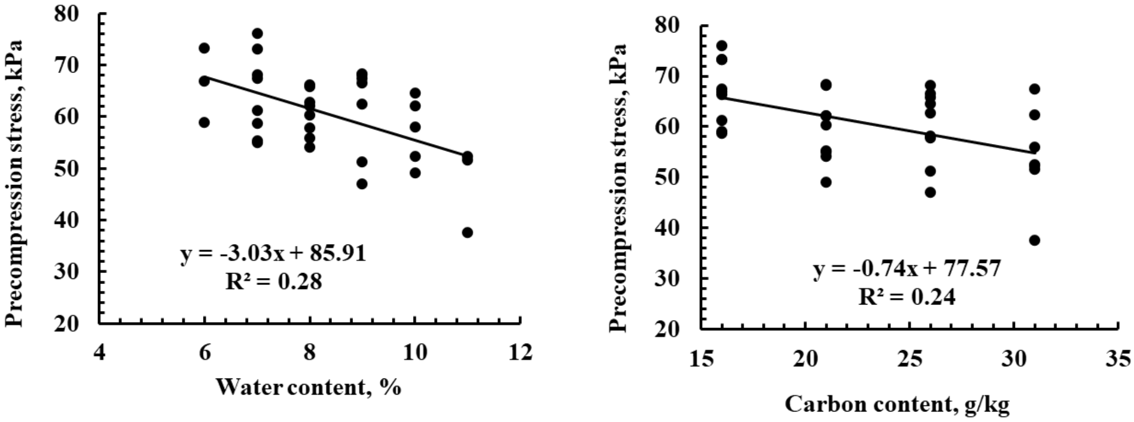
among the variables of 53% and 52%, respectively, in soil samples structured with maize straw (Figure 6B).

Figure 7 shows the simple linear regression model of the soil precompression stress as a function of water content and organic carbon to the soil samples structured with bean straw at density of 1.2 g cm-3 and 1.4 g cm^{-3} (Figure 7A and B). The results show similar behavior to those obtained with soil samples structured with maize straw to both soil densities. The results show that there is a positive, strong correlation between the variables soil precompression stress and organic carbon content and between water content, respectively, r = 0.557 and r = 0.557 ($p < 0.05$), indicating that the two variables covary proportionally for samples with soil density of 1.2 g cm^{-3} (Cohen, 1988). The model also indicates that 31% of the variation in soil precompression stress is explained by carbon content derived from bean straw and by water content in this soil density.

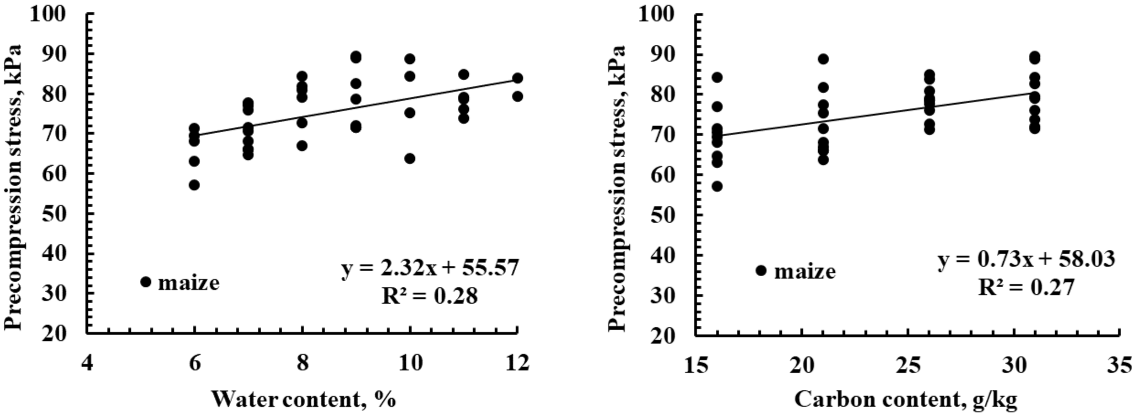
The results obtained for precompression stress for the density from 1.2 g/cm^3 in this study corroborate with Larson et al. (1980) and Kondo and Dias Junior (1999) revealing a reduction in the structural void index and precompression pressure as a function of the increase in water content and organic matter content. These results agree with those reported by Lebert and Horn (1991) from an analysis of 37 soils. Pereira et al., (2007) results also showed that pre-compression pressure can increase with carbon content in very wet conditions, as observed for the density from 1.4 g cm^{-3}. The analyzes with density of 1.2 g cm^{-3} are also confirmed by the results of Silva and Cabeda (2006) in which the compressibility characteristics are correlated with water content. Therefore, the increase in soil moisture reduces the results obtained in pre-compression stress, enhancing the soil compression index. The use of machines in agricultural production systems affects the dependence of precompression stress on the initial conditions of water and organic matter content. The application of these two factors as a qualitative evaluation criterion allows to define adequate optimization limits, mainly of soil water content for the allowed traffic capacity to protect the subsoil against compaction.

Materials and methods

The experiment was carry out on the Soil dynamics laboratory on the soil-machine interaction system of the "Universidade Federal Rural do Semi-Árido, UFERSA – Brazil. The studied soil was sandy (Oxisol) derived from limestone rock and is characterized by deep and weathered, containing 890 g kg^{-1} sand, 10 g kg^{-1} silt and 100 g kg^{-1} clay.

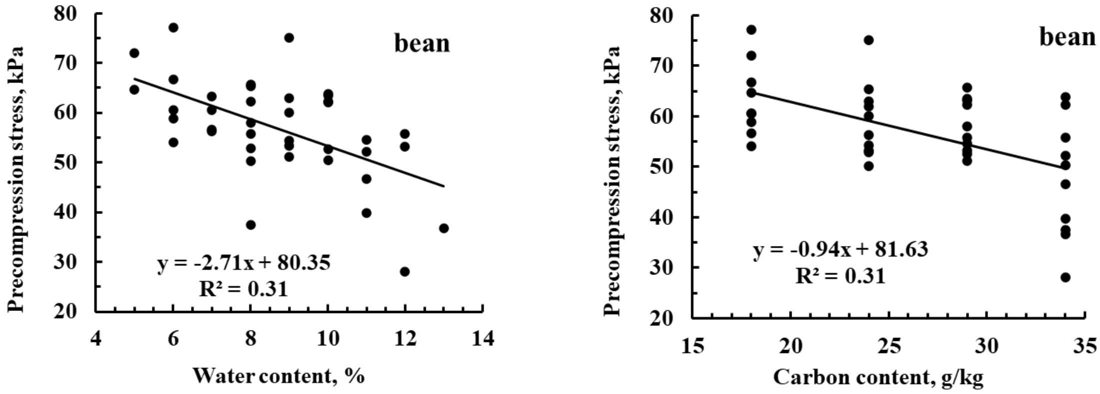


(A)



(B)

Fig 6. Soil precompression stress as a function of water content and carbon content from maize straw in soil samples to density of 1.2 g cm^{-3} and 1.4 g cm^{-3}.



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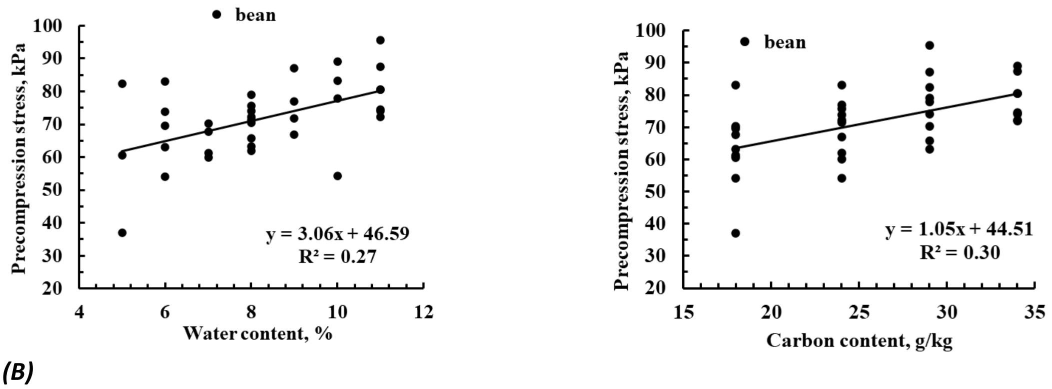

(B)

Fig 7. Soil precompression stress as a function of water content and carbon content from bean straw in soil samples to density of 1.2 g cm^{-3} and 1.4 g cm^{-3}.

Studied material
Two kinds of crop straw, maize (*Zea mays L.*) and cowpea beans (*Vigna unguiculata* L. Walp) were used as organic matter incorporated into the soil. The straw consisted of a fraction of size of 20 to 50mm, obtained from the chopped straw in the field after harvest and separated with sieve. The soil was collected in the field and air-dried in the laboratory and then passed through a 2.0 mm sieve. Four proportions of the fraction of air-dried straw from each crop were incorporated into the soil in the proportions of 2:100; 4:100; 6:100 and 8:100 g /g, respectively, m2, m4, m6, and m8, for maize and b2, b4, b6 and b8 for bean, in trays of 60 x 30 x 7 cm (length x width x height).
After incorporating the straw into the soil, the humidity of each treatment was controlled for four months in a laboratory simulating field conditions. Four earthworms were placed in each tray to accelerate the straw decomposition process.
At the end of the 120-day period, enough time was considered for the straw to decompose in the soil. Then, samples of each treatment of soil-straw decomposed, from the proportions already defined were collected to determine the organic matter.
The soil organic carbon content was determined colourimetrically by dichromate oxidation method as described by Raij et al. (2001).

Samples preparation for the soil compression test
Samples of soils deformed with aggregates with a diameter of less than 2.0 mm (Pereira et al. 2007) of the same compounds at the densities of 1.2 g/cm3 and 1.4 g/cm3. These samples were then fitted in cylinders with 70 mm diameter and 24 mm high and equilibrated at 20, 40, 60 and 80 kPa water tension. Oedometers test was used in order to study the effect of incorporating organic matter on soil resistance to compression.
Sequential cyclic pressures of 10, 25, 50, 75, 100, 200, 300, 450 and 600 kPa were applied using a pneumatic oedometer cell to each sample for a period of 30 s (Etana et al., 1997), with an interval of 60 s for decompression (relaxation), recording the deformation at end of each loading interval with recovery, with a resolution of 0.01 mm in a data acquisition system

Soil compression test
Soil compressibility is defined, according to Horn and Lebert (1994), as the property of the soil in which the volume reduction occurs when it is subjected to a mechanical load. It is generally determined with the confined compression test (Larson et al. 1980).

Evaluated parameters
Soil textural and structural porosity
The porosity was determined according to Monnier et al. (1973) as a function of pore origin. Soil porosity can be thought of as the sum of (i) macropores (structural pores) that result from tillage, traffic, weather and biological activity, and (ii) micropores (textural pores) that result from the arrangement of soil elementary particles. Structural pores are subjected to short term variations such as compaction by wheeling, whereas compaction does not affect the textural porosity (Bruand and Cousin, 1995; Richard et al., 2001). Soil porosity can be expressed by the void ratio and written by:

$$e = e_t + e_s \quad (1)$$

where e is the total void ratio, e_t is the textural void ratio, and e_s is the structural void ratio. The total void ratio can be calculated by:

e = ⍰$_s$/⍰$_d$ – 1 (2)

where ⍰$_s$ is the soil particle density and ⍰$_d$ is the soil bulk density. The particle density was determined by pycnometry with water (four replicates per soil) from the original soil. The same soil was used to textural void ratio which it was measured as a function of soil moisture on the aggregate fraction 2–3.15 mm using the kerosene method (Monnier et al., 1973). The bulk density was systematically measured in the mechanical tests. Therefore, first the total void ratio was calculated using Equation (2), and then calculated the structural void ratio using Equation (1).

Soil compression index (Cc).
Plotting the void ratio of each sample over the logarithm of the applied pression, a straight-line relationship over much of the stress range is obtained. The straight line is called the virgin compression line (vcl) and its slope is defined as compression index (Cc), that means how the soil can be compressed in the virgin compression line range (Zhang and Hartge, 1995).

Soil precompression stress (Pc)
Soil pre-compression stress (pc) was determined from soil strain as a function of the logarithm of the applied stress, using method the intercept of the vcl and a regression with the first three points of the curve as described in Dias Junior and Pierce, (1995) and Arvidsson and Keller, (2004).

Experimental design and statistical analysis
For each soil with organic matter from maize and bean residue, an isolated design was carried out with parameters consisting of two soil densities (1.2 and 1.4 g/cm3), 4 organic carbon contents and 4 water contents from tensions of 20, 40, 60 and 80 kPa (2x4x4) with 3 repetitions.
The structural voids index as a function of applied pressure, as well as the soil compression index and pre-compression stresses as a function of water content and carbon content were evaluated using linear regression models with coefficient of determination (R^2) at 95% confidence (Cohen, 1988).

Conclusion

The organic matter from the maize straw showed a better structuring of the soil in relation to the increase in the structural void ratio for the same water content at all applied pressures than the bean straw.

The soil compression index had a greater positive correlation with organic matter than with soil water content, both for soil samples structured incorporated with maize straw and bean straw at both soil densities (1.2 g cm^{-3} and 1.4 g cm^{-3}). In addition, the effect of organic matter and water content on soil compression was dependent on the initial structural state of the soil.

The dependence of the pre-compression pressure on the initial conditions of water and organic matter content justifies the application of these two factors as a qualitative assessment criterion allowing to define adequate optimization limits for the allowed traffic capacity, to protect the soil against compaction.

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