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Lavras – Brazil

May 26 – 29, 2019

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- PROCEEDINGS -

5th Brazilian Soil Physics Meeting

ISBN: 978-65-80760-00-8

1º Edição

Departamento de Física

Lavras - MG
2019

CONTENTS

1. KEYNOTE SPEAKERS

Ole Wendroth
University of Kentucky, USA
"Diagnosing Field-scale Soil Variability for Irrigation Management"

João Herbert Viana
Embrapa, Brazil
"The Brazilian sandy soils: how far soil physics matters for their management?"

Yves-Dady Botula
University of Québec in Abitibi-Témiscamingue, Canada
"Combining measurements and modelling for performance evaluation of a mine reclamation cover in Québec (Canada)"

Wenceslau Teixeira
Embrapa, Brazil
"Bimodal pore size distributions in some tropical soils"

Yan Jin
University of Delaware, USA
"Colloids and Interfaces: Soil Physics and Beyond"

Carla Carducci
University of Grande Dourados, Brazil
"Micromorphological concepts to 3D image analysis"

Loes van Schaik
Technische Universität Berlin, Germany
"Spatiotemporal variability in preferential flow from plot to catchment scale: the influence of soil organisms"

Javier Tomasella
CEMADEN, Brazil
"Soil water dynamics in Forest environments and the role of deep roots"

Scott B. Jones
Utah State Univ, USA
"Advances in sensors and instrumentation for soil physical property and process determination"

Bruno Montoani Silva
University of Lavras, Brazil
"The role of soil physics in overcoming limitations for better crops in southern Minas Gerais, Brazil"

2. ORAL PRESENTATIONS

Soil structure dynamics by weed control methods in coffee crop in the State of Paraná, Southern Brazil

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Coffee is one of the most important cash crop for Brazilian agribusiness. Weed control methods and traffic machines are the main causes of changes on soil physical properties related to structure. Due to that, the objective was to assess the effects of weed control in coffee crop methods on soil physical properties related to soil structure. A field experiment was installed in 2008 and has been conducted at Experimental Station of Agronomic Institute of the State of Paraná – IAPAR in Londrina, State of Paraná, Brazil (23° 22´ 11" S Latitude S e 51° 10´ 84" de Longitude W, 585 m a.s.l.). The average annual temperature of the study area 21,1 to 22° C (16,1 to 17 °C minimum, 27,1 to 28 °C maximum), the average annual rainfall is 1,600 to 1,800 mm and evapotranspiration – ETP 1,000 to 1,100 mm. The soil in the experimental area was classified according to Brazilian Soil Classification System as Dystropherric Red Latosol, (ferruginous Rhodic Hapludox), very clayey texture (80 dag kg-1), derived from basalt. Clay fraction of this soil is composed mainly by kaolinite and hematite is the main Fe-oxides in this fraction. The experiment was set in randomized complete block design, and seven treatments with four replicates. Plot size was 10.5 m by 16 m. The treatments consisted of seven weed control methods in the interrows area of coffee plantation: T1 – hand hoe; T2 – mechanical portable mower; T3 – herbicides; T4 – cover crop peanut horse; T5 – cover crop dwarf mucuna; T6 – no-weed control in the interrow area with hand hoe in row area; T7- no-weed control in the interrow and row area (Weed check). In this experiment cover crops are used for weed suppression and soil improvement. In October 2010, 2013, 2015 and 2018, undisturbed soil samples were collected in the center of the inter-rows from 1.75 m from stems of the coffee shrubs at the 3–8 cm, 13–18 cm, 23–28 cm and 33–38 cm depths. Based on the results of soil-water retention curves behavior it was possible to conclude that no-weed control between coffee rows (T6) in the interrow area improve soil structure without committing coffee yields. Therefore, this method must be useful for the farmers to protect the soil against processes of land degradation like hydric erosion and soil compaction.

Keywords: Soil water retention curve, soil compaction curve, soil organic carbon

Raman spectroscopy as a tool for soil carbonaceous materials and biochar structural characterization

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The high temperatures and rainfall of tropical environments contribute to the rapid degradation of organic matter and, consequently, the occurrence of poor soils with low nutrient retention. Regardless of the tropical climate, the occurrence of high fertility soil sites, the "Terras Pretas de Índio" (TPI's, or Indian Dark Earths) is observed at certain Amazon regions. These soils have a high carbonaceous material content with stable structure, which is related to its superior nutrient retention capacity. An approach inspired in these soils is the transformation of biomass into charcoal engineered at the nanostructure level, aiming its addition in soils to improve its quality (the so called "biochar"). Despite the knowledge about the beneficial qualities of the carbonaceous material present in TPI's, little is known about its generation process and structure. From another side, Raman spectroscopy is a nondestructive technique widely used to characterize the structure of carbon materials in condensed matter physics and materials science (nanotubes, graphene, and amorphous carbon, for example). In this work, Raman spectroscopy with visible laser light excitation is used to characterize carbon structures present in different TPI's samples, as well as charcoal from typical plant species, and biochars produced from residues like pouty litter and coffee husk, with and without co-pyrolysis with H_3PO_4 and MgO. The defect-induced mode (D band ≈ 1350 cm^{-1}) and the tangential stretching mode (G band ≈ 1580 cm^{-1}) are analyzed, and the band shapes allows their distinction from charcoal samples produced in laboratory conditions. We elaborate a model relating the Raman spectra with the structure, the nanocrystallite size, discussing the propensity of each sample to perform chemical bonds through the periphery of the crystallites. We determine the optimum crystallite size for TPI's as 5-7 nm, as well as induce structural changes in biochars due to the co-pyrolysis procedure. The increased disorder of nearly 2 nm in crystallite size in this case is beneficial to maximize chemical bonds with nutrients, and promising for biochar-based fertilizers.

Keywords: Biochar, crystallite size, Raman spectroscopy

Do the criteria for field capacity estimation matter in bucket-type models?

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In the bucket-type approach, field capacity (FC) models environmental processes, since it represents the threshold water content (θ) that control the processes that generate surface runoff and leaching out to root zone. Many approaches have been presented to estimate FC since its measurement in the field can be labour intensive and time consuming. Those estimations can be generically spread into static and dynamic criteria, and the response in variables such as the crop yield (CY) from a bucket-type model can be influenced by the result they present. We evaluated the consequences of using different criteria for FC in the soil water and air retention, evapotranspiration and CY generated by AquaCrop model. FC was estimated using the static criteria of fixed soil water retention curve (SWRC) points at pressure heads (h) of 0.6, 1.0 and 3.3 m and at the inflection point (h_i) and the model presented by Assouline and Or (AO). Four equations based on dynamic criteria for FC was also evaluated. All results were compared with a simple texture-based PTF to evaluate if it is worth the effort of measuring sophisticated data to predict FC (such as SWRC and saturated hydraulic conductivity). The methodology was applied in six different fields from tropical and temperate climates, under distinctive management practices. In tropical fields the smallest FC was obtained by θ(3.3 m) and from AO for the temperate ones. The higher values of FC were obtained by θ(h_i). The variation between FC and consequently other soil properties was higher for tropical sites than the temperate ones. The used PTF estimated FC within the range of results obtained by the other nine approaches. AquaCrop was used to study the effect of FC on CY by fixing all model parameters, whereas FC was the only flexible parameter. Based on three scenarios of rainfall in a soil profile from temperate climate, the variation obtained for CY was more sensitive to FC in the scenarios with less and average rainfall, for most FC criteria. In the scenario with high rainfall the results for CY were similar, except for inflection point, that presented much lower CY values because AC became yield limiting due to high values of FC. The choice of the best estimation criterion for FC should be based on the features and needs of every particular system, considering whether the user needs a very cautious or otherwise decision.

Keywords: Sensitivity analysis, pedotransfer function, crop yield.

Gardner dual model and its modification to calculate the hydraulic conductivity curve

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The Mualem-van Genuchten (MVG) model with the two parameters, K_M (matching point of the relative hydraulic conductivity at saturation) and L (pore connectivity), is a reference model of the relative hydraulic conductivity curve: $Y(h) = \log K_r = \log (K/Ksat)$ (h is the suction). In 77 soils without evidence of macropore flow from the UNSODA database, Ottoni Filho et al. (Journal of Hydrology and Hydrodynamics, to be published) showed that, with respect to MVG, their Gardner Dual (GD) model for Y(h) presented a drastic reduction in its fitting error to the dataset, from RMSE = 0.525 (MVG) to 0.191 (GD). In the 77 soils, the RMSE for GD was <0.32 for any soil, which may be used as a criterion of non-relevance of macropore flow (MF) effects in models where $K_r(h = 0) = 1$. The GD model, like MVG, has two free parameters, and calculates the normalized Y curve, Y/Y_o [$Y_o = Y(h_o)$, where h_o is the suction at the inflection point of the $K_r(h)$ curve at the log-log scale], with a simple dual expression depending only on $g = h/h_o$ and a dimensionless shape (positive) parameter, β: $Y(g)/Y_o = g$, if $g \leq 1$; $Y(g)/Y_o = 1 + (\beta/\log e)\,[1 - g^{-(\log e)/\beta}]$, if $g \geq 1$. However, in another 64 UNSODA soils, MVG was more accurate (RMSE = 0.410) than GD (RMSE = 0.566). In this study, we proposed a modification of GD to take into account MF effects and tested the modified GD (mGD) model in the 64 soils. We assumed that MF effects are only relevant in the suction interval of 0-10 cm and that they make the $K_r(h)$ curve have a linear variation at the log-log scale in this h interval, which is in accordance with Jarvis, 2008 (Vadose Zone J., 7:1302-1310). For h≥10 cm, we modified GD by introducing a multiplicative matching parameter, M (M>0), in the original GD-$K_r(h)$ equation in order to make $\log K_r(h = 0) = 10^{-M}$. So, in order to incorporate the MF effects, mGD introduces two new free parameters into GD: M and ha; the latter is an air-entry suction parameter, where $K_r(ha) = 1$ (ha<10 cm). Applying mGD to the 64 UNSODA soils, the RMSE was drastically reduced from 0.566 to 0.261, which indicates that MF effects were relevant for most of these soils. Comparing the global performance of MVG in the 141 (77 + 64) soils to the performance of GD (77 soils) and mGD (64 soils) together, the result is that the mean RMSE was reduced from 0.473 (MVG) to 0.223 (GD+mGD), a 53%-error reduction with respect to MVG, which is an indication of the relevance of the new models (GD and mGD) for improving flow modeling.

Keywords: Mualem van-Genuchten model, macropore flow, hydraulic conductivity curve.

Proposal of a soil classification system based on volume distribution in pore space

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We propose a soil classification system (Ottoni,M.V., 2017, Doct.deg.diss., COPPE, Federal University of Rio de Janeiro, Brazil), which groups soils according to their volume distribution in the pore space. The system is based on the van Genuchten equation (VG) for the water retention (WR) curve, $\theta(h)$, with parameters θ_s ,m ($0<m<1$), α (cm^{-1}) and θ_r, and on the θ-measurements: θ_s, θ_{60}, θ_{330}, θ_{15000}, where the numbers are h-values (cm). With the four θ-measures, parameters m, α and θ_r can be optimized in a standardized way and the two specific pore-size distribution values in the effective porosity (EP) space, $(\theta_s-\theta_r)$, can be calculated: $A(h_i) = [\theta_s-\theta(h_i)]/ (\theta_s- \theta_r)$, h_i = 60 or 15000 cm. By VG: $A(h_i) = \{1 – [1 + (\alpha h_i)^{1/(1-m)}]^{-m}\}(\theta_s-\theta_r)$. With A(60) and A(15000), the following fractions can be determined: Ma = A(60) (called macrospace); Me = A(15000)–A(60) (mesospace); Mi = 1-A(15000) (microspace). As Ma+Me+Mi = 1, a soil sample is represented by a point in a triangle, called the structural triangle (ST), the sides of which are the scales of Ma, Me and Mi (from 0 to 1), similarly to the textural triangle (Ma eq.sand; Me eq.silt; Mi eq.clay). Separating each of the Ma, Me and Mi scales into three equal fractions, ST is divided into nine equal areas, representing the nine Orders of the system. Orders A,B,D,F are of macrospaced soils (Ma>1/3); B,C,E,G of mesospaced soils (Me>1/3); F,G,H,I of microspaced soils (Mi>1/3) [B,F and G are hybrid Orders]. Each Order (O) is divided into four Suborders (SO1 to SO4), according to EP values: SOi, if $0.20(i-1)<EP\leq0.20i$, 1=1,2,3; SO4, if EP>0.60, comprising 36 (9x4) possible soil classes. As O groups soils with similar pore-size distributions, A(h), then, by construction, SO will group soils with similar air-availability curves, $Aa(h) = [\theta_s-\theta(h)] = (\theta_s-\theta_r)A(h)$, which are curves characteristic of the soil structure. A database comprising 2,407 soils (638 weathered Brazilian soils + 1,744 European soils + 25 recent volcanic soils) was used to test the system. Most of the Brazilian soils were in the macrospaced Orders and the volcanic (clayed) soils in the mesospaced Orders, while the clayed and sandy European soils were predominantly in the microspaced and macrospaced Orders, respectively. We confirmed that soils classified in the same class had similar Aa curves, even when they had quite distinct textures. Therefore, the system proposed may be useful to interpret soil behavior and build PTFS for hydraulic properties.

Keywords: Soil classification system, textural triangle, pore-size distribution.

Soil water retention and diffusivity of vertisols with different salinity levels irrigated with water from São Francisco river

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Change in vertisol water retention under different exchangeable sodium percentage values, as well as the influence of water quality, were investigated. Treatments consisted of four exchangeable sodium percentages (ESP): original soil, 0.18%, 1.37% and 3.34%, two water sources and three replicates. The waters used were water from the São Francisco River and deionized water to simulate rain water. In order to determine soil water retention curves (CRA), the samples were initially saturated and subjected to soil water retention of 2, 4, 6, 8 and 10 kPa, using the Buchner funnel suction units and 33, 60, 100, 500, 1,500 kPa in the Richards extractor. The water retention values were adjusted to the model proposed by Genuchten (1980). The results showed that the increase of ESP promoted clay dispersion. Moisture ranged from 0.167 to 0.338 cm^3cm^{-3} when treated with deionized water, and from 0.164 to 0.192 cm^3 cm^{-3} when treated with São Francisco river water. Soils with structure modified by salinity tend to store more water when submitted to the same levels of matrix potential using deionized water. A simple way for estimating soil water diffusivity by visual inspection of the wetting front versus time and adjusting a new empirical function using the method proposed by Bruce and Klute (1956) is proposed. The proposed model to fit θ versus λ data was efficient, obtaining a minimum determination coefficient of 79%, describing well the observed data. Soil water diffusivity and unsaturated hydraulic conductivity decreased with increasing PST and increased significantly with soil moisture. The sources of water used did not cause changes in soil properties revealing that the river water is not different from deionized water. The movement of water in the unsaturated soil was affected by the ESP elevation, due to the effects of soil expansion and clay dispersion.

Keywords: Soil water retention, diffusivity, hydraulic conductivity.

Hydrostatic equilibrium between soil samples and pressure plates used in soil water retention determination: a valid assumption?

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Soil water retention is among the soil hydraulic properties most routinely measured in studies of soil physics and related areas. This property is used in dynamic simulations of vadose zone processes such as soil water availability, surface boundary processes of evaporation and infiltration, and the fate of soil pollutants. The most common measurement technique consists in establishing a hydrostatic equilibrium between an initially saturated soil sample and a porous medium at a certain tension on a tension table or pressure plate. However, there is reasonable doubt about the assumed hydrostatic equilibrium, especially at low pressure heads. In this study we compared the traditional pressure plate apparatus protocol to an inverse parameter estimation protocol based on a transient evaporation experiment. Independent pressure head measurements using a dewpoint device were also performed. We sampled a variety of soil textures typical of the Brazilian subtropical humid zones, aiming to show differences between textures in their subjection to hydraulic nonequilibrium. The performed experiments allow to conclude that the two compared protocols showed real pressure heads in samples on a pressure plate to be lower than the assumed ones, leading to an overestimation of the soil water content at lower pressure heads, especially in fine-textured soil samples. This affects the reliability of most soil hydraulic databases, derived PTFs in the dry range, as well as the wilting point estimation. Water availability predictions based on total and readily available water are more sensitive to the water retention measurement method when the chosen lower limits of available water are closer to the wilting point. In this sense, irrigation timing criteria based on readily available water should be preferred over total available water, especially for fine-textured soils. Finally, given the low reliability of the pressure plate apparatus for low pressure heads, possibly biasing hydrological simulations and their interpretation, alternative measurement methods for the drier part of the soil water retention curve should be preferred, e.g. the proposed inverse modeling of evaporation experiments.

Keywords: Inverse parameter optimization, soil available water, wilting point.

Splintex 2.0 can estimate hydraulic parameters of tropical and temperate soils without calibration need

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Soil hydraulic conductivity [K(θ)] and soil water retention curve (SWRC) are important functions for the understanding and modeling of soil hydraulic processes. Because their measurement is costly and thus not feasible for large-scale monitoring, pedotransfer functions (PTFs) are useful to predict both SWRC and K(θ). The majority of PTFs are usually calibrated from soils of temperate regions and it means that they are uncertain when applied in soils elsewhere, e.g., tropical regions. On the other hand, Splintex 1.0 is a physico-empirical PTF developed in basic language that is based on particle size distribution (PSD) and other basic soil information to estimate SWRC parameters of van Genucthen-Mualem equation. As advantage, it does not need previous calibration. However, it estimates the saturated hydraulic conductivity (K_{sat}) using a texture-PTF presented by Rodas in 1970. To improve Splintex in order to benefit its use, a second version was developed with a user-friendly computational interface for estimating parameters of SWRC and K(θ). This PTF is based on two physico-empirical models that can be applied universally. Its computational procedures and equations are written in C ++ language and was tested using a database of 1,355 samples from several countries, thus allowing a more detailed quantification of the univariate and bivariate probability distributions of the estimated parameters in different hydrogeology, climate and soil settings. The performance of the Splintex 2.0 was analyzed using the indices of linear correlation (*r*) and both mean absolute error (MAE) and root mean square error (RMSE). This new version performed well in quantification of water retention presenting similar results of Rosetta and Neuropack models, showing that it can be used universally for any type of soil.

Keywords: Soil water retention, hydraulic conductivity, pedotransfer function.

Pedotransfer function instability resulting from dataset drifting

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Pedotransfer functions are used to estimate soil physical and chemical properties such as water retention, hydraulic conductivity or cation exchange capacity using more available soil properties including texture, bulk density and organic matter. Although there has been a great effort to improve the performance of PTFs using intelligent and machine learning algorithms, the effect of separation of data in training and testing set has not been addressed. Random selection of these data sets is common practice but may result in different outcomes for repetitions, as we showed for water content prediction of temperate (Denmark) and tropical (north east of Brazil) soils. These differences propagated in a large scatter of predicted van Genuchten parameters. Several resamplings should therefore be performed, and the importance of this was also confirmed by testing different machine learning based pedotransfer functions to predict cation exchange capacity using clay, sand and organic matter. Instability of PTFs due to random variations of the training data set indicates that they should not be used for prediction at large spatial scales and smaller regional and more stable PTFs should be preferred.

Keywords: Pedotransfer function, covariate shift, machine learning techniques.

Physical quality indicators to evaluate a soil under integrated crop-livestock system

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Two depths of a Haplohumox soil under integrated crop-livestock system were analyzed (0.0-0.10 and 0.10-0.20 m) in four tillage systems: conventional tillage (CT), minimum tillage (MT), no-tillage (NT) and chiseled no-tillage (CNT), taking into account the annual ryegrass cropped during the winter for grazing (G) and silage (S) uses. Soil structure was evaluated based on soil water retention curve (SWRC), pore volume distribution function (PVD), SPQ indices and the aeration hydraulic-energy function with other parameters obtained via micromorphological analysis. Areal porosity (AP) was determined to classify the shape of pores as rounded (R), elongated (E) and complex (C). The size of pores was chosen based on their function and classified as storage pores (0.5-50 μm), transmission pores (50-500 μm) and fissures (>500 μm). The number of pores (NPo) was also estimated considering the disconnected pores. Based on our results, the top layer is the most affected by tillage. Rounded pores were predominant for all evaluated systems, whereas complex pores such as fissures presented the largest connectivity. The plowing operation affected soil infiltration and water retention processes in MT and CT as well as AP and NPo in NT system. NT and CNT required less energy to drain water in both surface layers evaluated. In the top layer MT/S exhibited de largest energy to release water, presenting small value of AP and homogeneous SPS. Strong correlation was found between absolute aeration index and some shape parameters of PSD, evidencing the physical relation between these indices. The micromorphology analysis supported the understanding of the other SPQ indices and aeration function for the evaluated tillage systems.

Keywords: Soil quality, soil structure, micromorphology.

3. POSTERS

Water-dispersible clay of a Latosol in Direct Drilling System affected by time of mechanical shaking and crop rotation

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Water-dispersible clay – WDC is a physical property related to electrochemical properties and required to modeling water erosion. The time of shaking soil samples might affect the results and misleading interpretation. In this context, the aim of this study was to assess the time effect of shaking of soil samples on water-dispersible clay of a Red Dystroferric Latosol. The study was carried out at Experimental Station of Agricultural Research Institute of the State of Paraná – IAPAR (23° 22 '11' 'S south latitude and 51° 10' 84 " longitude west), at an altitude of 574 m above sea level, at Londrina County, State of Paraná, and Southern Brazil. The experiment was installed in October of the year 2012 in a randomized block design, with eighteen treatments (3 summer and 6 winter crops) and three replications. However, for this study six crop rotation were selected to assess the time effect of mechanical shaking behavior. T1 – Soybean / Black Oat cv. Iapar 61 Ibiporã; T2 – Soybean / Maize; T3 – Soybean / Safflower (*Carthamus tinctorius* L.); T4 – Maize / Safflower; T5 – Maize / Maize; T6 – Maize / Black Oat. In September 2018, soil samples were collected in layers 0–10 cm and 10–20 cm depth for the physical characterization (total dispersion, water-dispersible clay with 2 h and 16 h of mechanical shaking) and soil electrochemistry (pH in potassium chloride, pH in water, delta pH, Zero Load Point (PCZ). The results showed that water-dispersible clay increased with the time of mechanical shaking. At soil surface (0–10 cm), WDC for 2 h of shaking was medium 27 dag kg^{-1} with flocculation index equal to 67%. On the other hand, for 16 h of shaking, WDC was 45 dag kg^{-1} with 44% of flocculation index. At the depth 10–20 cm, WDC ranged from 30 to 49 dag kg^{-1} for 2 h and 16 h of shaken. Among the treatments it was observed that T11 - Maize / Maize and T12 - Maize / oats provided lower amounts of net negative charge and higher PCZ, values of 4.3 and 4.4, respectively, which may provide higher flocculation of the clay fraction in the pH values of cultivated soils and favor the process of aggregation of the soil.

Keywords: Mechanical dispersion, flocculation index, physical analysis.

Flocculation-dispersion of clay fraction of a Latosol affected by weed control methods in coffee crop

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Water-dispersible clay is a soil physical property related to electrochemical properties and develop a key role in aggregation processes and hydric erosion. Changes in pH, organic carbon content and organic acids of organic matter modify colloid surface chemistry and consequently flocculation-dispersion behavior of clay fraction. In this context, the aim of this study was to assess flocculation-dispersion behavior of clay fraction in a coffee plantation submitted to different weed control in the inter-rows area. A field experiment was installed in 2008 at the Experimental Station of Agronomic Institute of the State of Paraná – IAPAR, in Londrina County, Northern of State of Paraná, Brazil (23° 22´11´´S and 51° 10´84´´ W 574 m a.s.l.) to study weed management in the inter-rows area of coffee crop. The experiment was installed in randomized complete block design, seven treatments with four replicates. The soil in the experiment site is classified as Typical Dystropherric Red Latosol, very clayey texture (80 dag kg-1 clay) with kaolinitic mineralogy derived of the saprolites from basaltic rocks. The weed management were: T1 – hand-hoe weeding; T2 – portable mechanical mower; T3 – herbicides; T4 – cover crop peanut horse; T5 – cover crop dwarf mucuna; T6 – no-weeding control in the inter row area and T7 – weed check (no-weed control in the row and interrow area). Soil samples were collected at 0 – 10 cm, 10 – 20 cm, 20 – 30 cm e 30 – 40 cm depths. Soil electrochemical properties were determined: pH in relation 1:2.5 soil/solution in a 0.01 mol L^{-1} $CaCl_2$, KCl and water; point of zero charge – PCZ. Clay dispersible-water was determined by pipette method without chemical dispersion shaker for 2 h. Based on the results, pH in $CaCl_2$ were not changed by weed management. Water-dispersible clay had relation with organic carbon content and decreased with depth increment. The estimated PCZ values were: 4,2 (StDv. 0,54); 3,6(0,54), 3,7 (0,29) and 3,7 (0,37) lower than the pH in all depths which contribute to excess in negative charge. Weed managements in the interrow area did not affect electrochemical properties and flocculation-dispersion of clay fraction.

Keywords: Water-dispersible clay, surface charges, organic carbon.

Pedotransfer functions for critical limits of hydraulic permeability and air permeability for soil from Paraná state

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The saturated soil permeability (K_{sat}) and soil air permeability (K_{ar}) studies are in evolutionary processes in the country, regarding the quantity and quality of the analyses. In the state of Paraná little information are available for these physical attributes of the soil. Critical limits of K_{sat} and K_{ar} are variable according to soil class and crop demand. K_{sat} establishes the relationship between velocity and hydraulic gradient, indicating the permeability of the porous media, in this case the soil. K_{ar} depends on the quantity, size, continuity and geometry of porous space not occupied by water. Pedotransfer functions (PTFs) are used to estimate soil properties that are difficult to measure by other routinely measured properties, which are easier or less costly. In developing countries, empirical-calibrated PTFs are limited because of the lack of large databases. This study aims to determine critical limits of soil water and air permeability from pedotransfer functions for soils in the state of Paraná. Samples of soils with preserved and deformed structures will be collected in different locations in the state of Paraná, to increase a database that will be composed of physical-hydraulic and chemical attributes. K_{sat} will be determined in a constant charge permeameter and K_{ar} will be determined in a permeameter (ArNoSolo) with balanced samples at -6, -10 and -33 kPa matrix potentials. The data will be sorted according to the soil class, textural class, locality, vegetation and current use. Statistical analyses, classical and multivariate, of the physical-hydraulic and chemical variables of the entire database and each classification will be performed. PTFs will be developed for each soil classification. Multivariate and simple linear regressions will be tested. The selection of the variables will be given by stepwise, forward and backward methods, or by factorial analysis. The data will also be verified in models present in the literature for the prediction of K_{ar}. Error measure indices in relation to observed and estimated data will be established for the evaluation of the developed PTFs. For the validation of PTFs, they will be tested with data that did not integrate their development. The critical limits of K_{sat} and K_{ar} will be developed from analysis of crop development, present in each soil and of the physical-hydraulic properties related to compaction.

Keywords: Aeration porosity, database.

Soil moisture prediction in an Atlantic Forest-Oxisol site

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Soil moisture plays a crucial role in the hydrological processes, especially those that involved forest environments. In this context, this study aimed to simulate up to 1.0 m depth soil moisture in an Atlantic Forest-Oxisol site through the Richard's equation solution by means Hydrus-1D. The study was conducted using eighteen sets of hydrological monitoring, framed by a manual rain gauge, a stemflow apparatus and a 1.0 m profile tube to soil moisture measurements. After each rainfall event, throughfall, stemflow and soil moisture were measured between January/2016 and February/2018, forming a based-event dataset. Throughfall and stemflow were then summed to account for net precipitation (NP), which is defined as the gross precipitation (GP) portion that reaches the forest floor. In order to improve the Hydrus calibration, a daily measurement campaign was carried out in January and February of 2018, aiming to refine the water breakthrough in the soil profile. The validation period comprehended the years of 2016 and 2017. For periods longer than 15 days without rain the soil moisture measurement was carried out. Geostatistical procedure was used to map both observed and simulated soil moisture in order to analyze the Hydrus 1D ability to extend the simulation for the entire area. For the calibration phase, NS, ER and RMSE precision statistics ranged from 0.34 to 0.86; 0.0237 to 0.0398; and 0.0095 to 0.0185, respectively. Contrasting, in the validation phase these statistics ranged, respectively, from -0.35 to 0.63; 0.0368 to 0.0760; and 0.0138 to 0.0315. Despite nine sets had presented NS close to zero or even negative, the spatial distribution of the simulated and observed soil moisture was quite similar, allowing to strength the validation of Hydrus 1D under this kind of environment.

Keywords: Hydropedology, Hydrus, water balance.

Surface soil moisture mapping in a watershed located at Lavras, southeastern Brazil

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Water is an important natural resource in agricultural production and maintenance of ecosystems. The understanding of the spatial and temporal pattern of soil moisture is a relevant aspect for water resources management and water-soil-plant relationship investigation. In addition, soil moisture is an important explanation variable for the hydrological processes in a watershed scale. The present study aimed to evaluate the spatial behavior of the soil moisture at 10 cm depth in a watershed located at the Federal University of Lavras (UFLA) during the hydrologic year of 2017-2018. The soil classes in the watershed are composed by 42% of Argisols, 55% of Latosols and 3% of others minor occurrences. Regarding the land cover about 50% of the study area rotates between annual crops (maize) and pasture and the rest is covered by Tropical Mountain Semideciduous Forest (TMSF) and other minor occurrences. Soil moisture measurements were performed using Delta-T devices Ltd. capacitive probes at 26 points along the study area from October 2017 to September 2018. The results were interpolated for the entire basin using inverse distance weighting (IDW) and geostatistical interpolation. The soil moisture showed pure nugget effect for August and September of 2018, being used IDW interpolator for data mapping. For the other months the exponential semi-variogram model was fitted and a strong spatial dependence was observed according to the spatial dependency degree (SDD). Soil moisture in the surface layer ranged from 23.17% in May to 33.35% in December. The seasonality of the soil moisture can be explained by the rainfall regime in the watershed, where the summer is wet and the winter is dry. In regard to the spatial pattern of the soil moisture, lower values were observed in the northwest region. In this region of the watershed there is the occurrence of Argisols and TMSF and this result can be explained by the large forest interception, high concentration of the root system at superficial soil layer, high organic matter concentration and high soil hydraulic conductivity. The south region presented high soil moisture values in the watershed. In this region occurs annual crop with compacted soils and low hydraulic conductivity. We concluded that the spatial behavior of the soil moisture can be affected by soil properties and land use in the watershed scale.

Keywords: Water resource management, hydrology, interpolation.

Spatial behavior of soil saturated hydraulic conductivity in a Eucalyptus stand

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The soil saturated hydraulic conductivity (K_s) is an important hydrological attribute for rainfall-runoff modeling, irrigation and drainage systems, transportation of solutes in the soil, recharge of aquifers, surface runoff and sediment transport. Despite its importance, this attribute presents great spatial variability and its determination is laborious, because requires several field and lab procedures. For these reasons, there are few studies in this area. Therefore, the objective of this study was to analyze the spatial behavior of K_s in a clonal eucalyptus forest. The study area is located in the southern region of the state of Minas Gerais and has an area of 1.54 ha, where 78.6% of it is composed of Red-Yellow Latosol (LVA) and 21.4% is covered by Dark-Red Latosol (LV). In addition, the eucalyptus is planted in three different spacings: 3×2 m (0.77 ha), 3×3 m (0.42 ha) and 3×5 m (0.35 ha). The K_s was determined for 26 points inside the study area using a regular grid with a Guelph permeameter, which determines the K_s *in situ* using the Marriotte principle. The test was performed in the layers of 10 and 20 cm, applying a hydraulic load of 5 and 10 cm, respectively. After the determination of K_s, we use ordinary kriging adjusting a stable semivariogram model, to generate a spatially distributed map of K_s in the study area. We used the stable semivariogram model because it presented a strong spatial dependence degree (89.4%) and good cross-validation statistics, with mean standardized error near zero (0.03) and standardized root mean square near 1 (0.935). We observed that the K_s values ranged from 0.29 to 6.19 $m.d^{-1}$ in the study area. As a result of spatialization, moderate K_s were obtained in 8.3% of the area, mainly in the northeast region of the study area, where there is more concentration of LVA and a 3×2 spacing of plants. moderately fast K_s was present in 90.4% of the area and 1.3% of the area was classified as fast, where LVA soil is predominant. These results indicate that hydraulic conductivity of saturated soil varies not just according to soil type, but also as a function of plant spacing. In addition, it is important to point out that other attributes may also affect the K_s values, such as slope and soil texture. The results obtained in this study are very important for soil and water conservation because it is possible to infer that areas with moderate K_s could have more problems with soil degradation due to surface runoff.

Keywords: Guelph pemeameter, Oxisols, soil physics.

Comparing the soil moisture estimation of the SMOS and SMAP satellites with field measurements in a Semideciduous Atlantic Forest remnant

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Soil moisture plays an important role in the hydrological cycle, as it influences the generation of surface runoff, the groundwater recharge and the occurrence of extreme events such as droughts and floods. The objective of this study was to compare soil moisture products obtained from SMOS (Soil Moisture and Ocean Salinity) and SMAP (Soil Moisture Active and Passive) satellites products with *in situ* measurements made by a Profile Probe sensor at 18 points located in a Semideciduous Atlantic Forest remnant in Southeast, Brazil. The SMOS presents spatial resolution of 40 km, ascending and descending and the SMAP presents spatial resolutions of 36 and 9 km, ascending and descending. Both products have a temporal resolution of up to 3 days and were obtained from the platforms of the European Space Agency (ESA) and North American Space Agency (NASA). Daily field measurements were performed in January 2018 and only the matching dates with the satellite products were used. The Pearson correlation coefficient and the root mean square error (RMSE) were calculated to verify if there was correlation between the field measurements and the satellite data. It was possible to compare 22 measurements with the SMOS satellite products and 25 with the SMAP. A correlation between the field measurements and the satellite products was identified with the Pearson correlation coefficient being 0.71 for the SMOS descending products and 0.73 for the ascending products. For the SMAP data the correlation was even higher, being 0.86 for the ascending products and 0.79 for the descending products with a resolution of 36 km. For the SMAP products with spatial resolution of 9 km, the Pearson correlation was 0.91 for the ascending products and 0.75 for the descending products. Also, analyzing the root mean square error (RMSE) the product that presented the smallest error was the SMOS descending (0.01) followed by the SMOS ascending (0.03), SMAP descending (0.08) and SMAP ascending (0.09). There were no trends of overestimation or underestimation of the soil moisture data obtained by the satellite and, in general, they presented values close to those obtained in the field with the Profile probe sensor.

Keywords: Soil moisture, remote sensing, Semideciduous Atlantic Forest

Soil electrical resistivity as indicator of changes caused by occasional tillage in continuous no-tillage system

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Soil compaction in a continuous no-till system is a problem in Brazilian agriculture. The main causes are the lack of crop rotation, low input and persistence of the straw, traffic of heavy machinery and implements and traffic under inadequate soil moisture conditions. Non-invasive methods to diagnosis and monitoring of soil compaction are important because of their practicality, speed and low cost. Thus, the objective of this work was to evaluate the changes promoted by the occasional tillage in continuous no-tillage system in the soil electrical resistivity (SER). The experiment was set up in October 2015 on the Santa Helena Farm, Nazareno – Minas Gerais/Brazil, in a soil classified as a Typic Hapludox clayey texture. The following treatments were used: CNT – continuous no-tillage system (13 years); CNTS2 - continuous no-tillage system with subsoiling (Ikeda) every two years; CNTS3 - continuous no-tillage system with subsoiling (Ikeda) every three years; CNTSK - continuous no-tillage system with subsoiling (Kamaq) in 2015; continuous no-tillage system with subsoiling (Ikeda) in 2015; continuous no-tillage system with chisel plowing in 2015. The SER was conducted in August 2018 in a dipole-dipole array with 24 electrodes spaced 0.19 m. The transect was installed perpendicular to the occasional tillage and sowing rows. The SER was lower in the superficial layer (0.0 - 0.20 m) and higher in subsurface (0.20 - 0.50 m). The CNTS3 had the highest SER independent of depth (min = 25 Ωm and max = 1157 Ωm). The depth of 0.20 - 0.50 m of the CNTS3 showed the highest values. The other treatments presented similar values of SER. The results are due to the time between the occasional tillage and the SER evaluation. The CNTS3 was subsoiled two months before, the CNTS2 14 months and the other treatments the occasional tillage 36 months. The occasional tillage alleviates the soil structural conditions under continuous no-tillage system, increasing its porosity and reducing the bulk density and penetration resistance, consequently increasing the SER. SER is sensitive to the changes promoted shortly after occasional tillage in the soil structure, however, the persistence of this practice in the SER is short-term.

Keywords: Subsoiling, chisel plowing, soil compaction.

Compaction curve and mechanical behavior of a Latosol in Direct Drilling System for biofuel crops

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In Direct Drilling System (No-tillage System) soil compaction is one of the main processes of physical degradation. The aim of this study was to assess mechanical behavior of a Typical Dystroferric Red Latosol from compaction curve and estimate critical soil bulk density for biofuels crops in a. A field experiment was installed in October 2012 at the experimental station of the Agronomic Institute of the State of Paraná - IAPAR, in Londrina, State of Paraná and Southern Brazil. The experiment was installed in randomized complete block design, eighteen treatments with three replicates. Six crop rotation were selected to assess mechanical behavior. T1 – Soybean / Black Oat cv. Iapar 61 Ibiporã; T2 – Soybean / Maize; T3 – Soybean / Safflower (*Carthamus tinctorius* L.); T4 – Maize / Safflower; T5 – Maize / Maize; T6 – Maize / Black Oat. Disturbed soil samples were collected in September 2018, at the 0–0.1 m and 0.1 – 0.2 m layers. Proctor test with intermediate energy of compaction and soil reuse was done using a 4.5 kg hammer and a fall distance of 0.42 m, with large cylinder following the Brazilian Standard NBR 7182 (ABNT, 1986). Based on the results from compaction curves, there was no significant difference for the parameters of critical humidity and maximum soil density in the experimental area it was possible to concluded that crop rotation with biofuels crop species did not affected soil mechanical behavior. Therefore, all the observed data were used to regression analysis and obtained a single quadratic equation: $Ds = - 41.98\ Ug^2 + 24.46\ Ug – 2.04$; $R^2 = 0.94^{**}$; n = 41. Critical soil bulk density that cause root restriction of annual crops – CDB, was estimated by the equation developed for Bolivian Soils by Barber (1991) CBD = 320 / [166 + (% silt + % clay]. Values were considered high when field soil bulk density are higher than 1,25 kg dm^{-3}. This result is agreement with previous studies done for the same soil. Therefore, the equation above for determine critical soil bulk density must be useful for Brazilian soils. Maximum soil bulk density calculated through quadratic equation was 1.55 cm^3. Meanwhile, for critical soil moisture was 0.290 kg kg^{-1}.

Keywords: Crop rotation, critical soil bulk density, critical soil moisture content.

Physical properties of an Argisol cultivated with vegetables in direct seeding system

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The implementation of the Direct Planting System (SPD) in Brazil began in 1970, almost 50 years ago in the states of Paraná and Rio Grande do Sul, and is currently adopted in almost all regions of the country. Initially the SPD was considered a technology for large producers, however IAPAR (Paraná Agronomic Institute) and Emater (Paranaense Institute for Technical Assistance and Rural Extension) of Paraná, promoted and have been promoting adaptation and adoption of technology for small properties for vegetable production (SPDH - Direct Planting System for Vegetables), which has not yet been disseminated in the region of Oeste Paulista. According to Lima and Madeira (2013) the SPDH can provide benefits such as reduction in floods around 90%, minimizing erosive processes; water savings in irrigated crops by up to 30%; the reduction in mechanization by up to 75%; the thermal regulation provided by straw with reduction of temperature extremes up to 10ºC at the soil surface; Therefore, the objective of this project was to evaluate the physical attributes of the soil after harvesting the cabbage in different vegetation cover and two planting systems. The experiment was designed in randomized blocks, with four replications in subdivided plots. The treatments were three vegetal coverages in the plots (lupine, black oats, 70% of lupine + 30% of black oats), and two cropping systems in the subplot (no-tillage and conventional), after the development of the vegetation cover until the beginning of the flowering the plants were grazed, and later the cabbage was transplanted. The soil resistance to penetration was analyzed with Falker's penetroLOG device, which stores the data in an internal memory and after sampling, the data are analyzed by the software provided by the company. These samples were performed in four points per plot, and then, 2 replicates per treatment. Since it is the beginning of the system, there isn't a consistent data on soil's physics as a whole yet, besides it's possible to visualize a layer that is thicker in the 10-20 cm, however far from being a compacted layer. It is expected that with the follow-up of the project, in some years it will be possible to verify the improvement in the soil's physical attributes.

Keywords: SPDH, vegetable cover.

Aggregate stability index and total organic carbon as soil quality indicators in different land uses in Southern Brazil

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Aggregate stability and total organic carbon are soil quality indicators well-reviewed in the literature. Monitoring such indicators may help farmers, advisors and researches to manage soils in order to promote sustainability. This study aimed to assess soil aggregate stability and total organic carbon in different management systems in order to identify changes in soil quality according to farming practices. The study was carried out in the Atlantic Forest biome located on the coast of the Brazilian state of Paraná, in the municipality of Morretes, during 2017/18. Soil samples were taken in the 0-25 cm depth in five different fields: conventional vegetable farming (CF), organic vegetable farming (OF), agroforestry systems of 7 (AGF7) and 11 (AGF11) years old and native vegetation (NV). Soil order according to the World Reference Base (WRB/FAO) was Cambisol for all fields, with clay content ranging from 29 to 55%. The aggregate stability index was calculated as the ratio between the wet and dry mean weight diameter, wherein an apparatus for vertical oscillation with three sieve sizes (2000, 250 and 53 μm) were used. Total organic carbon was determined by dry combustion on a Vario EL III CHNOS elemental analyser. The soil aggregate index and total organic carbon in the CF, OF, AGF7, AGF11 and NV were: 68 and 1.35, 71 and 2.04, 79 and 1.54, 76 and 2.03, 87 and 2.48%, respectively. The Pearson correlation between aggregate stability index and total organic carbon was 0.56 ($p<0.01$). Both soil quality indicators were efficient to identify changes in the land uses and they were moderately correlated with each other, with lower values for the CF, intermediate values for the OF, AGF7 and AGF11 and higher values for the NV. These results confirm the significant contribution of organic vegetable farming and agroforestry systems, as their agroecological managements enhanced soil quality in Brazilian Cambisols in comparison with conventional vegetable farming. The higher aggregate stability index in the agroforestry systems than in the organic farming is probably related with more plant biodiversity and litter inputs in the field, which adds carbon to the soil and contributes to aggregate stabilisation. Overall, the use of aggregate stability and total organic carbon were efficient to detect changes in soil quality in different management systems, which strengthens their fitness as soil quality indicators.

Keywords: Agroecological farming, agroforestry systems, Brazilian Cambisols.

Root and aerial part production of corn plants cultivated in two soils submitted to artificially compaction

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Soil compaction is a limiting factor for crops, affecting the aerial part and root system of plants. Although soil bulk density is the primary indicator used to measure soil compaction, the relative density has been preferred when different soils are compared. In this scenario, this study aimed to evaluate the effect of relative density on the root and aerial part production of corn plants cultivated on two artificially compacted soils of contrasting texture. Samples collected from 20 to 40 cm depth of two Oxisols (sandy and clayed) were used to fill rigid PVC tubes composed by three joined segments. The upper (height 5 cm) and lower segments (height 10 cm) were filled with a soil mass to obtain a bulk density of 1.0 kg dm^{-3}, while the intermediate segment (height 10 cm) was filled to reach the degrees of compactness of 75, 80, 85 and 90% (DG75, DG80, DG85, and DG90). Corn plants were cultivated during 45 days, and after the harvest, the aerial part and root system were collected for the dry mass estimation. The corn aerial part production was increased in the sandy soil up to DG80, reducing in the larger DGs values. In the clayey soil, aerial part production was reduced with increasing DG. The corn root production decreased with increasing DG in both soils, mainly in the sandy soil. The fact of root production did not increase with DG disagreed with our hypothesis, because we expected under soil compaction stress, the plants would direct their growth to the root system, disfavoring the aerial part. Neither the root/aerial part ratio increased with increasing DG, except just for the sandy when moving from DG75 to DG80. The maximum root/aerial part ratio was verified in DG80 and DG75 for sandy and clayed soil, respectively, with root production representing circa 10% of aerial part production in both soils. In general, the results showed similar effects of soil compaction decreasing root system and aerial part of corn when cultivated in clayed soils. In sandy soil, the main effects of soil compaction are in the root system of corn plants.

Keywords: Degree of compaction, relative bulk density, sandy soil.

Methylene blue adsorption on biochars from eucalyptus wood: the effect of the heat treatment final temperature in the pyrolyze process

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Amazonian soils whose properties resulted from intense anthropogenic activities, known as "Terras Pretas de Índio" (TPI), have attracted great attention due to their high fertility which has been attributed to their high contents of biochars (BC). In addition to this ability to improve soil fertility, BC are more recalcitrant organic carbon forms, generating a great environmental and economical appeal for their use as sustainable soil modifiers. However, understanding the physical-chemical properties of BC surface is fundamental to modulate their applications. Here, methylene blue (MB) was used as a molecular probe to evaluate the adsorption process occurring on the surface of BC obtained from different heat treatment final temperatures (T_f) of eucalyptus wood (EW). For the BC production, EW was submitted to an initial temperature of 100°C and heated to T_f values of 350, 450, 550 or 900°C. The heating rate was 1°C/min. For each BC (BC350, BC450, BC550 and BC900), adsorption isotherms of AM were obtained by mixing 10,00 mL of AM solutions, at different concentrations, with 20,0 mg of BC, at 25°C. Each system was stirred and left to reach the thermodynamic equilibrium. Then, aliquots of the samples, without the BC, were collected and analyzed spectrophotometrically for determination of the MB equilibrium concentration. The isotherms were fitted by Freundlich and Langmuir models, being the latter the best one ($R^2 > 0.993$). The BC adsorption capacity (Qe) depended on T_f, decreasing in the order Qe (BC900) ≈ Qe (BC350) > Qe (BC450) > Qe (BC550). This behavior resulted from the difference among the surface composition and structure of the BC, which depended on T_f. Biochar characterization showed that when T_f increased from 350 to 550°C, the carboxylic groups content on the BC surface decreased. At the same time, the pH of the solutions was greater than 7, in which MB was positively charged ($pK_a = 5,40$). Thus, the intensity of non-hydrophobic interactions, especially attractive electrostatic ones, between the BM and the BC surface decreased as T_f increased, causing the Qe decrease. For BC900, FTIR analysis showed a lack of oxygenated functional groups on its surface, providing a high hydrophobicity that favored hydrophobic interactions between the MB hydrophobic groups and the.

Keywords: Methylene Blue, biochars, adsorption.

A new version of the PDI retention and conductivity curve

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Different approaches to extend the range of most commonly used soil water retention $h(\theta)$ and $K(h)$ functions are available in literature. An example is the PDI model. It uses a smooth function to extend the reliability of the output data of retention and conductivity curves. In this work we show a new version of the PDI model, removing the need of rescaling the relative saturation function. The new model is interchangeable with other models like Kosugi, Groeneveld & Grant and van Genuchten with Mualem's restriction models. A modification to remove the residual water content in retention functions with mathematical structure $\theta=\theta_r+(\theta_s-\theta_r)S(h)$ is also proposed [θ_r is the residual water content, θ_s is the saturated water content and $S(h)$ is the relative saturation]. With the proposed modification, the soil water retention curve becomes anchored to an arbitrary point (θ_i, h_i). The modifications in the PDI model do not require a new parameterization. The new model is more intuitive, allowing the use of available soil parameters without changes.

Keywords: Soil hydraulic properties, PDI model.

Maintenance of the sugarcane straw on the soil mitigates the impacts of the cultivation on the Oxisol physical quality

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In last decade, the sugarcane production in Brazil has undergone changes in the harvesting system, changing from the burn crop system, followed by manual harvesting, to the system without burning and using mechanization. However, the mechanized harvesting system leads to an intensive traffic of machines and implements, and can contribute to the soil physical degradation in agricultural areas, leading to soil compaction. Thus, straw, derived from sugarcane harvesting, can mitigate the negative effects of compaction on soil attributes and intervene positively on the soil physical quality. In this sense, the objective was to evaluate and compare the soil physical quality in areas cultivated with sugarcane with maintenance of the straw on the soil, after the first and fourth harvest of the crop, with an area of native forest. Two areas cultivated with sugarcane, representative at the beginning and at the end of the productive crop cycle, were evaluated in a Red Oxisol with a very clayey texture. One area was evaluated after the first mechanized harvesting (C1) of the sugarcane and the other after the fourth harvest (C4). These areas were compared to an area of native forest (NF). In each area, 30 disturbed and undisturbed soil samples were collected in the 0.00-0.20 m, 0.20-0.40 m and 0.40-0.60 m layers, determining the stability aggregate index, organic matter, soil bulk density, soil penetration resistance, macroporosity, microporosity and total porosity. For the characterization of the areas and layers, descriptive statistics were used for each soil attribute in relation to the natural ecosystem (NE). Due to the dependency structure contained in the original set of variables, the data were submitted to the principal components multivariate analysis. The C1 area presented soil structural quality lower to the NE area. The C4 area presented an intermediate condition between NE and C1. Macroporosity and soil bulk density were the most sensitive soil physical attributes in the area discrimination. This indicates that these attributes are those that correlate more closely with the changes occurred on the soil structure in areas of sugarcane compared to the native forest area. The negative impact of sugarcane crop on the soil physical quality is attenuated after four crop harvests in areas with mechanized harvesting and with maintenance of straw on the soil, especially in the 0.00-0.20 m layer.

Keywords: Macroporosity, bulk density, soil penetration resistance

Physical attributes and organic carbon of Red Oxisol under fertigation with treated sewage effluent levels

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The agricultural wastewater use is an alternative to supply the crop water and nutritional demands. However, the application of the residue over a long period can damage the soil attributes. The aim of this study was to evaluate the soil physical attributes and organic carbon content of an Oxisol under application of treated sewage effluent (TSE) levels. The experiment was carried out in an area under TSE application for 4 years (2013 to 2017), in an Eutrophic Red Oxisol cultivated with *Urochloa brizantha* (cv Marandu). The irrigation depth was constant for all treatments. However, TSE levels in the irrigation depth were 0%, 11%, 31%, 60%, 87% and 100% for treatments E0, E1, E2, E3, E4 and E5, respectively, with 4 repetitions. The irrigation depth applied during the 4 years was 8,493 mm. An undisturbed and one disturbed soil sample was collected for each repetition in 3 layers (0.00-0.10 m, 0.10-0.20 m, and 0.20-0.30 m). The variables evaluated were macroporosity, microporosity, soil bulk density (Sd), soil penetration resistance (SPR), particulate organic carbon (COP) and organic carbon minerals associated (COAM), aggregate stability index (ASI), water rate infiltration (WRI), aggregate weighted mean diameter (WMD) and aggregate classes (AC). Descriptive statistics of the evaluated attributes and multivariate statistics were performed by analysis of main components and factors for the identification of processes. Through the factor multivariate analysis, three processes were identified: soil aggregation (40% of total variability), soil porosity (14%) and water rate infiltration (13%). No significant differences were observed for any soil process in function on the applied TSE levels. By the analysis of main components only differences between layers were verified, with the layer of 0.00-0.10 m presenting higher aggregation and particulate organic carbon content and minerals associated. From the data set, SPR varied between 1.5 and 2.8 MPa, at Sd between 1.3 and 1.5 kg m^{-3}, WMD between 3.5 and 5.1 mm, ASI between 88 and 95%, COP between 2 and 7.1 g dm^{-3} and COAM between 12 and 22 g dm^{-3}. The TSE application, regardless of the level, does not alter the aggregation, porosity and water rate infiltration in the soil. Surface layers presented higher aggregation than subsurface layers. The application of TSE does not increase the soil organic carbon content.

Keywords: Soil aggregation, soil water infiltration, wastewater.

Modeling soil moisture using electrical resistivity in Oxisol

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The evaluation of soil moisture is an important factor for the good performance of the crops, however under field conditions this becomes a difficult task, especially on large surfaces. In this sense, the soil electrical resistivity can be used for soil moisture indirect estimation. We aimed to model soil moisture as a function of soil moisture in order to obtain a calibration equation for tropical conditions to better water management. The study was conducted under coffee crop in Lavras, Minas Gerais state. Undisturbed soil samples were collected in three replicates, using plastic PVC cylinders, in the coffee planting line on the superficial layer of an Acrustox. In the laboratory the samples were saturated, and then air dried for 25 days. While losing water, the samples were weighed daily and the electrical resistivity measurements were performed simultaneously with the X5xtal 250 Auto Energy Resistivity Meter. The work was conducted in a Wenner arrangement, with four electrodes spaced 1.9 cm apart and inserted at a depth of 5 cm, to calculate soil apparent electrical resistivity (ϱ). At the end, the samples were dried in an oven at 105-110ºC to determine the soil density (Ds) and the volumetric moisture (θ) at the time of each measurement. The data of θ as a function of ϱ were adjusted using three different models: power (θ=a*ϱb), exponential (θ=a*exp(b*ϱ)) and logarithmic (θ=a+b*log10(ϱ)). Values of ϱ less than 1 were not considered for model adjustment. The coefficients of adjustment (a and b) were significant (p <0.001) for the three adjusted models, however, power model presented the lowest RMSE (0.060 m^3 m^{-3}) and higher R^2 (0.71), followed by logarithmic model (RMSE = 0.074 m^3 m^{-3} and R^2 = 0.69) and the exponential model presented the worst fit (RMSE = 0.074 m^3 m^{-3} and R^2 = 0.56). The Akaike Information Criterion (AIC) indicated that the power model best described the relationship between θ and ϱ, corroborating with other studies for temperate climate soils. Therefore, soil moisture can be estimated by the electrical resistivity through the power model for tropical climate Oxisol.

Keywords: Laboratory calibration, tropical soil, soil water.

Egg shells versus sludge from water treatment as soil conditioners

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The roots, besides attaching plants in soil, play a fundamental role in the absorption of water and mineral salts. The application of gypsum is an alternative to improve soil structure, allowing plant root systems reach greater depths, thus enabling access to a higher water content. The eggshell, as it presents chemical characteristics similar to gypsum, can provide the same benefit in soil. In the same way, the sludge from water treatment could be another alternative, due to its alkalinity characteristics. The objective of this work was to evaluate the influence of the use of crushed egg shell (CES) and water treatment sludge (WTS) on root growth of corn, soybean and bean seedlings after a 5-day incubation period. For this, a laboratory experiment was carried out with four treatments: soil (T0), soil with CES (T1), soil with WTS (T2) and soil with gypsum (T3) each with 5 replicates. The soil used in the experiment was collected at the campus of the Federal University of Lavras at 0-20 cm depth, air dried and homogenized in a 2 mm sieve. For seedlings development were used plastic cups with small holes in the base to drain excess water. In the cups were added 200 cm^3 of soil in all treatments, added to 2 g of CES for T1, 2 g of WTS for T2, and 2 g of gypsum for T3. The volume of water added was equivalent to 1/3 of the total volume of the plastic cup. Then, three previously germinated grains of each species were seeded according to each treatment. The cups were transferred to a box covered with film paper to prevent evaporation of water. After four days, the plants were removed from the cups and the roots were evaluated by determining the length of the main roots using a ruler. The results were submitted to analysis of variance and the means were compared by the Tukey test at 5%. For corn culture, it was observed that the use of CES promoted a greater root growth compared to the other treatments, and T0, T2 e T3 presented similar averages. For soybean and bean, the averages of root growth were significantly similar for all treatments. This led to the conclusion that crushed egg shell can be used as a conditioner of soil physical quality in corn culture.

Keywords: Soil fertility, root growth, gypsum.

Effect of flax cultivation on aggregates morphometry in an Inceptisol

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The flax can be considered an alternative for greater diversification of productive systems, being of great relevance its implementation in crop rotation (Stank et al., 2017). Due to the importance and improvement that the culture can promote in relation to the physical aspects of soil (Carducci et al., 2017; Kohn et al., 2016), and for presenting high productive potential, especially in the southern of Brazil, scientific studies of flax are still limited (Bassegio et al., 2012). Based on the aforementioned information, the present study had aimed to evaluate the physical quality of an Inceptisol clayey (507 g kg^{-1}, 415 g kg^{-1} and 78 g kg^{-1} of clay, silt and sand, respectively), characterizing the aggregates morphometry under the cultivation of three genotypes of flax. The experiment was carried out in 2016 in an experimental area belonging to the UFSC – County of Curitibanos (27°16'58" S and 50°35'04" W) with climate Cfb type. The plant materials used were three genotypes of flax: the golden variety, and the brown cultivars Aguará and Caburé - INTA. Reaching the plant harvest stage, soil blocks were collected in the row and interrow of cultivation, at depths of 0-0.05 m and 0.05-0.20 m, which they passed through a set of sieves with a mesh size of 9.52-4.76 mm and 4.76-1 mm, subjected to light movements in pre-established quantities. 60 aggregates were chosen randomly and placed on a desktop scanner and the acquired images were processed in the program Quantporo, which analyzes taking geometric measurement and the shape, such as the surface area and the aspect of the aggregates. The data were submitted to analysis of variance and, when pertinent, the means were compared by the Tukey test ($p < 0.05$) using the Sisvar program. The aggregates evaluated had a surface area of ≈ 0.12 cm^2 for those retained in the range of 4.76-1 mm and did not differ significantly. The aggregates retained in a sieve with a mesh of 9.52-4.76 mm also did not differ significantly, and they presented more than 0.26 cm^2 of surface area. Aggregates with larger area, are related to a better structure, and can be considered good indicator of soil physical quality. Regarding its aspect, the aggregates reminded the shape of a cube with values about 0.84. Considering that the flax was cultivated in a minimum cultivation system, the non-tillage of the soil was one of the main factors for its good aggregation.

Keywords: *Linum usitatissimum* L., soil structure, soil aggregation.

Performance of a Physical-Distributed Hydrological Model Using Soil Map Based On Geomorphology

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Hydrology modelling is an important tool to simulate changes in watershed and anticipate its response in terms of water efficiency. In order to represent the basin, it demands as an input a soil map. Each class is a representation of soil with similar characteristics, used to identify the soil parameters used in the equations for the model. As geomorphology is known as one of the primary characteristics in soil formation, this study aims to use soil maps based on terrain morphology as an input for a Distributed Hydrology Soil Vegetation Model (DHSVM). The study was carried out in a micro subbasin (6,76 km^2) located at the Mantiqueira Range, among the Minas Gerais and Rio de Janeiro boarder, in Brazil. The area is composed by 63% of native vegetation (Atlantic Forest) and the remaining 37% of pasture. The Geomorphons tool was used to generate the soil map with a Digital Elevation Model (DEM) of 30m resolution and look up distance of 25 pixels, same as previous studies in the same basin. Meteorological and precipitation data was used in hourly time step from October of 2006 to September of 2010. The first two years were used for calibration and the following for validation. The parametrization of the model was carried out using previous studies as reference. For the calibration it was altered the soil hydraulic conductivity parameter for each soil class in order to achieve the highest adjustment for Nash-Sutcliffe (NSE) index in runoff simulation. As a result, it was obtained seven classes for the soil map based in geomorphology. The NSE for daily runoff data in calibration period was 0,60 and 0,57 for validation. While changing the soil map and calibrating a single soil parameter, the adjust of the model improved considerably from previous study were the NSE was 0,52 for both periods. It also improved runoff simulation in the dry season, reducing underestimation. As for evapotranspiration, no major difference occurred, remaining the same 47% of precipitation. In conclusion, the geomorphology map was able to better represent the basin over DHSVM in terms of runoff simulation.

Keywords: Geomorphons, DHSVM.

Aggregation of soil is influenced by the use of inoculants with arbuscular mycorrhizal fungi?

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Intensive use and inadequate management of grazing areas cause degradation of the soil structure, reducing its productive potential and pasture yield. Adoption of alternative technologies is necessary to improve the capacity of use and management of soil, making this system more sustainable. In this context, the objective was to evaluate the inoculation of different species of arbuscular mycorrhizal fungi (AMF) in *Urochlo*a híbrido stability of aggregates in a ferruginous nodular Gley soil in Cuba. The experiment was conducted out in the Pastures and Forages Station of Cascajal Villa Clara Province, Cuba, using híbrido *Urochloa* cv. CIAT BR 02/1752, inoculated with three strains of AMF EcoMic® (*Glomus cubense, Funneliformis mosseae* and *Rhizophagus intraradices*), produced in the Instituto Nacional de Ciências Agrícola (INCA) – Cuba in a Ferruginous Nodular Gley soil, whose chemical characteristics were: pH (H_2O) = 4.7; Ca= 3.5 $cmol_c$ dm^{-3}; Mg = 1.2 $cmol_c$ dm^{-3}; K= 0.11 mg dm^{-3}; P= 2.2 mg dm^{-3}; MO= 2.43 dag kg^{-1}. The design was in randomized blocks, in a factorial scheme 4x2 with inoculation and not inoculation treatement, four replicates and two times. Soil samples were collected at (end of rainy season (2014) and beginning of rainy season (2017) in the 0-10 cm layer, being evaluated the number of spore (NS), the production of glomalin-related soil protein (GRSP), the length of extraradicular mycelium (ML), the coefficient of structural stability of the soil through dry sieving (Kes) and immersed in water (Keh) and the Soil Structural Stability Index (Ie). Greater stability of the aggregates obtained by dry sieving (Kes) was verified at 876 days of cultivation, under the influence of the AMF inoculation. With emphasis on inoculation with *G. cubense*, which presented higher (Ie) and higher (ML) at 876 days of cultivation. The influence of inoculation on soil aggregates is associated to the effect of ML and the cementing action of GRSP. The mycelia act in the directing and folding of the mineral and organic particles of the soil that favors the aggregation. These results showed the importance of inoculation and/or management of native AMF for formation and stability of soil physical structure.

Keywords: Extraradicular mycelia, glomalin, aggregate stability.

Determination of field capacity in situ using water with magnetic treatment

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The knowledge of soil moisture is very important, as it indicates at what water conditions the soil is. The amount of water to be applied by an irrigation system is directly linked to soil moisture. There are two soil attributes that are of fundamental importance for the understanding and use of soil moisture data: the permanent wilting point (PWP) and the field capacity (FC). The FC is defined as the upper limit of water retention of the soil, being the maximum amount of water that it can retain without causing damage to the system and the PWP the lower limit. The present work aims to determine in site the humidity at FC of a clayey soil for irrigation management of a dripping system for lettuce. This work was conducted inside a greenhouse of Water Resources and Sanitation department of the Federal University of Lavras. The study was conducted in two beds with dimensions of 1.2×2.4 meters, where a battery with 3 tensiometers of 12.5 cm depth, 3 tensiometers of 25 centimeters depth and 2 tensiometers 40 cm deep was installed at each bed. After assembly, the beds were saturated for approximately 3 days until the tensiometers recorded the saturation tension, 0 kPa, using common water in one bed, and magnetized water in the other bed. With the soil saturated a plastic canvas was placed on the beds to minimize water loss by evaporation. Then the tension was monitored and nine soil samples per bed were taken, three at each depth, to define the correspondent humidity. The FC humidity was defined as the one where the humidity variation stabilized, that is, when it varied less than 15% between the time interval of one day. For the bed with the use of magnetized water the moisture and the FC tension were 0.297 cm^3cm^{-3} and 10 kPa respectively, and for the bed with common water the humidity and the FC tension were 0.342 cm^3cm^{-3} and 10 kPa respectively. These values can be explained by the difference in soil density between the beds, since the bed with magnetized water density was 0.988 g cm^{-3} and the bed with common water density was 1.135 g cm^{-3}. Furthermore, the higher moister for the soil irrigated with magnetized water could be due to the magnetic field which changes the structure and some physical characteristics that makes the water molecules more cohesive and more difficult to drain, as it penetrates more easily into the micro spaces of the soil particles.

Keywords: Soil water retention, soil moisture, magnetic water.

Gaussian Sequential Simulation and Ordinary Kriging geostatistical methods for evaluating the saturated soil hydraulic conductivity and spatial variability in a headwater watershed

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The saturated soil hydraulic conductivity (K_{sat}) is one of the key factors to understand the different processes of the hydrological cycle, as well a critical parameter for the application in hydrological models. It is influenced by intrinsic and extrinsic soil factors, which are responsible for its different spatial distribution patterns. The objective of this work was to use the Ordinary Kriging (OK) and Gaussian Sequential Simulation (GSS) geostatistical methods to evaluate which is the best one to characterize the K_{sat} spatial variability structure in a headwater watershed called Sanga Ellert Watershed (SEW), Southern Brazil. The SEW is located in the municipality of Canguçu, Rio Grande do Sul state, Brazil, and has an area of 0.66 km², relief varies from undulated to strong undulated with predominantly shallow soils. Undisturbed soil samples were collected, in the 0-0.20 soil layer, to determine K_{sat} values in each point of an established grid of 179 points. An exploratory analysis was performed to calculate the descriptive statistics and to check the normality of K_{sat} data set. Anisotropic experimental and theoretical semivariograms were calculated to map the K_{sat} spatial variability by the OK method. The GSS method was used to generate 100 equiprobable fields of K_{sat}, which were adequately validated. Results showed that all histograms of the simulated data were quite similar to those of the observed data. Similar results were found when comparing simulated and experimental semivariograms for each equiprobable field. The map generated by OK produced an overestimation of low values of K_{sat} and an underestimation of high values of K_{sat} in the studied area, while the SSG maps did not present such drawback. It can be concluded that the GSS geostatistical method was the best one to characterize and map the K_{sat} spatial variability structure in the study area, since it was more efficient to replicate the statistics measures of the K_{sat} data distribution, providing a better local estimate of its values.

Keywords: Uncertainty analysis, geostatistical simulation, soil spatial variability.

Mechanical and vegetative practices in soybean root development on soil compaction levels

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The soybean root development is strongly influenced by soil structure conditions. Management systems that cause soil compaction, can generate stresses and change the plant roots behavior. Therefore, it is necessary to use practices to mitigate compaction and thus minimize its effects. The objective of this study was to evaluate the soybean root development on different compaction levels, after mechanical and vegetative practices of compaction mitigation. The study was carried out in Candói / PR in the year 2018. The soil in the area is an Oxisol, with 52% clay and 5.5% organic matter in the surface layer. The experiment was designed in a randomized block with three replicates, in a factorial with 2 compaction levels: 0 and 440 kPa, 2 cropping systems: barley-soybean (BS), millet-oat+turnip-soybean oats (MOTS) and 3 mechanical practices: seeder equipped with double disc (DD), equipped with chisel plow (CP) and chiseling (CH). The roots were sampled by the monolith method up to 50 cm depth, scanned and processed by the Winrhizo software to determine the diameter and length, and dried in an oven to determine the dry mass. Among the compaction levels, the main variation occurred in the root length, which the compacted area presented higher values (2.46 cm cm^{-3}) than area without compaction (2.29 cm cm^{-3}). Among the cultures, BS had the highest values: diameter of 0.239 mm; length of 2.44 cm cm^{-3} and mass of 442.76 g m^{-3} in the profile, while MOTS presented: 0.226 mm; 2.31 cm^{-3} and 427.06 g m^{-3} respectively. Comparing the mechanical practices, mean root diameter was higher in the CP treatment (0.242 mm), followed by DD (0,231 mm) and finally the CH (0.225 mm). The CH treatment presented higher root length and mass in relation to the other treatments, however this behavior was due to the higher root concentration in the 0-10 cm soil layer. In the mean profile, roots of the CH treatment presented length of 2.45 cm cm^{-3} and mass of 454.93 g m^{-3}, CP treatment of 2.28 cm cm^{-3} and 445.77 g m^{-3}, and DD treatment of 2.40 cm^{-3} and 404.03 g m^{-3}, respectively. We concluded under the study conditions that soybean crop develops more roots in compacted soil, chiseling practice increases the amount of roots on the surface and decreases in depth, and the use of barley in the winter causes more rooting of the soybean crop.

Keywords: No-tillage, compaction, chiseling.

Stability of aggregates in Brazilian Latosol (Oxisol) under no-tillage system in the semi-arid region of Paraíba state

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Aggregate stability is an indicator of soil quality and its formation involves a set of mineral and organic elements. However, it is sensitive to soil management practices and its formation is affected in areas with low supply of organic matter. No-tillage can be a sustainable practice for the promotion of vegetation cover in semiarid soils, favoring the formation and stability of aggregates. The Objective of this work was to evaluate the aggregate stability index (SI) in a yellow Latosol (LA) under no-tillage system in the Agreste mesoregion native of Paraíba. The experiment was installed in 2013 in an experimental area of the Centro de Ciências Agrárias, Universidade Federal da Paraíba - Areia (PB) (Lat. 6 ° 58 ' 12 ' ' S e Long. 35 ° 43 ' 44.4 ' ' W, altitude of 618 m). The experimental design was in randomized blocks with 11 treatments and 5 replications in LA of sand clay texture (563; 49; 388 g kg^{-1} sand, silt and clay). The treatments were arranged according to Plan Puebla matrix, resulting in the combination of five doses, in kg ha^{-1} by N-CH_4N_2O and five doses of K- KCl, more control without fertilization. T_1- (30 N e 24 K); T_2- (30 N e 56 K); T_3- (70 N e 24 K); T_4- (70 N e 56 K); T_5- (50 N e 40 K); T_6- (5 N e 24 K); T_7- (95 N e 56 K); T_8- (30 N e 4 K); T_9- (70 N e 76 K); T_{10}- (5 N e 4 K); T_{11}- (No fertilization). The soil samples were collected in the layers of 0.00-0.10 and 0.10-0.20 m depth, air-dried and analyzed in the Laboratory of Soil Physical Analysis of the Universidade Federal da Paraíba for determination of aggregate stability and obtaining the SI. The best values of SI for the depth of 0.00-0.10 m were verified in the T_4- 0.71 e T_{10}- 0.72 when samples were collected online. In the interline for the same depth the best averages were verified in the T_5- 0.73 e T_{11}- 0.75. For the 0.10-0.20 m layer, the best averages were verified in the T_3 e T_4, both with SI = 0.69. And in the interline the highest value of SI was verified in the T_{10}= 0.79. It was concluded that there was no significant interaction between the fertilizer doses and the forms of collection for the SI in no-tillage system in Agreste native of Paraíba, after five years of adopting the system.

Keywords: Aggregation, conservation management, no-tillage.

Potassium adsorption on substrate formulated with vermiculite and peat

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Substrates are used as growth medium and its components can be varied, being difficult to characterize the physical, chemical and nutritional parameters of them. In order to improve productive management, as well as minimize losses caused by irrigation excess and nutrient leaching, classification of substrates and their components is necessary. Thus, this paper aims to analyze the potassium adsorption dynamics in a substrate formulated with peat and vermiculite with the proportion of 25% and 75%, respectively, carrying out batch experiments with contact times of one and seven days, fitting the parameters of Linear, Langmuir and Freundlich sorption mathematical models, also verifying the suitability of these models to the observed data. To this end, 5 g of substrate and 75 mL of Potassium Chloride solution were placed in beakers at concentrations of 0, 25, 50, 75 and 100 mg/L of K. After the determined period, the supernatant solutions of the beakers were filtered, being the equilibrium concentration (Ce) of K determined using a flame photometer. To quantitatively characterize the mathematical models of sorption isotherms fitting to the observed data, we used the root mean square error (RMSE), Mean Absolute Error (MAE), coefficient of determination (R^2) and the F test. We observed that there was higher adsorption in the substrates with higher initial concentrations K, e.g. for 100 mg/L of K, the adsorption value was 750 mg K/kg substrate. For the one day of contact between substrate and K solutions the Linear model (kd = 17.99) had best fit to describe the adsorption process, with values of 0.97 to R^2; 29.21 for the F test, 81.22 to MAE and 101.24 of RMSE. For the samples that remained in contact with the K solutions for seven days, the Freundlich model (n = 0.81 and kf = 7.71) was the best to describe the adsorption phenomenon, with a value of 0.95 to R^2; 48.88 for the F test, and 45.85 and 71.42 for MAR and RMSE respectively.

Keywords : Freundlich model, Langmuir, sorption isotherms.

Physical attributes of soil and carbon stocks in Luvisol under different conditions of use in the Paraíba semiarid

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The removal of the vegetation cover and unbridled search for natural resources has caused the degradation process of the soils of the Caatinga biome, significantly compromising the plant and animal production under the conditions of semiarid climate. Therefore, this study aimed to evaluate the physical attributes and the carbon stock in Luvisol under different conditions of use in the Paraíba semiarid. The experiment was conducted in São João do Cariri (PB) (Lat. 07º 23' 27" S and Long. 36° 31' 58" W, 548 meters altitude) considered an area affected by the desertification process in the state. Three conditions of use were selected: 1-area with native vegetation ANV, 2-cultivated area CA and 3-area in the process of degradation APD. The selected soil conditions were classified as Vertic Luvisol by FAO, with sandy loam texture. Soil samples with undisturbed structure were collected in the layers: 0.00-0.05, 0.05-0.10, 0.10-0.20 m depth and forwarded to the Laboratory of Physical Analysis of Soil of Universidade Federal da Paraíba to determination these next variables: total porosity TP, soil density SD, aggregate stability index SI and carbon stock CS. The TP did not vary among the conditions of use evaluated, with values of 0.39 and 0.41 m^3 m^{-3} to APD and ANV treatments in the superficial layer of 0.00-0.05 m. The highest SD value was verified in the ANV condition with 1.69 kg dm^{-3} to 0.00-0.05 m layer but did not vary significantly between the conditions of use evaluated. The SI was higher in the CA treatment with 0.28 to 0.00-0.05 m layer, this 45.8% higher than the APD treatment. Regarding the CS, there was a significant variation between the conditions of use with: 31.68, 20.20 and 1.76 Mg ha^{-1} in the next conditions ANV, CA and APD, respectively, considering the 0.00-0.20 m layer. It was concluded that the conditions of use did not affect the TP and SD attributes, but exerted influence on the SI and CS. The area of native vegetation presents greater efficiency in the carbon accumulation and CS in relation to the other conditions of land use, which did not reflect in the SI.

Keywords: Indicators of soil quality, soil degradation, caatinga biome.

Pedotransfer functions performance to predict soil hydraulic properties and to capture their spatial variability structure at a watershed scale

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The soil water retention curve (SWRC) is important to the understanding of water availability to crops, water stress, solute transport, infiltration, drainage and modeling soil water. Pedotransfer functions (PTFs) have been developed to predict soil hydraulic properties (e.g., soil water contents at field capacity and permanent wilting point) from widely available or more easy-to-obtain soil physical properties because their determination are cost and labor-intensive. This study assessed the performance of developed PTFs in the literature to predict the SWRC and their potential to capture the SWRC spatial variability structure at a watershed scale. A 25,000 m-spatial transect was established in a Brazilian Southern watershed where soil samples in the 0-0.20 m soil layer were collected at 100 equidistant points. At each point, clay, silt and sand contents, soil bulk density, organic carbon and soil water retention curves (soil water contents retained at matric potentials of 0, -6, -10, -33, -100 and -1500 kPa) were determined. Each experimental SWRC was adjusted to the van Genuchten (VG) model (1980), obtained residual soil water content (θr), α, and n parameters. Sixteen tropical and temperate parametric PTFs were used to predict the VG parameters being assessed their performance through ME, RMSE and r^2 statistical measures. Then, soil water contents retained at matric potentials of -10, -33 and -1,500 kPa were estimated using the VG model. The same statistical measures were used to evaluate the PTFs, which were ranked according to their performance in order to choose the best one and the worst one in estimating soil water contents at those selected matric potentials. The capacity of the best and the worst PTF in describing the spatial dependence structure of all three selected soil water contents was evaluated through geostatistical analysis. The tropical parametric PTF developed by Medrado and Lima (full model) showed the best performance in estimating all selected soil water contents, while the temperate PTF developed by Rajkai showed the worst one. Both PTFs failed in capturing the spatial dependence structure of all selected soil water contents.

Keywords: Soil water retention curve, Van Genuchten model, Pelotas river watershed.

Soil Aggregation and total carbon after organic and mineral fertilization

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Due to the concentration of animals in confinement, there is the greatest accumulation of organic waste. Alternative and less expensive organic wastes can be used in the soil to improve its physical quality, preventing them from being discarded in inappropriate places. The objective of this work was to evaluate the effect of organic compost and mineral fertilizer on soil physical attributes after one year of installation of the Compost Barn system. The experiment was carried out at Fazenda Barreiro Alto, located in the municipality of Sete Lagoas (MG), in a clayey "Latossolo". The experiment was conducted in maize growing strains. The experimental design was a randomized complete block design, with four replications and nine treatments. The treatments corresponded to the combination of doses of mineral fertilizer and organic compost, in planting and cover. The stability of aggregates and classes of aggregates was determined via wet sieving at depths of 0-5 and 5-10 cm. The organic matter was determined using the data obtained from the total carbon analysis using the dry combustion method. For the granulometric characterization, the textural analysis was done at both depths. The values of organic matter were influenced by the application of organic and mineral fertilizer in the 0-5 cm layer. In general, the other soil physical attributes evaluated, there were no significant differences between treatments. Since it was the first year of installation of the system, there was no difference in soil aggregation, for this, there is a need for a larger study and to verify the influence of the compound in the aggregation of the soil particles. The compost from the agricultural activity of the farm can be considered promising, as long as it has studies of its characteristics and its impact on the environment and on the improvement of the physical quality of the soil.

Keywords: Organic compost, physical attributes, organic matter.

Phenylmethane dyes adsorption on biochar from eucalyptus wood

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In the last decade, intense scientific discussion has been devoted to the benefits of biochars (BC) as conditioners in soils to improve their properties, as observed in the rich-biochars fertile Amazonian anthropic soils. In this context, the amendment in soils using BC from biomass arises as a solution to improve sustainable agriculture practices. However, despite the advances in the investigations involving synthesis and use of biochars to improve soil quality, the study of the mechanisms involved in the adsorption process on BC, important to determine the soil ability to retain contaminants and essential nutrients for vegetal growth, is still in its beginning. Here, we investigated the adsorption process of a class of phenylmethane dyes, used as molecular probes, on BC obtained from *Eucalyptus urophylla* wood (EW). Dry EW was submitted to an initial temperature of 100°C and heated to 450°C with a heating rate of 1°C/min to generate BC450. Adsorption isotherms of pararosanilin (PRA), methyl violet 2B (MV2B), and methyl violet 10B (MV10B) were obtained by mixing 10,00 mL of dye solutions (0 – 25 mg L^{-1}) with 20,0 mg of BC450, at 25 °C. Each system was stirred and left to reach the thermodynamic equilibrium. Afterwards, aliquots without the BC were collected and analyzed spectrophotometrically for determination of the dye equilibrium concentration (Ce). The pH effect on the MV2B and MV10B adsorption was also investigated. Interestingly, at low Ce values, the adsorption amount of the dyes (Qe) on the BC450 in pure water (pH ~ 7) was almost independent of the dye structure, indicating that hydrophobic interactions did not determined the adsorption at low surface coverage. All the dyes were positively charged in pH 7 as well as the BC450 (PZC = 8,17), promoting a repulsive electrostatic interaction between the dye and the BC surface that disadvantage the adsorption. This repulsion was expected being more intense for PRA dye, showing that other interactions, such as hydrogen bonds and dipole-dipole ones, were determining the adsorption of the dyes at low surface coverage. As Ce increased (high surface coverage), Qe increased in the order Qe(MV10B) < Qe(MV2B) < Qe(PRA), i.e., the same order in which the molecular size of the dyes decreased. Probably, for higher Ce values, adsorption sites in narrow pores became inaccessible for MV10B, reducing its adsorption.

Keywords: Phenylmethane dyes, biochars, adsorption.

Annual soil loss rate estimation in a watershed in Nepomuceno, Minas Gerais, Brazil

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Erosion is one of the most damaging forms of soil degradation and it is responsible for reducing the productive potential of crops. In addition, erosion can cause serious environmental problems, such as water resources pollution, that, consequently, alters aquatic ecosystems and causes silting of watercourses. The Revised Universal Soil Equation (RUSLE) allows estimating soil loss under various conditions, considering soil use and cover, topographic characteristics, soil types and rainfall. Through the elaboration of thematic maps, this model is an important research tool on the erosive process and allows the compartmentalization of the landscape in different levels of instability. In this context, the aim of this work was to estimate and map the annual soil loss rate by using GIS and Remote sensing techniques in a small watershed located in Nepomuceno, Minas Gerais, Brazil. The watershed is located between latitude 21° 18' 00" S and 21° 16' 30" S and longitude 45° 14' 00" W and 45° 12' 00" W, with an area of 495.86 ha, mainly composed by coffee crop (41%). The soil loss was estimated by the RUSLE model, with the parameters and their corresponding factors spatial interpolated. The equation factors spatialized were: the rainfall-runoff factor (R) based on a model proposed by Mello el al. (2013); the erodibility factor (K) based on the pedologic map elaborated from soil profile samples and laboratory analyses of soil samples, and based on maps of the declivity and topographic index of humidity; slope length and steepness (LS) by the Digital Elevation Model (DEM) obtained from the satellite Alos/Palsar with spatial resolution of 12.5 m; Factor C, based on the use and landcover map elaborated by images of 2018 from *Google Earth Pro*; and support practice factors (P). The studied watershed presented an annual soil loss rate ranging from 0 to 892.49 ton ha^{-1} $year^{-1}$, and an average soil loss rate of 29.55 ton ha^{-1} $year^{-1}$. However, more than 60% of the watershed area presented soil loss rates lower than 25 ton ha^{-1} $year^{-1}$. Therefore, it could be classified as a watershed of moderate soil susceptibility to erosion. In view of the results, it was observed that the greatest soil loss occurred in areas with high slopes tied to areas with intensive soil use without support practices. For this reason, there is the need to adapt land use and occupation and apply support practices in order to reduce the rates of soil loss in the study area, given the importance of the river watershed to the region.

Keywords: Erosion, soil degradation, GIS.

Aggregates morphometry and carbon stock in an Inceptisol under flax cultivation

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The flax culture presents high productive potential in the South of Brazil, being able to be used in crop rotation since it has low cost and high versatility. In addition, its roots positively influence the aggregation and physical quality of the soil. Based on this, the present study had aimed to evaluate the physical quality of an Inceptisol clayey (507 g kg^{-1}, 415 g kg^{-1} and 78 g kg^{-1} of clay, silt and sand, respectively) characterizing the aggregates morphometry and their carbon storage under the cultivation of three genotypes of flax. The experiment was carried out in 2016 in an experimental area belonging to the UFSC – County of Curitibanos (27º 16' 58" S e 50º 35' 04" W) with climate Cfb type. The plant materials used were three genotypes of flax: the golden variety, and the brown cultivars Aguará and Caburé - INTA. The aggregates (which they passed through a set of sieves with a mesh size of 9.52-4.76 mm and 4.76-1 mm at depths of 0-0.05 and 0.05-0.20 m) were evaluated as to its roughness with digital analyses processed in the program Quantporo. After using the aggregates for image analysis, they were used to determine the organic carbon in the fractions of the aggregates, adapting the methodology similar to that used by Castro Filho et al. (1998, 2002). The carbon storage was calculated with the data of total C content, soil bulk density and thickness of the soil layer. The data were submitted to analysis of variance and, when pertinent, the means were compared by the Tukey test ($p < 0.05$) using the Sisvar program. The soil presented high levels of organic carbon and, similarly, to the carbon stock values (≈ 0,30 g kg^{-1} in the depth of 0-0,05 m; > 80 g kg^{1} in the depth of 0,05-0,20 m), which may have been attributed to the contribution of roots, being also associated with pedogenetic factors of the soil under study. The conservation management system that has been used in the area (minimum cultivation) contributed to the maintenance of carbon stock, reducing the soil carbon emissions and contributing to better aggregation and soil structure. The closer the roughness value to 0.90 indicates that the surface is smoother (rounded). The aggregates present roughness varying their values from 0.69 to 0.73, which may be related to the type of management adopted, without the use of equipment that revolves and modifies the soil structure. The results showed good physical soil quality and structure for the genetic materials used.

Keywords: *Linum usitatissimum* L., aggregation, physical soil quality.

Robust cokriging for mapping soil saturated hydraulic conductivity at watershed scale

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The soil saturated hydraulic conductivity (K_{Sat}) is a key parameter for the understanding of phenomena such as the storage and movement of water in the soil. Also, it is one of the main input data for hydrological models. Due to the high spatial and temporal variability of K_{Sat}, and the efforts required for field-representative data sampling, it is often difficult to obtain accurate K_{Sat} information at the watershed scale. The present study proposes the use of the Cressie and Hawkins robust estimator for calculating the cross-semivariogram and subsequent mapping of K_{Sat} by cokriging using as covariate some hydro-physical attributes that present a close linear correlation with K_{Sat}. Data sets were obtained in a sample grid of 179 points established in the Ellert creek watershed (ECW), located in Canguçu-Rio Grande do Sul state, Southern Brazil. The area of the watershed is around 0.7 km^2 where relief varies from undulating to strong undulating and the soils are shallow and sparse between rocky outcrops. The Spearman correlation coefficient was used for selecting the soil hydro-physical covariates and the Root Mean Squared Error (RMSE), Mean Error (ME) and r^2 statistical measures for comparing observed and estimated K_{Sat} values from co-kriging. The selected covariates were macroporosity (Mac) and soil bulk density (BD) since their Spearman correlation coefficients with K_{Sat} were considered acceptable (0.72 and -0.50, respectively). The Spherical model best described the spatial dependence between K_{Sat} and Mac and K_{Sat} and BD with ranges of 152 and 212 m, respectively. Co-kriging results showed that spatial variations of Mac and BD provided satisfactory spatial estimations of K_{Sat} since RMSE, ME and r^2 values were considered adequate in our study (RMSE ranged from 0.2 to 0.3; ME ranged from -0.0044 to -0.0054; and r^2 from 0.83 to 0.91). A slight increase of accuracy, in terms of statistical measures, was observed when using Mac as a covariate to estimate K_{Sat}.

Keywords: Cross-semivariogram, spatial variability, covariates

Soil particle size distribution by radiometry: proportion and mineralogy of soil fractions at the same time

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The particle size distribution is the most important and fundamental soil physical analysis, since inferences about many other physical properties (aggregation, density, porosity, consistency) and about mechanical (aggregate stability, penetration resistance, compaction susceptibility) and hydrological (storage capacity, hydraulic conductivity, infiltration rate) behaviors of soils are possible from its results. However, knowing the mineralogy of each granulometric fraction (sand, silt, and clay) is also necessary for these inferences correspond to reality. Thus, the mineralogical nature is so important as the proportion of the soil particle sizes. The soil reflectance spectrum resulting from the radiometric analysis is directly influenced by its mineral and organic composition. By the soil reflectance spectroscopy, it is possible to simultaneously quantity contents of sand, silt, and clay and qualify the predominant mineral assemblage. So, we aimed to spectrally model sand and clay contents of a soil sample database and to cluster these soils based on their mineralogical similarities. We used 1259 soil samples from central region of Brazil, and their contents of sand and clay were determined by sieving and densimeter methods, respectively. Vis–NIR (400 to 2,500 nm) reflectance spectra were obtained by FieldSpec Pro, and they were log-transformed into absorbance values. Soil mineral fractions were modeled by Support Vector Machine with linear kernel function, and modeling performance was assessed by R^2 and RMSE. The modeled fractions showed the following mean values for clay: 465.00 g kg^{-1} (± 251.10 g kg^{-1}) and sand: 419.20 g kg^{-1} (± 283.79 g kg^{-1}). For clay, the model showed the following results: R^2: 0.86 and RMSE: 92.34 g kg^{-1}, and for sand, the results were: R^2: 0.87 and RMSE: 104.60 g kg^{-1}. Continuum removed spectral data were transformed by Principal Component Analysis (PCA), and Fuzzy K-mean algorithm was applied to cluster the soil samples based on their mineralogical characteristics. Differences in reflectance intensity and absorption features enabled to distinguish six clusters regarding differences in particle size distribution, mineralogy, and weathering intensification. Soil samples with different contents of quartz, phyllosilicates (2:1 and 1:1 minerals), oxides (hematite, goethite, and gibbsite), and organic carbon were properly discriminated. The radiometry is efficient to model the quantity and quality of the mineral fractions in soils.

Keywords: Reflectance spectroscopy, vis-NIR, granulometry.

Empirical equations to relate Van Genuchten-Mualem and Groenevelt-Grant parameters

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The equation of Van Genuchten-Mualem (VGM) is one of the most used models to represent the soil water retention curve (SWRC). An alternative equation was proposed by Groenevelt-Grant (GRG) and presents advantages regarding mathematical versatility and the physical meaning of the parameters. Considering the VGM equation cannot be mathematically converted into the parameters of the GRG equation, we aimed to relate the parameters n and α of VGM to the parameters p and k of GRG empirically. Values for p and k were estimated by combining 12 values of n (from 1.02 to 6.00) and 9 values of α (from 0.01 to 1.00), minimizing the difference between the estimated value of soil water content by the two models, for 247 values of matric potential (from -1 to -100 m). The relation between p and n was defined by fitting one equation to all values of α. The relation between k and α was defined by a three-step approach: in the first step, we obtained equations of k as a function of α, taking n as constant. In the second one, the coefficients obtained in the first step were used to fit equations as a function of n. Equations of up to three parameters were adjusted by the software TableCurve 2D v.5.01 and selected based on the largest value of the coefficient of determination (R^2). For each combination of n and α, the Root Mean Square Error (RMSE) was calculated for the 247 pairs of soil water content values estimated by the VGM and GRG models. The relation between p and n was defined by: $p=-0.0308n^2+0.9988n-0.8710$ ($R^2=0.99996$). For each value of n, linear equations of the logarithm of k (log[k]) as a function of the logarithm of $1/\alpha$ (log[$1/\alpha$]) were obtained ($R^2\geq0.99779$). The relation between the angular coefficients (a) and n was defined by $a=1.068-0.017n/\ln[n]$ ($R^2=0.98093$) and between the linear coefficients (b) and n by $b+0.050=1/[1.186n^3-1.125]$ ($R^2=0.99996$). The relation between k and α for all values of n was defined by: $\log[k]=a\log[1/\alpha]+b$, based on the linearity observed in the first step. The highest and the lowest RMSE values were 0.040 $m^3\ m^{-3}$ (n=1.02 and α=1.00) and 0.003 $m^3\ m^{-3}$ (n=2.50 and α=1.00). The largest differences between the models occurred in potentials close to the bubbling pressure due to overestimations by the GRG model. For the other regions of the SWRC, the results were satisfactory.

Keywords: Soil water retention curve, parameters estimation, bubbling pressure.

Accuracy of the van Genuchten-Mualem empirical model on determination of unsaturated hydraulic conductivity in sandy soil

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The hydraulic conductivity of unsaturated soil (K) is a core property for understanding hydrological processes, e. g. water flux, because the soil is predominantly in the unsaturated condition. Several empirical models were developed to estimate K, relating hydraulic conductivity of saturated soil (K_s) with volumetric water content (θ) or matric potential (Ψ_m). A widely used model for the empirical determination of K is the Van Genuchten-Mualen (vGM) one. But does this model provide a good estimation of K in soil with different densities? The objective of this work was to evaluate the accuracy of the vGM model in the estimative of K in relation of the values obtained by the evaporimetric method (HYPROP) in two bulk densities of a sandy soil. For this, undisturbed soil samples of a Argissolo Vermelho Distrófico arênico (Ultisol), with sandy texture (690, 225, and 85 g kg^{-1} of sand, silt and clay respectively), were collected in cylinders of 100 cm^3 in the 0-10 cm layer in two bulk density conditions: high (1.74 g cm^{-3}) and low (1.34 g cm^{-3}), with 4 replicates. The samples were saturated by capillarity for 48h. Then, they were prepared and analyzed on the automated measuring device HYPROP© to obtain θ and K. Based on these values, the Ks and the coefficients of retention curve (saturation moisture (θ_s), residual moisture (θ_s), α, *m* and *n*) were determined using the standard configuration of the HYPROP-Fit software version 4.1.0.0. for the vGM model. From the K_s and coefficient *m* of retention curve determined by the software, K was estimated as a function of Ψ_m by the vGM model. The K estimated by HYPROP-Fit (K_{Hy}) and K estimated by the vGM model (K_{vGM}) were compared with the reference values obtained by the evaporimetric method (K_{cal}) using the root mean squared error (RMSE) as a statistical indicator of accuracy. Regardless of the soil bulk density, the vGM model underestimated the K in all of the range of Ψ_m analyzed, and this underestimation increased as Ψ_m became more negative. It can be happened because the vGM model disregards the water flow in interconnected pores in Ψ_m intermediaries, as well as disregards the water flow in particles surface in more negative Ψ_m. The RSME of K_{vGM} were 11.32 and 3.48 for low and high soil bulk density respectively, while RSME of K_{Hy} were 0.61 and 0.44. Therefore, the vGM model is less accurate than HYPROP-Fit to estimate K of a sandy soil.

Keywords: Evaporation method, hyprop, bulk density.

Soil electrical resistivity and physical properties of no-tillage systems in the central region of Minas Gerais, Brazil

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No-till agriculture can lead to compaction due to constant machine traffic without soil plowing. An alternative to mitigate compaction is to introduce crop rotation with grasses that has an aggressive root system. Electrical resistivity (ER) have been a suitable method for soil structure evaluation in temperate climate soils. However, uncertainly exists as to the effectiveness of ER correlation with tropical soil properties. Thus, our objective was to test RE in contrasting soil management to mitigate compaction. The study was conducted at Sete Lagoas-MG in a very clayey Typic Haplustox. Six treatments were tested: soybean (S) and maize monoculture (M), maize-soybean rotation (MS), maize-brachiaria-soybean-brachiaria rotation (MBSB), and two treatments with high investment in fertilizers being MBSB-HI and MS-HI. Total porosity, macroporosity (Ma), microporosity (Mi), relative field capacity (RFC), bulk density (BD) and air capacity (AC) were evaluated by core method, sampled at 0-20 cm depth, with three replicates. ER tomography was evaluated at 0-80 cm depth, performed in a dipole-dipole arrangement allowing a spatial evaluation of 4 meters. The 150 ER data points were interpolated by the triangulation method. Pearson correlation test between soil properties and ER (0-20 cm depth) were performed. The results from core method did not differ by ANOVA. ER correlation with CA ($r = 0.69$) and BD ($r = -0.71$) were not significant. However, correlation between ER and M ($r = 0.85$) was significant The ER tomography results indicate greater zones of high ER in MBSB-HI, which implies greater air presence, therefore, greater soil porosity. We infer this result was caused by the brachiaria forming biopores which improves soil porosity, as well as promote high biomass production, yielding a straw with high C/N ratio, which protects and persists on soil surface for a long time. Therefore, ER results allowed more information than core method, due low soil volume evaluated by the latter and high spatial variability in cropping areas. At least, we suggest more tests increasing number of observations to better evaluate the correlation between ER and physical properties, allowing conclusions for soil management scale.

Keywords: Compaction, crop rotation, biopores.

Mechanical and biological scarification: impacts in the soil physical characteristics

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The objective of this study was to evaluate the effect of the mechanical and biological scarifying over the soil physical properties in different times of collection. It was used a randomized blocks design with five treatments and four replications. The treatments consisted in the cultivation of the following species: (T1) forage turnip + black oats with mechanical scarifying after seeding; (T2) forage turnip + black oats without scarifying; (T3) maize second crop with scarifying after harvest; (T4) maize second crop with succession of buckwheat; (T5) maize second crop in no-till system (control). The soil collections were made in three periods: March 2018 (before the experiment was implemented), October 2018 (after the management of the winter crops) and March 2019 (after the soybean was harvested). Were evaluated the soil bulk density (BD), macroporosity (Ma), microporosity (Mi) and total porosity (TP), in three depths of 5 to 10 cm, 10 to 15 cm and 15 to 20 cm, by collecting rings of known volume. The soil was scarified with a subsoiler model SPDA, with seven shanks spaced from one another in 37 cm, with points of 7,5 cm wide and a work depth of 40 cm. After the data were tabulated, a conjunction analysis was made. The results show improvements in soil bulk density, macroporosity after the scarifying; however, these improvements did not persist after the soybean cultivation at all depths evaluated; except for the total porosity were the forage turnip + black oats and maize followed by buckwheat had similar result to the scarified. Thus, in the present study it is concluded that the scarification is not justified as a measure of improvements in soil physical quality in the long term.

Keywords: Cover crops, soil porosity, soil bulk density.

Impact of sugarcane straw management on soil resistance to penetration in a clay Oxisol

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Globally, the population growth results increasing demand for energy, currently supplied by fossil sources. In this sense, public policies have stimulated the production of renewable energy, such as cellulosic ethanol and bioelectricity from sugarcane straw. However, straw removal can impact several processes in the soil and, finally, the crop yield. In term of soil compaction, the impacts of straw removal are magnified by intensive and uncontrolled traffic of heavy agricultural machinery associated with harvesting operation. Therefore, we evaluated the straw removal management effects on soil compaction, through soil resistance to penetration measurements, in a clay Oxisol located in Igaraçu do Tietê-SP, Brazil. The experimental design used was a randomized block with five treatments and three replications. The evaluated treatments were the following amounts of straw deposited uniformly on the soil surface: 0; 2; 3.2 and 7.5 Mg ha^{-1} of dry matter mass. In addition, a treatment with 7.5 Mg ha^{-1} of straw piled within inter-row position was tested (15 Mg ha^{-1}). Soil resistance to penetration and soil moisture were evaluated at the 0-10; 10-20; 20-30; 30-40; 40-50; 50-60 cm depths in the sugarcane row (90 cm) and inter-row (150 cm) with an impact penetrometer, at the beginning and ending of the sugarcane cycle (after 390 days). Our results indicated that short-term straw removal increased soil resistance to penetration (10 MPa under no-removal vs 13.5 MPa under total removal for 0-10 cm soil layer, decreasing to 7.2 MPa under no-removal vs 9.5 MPa under total removal for 50-60 cm soil layer), especially within the inter-row position, whereas no significant difference on soil moisture were found. These results suggested that straw removal can increase soil compaction problems in sugarcane fields. Nevertheless, medium- and long-term studies are necessary to monitor the effects of this emergent management practice in Brazilian sugarcane production.

Keywords: Bioenergy, crop residue, soil compaction.