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SCIENTIFIC ARTICLE

Comparison of samplers in the evaluation of soil physical properties

Comparación de muestreadores en la evaluación de propiedades físicas del suelo

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ABSTRACT

One of the methods most used in obtaining undisturbed soil samples is the volumetric ring method. Undeformed samples are used, for example, in the evaluation of soil physical properties, such as soil bulk density and porosity. However, there is a diversity of volumetric rings used in the research, which makes it difficult to compare results obtained in these studies. Thus, the objective of this investigation was to compare the values of soil bulk density, microporosity and total porosity, determined from sampling with volume volumetric rings of 100 and 272 cm³, and establish the correlation between them, verifying if the comparison is valid. Soil samples were taken in 25 cultivation sites in Hapludox, which differed in the tillage, culture and/or management system, in the municipality of Rio Paranaíba, MG, at different depths. Data were submitted to Pearson correlation analysis. The correlation between the volumetric rings for all variables was significant, described by the correlation equations y=0.3788+0.7054*x (R=0.68), y=0.1342+0.6582*x (R=0.62), and y=0.1107+0.6071*x (R=0.67), for the variables density, total porosity and microporosity, respectively. It is concluded that it is possible to compare values for the variables determined from the sampling with the two volumetric rings tested.

Keywords: cylinder volume, porosity, soil bulk density, undisturbed sample, Uhland soil sampler

RESUMEN

Uno de los métodos más utilizados para obtener muestras de suelo inalterado es el método de anillo volumétrico. Las muestras inalteradas se utilizan, por ejemplo, en la evaluación de las propiedades físicas del suelo, como la densidad y la porosidad. Sin embargo, existe una diversidad de anillos volumétricos utilizados en investigación, lo que dificulta la comparación de los resultados obtenidos en estos estudios. Así, el objetivo de esta investigación fue comparar los valores de densidad, microporosidad y porosidad total, determinados a partir de muestreos con anillos volumétricos con un volumen de 100 y 272 cm³, y establecer la correlación entre ellos, verificando si la comparación es válida. Se tomaron muestras de suelo en 25 sitios de cultivo en Hapludox, los cuales se diferenciaron en el sistema de labranza, cultivo y / o manejo, en el municipio de Rio Paranaíba, MG, a diferentes profundidades. Los datos obtenidos se sometieron al análisis de correlación de Pearson. La correlación entre los anillos volumétricos para todas las variables fue significativa, descrita por las ecuaciones de correlación y = 0.3788 + 0.7054 * x (R = 0.68), y = 0.1342 + 0.6582 * x (R = 0.62) e y = 0.1107 + 0.6071 * x (R = 0,67), para las variables densidad, porosidad total y microporosidad, respectivamente. Se concluye que la comparación de valores de las variables determinadas a partir del muestreo con los dos anillos volumétricos ensayados es válida.

Palabras clave: barrena Uhland, cilindro volumétrico, densidad, muestra no perturbada, porosidad

INTRODUCTION

Soil compaction is a well-known and important process as it impacts the productivity of agricultural crops directly and indirectly. According to Machado (2003), compacted soil results in decreased root growth at depth, accentuating water stress in short periods of drought, in soil surface water accumulation restricting O2 availability to the roots and favoring soil water erosion.

Soil bulk density is a measure used to diagnose compaction and consists of collecting undisturbed samples using a 100 cm³ metal cylinder with Uhland auger (Teixeira, Donagema, Fontana & Teixeira, 2017). Pires, Rosa & Timm, (2011) point out that sampling is the most critical operation due to soil heterogeneity and careful not to neglect the results by compressing the sample and affecting its structure, arrangement and volume.

To perform soil bulk density studies, quality sampling is required, and the data must be comparable. However, there is still no consensus on the sample cylinder volume to meet the above requirements. Some authors used 50 cm^3 cylinders (Brown, Barbosa, Bertol, Mafra & Muzeka, 2018), others 100 cm^3 (Ortigara, Koppe, Luz, Kaiser & Silva, 2014; Rodrigues et al., 2016) and some considered sampling more efficient when using larger cylinders (Gubiani, Reinert & Reichert, 2014), which makes interpretation and comparison of published results difficult.

Studies on the influence of different equipment used for sampling are incipient, and there is little clarification regarding sample size, appropriate moisture for each soil type and operational difficulties. This information is important in order to work with appropriate equipment and conditions for each soil type, standardize equipment and have comparable samples even from different sources (Folegatti, Brasil & Blanco, 2001).

In this context, the objective of this work was to verify if there is a correlation between the data obtained from sampling with cylinders of 100 and 272 cm^3 for the physical parameters of soil bulk density, total porosity and soil microporosity, to analyze the veracity of the comparison between them, scientific point of view.

MATERIAL AND METHODS

Soil sampling was carried out in 25 sites that differed in the tillage system, crop and/or management as described in Table 1, located in Rio Paranaíba, MG. In all sampled sites, the soil was classified as Dystrofic Haplustox and the climate of the region is classified as Cwa, according to Köppen. The collection in different depths was carried out to obtain different soil densities, making the analysis more comprehensive. According to Zinn et al. (2012), the lower organic carbon content in the deeper layers influences soil density.

At each site, three samples (replicates) with the small 100 cm^3 (P) volumetric ring with 4.72 cm in diameter and 5.72 cm in height, and three samples with the large ring of 272 cm^3 (G), of 7 and 7.0 cm in diameter and height, respectively, totaling 150 undisturbed samples obtained at different depths. The rings had a beveled bottom, and sampling was performed in May 2018, during the dry season in the region.

The collection sites were cleaned and leveled before sampling, and collected at the same point with the two cylinders, up to 20 cm apart. The collector with the ring was penetrated he ground until it was filled using an Uhland auger without previous wetting. The samples were taken from the collectors and the excess soil was removed with the help of a stylus. Subsequently, the soil rings were wrapped in aluminum foil to prevent soil loss and carefully transported to the Soils Laboratory of the Federal University of Viçosa, Rio Paranaíba Campus, for processing and analysis.

Soil bulk density (Ds), total porosity (Pt) and microporosity were determined by the stress table method, according to the methodologies of Teixeira et al. (2017). The data were submitted to Pearson correlation analysis between the volumetric rings P and G for the determined variables, using the SigmaPlot 11 software.

RESULTS AND DISCUSSION

There was a significant positive correlation between the volumetric rings for all variables studied. Figure 1 shows the correlation coefficients. The significant correlation between the samplers allows, after correction by the equation, that the comparison of values of the same variable determined from samples of different sizes is valid. This result corroborates Costantini (1995), who found no difference between cylinders and approximately 280 and 653 cm^3. Silva, Medina & Jolomba (2017), observed that the sampler with a volume of 90 cm^3 was sensitive to differentiate the action of animal trampling on the surface in soil density, total porosity and macroporosity attributes.

Given the coefficients found, it cannot be considered that there was a quality correlation, and the spatial variability and heterogeneity resulting from various soil formation factors may have influenced the correlation, since, although the Oxisols are considered quite weathered, there is variability for certain attributes (Souza, Marques Júnior, Pereira & Barbieri, 2004; Amaro Filho, Negreiros, Assis Júnior & Mota, 2007). Schaffrath, Tormena, Fidalsk & Gonçalves (2008) consider that the soil management system is one of the most important sources of spatial variability of soil physical properties. However, the authors Santos et al. (2012) identified a coefficient of variation of 5.3% in soil density and 1.3% in particle density, showing lower spatial heterogeneity compared to other physical attributes. These results were obtained using the same ring with a volume of 100 cm^3.

In this study, the correlation was low even when comparing variables determined with samples from the same volumetric ring; (Table 2), which means that the variability of the method itself is high, that is, the volumetric cylinder method did not have good repeatability regardless of ring size used, due to intrinsic method and soil factors.

Pacheco & Cantalice (2011) using 42.47 cm^3 cylinder and Uhland auger also had a low correlation for

Table 1. Locations, depths and geographic coordinates where undisturbed soil samples were collected using 100 and 272 cm^3 cylinders in Rio Paranaíba, MG.

Location	Depth (cm)	Coordinates
Tractor trail (coffee)	00-10	19° 12′ 39,20″ S 46° 13′ 31,14″ O
Midway between coffee rows	00-10	19° 12′ 39,20″ S 46° 13′ 31,14″ O
Country road (coffee)	00-10	19° 12′ 43,88″ S 46° 13′ 29,42″ O
Carrot bed	00-10	19° 12′ 44,90″ S 46° 13′ 49,06″ O
Carrot bed	10-20	19° 12′ 44,90″ S 46° 13′ 49,06″ O
Cenoura between beds	00-10	19° 12′ 44,90″ S 46° 13′ 49,06″ O
Hoses (mango trees)	00-10	19° 12′ 56,47″ S 46° 13′ 56,02″ O
Maize (DSS)	00-10	19° 13′ 10,57″ S 46° 13′ 19,74″ O
Eucalyptus	00-10	19° 13′ 23,33″ S 46° 13′ 26,85″ O
Degraded Pasture	00-10	19° 13′ 25,10″ S 46° 12′ 57,76″ O
Cerrado/Savannah 1	00-10	19° 13′ 26,01″ S 46° 12′ 56,20″ O
Cerrado/ Savannah 2	00-10	19° 13′ 44,38″ S 46° 10′ 41,96″ O
Tractor trail (coffee)	00-10	19° 13′ 44,30″ S 46° 09′ 22,11″ O
Midway between coffee rows	00-10	19° 13′ 44,30″ S 46° 09′ 22,11″ O
Country road (coffee)	00-10	19° 13′ 44,30″ S 46° 09′ 22,11″ O
Maize	00-10	19° 13′ 41,25″ S 46° 09′ 06,60″ O
Maize	10-20	19° 13′ 41,25″ S 46° 09′ 06,60″ O
Trench	00-10	19° 12′ 41,54″ S 46° 08′ 00,69″ O
Trench	Horizon B (150-160)	19° 12′ 41,54″ S 46° 08′ 00,69″ O
Grid	00-10	19° 12′ 41,93″ S 46° 07′ 58,88″ O
Grid	10-20	19° 12′ 41,93″ S 46° 07′ 58,88″ O
Plow	00-10	19° 12′ 42,28″ S 46° 07′ 57,63″ O
Plow	10-20	19° 12′ 42,28″ S 46° 07′ 57,63″ O
Rotating hoe	00-10	19° 12′ 42,86″ S 46° 07′ 56,25″ O
Rotating hoe	10-20	19° 12′ 42,86″ S 46° 07′ 56,25″ O

the Ds parameter, and the coefficients ranged from 0.13 to 0.79, confirming the low repeatability of the volumetric ring method in regarding the determination of this physical property of the soil.

The coefficients found for the variables are very close for both cylinders, indicating that the use of the larger volume sampler did not improve the correlation between the variables. This can be observed, for example, for Ds, where the variability between P was 0.69 and G 0.67, which means that there was no reduction in variability due to using a larger cylinder. From an operational standpoint, using a larger cylinder means working with a heavier Uhland bit or using more impacts to penetrate the cylinder into the ground.

Therefore, the sampling process becomes more time-consuming and stressful, and increases the possibility that this greater impact applied to the soil influences the results of the physical analyses.

Folegatti, Brasil & Blanco (2001) studied five types of augers for undisturbed samples and concluded that the auger type altered soil bulk density results, with greater intensity in clay than sandy soil, demonstrating the importance of soil texture in the sampling process. In addition, soil variability occurs according to soil class and relief, management adopted, cultivar chosen for planting, erosive processes, among others (Skorup et al., 2012; Bottega, Queiroz, Pinto & Souza (2013) and should be taken as a parameter to plan the sampling.

Bortolon, Gianello, Conte, Oliveira & Levien (2009) proposed soil sampling equipment that can be used in soils with different textural classes; due to the method of introduction by the manual hydraulic lift of the tractor that provides a slow and continuous pressure without impact. According to these authors,

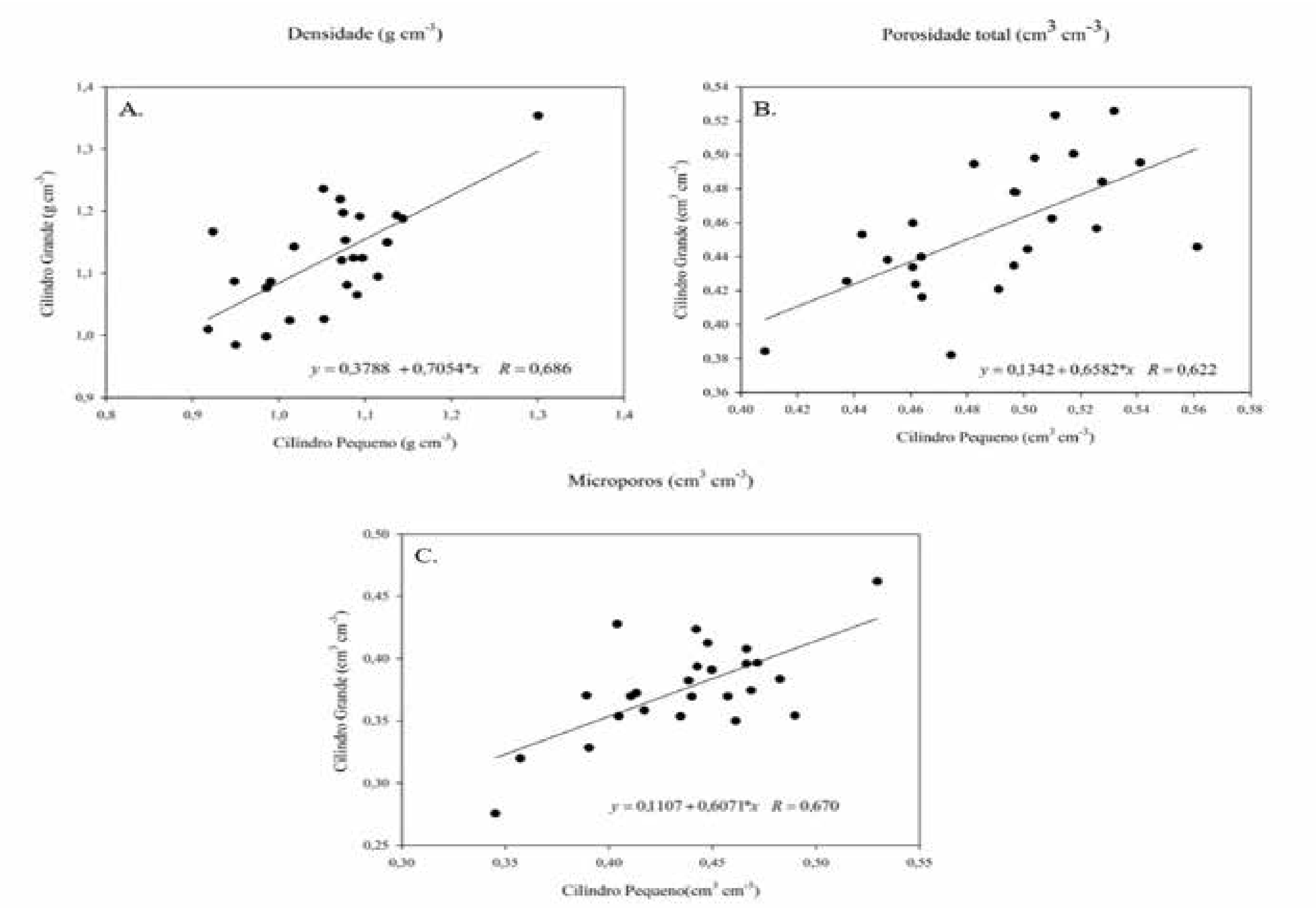

Figure 1. Correlation between 100 and 272 cm3 volumetric rings for the soil bulk density (A), total porosity (B) and soil microporosity (C) variables. * Significant at 1% by Pearson correlation.

Table 2. Pearson correlation for the soil density, total porosity and microporosity variables among three replicates obtained with volumetric rings of 100 (P) and 272 cm^3 (G).

	Bulk density		**Total porosity**		**Microporosity**	
	P	G	P	G	P	G
P	0,699*		0,640*		0,736*	
G		0,677*		0,643*		0,632*

* Significant at 1% by Pearson correlation.

the structural changes of the samples near the cylinder wall can re-settle and de-structure the soil particles at the moment of sampler entry into the soil profile, modifying the density values.

In this study, when the soil was drier and looser, it was more difficult to obtain the undisturbed sample with the small cylinder, while under these same conditions with the 272 cm^3 cylinder, fewer attempts were needed to obtain the sample. In the places with moist soil, there was a higher sampling yield for both cylinders, which highlights the importance of planning for fieldwork.

CONCLUSION

It is valid to compare results of soil bulk density and porosity evaluations obtained by cylinders of different sizes using Uhland auger.

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