Interrelation of mechanical and physical soil properties of six south brazilian soils under no-tillage

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1. Introduction

The estimation of soil mechanical behavior from basic soil properties is difficult and site dependent, since no established and general accepted pedotransfer functions are available, particularly for soils under no-tillage in southern Brazil. Horn & Fleige (2003) studied the use of pedotransfer functions to assess the mechanical stability of soils by the precompression stress. Approaches for assessing compaction susceptibility of soils have usually involved the determination of maximum bulk density or compression index (Smith et al., 1997). Interrelations between physical and mechanical soil properties may improve the understanding of soil susceptibility to compaction and load support capacity, and contribute to developing pedotransfer functions, which in turn allow the estimation of some soil properties difficult to obtain. The present study aimed to evaluate the interrelation of some soil mechanical and physical properties, to understand their behavior and to develop pedotransfer functions for some soils under no-tillage in southern Brazil.

2. Material and methods

Three Alfisols and three Oxisols with clay content ranging from 86 to 664 g kg^{-1} and silt ranging from 196 to 503 g kg^{-1}, from Rio Grande do Sul state, Brazil, under different tillages, predominantly no-tillage, were sampled during the first six months of 2004. Soil samples were collected in cylinders with height of 2.50 cm and diameter of 6.10 cm, in the depth of 0.08-0.13 m. Soil samples were equilibrated at a tension of 33 kPa and submitted to the uniaxial compression test with the application of successive and static loads of 12,5; 25; 50; 100; 200; 400; 800 and 1600 kPa. The initial bulk density (BDi), soil deformation (Def), bulk density at the end of the compression test (BDf), compression index (Cc), and precompression stress (σp) were quantified. Compression index and precompression stress were evaluated with the Casagrande's method (Casagrande, 1936), using manual adjustment (method 2) of the software Compress (Reinert et al., 2003). The data were submitted to Pearson correlation and linear regression analysis.

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3. Results and discussion

Pearson correlation analysis demonstrated significant correlation between BDi with Def (r = -0.72), BDf (r = 0.69) and Cc (r = -0.87), and no significant correlation between BDi with óp (Table 1). Significant correlation was observed between Def with Cc (r = 0.82) and óp (r = -0.35) (Table 1). An increase in BDi resulted in a decrease in Def (r^2 = 0.51) (Fig. 1a) and in Cc (r^2 = 0.76) (Fig. 1c) and an increase in BDf (r^2 = 0.48) (Fig. 1b). Imhoff et al. (2004) observed an inverse relation between BDi and Cc, as reported in this study. Similar to the observed in this study, Mosaddeghi et al. (2003) did not observe a significant correlation between óp and BDi, although they verified a tendency of óp to increase with increase in BDi (Fig. 1d). Imhoff et al. (2004) observed positive and significantly correlation between óp and BDi.

Table 1
Pearson correlation matrix of mechanical and physical soil properties.

	BDi	Def	BDf	Cc
BDi	-	-	-	-
Def	-0.720 **	-	-	-
BDf	0.694 **	-0.129 ns	-	-
Cc	-0.872 **	0.816 **	-0.324 **	-
σp	0.102 ns	-0.350 **	-0.200 *	-0.048 ns

** = significative at 1% of probability; * significative at 5% of probability; ns = no significative; BDi = initial bulk density; Def = soil deformation; BDf = bulk density at the end of the compression test; Cc = compression index; σp = pre compression stress.

An increase in Def was associated with an increase in Cc (r^2 = 066) (Fig. 2a). Although correlation between Def with óp (Table 1) was observed and the linear model was significant, the coefficient of determination (r^2 = 0.12), which expresses how much of variation of óp is explained by Def was low (Fig. 2b).

A decrease in BDi and in BDf with increase of clay content Implies that both are function of clay content, and the value of BDf is proportional to the value of BDi (Fig. 3a). Smith et al. (1997) verified an increasing of BDf with increasing of the clay content up to about 20% and then decreasing with increasing clay content. The Cc increased linearly with clay content up to a value of 39%, remaining relatively constant (Fig. 3b). Larson et al. (1980) verified linear increase of Cc with clay content up to a value of 33% and Imhoff et al. (2004) up to a clay content of 30%. When the Cc remains relatively constant, Larson et al. (1980) using disturbed samples verified a value of Cc around 0.50 while Imhoff et al. (2004) using undisturbed samples verified a value of 0.24. Smith et al (1997) demonstrated significant correlation between clay content and Cc, using a quadratic equation to explain this behavior. Soils with high values of BDi present smaller deformation due traffic and less susceptibility to compaction, which does not mean that this soil is able to support traffic without damages on its structure. The knowledge of physical soil limits which may be estimated from parameters via pedotransfer fuction, and ultimately used to estimate limits to avoid damages to soil structure, can be built by the study of different soils, with wide range of clay content, initial bulk density, soil moisture, and many others soil attributes.

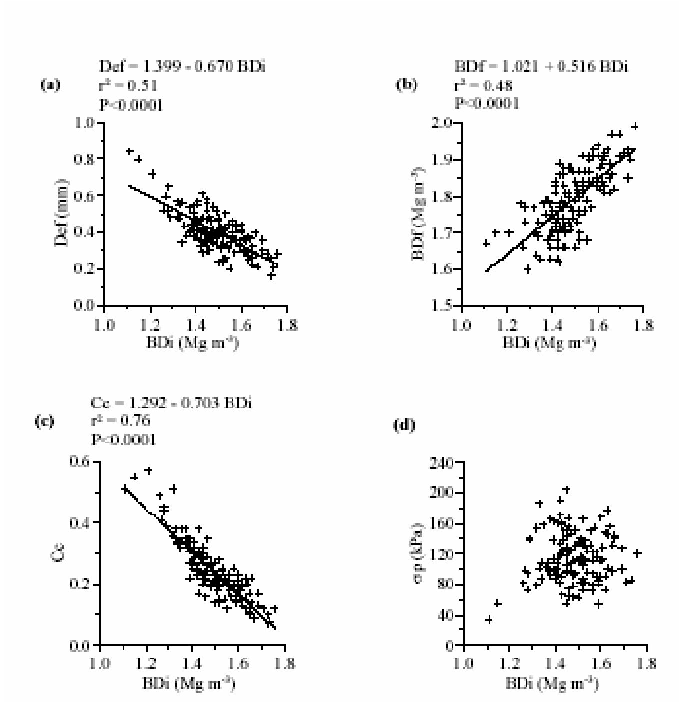

Fig. 1. Linear model, coefficient of determination (r2), and significance between bulk density (BDi) and soil deformation (Def) (a), final bulk density (BDf) (b), compression index (Cc) (c), and precompression stress (óp) (d).

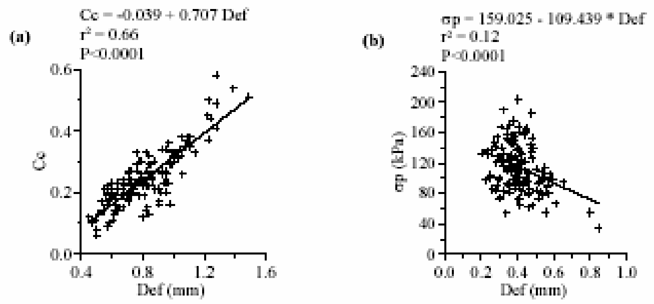

Fig. 2. Linear model, coefficient of determination (r2) and significance between soil deformation (Def) and compression index (Cc) (a) and pre compression stress (óp) (b).
0 20 40 60 80 Clay (g kg-1)

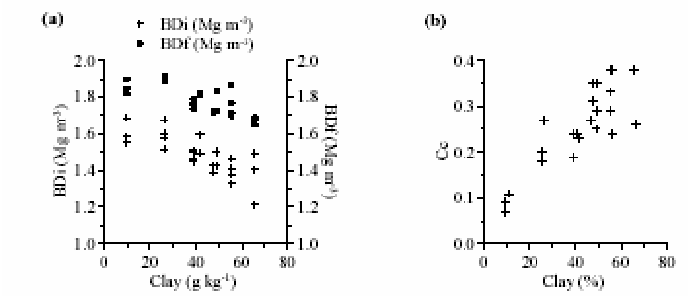

Fig. 3. Behavior of initial and final bulk density (a) and compression index (b) with clay.

4. Conclusion

Soils with high bulk density presented smaller deformation due traffic and were less susceptible to compaction. The effect of this smaller deformation and susceptibility to compaction on soil structure may also be associated to high levels of compaction. The larger soil deformation and smaller bulk density the smaller the load support ability, which may be attributed to the soil structure, moisture and clay content. The compression index and initial and final bulk density were related to clay content. When considering limits and physical and mechanical properties, the soil type and clay content should be considered, along with soil management. Compression index may be estimated by pedotransfer functions, mainly based on bulk density. Load support ability was not possible to be estimated by bulk density. Thus, it is 1601 necessary the study of other soil properties of easy determination to estimate this soil mechanical property.

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