INTEGRAL VARIABLE OF SOIL PENETRATION RESISTANCE AS SOIL PHYSICAL QUALITY INDICATOR

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INTRODUCTION / OBJECTIVE

Inadequate agricultural land use leads to environmental degradation, including structure depreciation and compaction of soil, which can be both identified by soil penetration resistance (PR). Since PR is closely related to bulk density (BD) and water content (WC), these soil attributes should be both accessed at the same time than PR, otherwise PR can not be adequately interpreted.

Based on Letey (1985), Silva et al. (1994) proposed a systematic methodology to obtain PR as function of BD and WC during the soil water retention curve determination from structurally preserved soil samples. This procedure allows obtaining the “least limiting water range” (LLWR) and the BD critical value related to a PR value also critical. Particularly in Brazil, a significant amount of data regarding PR and its relation with BD and WC was obtained, which was possibly underutilized concerning to ecological significance in affecting the growth of plant roots throughout the year seasons.

The mathematical integration of functions can produce useful variables for both the characterization of physical systems and the interpretation of dynamic processes. The "integral water energy" between the field capacity and the permanent wilting point (Minasny and McBratney, 2003), which refines the concept of available water, and the "matric flux potential" (Gardner, 1958), related to movement of water in unsaturated soil, can be cited as examples.

The aim of this work was to propose a soil quality indicator variable, named IntPR, that can be obtained by the mathematical integration of the equation that expresses PR as a function of soil water tension (WT). It is expected that the proposed variable allows that physical differences of the same soil under different uses and management systems and even differences between several different soils have both a more useful edaphic interpretation.

MATERIAL AND METHODS

The experimental area is located in Conceição de Macabú County, RJ, Brazil. The studied soil is a Typic Hapludult under five vegetation covers, which are a secondary forest, a pasture, and three species of leguminous trees - acácia, ingá and sabiá. In July/2015, 240 soil samples with preserved structure were collected in metallic rings, equitably obtained from each one of five studied sites, from 0-0.10 and 0.10-0.20 m layers, at six sample points by site. The vegetation covers are illustrated beside.

The samples were used to soil physics characterization according to Silva et al. (1994). For three sample sets from each layer of each site, tests with a lab penetrometer were performed to measure PR after the samples were equilibrated in Richards pressure chambers at water tensions of 10, 33, 100, 500 and 1500 kPa. Thirty equations of the power type relating PR to BD and WT were adjusted, similarly to Busscher (1990)'s proposal, but with WT instead of soil moisture. Considering the mean BD values of each sample set, these equations were simplified as $PR = a\,WT^b$. Afterwards, they were integrated from field capacity (WT = 10 kPa) to permanent wilting point (WT = 1500 kPa), resulting in the proposed variable, IntPR, which covers the whole range of available water to plants.

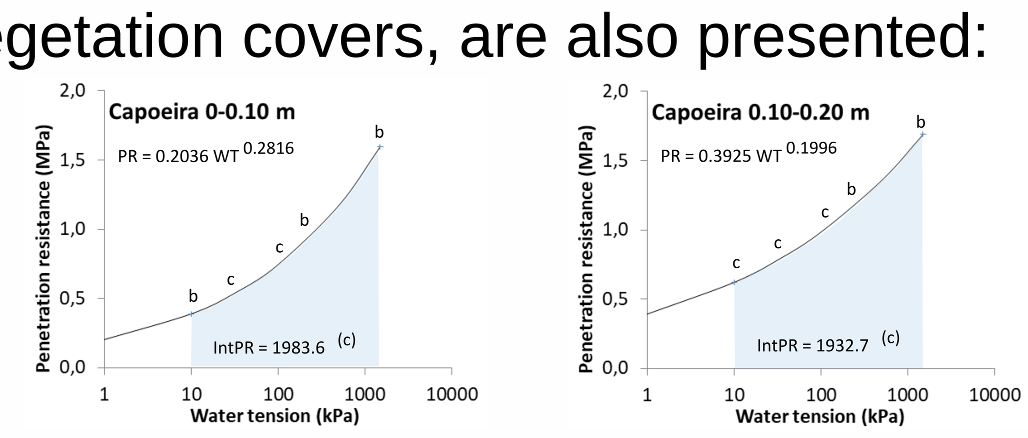
RESULTS

Some chemical and physical attributes in 0-0.10 and 0.10-0.20 m layers of soil under different vegetation covers are presented below, as in Gomes et al. (2018):

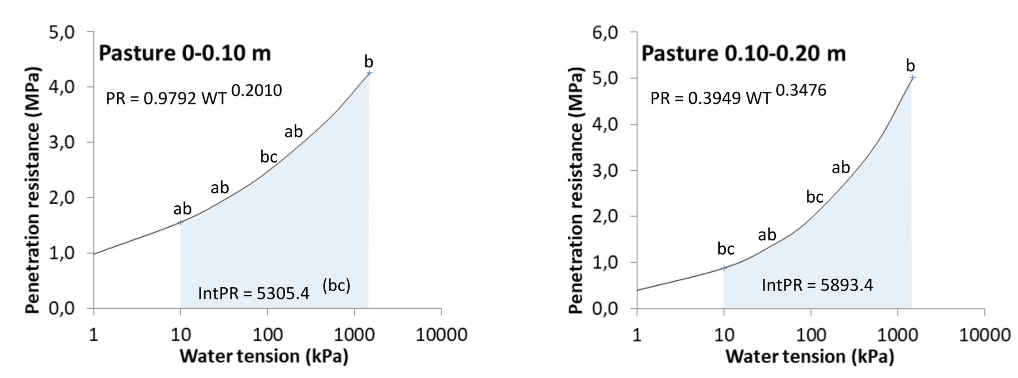
Vegetation cover	pH	C	P	SB	CEC_{efect}	$CEC_{pH=7}$	Sand	Silt	Clay	BD	TP
	(in H_2O)	--- (mg kg^{-1}) ---		--------- ($cmol_c\ kg^{-1}$) --------			-----------($g\ kg^{-1}$)--- --------			($Mg\ m^{-3}$)	($m^3\ m^{-3}$)
0-0.10 m layer											
Forest	4.22	18.8	0.12	0.79	1.9	8.6	640.0	85.5	274.5	1.114	0.580
Pasture	4.26	13.1	0.22	0.41	1.3	6.8	637.6	90.7	271.7	1.361	0.486
Acácia	4.48	14.6	0.17	2.14	2.5	8.9	627.1	70.1	302.8	1.386	0.477
Ingá	4.22	13.9	0.15	0.90	1.9	7.5	610.8	93.1	296.1	1.215	0.542
Sabiá	4.26	16.0	0.18	1.05	2.2	8.8	603.8	96.8	299.4	1.255	0.527
0.10-0.20 m layer											
Forest	4.12	12.2	0.08	0.30	1.4	7.8	598.5	93.8	307.6	1.093	0.587
Pasture	4.18	11.3	0.04	0.16	1.1	7.2	533.3	110.2	356.5	1.271	0.520
Acácia	4.34	11.1	0.11	0.79	1.7	7.4	510.0	96.0	394.1	1.474	0.444
Ingá	4.28	10.8	0.08	0.40	1.5	7.0	535.7	108.4	356.0	1.283	0.516
Sabiá	4.22	11.9	0.10	0.46	1.7	7.1	515.4	111.7	372.9	1.370	0.483

Graphics with PR x WT adjusted models and their defined integral (IntPR) values calculated from 10 to 1500 kPa water tension, for 0-0.10 and 0.10-0.20 m soil layers of studied vegetation covers, are also presented:

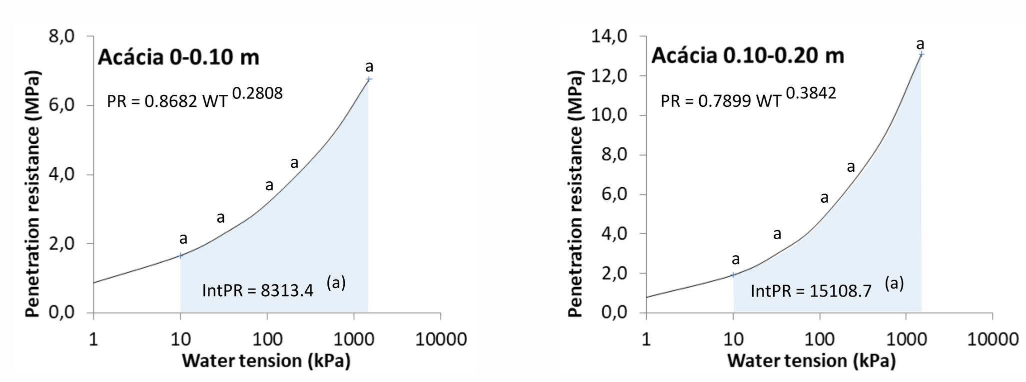
Secondary forest



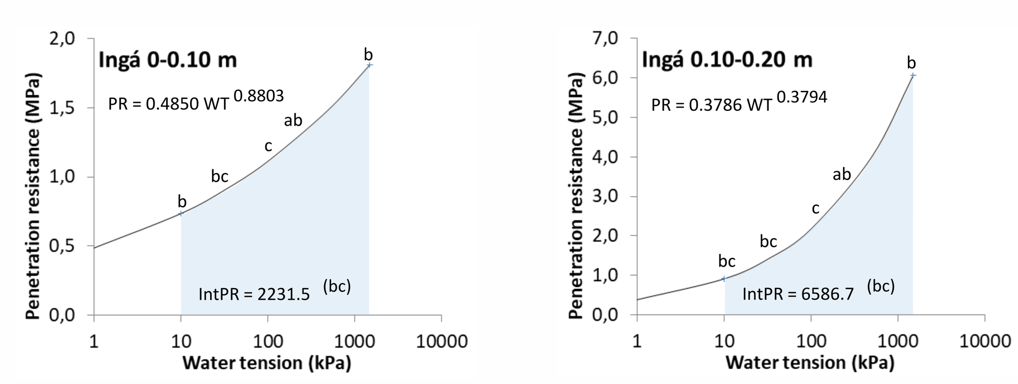
Pasture



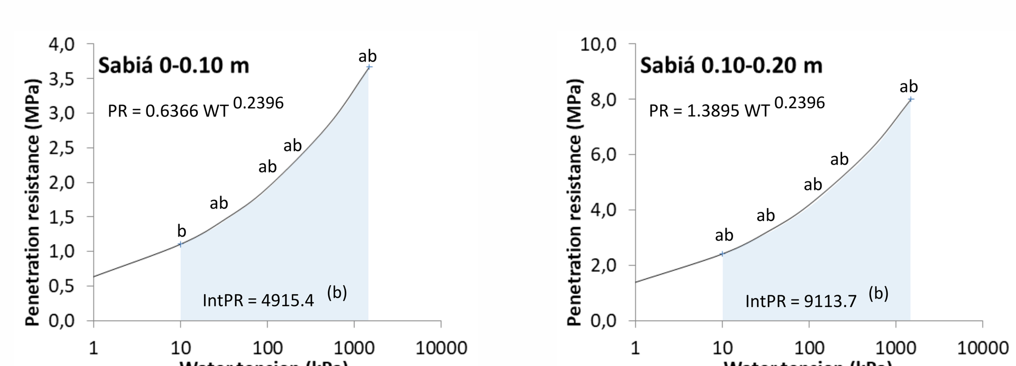
Acácia



Ingá



Sabiá



Note: For each layer, the mean values of PR for each studied water tension (which are increasing along the model line) and intPR (written into filled area) do not differ from those mean values from the other vegetation covers which have close the same letter, by the Tukey test at 5% probability.

The Tukey test of means made with IntPR allowed to differentiate the vegetation covers similarly to tests with RP of each water tension, but in an unequivocal and simpler way. The IntPR values were significantly correlated to those of others physical and chemical variables, such as effective CEC (R=0,66), sum of basis (R=0,43), P (R=0,55), macroporosity (R=-0,81), and BD (R=0,85).

As future research efforts, it is suggested that the proposed variable be confronted to root growth and even be modified in relation to the water tension limits that define it, aiming to achieve high correlations values that validate IntPR as a good soil physical quality indicator.

CONCLUSION

The proposed variable IntPR allows discriminate soils and it is promising as a soil physical quality indicator.

GRATEFUL

CAPES FAPERJ Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro UENF Universidade Estadual do Norte Fluminense Darcy Ribeiro
PROGRAMA DE PÓS GRADUAÇÃO EM PRODUÇÃO VEGETAL MESTRADO E DOUTORADO