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Effect of vegetation and seasons on the water content of soil climatic conditions of the Atlantic Forest in Southern Brazil

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Abstract. *The objetive of this work was monitoring of the soil water content behavior, for grass native field and native forest vegetation cover, in an area characteristic of Atlantic Forest in Southern Brazil. To obtain the soil water content, some electronics tensiometers with pressure transducer were utilized and were placed 0.10, 0.30 and 0.70 m below the soil surface, from October 2010 to May 2011. The values of matric potential, measured by tensiometers, were transformed into soil water content values based on a soil water retention curve for each depth. The obtained results showed that in native fields and native forests, the greatest variations of tension, water content, and water storage in the soil happened at a depth of 0.10 and 0.30 m. At a depth of 0.70 m these variables presented less variations, mainly in native field soil cover. The soil water content was greater in the forested land cover than in the native field. Different seasons throughout the year directly influenced the behavior of analyzed variables. In the summer, the values of soil water tension observed in the forested land cover were higher than those observed in the native field. In the winter season, there was a change in that behavior at depths of 0.30 and 0.70 m and the values of soil water tension became smaller than the forested land cover. Great variations in the soil water tension were observed from October to April (summer), and became steady after May (in the beginning of winter). In the grass native field, most of the time, the greatest soil water content was observed at a depth of 0.10 m followed by depths of 0.70 and 0.30 m, respectively. During dry periods, the greatest soil water content was observed at a depth of 0.70 m, followed by depths of 0.10 and 0.30 m, respectively. In the forest, except for rainy periods, the greatest content of the soil water occurred at a depth of 0.70 m. For the conditions of this study, the total storage of water in the soil was 31.05% greater in the native forest than in the native field.*

Keywords. Soil moisture variation, Soil water content, Soil water storage, Tensiometry, Atlantic Forest

Introduction

The available soil water content for plant roots is one of the main features which defines the response of vegetation under the hydric stress condition. And, it is determinant to the process of exchanging between the soil and the atmosphere. Knowledge of this content is important in studies of infiltration, drainage and irrigation. (Rosato, 2012).

With regards to the different forest covers, Yi-Zhih and Li-Ling (2010) stated that the root systems of forests are distributed deeply in the soil profile, and that soil moisture variations are greater in deeper layers of soil than in shallow ones. *In areas covered by grass,* the root system is shallow, *and great variations occur close to the soil surface. Pinheiro et al. (2009), observed in field research results that the greatest values of infiltration capacity occurred in native forest and the lowest ones occurred in pastures. According to Pereira et. Al. (1997), under the same climatic conditions, a surface covered by forest has an evapotranspiration higher than a lawn, due to the different physical characteristics of the vegetation.*

This paper presents a monitoring *of the soil water content behavior in a grass native field and in a native forest vegetation cover, in an area characteristic of the Atlantic forest in Southern Brazil, aiming to obtain detailed information about the flux of water in the soil under that land cover condition.*

Material and Methods

The study was accomplished in the City of Santa Maria, which is in Southern Brazil (latitude of 29°37’49.7”S, longitude of 53°48’39.8”W, and altitude of 205 m) (fig.1). The climate of this region is subtropical, according to Köppen classification, which is characterized by the occurrence of rainfall in all months of the year without great differences in the amount between the rainiest month and the least rainy month. The total annual rainfall varies from 1700 and 1800 mm, with an average of 113 rainy days per year. However, the region can present an annual deficit of rainfall greater than 200 mm. The average annual temperature is close to 19.3ºC, and the average of the maximum temperatures of the warmest (January) and of the coolest months are equal to 31.5ºC and 9.3°C, respectively. The average relative air humidity is 82% and the predominant winds blow from east to southeast, beside the winds that blow from the north quadrant (Moreno, 1961). According to EMBRAPA (1979), the soil is classified as an association of *Lithic Eutrophic Neosol* with a sandy texture. The predominant vegetation is native grasses and Atlantic forest.

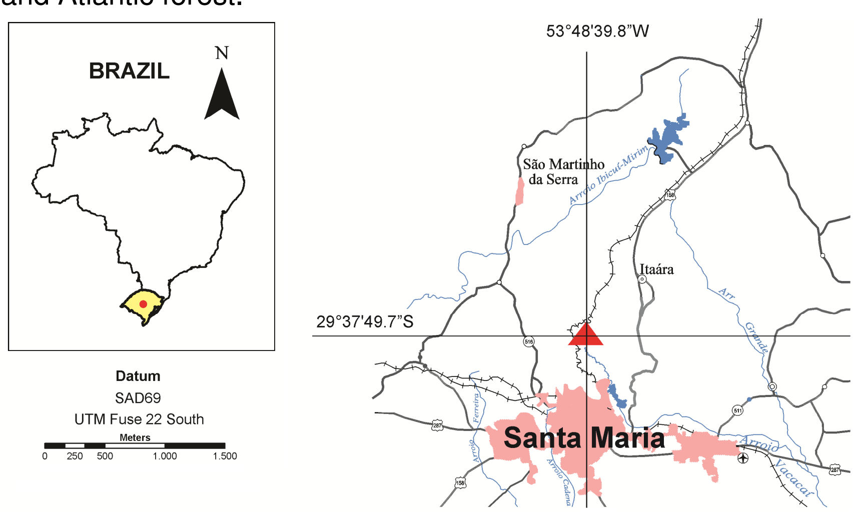

Figure 1. Study area location.

The maximum values of potential evapotranspiration in Southern Brazil vary among three and five millimeters in January and February. From April to August, it can decrease up to one millimeter for almost all of the Rio Grande do Sul State. After October, the values increase again to the maximum ones. Regarding to the soil water storage, from June to September, its values decrease for almost entire regions of Brazil, reaching values as low as 10% in some areas, which are mainly for the Northeast region. However, in the Southern region presents values varying from 90 to 100%. This occurs due to the synoptic systems present in that region, which are responsible for the increasing rainfall. Between January and April, the soil water storage varies between 40% and 60% (Rossato, 2002).

Monitoring of the Soil Water Content

The monitoring of the soil water tension was done using electronic tensiometers with a pressure transducer installed under different vegetation land cover conditions, at depths of 0.10, 0.30 and 0.70 m. The values of soil water tension were transformed into volumetric soil water content using the Van Genuchten (1980) equation, as shown in equation 1:

$$\theta = \theta_r + \frac{(\theta_s - \theta_r)}{\left[1+(\alpha h)^n\right]^b} \tag{1}$$

Where:
θ = volumetric soil water content ($cm^3 \ cm^{-3}$)
θr = residual water content ($cm^3 \ cm^{-3}$)
θs = saturated water content ($cm^3 \ cm^{-3}$)
α, n e b = emphirical parameters
h = matric potential or soil water tension (- kPa).

The soil water retention curve for each sampled depth was determined using Richard's pan of pressure as described by Klute (1986), assuming that the value of matric potential is equal to - 10 kPa as the field capacity (FC) and the value of - 1500 kPa as the permanent wilting point (PWP).

For the calculation of the soil water storage, the soil profile was divided into layers of 0-0.20 m, 0.20-0.40 m and 0.50-0.90 m, according to the position of instalation of tensiometers. The total soil water storage was determined integrating the storage calculated for each layer, and using equation 2. The variation of storage was obtained by the difference between the storages at the final and at the initial time of each considerd period, as shown in equation 3.

$$A = \int_0^L \theta dz \cong \sum \theta \Delta z = \theta L \tag{2}$$

$$\Delta A = A_{(f)} + A_{(i)} \tag{3}$$

Where:

A = soil water storage (mm)
θ = soil water content ($cm^3 \ cm^{-3}$)
L = considered soil depth (mm)
ΔA = soil water storage variation (mm)
$A_{(f)}$ = final soil water storage (mm)
$A_{(i)}$ = initial soil water storage (mm).

Results and Discussion

Table 1 presents the physical hydric features for the different layers of soil and the land cover studied. The soil in the area of native grass presents a total percentage of sand varying from 87% to 90.6%, while in the forested area, these values varied from 71.1% to 78%. In the forested area, the coarse sand fraction represents 34% of the total, while in the native grass area, this value is close to 5%. The fine sand fraction is higher in the native field area, with average value close 83%, while in the forest, this value is close 41%. For both conditions of soil cover, the depth of 0.30 m presented the greatest percentage of sand. Due to these characteristics, the soil of the forested area has a greater field capacity (FC), permanent wilting point (PWP), and available water content (AWC), than the soil of the native field area. Figure 2 presents the soil water retention curve for depths of 0.10, 0.30 and 0.70, for the soils of both studied areas.

Table 1. Physical-Hydric Parameters of soil for sampled depths

	Depth	Bulk density	Micro porosity	Coarse Sand	Fine Sand	Silt	Clay	FC[a]	PWP[b]	AWC[c]
	M	g cm^{-3}	%					cm^3 cm^{-3}		
Forest	0.10	1.40	26.14	32.3	44.4	12.0	11.2	0.2385	0.1035	0.1349
	0.30	1.29	31.92	34.8	43.2	10.8	11.3	0.251	0.107	0.143
	0.70	1.26	23.65	35.2	35.9	17.4	11.6	0.284	0.153	0.131
Grass	0.10	1.44	21.54	6.0	82.5	6.5	5.0	0.1783	0.0867	0.0916
	0.30	1.37	18.15	3.0	87.6	3.1	6.3	0.139	0.054	0.085
	0.70	1.41	21.11	6.5	80.5	5.5	7.5	0.164	0.061	0.103

[a]FC = Field Capacity.
[b]PWP = Permanent Wilting Point.
[c]AWC = Available water content.

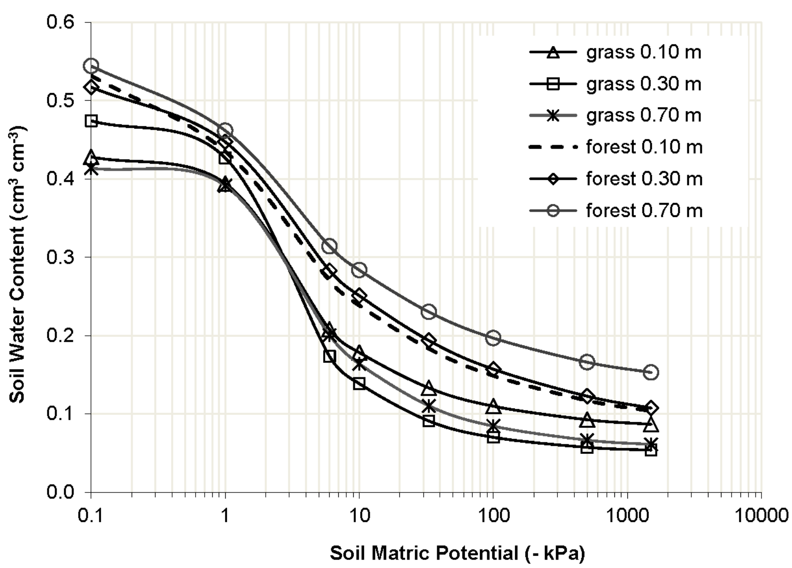

Figure 2. Soil water retention curves for different analyzed depths.

The behavior of analyzed variables in both soil covers are influenced by the different seasons throughout the year. The greatest variations that were observed in soil water tension are from October to March (summer), and there is a clear decreasing tendency of variations and values after April (beginning winter), as shown in figure 3.

For the grass native field, the greatest values and variations in soil water tension occurred at depths of 0.30 and 0.10. Between October and December, these values are close for both depths. However, from the middle of December, the differences became greater. The depth of 0.70 m presented the lowest values and variations of soil water tension. In the summer (after April) the greatest values of soil water tension were observed at depths of 0.70, 0.30 and 0.10 m.

Inside the forest, during the summer, in which the surface layers are the deepest ones, there were significant variations of soil water tension. The biggest oscillations of the soil water tension occurred in a decreasing order at depths of 0.10, 0.30 and 0.70 m. In the winter, values and oscillations of soil water tension drop for all depths, and the greatest values were observed in a decreasing order at depths of 0.10, 0.70 and 0.30 m. At a depth of 0.10 m, the soil water content and soil water tension variation were more susceptive to changes, while at depths of 0.30 and 0.70 m these changes were more slow.

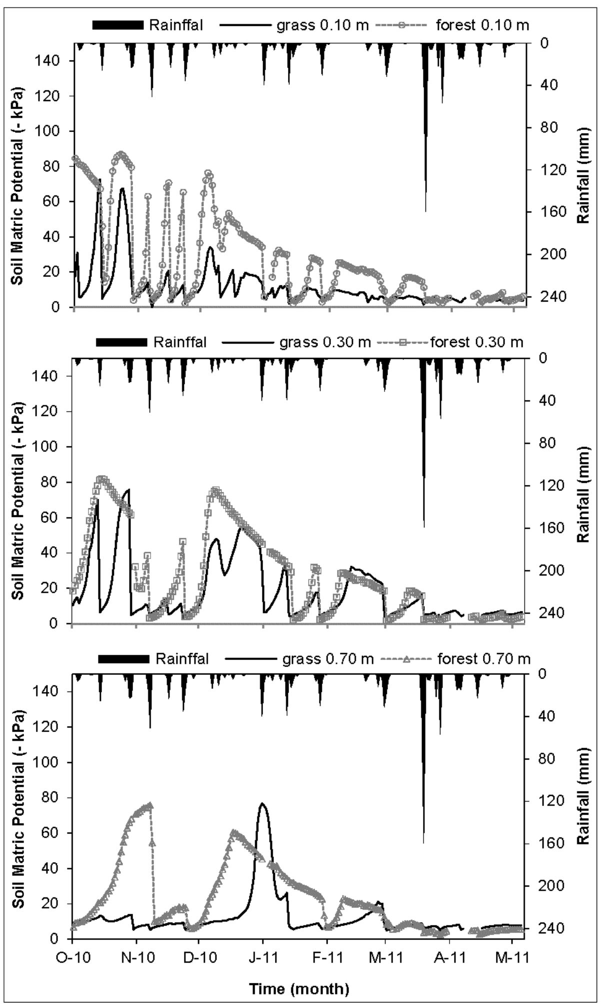

Figure 3. Soil matric potential for different analyzed depths.

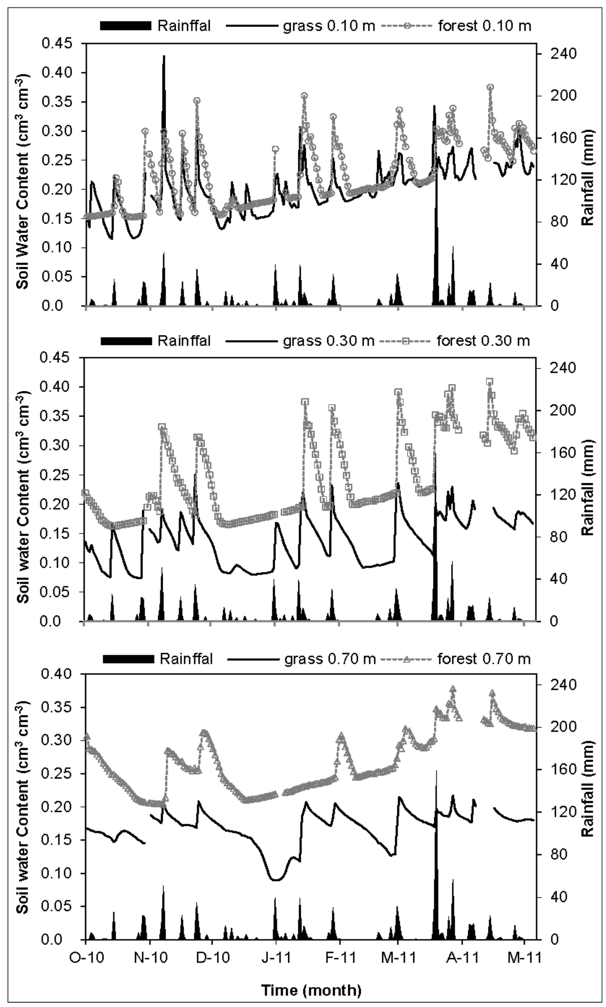

Figure 4. Soil water content for different analyzed depths.

For all depths, the soil water content was greater inside the forest than in the native field (fig. 4). For a depth of 0.10 m the soil water content in both land covers are closer than for the others. Thus, for a depth of 0.10 m , the difference between the soil water content in native field and the native forest was 5.73%, while that for the depths of 0.30 and 0.70 m, these differences were 41.12 and 35.8% respectively.

With regards to the soil water content for native fields, the biggest values in a decreasing order were observed at depths of 0.10, 0.70 and 0.30 m , with a trend of increasing and becoming more steady in the winter (fig. 5a). On the other hand, inside the forest, the soil water content was bigger at a depth of 0.70 m, followed by ones of 0.30 and 0.10 m, respectively (fig. 5b).

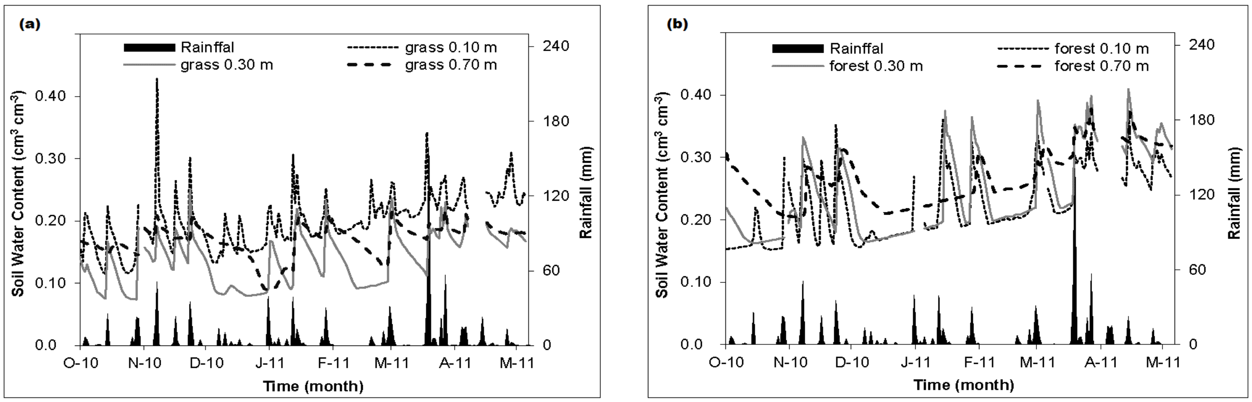

Figure 5. Soil water content for different analyzed depths: (a) grass, (b) forest.

Considering the soil water profile from a depth of zero to 0.90 m, the biggest soil water content were found inside the forested area (fig. 6). The total water storage was 31.05% greater inside the forest than in the native grass. Inside the forest, the soil water storage varied between 169.08 and 336.54 mm, and had an average of 225.81 mm. In native grass, the soil water storage varied between 94.48 and 244.30 mm, having an average of 155.57 mm.

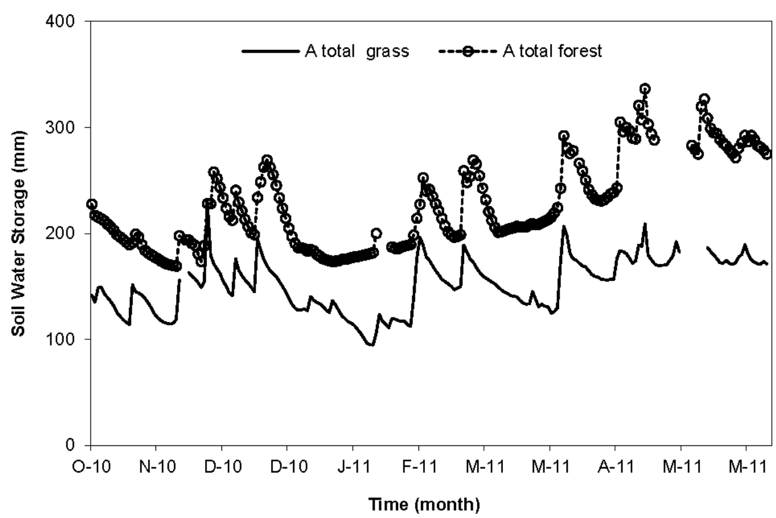

Figure 6. Soil water storage for different analyzed depths.

These results are in accordance with those published by Feltrin and Paiva (2009) and, Feltrin et al. 2011, which were obtained in tensiometers that were installed at depths of 0.10, 0.30 and 0.70 m inside of a drainage lysimeter, and at the same place where *the behavior of the soil water content, for grass native field was monitored.*

Conclusion

Based on the obtained results and, for the conditions in wich this work was realized, it is possible to conclude that:

During summer, the soil water content is greater for the native field area than inside the forest, while during winter, the opposite occurs;

The different seasons throughout the year directly influenced the behavior of the variables analyzed for both soil covers. The greatest variations were observed in the soil water tension between October and March (summer) and, a clear decreasing tendency of variations and values after April (beginning winter);

The soil water tension and the soil water storage presented similar trends of variation for both of the studied land covers;

The soil water storage presented an increasing trend during winter:

For all studied depths, the soil water content was greater inside the forested area than in the native grass field;

For both studied land covers, the greatest variations of the soil water tension occurred at the layers that were more close the soil surface and,

For the soil layer at 0.70 m of depth, in the case of the native grass field, the soil water tension stayed slightly constant throughout the study, while inside the native forest, due to the deepest root system of vegetation, its behavior was the same as the others layers.

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References

COMPANHIA DE PESQUISA DE RECURSOS MINERAIS - CPRM. 1994. Mapa hidrogeológico. Folha Santa Maria. 1:100.000. Brasília.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA - EMBRAPA. 2006. Sistema Brasileiro de Classificação de Solos - SiBICS. Rio de janeiro. RJ. 388 p.

Farias, P.V.C. 2011. Flutuação dos níveis de água subterrânea em microbacias hidrográficas do Rio Vacacaí-mirim. Dissertação de Mestrado. Programa de Pós-Graduação Em Engenharia Civil. Universidade Federal de Santa Maria. Santa Maria, RS, Brasil.

Feltrin, R.M. and Paiva,J.B.D. 2010. Storage of water in the soil in a drainage lysimeter. The Meeting of the Americas. 8-1*2* August, Foz do Iguassu. Brazil

Feltrin, R. M., de Paiva, J. B. D., de Paiva, E. M. C. D. and Beling, F. A. 2011. Lysimeter soil water balance evaluation for an experiment developed in the Southern Brazilian Atlantic Forest region. Hydrol. Process., 25: 2321–2328. doi: 10.1002/hyp.7971

Kaiser, D.R. 2010. Estrutura e água em argissolo sob distintos preparos na cultura do milho. Tese de Doutorado. Programa de Pós-Graduação em Ciência do Solo. Universidade Federal de Santa Maria. Santa Maria, RS, Brasil.

Klute, A. 1986. Water retention: Laboratory methods: IN: A. Klute (ed.). Methods of soil and analysis. Part 1. 2a edition. Agronomy Monograph 9: 635-662. ASA and SSSA, Madison, WI.

Moreno, J. A. 1961. Clima do Rio Grande do Sul. Porto Alegre, Secretaria da Agricultura. 42p.

Pereira, A. R.; Nova, N. A. V.; Sediyama, G. C. 1997. Evapo(transpi)ração. Piracicaba: FEALQ, 183p.

Pinheiro, A.; Teixeira, L P.; Kaufmann, V. 2009. Capacidade de infiltração de água em solos sob diferentes usos e práticas de manejo agrícola. Ambi-Agua, Taubaté, v. 4, a 2, p. 188-199. (doi: 10.4136/ambi-agua. 97)

Rossato, L. 2002. Estimativa da capacidade de armazenamento de água no solo do Brasil. Dissertação (Mestrado em Meteorologia). Instituto Nacional de Pesquisas Espaciais. São José dos Campos, 145p.

Yi-Zhih, T., Li-Ling, L. 2010. Soil water distribution for the forest and grass area in Chiu-Fen-Erh-Shan, Taiwan after Chi-Chi Earthquake. p 642-651.

Van Genuchten, M.T. 1980. A closed-form equation for predicting the hydraulic conductivity of unsatured soils. Soil Science Society of American Journal, Madison, v.44, n.5, p.892-8.