XXIII SIMPÓSIO BRASILEIRO DE RECURSOS HIDRÍCOS

SOIL LOSS AND WATER INFILTRATION IN DIFFERENT SOIL USES IN HYDROGRAPHIC BASIN

Danielle Amorim Freitas de Souza[1]; Glauber Altrão Carvalho[2];Thais Caregnatto Thomé[3] & Teodorico Alves Sobrinho[4]

RESUMO – A prática de atividades relativas à pecuária extensiva e ações antrópicas promovem processo de degradação em áreas de pastagem ou de cultivos, sendo necessários estudos para dar suporte ao gerenciamento ambiental dessas áreas. Alguns dos fatores que caracterizam o solo e indicam sua qualidade são, principalmente, o teor de matéria orgânica, infiltração de água no solo e perda de solo. Analisando esses fatores e os tipos de usos do solo, podemos ter uma ideia das condições do solo e de suas necessidades. Assim, o objetivo do estudo foi caracterizar o processo de infiltração de água, o conteúdo de matéria orgânica e as perdas de solo em diferentes usos do solo, para que possa servir de subsídio para gestão e planejamento de áreas sob cultivo ou pastagem. Realizamos testes em três condições de uso do solo, pastagem degradada, pastagem recuperada e cultivo de eucalipto, utilizando simulador de chuva e análise de amostras de solo para determinação do teor de matéria orgânica. Observamos que o cultivo de eucalipto teve o maior e mais significativo impacto no aumento da infiltração de água e na redução da perda de solo e concluímos que a manutenção da matéria orgânica no solo é fundamental para a conservação do solo.

ABSTRACT– The practice of activities related to extensive livestock and anthropogenic actions promote degradation processes in pasture or crop areas, and studies are needed to support the environmental management of these areas. Some of the factors that characterize the soil and indicate its quality are, mainly, the organic matter content, water infiltration in the soil and soil loss. By analyzing these factors and the types of land uses, we can get an idea of the soil conditions and their needs. Thus, the objective of the study was to characterize the process of water infiltration, organic matter content and soil losses in different soil uses, so that it can serve as a subsidy for the management and planning of areas under cultivation or pasture. We perform tests under three soil use conditions, degraded pasture, recovered pasture and eucalyptus cultivation, using rainfall simulator and analysis of soil samples to determine the organic matter content. We observed that eucalyptus cultivation had the largest and most significant impact on the increase of water infiltration and on reduction of soil loss and we concluded that maintenance of organic matter in soil is a key to the soil conservation.

Palavras-Chave – conservation; erosion; agricultural

1) Mestranda PPGTA/UFMS, Cidade Universitária, Av. Costa e Silva - Pioneiros, MS,+55 (67) 3345-7440, danielleamorim.eng@gmail.com
2) Doutorando PPGTA/UFMS, Cidade Universitária, Av. Costa e Silva - Pioneiros, MS,+55 (67) 3345-7440, glauber.altrao@gmail.com
3) Mestranda PPGTA/UFMS, Cidade Universitária, Av. Costa e Silva - Pioneiros, MS,+55 (67) 3345-7440, thaisthome04@gmail.com
4) Professor PPGTA/UFMS, Cidade Universitária, Av. Costa e Silva - Pioneiros, MS,+55 (67) 3345-7440, teodorico.alves@ufms.br

INTRODUCTION

Agroecosystems in the 21st century must be capable to provide the adequate quantity and quality of products and simultaneously not cause harm to the environment (Balbino *et al*., 2011). Rural planning and management require strategic projects and analysis tools capable of qualitatively and quantitatively assessing the factors that influence land degradation and water resources in an integrated manner. In watersheds, erosion and soil loss are related to the impacts observed in rivers, both physically, chemically and biologically.

In each type of soil use and management, there are specific values of soil water infiltration, organic matter and soil loss that, among other factors, greatly influence soil quality, in relation to food production and water resources conservation. Vegetation characteristics influence water dynamics, reduce evaporation, increase soil infiltration and protection against damaging effects of raindrops, prevent particulate loading and sedimentation in the lower parts of the terrain, especially for waterways altering their quality (Da Silva *et al.,* 2007).

The combination of the soil tillage system and the stages of crop development interfere with soil and water losses. Initially, the type of soil preparation has a greater influence on the erosive process and, along the development of the crops, reduces soil and water losses (Carvalho *et al*., 2015).

In addition, the practice of extensive livestock activities and anthropogenic actions promoted an intense process of degradation in the area, mainly due to the removal of vegetation from the soil. Organic matter influences the physical conditions of a soil in several ways. Plant residues that cover the soil surface protect the soil from sealing and crusting by rain drop impact, thereby enhancing rainwater infiltration and reducing runoff (FAO, 2005).

The research was carried out with common species in Brazil, Brachiaria and Eucalyptus. It is estimated that Brazil currently has about 100 million hectares of cultivated pasture, of which more than 60% are of Brachiaria species (Rao *et al*., 1996). Eucalyptus plantations occupy an area of more than 3.5 million hectares in Brazil, with a commercial volume of up to 45 m³ ha^{-1} year^{-1} of wood, from hybrid clones of the most cultivated species (Mora and Garcia, 2000; Rapassi *et al*., 2008).

Thus, the objective of this study is to verify if the different soil uses and the organic matter content interfere in the process of water infiltration and soil losses, so that it can be used in the management and planning of basins.

METHODOLOGY
Study Area

The study was carried out in the Guariroba River Basin (Figure 1), which it is located on the rural side of Campo Grande, Mato Grosso do Sul state, Brazil and has an area of 36,190 ha. The basin is the main water supply, as it provides about 40% of the total water consumed by the urban area, and therefore, needs actions that guarantee water security. According to Koppen, the climate of the region is Aw, defined as hot and humid. It presents high temperatures and well defined rainy periods with an average annual rainfall of 1,500 mm, varying from 750 mm to 2,000 mm.

Figure 1. Guariroba's River Basin location

The predominant use of the land corresponds to pastures, for extensive breeding livestock, the remainder being composed of fractions of vegetation native to the Cerrado biome. In 2015, 47.4% of the basin presented agricultural suitability for pasture, forestry or integrated systems (Agua Brasil, 2015). However, in 2008 about 82% of the basin territory had already been occupied by cultivated pastures (Campo Grande, 2008), demonstrating the past occupation of the area without observing soil skills.

Infiltration and Soil Loss

The water infiltration and soil loss was analyzed in three soil use conditions: degraded pasture area (Brachiaria ssp.) (Figure 2), recovered pasture (Brachiaria brizantha cv. Piatã and Stylosanthes ssp. Cv. Campo Grande) (Figure 3) and eucalyptus cultivation (Eucalyptus grandis x urophylla) (Figure 4) established 6 years ago. The tests were carried out with and without the vegetal cover for each of the plots. At the end of each test the vegetative cover of each plot was removed in order to evaluate the influence of the vegetation cover on the processes.
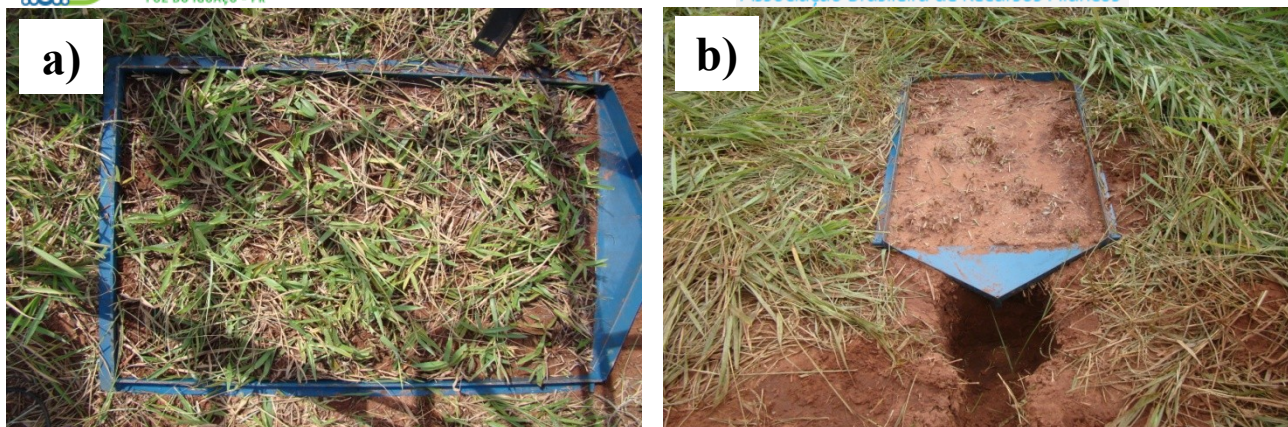
Figure 2. Experimental plot of degraded pasture (Brachiaria ssp.): a) with vegetation cover and b) without vegetation cover
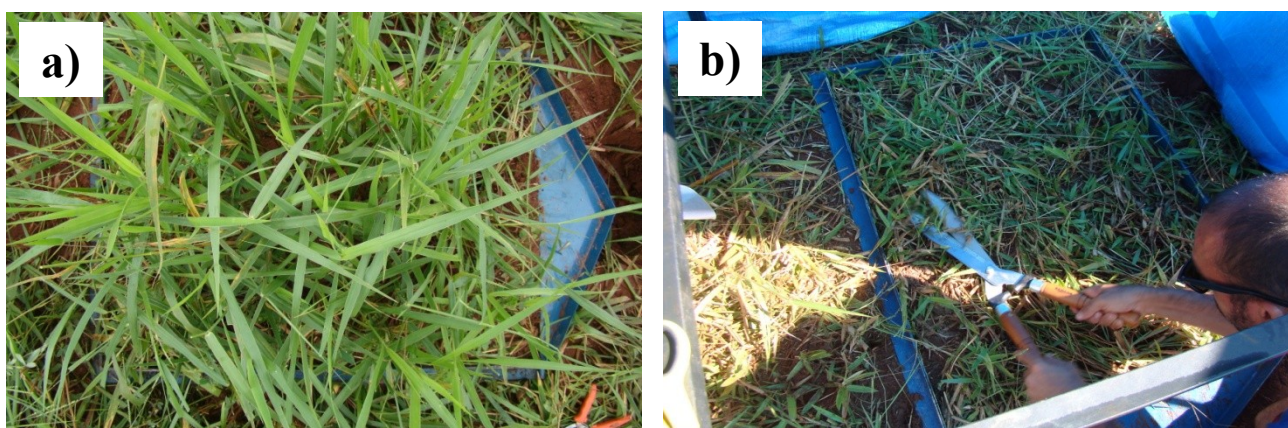

Figure 3. Experimental plot of recovered pasture (Brachiaria brizantha cv. Piatã and Stylosanthes ssp. Cv. Campo Grande): a) with vegetation cover and b) without vegetation cover
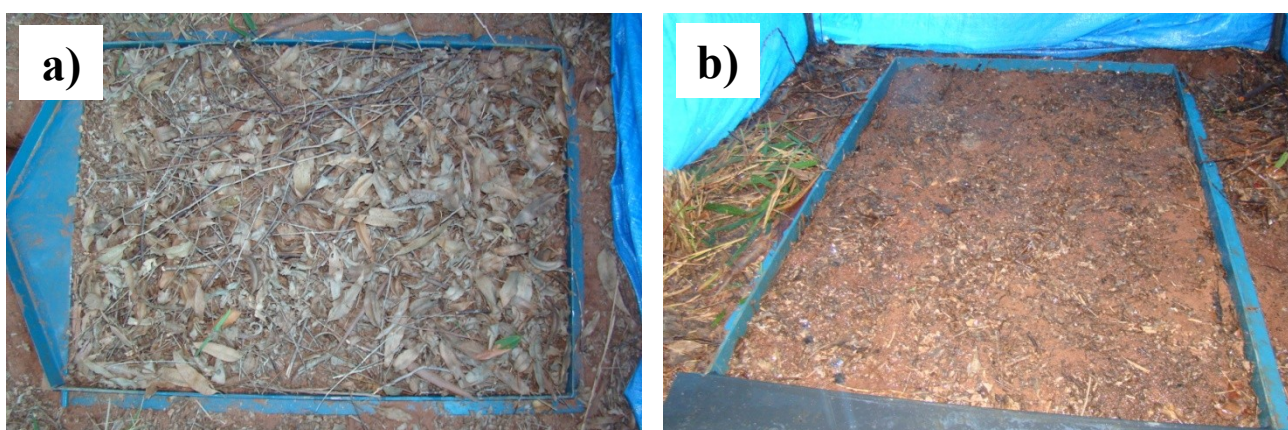

Figure 4. Experimental plot of eucalyptus cultivation (Eucalyptus grandis x urophylla): a) with vegetation cover and b) without vegetation cover

To characterize the process of water infiltration and soil loss we used a portable rainfall simulator (Alves Sobrinho *et al.*, 2002) (Figure 5). The experimental plots, which received the simulated rainfall, were contoured by rectangular plates of galvanized steel, with 0.70 meters wide and 1 meter long in the direction of the slope, reaching 0.70 m² of useful area. The soil was wetted, at least 12 hours before the field tests, aiming to standardize the humidity conditions in the

experimental plots, constituting a requirement before the application of the artificial rainfall (Cogo *et al*., 1984).
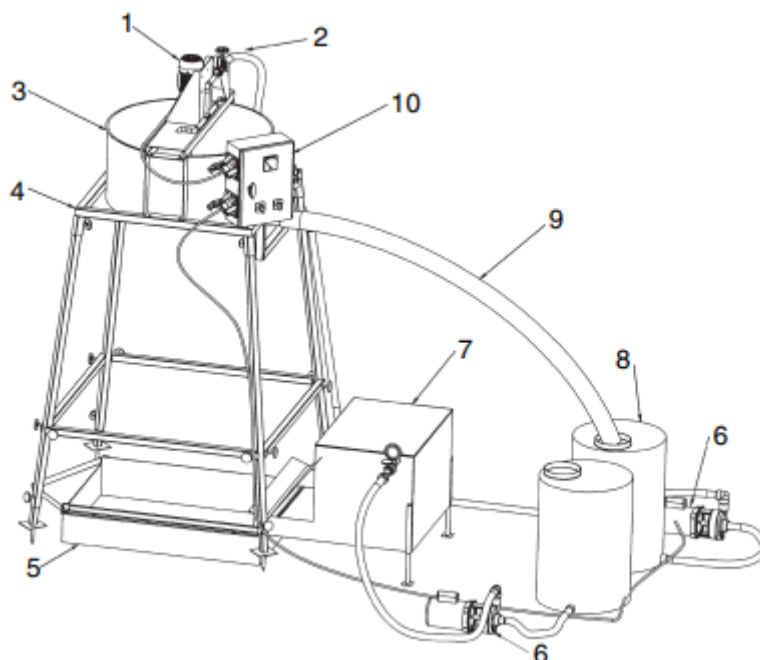

Figure 5. General view of rainfall simulator: (1) motor; (2) water application; (3) blocking device; (4) upper frame; (5) run-off collector; (6) water pump; (7) overland flow module; (8) tank; (9) excess water; (10) electric panel control (Alves Sobrinho *et al*., 2008)

At the beginning of surface runoff, samples of the flow volume in the plot were collected. The time interval between the beginning of the application of the rain and the beginning of the surface runoff was identified for each experimental plot, since it corresponds to the time of beginning of the surface runoff. The surface runoff was calculated by the relation between the volume of water drained and the area of the experimental plot that received the precipitation (0.70 m²). The infiltrated water was obtained by the difference between the applied water (artificial rain) and the surface runoff at each time interval. The values of infiltration rate ($mm.h^{-1}$) were obtained by the relationship between infiltrated water and infiltration time considered.

In order to determine soil loss, the direct method described by Bertoni and Lombardi Neto (2012) was used. The values were obtained through Gooch crucible filtration, oven drying and weighing of each sample. Thus, from the results of sediment concentration and surface volume, the data were extrapolated in order to estimate the rate of soil loss ($g\,m^{-2}\,h^{-1}$).

Organic matter and dry matter

For the characterization of the experimental area, soil samples were also analyzed to determine the organic matter content, which was determined by muffle firing at 440 °C, according to NBR 13600 (ABNT, 1996). The quantification of the dry matter yield of each treatment was

obtained by oven drying at 60 °C until weight stability of the vegetal cover contained in the area of each plot.

RESULTS AND DISCUSSION

From the analyzes in the laboratory, we observed similar values of organic matter in the three types of soil uses (Table 1). This similarity occurs due to the slow aggregation of organic matter in soil dynamics. The dry matter content of the recovered pasture was higher than the degraded pasture. According to Botrel *et al*. (1999), the brachiaria, in general, have been shown to be plants with high potential of dry matter production, besides being satisfactorily accepted by cattle, providing significant gains of weight. This vegetation has always aroused interest among researchers and producers, due to its morphological characteristics that provide high dry matter yield and wide adaptability (Jank, 1995).

We still observed that the dry matter content of Eucalyptus was higher in relation to the pasture values. Approximate values of 13.5 t.ha^{-1} were found by Gama-Rodrigues and Barros (2002) in planting the same species of Eucalyptus (Eucalyptus grandis x urophylla) in secondary forest with 16 years. Vieira *et al*. (2014) obtained a mean of 6.9 t.ha^{-1} for Eucalyptus urophylla x Eucalyptus globulus of six years.

Table 1. Average values of organic matter and dry matter

	Organic Matter (%)	Dry Matter (t.ha^{-1})
Degraded pasture	1.32	3.2
Recovered pasture	1.32	5.3
Eucalyptus	1.26	11.9

The recent soil preparation in the reclaimed pasture area also implied higher infiltration rates compared to the degraded pasture (Table 2), due to the rupture of the soil surface layer structure after soil preparation, the infiltration capacity increases (Pruski, 2009). If storage conditions are not maintained, the infiltration capacity may become less than that of an unprepared soil, especially in the case of removal of the vegetation cover. For, the surface sealing is rapidly formed and the infiltration capacity is reduced, as observed after the removal of the cover in the recovered pasture, where the infiltration rates assumed values very close to natural pasture.

Table 2. Values of initial and final infiltration rates, after 60 minutes of rainfall simulation, with and without vegetation cover.

		Infiltration Rates (mm.h^{-1})		Soil Loss (g.m^{-2}.h^{-1})
		Initial	Estable	
Degraded pasture	With vegetation cover	99.1	85.8	52.6
	Without vegetation cover	100	71.5	113.4
Recovered pasture	With vegetation cover	106.1	104.2	16.3
	Without vegetation cover	102.8	72.9	163.9
Eucalyptus	With vegetation cover	113.3	113.4	4.3
	Without vegetation cover	113.6	110.9	20.2

The control of water erosion promoted by vegetation cover can be observed among the studied areas. We observed that Eucalyptus is the use of soil that presented the greatest contribution of residues on the soil and also the one that obtained better erosive control, in the presence and in the absence of the vegetal cover on the soil. In a study developed by Silva *et al*. (2011), eucalyptus cultivation was also the most efficient in the fight against erosion, being more efficient than the pasture itself. The same authors point out that eucalyptus presents higher soil losses in the initial years, decreasing with the years.

In addition to the fact that the eucalyptus cultivation presented a high organic matter content, it can be affirmed that the accumulation of litter benefited the aggregation of organic material to the soil, which influenced the stabilization of aggregates, increasing the cohesion between the particles of soil, and provided residues that functioned as physical barriers to surface runoff and consequent laminar erosion. Lima (1990) states that eucalyptus plantations can have a significant impact both on the control of runoff and on loss of soil and nutrients by leaching, and this effect is more efficient as the planting develops.

In general, all soil uses showed good performance in terms of water infiltration rate. It is observed the decay of infiltration rates when vegetation is removed in pasture areas, while in the eucalyptus plantation area the infiltration capacity practically remains, even after the litter removal. This demonstrates the influence of the superficial organic matter in favoring the infiltration.

CONCLUSIONS

In this study, we analyzed the process of water infiltration, organic matter content and soil losses in different soil uses. We perform tests under three soil use conditions, degraded pasture area, recovered pasture and eucalyptus cultivation, using a rainfall simulator with a constant intensity rain in plots of 0.7 m² in size. We also analyzed soil samples to determine the organic matter content.

We observed that the area with eucalyptus cultivation had the largest and most significant impact (percentage difference in soil loss of more than 710% compared to a recovered pasture area) on the increase of water infiltration in the soil and on the reduction of soil loss, both in the uncovered condition and in the soil cover, due to the capacity of dry matter formation. This demonstrates the greater the dry mass, the better the soil protection (reducing the impact of the raindrops on the soil), providing greater infiltration of water in the soil and less soil loss.

So, the maintenance of organic matter in soil is a key to the soil conservation. In this sense, crop-livestock-forest systems, which allow this maintenance due to the presence of forest species, may represent an increase in productivity and decrease in the effects of the environment. This work reaffirms that studies of the process of water infiltration, interaction of organic matter and soil loss are essential to support the environmental management of hydrographic basin soils, improving the water quality available to consumers.

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