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Runoff and particle detachment of a ferralsol under pastures (Cerrado, Brazil)

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Abstract

Cultivated pastures covers 49.5 Mha in the Cerrado area, and 50% of them have a low productivity or are degraded. An inadequated management of pastures is one of the responsible factors for that damage. Another one which intervenes is the soil factor and its physic attributes. In fact, the topsoil of the old pastures which have a low productivity presents, in general, a low porosity. Its structure is characterized by the juxtaposition of compact volumes, formed by centimetric aggregates, and also by volumes more porous organized in agglomerated very porous micro-aggregates. The pasture cover rate influences the stamping which facilitates the crust formation. This work has for objective to highlight, during a field trial, the importance of runoff and soil particle detachment of a clayey Ferralsol of Central Plateau (yearly pluviometry 1,200 mm) under cultivated pastures. These two parameters are studied for the first time in that area at the one-square meter scale.

Three pastures are compared, a 10 years old *Brachiaria brizantha, cv marandu* low productivity pasture as control, a pasture associating the same graminee with the *Stylosanthes guianensis,* var. *vulgaris,* cv *minerão* legume, and a pure *Brachiaria brizantha* pasture. These last two treatments, from same origin than the control, have been rehabilitated in 1999. Two crossed superficial passages of diskplow were performed, in order to permit the raise of *Brachiaria* seeds present in the soil, the legume sowing and the fertiliser spreading. Every treatment includes 3 erosion micro-plots installed in 1999 at lower, mid and upper slope, with a declivity of 3.5%, on average. The pluviometry was recorded by weekly paper tape-recording pluviograph. The runoff and sediments sampling was done twice a week. The sediments were dried at 65°C.

During the period of observation, from October 2000 to March 2001, the runoff between the three pastures is significantly different, as well as the particles detachment. The runoff is correlated negatively with the average percentage of pasture cover (r: -0.91). Nevertheless, the runoff coefficient is low, 0.14% for the *Brachiaria* treatment, 0.25% for the associated treatment and 1.35 % for the control, what confirms the observed datas on large plots in the region. The particle detachment is low as well, with the lowest average (42 g m^2) recorded in the pure *Brachiaria* treatment, and the highest (116 g m^2) recorded in the control. This work shows that the runoff and the particles detachment intervene slightly in the degradation process of Cerrados' soils under pastures with an adequat management.

Keywords: micro-plot, runoff, pasture, *Brachiaria brizantha*, *Stylosanthes guianensis*, Cerrados

Introduction

In the 204 Mha of Cerrado region, 49.5 Mha are cultivated with pastures (Sano *et al.*, 2000). About 50% of these pastures are damaged or with a low productivity. Among the factors responsible for this damage, an inadequate pasture management and the physical properties of soils. In fact, the topsoil of low productivity old pastures shows a low porosity on ferralsols. Its structure is characterized by a juxtaposition of compact volumes, formed by centimetric aggregates, and volumes organized in agglomerated very porous micro-aggregates. The rate of the soil surface cover by pasture plants influences the stamping which makes easier a crust formation. Thus, one of the hypothesis for the pasture decline process was the loss of water by runoff from the plant-soil system.

The ferralsols represent 46% of Cerrado area. Studies about runoff and soil losses have been conducted in large plots in this region (*e.g.* Dedecek *et al.*, 1986; Leprun, 1994; Santos *et al.*, 1998) or at the watershed scale (Silva *et al.*, 1999), but these evaluations were made on high productivity pastures, and none of them has been realized at one square meter scale.

This communication presents the results obtained during a field trial, established to evaluate the part of runoff and particle detachment of a clayey Ferralsols (Latosol) on the pasture decline process.

Materials and Methods

The experimental site has been installed in a farm located at an altitude of 1,000 m on the Central Plateau and 100 km to the north of Brasilia (15°13′ S and 47°41′ W). The soil is a homogeneous clayey Ferralsol (dark red Latosol) which contains 65% of clay and 14% of fine sand in the upper layers, and 75% of clay and 13-15% of fine sand in the lower layers. The annually rainfall average is 1200 mm, and the rainy season lasts about 7 months, from the end of September to the beginning of April. The average of monthly temperatures vary from 20°C in July to 23°C in October.

Three treatments were compared: (i) the control which is a 10 years old low productivity pasture of *Brachiaria brizantha,* cv *Marandu*; (ii) a 21 months old pasture combining this graminee with a legume, *Stylosanthes guianensis,* var. *vulgaris,* cv *mineirão*, and (iii) a 21 months old pasture of pure *Brachiaria brizantha.* These 2 last treatments, stemmed from the same pasture than the control, were rehabilitated in 1999. Two crossed superficial passages of diskplow were performed in order to allow the raise of *Brachiaria* seeds present in the soil, the legume sowing and the fertiliser spreading. Each treatment includes 3 one square meter erosion micro-plots installed in March 1999 at three slope positions (lower, mid and upper slope) on 500-m long slope, with a 3.5% gradient. Under control pasture, the soil had a strong platy structure from the surface to 3 cm deep, a small to medium blocky structure from 3 to 18 cm deep.

The runoff water and the sediment were collected twice a week, from October 2000 to March 2001, under natural rainfall, 21 months after micro-plots installation. The sediment were dried at 65°C. The pluviometry was recorded by a weekly paper tape-recording pluviograph.

Results and discussion

During the experiment period, the total of rainfalls was 1,062 mm. The months of November and December were the rainiest. Together, they represent 53% of the pluviometry. The rainfall structure, in general, is not very erosive in the region. Thus, in this rainy season, only 3 rainfalls were superior to 50 mm and 5 rainy episodes had intensities superior to 50 mm h^{-1} within a lenght inferior to 30 minutes.

Figure 1 presents the amount of water and soil losses for every rainfall episode from the control treatment located on the lower position of the slope which are the highest of the experimentation.

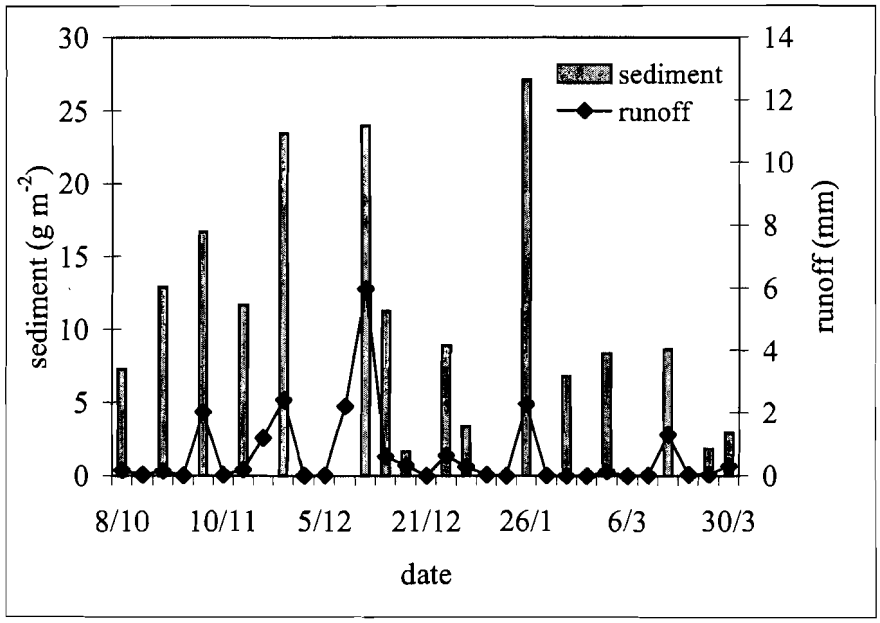

Figure 1 Runoff (mm) and sediment (g m^{-2}) at control lower slope micro-plot.

The runoff coefficient (RC = (runoff/rainfall) x 100), for the considered period, is superior to 1% at the bottom slope and also at mid-slope of control (Table 1). The two rehabilitated treatments have runoff coefficients very low. The mean runoffs are respectively 1.4, 2.6 and 14.3 mm for the treatments *Brachiaria, Brachiaria + Stylosanthes* and control, with a runoff coefficient inferior to 1% for the first two treatments and 1.3% for the control.

Table 1 Runoff coefficient (%) and soil losses (g m^{-2}).

	Brachiaria			*Brachiaria + Stylosanthes*			Control		
	Ls*	Ms*	Us*	Ls	Ms	Us	Ls	Ms	Us
RC	0.1	0.2	0.1	0.5	0.2	0.1	1.9	1.3	0.8
Soil losses	36	42	49	136	17	57	177	12	160

* Ls: lower slope, Ms: mid slope, Us: upper slope

Throughout the rainy season, both the runoff coefficient and the soil loss remained at very low levels, even for very long rain episodes. So, for December 2000, when it rained 104 mm in four consecutive days (75 mm in just one rain event), the runoff coefficient was 0.13% for the *Brachiaria*, 0.28% for the *Brachiaria* + *Stylosanthes* and 6% for the control.

The soil surface plant cover, estimated visually and regularly throughout the rainy season, was respectively 69%, 77% and 54% for the *Brachiaria*, *Brachiaria* + *Stylosanthes* and control. Soil surface plant cover was negatively correlated with runoff ($r = -0.91$).

Low runoff coefficients implied in low soil losses, as shown in table 1. At the scale of the experiment, the amount of soil particles detached and transported in the three topographic positions averaged respectively 42 g m^{-2}, 70 g m^{-2} and 116 g m^{-2} for the *Brachiaria*, *Brachiaria* + *Stylosanthes* and control, and also correlated negatively with the soil surface plant cover ($r = -0.67$).

The results presented here confirm the ones obtained by Dedecek *et al.* (1986) and Blancaneaux *et al.* (1993) on ten square meter plots. However, when extrapolated for the watershed level, the hillslope runoff coefficients obtained on the one square meter plots overestimated the actual values (Harms *et al.*, 2000). A research about "scale effect" over runoff measurements (Molinier *et al.*, 1990) has shown that the sheet flow decreased when the surface increased for a given rainfall.

Conclusion

Soil and water losses were negligible from plots with damaged or rehabilitated pastures in a two year experiment. Therefore, these two parameters affect very slightly pastures in the degradation process. The results confirm the soil conservative role of pastures, even for the low productive ones. This conclusion is valid, however, only in the cases where soil surface cover is preserved.

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