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RESEARCH ARTICLE

SOIL LOSS CONTROL USING PLANT FIBER BARRIERS (BAMBOO) IN AN AREA DEGRADED BY GULLY

***Alyson Bueno Francisco**

Sao Paulo State University, Brazil

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ABSTRACT

This paper puts forward a linear erosion control measure in an area degraded by gully by means of implanting barriers of bamboo fiber. The pin method was applied in order to analyze the efficiency of this methodology. An estimate of soil loss was calculated from the variation in the soil levels in the experimental plots to consider this variation, the area of the experimental plots, and the soil density. After 17 months of monitoring the experimental plots, the efficiency of the barriers in controlling accelerated loss due to a greater concentration of sediment accumulation in the barriers' upstream pins and a greater soil loss in the pin farthest from the barriers could be observed. In the experimental plot with barriers, a soil loss rate of 4.4 Mg / year was observed, and a 10.25 Mg / year rate was estimated for the experimental plot with no barrier. An efficiency rate of 66% in controlling erosion in the experimental plot with barriers was calculated from these estimates. The adoption of these low cost barriers, there being abundant material in the study region, is recommended as a control method due to the ease of handling the plant fiber and its fixation in ravines with slopes of nearly 15º.

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INTRODUCTION

The western region of the State of São Paulo, in Brazil, suffers from the existence of numerous gullies located at the peripheries of cities, which present risks to the population. The control of urban erosion depends on the implantation of engineering structures at high cost to control the flow of rainwater from urban areas. In 2012, 949 urban gullies were identified throughout the State of São Paulo (Almeida Filho *et al*., 2015).Despite the hazards generated by these gullies, they partly extend into the surrounding rural areas, with lateral ravines caused by the action of superficial flows. When these lateral ravines have depths less than two meters, they can be controlled at low cost by the use of natural materials, such as plant fibers. The linear erosive processes are developed initially from superficial flows, which, when they become concentrated, form channels generating ravines (Díaz, 2001). Against this background, the technique of erosion control using barriers aims to reduce the velocity of surface flows in order to avoid channel concentration and contribute to the diffusion and percolation of rainwater (Smets and Poesen, 2009). In regions with low financial resources, the implementation of barriers with low cost materials is an efficient alternative to the monitoring of sediment deposition (Shit *et al*., 2013). Brazil is a country that suffers from soil loss due to forms of land use (mainly mono-cultures) and the presence of sandy soils and concentrated rainfall in tropical regions. Despite these factors contributing to erosive processes, the country is rich in plant fibers due to the diversity of its biomes and the adaptation of some exotic species to the humid climate conditions. Subedi *et al*. (2012) advocate the use of geotextile blankets made with vegetable fibers: borassus fiber in Gambia (whose international erosion control project was called Borassus), buriti in Brazil, rice straw in China, bamboo fiber in Thailand and corn straw in Vietnam. Bamboo (Bambusaspp) is a plant species that stands out for its ease of production and easy handling for the building of structures, and conditions that favor the implantation of barriers in degraded areas. The use of bamboo barriers in erosion control was suggested by White and Childers (1945) in a recovery area in Puerto Rico (USA).This paper discusses a technique of erosion control using bamboo barriers in a ravine that is part of an area degraded by a gully. Because of the high degradation conditions of the area, this technique not only aims to control the erosive process in a restricted area, but also contributes to avoiding the expansion of this degraded area, and the bamboo species used is present in a regeneration area inside the gully in the study area.

MATERIAL AND METHODS

Description of the study area

The area selected for the implementation of linear erosion control methodologies is located in the west of São Paulo

Corresponding author:* **Dr. Alyson Bueno Francisco
Sao Paulo State University, Brazil.

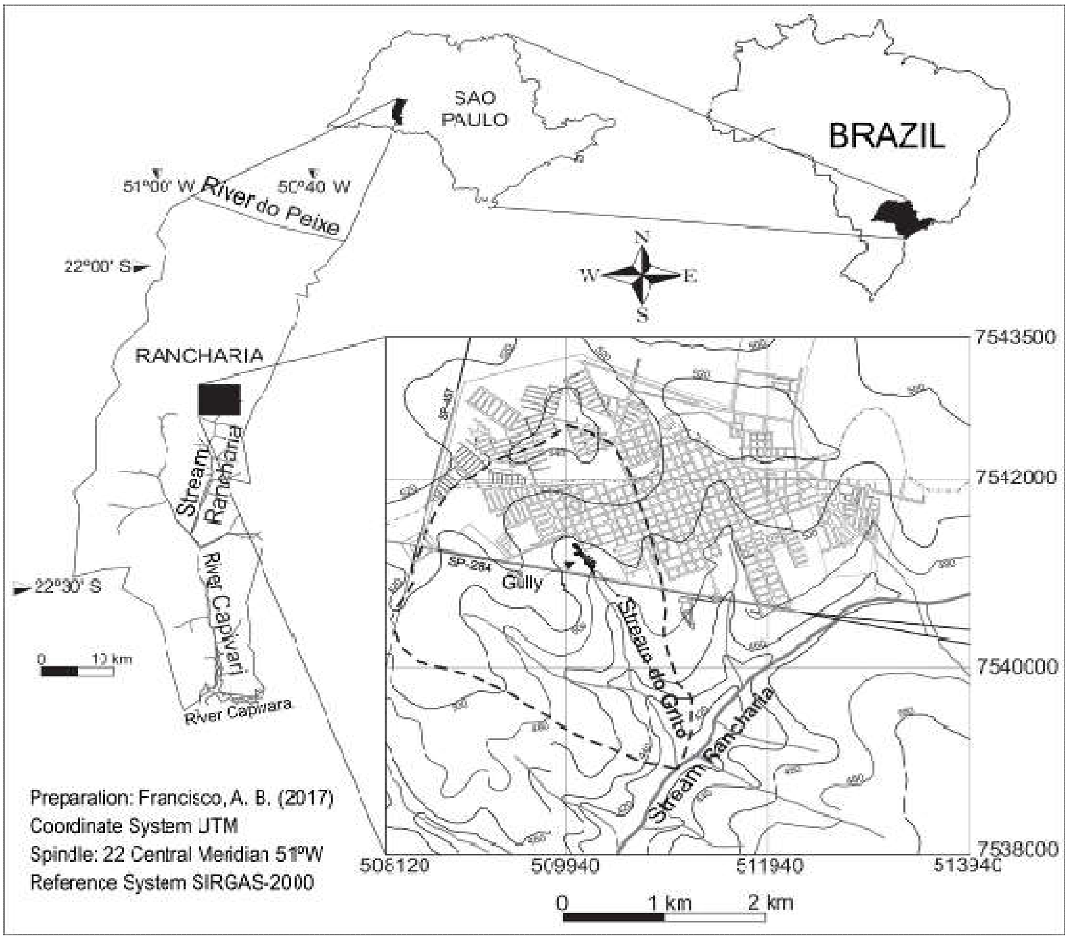

Fig. 1. Location map of the sub-basin and the gully Grito stream

State, Brazil, in the county of Rancharia, part of the Paranapanema River basin and the Grito stream sub-basin (Fig. 1). Rancharia is located in an area of Cwamesothermic climate, with rainy summers and dry winters having an average annual rainfall of 1,300 mm. An average rainfall of 450 mm occurs in the four summer months with an average erosivity of annual rainfall of 7,500 MJ.mm/h/ha (Boin, 2000). The relief of Rancharia is characterized by the predominance of wide hills with the presence of more pronounced slopes in stretches with hills of resistant geology and convex slopes with ruptures that delimit the valley bottoms. This morphology of the local relief is marked by the presence of drainage headwaters in amphitheater formats, which are areas favorable to the development of gullies (Oliveira, 1994). The soils of the Grito Stream sub-basin have sandy-loam textures, high densities in the surface horizons (mean of 1.8 g / cm³) and depths between 2 and 3 meters (Francisco, 2017). The gully of the Grito stream has an area of approximately 17,000 m², with an average width of 40 m and length of approximately 370 m. The lateral ravines of the gully, where the erosion control plots were implanted, have an average width of 2 m and are approximately 25 m in length.

Installation of the experimental plots

This methodology aims to present a comparison of the soil loss estimates in two experimental plots in an area degraded by a gully. In one plot, two barriers of bamboo (A and B) were installed while the other plot was left without barriers. In order to measure the amount of soil eroded and deposited in the experimental plots, erosion pins were implanted according to the procedure described by Morgan (2005).

The bamboo barriers are implanted with an assembly of stakes stacked horizontally. Afterwards, slits are opened from the sides of the ravine where the ends of the stakes are docked. The two barriers have heights of 0.55 m and 0.65 m and widths of 1.30 m and 1.80 m respectively. The upstream side of the barriers was covered with raffia screen. The experimental plot for the implementation of the barriers is a ravine with exposed soil and a ramp of 15 m in length and a slope of approximately 13 °. Fig. 2 shows a topographic map of the experimental plot with the location of barriers and erosion pins. Fig. 3 presents the topographic map of the experimental plot without barriers, represented by a ramp of 18 m in length and a slope of approximately 12.5 °.Measurements of soil levels were made from September 2015. The months of December, February and April were selected because the rainy season is between December and March (summer). The variations in the soil levels were recorded in the field book and later compared to the rainfall indexes referring to the interval of the monitoring period.

Soil density analysis and soil loss calculation

In order to determine soil loss in the experimental plots, soil density was analyzed using the Kopeck ring method described by Camargo *et al.* (2009) and the soil loss volume calculation from the expression proposed by Bertoniand Lombardi Neto (1999).

$P = h.A.Ds$ (1)

where
P = soil loss (t)
h = height of the layer of soil lost (m)

A = area of the experimental plot (m²)
Ds = soil density ($Mg.m^{-3}$)

RESULTS AND DISCUSSION

Table 1 the soil level variation in the erosion pins of the experimental plot with bamboo barriers over 17 months. The data indicates higher soil loss at pin 5 due to its greater distance from the bamboo barriers and a greater accumulation of sediments at pin 7 due to the upstream location of barrier B. differences in terrain slopes and soil properties also influence soil loss dynamics. In the experimental plots, a high soil density was found in the degraded area because extensive cattle ranching took place there for decades. Table 3.presents data on soil density in this area. The average soil density in the four samples was 1.89 $Mg.m^{-3}$. In the experimental plot with barriers, the average layer of soil erosion was 0.127 m in an area of 26 m², resulting in an erosion rate of 6.24 t in 17 months of monitoring, equivalent to 4.4 $Mg.year^{-1}$, or 169 $kg.m^{-2}.year^{-1}$.

Table 1. Variations in the soil level (cm) of the experimental plot with bamboo barriers

Pin	Dec. 2015	Feb. 2016	Apr. 2016	Sep. 2016	Dec. 2016	Feb. 2017	Σ
01	4.8	3.0	2.2	3.0	1.8	2.5	17.3
02	5.4	3.8	2.3	4.0	2.0	2.5	20.0
03	-2.5	-0.9	-0.6	-1.0	-0.5	-0.8	-06.3
04	-3.8	-2.2	-1.8	-2.0	-2.0	-1.7	-13.5
05	-6.5	-4.1	-3.5	-4.5	-3.0	-3.5	-25.1
06	3.7	2.5	1.8	2.7	2.0	2.0	14.7
07	5.5	4.4	3.2	4.5	3.0	3.0	23.6
08	-1.5	-0.5	0.0	-1.0	-0.2	-0.3	-03.7
09	-3.5	-3.1	-2.0	-3.0	-1.5	-1.8	-14.9
Average	±4.13	±2.72	±2.18	±2.85	±1.77	±2.01	±15.46
Rainfall (mm)	Sep. 2015 - Dec. 2015 604.4	Dec. 2015 - Feb. 2016 421.4	Feb. 2016 – Apr. 2016 293.0	Apr. 2016 – Sep. 2016 454.6	Sep. 2016 - Dec. 2016 275.2	Dec. 2016 – Feb. 2017 334.6	2,383.2

Legend: ± average between erosion (-) and deposition (+)

Table 2. Variations in soil level (cm) of the experimental plot without barriers

Pin	Dec. 2015	Feb. 2016	Apr. 2016	Sep. 2016	Dec. 2016	Feb. 2017	Σ
10	-5.5	-5.0	-3.8	-5.5	-3.2	-3.5	-26.5
11	-5.7	-5.2	-3.6	-5.5	-3.0	-3.5	-26.5
12	-7.0	-5.5	-4.0	-5.7	-3.5	-4.0	-29.7
13	-6.2	-4.6	-3.2	-5.0	-3.0	-3.5	-25.5
14	-5.5	-4.2	-3.0	-4.5	-2.5	-3.2	-22.9
15	-5.8	-5.0	-3.5	-5.0	-2.7	-3.7	-25.7
16	-4.9	-4.5	-3.0	-4.5	-2.5	-3.3	-22.7
Average	-5.8	-4.9	-3.4	-5.1	-2.9	-3.5	-25.6
Rainfall (mm)	Sep. 2015 Dec. 2015 604.4	Dec. 2015 Feb. 2016 421.4	Feb. 2016 Apr. 2016 293.0	Apr. 2016 Sep. 2016 454.6	Sep. 2016 Dec. 2016 275.2	Dec. 2016 Feb. 2017 334.6	2.383.2

Legend: - erosion (cm)

Table 3. Soil density of experimental plot area

Sample	Coordinates (UTM)	Depth (m)	Volume of the ring (cm³)	Mass of the ring (g)	Mass of the soil (g)	Density (g/cm³)
Installment 1A	7541031 N 510173 E	0.30	43.80	60.27	77.36	1.7662
Installment 1B	7541034 N 510181 E	1.80	42.34	59.18	78.96	1.8649
Installment 2A	7541051 N 510220 E	0.45	45.26	60.44	85.74	1.8943
Installment 2B	7541035 N 510218 E	2.10	43.80	60.64	88.69	2.0248

During the 17 months of monitoring in the experimental plot without barriers, soil loss higher than 20 cm was observed in the 7 erosion peaks. The highest soil loss (Table 2.) occurred on the upstream pins (10, 11 and 12). Slope conditions higher than the downstream pins was one of the main factors.The relationship between soil level variations and precipitation indexes during the monitoring period showed a strong determination (R^2) of approximately 0.98 in the barrier plot (A) and approximately 0.96 in the barrier-free plot (B), as shown in the graph of Fig. 4, indicating precipitation as a determinant factor in water erosion. This indicates that local

In the experimental plot without barriers, with an area of 30 m², the average layer of soil erosion was 0.256 m, resulting in an erosion rate of 14.52 t in the 17 months of monitoring, equivalent to 10.25 $Mg.year^{-1}$, or 342 $kg.m^{-2}.year^{-1}$.Oliveira (1994) found an estimated 42 $Mg.ha^{-1}.year^{-1}$ of soil loss from the analysis of technogenic deposits generated by the production of sediments in the gullies located in the sub-basin of this degraded area. The closely related values of the soil loss estimate in the sub-basin of the area degraded by the gully and the erosion rates shown in plots of reduced areas guarantees that the soil loss in the experimental plots is increased by the exposed soil conditions and sharp slopes.

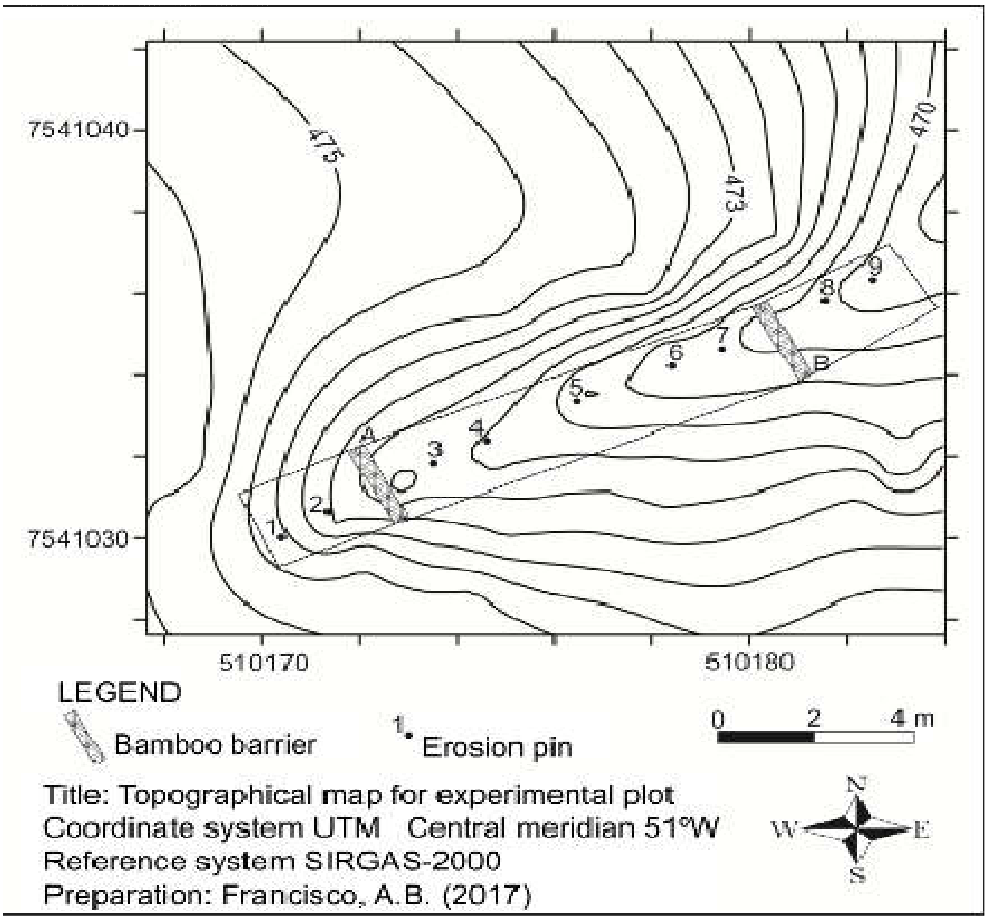

Fig. 2. Topographical chart of the experimental plot with barriers

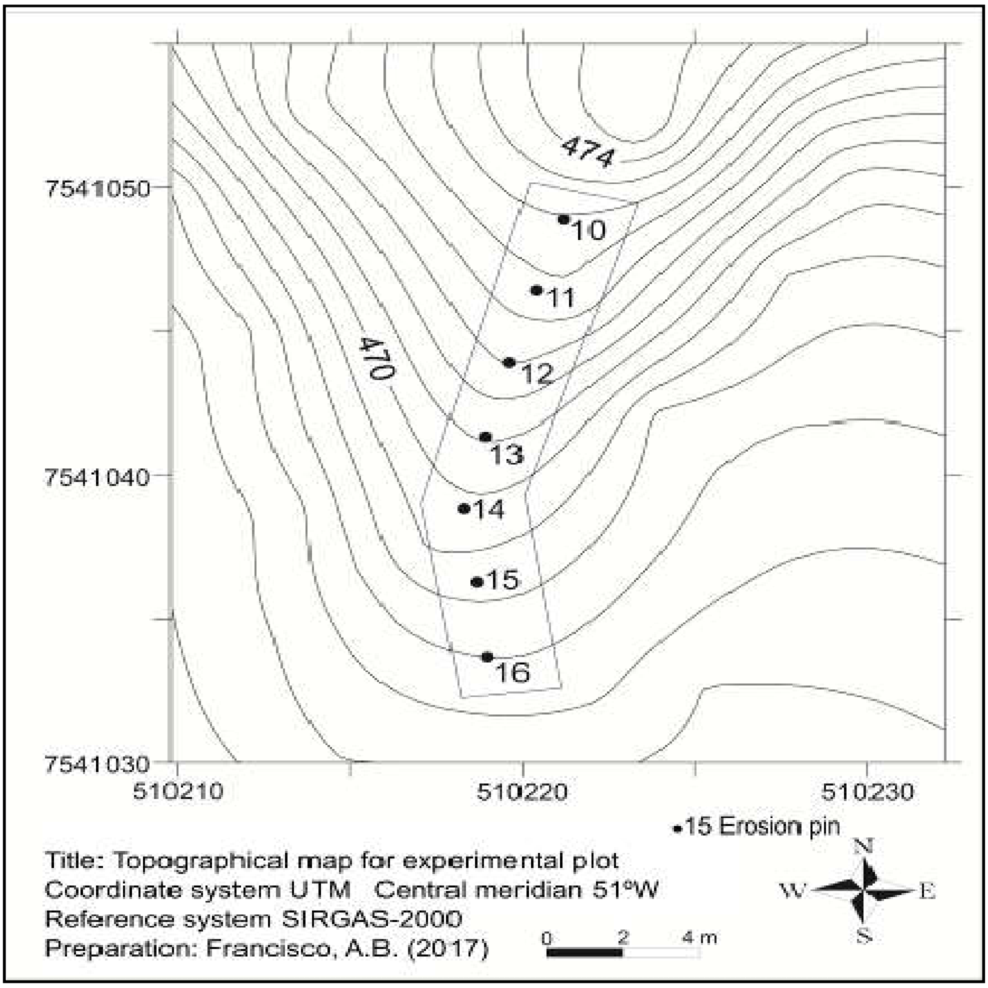

Fig. 3. Topographical chart of the experimental plot without barriers

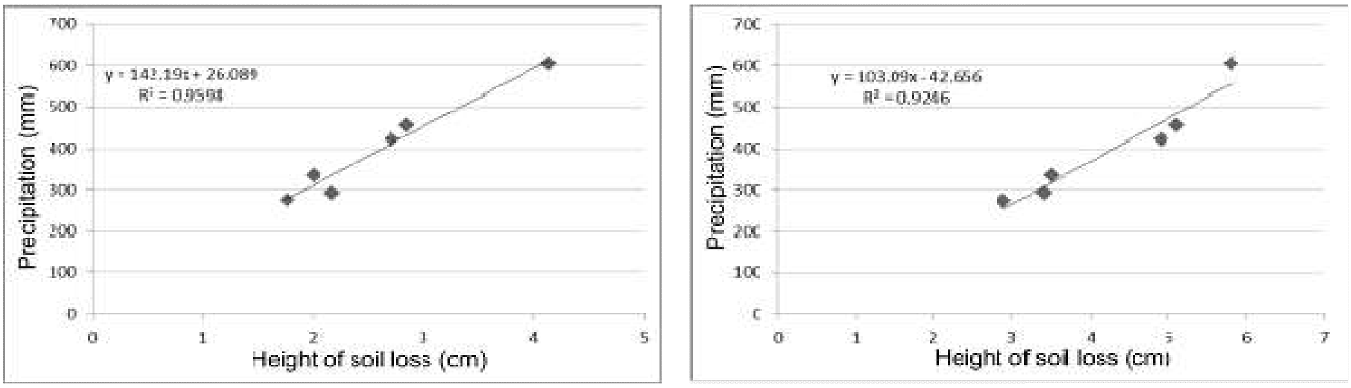

Fig. 4. Linear regression between soil loss values in layers and precipitation indexes

Conclusion

Based upon this study the following conclusions can be drawn

- Plant fiber barriers were efficient in controlling soil loss, yielding an estimated 66% lower soil loss in the experimental plot compared to the experimental plot without barriers. Despite the marked declivity and presence of exposed soil under conditions of degradation caused by the trampling of the herd, the plant material barriers are suitable in a region of tropical climate rich in plant fibers and with problems related to erosive processes
- The erosion control technique was applied in a degraded area, where the empiricism guarantees a closer approach to a better understanding of the phenomenon of accelerated soil loss.

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REFERENCES

Almeida Filho, G. S., Costa, S. B., Hellmeister Junior, Z., Gomes, C. L. R. and Frota, A. S. 2015. Processos erosivos lineares no Estado de São Paulo. *Congresso Brasileiro de Ciência do Solo*, ed.35, Sociedade Brasileira de Ciência do Solo.

Bertoni, J. and Lombardi Neto, F. 1999. *Conservação do solo*. São Paulo: Ícone.

Boin, M. N. 2000. *Chuvas e erosões no Oeste Paulista: uma análise climatológica aplicada*. (Tese de Doutorado), Universidade de Sao Paulo, Instituto de Geociências e Ciências Exatas, 264p.

Díaz, J. S. 2001. *Control de erosión en zonas tropicales*. Bucaramanga, Universidad Industrial del Santander.

Francisco, A. B. 2017. *A erosão periurbana em Rancharia-SP: a análise geográfica e as propostas de recuperação da boçoroca do Córrego do Grito*. (Tese de doutorado), Universidade Estadual Paulista, Faculdade de Ciências e Tecnologia, 186p.

Morgan, R. P. C. 2005. *Soil erosion and conservation*. London: Longman Group.

Oliveira, A. M. S. 1994. *Depósitos tecnogênicos e assoreamento de reservatórios*: *exemplo do Reservatório de Capivara, SP/PR*. (Tese de doutorado), Universidade de São Paulo, Faculdade de Filosofia, Letras e Ciências Humanas, 211p.

Smets, T. andPoesen, J. 2009.Impacts of soil tilth on the effectiveness of biological geotextiles in reducing runoff and interrill erosion.*Soil and Tillage Research*, 103(2): 356-363 dx.doi.org/10.1016/j.still.2008.11.001.

Shit, P. K., Bhunia, G. S. andMaiti, R. 2013. Assessing the performance of check dams to control rill-gully erosion: small catchment scale study.*International Journal of Current Research*, 4(5): 899-906.

Subedi, M., Fullen, M., Booth, C. A., Dao Chau Thu, Tran HuuCuong, TroungThiToan, Jonsyn-Ellis, F., Cole, A., Guerra, A. J. T., Bezerra, J. F. R., Zheng Yi, Buhmann, C. and Paterson, D. G. 2012. Contribution of biogeotextiles to soil conservation and socioeconomic development. *Agriculture*, 41(1), dx.doi.org/ 10.5367/oa.2012.0093

White, D. G. and Childers, N. F. 1945.Bamboo for controlling soil erosion.*American Society of Agronomy*, 37(1): 839-847.

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