ISSN 2175-6813

Revista Engenharia na Agricultura

Viçosa, MG, DEA/UFV - DOI: 10.13083/reveng.v30i1.15028 v.31, p.85-97, 2023

EVALUATION OF SOIL AND WATER LOSS UNDER DIFFERENT SOIL COVERS

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Keywords:
Agriculture
Biodegradable blanket
Erosion
Soil cover

ABSTRACT

The current hegemonic agricultural model, which is based on the green revolution, is intrinsically related to environmental and social impacts, such as erosion, desertification, and abandonment of agricultural areas. Thus, the objective of this study was to evaluate the loss of soil and water through runoff during a simulated rainfall event, testing the efficiency of different types of coverings on beds with watermelon crops, inferring that in relation to soil loss, this was greater in uncovered soil. Therefore, it should be observed that this work has applicability in the choice of efficient soil management techniques, to minimize the effects of erosion and, consequently, the environmental impacts as a result of agricultural activities. The results obtained showed a loss equivalent to 72.72% of the total for bare soil, which means a greater sedimentation of the soil, while for soils covered with corn straw and the biodegradable blanket, a loss of 19.70% and 7.58% of the total were observed, respectively. Surface water runoff, with the use of corn straw and the biodegradable blanket, was reduced by 81.22% and 67.42%, respectively. It was concluded that soil cover is effective in controlling water erosion.

Palavras-chave:
Cobertura de solo
Biomanta
Agricultura
Erosão

AVALIAÇÃO DA PERDA DE SOLO E ÁGUA SOB DIFERENTES COBERTURAS DO SOLO

RESUMO

O modelo agrícola hegemônico atual, que se ampara na revolução verde, está intrinsecamente relacionado a impactos ambientais e sociais, como a erosão, a desertificação e o abandono de áreas agrícolas. Desta forma, o objetivo deste estudo foi avaliar a perda de solo e água por escoamento superficial diante de um evento de chuva simulada, testando a eficiência de diferentes tipos de coberturas em canteiros com a cultura da melancia, concluindo-se que em relação à perda de solo, esta foi maior no solo descoberto. Destaca-se, portanto, que esse estudo possui aplicabilidade na escolha de técnicas de manejo do solo eficientes, para minimizar os efeitos da erosão e, consequentemente, os impactos ambientais, em decorrência das atividades agrícolas. Os resultados obtidos apresentaram, para o solo descoberto, uma perda equivalente a 72,72% do total, o que significa maior sedimentação do mesmo, enquanto nos solos cobertos com a palhada de milho e com a biomanta, houve uma perda de 19,70% e 7,58% do total, respectivamente. O escoamento superficial da água, com a utilização da palhada de milho e da biomanta, foi, respectivamente, reduzido em 81,22% e 67,42%. Concluiu-se que a cobertura dos solos é efetiva no controle da erosão hídrica.

Received 23 Nov, 2022 • Accepted 4 Apr, 2023 • Published 15 Jun, 2023

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SECTION EDITOR IN CHARGE
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INTRODUCTION

The Brazilian semi-arid region is characterized by high temperatures, high insolation, seasonality, and irregular rainfall (NIMER, 1989; MENDONÇA, 2007). Because of the climatic conditions shown in this region, it is known that farming faces several challenges that need to be controlled, among them the rapid evaporation of water, high soil temperature, and erodibility. In this context, knowing the dynamics of environmental phenomena, including the behavior of water infiltration into the soil and surface runoff, is paramount as they exert influence on soil loss and consequently on the erosion process, generating impacts on activities such as in farming.

A high proportion of soils in Northeastern Brazil have a low productive potential and high vulnerability to erosion, either because of their drainage limitations or because of their low organic carbon content (GIONGO et al., 2011). However, according to Guerra (2012), erosion processes in arable areas can be minimized or controlled with the application of practices that guarantee maximum infiltration and less surface water runoff.

Both plastic cover and plant debris have been exploited to reduce reduce water evaporation from the soil surface; reduce soil temperature oscillations (ARAÚJO *et al*., 1993; JATOBÁ & SILVA, 2020). Weed control and reduction of nutrient losses through leaching have also been associated with the use of soil mulch (CARTER & JOHNSON, 1988; CHRISTOFOLETTI et al., 2015; CARVALHO, 2013; PUCCI, 2020).

Mapping the current academic production within our subject of study allowed us to find references in the Scopus bibliographic database, where, in the search for "soil loss and ground cover", 163 results are obtained, and the United States leads in the chart of the country/territory category with 41 documents, while Brazil has only five. In addition, a drastic decrease was found in the work carried out in recent years, falling from 9 documents in 2020 to 7 in 2021 and only 3 in 2022. This was not observed when searching for these same terms in Portuguese "loss of soil and soil coverage" as no results were found in the base. When narrowing down the search, there are no documents found on the use of the terms "loss of soil and bio blanket" nor for its translation into English "soil loss and bio blanket", showing the scarcity of works that relate the two themes and emphasizing the technical-impact scientist of the present study.

Among the initiatives related to the investigation of soil and water losses caused by water erosion in arable areas, the work carried out by Martins *et al*. (2010), who quantified soil losses at different stages of eucalyptus crop development, determining the C factor, which represents the effect of cover and soil management. According to Lima *et al*. (2020), the use of soil cover in semi-arid regions promotes greater moisture retention, reduces the direct incidence of sunlight on the soil and temperature fluctuations, providing high root production, higher growth rate, and productivity of the aerial part, in addition to fulfilling the role of controlling water erosion, with the reduction of values of the surface runoff. Concerning biodegradable blankets, it is necessary to carry out work to assess their effects on increasing plant productivity and controlling erosion.

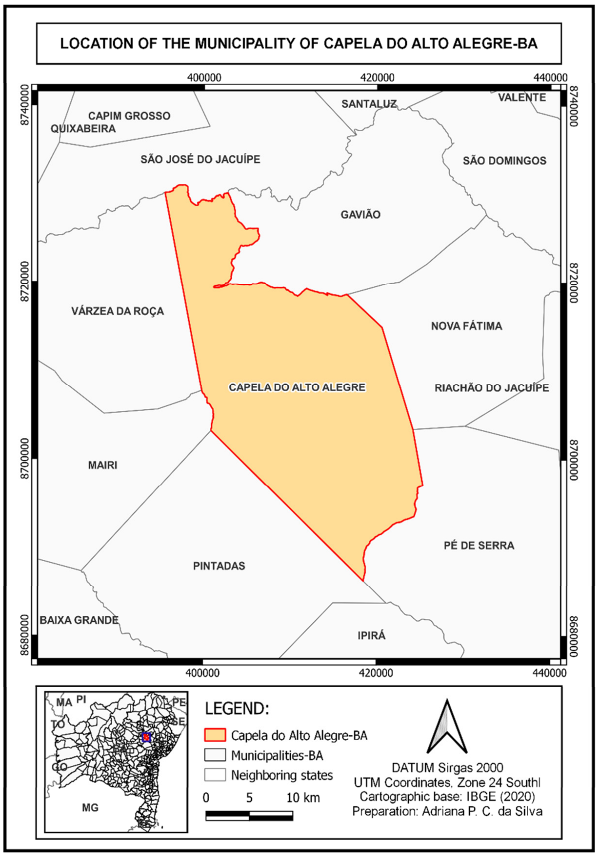
The objective of this study was to evaluate the loss of soil and water through surface runoff in the face of a simulated rainfall event, by testing the efficiency of different types of coverings in beds with the watermelon crop.

MATERIAL AND METHODS

The experiment was carried out in an agricultural area on Campos Farm, in Capela do Alto Alegre, Bahia, (latitude 11º40'52" S and longitude 39º48'29" W), in June 2022. The location of the municipality is shown in Figure 1.

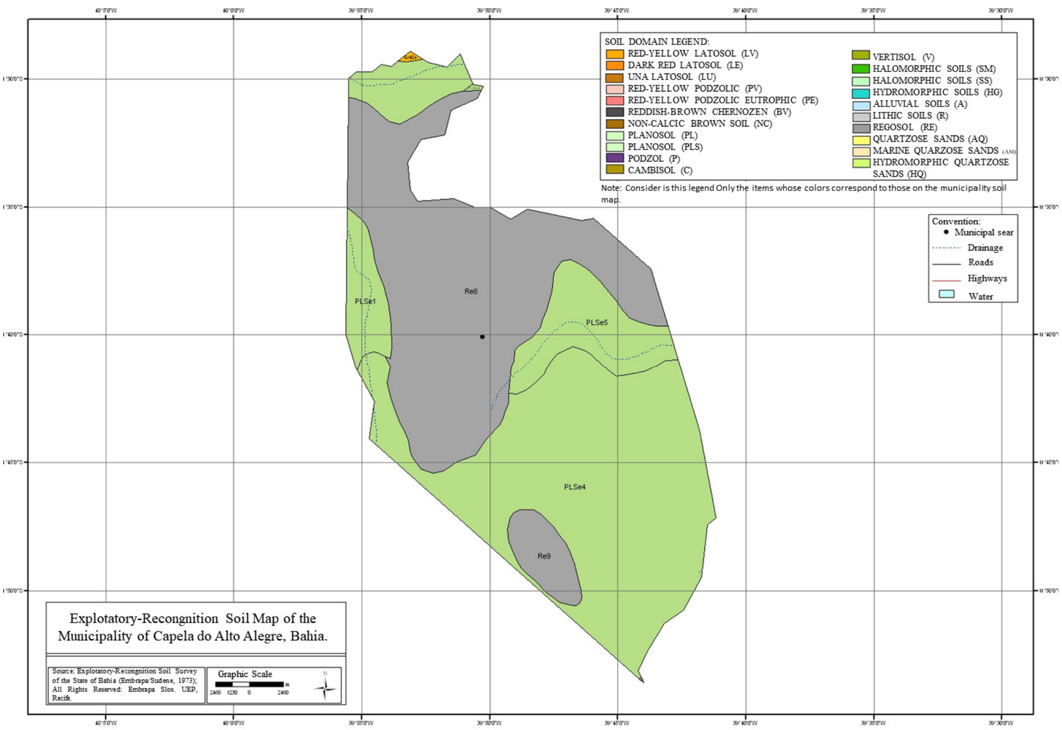
The terrain in the experimental area is flat and the soil is characterized as Neosol regolith, according to the exploratory-recognition map of soils in the municipality of Capela do Alto Alegre (EMBRAPA & SUDENE, 1973) (Figure 2).

According to the Koppen climate classification, the municipality has a BSwh climate, characterized as a hot semi-arid climate, with summer rains and a well-defined dry winter period, with an average temperature above 18ºC, and absence of water surplus (SEI, 1997; SANTOS et al., 2018). Annual precipitation is irregular, with an average of 798.25 mm. The average monthly distribution of rainfall in the municipality, according to data from the



Source: Authors' own elaboration

Figure 1. Map of the municipality of Capela do Alto Alegre, Bahia



Source: Embrapa and Sudene (1973)

Figure 2. Soils occurring in the municipality of Capela do Alto Alegre, Bahia

Hidroweb Portal (ANA, 2022), can be seen in Figure 3.

The experiment was modeled according to the randomized block design (RBD), with three replications, totaling nine experimental units. The experiment area totaled approximately 10 m² and each experimental plot, rectangular in shape, was dimensioned with 0.5 m in width, 0.7 m in length, and 0.15 m in height. The inclination of the plots was 45º, reproducing the conditions of land with a steep slope and having a significant effect on soil erosion. A space of 0.4 m was left between each plot of the same block and also between blocks,

The plots were surveyed manually, by distributing a layer of soil above the surface and then demarcating and compacting the sides (Figure 4). For fertilization, tanned bovine manure was used, which was uniformly applied and leveled over each plot. Subsequently, the watermelon seedlings were transferred to the area, arranged in planting cradles, and opened in the center of each plot, proceeding with irrigation.

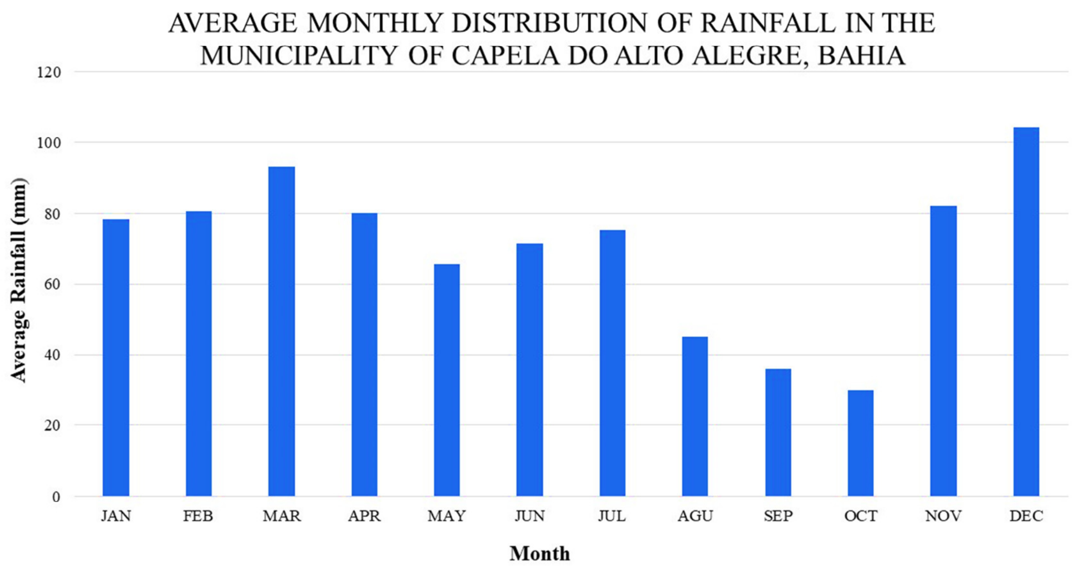
At the end of the initial preparation of the soil and implantation of the culture, the treatments were distributed in the area (Figure 5). In the experiment, soil loss and runoff were evaluated under the conditions of uncovered soil (T1), soil covered with straw (T2), and soil covered with biodegradable blanket (T3), subjected to conditions of rain simulation.

The corn straw used to cover the plots corresponding to Treatment 2 was evenly distributed, in the amount of 300 g plot^{-1}.

The biodegradable blanket applied in the plots with Treatments 3 was made in loco, manually, consisting of the petioles of dry banana leaves. After collecting the dry leaves directly from the plants, the leaf blades were removed, leaving the petioles, which were cut into pieces of approximately 0.7 m. For each biodegradable blanket, 40 pieces of petioles were placed side by side and later joined by cotton string, forming a mat (Figure 6).

Collecting gutters were installed at the lower end of the experimental plots. The soil carried by the induced flood, accumulated in the gutter, was collected at the end of the 1 hour of period of the experiment, and weighed, being expressed in kg/area of the plot (0.35 m²). The collector structure adopted was ceramic tiles.

The rain simulation was carried out using two irrigation hoses with sprinkler nozzles adjusted to uniformly cover the entire experimental area and produce medium-sized drops, which were previously measured through volumetric and photographic analyses of the sprinkler jet, adapted from Chaves' proposal (1985), and complemented by the method proposed by Carvalho *et al*. (2012), to ensure a relative homogeneity of raindrops. The irrigation hoses were fixed at 1.50 m high tutors. The intensity of the rain applied in the 1-hour



Source: Authors' own elaboration

Figure 3. Average monthly distribution of rainfall in the municipality of Capela do Alto Alegre, Bahia

Source: Authors' own elaboration

Figure 4. Experimental plots raised manually, rectangular in shape, 45º inclination, and individual area of 0.35 m²

Source: Authors' own elaboration

Figure 5. Experimental area after random distribution of treatments. Three plots with uncovered soil (T1), three plots with soil covered with straw (T2), and three plots covered with bio blanket (T3)

interval was also measured, with the pluviometer placed between the plots.

Water loss through surface runoff was determined after 1 hour of simulated rain, and the removal of the soil collection gutters. At the lower end of each plot, one at a time, a small opening was made with dimensions sufficient to hold a plastic container with a storage capacity of 250 mL was

Source: Authors' own elaboration

Figure 6. Biodegradable blanket made with petioles of banana leaves, joined with cotton strings, applied in the experimental plots with Treatments 3

Figure 7. Plastic container for collecting surface runoff, installed at the lower end of the experimental plot, at ground level and following a 45º slope

made. It was placed at ground level and following the slope of the plot (Figure 7). The water drained from the ground moved in the direction of the slope by the effect of gravity, falling into the container. The collection was made for five minutes, and expressed in liters / 5 minutes.

The collected data underwent statistical treatments, where the mean, variance, standard deviation, and coefficient of variation were calculated. Analysis of variance (ANOVA) was also performed between treatments, using the Statistical Analysis System-SAS program, version 6.12, and to identify the statistically best treatment, the Tukey Test was used, at a significance level of 0, 05. Then, the interpretation of the results was performed.

RESULTS AND DISCUSSION

Qualitative analysis of the dataset

The intensity of the rain applied during the experiment, in 1 hour, was 30 mm. Table 1 displays the data set collected in the soil loss evaluation experiment.

The total soil losses were 0.240, 0.065, and 0.025 kg/0.35 m² for the uncovered soil (T1), soil covered with straw (T2), and soil covered with biodegradable blanket (T3) treatments, respectively. It was observed that the soil covers were decisive for the reduction of soil loss, since for treatments T2 and T3, these losses corresponded to 19.70% and 7.58% of the total (0.330 kg/0 .35 m²), respectively. On the other hand, cultivation in uncovered soil (T1), caused the loss of soil to be greater (Figure 8), reaching 72.72% of the total, which can be explained by the fact that the exposed soil favors surface runoff, disaggregating the particles soil and transporting them, which causes water erosion.

Table 1. Mass of the soil collected in treatments uncovered soil (T1), soil covered with straw (T2), and soil covered with biodegradable blanket (T3), per experimental block. (kg/0.35 m²)

	T1	T2	T3	Totals
B1	0.110	0.030	0.010	0.150
B2	0.075	0.015	0.010	0.100
B3	0.055	0.020	0.005	0.080
Totais	0.240	0.065	0.025	0.330
Média	0.075	0.020	0.010	0.105

Source: Authors' own elaboration

Source: Authors' own elaboration

Figure 8. Soil losses in the collecting gutters installed at the lower end of the experimental plots, for treatments uncovered soil (T1), soil covered with straw (T2), and soil covered with a biodegradable blanket

The total values of soil loss ranged from 0.005 to 0.115 kg/0.35 m², corresponding to the treatments soil covered with biodegradable blanket (T3) and bare soil (T1), respectively, which indicates the potential of biodegradable blanket to minimize losses of soil.

The comparison between the mean values of soil loss in treatments T2 (0.020 kg/0.35 m²) and T3 (0.010 kg/0.35 m²) showed twice as much soil protection when biodegradable blankets were used. Mariani (2016), in evaluating the application of coconut fiber and sisal biodegradable blanket to control erosion on taludes slopes, found a reduction in soil losses by 99.91% and 99.94%, respectively, compared to only the sowing of grasses without the protection of the biomanta bio blanket. Similar results were found by Begnini and Menegotto (2022), who recommend the use of the biodegradable blanket as the best alternative for controlling erosion caused by the impact of raindrops, as it significantly reduces soil loss rates.

Figure 9 shows the amount of soil that was collected in the gutters of block 1, in the different installed treatments.

Table 2 displays the data set collected in the soil water loss evaluation experiment.

The blocks that received treatment 1 (soil without cover) suffered a greater water runoff (0.301 L/5 min), corresponding to 48.31% of the total, in addition to having a loss of soil as a whole (0.240 kg /0.35 m²). The blocks with treatment 2 (covered with straw) obtained the best results in terms of surface water runoff (0.117 L/5 min), with lower values, equivalent to 18.78% of the total water loss. The blocks with treatment 3 (banana biodegradable blanket), despite the lower soil loss (0.025 kg/0.35 m²), obtained an intermediate runoff between the values found for T1 (0.301 L/5 min) and T2 (0.117 L/5 min), from 0.205 L/5 min, which corresponds to 32.58% of the total water that was lost.

Figure 10 shows the amount of water resulting from surface runoff, in different treatments.

Thus, the results indicate, for the experimental conditions, that the soil covered with a biodegradable blanket and the soil covered with straw loses less soil and water, similar to those obtained by Lima et al. (2020), where the mulch acted as a sink for the kinetic energy of rain, reducing runoff and soil losses, in addition to retaining water in it, therefore absorbing and intercepting rainwater.

Based on the qualitative analysis of the experiment of water loss through runoff, it was observed that the corn straw (T2) absorbed some of the precipitated water, and consequently, less water was lost by the runoff, which leads us to predict that the maintenance of soil moisture can be favored

Source: Authors' own Elaboration

Figure 9. Losses of the soil removed from the collector gutters of block 1, in the uncovered soil (T1), soil covered with straw (T2), and soil covered with biodegradable blanket treatments

Table 2. Volume of water lost through surface runoff (L/5 min) in treatments uncovered soil (T1), soil covered with straw (T2), and soil covered with biodegradable blanket (T3), per experimental block (L/5 min)

	T1	T2	T3	Totals
B1	0.095	0.024	0.044	0.163
B2	0.110	0.036	0.084	0.230
B3	0.096	0.057	0.077	0.230
Totals	0.301	0.117	0.205	0.623
Mean	0.096	0.036	0.077	0.209

Source: Authors' own elaboration

Source: Author's own elaboration

Figure 10. Water lost through surface runoff in treatments uncovered soil (T1), soil covered with straw (T2), and soil covered with biodegradable blanket

by the use of straw cover. In the soil covered with biodegradable blanket (T3), the precipitated water found greater impediment to infiltrate due to the characteristic of the material, which can be taken into account to explain the similarity with the behavior observed in the uncovered soil (T1).

Statistical analysis of data

Analysis of variance for soil loss data showed that a statistical difference between treatments (Pr<0.05). Nevethreless, no significant difference was found between blocks (Pr>0.05), as shown in Table 3.

The test of Tukey test showed that treatment 1 (uncovered soil) achieved the highest mean (0.075 kg/0.35 m²) and differed from treatment 2 (soil covered with corn straw) and 3 (soil covered with biodegradable blanket). There was no statistical difference between T2 and T3, as shown in Table 4.

As for soil loss, we can conclude that it was greater in Treatment 1 (bare soil); and that Treatments 2 and 3 similarly protect the soil.

In the work on water loss through surface runoff, the analysis of variance showed a significant difference between the treatments, but no statistical difference was observed among the blocks (Table 5).

The test of Tukey showed that treatments 1 (uncovered soil) and 3 (soil covered with biodegradable blanket) are similar in terms of water loss. As well as there is also a similarity between treatments 2 (soil covered with straw) and 3 (soil covered with biodegradable blanket). However, treatment 1 differed from treatment 2, as can be seen in Table 6.

Table 3. Analysis of variance for soil loss under different soil covers

SV	DFGL	SS	MS	Vlr F	P (Pr>F)
Treatment	2	0.008716	0.004	21.35	0.0073
Block	2	0.000866	0.000	2.12	0.2354
Total (kg/0.35 m²)					0.330
Overall mean (kg/0.35 m²)					0.020
CV%					38.970
Error					0.001021

Source: Authors' own elaboration

SV: sources of variation; DF: number of degrees of freedom; SS: sum of the squares; MS: mean square; Vlr F: value F; P (Pr>F):Value P for the level of significance of 0.05

Table 4. Mean test for the variable soil loss for the different assessed covers

Treatment	Mean
T1	0.075a
T2	0.020b
T3	0.010b

Source: Author's own elaboration

Uncovered soil (T1), Soil covered with straw (T2), Soil covered with biodegradable blanket (T3). Means followed by the same lowercase letter in the column do not differ statistically by the test of Tukey, at a significance level of 0.05

Table 5. Analysis of variance for water loss through runoff under different soil covers

SV	DF	SS	MS	F tabled	P (Pr>F)
Treatment	2	0.005627	0.003	18.70	0.0093
Block	2	0.000993	0.000	3.30	0.1424
Total (L/5 min)					0.6236
Overall mean (L/5 min)					0.077
CV%					17.704
Error					0.000752

Source: Author's own elaboration

SV: sources of variation; DF: number of degree of freedom; SS: sum of the squares; MS: mean square; Vlr F: value F; P (Pr>F):Value for the significance level of 0.05

Table 6. Mean test for the variable water loss for the different assessed covers

Treatment	Mean
T1	0.096a
T3	0.077ab
T2	0.036b

Source: author's own elaboration

Uncovered soil (T1), Soil covered with straw (T2), soil covered with biodegradable blanket (T3). Means followed by the same lowercase letter in the column do not differ statistically using the test of Tukey at a significance level of 0.05

As for the loss of water through surface runoff, the soil covered with corn straw (T2) and the soil covered with the biodegradable blanket (T3) showed the lowest means of water loss through surface runoff; however, it is observed that the loss of water in Treatment 3 (soil covered with biomat) is similar to water loss in Treatment 1 (uncovered soil).

By assuming the hypothesis that the blocks are homogeneous, in both experiments, it can be seen that the conduction methods and the choice for the randomized block design (RBD) acted positively in the analysis of the variables soil loss and water loss through surface runoff.

The results obtained in this work were in line with those achieved by Carvalho *et al*. (2012), although they varied rainfall patterns using a portable rainfall simulator, in addition to land cover factors. However, they concluded that the denser the soil cover, the more difficult the movement of water along the slope, due to the reduction of kinetic energy and direct impacts of raindrops, which reduces the erosive power of runoff, thus corroborating the results also found by Castro *et al*. (2006).

Also, the comparison of the results obtained by Castro *et al*. (2006) and Volk (2006), who drew the conclusion that the soil cover should be analyzed associated with the roughness it causes, as these factors, together, would control the removal of soil particles, reducing their accumulated loss; however, we observed that the loss of water itself is not reduced in the same proportion. In agreement with the observation of Volk (2006), that the soil cover assumes a relevant role, being able to avoid the formation of a superficial crust that reduces the infiltration capacity of the soil.

Martins *et al.* (2010), working in coastal tableland soils, in Espírito Santo, evaluated water erosion under different use covers (eucalyptus production forest), native forest (Atlantic Forest), and conventionally tillage (kept uncovered), obtained values of 0.04 Mg ha^{-1} yr^{-1} to 25.55 Mg ha^{-1} yr^{-1} for the Atlantic Forest and bare soil, respectively. The same trend was observed for water losses. The values obtained in the Atlantic Forest were, according to them, due to greater soil protection, the existence of a rich layer of leaves (litter) and higher levels of organic matter, and consequently, better soil structure and greater permeability.

CONCLUSION

- The loss of water and soil under the different types of coverage was significant, reflecting the type and degree of coverage received under the proposed conditions. The soils with corn straw and biodegradable blanket lost much less sediment, corresponding, respectively, to 19.70% and 7.58% of the total soil loss, in relation to the uncovered soil, whose soil loss reached 72. 72% of the total. As for the percentages of water loss through surface runoff, they were reduced by 81.22% and 67.42% with the use of corn straw and biodegradable blanket, respectively, indicating that soil cover effectively helps in controlling water erosion, mainly on land cropped on a slope, even though it is high, reducing the volume of surface runoff, which is sufficient to reduce the transport capacity, as well as the ability to remove larger sediments.

AUTHORSHIP CONTRIBUTION STATEMENT

SILVA, A.P.C.: Data curation, Formal Analysis, Methodology, Writing – original draft, Writing – review & editing; **CARNEIRO, E.S.:** Conceptualization, Funding acquisition, Writing – original draft, Writing – review & editing; **CARNEIRO, L.O.:** Conceptualization, Methodology, Resources,Writing – review & editing; **SILVA, N.G.:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing; **SANTOS, R.L.:** Conceptualization, Methodology, Writing – review & editing.

DECLARATION OF INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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