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Impact of Land Topography on Runoff and Soil Erosion: An Experimental Approach

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A b s t r a c t

Soil erosion is causing major concerns across the world, as the loss of soil jeopardises not only environmental sustainability, but also land productivity, eventually leading to reduced resources for populations that heavily rely on land. However, how runoff drives soil erosion and the impact of different land coverages on this is not yet well understood, also because of the lack of data acquired in controlled conditions. To fill this gap, experiments were performed in the Yan Gou runoff observation site (China) by controlling runoff volume, sediment transport, soil loss, and soil water content in five square plots, each with an area of 100 m^2, covered by different vegetation and having different topography. The results presented here focus only on plots covered by citrus but have different slopes, to decouple the effects of vegetation coverage and soil topography. Assuming a constant hydrological forcing (i.e., fixed precipitation), it was observed that plots with down-slop ridge drive a larger runoff, as expected, which implies that more sediments are mobilized causing higher soil loss. At the same time, this loss of soil influences the content of water differently, which changes more significantly in the horizontal plot than in the inclined one. Comparing all plots, it was noticed that standard terraces are the most effective method to conserve soil, reducing the runoff and keeping the content of water more constant over time.

Keywords: Yangou watershed, cross-slope tillage, down-slope tillage, typical terrace.

1. METHODS

1.1 Study area and experimental environment

Located in the south of De'an County (Fig. 1B and C), the Yangon Small watershed (YGSW) has a total area of 27.1 km^2 and an elevation of 45–75 m. The YGSW belongs to the red soil hilly region of South China, and the total area subjected to soil erosion is 9.8 km^2.

A total of 16 runoff observation runoff plots have been constructed within the YGSW (Fig. 1D), and the observations from 5 of them are used in this study. To investigate the impact of different vegetation coverage on soil erosion, the five plots are covered with trifolium repens + citrus tree, cross-slope tillage + citrus tree, down-slope tillage + citrus tree, and typical terrace + citrus tree (hereinafter referred to as trifolium repens, cross-slope tillage, down-slope tillage, and typical terrace), and bare land used as reference conditions.

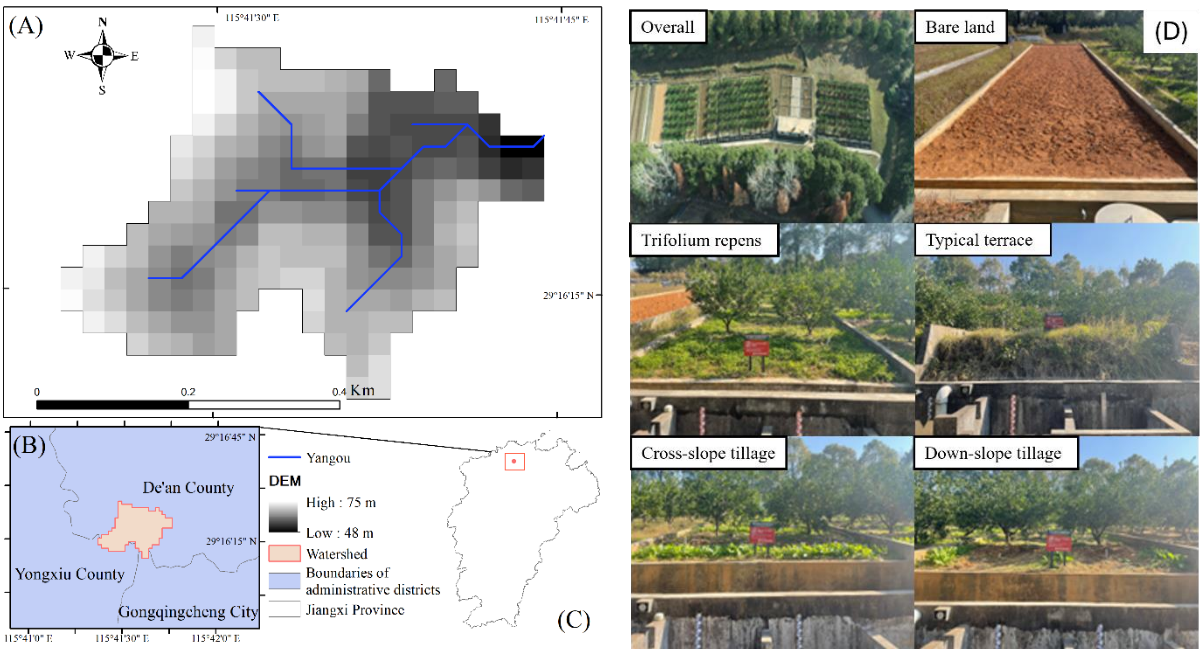

Fig. 1. Location of the study area (YGSW) and the experimental environment. Note that (A) is the DEM of the YGSW, (B) and (C) are its location in the Jiangxi Province, and (D) is the picture of the whole experimental field and each runoff plot.

2.2 Date collection and processing

144 rainfall events have been recorded from 2018.12.31 to 2022.07.20, and 12 rainstorm events, whose precipitation exceeded 50 mm in 24 hours, are analyzed in this study (Table 1).

Table 1

Analysed rainfall events

Rainfall events no.		1	2	3	4	5	6	7	8	9	10	11	12
Data	Year	2019				2020				2021			2021
	Month and day	3.1	3.20	7.4	7.12	5.29	6.2	7.7	7.29	5.10	5.15	7.17	4.12

2. RESULTS AND CONCLUSIONS

The precipitation of 12 selected rainstorms and the generated runoff and sediment after every rainfall event of runoff plots with different vegetation cover are illustrated in Fig. 2A. Figure 2B shows the reduction rate of runoff and sediment of every plot with different coverages.

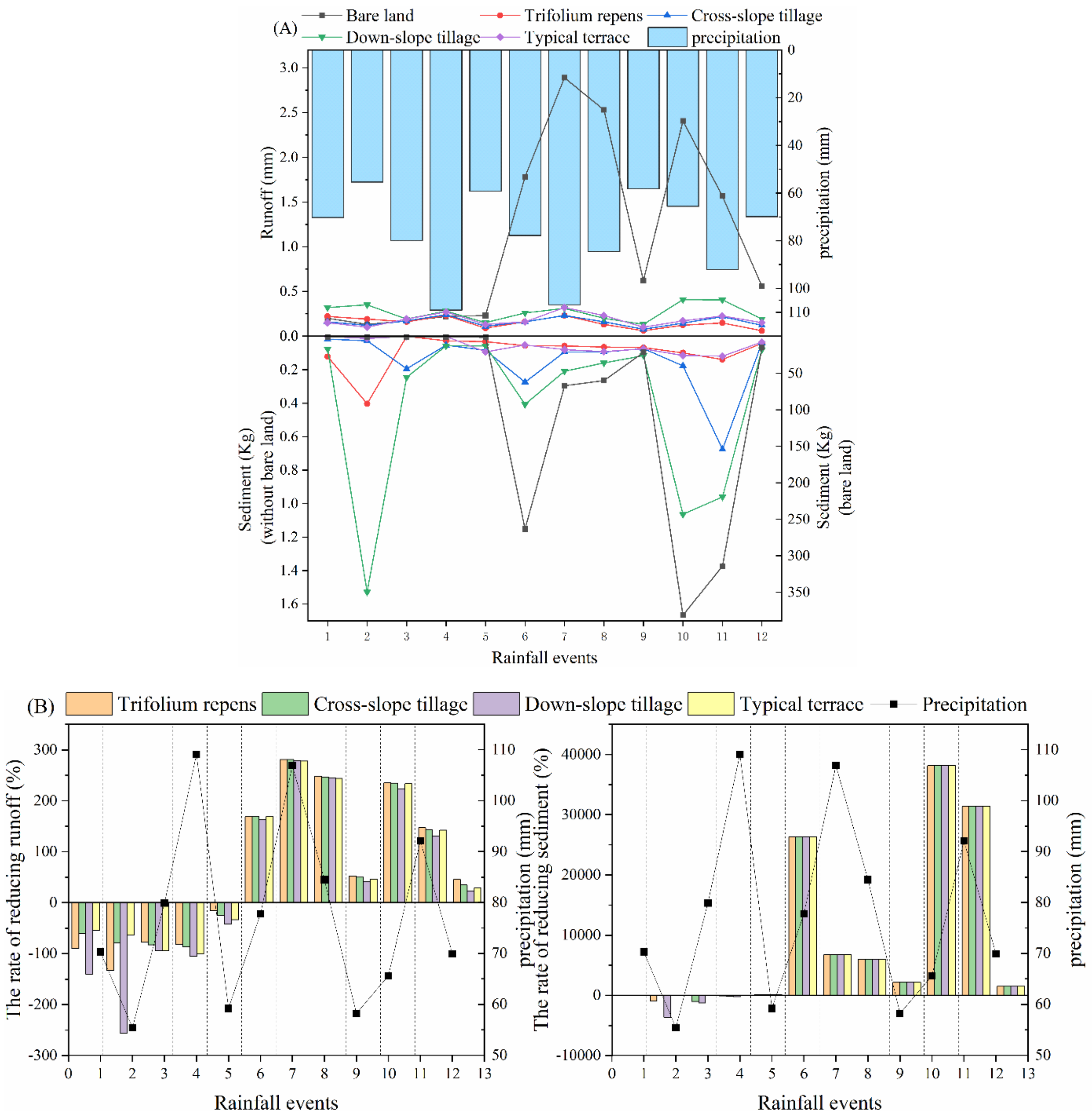

Fig. 2: (A) Rainfall event, runoff yield, and sediment produced after each rainfall event; (B) Reduction rate of flow generation and sediment production of different vegetation cover under different rainfall events.

The results are shown as follows:

1. The produced runoff and sediment of the bare land is the highest, especially the sediment generation, with the lowest value of 50 kg, indicating that the vegetation inhibits sediment and runoff production.

2. The plot for down-slope tillage produced more runoff than plots used for other practices. For the sediment generation, that of the plots for down-slope tillage is the highest and that of plot for cross-slope tillage ranks second.

3. The reduction rates of runoff and sediment of all plots after the rainfall events of 2019 are negative, meaning that all practices did not reduce flow and sediment. After 2019, the trifolium repens performed better in terms of reducing runoff, while down-slope tillage did not perform properly. On the other part, the performance of the four vegetation cover methods in reducing sediment production was rather similar.

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