雨强和坡度对红壤坡耕地有机碳迁移规律的影响

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摘 要：【目的】土壤侵蚀是土壤有机碳流失的主要驱动力，探究土壤侵蚀对土壤有机碳动态过程的作用机制，对于全球碳循环研究具有重要意义。针对微量可溶性有机碳损失可能引发碳氮生物地球化学循环的连锁反应，这一问题已引起广泛关注也需要深入研究。【方法】本文通过室内模拟降雨试验，以红壤坡地（10°、15°）翻耕种植的花生（幼苗期）为研究对象，设置不同雨强 60、90、120mm/h，研究土壤有机碳流失规律及影响因素。【结果】结果表明：（1）小坡度小雨强时壤中初始产流较早，伴随雨强和坡度增加，地表径流产生加快，壤中流出现不同程度的延迟；（2）I60/10°、I90/10°、I120/10°、I60/15°、I90/15°、I120/15°不同降雨条件（下同）地表和壤中径流量的分配比分别为 1.26、57.51、727.98、399.84、324.20、367.37，地表径流是形成坡面径流的主要形式；随雨强增加产沙量波动程度增大，坡度增加促使泥沙量峰值较早出现；（3）不同降雨条件地表径流和壤中流 DOC 分配比分别为 1.91、20.07、449.87、269.29、245.52、245.82，地表径流是土壤 DOC 主要流失途径，流失量为 175.40~1714.01 mg/m^2，壤中流 DOC 为 1.61~92.00 mg/m^2；泥沙是土壤有机碳流失最主要的途径，不同降雨条件下有机碳流失量为 1120~8520 mg/m^2；（4）产流量是径流 DOC 流失率的显著或主导影响因子，DOC 浓度作用不明显，但泥沙量与有机碳浓度之间有着极显著的负相关性（P＜0.01）；（5）伴随坡度增加，雨强与径流 DOC 单位面积流失量的相关性减弱，与泥沙有机碳流失量的相关性小幅增加；不同坡度下地表径流 DOC、泥沙中有机碳单位面积流失量与雨强有着较强的线性关系（P<0.05），但这种相关性在壤中流时主要体现在 10°小区；（6）雨强增大加剧单位面积 DOC 流失量，但变化趋势对坡度的依赖性不强；DOC 流失量与坡度的线性关系也随雨强增加而减弱，I120 时这种线性特征在地表径流、壤中流中不再明显；不同雨强下，坡度均可显著影响泥沙中有机碳流失量，二者间呈显著线性关系（P<0.05）。【结论】坡度和雨强是土壤有机碳流失的显著影响因子（P<0.05），地表径流、壤中流、泥沙中均具有显著线性关系（P<0.05），这种相关程度在地表径流中最大；其中，雨强对地表径流 DOC 单位面积流失量的影响程度大于坡度，与壤中流的响应效应相反，坡度和雨强对泥沙有机碳单位面积流失量的共同作用程度介于地表径流和壤中流之间。

关键词： 红壤；坡耕地；雨强；有机碳；迁移特征

Effects of rainfall intensity and slope gradient on the migration of organic carbon in red soil sloping farmland

Abstract:【Objective】Soil erosion is the main driving force of soil organic carbon loss. Exploring the mechanism of soil erosion on the dynamic process of soil organic carbon is of great significance for the study of global carbon cycle. The loss of trace soluble organic carbon may lead to a chain reaction of carbon and nitrogen biogeochemical cycle, which has attracted wide attention and needs further study.【Method】In this paper, we designed the indoor simulated rainfall experiments, and used peanuts from red soil sloping farmland as research objects, which had two ways of slopes include 10°and 15. A total of three rainfall intensity modes (60,90,120 mm/h) were set up. The purpose was to study the law of soil organic carbon loss and its influencing factors.【Result】(1) Small slope and light rainfall intensity promoted the initial runoff in the soil earlier. With the increase of rainfall intensity and slope, the surface runoff was

accelerated, and the interflow was delayed to varying degrees.(2) Under different rainfall conditions of I60/10°,I90/10°,I120/10°,I60/15°,I90/15°,I120/15°, the distribution ratio of surface and soil runoff were 1.26,57.51,727.98,399.84,324.20,367.37. Which showed that surface runoff was the main form of slope runoff . The fluctuation of sediment yield increased with the increased of rainfall intensity, and with the slope became larger which could promoted the peak value of sediment yield to appear earlier. (3)The distribution ratios of DOC in surface runoff and interflow under different rainfall conditions were 1.91,20.07,449.87,269.29,245.52,245.82, respectively. Surface runoff was the main loss pathway of soil DOC, and the loss amount was 175.40~1714.01 mg/m^2, and the interflow DOC was 1.61~92.00 mg/m^2. Sediment was the main way of soil organic carbon loss, and the amount of organic carbon loss under different rainfall conditions was 1120~8520 mg/m^2.(4) Runoff yield was the significant or dominant factor affecting the runoff DOC loss rate, but the effect of DOC concentration was not obvious, whereas there was a significant negative correlation between sediment yield and organic carbon concentration (P<0.01).(5) With the increase of slope, the correlation between rainfall intensity and runoff DOC loss per unit area decreased, and the correlation between rainfall intensity and sediment organic carbon loss increased slightly. There was a strong linear relationship between rainfall intensity and DOC in surface runoff and organic carbon loss per unit area in sediment under different slope gradients(P<0.01), but this correlation was mainly reflected in the 10° plot. (6) The increase of rainfall intensity aggravated the loss of DOC per unit area, but the change trend was not strongly dependent on the slope. The linear relationship between DOC loss and slope also decreased with the increase of rainfall intensity, and this linear feature was no longer obvious in surface runoff and interflow at I120. Under different rainfall intensities, slope could significantly affect the loss of organic carbon in sediment, and there was a significant linear relationship between them (P<0.05).

【Conclusion】Slope and rainfall intensity were the significant factors affecting soil organic carbon loss (P<0.05). There was a significant linear relationship among surface runoff, interflow and sediment (P<0.05), and this correlation was the largest in surface runoff. Among them, the influence of rainfall intensity on DOC loss of surface runoff was greater than that of slope, which was opposite to the response effect of interflow. The combined effect of slope and rainfall intensity on sediment organic carbon loss per unit area was between surface runoff and interflow.

Keywords : Red soil ; Slope farmland ; Rain intensity ; Rrganic carbon ; Migration characteristics