Impact of cornstalk buffer strip on hillslope soil erosion and its hydrodynamic understanding

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Introduction

Soil erosion is a serious concern on the Loess Plateau of China. Cornstalk buffer strips may prove to be effective practice for soil erosion control.

Shear stress, unit stream power, and unit energy of cross section are basic hydrodynamic parameters used to characterize **critical conditions required to initiate soil erosion** (Nearing et al., 1997; Reichert and Norton, 2013). Although hydrodynamic understanding of soil erosion has received more attention lately, the **hydrodynamic characteristics associated with organic mulches** are still unclear and need quantification and understanding.

Objectives

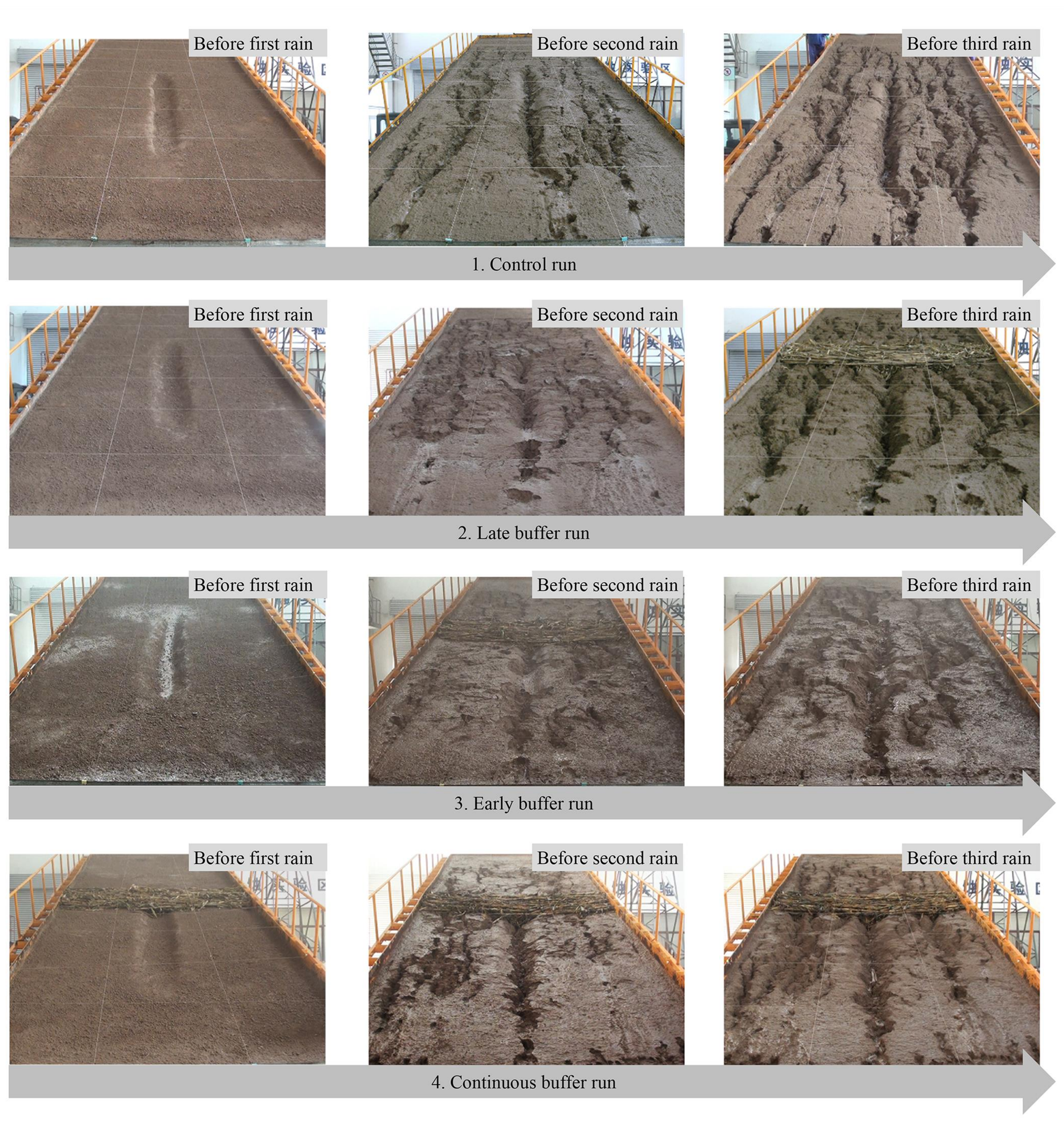
1) to quantify the **reduction of soil erosion** induced by a cornstalk buffer strip;

2) to determine the **relationship between runoff and sediment yield** on the hillslope;

3) to **enhance the hydrodynamic understanding** of cornstalk buffer effects on soil erosion processes.

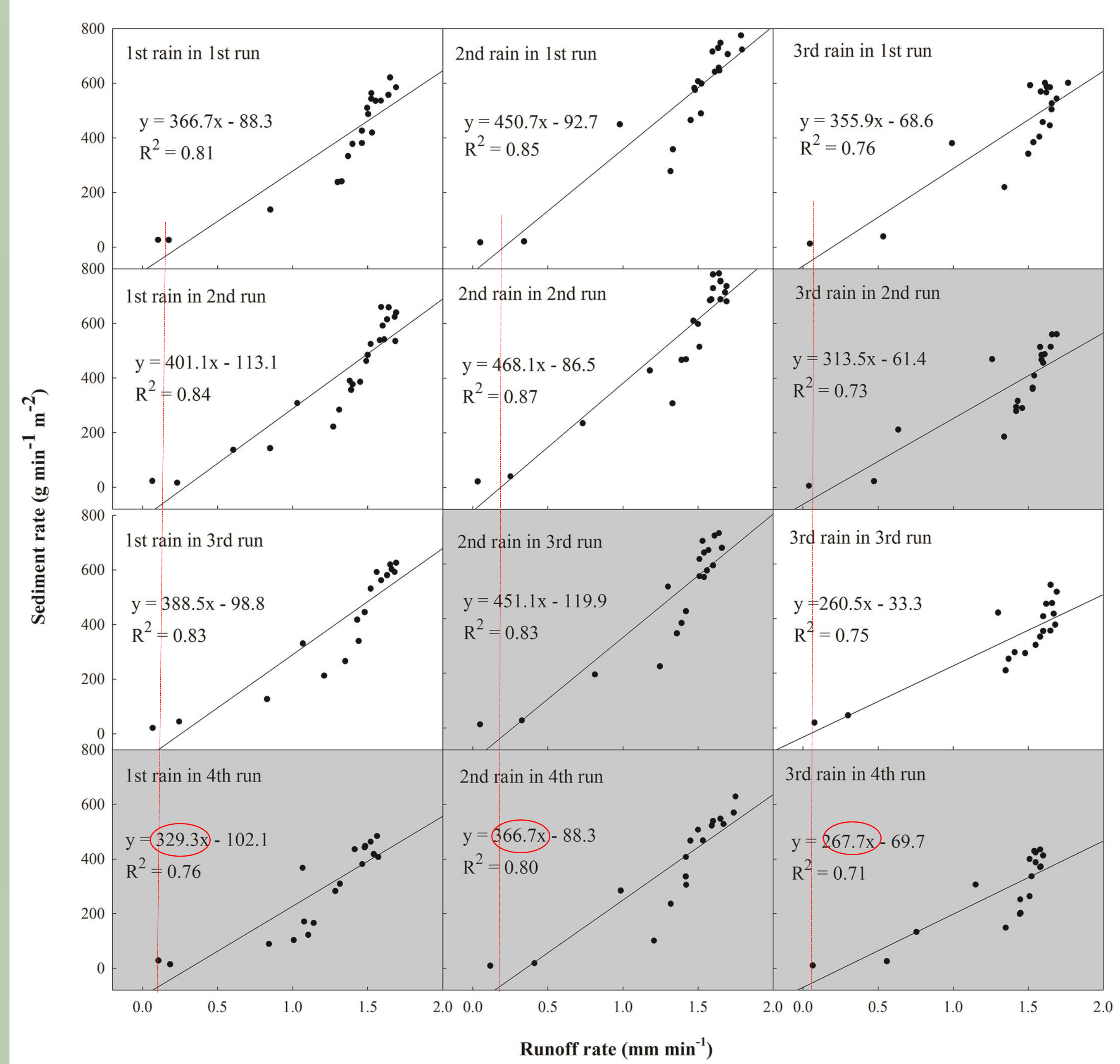
Materials and Methods

❖Experimental runs designed



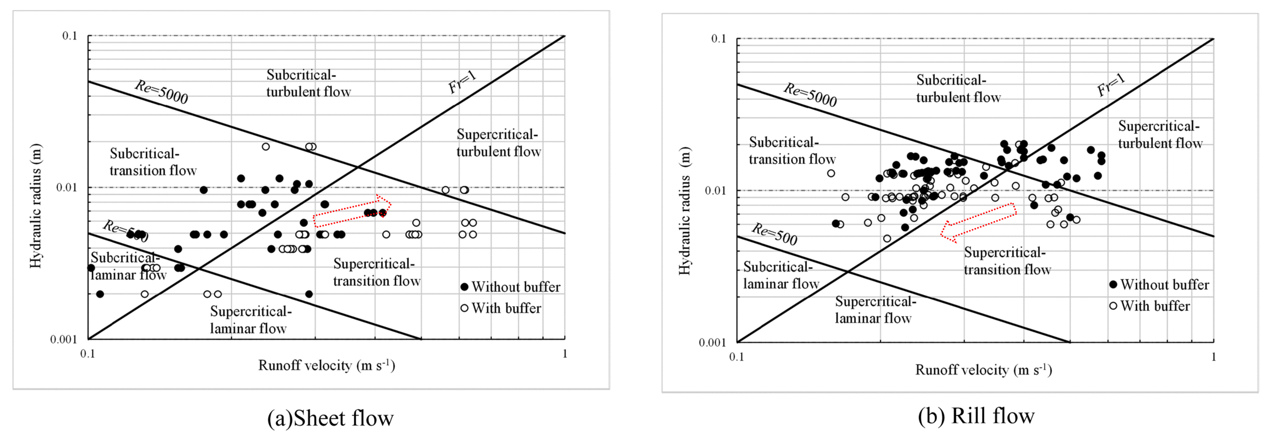
Results

❖ Compared with control, continuous buffer run **reduced soil loss by 29.1%**; **Early buffer run** had a **larger reduction** in soil erosion than late buffer run.



Runoff-sediment linear. runs with buffer are in gray.

❖ The **runoff-sediment relationship coefficients** revealed a decrease in soil erosion and an increase in the runoff threshold required to initiate soil loss.



Flow regime zoning of sheet flow (a) and rill flow (b).

❖ After buffer applied, sheet flow shifted **from subcritical to supercritical** flow and **from laminar to transition and/or turbulent** flow

❖ In contrasts, **rill flow** switched **from supercritical-turbulent flow to subcritical-transition flow**

❖ Soil loss and hydrodynamic parameters

Rainfall events **without buffer**:

$Sr = 0.417(\tau - 1.207)$ ($R^2 = 0.91$, n = 14)

$Sr = 248.24(P - 0.0291)$ ($R^2 = 0.80$, n = 14)

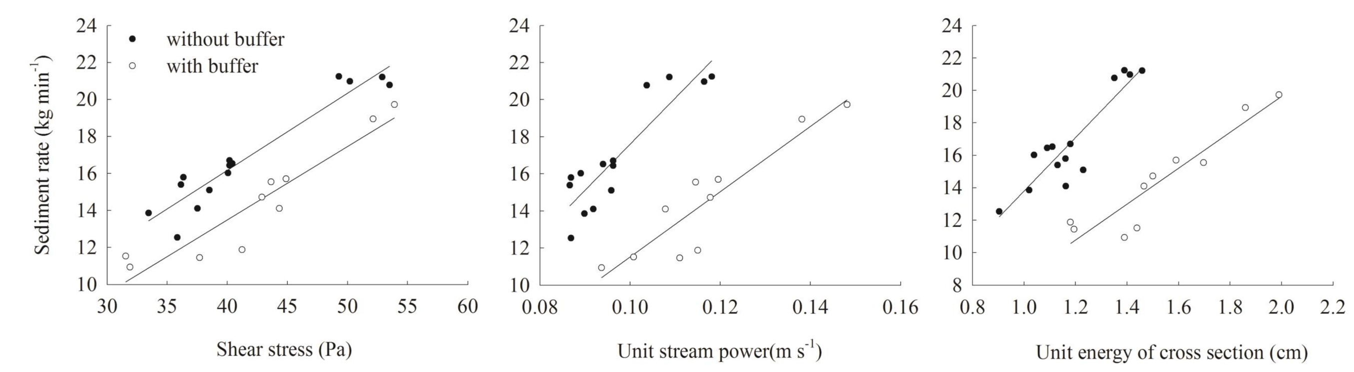
$Sr = 16.46(E - 0.161)$ ($R^2 = 0.82$, n = 14)

Rainfall events **with buffer**:

$Sr = 0.396(\tau - 5.916)$ ($R^2 = 0.88$, n=10)

$Sr = 176.17(P - 0.0346)$ ($R^2 = 0.84$, n=10)

$Sr = 11.04(E - 0.222)$ ($R^2 = 0.86$, n=10)



Relationship between sediment rate and shear stress, unit stream power, as well as unit energy of cross section

❖ Critical shear stress, critical unit stream power, and critical unit energy of cross section for soil erosion initiation increased by 390.1%, 18.9%, and 37.9%.

Conclusions

1) cornstalk buffer strips delayed runoff occurrence time, increased the infiltration volume and decreased the soil loss.

2) According to the coefficients of runoff-sediment relationship, cornstalk buffer strip decreased the sediment concentration and increased the runoff rate threshold for soil erosion initiation.

3) Buffer **decreased the rill flow velocity** and promoted rill flow **shift from supercritical turbulent towards subcritical laminar** flow conditions, which is meaningful for reducing soil erosion.

4) cornstalk buffer strip enhanced **the critical hydrodynamic forces** required for the initiation of soil erosion which contributed to the reduction of soil loss.

DOI: 10.1016/j.catena.2016.10.016