Overland flow and erosion from runoff plots on a Mollisol in Northeast China

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Introduction

While conceptually simple, the dynamic process of surface runoff and soil loss are quite complex. As the effect of the detachment by raindrops and transport of surface runoff on soil erosion by erosive rainfall, soil loss occurs as an ill-defined mix of both particles and aggregates. The objective of this study was to (1) evaluate surface runoff and soil erosion under two different tillage treatments and two slope gradients as related to actual rainfall events and (2) analysis of the dynamic variation of surface runoff, sediment transport and soil solid size during the single natural rainfall case under different treatments.

Methods

This study site is located at the runoff plots in the Hailun Monitoring and Research Station of Soil and Water Conservation, which is situated at the center of the typical Mollisol zone of Northeast China (Fig. 1 and Fig. 2). This study involved different tillage treatments (no-till and conventional till) and slope gradients (5° and 7°). By using Runoff-Sediment Monitoring Device (Fig. 3) and EyeTech Particle Size Analyzer (Ankersmid, Netherlands) to record and analysis the soil solid sizes changes associated with surface runoff and sediment transport process.

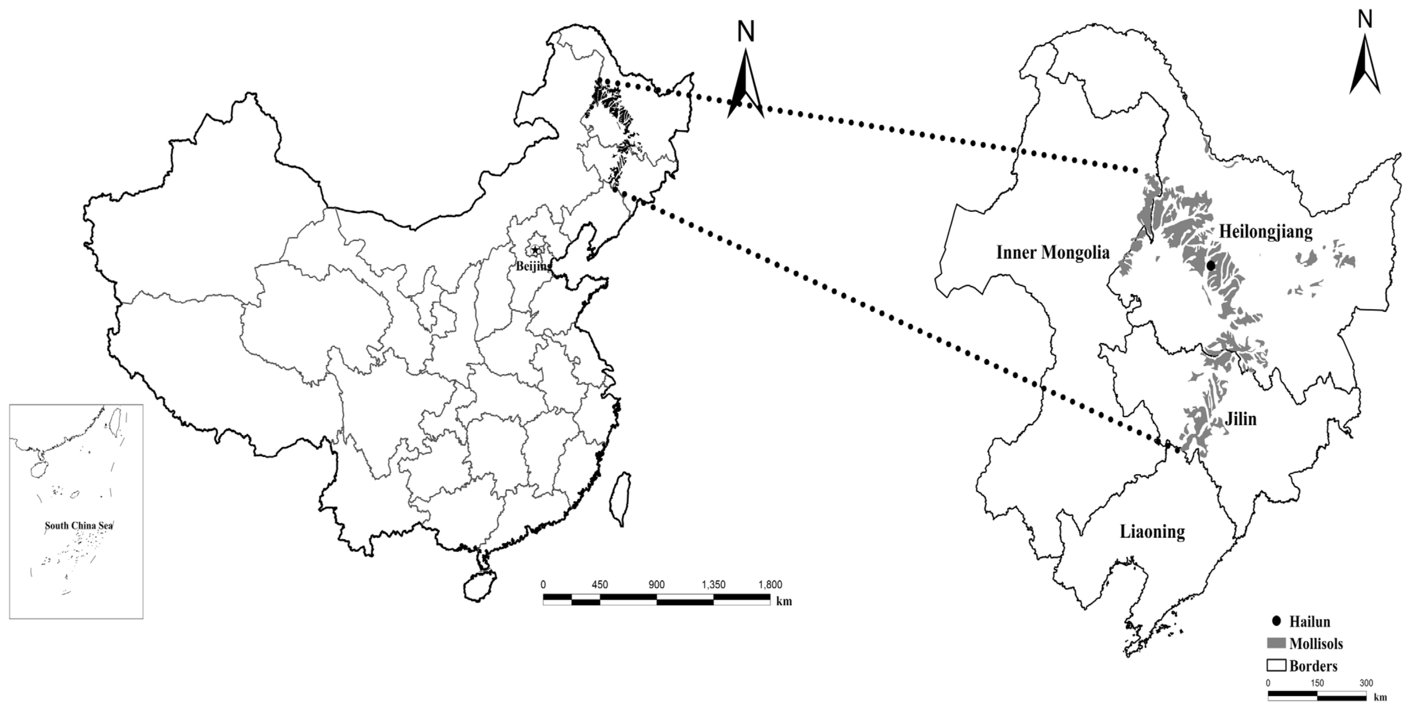

Figure 1. Location of Hailun Monitoring and Research Station of Soil and Water Conservation, Northeast Institute of Geography and Agroecology, Chinese Academy of Science in the Northeast China (Hailun, Heilongjiang Province)

Figure 2. Hailun Monitoring and Research Station of Soil and Water Conservation

Figure 3. Runoff-Sediment Monitoring Device

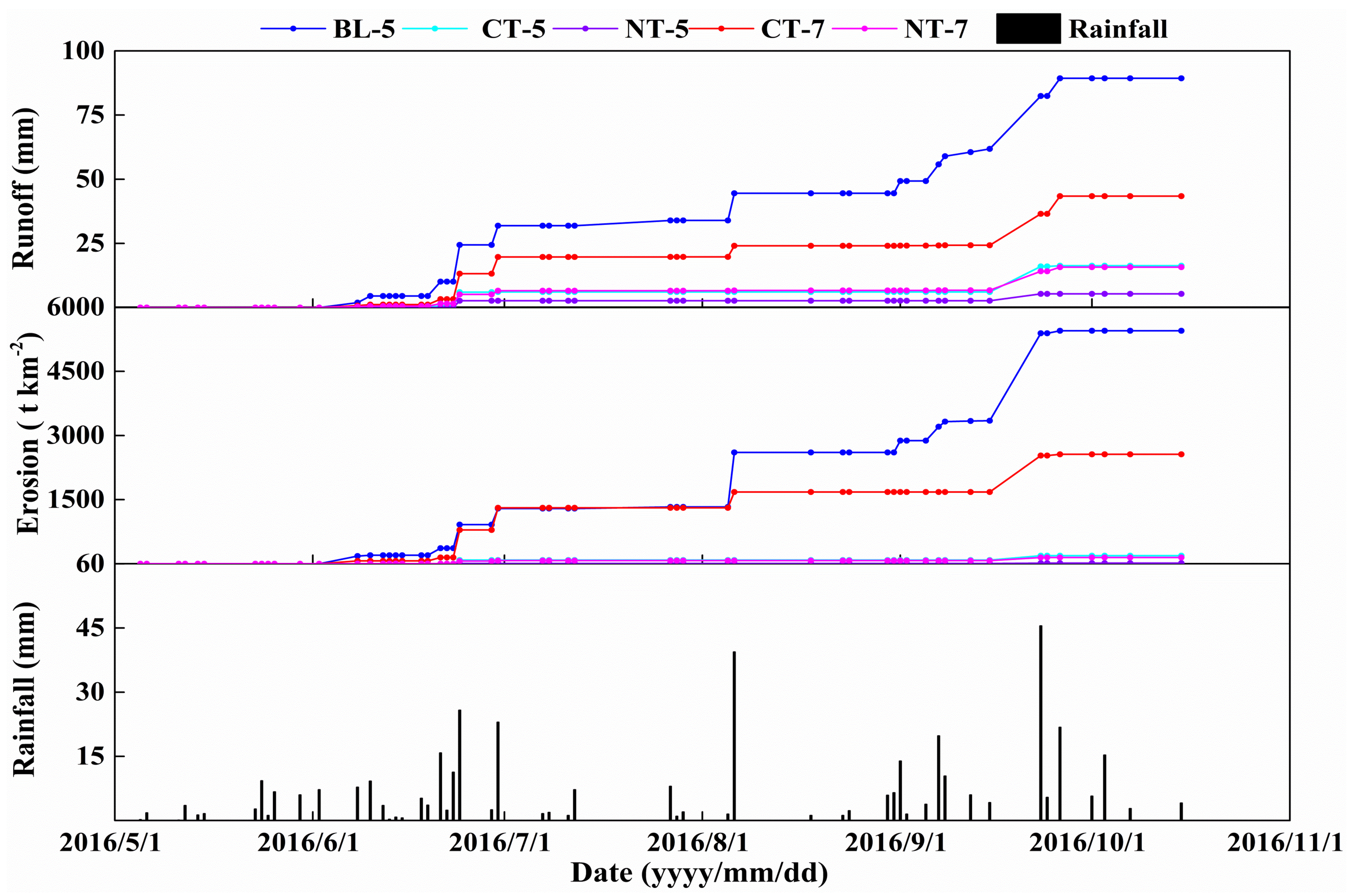

Figure 4. Cumulative surface runoff (mm) and soil loss (t km-2) of each combination of the tillage treatment and slope gradient over the period May 1st-October 30th, 2016. (BL-5: Bare land on 5° slope gradients; CT-5: Conventional tillage on 5° slope gradients; NT-5: No-tillage on 5° slope gradients; CT-7: Conventional tillage on 7° slope gradients; NT-7: No-tillage on 7° slope gradients)

Treatment	Rainfall (mm)	Number of runoff	Runoff coefficient (%)	Number of Sediment transport	Erosion modulus (t km^{-2} a^{-1})
BL-5	394.3	16	35.6±1.10a	14	5448.7±13.38a
CT-5		6	6.5±0.17c	4	188.5±0.55c
NT-5		2	2.1±0.15d	2	15.1±1.65e
CT-7		13	17.3±0.98b	8	1561.2±6.01b
NT-7		10	6.3±0.26c	4	145.5±3.01d

Table 1. Annual runoff and soil loss as affected by tillage

Treatment	Without coverage (%).				Add coverage (%)			
	Runoff		Soil loss		Runoff		Soil loss	
	Equation	r^2	Equation	r^2		r^2	Equation	r^2
BL-5	RF=0.035F+2.728	0.87	SL=3.799F-5.730	0.93	RF=0.035F+2.728	0.87	SL=3.799F-5.730	0.93
CT-5	RF=0.016F-0.486	0.65	SL=0.182F-5.435	0.62	RF=0.015F-0.027C+1.377	0.74	SL=0.174F-0.28C+13.631	0.69
NT-5	RF=0.005F-0.143	0.58	SL=0.015F-0.445	0.61	RF=0.005F-0.007C+0.287	0.65	SL=0.014F-0.02C+0.779	0.68
CT-7	RF=0.022F+0.781	0.62	SL=1.748F+1.197	0.79	RF=0.021F-0.054C+4.377	0.78	SL=1.705F-1.726C+116.109	0.83
NT-7	RF=0.011F-0.009	0.60	SL=0.129F-3.029	0.63	RF=0.01F-0.023C+1.357	0.75	SL=0.125F-0.189C+8.285	0.71

Table 2. Linear regression equations relating surface runoff (mm), soil loss (t km^{-2}), rainfall erosivity (MJ mm ha-1 h-1) and canopy (%) under different treatment on a Mollisol in Northeast China (RF=Runoff (mm), SL=Soil loss (t km^{-2}), C = Coverage(%), F=Rainfall erosivity (MJ mm ha^{-1} h^{-1}))

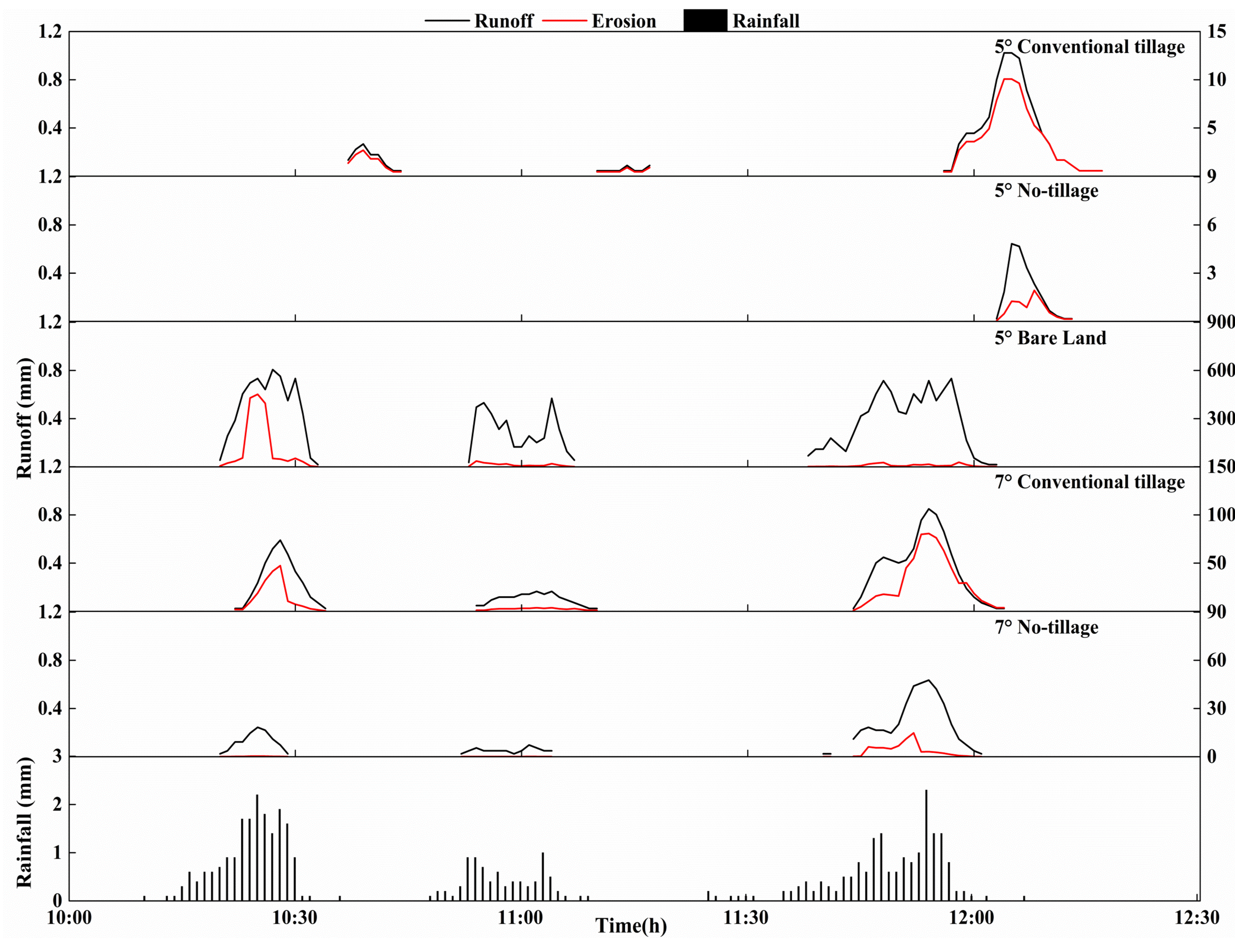

Figure 5. The precipitation, surface runoff and sediment transport process of different tillage system and slope combinations for three rainfall event (September 23 in 2016).

Figure 6. The picture of Bare Land plot after one rainfall event. Flow channels of runoff are apparent as are zones of sedimentation. The color of moving down material was different from the upslope to downslope after one rainfall event. Some of them were white sediment (sand grains), while others were black sediment (aggregates).

Results

1. There was 394.3 mm rainfall during 54 events between May and November 2016. Runoff as overland flow occurred 14 times in the control, accounted for 25.9% of the precipitation and caused 54.5 tons/ha erosion. Runoff only occurred twice in the 5 no-till plot and caused 0.2 tons/ha (Fig. 4 and Table 1).

2. R^2 between soil loss, rainfall erosivity and crop canopy to the tillage plots increased 10.2%, compared the value of R2 in the regression equation which just used rainfall erosivity as the factor to express the soil loss in each tillage plot. (Table 2).

3. The curve of surface runoff and soil loss under each treatment were basically consistent with the rainfall curve in every rainfall case (Fig. 5). For the different sized and density material, the movement is differential in the plot and there are ephemeral preferential flows paths across the plot (Fig. 6).

Conclusion

1. Treatment plot with gentle slope gradient and greater crop coverage better weakened the generation of surface runoff and protected the soil from erosive forces of rainfall.

2. The proportion of large soil solid decreased with an increase of rainfall intensity, and more silt-size soil solid was found at the end of rainfall event.

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