Field measurement of infiltration rates using an oscillating nozzle rainfall simulator in Mongolia

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1. Introduction

Overgrazing is considered to cause recent intensive soil erosion of grassland in Mongolia. Surface vegetation cover is considered to be a primary control factor of soil erosion in semi-arid environment (Cammeraat, 2004). Reduction of surface vegetation cover by grazing may increase direct raindrop impacts on soil surface hence increase splash erosion and susceptibility to surface crusting, thereby causing enhanced overland flow and erosion (Fredrickson et al., 1998; Manzano and Navar, 2000). Therefore overgrazing may trigger intensive soil erosion and subsequent desertification (Zhao et al., 2005), which is one of the key issues concerning the global environment.

Although numerous studies have been conducted on the influence of grazing on overland flow generation and soil erosion (Evans, 1977; Sharma, 1997), the effect of surface vegetation cover on infiltration rate and interrill erosion are not yet fully understood. In addition to that, very few studies are available concerning runoff response of grassland to the recovery of vegetation cover after the rest from grazing.

The objective of this study is to investigate the effect of surface vegetation cover on infiltration rate by means of simulated rainfall experiment in Mongolian grassland.

2. Methods

2-1 S*ite description*

Two study sites with different grazing history are located at Kherlen river basin in north-eastern part of Mongolia. One site is Baganuur, where the number of grazing animal has been increasing in the last decade. The other site is Kherlen-bayan Ulaan, where has been experienced intensive grazing as a wintering ground for livestock. Two hillslope plots (50 m × 25 m), surrounded by 20 cm high concrete wall were constructed in each site, one plot was surrounded by a fence for protection from grazing.

After three growing season since prohibit of grazing, vegetation covers of ungrazed and grazed plot were 88 % and 43% for Baganuur (Uyunna and Tamura, 2006), 47 % and 22 % for Kherlen-bayan Ulaan, respectively. Vegetation covers in ungrazed plot were 45 % and 25 % higher than that in grazed plot, indicating recovery of surface vegetation cover after the rest from grazing.

2-2 *Measurement of infiltration rate*

Infiltration and soil erosion were studied using an oscillating nozzle rainfall simulator. The simulated rain with intensity of 170-220 mm/h was generated using industrial spray nozzle (Veejet 80150, Spraying Systems, USA) and an engine operated water pump. Raindrop impact of simulated rain was adjusted to that of natural rainfall in storm event in study area.

The simulated rainfall was applied on 1m × 1 m plot for 15 to 25 minute, measurement included runoff rate from the plot, concentration of sediment in runoff and splash erosion rate for every minute. Infiltration rate was calculated by subtracting runoff depth from applied rainfall depth of simulated rain for every minute.

Four simulated rainfall experiments, one ungrazed site and three grazed sites, were conducted in each site in July 2005 and October 2006.

2-3 *Estimation of vegetation and stone cover*

Vegetation and stone cover of experimental plot was estimated visually from photo taken by digital camera, using imaging software (Photoshop 7.0, Adobe Systems, USA). All above-ground plant and litter material inside the plot was collected, then oven-dried at 85 degrees for 24 hours and weighed in the laboratory.

3. Results and Discussion

The plot with dense vegetation cover generally have relatively high infiltration rate >90 mm/h, on the contrary, for the plots with <40% surface vegetation cover, low infiltration rates less than 60 mm/h were observed (Fig.1).

The plot with stone cover showed slight increase on infiltration rate with increase of percentage of stone cover. Final infiltration rate increased as total surface cover (vegetation and stone) increased, not only vegetation cover but also stone cover likely have an effect on infiltration rate. Final infiltration showed better correlation with total surface cover than surface vegetation cover.

Infiltration rates of ungrazed and grazed plot were 91.6 mm/h and 34.9 mm/h for Baganuur, 99.9 mm/h and 39.7 mm/h for Kherlen-bayan Ulaan, respectively (Table1). Infiltration rates of ungrazed plot were higher than that of grazed plot in both study sites; this indicated that infiltration rate likely recovered quickly with re-growth of surface vegetation after the three years of rest from grazing. These data suggested that surface vegetation cover greatly increased infiltration rate and hence reduced interrill erosion (Fig.2).

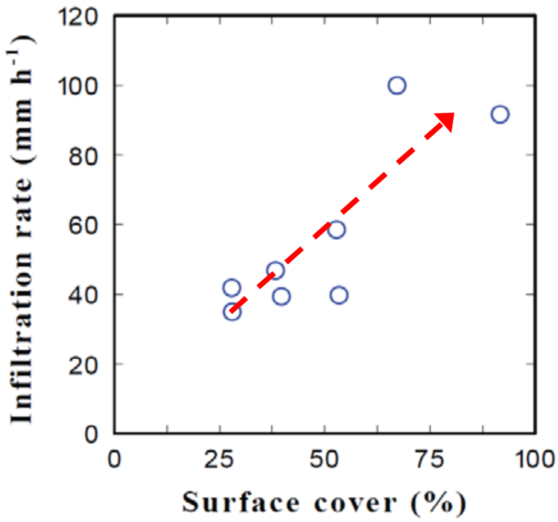

Fig.1 Effects of surface vegetation cover on final infiltration rate of simulated rain.

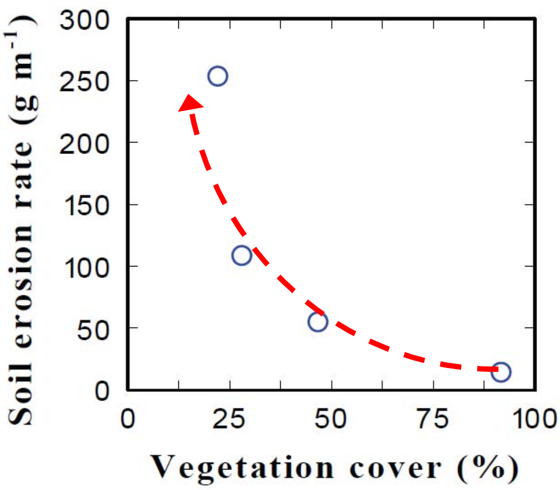

Fig.2 Effects of surface cover on final infiltration rate of simulated rain.

4. Concluding remarks

The results from this study indicated that surface vegetation cover greatly increased infiltration rate. The three years prohibition of grazing effectively increased surface vegetation cover and hence increased infiltration rate. The surface stone likely increase infiltration rate, however further study is needed to understand the effect of surface stone cover on infiltration rate and soil erosion.

Table 1 Measured infiltration rate for percentage cover of vegetation and stone

	Vegetation cover (%)	Stone cover (%)	Total surface cover (%)	Final IR* (mm/h)	Minimum IR** (mm/h)
Baganuur					
Ungrazed	91.7	0.0	91.7	91.6	80.2
Grazed	28.0	0.0	28.0	34.9	34.9
Grazed (Eroding area)	16.6	11.3	27.9	41.8	40.1
Grazed (Depositional location)	39.3	0.4	39.7	39.3	39.3
Kherlen-bayan Ulaan					
Ungrazed	46.7	20.5	67.2	99.9	99.9
Grazed	22.1	31.3	53.4	39.7	39.7
Grazed (Eroding area)	10.1	42.7	52.8	58.5	49.8
Grazed (Depositional location)	18.7	19.6	38.3	46.8	46.8

*Final IR represents averaged infiltration rate of last 3 minutes of the experiment.

**Minimum IR represents the lowest value (3 points moving average) of measured infiltration rate through the experiment.

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