

## EFFECT OF VEGETATION COVER TYPES ON SOIL INFILTRATION UNDER SIMULATING RAINFALL

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### Abstract

In this study, simulated rainfall was used to study the effect of herbaceous vegetation cover types on infiltration of rainfall. Results indicated that on annual vegetation plot, water infiltration was high. While on perennial vegetation plot, water infiltration rates decreased. In addition, results on the clipped vegetation plots indicated that at the start of the rainfall, soil infiltration rate was low; with the progress of the rainfall, water infiltration rates were improved, which indicated that the existence of microbiotic soil crust reduced the soil infiltration rate. Thus it is of great importance to improve soil infiltration by destroying the microbiotic soil crust with proper measures such as grazing and fire in arid and semi-arid areas.

Keywords: vegetation succession stage, simulating rainfall, microbiotic soil crust, infiltration rate.

### Introduction

Soil hydrologic condition is the result of interactions between soil and vegetation. Infiltration rate and sediment yield integrate these factors and are good indicators of hydrologic condition (Thurow, 1986). Vegetation succession is the results of interactions between soil and vegetation, which induced changes in soil hydrology. One consequence of this change is the amelioration of soil (Fisher 1990) resulting in an alteration of the hydrologic characteristics of the site (Thurow 1991). Under the cover of the vegetation, the accumulation of organic matter and the moderation of soil microclimate (Kittredge 1948) favor microbial activity and creation of water stable soil aggregates (La1 1987). The enhanced soil structure that results from these factors improves infiltration. Consequently, infiltration rates are often observed to be different under different life forms (Blackbum 1975; Wood 1981; Knight 1984; Thurow, 1986). Recently, number of studies demonstrated the effect of increasing cover of ground-storey plants, particularly grasses, on reducing runoff and erosion (Pressland, 1982; Eldridge, 1993). Perennial plants are generally more effective than annual or ephemeral plants (Eldridge, 1992).

In addition, human-induced disturbance also has profound effect on soil infiltration through its impact on soil and vegetation. Burning reduced infiltration rates in soils of Missouri Ozark forests (Arend 1941), of chaparral communities of northern California (Sampson 1944), of Flint Hills tall grass prairie of Kansas (Hanks and Anderson 1957), and of Douglas fir forests of British Columbia (Beaton 1959). However, Scott (1956) reported increased infiltration on upland soils in California following fire, as did Tarrant (1956) for a ponderosa pine forest in eastern Washington. Veihmeyer and Justin (1997) on oak site, Justin (1997) also detected no significant difference between cut and burned juniper sites. Darrell (1978) has verified that the fire affected soil infiltration, but its effect varied with soil moisture content. Seasonal variability in precipitation may interact with grazing to alter the hydrologic condition of rangeland (Warren et al. 1986a). Currently in China, ecological restoration is the main step for eco-environment construction. But few studies were available dealing with soil hydrological changes associated with the recovery of vegetation. Thus the target of this research was to study the effect of vegetation cover types on runoff and soil infiltration using simulated rainfall.

### Materials and Methods

#### *Site conditions*

The studies were conducted during the growing season of 2002 on 1×4m plots. Experimental sites were located in Wangdong watershed, with local elevation ranging from 950-1225m. The climate is described as warm temperate continental, with average annual temperature 9.1 °C, average annual rainfall 584 mm, most of which falls in Jul--Sept. The main soil type on most sites was loess. Dominant species in herbaceous communities were perennial herbaceous grasses, *Stipa bungeana* and *Bothriochlon ischaemum*, with associate species *Lespedeza bicolor*, *Dendranthema indicum*. Simulated rainfall was applied on natural annual and perennial herbaceous grass plots (Table 1).

**Table 1. General conditions of simulating rainfall plots**

Plot number	Vegetation type	Gradient	Vegetation cover	Soil bulk density	Slope exposition	Location on slope
1	Annual	32	0.69	1.1	Southern	Under
2	Annual	32	0.42	1.08	Southern	Under
3	Annual	32	0.78	1.06	Southern	Under
4	Annual	32	0.88	1.05	Southern	Under
5	Perennial	20	0.81	1.23	Southern	Middle
6	Perennial (clipped)	20	0.82	1.22	Southern	Middle
7	Perennial (fired)	20	0.80	1.25	Southern	Middle

#### *Simulated rainfall plots*

To annual herbaceous plots, 4 plots with different vegetative cover were determined as simulating rainfall plots with 3 target-rainfall intensities of 1mm/min, 2mm/min, and 3mm/min from the height of 2m (upper)~4.64m (bottom), which was applied in the sequence of 2mm/min, 1mm/min and 3mm/min, 24 hours followed another one.

On perennial herbaceous plots, to verify the effect of different vegetative components on runoff production, simulating rainfall plots were setup with different treatments. In one plot, upper parts of the vegetation was clipped to a 2cm stubble height; while in another one, herbicide was spread over all vegetation, then fire was applied to get rid of all the surface cover (including litter, live vegetation). After that, simulating rainfall of different rainfall intensity was applied at the same height and sequence.

#### *Rainfall simulating and runoff study*

In this study, a new rainfall simulator was designed, which was consisted by 16 pieces of boards of 26 x 102.0cm<sup>2</sup>, with 333 6.5# medical syringe needles on it. Monitoring the water discharge into the simulator, which indirectly influenced the air pressure in the simulator, controlled rainfall intensity. Soil moisture content on the profile within 50cm was determined by soil auger before the rainfall. Runoff yield in each minute was determined by measuring its volume. After that, infiltration curve was determined according to Horton equation, and  $f_0$  preliminary infiltration ability between treatments, is determined and compared.

#### *Vegetative cover and biomass*

Based on former studies, vegetative cover and ground cover was estimated by point-frame method (Hoffmann, 1983, 1991). Various cover components can be estimated from either the first point contact by the needles of the point frame, or from contact at the soil surface. In this study, vegetative cover measurements were taken within runoff plots with vertical point frames of 33 sliding pins spaced about 3.3cm apart. Plots cover estimates were taken with 10 frames of 33 pins producing 330 hits before the simulating rainfall.

## **Results**

#### *Upper part biomass and cover types composition of annual and perennial vegetation*

Due to the difference in microclimate and tissue C:N ratio, litter decay rate under the cover of annual and perennial vegetation was different (Melvin. 1995, Liacos, 1962a Liacos, 1962b). Under annual vegetation, soil moisture evaporated quickly, most part of the vegetation litter was mineralized, and little organic matter was returned to soil. While under perennial vegetation, microenvironment favored the activity of the microorganism in soil, and litters decomposed easily and formed humus. Vitt (1989) has verified that the formation of microbiotic soil crust and surface vegetation (moss, lichen, algae, and fungi.) was closely related to its microenvironments, and can be treated as a kind of indicator species of the microenvironment.

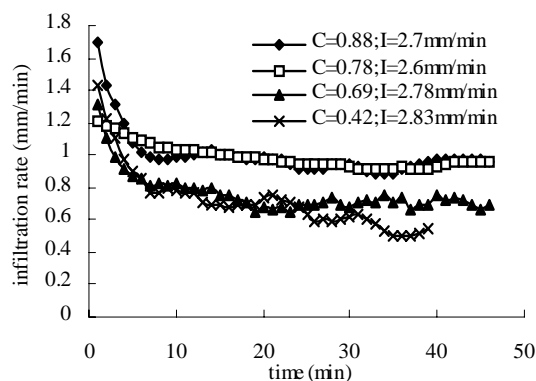
As shown in Table 2, there was almost no microbiotic soil crust or surface vegetation on annual herbaceous vegetation plots; while on the perennial herbaceous vegetation plots, there were all cover types, including live vegetation, surface vegetation (moss and lichen), litter and microbiotic crust, even on southern exposure slopes. This result indicated that microenvironments under the cover perennial herbaceous grass cover have been greatly improved. In addition, surface cover compositions on perennial vegetation plots was more complex than that on the annual vegetation, and may play more important ecological role (such as soil and water conservation) in the nature.

**Table 2. Surface cover (fraction) and composition of plots used for simulated rainfall**

	Micobiocrust	Live vegetation	Surface vegetation	Litter	Bare soil
Plot 1	0.01	0.30		0.12	0.57
Plot 2	0.00	0.44		0.24	0.32
Plot 3	0.02	0.40		0.45	0.13
Plot 4	0.03	0.36		0.52	0.09
Perennial plot	0.10	0.53	0.06	0.24	0.07
Clipped plot	0.14	0.23	0.09	0.34	0.20
Fired plot	0.16	0.05	0.13	0.18	0.48

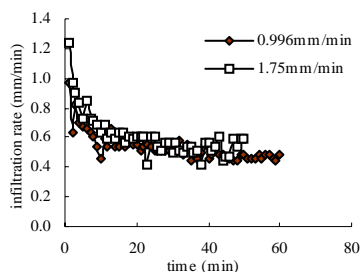
*Soil infiltration on annual and perennial vegetation plots*

As the stable infiltration on the same site was similar, not all the infiltration process was listed for simplification. Simulating rainfall results on annual vegetation plot of 1~4 showed that the soil infiltration tended to be stable in 15 minutes. And the stable infiltration rate on plot 1~4 was higher, which were 0.71, 0.94, 0.92 and 0.55 mm/min, respectively. With the increase of vegetation cover, soil infiltration decreased.

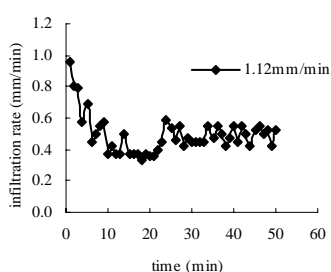


**Figure 1. Water infiltration on annual plots**

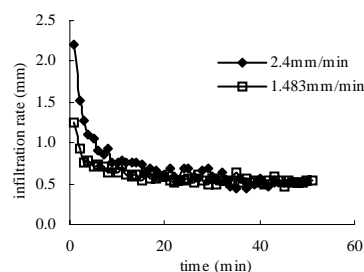
While on perennial vegetation plots, stable infiltration rate was under 0.47 mm/min. Simulating results on clipped plots (Figure 2) indicated that at the start of rainfall (0-20 min), stable soil infiltration rate was 0.38 mm/min. With the progress of rainfall (24-50 min), soil infiltration increased to 0.52 mm/min. Investigations of soil surface cover types before and after the rainfall (Table 3) showed that the cover of microbiotic soil crust decreased. These results indicated that crust was broken gradually under the raindrop splash after the removal of perennial vegetation canopy. The increase of litter cover was a result of gathering of residues by surface flow. Removing its protection by clipping the canopy over it can destroy this crust, and improve the soil infiltration rate.



**Figure 2. Natural grasses plot**



**Figure 3. Vegetation clipped plot**



**Figure 4. Fired plot**

Soil infiltration on the burned plot (Figure 4) was close to that on the clipped plot in later time of 20~50min. The reason was that fire destroyed almost all the upper parts of the vegetation; crust was exposed under the direct raindrop splash, and was destroyed quickly.

**Table 3. Changes of soil surface cover types before and after the rainfall on plot #?**

	Microbio-crust	Live vegetation	Surface vegetation	Litter	Bare soil
Before first rainfall	0.24	0.30	0.08	0.19	0.19
Before second rainfall	0.16	0.23	0.12	0.28	0.20
Before third rainfall	0.10	0.19	0.15	0.34	0.22

### Conclusion

Based on the results in this study, following conclusions can be reached: On the annual vegetation plots, soil infiltration rate was higher as the aeration conditions were better. With the increase of vegetation cover, soil infiltration was lowered. Stable infiltration rate on perennial was lowered than that on annual plot. Existence of surface vegetation protected the soil from direct splash of raindrop; microbiotic soil crust decreased soil infiltration rates. Thus proper human activities (including mowing, grazing, and fire etc) in arid and semiarid areas would help to destroy the microbiotic soil crust over soil surface, and help to improve soil infiltration ability, but increased the risk of soil erosion.

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