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Distribution Characteristics of Soil Moisture in Gully and Slope in Hilly-gullied Loess Region

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Abstract

In order to explore the characteristics of soil moisture distribution in the channel and slope surface of the small watershed in the loess hilly and gully area, a typical small watershed in Yan'an was selected for the channel and slope location observation experiment, and Trime-PICO TDR was used to determine the soil moisture in the gully and slope. The results showed that in the 0-160 cm soil layer, the soil moisture content of the slope presents an overall trend of down-slope>middle-slope>up-slope, and the soil layer below 60 cm under the slope was higher than the field water holding capacity of loess soil. The soil moisture content of the gully showed trend of upstream of the gully>downstream of the gully. The thinning of the soil layer in the downstream of the gully was prone to produce a saturated flow that was greater than the field water holding capacity. The volumetric water content of the soil downstream of the gully reached 22.8% in the 160 cm soil layer.

Keywords

Hilly-gullied Loess Region; Gully and slope; Soil volumetric moisture content.

1. Introduction

Water is one of the basic elements of agricultural production. Understanding of the dynamic changes of water is important research content to realize the sustainable utilization of regional water and soil resources, planning and management of water and soil resources, and the promotion of high-efficiency water-saving agriculture [1]. The Loess Plateau belongs to a semi-arid continental monsoon climate zone, with serious soil erosion, a small amount of water resources, and uneven temporal and spatial distribution, which greatly restricts regional agricultural production and ecological restoration and reconstruction. On the other hand, due to the lack of technical support, the utilization rate of shallow groundwater resources and soil water resources in the valley is low, and the secondary salinization of the soil, droughts and floods, and other problems are prominent, which seriously affects the production of crops and the construction of high-standard farmland [2-5]. Therefore, research on the characteristics of water distribution in the gullies of the Loess Plateau is of great significance for solving the problem of local water and soil resource utilization and preventing soil erosion.

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2. Materials and Methods

2.1. Study Area

The Jiulongquangou land improvement project in Nanniwan Town is located in the southern part of Baota District, Yan'an City (6°14′40″~36°19′25″N, 109°35′50″~109°39′50″E). It belongs to the hilly and gully area of the Loess Plateau. The gullies are vertical and horizontal, the beams are undulating, and the loess beam hills are the main ones. The climatic type is a plateau continental warm temperate semi-arid climate, arid and windy in spring, hot and rainy in summer. The annual average temperature is 7.7~10.6°C. The average temperature in January is -6.7°C, the average temperature in July is 22.9°C, the extreme maximum temperature is 39.7°C, and the extreme minimum temperature is -25.4°C. The annual sunshine is 2445 hours, the annual precipitation is 450-650 mm, and the frost-free period is 155-188 days. Loess soil is the main soil type, collapse and landslide are relatively easy to occur, and the ecological environment is very fragile. maize and millet are the main local crops.

2.2. Measurement Methods

The traditional soil moisture test method is mainly drying method, which disturbs the soil greatly. Therefore, we used the Trime-PICO TDR portable soil moisture meter for long-term location determination of soil moisture. The monitoring depth was 0~160 cm, and the soil moisture content was measured every 10 cm. The measured soil moisture content was all volumetric water content. The data were processed and analyzed by Microsoft Excel 2010. Figure generation was performed by using SigmaPlot12.5.

3. Results and Analysis

3.1. Soil Moisture Content at Different Positions of Slope

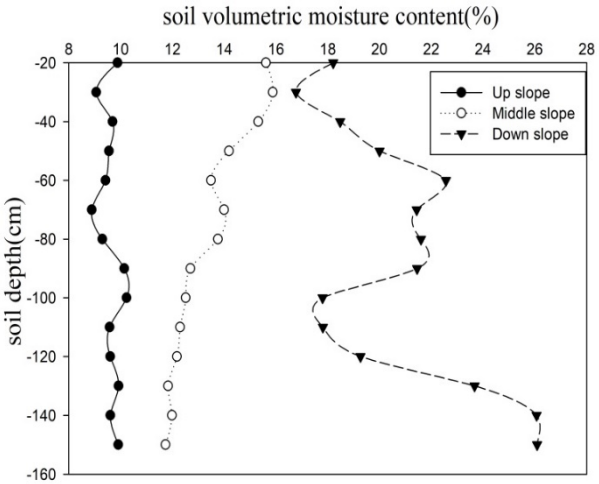

Figure 1. The soil moisture at different soil depths on slopes

As a state variable of water balance, soil moisture content is a comprehensive reflection of factors such as local precipitation, land use conditions, topography and soil type. Among various conditions, topographical conditions have a decisive influence on the distribution and movement of soil moisture. The results of continuous positioning and monitoring of soil moisture at different locations on the slopes of the Jiulongquan Spring Basin showed that in the 0-160 cm soil layer, the soil moisture content showed an overall trend of downslope>middle-slope>upslope (Figure 1). The soil moisture content under the slope was significantly higher than that in the middle and upper slope, even below the 60 cm soil layer, higher than the field water holding capacity standard of loess soil. The soil moisture content reached 22.57% at the

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60cm soil layer at the foot of the slope. Analysis of the soil texture within the depth of 160 cm of the slope show3e that the soil texture was relatively stable, and the soil type was loess soil. When sampling at the position under the slope, it was found that there were obvious soil layering characteristics at the depth of 60~70 cm. Therefore, soil moisture is easy to accumulate below the 60 cm soil layer at the lower slope of the Jiulongquan Spring Basin, resulting in lateral subsurface flow.

3.2. Soil Moisture Content at Different Locations of Gully

The general survey results of the gully soil in the Jiulongquan Watershed showed that the thickness of the gully soil in the study area has a significant slope along the direction of the gully, and there was a certain gravel layer and calcite layer under the soil in the downstream part of the gully, which could prevent the infiltration of surface water. From the monitoring data of soil moisture at different locations in the gully, it could be concluded that the soil moisture content in the entire gully tended to be greater in the downstream of the gully than in the upstream of the gully(Figure 2). Because there was a certain slope drop in the gully, precipitation will infiltrate and produce surface runoff, which flowed downstream of the gully along the slope. Therefore, the soil moisture content in the downstream of the gully was significantly higher than that in the upstream of the channel, and the soil volumetric moisture content reached 22.8% in the 160 cm soil layer. At the same time, due to the thinning of the soil layer downstream of the gully, there was a certain layered structure, which was likely to produce a saturated flow larger than the field water holding capacity. The above results lead to the problems of waterlogging and salinization in the downstream of the gully when there was relatively high rainfall.

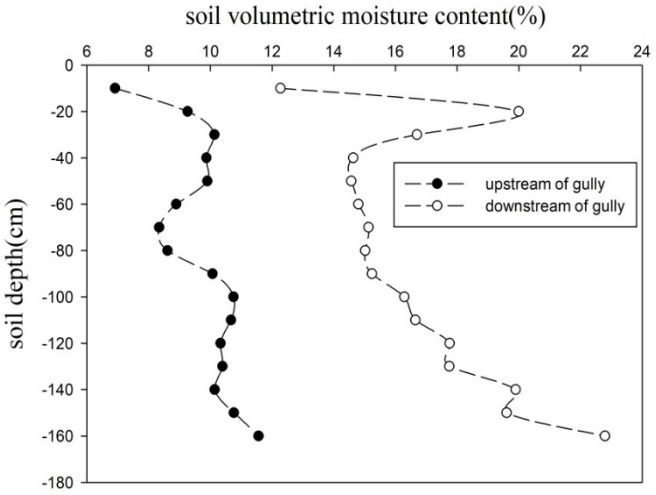

Figure 2. Soil moisture content at different locations of gully

4. Conclusions

The distribution of soil moisture in gully and slope in the hilly and gully regions of the Loess Plateau is greatly affected by factors such as slope position, vegetation, and precipitation, and has obvious temporal and spatial variability. Within the range of 0-160 cm soil depth, as the slope position and gully topography decrease, the soil moisture on the slope surface and gully tended to increase, even at the foot of the slope and the lower reaches of the gully, there was a lateral subsurface flow exceeding the field water holding capacity below 60 cm soil layer. Therefore, the comprehensive regulation and utilization of gully water in the loess hilly and gully area has an important guiding role in improving the efficiency of water and soil utilization.

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