

Research on the effects of canopy and vegetation roots on the slope erosion

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Abstract

Through overall elaborated the reasons of slope surface erosion and the role of vegetation for slope protection, then the effects of the vegetation canopy for the slope surface erosion process and the influence of vegetation roots for the slope surface erosion mechanism were analyzed. The results show that there are two main reasons of the vegetation sediment reduction effect and the reducing of soil erosion; on the one hand because of the water retaining effect of vegetation, the runoff velocity reduce, reduce the scouring force of soil; on the other hand, because the surface root vegetation generate can bind soil particles enhance the ability of soil, polymerization, and the absorption roots on soil moisture, reduce the pore water pressure, improve the negative pressure of soil, enhance soil strength, which greatly improve the impact resistance, the corrosion resistance of the soil. Finally, the existing problems of in the study of the influence of the vegetation on the slope erosion are summarized, and future research directions and issues should be noted that the author put forward views and perspectives.

Keywords

Slope erosion, vegetation, impact process, influencing mechanism, prospect.

1. Introduction

China is one of the world's most serious soil erosion in the country, soil and water loss is China's most prominent environmental problems currently, which is a significant obstacle to national and local economic development[1]. Besides natural factors, the important cause of China's soil and water loss is deforestation, destruction of forests and grassland, grain and other unreasonable land utilization process[2]. In addition, along with all kinds of engineering construction, large vegetation was destroyed. These human factors also caused serious soil erosion in recent years.

The core mission of Soil and Water Conservation is to combat soil erosion [3]. Vegetation can increase the ability of soil erosion by improving the soil's natural environment. Plants measure can control soil erosion and reduce slope erosion effectively. Therefore, in the area of soil erosion vegetation restoration and construction has become one of the focus of the soil conservation work.

Because of different vegetation measures on the effects of slope erosion and effectiveness of soil and water conservation is different. So a clear understanding of the impact of vegetation on the slope erosion mechanism and process of soil erosion control has important significance, while for slope protection and ecological restoration also played a guiding role.

2. the Effects of the vegetation canopy for the slope surface erosion process

2.1 Closure water

Vegetation hydrological effect has a very important position on vegetation ecosystem. Wherein vegetation canopy is the starting point of vegetation on the rainfall input. From rainfall to vegetation canopy will be conducted after a series of redistribution process, including forest rainfall (S) and

canopy interception (I) which is in the form of penetrating rainfall (P_i) tree and trunk run-off to reach the ground, So canopy sectional flows can be formulated as follows:

$$I = P - P_i - S$$

In addition, During the process of rainfall canopy interception will be consumed in evaporation, reducing the actual effective rainfall and soil water supply areas, which is invalid loss of rainwater resources. However, the loss of rainwater resources that through the canopy interception is affected by many factors, including rainfall, rainfall intensity, vegetation type, canopy cover, leaf area index and so on. There a significant difference was found in different types of vegetation canopy interception of rainfall characteristics, and it's determination work is very heavy.

How to compare or judge the size of the canopy interception role between the different climatic zones and each stands, is still worth exploring. For this reason, some scholars have proposed the concept of canopy interception capabilities and build a canopy interception model which can provide a reasonable basis for comparison, judge the effect of canopy interception.

Shixiang Fan, who references hydrology runoff fills literary theory, build a canopy interception of rainfall models. In addition, combined with a concrete forest field conditions, it is difficult to obtain the ability of canopy of rainfall interception through the measurements, Let along obtaining the relationship between rainfall and canopy intercept ability. However, when the observation data fully, canopy intercept ability can be determined by approximate method analysis [4]. They are:

$$\begin{aligned} \text{当 } P < H \text{ 时, } I &= \alpha W \left[1 - \left(1 - \frac{P}{H} \right)^\beta \right] \\ \text{当 } P \geq H \text{ 时, } I &= \alpha W \end{aligned}$$

Note ;

H : Canopy saturation at the thick of the intercept

W : Actually it is the maximum intercept ability when the most thick canopy in saturated , namely the canopy interception capacity

β : For the integrated parameters, it is associated with stand characteristics, such as the uniformity of the thickness of layer of the canopy , forest species, species composition and forest age, etc.

α :Crown density, canopy density is actually relatively closed area

The measures are determined by this approximate method, and they compared with the results of the model. Results show that both fit well, which indicates that shi-xiang fan and others whom established canopy intercept ability model is effective and can be used to judge and compare the size of the effect that different forest effect on rainfall interception.

This shows that both vegetation canopy and litter which is produced by vegetation canopy or canopy can be interception of precipitation .what's more ,they can reduce rainfall on the slope surface erosion directly.

2.2 Decreased rainfall energy

The vegetation canopy can not only hold precipitation, but also can be reduced rainfall erosion energy. The past research shows that the main driving force of soil erosion from the energy produced by rain, so only reducing rainfall energy, can we prevent and slow down the soil erosion fundamentally. As one of the important measures to prevent soil erosion, vegetation have long been recognized, but the relationship between vegetation and rainfall energy which be researched at home and abroad are very

little. In 1986, Beijing forestry university xin-xiao yu used the measured data to analyses the influence of forest vegetation that reduced rainfall erosion energy function. He think that vegetation weakening effect on rainfall potential energy can be divided into two aspects of rainfall interception by canopy and canopy buffer potential energy [5]. It is worth mentioning that litter vegetation also can effectively avoid splash erosion, obstruct the rainfall kinetic energy consumption, thereby reducing the kinetic energy of perturbation and the carrying capacity of surface runoff .

2.3 Reduce the topsoil crust

Vegetation can effectively protect the ground from the raindrops hitting and reduce the topsoil crust,It is advantageous to the soil infiltration. But the surface soil crust would destroy the soil pore and make rain duration of the slope surface shorter, increased the runoff, decrease the amount of infiltration. At last it will increase soil erosion

In a word, through the above you can see, the raindrop splash effect and the runoff that be produced by rainfall is the main soil erosion. Canopy not only in the number of rainwater to form a closure interception of rainfall and evaporation as well as buffering effect on rainfall, further protecting the topsoil, but at the same time, these effects of rainfall characteristics on canopy have a serious impact, including rainfall runoff start time, rainfall duration, rainfall intensity ,which have significant effect.

3. Vegetation root system's influence on the slope surface erosion mechanism

Plant roots from two aspects of hydrological effect and mechanical effect to improve the soil erosion resistance, impact resistance, shear strength and root network function of soil, Eventually to improving the ability to resist erosion of the soil.

3.1 Improve the corrosion resistance and impact resistance

Root growth and soil erosion resistance was significant, Wu Farong pointed out that corrosion resistance and tree root length, root volume was significantly positively correlated, which mainly depends on how much ≤ 1 mm fine roots. The more the amount of fine roots, soil corrosion resistance is stronger, so the control of plant roots in the root diameter of less than 1mm in soil erosion is in the largest.

Especially Li Yongdeng research in resistance of plant roots and soil erosion systematically. After nearly a decade of research, he puts forward the plant root system can increase the impact resistance of the soil directly and strength the permeability of soil indirectly. The soil hydraulic effect of improvement on soil physical properties is to improve the effect significantly, through to regard pinus tabulaeformis plantation root system as the research object, and before Wu Fa honor to summary that improving the effect of soil physical property mainly depends on the $< LMM$ effective root density fine roots.

Many scholars have done a lot of penetration experiments to study the effect of vegetation on soil infiltration capability in tun. The study found that vegetation can improve soil physical and chemical properties, soil bulk density gets smaller, capillary and total porosity both increased. At the same time, it prevent the formation of a surface crust, increased infiltration, abate the flushing action of water on the earth's surface. Thus it can be seen that the root system has important influence on soil infiltration, and different plant root biomass and soil resistance to erosion is not match.

Ding Jun and others through the research on the enhancement effect of the study found that the root system on soil resistance to erosion under different rainfall intensity enhanced value decreases with the increase of soil depth, and it is concluded that the root system on soil resistance to erosion enhancement value under a light rain strong $>$ under moderate rain $>$ strong rain intensity [6].

3.2 Improve shear strength and solid soil function

Plant roots another role is mainly reflected in the root system of soil mechanics. It can be made true by stabling of soil structure, improving soil resistance to erosion resistance. Considering the roots of the solid earth ability is not only determined by the strength of the root or the strength of the soil, but determined by the interaction between root and soil together. In ecological restoration area, through

ecological restoration halosols deserts, multiple roots cross each other, together form the root system of integrated network, in the process of interact and soil, can improve the tensile strength and shear strength of soil and the stability of slope, soil and water conservation function. The study found that the ability of plants to solid soil trees, shrubs, shrub and grass, herb descending order. If tree, shrub and grass make rational distribution, solid soil plants, solid slope can play to the best effect, which provides a theoretical basis for ecological restoration projects.

In addition, the litter is the main source of soil organic nutrients, It can improve soil, increase soil granular structure and promote the effect of infiltration.

Root can also greatly improve the soil shear strength. Shear strength of soil decided jointly by internal friction force and cohesive force. Huge trees root in the soil porosity and soil forming is in soil - root composite On the one hand root system, such as through secretion gathered around fine soil particles, increase the cohesive force of the soil, root anchorage in the soil .On the other hand, It have significant "reinforcement" effect on soil, solid soil effect, thereby increasing the overall shear strength of soil [7]. At the same time, the process of the soil being destroyed, the displacement of the soil resistance destruction of soil relative displacement. The related research mainly focused on the mechanical aspects.

See from the above review, we also continue to further understanding the mechanism of plant roots on soil erosion control. It has very important significance to more effectively control soil erosion, to reduce the slope erosion, to protect and improve the ecological environment.

4. Summary

At the conclusion of the research on the effect of vegetation on slope erosion that has the following shortcomings, first, the vegetation of slope erosion in the Loess Plateau of Northern Research on, and for the purple soil of hilly red soil area of Southwest China is less. Third, for the grass and trees are separately, the combined study is less, and in an area which is the largest planting benefit of sediment reduction research. Fourth, Because of their unique differences, the different experimental conditions and environment, It is difficult to widespread, popularize and apply the results of study. Fifth, Although so much of the research, the more important and theoretical guidance significance formula is less.

Therefore, we should not only set up to consider more factors, but also to strengthen joint research and multi-disciplinary, multi field, systematic understanding of vegetation on the slope erosion effect on selection; Focusing on selecting the optimal mix of species and reasonable tree, shrub and grass to reduce slope erosion; In addition Vegetation on the slope erosion factors along with larger-scale research is becoming increasingly complex, which is necessary to study the scale effect of strengthening .It need systematic research from the area, slope, small watershed, watershed and regional scales for residential and small scale of slope vegetation effects on the slope erosion extrapolation to larger scale regional basis.

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References

- [1] D.Y. Xiang, Y.C. Teng, X.H. Dang. Research on the status quo of China's soil and water conservation [J] Water Science Technology and Economy, 2010,16 (1): 82-93.
- [2] P.L. Wu, Q. L. Reasons of soil erosion occurring hazards and prevention pathway [J] Shandong Normal University, 2004, (3): 55-611
- [3] R. Mao, G.T. Meng, Y. Zhou .The research of controlling mechanism about the plant roots on soil erosion [J] Soil and Water Conservation Research, 2006,13 (2): 241-243.

- [4] S.X. Fan, Y. Gao, Y.C. Cheng, et al. Research canopy rainfall interception capability [J] Geographical Science , 2007,27 (2) : 200-204 .
- [5] X.X. Yu. The data analysis of Forest vegetation decreased rainfall erosion energy [J] Water Conservation, 1998, 2 (3). 91-96.
- [6] J. D, Z.S Wang, X. Chen, et al. Red soil hilly area of woodland roots on soil erosion enhancement effects [J] Water Conservation, 2002 (4): 9-12.
- [7] W.Y. Xu, X.C. Wang, D.H. Liu. The effects of plant roots on soil erosion resistance [J] Anhui Agricultural Sciences, 2011, 39 (4): 2155-2157, 2160.