高羊茅根土复合体阻抗红壤、高岭土、河沙水力分离的机制试验

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摘 要：【目的】为揭示根土物质之间复杂关系即植物根系一方面提高土壤颗粒粘聚力同时又阻抗或延缓土壤颗粒因水力侵蚀发生分离的双重作用机制；【方法】选择山水林田湖草系统和水土保持生产实际应用广泛的代表性植物高羊茅(*Festuca arundinacea*) 为实验材料，分别播种于以红壤、高岭土和河沙为生长基质的剪切环刀盒内，对其形成根土复合体进行研究包括颗粒组成、根系结构扫描、有机质碳测定，复合体的水力冲刷实验，复合体的抗剪强度实验等。【结果】结果表明：

（1）根系因子中的根长密度、根表面积密度、根体积密度相互间极显著正相关，并且与复合体有机质增长量显著正相关；根系因子与分布受土壤种类的影响显著、以在河沙中根系因子表现最好。

（2）与无草空白对比，高羊茅对红壤、高岭土和河沙根土复合体的粘聚力、及抗冲性能都有显著提升；根土复合体河沙粘聚力由 0.45 提高到 1.8（提高 382%）、抗冲性指数由 1.26 提高到 2.7 （提高 117%）；红壤根土复合体粘聚力由 4.6 提高到 6.9（提高 50%），抗冲性 1.18 提高到 6.47（提高 449%）；高岭土根土复合体粘聚力 5.54 提高到 6.21，抗冲性 0.92 提高到 4.55（提高 395%）。三种土壤的抗冲性大小排序为：红壤>高岭土>沙土。

（3）不同深度的土壤抗冲性具有极显著差异，0-2 cm 土层深度的抗冲性远远大于其他土层，抗冲性能大小排序为：表层>次底层>次表层＞底层。

（4）对抗冲指数、冲刷模数转化为冲刷每克土耗时、冲刷每克土耗水能量表达后发现，根土复合体的根表面积密度与第一分钟冲刷每克土耗能显著负相关，与第二分钟冲刷每克土耗时正相关、耗能显著负相关；第二分钟相似关系还有根长密度、根表面积密度都与第二分钟冲刷每克土耗时正相关、和耗能显著负相关；因此根土复合体形成提高了沙土、红壤、高岭土分离的耗时与耗能，薄层水流剥蚀时间第一分钟延迟了 0.101-0.208 秒，第二分钟延迟了 0.36-0.488 秒，增加了能量消耗第一分钟 0.186-0.311、第二分钟 0.28-0.429 水能量单位。【意义】该研究结果为根系固土机制降低土壤分离研究提供新的科学参考依据。

关键词： 高羊茅根系；粘聚力； 抗冲性； 土壤分离； 水力侵蚀

Experimental Study on Mechanism of Resistance of Tall Fescue Root-soil Complex to Hydraulic Separation of Red Soil, Kaolin and River Sand

Abstract:【Objective】 In order to reveal the complex relationship between root and soil substances, i.e. The dual action mechanism of plant root system on the one hand improving the cohesion of soil particles while impeding or delaying the separation of soil particles due to hydraulic erosion; 【Method】*Festuca arundinacea,* a representative plant widely used in water and soil conservation, was selected as the experimental material, The root-soil complex was formed by sowing in a shear ring box with red soil, kaolin and river sand as growth substrates, including particle composition, scanning of root structure, determination of organic matter carbon, hydraulic scouring experiment of the complex and shear strength experiment of the complex. 【Result】The results showed that:

(1).Root length density, root surface area density and root volume density in root factors are significantly positively correlated with each other, and are significantly positively correlated with the growth of organic matter in the complex; Root factors and distribution are significantly affected by soil types, with the best performance in river sand.

(2).Compared with the blank without grass, the cohesion and impact resistance of tall fescue to red soil, kaolin and river sand root soil complexes are significantly improved. The cohesion of river sand of root-soil composite increased from 0.034 to 1.72kpa, and the scour resistance index increased from 1.26 to 2.7 (117%). The cohesion of red soil root-soil complex increased from 4.31 to 6.78kpa

(increased by 57%), and the impact resistance increased from 1.18 to 6.47 (increased by 449%). The cohesion of kaolin root-soil composite was increased from 3.11 to 5.39kpa, and the impact resistance was increased from 0.92 to 4.55 (395%). The order of scour resistance of the three soils is red soil > kaolin > sandy soil.

(3).There are significant differences in the soil anti-scour properties in different depths. The soil anti-scour properties in 0-2 cm depth are much greater than those in other soil layers. The order of anti-scour properties is: surface layer > sub-bottom layer > sub-surface layer > bottom layer.

(4).After the expression of anti-scour index and scour modulus converted into scour time per gram of soil and scour water consumption per gram of soil, it was found that the root surface area density of root-soil complex was significantly negatively correlated with the energy consumption per gram of soil scoured in the first minute, positively correlated with the time consumption per gram of soil scoured in the second minute, and significantly negatively correlated with the energy consumption per gram of soil scoured in the second minute. The similarity relationship in the second minute also includes root length density and root surface area density, which are positively correlated with the time consumption of scouring per gram of soil in the second minute and significantly negatively correlated with energy consumption. As a result, that formation of the root-soil complex increase the time and energy consumption of the separation of sandy soil, red soil and kaolin, The denudation time of thin-layer water flow was delayed by 0.101-0.208 seconds in the first minute and 0.36-0.488 seconds in the second minute, increasing the energy consumption by 0.186-0.311 units of water energy in the first minute and 0.28-0.429 units of water energy in the second minute. 【meaning】The research results provide new scientific reference basis for the research on the reduction of soil separation by root soil fixation mechanism.

Key words: root system of tall fescue; Cohesion; Impact resistance; Soil separation; Hydraulic erosion.