Study on the Root Structure of Rehmannia glutinosa in Different Habitats

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Abstract. The free-hand section comparison of the roots of Rehmannia glutinosa in different habitats shows that the root structure of Rehmannia glutinosa in different habitats is significantly different: the test group (salt environment) has a thinner pericarp, smaller cells and tightly arranged cells; The cortical cells are small and dense; the xylem cells of the vascular column are larger, the ducts are thin and the myelin rays are obvious. In the control group (normal habitat), the rhizomes of rhizome glutinosa had thick pericytes, large cells and loose arrangement; the cortical cells were large and loosely arranged; the volume of xylem cells in vascular columns was relatively small, the ducts were thick and few, and the myelin rays were not obvious.

1. Introduction
Salt stress, as a kind of abiotic stress, is one of the main environmental factors restricting the growth and development of plants. Research on salt tolerance of plants and screening of salt-tolerant plants have become research hotspots in academic circles [1-3]. The root system is the main organ for plants to absorb water and nutrients, which directly affects the survival and development of the entire plant [4]. The most direct part of saline-alkali harm to plants in the soil is the root system. The structural characteristics of plant roots under adversity are the result of long-term evolution of plants. Therefore, it is of great significance to study the biology of salt-tolerant plant roots.

Yuncheng City is located in the south of Shanxi Province, between 110°15’-112°04’E and 34°35’-35°49’N. Affected by monsoon activities throughout the year, it belongs to a warm temperate continental monsoon climate. Yuncheng Salt Lake is a typical inland saltwater lake where a large amount of salt-containing minerals accumulate. High temperature in summer, the lake water evaporates strongly, and a large amount of salt accumulates in part of the topsoil, and there is a certain salinization phenomenon in the soil. Rehmannia glutinosa belongs to the genus Rehmannia of the Scrophulariaceae family [5], and is a common perennial herb around the salt lake. The purpose of this project is to explore the differences in the root structure of Rehmannia glutinosa under different soil
environments, and to provide a theoretical reference for breeding, introduction and cultivation of *Rehmannia glutinosa* on a larger scale.

**2. Materials and Method**

2.1. **Sample Collection**

The sampling point near the salt lake in Yuncheng was selected as the test group, and the sampling point far away from the salt lake (about 10km) was used as the control group. A number of plants with similar growth conditions were harvested and placed in the sampling bag and brought back to the laboratory. After pretreatment, the root system was sliced by hand. In addition, a five-point sampling method is used next to the roots of the plant to collect a topsoil sample, and the part is mixed into an EP tube that has been sterilized beforehand to determine the concentration of soil culturable microorganisms. One part was packed in a ziplock bag and brought back to the laboratory for natural air drying to determine the physical and chemical properties of the soil.

2.2. **Temporary loading and observation with free hand slicing**

Cut several pieces of the rhizome continuously at the junction of the rhizome of *Rehmannia glutinosa* 3 cm down. Put the sliced material in 30% alcohol, and then move into clear water after 5 minutes. After washing, stain with 1% safran solution for 1 h, pour off the safran solution, rinse it with water several times, and soak it in 50% alcohol for 5 min. Then transfer the material from 50% alcohol to 70% alcohol to continue Decolorize until the lignified cell wall is red and the other parts are pink or nearly colorless. Rinse off the excess staining solution with 95% alcohol and dehydrate with anhydrous alcohol for 5 min. Drop a drop of water on a glass slide with a dropper, and place a well-stained section on the glass slide with a writing brush. When covering the glass, avoid creating bubbles at an angle of 45 ° to affect the observation effect. After the tableting is done, put it under a microscope to observe and take a picture.

2.3. **Analysis of soil physical and chemical properties**

Soil moisture content was measured by the drying method [6].

The pH was measured using the gravimetric method [7].

Gravimetric method for determination of soil soluble salt content.

Determination of culturable microorganism content in plant rhizosphere Microorganisms were cultured by diluting and coating the plate with CY medium, and the colony-forming unit (CFU) in each ml of the soil solution was calculated by the plate counting method.

**3. Results and analysis**

3.1. **Comparative analysis of physical and chemical properties and CFU**

It can be seen from Fig.1 that the soil soluble salt content, water content, pH, and CFU are significantly different between the experimental group and the control group. Among them, soil soluble salt content, water content, and pH showed that the experimental group was significantly higher than the control group, and the CFU of the control group was about 2900·ml⁻¹, which was significantly higher than the experimental group's 2250·ml⁻¹.
Figure 1. Comparative analysis of physico-chemical properties and CFU in different habitats

3.2. Cross section comparison of Rehmannia glutinosa

It can be seen from Figure 2 that the cross section of the root system of Rehmannia glutinosa is a nearly circular structure (Fig.2 A, C). The xylem volume in the root cross-section of the experimental group (salt environment) was larger; the ducts were thinner and more numerous, and the marrow rays were obvious; the cortical cells were smaller and denser, occupying a smaller volume of the entire root system; However, the cells are densely packed and tightly connected to the outer cortex (Fig.2 A, B). This structure facilitates the horizontal transport of water and nutrients from the soil to the root xylem; vascular columns are the main component of the root cross section, accounting for about 3/4 of the entire root cross section. Many clusters of calcium oxalate are important structures produced by plants in response to salt stress. In the control group (normal habitat), the xylem occupies a small volume of the entire root system; the number of ducts is small and thick; the medullary rays are not prominent; the cortical cells are large and scattered, and the entire cortical area occupies a larger volume of the root system; Attrition, large and loose cells (Fig.2 C, D), these structural characteristics are significantly different from the experimental group, see Tab.1.
Figure 2. Cross section of roots of Rehmannia glutinosa (A, B: experimental group; C, Ccontrol group, CK)

Table 1. Comparison of the root section structure of Rehmannia glutinosa

| Root structure  | Test group                                      | CK                                                   |
|-----------------|-------------------------------------------------|-----------------------------------------------------|
| epidermis       | Thinner, but densely packed cells, tightly connect to the outer cortex | Thick and frayed, large and loosely arranged cells |
| Cortex          | The cells are smaller and dense, occupying a small volume of the entire root system | The cells are large and scattered, and the entire cortical area occupies a larger volume of the root system |
| Vascular column | Xylem volume is larger; ducts are thinner and numerous; medullary rays are obvious | The xylem occupies a small volume in the entire root system; the number of ducts is small and thick; the medullary rays are not prominent |

4. Discussion and conclusion

In this experiment, the root structure of Rehmannia glutinosa in different habitats was studied for the first time using free-hand sectioning. By comparing the cross sections of the roots of Rehmannia glutinosa, it is found that the root structure of Rehmannia glutinosa in different habitats is significantly different, but it does not affect the normal growth and development of the plants. In the experimental group, the number of cortical cells in the root section was less, and the cells were densely packed, because the less the number of cortical cells, the shorter the lateral transport distance of water and nutrients absorbed by the roots, and the faster the lateral transport of water and nutrients. A structural feature facilitates the lateral transport of water and nutrients from the soil to the root xylem [8]. The number of xylem ducts is relatively large, and the diameter of the ducts is relatively small. Some scholars believe that: the diameter of xylem ducts is small, which increases the resistance to water flow, thereby preserving part of the water for key periods such as the flowering period of the plant [9-11]. This structure Characteristics are of great significance to the rational use of water in soil by plants. The marrow has a large volume and the marrow is composed of a large number of thin-walled cells. The plant dilutes the absorbed salt by increasing the number of thin-walled cells, absorbing and storing a large amount of water, that is, by absorbing a large amount of water to dilute the salt concentration in
the cell, so that the plant body. The salt concentration was maintained at a low level [12-13], which is beneficial for plants to adapt to salt stress environment. Relatively few cell layers, densely arranged cells, and small volume are the characteristics of Dihuang to adapt to the environment of salt stress. These structural characteristics are conducive to the plant to absorb water and nutrients in the soil.

Bian et al found that environmental factors such as pH, soil bulk density, and soil moisture content significantly affected the root structure of giant cypress in eastern Tibet [14]. Yang et al also found that the root structure of mixed forests of Liquidambar form Osama Hance and Aipinae Oxyphylla Miq. Was seriously affected by soil physical and chemical properties [15]. In this study, the differences in soluble salt content, water content, and pH between different habitats reached significant levels, which may be one of the reasons for the differences in plant root slice between the two places. In addition, by analysing and comparing the content of culturable microorganisms in the rhizosphere of plants, it was found that the content of culturable microorganisms in the rhizosphere soil of the experimental group was less than that in the control group. Higher numbers of microbes can survive in higher environments. The soil around the plant rhizosphere and the plant rhizosphere constitute a unique micro-ecological environment [16]. The microorganisms in the soil are closely related to the plants, which shows that the difference in the content of microorganisms may also be an important reason for affecting the root structure of Rehmannia glutinosa. Plant root structure differences are the result of millions of years of plant evolution. The use of freehand slicing techniques alone cannot explain the differences in plant root structure in different habitats. Future work will also reveal more from the level of genomics. Mechanism of plant root structure difference caused by soil environment.

To sum up, we found significant differences in the root structure of Rehmannia glutinosa in different habitats. Compared with the root structure of digitalis in normal habitats, the epidermal and cortical cells of the roots of digitalis in the halophytic environment are smaller and tightly arranged. A structural feature facilitates the absorption of water and inorganic nutrients by the roots of Rehmannia glutinosa in the halophytic environment.

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