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Drought Resistance and Heavy Metal Adsorption Capacity of Mulberry in Alpine Regions

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Abstract: *Mulberry is an important perennial economic crop. It is the pursuit of modern mulberry breeders to continuously improve the drought resistance and heavy metal adsorption capacity of mulberry varieties. In this paper, three excellent mulberry varieties were introduced and cultivated in the alpine region, and the drought resistance of mulberry seedlings under different drought degrees and different days of drought was analysed. The root powder of mulberry seedlings was ground and dissolved by combining physical and chemical methods. The heavy metal ions are taken as an example. The heavy metal adsorption capacity of the root powder of mulberry seedlings under different initial ion concentrations and different pH values is analysed. The experimental results show that the drought resistance of different varieties is different. The concentration of heavy metal ions and pH value can only be achieved.*

Keywords: *Mulberry Seedlings; Drought Resistance; Heavy Metals; Adsorption Capacity*

1. Introduction

The ecological environment has been seriously damaged due to human life and production activities. Solving heavy metal pollution has become a research hotspot in the scientific community and has also received attention from the government, making the reduction of heavy metal pollution a key task. In order to maintain the ecological balance, it is urgent to study an environment-friendly pollution control method. The plant adsorption method has the advantages of high efficiency, simple operation, and no secondary pollution. It can not only protect the ecological environment, but also one of the best ways to control heavy metal pollution.

Scholars at home and abroad have carried out many studies on the drought resistance and heavy metal adsorption capacity of mulberry trees in alpine regions, and have achieved fruitful results. For example, when the plant host cells are in a swollen state, the relative water content of the host is the saturated water content, which can be used to measure the drought resistance of the plant. Some scientists have studied the changes in the relative water content of plants under the condition of water loss, and the results show that when the water is gradually depleted, the relative water content of the host can remain basically unchanged at first, and as the degree of water shortage continues to increase, the relative water content suddenly increases. After a sharp decline, plants can return to the initial level after water restoration treatment [1]. When plants are under water stress, the permeability of the cell membrane first changes, a large amount of electrolytes are released, and the relative conductivity changes. A scholar's study found that the permeability of drought-resistant plant varieties did not change much under water stress, while the diversity of drought-resistant varieties increased more. Therefore, changes in relative conductivity can be used to measure the drought resistance of plants [2]. A scholar conducted a research on the adsorption capacity of straw for different heavy metals, and found that under a certain temperature and heavy metal concentration, the heavy metal adsorption effect of straw can reach the best, when the temperature is too high or too low, and the heavy metal concentration is too large, the adsorption effect is not good. Not ideal [3]. Although there are many research literatures on the drought resistance and heavy metal adsorption capacity of mulberry trees in alpine regions, how to improve the drought resistance and heavy metal adsorption capacity of plants

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needs further research.

In this paper, the drought resistance of plants and the harm of heavy metals are explained in depth, and then the kinetic model of heavy metal adsorption is proposed. Using this model, the adsorption rate of heavy metals can be calculated. Different varieties of mulberry have different drought resistance, and the adsorption capacity of heavy metals needs to be under certain conditions to achieve the best adsorption effect.

2. Overview of Drought Resistance and Heavy Metal Pollution

2.1 Plant Drought Resistance

Plant resistance to drought generally refers to the ability of terrestrial plants to adapt to arid environments. Since terrestrial plants often live in arid environments, they have developed different drought resistance functions during long-term adaptation. From a morphological point of view, common terrestrial plants have cuticles on the surrounding surface, and the palisade cells are closely arranged. If there is a drought, the plant leaves will form a tube shape to maintain water. Generally speaking, the opening of stomata in the leaves of plants can control the evaporation of water, and some induction methods can enhance the resistance of plants to drought [4-5].

2.2 Heavy Metal Hazards

(1) Hazards of metals to water bodies

In the new century, with the continuous improvement of people's living standards and the rapid development of economic level, in order to meet the needs of life and production, a large amount of industrial wastewater is produced. These industrial wastewater contains a large number of different heavy metals, and the wastewater is discharged into rivers, rivers, lakes, In the sea, the concentration of heavy metals in the water body exceeds the standard, and the organisms in the water cannot decompose these heavy metals, which also pollutes the environment and deteriorates the water source. Industrial wastewater and waste contribute to the accumulation of heavy metal pollution in water systems. Since microorganisms in water cannot effectively decompose heavy metal ions, the situation of heavy metal pollution is becoming more and more serious, which is very harmful to the environment, human survival and social development, making the prevention and control of heavy metal pollution more and more important [6]. The content of copper, zinc, cadmium and lead in most aquatic systems exceeds the standard, resulting in serious pollution in downstream areas and great potential safety hazards. Once heavy metals enter the aquatic environment, they will affect the survival of aquatic organisms and destroy the entire water balance [7]. Due to the high toxicity of heavy metals, the people and the government have increased the importance of sewage treatment, and the current plan for sewage treatment has been in progress.

(2) Harmful effects of heavy metals on soil

From the current social development point of view, wastewater can be divided into domestic wastewater, industrial wastewater, chemical wastewater, etc. [8]. The heavy metal content in domestic sewage is actually relatively low, but it is delayed due to the rapid growth of the industry. During the development of environmental protection projects, a large amount of industrial wastewater is directly discharged without treatment. The drainage pipe network mixed with domestic sewage flows into natural irrigation water or directly into the irrigation water in agricultural areas, resulting in heavy metal pollution of large-scale agricultural areas [9]. The ecological environment not only provides air for human survival, but also provides necessary nutrients for the growth of plants, and plants are the basis of human growth. My country's soil heavy metal pollution problem is becoming more and more serious, resulting in various joint reactions, and even destroying ecological diversity. At present, nearly 20% of the land in my country is polluted by heavy metals, and the polluted area is still increasing [11]. Soil contamination is not so intuitive and not so easily detectable by humans. With the accumulation of heavy metals in the soil, the farmland area of farmers is affected. Heavy metals in the cultivated soil, such as cadmium, arsenic and copper, are the most serious pollutants exceeding the standard [12]. After soil pollution, this will also lead to some other environmental damage problems.

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2.3 Adsorption Kinetics

The adsorption process is usually analyzed using first- and second-order kinetic equations. The first-order kinetic model is based on the assumption that the absorption is affected by the diffusion process; the second-order error kinetic model suggests that the absorption process is controlled by a chemical absorption mechanism, manifesting as a variety of compounds [13-14].

The first-order kinetic equation is:

$$\ln(p_m - p_t) = \ln p_m - At \quad (1)$$

Among them, A represents the rate constant number (min-1) of the first-order velocity equation, p_m represents the equilibrium absorption capacity (mg/g); p_t represents the absorption capacity relative to the metal ion at time t (mg/g)

The second-order kinetic equation is:

$$\frac{t}{p_t} = \frac{1}{B p_m^2} + \frac{1}{p_m} t \quad (2)$$

Among them, B represents the second-order rate equation adsorption rate constant (g/mg×min).

3. Experimental Research

3.1 Experiment Preparation

In the drought resistance experiment, the mulberry seedlings were first cultivated in outdoor pots, as shown in Figure 1. Three excellent varieties of mulberry seedlings suitable for alpine regions were selected, and were labelled as A seedling, B seedling and C seedling respectively.

Figure 1: Potted cultivation of mulberry seedlings

In an adsorption experiment for heavy metals, the copper ions in the sewage were adsorbed and removed from the roots of mulberry saplings after cleaning, ultrasonication, pulverization and drying, and by changing the experimental conditions (such as the initial ion concentration and pH value of heavy metal copper) on the adsorption characteristics of heavy metals in the roots of mulberry seedlings.

3.2 Experimental Method

Weigh about 10 mg of the mulberry seedling root powder before separation and purification and

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after separation and purification, mix with 10 mg/L copper ion solution, dissolve the absorption liquid of root powder evenly with ultrasonic waves, and centrifuge the mixed solution every five minutes. According to the ratio of Cu^{2+}, the spectrophotometer measures the concentration of copper ions at the absorption wavelength at the maximum absorption wave, and quickly measures the concentration of copper ions in the solution. Calculate the adsorption rate, determine the adsorption amount and removal rate, and analyze the results of the experimental data processing.

4. Analysis of Experimental Results

4.1 Drought Resistance Research

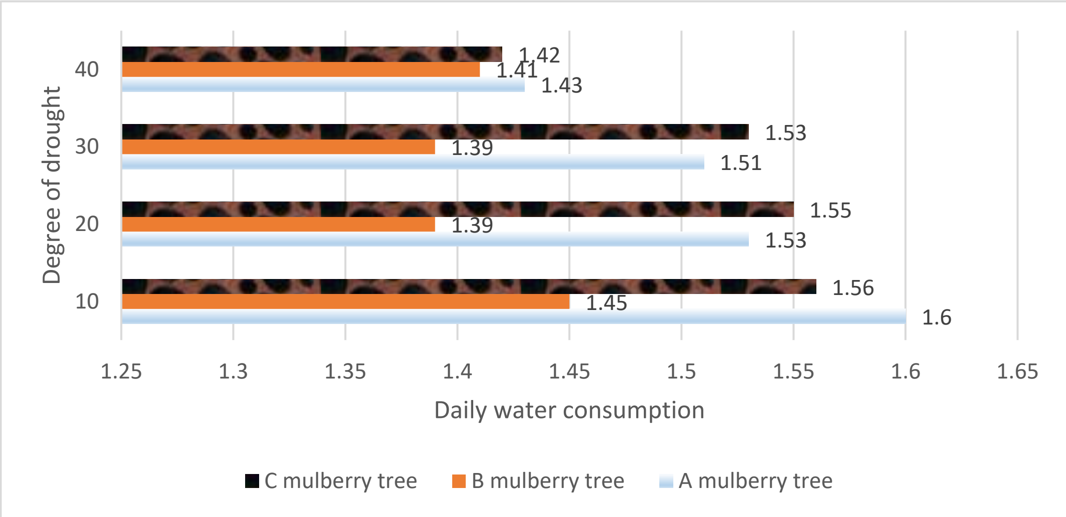

Figure 2: Changes in the total transpirational water consumption of three mulberry seedlings throughout the day under different drought degrees

It can be seen from Figure 2 that the total daily water consumption of the three mulberry seedlings is inversely proportional to the degree of drought stress. Under normal water conditions, the total daily water consumption of the three seedlings was relatively large, and the order (from largest to smallest) was: mulberry tree A > mulberry tree C > mulberry tree B.

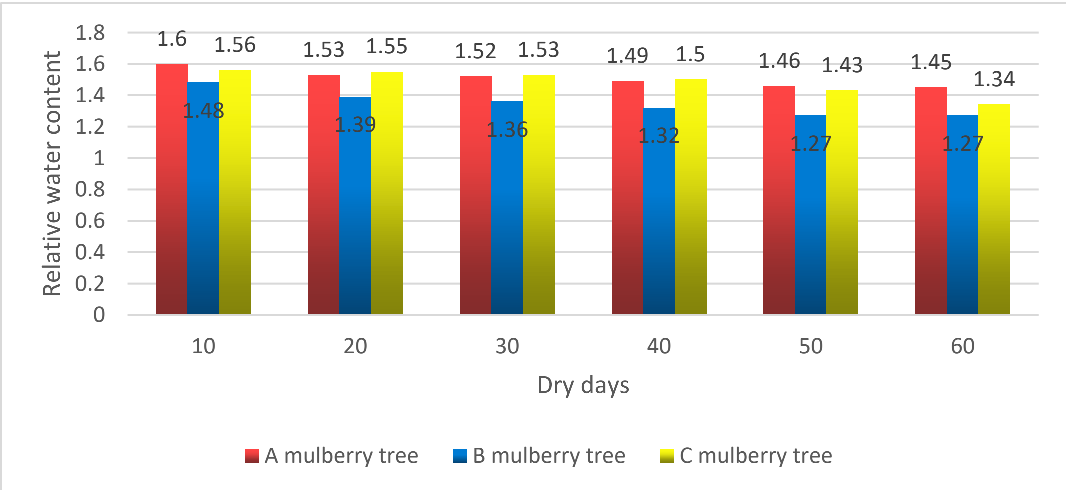

Figure 3: Relative water content of three mulberry seedlings under different drought days

As shown in Figure 3, the relative value of water content of the three mulberry seedlings decreased with the increase of the number of drought days. When the number of drought days was 10 days, the relative value of water content of the mulberry seedling A was greater than that of the other two mulberry seedlings. When the drought days are 20-40 days, the relative value of water content of No. C mulberry seedlings is the largest, when the dry days are 50 and 60 days, the relative value of water content of No. A mulberry seedlings is the largest, and relative value of water content of No. B

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mulberry seedlings was always lower than that of No. A and No. B mulberry seedlings.

4.2 Study on the Adsorption Capacity of Heavy Metals

(1) Influence of initial ion concentration

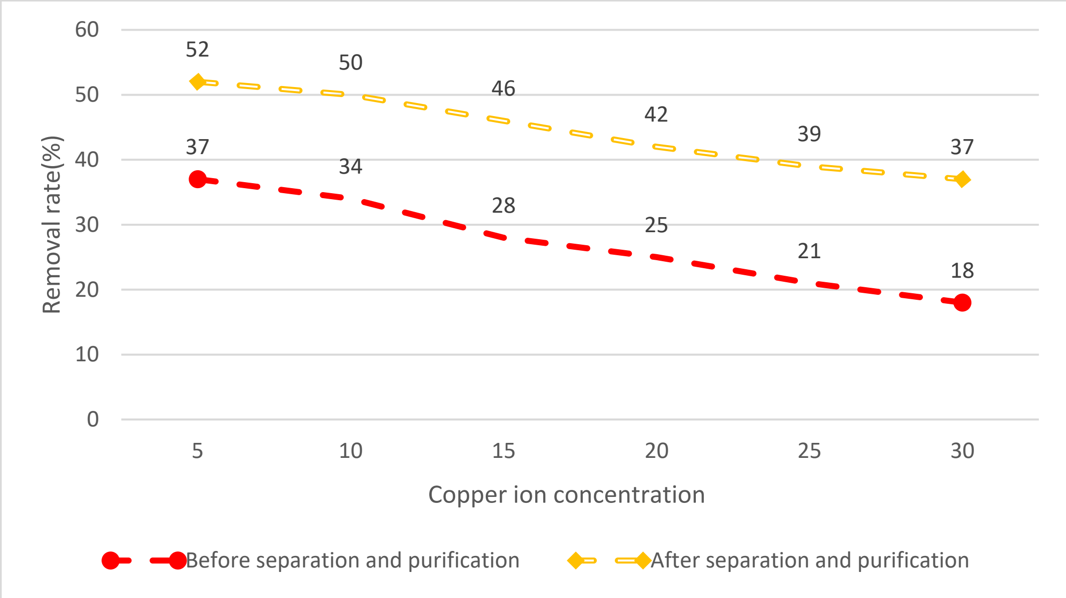

Figure 4: Copper ion removal rates at different initial concentrations of copper ions

During the experiment, the higher the ion concentration, the worse the adsorption effect. In this experiment, under the condition of neutral pH value, the change of the copper adsorption performance of the root and seedling powder to heavy metals with the ion concentration ranging from 5 to 30 mg/L was investigated. As shown in Figure 4. It can be seen from the figure that when the Cu2+ concentration is 5.0 mg/L, the removal rate of Cu2+ from the root powder before separation and purification is 37%, and the removal rate of Cu2+ after separation and purification is 52%. With the increase of the initial concentration of Cu2+, the removal rate of Cu2+ by the roots of mulberry seedlings before and after separation and purification showed a downward trend, indicating that the adsorption effect gradually weakened with the increase of the initial concentration of Cu2+. Generally, when the dosage of mulberry root powder is certain, under a certain concentration, the absorption site of the root is gradually saturated. As the concentration of copper ions increases, the contact between copper ions and free radicals increases, and the absorption capacity increases. However, due to the limited absorption capacity of the root system, the absorption rate will be reduced. The absorption efficiency of free radicals is the highest at lower concentrations, and it can be found that the ion concentration is too high or too low, which does not help the absorption of root powder. The comparison shows that under different concentrations of copper ions, the removal rate after separation and purification is better than that before separation, and the activity is stronger. This may be because the mulberry root powder is cleaner after separation and cleaning, with stronger chemical effects and more active functional groups, which will have a higher absorption rate under the same conditions.

(2) The influence of pH

The experiment investigated the change of the copper adsorption performance of the root powder to heavy metals between the initial concentration of 15 mg/L and pH 3 to 8, as shown in Table 1.

Table 1: Copper ion removal rate (%) at different pH values

	3	4	5	6	7	8
Before separation and purification	15.4	17.2	26.7	27.1	24.9	18.8
After separation and purification	23.5	29.6	31.8	35.5	32.0	27.9

It can be seen from Table 1 that in the range of pH from 3 to 6, the removal rate of root powder before and after separation and purification increases with the increase of pH, and the adsorption amount increases. The separated and purified root powder has stronger chemical effect, and the highest removal rate of copper ions reaches 35.5%. The biological activity of root powder requires the best pH conditions. When the pH value slowly rises from 3 to a neutral value, the removal rate of heavy metals by root powder shows an upward trend.) has a higher adsorption efficiency, and when the pH value increases to alkaline, the removal rate of heavy metals decreases. It can be seen that low or high pH is not suitable for the adsorption of heavy metal copper by mulberry powder, which also proves that the neutral acid environment is more conducive to the absorption of heavy metals by root powder.

5. Conclusion

In this paper, in the drought resistance experiment of mulberry trees in alpine regions, three varieties of mulberry seedlings were first cultivated by pot culture method, and the transpiration water consumption of mulberry seedlings was tested under different drought conditions. The transpiration water consumption is the least. The relative water content of mulberry seedlings was tested under the conditions of different drought days, and it was found that the relative water content of seedlings A was larger. The adsorption experiments of copper under different conditions showed that with the increase of the initial concentration of copper ions, the removal rate of the root powder gradually decreased. When the pH value is neutral and acidic, the removal rate of copper ions is the largest. Therefore, it can be seen that the strongest adsorption capacity can be achieved under the condition of a certain concentration and a certain pH value.

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Authors' Contributions

Jianguo Shi conceived and designed the study. Shanshan Song and Jingjing Wang performed the experiments. Haofeng Gao and Ben Liu contributed materials/analysis tools. Shanshan Song and Jingjing Wang revised the paper. All authors approved and helped shape the final manuscript.

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Availability of Data and Materials

The data-sets used and/or analysed during the current study available from the corresponding author on reasonable request.

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