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Effects of Garbage Enzyme on the Heavy Metal Contents and the Growth of Castor under Mine Tailing

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Abstract: Pot experiment was performed to study the effect of garbage enzyme from the peel dregs of kiwifruit and *Rosa roxburghii* on the growth of castor and the contents of heavy metals (Cu, Zn, Cd and Pb) in the aerial part. The results indicated that the addition of two kinds of garbage enzyme with different concentrations was beneficial to the growth of castor, and the biomass of castor could be increased by up to 80%. High-concentration of *Rosa roxburghii* enzyme inhibited the absorption of heavy metals by castor, low-concentration of *Rosa roxburghii* enzyme showed a promotion effect; while high-concentration of kiwifruit enzyme increased the content of heavy metals in the aerial part of castor, low-concentration of kiwifruit enzyme showed inhibition, with a maximum decrease of 21% ~ 42%. The results showed that kiwifruit enzyme with 1:800 diluted concentration could promote the growth of castor, and had the best inhibition effect on heavy metal absorption of castor.

1. Introduction

Garbage enzyme, a fermentation product of waste vegetables, fruits, or its peels along with sugar and water, is claimed in the media as a multipurpose solution for household and agricultural uses [1]. No chemical synthetic substances are used in the production of garbage enzyme. After fermentation, a complex and stable ecological complex with multiple functions is formed, which has three functions of decomposition, combination and transformation [2]. The analysis of the active components of garbage enzyme showed that the main active components are various nutrients provided by plant raw materials and microorganisms, plant functional chemical components in natural plants, some physiological active substances and various trace elements produced by fermentation, with less toxic and harmful chemicals [3, 4]. At present, garbage enzyme are increasingly exploited and utilized in water and air purification, soil fertility improvement, crop growth and quality improvement, decomposition of chemical components such as chemical fertilizer and pesticide residues in the soil, control of crop diseases, as well as insect pests [2, 5-7].

The development and utilization of mineral resources has made greater contributions to Guizhou's economic development in China. However, due to the long-term unreasonable process of mineral development, production and management, mining wasteland such as tailings ponds, waste residues, no only occupies a large amount of land resources, but also leads to ecological destruction, biological imbalance and environmental pollution in the mines and surrounding areas. Heavy metals can also accumulate in the living body through the food chain or be transported in dust as a carrier through breathing and body surface adsorption, causing serious threats to human health [8, 9].

Traditional remediation methods of heavy metal pollution can be divided into chemical, physical and biological methods. Chemical additives will cause secondary pollution, and the application of physical repair methods was always restricted for high cost and complex equipment. Bioremediation technology, which is environmental friendly and efficient, is showing a broad application prospect in the field of heavy metal pollution remediation. And it has become a main technical strategy of in-situ remediation of heavy metal polluted soil in recent years [10]. At present, there are few reports on the application of environmental enzymes in soil heavy metal pollution remediation. In addition, the soils in Guizhou karst region have the disadvantages of low nutrient content, poor physical structure, low vegetation survival rate, and slow growth [11]. Adopting microbial technology can effectively alleviate these problems and conform to the concept of sustainable development.

In this paper, garbage enzymes from the peel waste of kiwifruit and *Rosa roxburghii* in Guizhou Province were used to improve the soil and regulate the growth of crops in karst mining area. Through the pot experiment, the effects of different garbage enzyme and their dosage on the growth of crops and the absorption of heavy metals were studied, and the garbage enzyme suitable for the improvement of the soil in mining area and the best dosage were selected as the resource of the peel waste to provide technical guidance and scientific basis for the utilization of resources and the acceleration of soil fertility improvement and pollution remediation in karst mining region.

2. Materials and Methods

2.1 Experimental materials

The peels used for garbage enzyme were from kiwifruit and *Rosa roxburghii*. The production process is as follows: brown sugar, peel residue, and water are mixed into a sealed plastic bucket at a ratio of 3: 1: 10, stirred evenly and tightly sealed, kept anaerobic fermentation for at least 3 months. The bottle cap should be loosened once a day and closed immediately during the first month.

The test plant was castor (Zibo-9), purchased from Zibo Academy of Agricultural Sciences.

The test soil was from a typical karst lead-zinc tailings area in northwestern Guizhou. Its basic physical and chemical properties and heavy metal content are shown in Table 1. The test soil was highly contaminated by Cd, Pb, Zn, and Cu.

Table 1 Physical and chemical properties and heavy metal contents of the test soil (mg/kg)

pH	Organic	Available N	Available P	Available K	Cd	Cr	Cu	Ni	Pb	Zn
5.53	7680	71.8	62.3	40.5	11.8	162	37.9	69.2	1724	2043

2.2 Experimental methods

Mix the soil samples and put them into plastic flower pots (19cm in diameter and 23cm in height). The test was set up with 6 enzyme solution concentration gradients (enzyme-water ratio): blank control CK (no enzyme added), 1:50 (*Rosa roxburghii* and kiwifruit enzyme labeled L1 and T1 respectively, similarly as blew), 1: 100 (L2 and T2), 1: 200 (L3 and T3), 1: 400 (L4 and T4) and 1: 800 (L5 and T5), 100 mL of garbage enzyme solution was poured into each pot, the experimental design was in a completely randomized complete block with four treatments in quadruplicate. Full crop seeds were selected and planted directly in pots. The enzyme solution is applied every two weeks and routine water management was performed. When the plants germinated to a height of about 5 cm, 3 plants were kept in each pot. During the harvesting stage, plant samples were collected for later analysis, and the plant height, weight and root length were measured.

The plant samples were digested with a 4:1 ratio of concentrated HNO_3 to $HClO_4$. The soil samples were digested using a concentrated mixture of HNO_3, $HClO_4$, and HF with a ratio of 6:2:2 for the analysis of total heavy metals. The total metal concentrations in digestive solutions were determined by inductively coupled plasma optical emission spectrometry (ICP-OES).

2.3 Data processing

The experimental data were processed and plotted using Excel 2013, and the single-factor analysis of variance of the relevant data was performed by SPSS 22.0.

3.Results and analysis

3.1 Effects of garbage enzyme on plant growth

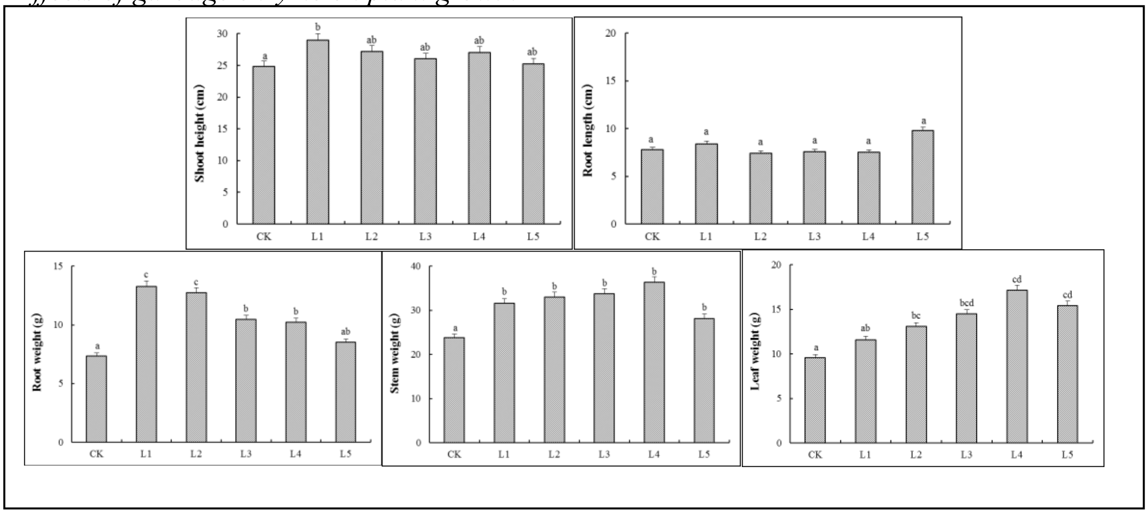

Fig. 1 Effect of the addition of *Rosa roxburghii* enzymes on the growth of castor; Letters a, b, c, and d represent significant differences between treatments (P <0.05)

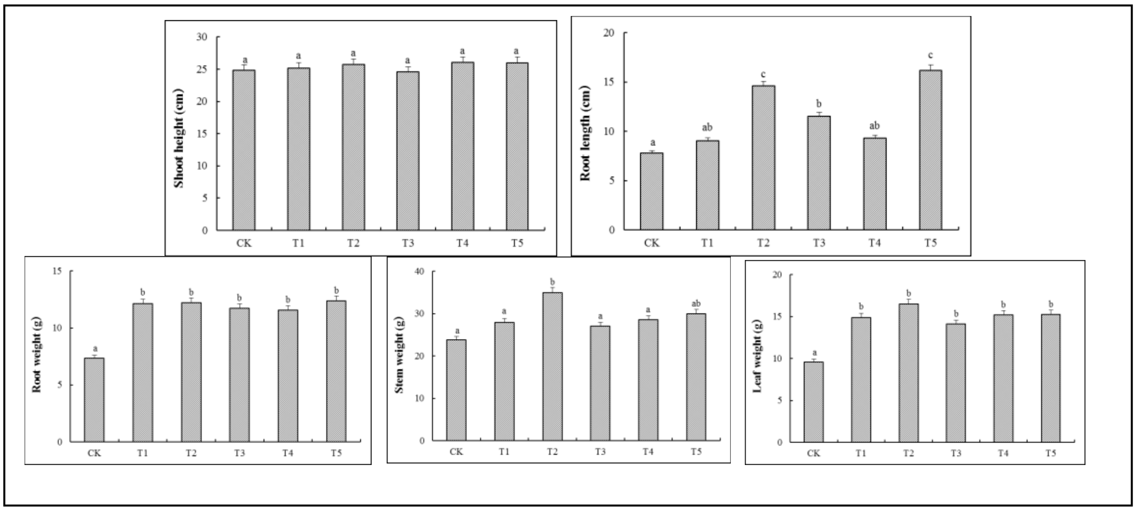

Fig. 2 Effect of the addition of kiwifruit enzymes on the growth of castor; Letters a, b, c, and d represent significant differences between treatments (P <0.05)

Fig. 1 and Fig. 2 showed the effects of different concentrations of garbage enzyme on the average plant height, average root length, average root weight, average stem weight and average leaf weight of the tested plants. It can be seen from the figure that, compared with the control, *Rosa roxburghii* enzyme treatment increased plant height and root length slightly, but not significantly, while kiwifruit enzyme significantly increased plant root length ($P<0.05$), in which, the root length of castor treated with T2 and T5 was 1.88 times and 2.09 times of the control, respectively, which shows that kiwifruit enzyme has a significant effect on the growth of castor root length ($P<0.05$).

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3.2 Effects of garbage enzyme on heavy metal uptake in test plants

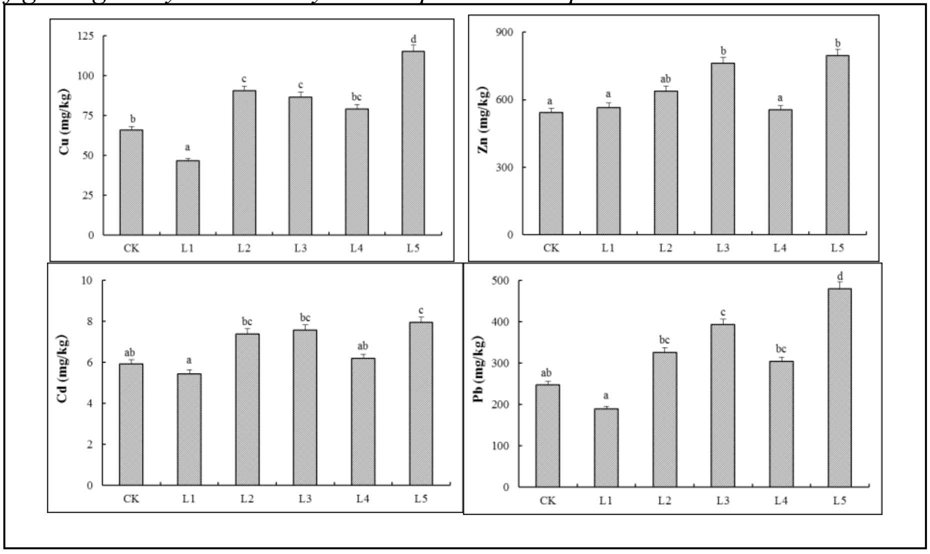

Fig.3 Effect of the addition of *Rosa roxburghii* enzymes on the content of heavy metals in castor

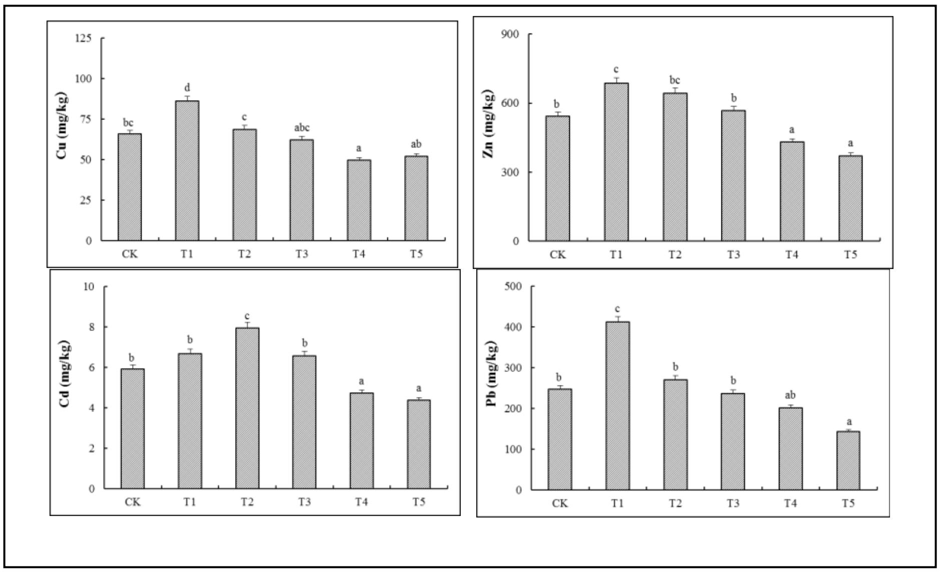

Fig.4 Effect of the addition of kiwifruit enzymes on the content of heavy metals in castor

The effects of the two enzyme treatments on the contents of heavy metals (Cu, Zn, Cd and Pb) in the aerial part of castor showed great difference (Fig. 3 and Fig. 4). Among them, high-concentration of *Rosa roxburghii* enzyme showed a certain inhibition effect on the absorption of heavy metals by castor, but the effect was not significant. Other concentrations of *Rosa roxburghii* enzyme promoted the absorption of heavy metals to varying degrees. Compared with the control, the increase of Cu, Zn, Cd and Pb content was 20% ~ 75%, 3% ~ 46%, 4% ~ 34%, 23% ~ 97% respectively, and the increase of L5 treatment was the most obvious.

High-concentration kiwifruit enzyme treatment could increase the absorption of castor by heavy metals. The contents of Cu, Zn, Cd and Pb in the aerial part of castor under T1 treatment were 1.31, 1.26, 1.13, and 1.66 times that of the control treatment, respectively. As the concentration decreased, the content of heavy metals in castor ground decreased. The low concentration of kiwifruit enzyme inhibited the absorption of heavy metals by castor. The contents of Cu, Zn, Cd, and Pb in the shoots were reduced by 21%, compared with the control treatment. 32%, 26%, and 42%.

4.Discussion

Garbage enzyme as a kind of high-efficiency biological preparation rich in beneficial microorganisms, produces a large number of anaerobic and facultative anaerobic bacteria in the fermentation process, which can provide a certain amount of microbial decomposers for the soil [2, 6]. Microorganism in soil is the driving force of decomposition and transformation of soil nutrients, organic carbon metabolism and pollutant degradation, which plays an important role in improving soil fertility and promoting the absorption and utilization of plants, and it is also the reserve or source of effective nutrients of plants in soil [12]. Therefore, garbage enzyme, which are rich in various nutrients, beneficial microorganisms, active enzymes and secondary metabolites of microorganisms, can improve soil fertility and crop growth environment, promote crop growth and increase crop yield.

Microorganisms, as active organic colloids in the soil, have superior physical and chemical characteristics, such as large specific surface area, strong adsorption and complexation capabilities, and rich surface groups. In addition, microorganisms have the characteristics of small individuals, large numbers, easy cultivation, and fast growth speed. Soil microorganisms have a profound impact on the remediation of soil pollution [13]. Microbes, plants, and soil are an extremely complex system. Microbes in the soil can change the soil acid-base environment, promote plant nutrient absorption, change the form of heavy metals, and assist Hyperaccumulator plants to absorb heavy metals [14].

In the present study, high-concentration of *Rosa roxburghii* enzyme inhibited the absorption of heavy metals by castor, low-concentration of *Rosa roxburghii* enzyme showed a promotion effect; while high-concentration of kiwifruit enzyme increased the content of heavy metals in the aerial part of castor, low-concentration of kiwifruit enzyme showed inhibition. In most cases the mechanisms of enzyme activity are complex and not fully understood. In the next step, the interaction mechanism between heavy metal ions and microbial cells can be explored by combining the changes of soil nutrient index, microbial activity and chemical forms of heavy metals in the soil, and using a variety of histology and technology to study each link of microbial remediation. Combining castor biomass and heavy metal content, kiwifruit enzyme diluted 1: 800 can promote plant growth, and have the best inhibitory effect on castor absorption of heavy metals.

Acknowledgments

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References

[1] Arun C, Sivashanmugam P. (2015) Identification and optimization of parameters for the semi-continuous production of garbage enzyme from pre-consumer organic waste by green RP-HPLC method. Waste Management, 44: 28-33.
[2] Rani A, Negi S, Hussain A, et al. (2019) Treatment of urban municipal landfill leachate utilizing garbage enzyme. Bioresource Technology, 18:122437.
[3] Arun C, Sivashanmugam P. (2018) Enhanced production of biohydrogen from dairy waste activated sludge pre-treated using multi hydrolytic garbage enzyme complex and ultrasound-optimization. Energy Conversion and Management, 164: 277-287.
[4] Arun C, Sivashanmugam P. (2017) Study on optimization of process parameters for enhancing the multi-hydrolytic enzyme activity in garbage enzyme produced from preconsumer organic waste. Bioresource Technology, 226: 200-210.
[5] Abdelhaleem HAR, Zein HS, Azeiz AZA, et al. (2019) Identification and characterization of novel bacterial polyaromatic hydrocarbon-degrading enzymes as potential tools for cleaning up hydrocarbon pollutants from different environmental sources. Environmental Toxicology and Pharmacology, 67: 108-116.

[6] Arun C, Sivashanmuagm P. (2015) Investigation of biocatalytic potential of garbage enzyme and its influence on stabilization of industrial waste activated sludge. Process Safety & Environmental Protection, 94: 471-478.
[7] Han JH, LiuZX, Zhang LK, et al. (2019) Effects of garbage enzymes on key chemical properties of saline- alkali soil. Bulletin of Soil and Water Conservation, 39(3): 126-131. (In Chinese with English abatract)
[8] Ghazaryan K, Movsesyan H, Ghazaryan N, et al. (2019) Copper phytoremediation potential of wild plant species growing in the mine polluted areas of Armenia. Environ Pollut., 249: 491-501.
[9] Xiao R, Wang S, Li R, et al. (2017) Soil heavy metal contamination and health risks associated with artisanal gold mining in Tongguan, Shaanxi, China. Ecotox Environ Saf., 141: 17-24.
[10] Gaur N, Flora G, Yadav M, et al. (2013) A review with recent advancements on bioremediation-based abolition of heavy metals. Environmental Science: Processes and Impacts, 15(2):180-193.
[11] Zhao J, He X, Nie Y, et al. (2015) Unusual soil nematode communities on karst mountain peaks in southwest China. Soil Biology & Biochemistry, 88: 414-419.
[12] Lozano YM, Armas C, Hortal S, et al. (2017) Disentangling above- and below- ground facilitation drivers in arid environments: the role of soil microorganisms, soil properties and microhabitat. New Phytologist, 216(4): 1236-1246.
[13] Gorovtsov AV, Minkina TM, Mandzhieva SS, et al. (2019) The mechanisms of biochar interactions with microorganisms in soil. Environmental Geochemistry and Health, (1).
[14] Chang HW, Liu DH, He QF. (2018) Advances in microbial redemption mechanism of heavy metal polluted farmland. Journal of Microbiology, 38(2): 114-121. (In Chinese with English abatract)