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Research Progress on Microbial Remediation of Saline Soil

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Abstract

Soil salinization is one of the major ecological problems currently facing mankind and is a serious threat to plant production and ecological security. Soil microorganisms are an integral part of soil living organisms and ecosystems, and are involved in almost all soil processes. Exogenous addition of beneficial microorganisms can improve the physical, chemical and biological properties of soil, and is one of the effective methods to ameliorate saline soils. Microbial remediation is cost-effective, energy-saving, non-polluting and widely applicable. The purpose of this paper is to summarize the effects of microbial remediation on the microenvironment of saline soils in order to provide a basis for the improvement and restoration of saline soils.

Keywords

Microorganisms; Saline soils; Soil environment.

1. Introduction

Saline-alkali soil is one of the widely distributed soil types in China, which occupies a total land area of $3.6\times10^5 km^2$, accounting for 4.88% of the available land area in the country, and about $10\times10^4 km^2$ of land is abandoned due to salinization every year. With the advancement of urbanization and industrialization in China, the average annual reduction of arable land in the country is $0.04\times10^7 hm^2$, and the total amount of arable land declines seriously [1]. As an important reserve arable land resource in China, the development and utilization of saline land plays an important role in guaranteeing the absolute safety of food rations, maintaining the stability of existing arable land and holding the safety bottom line of basic self-sufficiency in food.

A variety of soluble salts in saline soils increase osmotic pressure, and crop uptake of water and nutrients is severely affected, resulting in nutrient deficiencies and nutritional disorders, which in turn affect physiological processes at the plant and cellular levels, hinder seed germination, reduce photosynthetic capacity, increase energy consumption, accelerate senescence, and even lead to plant wilting or death. Rice is one of the four staple foods in China, and planting rice is an effective way to biologically improve saline lands, but under saline stress rice traits are inhibited throughout the reproductive cycle, with leaves gradually becoming shorter and smaller and subsequently lighter in color, which seriously affects rice yield [2]. At the same time, salt routing will increase the salt content and pH of the soil, and the exchangeable sodium ions in the soil have a strong dispersing ability to soil colloids, which destroys the soil structure,

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resulting in muddy wet soil, hard dry soil, poor ventilation and permeability, poor tillage, and reduced soil phosphorus, iron, zinc, manganese and other trace elements, organic matter content and beneficial microbial activity, which is not conducive to the increase and activation of soil nutrients and seriously limits agricultural With the frequent occurrence of natural disasters and human causes, the area of secondary saline land is still expanding year by year. Microbial remediation is one of the effective methods to improve saline soils, with the characteristics of economic efficiency, energy saving, no pollution and wide application. Therefore, the aim of this paper is to summarize the effects of microbial remediation on the microenvironment of saline soils, with a view to providing a basis for the improvement and restoration of saline soils.

2. Microbial Diversity in Salinized Soils

Soil is a natural medium for microbial growth and reproduction, and soil microbial resources are extremely rich in nature and are an important part of the earth's elemental cycle and energy exchange, and are of great significance in maintaining soil quality and ecosystem stability. The microbial diversity of primary saline soils, secondary saline soils and farmland in Hexi Corridor, and the results showed that the diversity of primary saline soils was the lowest and the diversity of secondary saline soils was the highest, and there were nine phyla in the main communities, among which the dominant phylum was Proteobacteria, and the rest were Actinobacteria, Bacteroidetes, Acidobacteria, etc. The dominant community in primary saline and agricultural soils is the Proteobacteria, while in secondary saline soils it is the Actinobacteria [3]. Amoebacteria were the dominant taxa in saline soils in the Inner Mongolia Loop, and the diversity and abundance decreased with increasing soil depth. Bacterial diversity decreased and archaeal diversity increased in the conversion of saline fields from early to hydrophytic fields in Daqing area, in which Proteobacteria and Crenarchaeota were the dominant phyla; when hydrophytic fields were converted to early fields, the most influential factor on microbial community structure was pH. In the saline zone of the Yellow River Delta, the bacteria of the Proteobacteria and Firmicutes were more abundant in the inter-rhizosphere of moderately salt-tolerant plants, while the bacteria of the Acidobacteria and Gemmatimonadetes were more abundant in the inter-rhizosphere of mildly salt-tolerant plants, and the dominant communities were related to the environmental salt concentration [4]. The dominant phyla in salinized soils in Ningxia were Proteobacteria, Bacteroidetes, Firmicutes, and Actinobacteria, and the microbial diversity had obvious regional specificity. The Phylum Proteobacteria has a large abundance in all types of saline soils in all regions, but it also changes according to land use practices, natural environmental changes, and vegetation types [5].

3. Effect of Microorganisms on Salinized Soil Environment

Soil salinization is one of the major ecological problems currently facing mankind and is a serious threat to plant production and ecological security. Microorganisms are an integral part of soil living organisms and ecosystems and are involved in almost all soil processes, and exogenous addition of beneficial microorganisms, which can improve the physical, chemical and biological properties of soil, is one of the effective methods to ameliorate salinized soil.

3.1. Effect of Microorganisms on Physical Properties of Salinized Soils

Microorganisms enter the soil in different forms and have a good contribution to the formation of the physical structure of the soil in all types of saline soils. Bacillus subtilis can significantly reduce water infiltration in saline soils and also improve the agglomerate structure of soils [6]; salinity-loving (salt-tolerant) bacteria have a better promotion effect on the formation of large agglomerates in saline soils, and the treatment effect of composite strains is better than that of single strains, and the addition of organic fertilizer and inoculation of exogenous microbial treatments in saline soils in Qinghai promoted the formation of >0.25 mm agglomerates [7].

3.2. Effect of Microorganisms on Chemical Properties of Salinized Soils

A variety of microorganisms play an important role in soil enrichment and in reducing pH and salt-based ion content. Moderately halophilic bacteria applied to cotton fields were found to increase the content of alkaline nitrogen and fast-acting potassium in the soil at appropriate concentrations, and to increase the content of organic matter in the soil during the seedling stage. Pseudomonas sp., Bacilussubtilis, Bacilus megaterium, and Yeast isolated from saline soils, have been bred by He-Ne laser mutagenesis and compounded into microbial agents, which can effectively reduce the salt content and pH value of the soil and increase the organic matter content. The addition of autotrophic nitrogen-fixing bacteria to maize fields in coastal saline soils reduced the electrical conductivity of the soil and increased the content of effective nitrogen, effective phosphorus and effective potassium in the soil [8]; microbial bacterial fertilizer reduced the content of Na+, Mg2+, Cl- and HCO3- in the soil after 50 days of treatment of saline soils. Geng used bio-organic fertilizers to improve saline soils with maize as the indicator crop, and the results of the study showed that the application of bio-organic fertilizers significantly improved the amount of cation exchange, the content of water-soluble salt ions, pH, nutrient content and alkalinity of the soil, and the longer the application time, the more obvious the reduction of alkalinity [9].

3.3. Effect of Microorganisms on Chemical Properties of Salinized Soils

Soil microbial properties are closely related to soil quality and can be used as a potential indicator for scientific evaluation of the health quality of agricultural soils. The high saline environment inhibits microbial growth and low activity, and enzyme activities such as urease, protease, phosphatase, dehydrogenase and β-glucosidase are significantly lower in saline soils than in normal soils, and exogenous addition of beneficial microorganisms is an effective means to increase microbial abundance and enzyme activity in saline soils. Soils treated with salinity-loving bacteria Bacillus sp. XJ 1-05 showed a significant increase in the number of bacteria and fungi in the short term and were able to alleviate saline conditions to some extent. The salinity-resistant actinomycete Streptomyces pratensis isolated from the inter-rhizosphere of Elaeagrcus angustifolia, in combination with Rhizophagusintraradices, was effective in enhancing inter-rhizosphere soil enzyme activity with or without salt stress conditions [10]. The application of lactic acid bacteria increased the number of six carbohydrate-activated enzymes (CAZy) gene sequences, increased the number of actinomycetes in the soil, and decreased the number of pathogenic microorganisms. And applied Bacilus mucilaginosus Krassilnikov to significantly reduce the relative abundance of pathogenic bacteria in soil, increase the relative abundance of biocontrol bacteria, and improve soil enzyme activity [11].

3.4. Plant Growth Promotion by Microorganisms in Salinized Soils

Salt stress is caused by excess salt that disrupts the ionic balance in the soil, exposing plants to threats such as ionic stress and osmotic stress at the same time, with large amounts of salt ions flowing into cells, affecting almost all plant life processes and causing metabolic disorders and even yield reduction or death. Plant growth promoting rhizobacteria (PGPR) play an important role in promoting plant growth in salt environments.

A number of experts and scholars have done a lot of research on microorganisms to alleviate salt stress and promote plant growth, and have some understanding of their mechanism of action. The exogenous addition of Pseudomonas fluorescens and Azospirillum brasilense to paddy soil can alleviate the inhibitory effect of salinity on rice growth, enhance photosynthetic strength, salt tolerance, growth and development, and increase rice yield [12]; Pseudomonas fluorescens (Kocuriarhizophila can increase chlorophyll content and CAT activity in maize,

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reduce MDA content in leaves to alleviate salt stress and increase plant height and root length, and cucumber inoculation with Agrobacterium sp. DF-2 can enhance salt tolerance by regulating K*/Nat value through ACC deaminase, significantly increasing plant height, root length, biomass and chlorophyll content. The PGPR complex [Pseudomonas putida, Bacillus flexus, Bacillus usvelezensis and Bacillus firmus] significantly promoted the growth of pepper with a significant increase in yield [13]; saline-tolerant strain Nesterenko niarhizosphaerae can increase the biomass of wheat seedlings, significantly reduce the root MDA content, significantly increase the activities of antioxidant enzymes such as SOD, POD, CAT and proline content, effectively alleviate the salt stress on wheat roots and promote seedling growth [14], inoculation with PGPR can help alfalfa scavenge excessive superoxide anion radicals and other harmful substances under salinity stress, accumulate osmoprotective substances, and improve the plant's ability to resist salinity. After plants are subjected to salt stress, microorganisms alleviate salt stress and promote plant growth by participating in regulating plant enzyme activity, photosynthetic intensity, phytohormones, and ion homeostasis, and microorganisms, as an important regulator, have broad application prospects in saline lands.

4. Conclusion and Prospect

Saline soils limit the development of agricultural productivity, and the development and utilization of saline soils to reduce the crisis of saline soils is getting more and more attention. Bioremediation is one of the important means of soil remediation, which mainly includes phytoremediation and microbial remediation. Microbial remediation is economical and efficient, energy-saving, pollution-free, and widely applicable, etc. Among them, salt-tolerant microorganisms, as a class of microorganisms that promote plant growth under salt stress, have received more and more attention from researchers, and the use of salt-tolerant microorganisms to alleviate salt stress can not only enrich the resources of efficient strains but also The use of salt-tolerant microorganisms to alleviate salt stress can not only enrich the resources of efficient strains but also improve the sustainable use of salt-stressed soils, which has great potential for application in saline lands. The isolation and identification of salt-tolerant strains and their resource utilization are of great importance for the development and utilization of saline soils.

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