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Effect of Plant Root Secretions on Soil Microorganisms and Seed Germination

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Abstract

Root Exudate (RX) is a general term for a series of complex organic substances that are released by plants through the root system into the inter-root soil as part of their photosynthetic products and their own nutrients under certain soil conditions. Root exudate mainly comes from the accumulation of photosynthesis and the decomposition and absorption of nutrients carried out by plants, accounting for about 5% to 30% of photosynthetic products. Its secretion process to the soil is mainly divided into two ways, the first is through the concentration gradient between the plant root cells and the soil solution, and the secretion is passively released to the soil along the concentration gradient; the other is actively secreted by the plant body under various kinds of stresses (drought stress, heavy metal stress) and interactions with the inter-root microorganisms. The number, type and amount of root secretions are influenced by many factors (mycorrhiza formation, soil organic matter content and temperature).

Keywords

Soil Microorganisms; Root Exudate (RX); Seed Germination.

1. Introduction

Plant root secretion is an important substance to maintain the soil and plant inter-root micro-ecological environment [1], and is also a chemical communication substance for material-energy exchanges and information exchanges between plants and soil inter-root micro-environments, which has various functions such as promoting or inhibiting plant growth, producing chemosensory effects and defense effects. Changes in soil properties and soil microbial structure are important for the natural succession of post-fire forests and can affect soil physicochemical properties. Nutrients secreted by root secretions account for about 5% to 30% of plant photosynthesis and are continuously injected into the inter-root soil as organic matter, providing nutrients to the soil and recruiting specific inter-root bacteria and fungi to colonize the soil. Polysaccharide macromolecules contained in root secretions can utilize their adhesive properties to aggregate with soil particles to form soil aggregates, which affects the size, distribution, adsorption, and other properties of forest soil microaggregates. Various

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organic acids in root secretions can change soil pH, chelate metal ions and other ways to change soil physicochemical properties. Root secretions can increase the effectiveness of inter-root soil nutrients, especially for the activation and utilization of insoluble phosphorus in the soil is very significant.

2. Effects of Root Secretions on Forest Soil Microorganisms

Forest soil microorganisms are one of the important factors to ensure the stability of forest ecosystems and promote plant growth and development, which are mainly composed of bacteria, fungi, algae, actinomycetes, protozoa and viruses together [2]. As active organisms in the soil, the community composition, structure and change in number and diversity of soil microorganisms can reflect the level of forest soil health, which is important for maintaining the fertility of forest soil and maintaining the health of forest ecosystem.

2.1. Types of Plant Root Secretions

It has been found that successful invasions of exotic plants have a strong chemosensory effect on the plants around them. Some major species in the forest also secrete chemosensory substances that affect the growth of surrounding plants by inhibiting the germination rate and seedling growth of other plant species. Experiments conducted by Liu Fangli et al. showed that fresh and dead leaf litter infusions of the large tree rhododendron significantly inhibited the germination of its own seeds. The experimental results showed that apoplastic material at a distance of 5 meters from the crown of Rhododendron macrophylla had the strongest inhibitory effect on seed germination, with seed germination rate decreasing by 18.3% and seed germination index decreasing by20.5%.

2.2. Plants and Soil Microorganisms

Apoplastic water content in the Daxinganling region plays an important role in the occurrence of wildfires; therefore, the study neglected the role of apoplastic material in forest ecosystems in the natural succession of forests after fires. When plant seeds fall in the forest topsoil covered with a layer of dead leaves waiting to germinate, some factors in the environment, such as light, temperature, humidity and root secretions of other plants, will have an effect on seed germination and seedling growth. The presence of apoplastic material in the forest has a significantly greater effect on seed germination in trees than in herbaceous plants. The continuous accumulation of litter can affect soil microbial species richness and can also influence plant seed germination and seedling establishment. This effect can be positive or negative, depending on the environment in which the seeds are planted. A thick layer of deadfall on the surface prevents seed contact with the soil and reduces the probability of seed germination.

The indirect inhibitory effect of seed germination from deadfall has a great impact on the germination of the soil seed bank [3]. Seeds falling on the ground surface cannot germinate normally, and even if the seeds can germinate, the thick layer of dead leaves on the forest floor is able to block the contact between the seedling root system and the soil, which further hinders the growth and development of plants. Therefore, the study of effective decomposition and utilization of withered material is also of great significance in analyzing the natural succession of post-fire forests.

2.3. Mycorrhizal Fungi in Relation to the Root System of Their Host Plants

The establishment of a symbiotic relationship between mycorrhizal fungi and their host plant root system is a process of mutual recognition and mutual benefit. In the uncolonized stage, both plant roots and mycorrhizal fungi can release specific signaling molecules, which activate plant or microbial sensing pathways and form a specific recognition mechanism, which can

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induce the expression of specific functional genes, thus causing changes in the cell structure and immune response of the host plant, and then finally complete the mutualism cycle between mycorrhizae and plants through mycelium colonization in the cells. The mycorrhizal-plant interaction cycle is completed through intracellular colonization of mycelium.

2.4. Rhododendron-like Mycorrhiza

After the intracellular mycelium of azalea-like mycorrhizas matures, the root cells are completely occupied by mycelium forming mycelial nodes, followed by degradation of the plant cytoplasm until the root cells are completely inactive, immediately followed by mycelium disintegration. The life cycle of mycorrhizal fungi in symbiosis with Rhododendron species is only about 5-6 weeks, during which nutrient uptake and transfer between plant microorganisms will take place. How do rhododendron mycorrhizae alleviate environmental stresses on plants and improve nutrient acquisition by rhododendron host plants, thus promoting rhododendron growth? This can be elaborated in the following aspects.

2.5. Mycorrhizal Fungi

Soil microorganisms, such as mycorrhizal fungi and inter-root bacteria, form symbiotic relationships with host plants and promote plant growth, development and reproduction [4]. In addition, soil microorganisms indirectly influence the ability and process of nutrient uptake by plant roots through plant root growth, root morphogenesis and plant physiological and biochemical properties. In the process of material transfer, transformation and energy flow reactions in the soil, inter-root and soil microorganisms mainly include: decomposition of organic compounds in the soil, enzymatic digestion and conversion and absorption of higher plant residues and microbial residues, decomposition and utilization of humus, biological nitrogen fixation, and transformation of nutrients, such as phosphorus, iron, and sulfur [5].

3. Conclusion

In conclusion, the interactions, interactions and mutual benefits between plants and inter-root microorganisms, and the dynamics of the plant and microbial communities reflect, to some extent, the feedback between them. There are many positive applications of inter-root microorganisms to plants, and the forms and mechanisms of interaction are diverse. If researchers can reasonably utilize these characteristics of inter-root microorganisms and give full play to the advantages of inter-root microorganisms, it will play an immeasurable role in promoting plant growth, improving plant growth, and increasing plant resistance.

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