

Research progress on the growth promoting effect of microbial fertilizer on plants

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Abstract: Microbial fertilizer is a kind of live bacteria preparation that can make plants obtain specific fertilizer effect. With the extensive use of chemical fertilizers and pesticides caused by a series of problems, people began to pay more and more attention to the research and use of microbial fertilizer. This paper describes the application of microbial fertilizer in food crops, vegetables, fruit trees and so on. The mechanism of microbial fertilizer was explained from five aspects: improving soil fertility, promoting plant growth, biological control, improving plant product quality and improving environmental conditions.

Keywords: Microbial fertilizer; Growth promoting effect.

1. Introduction

In recent years, the use of pesticides and fertilizers has been increasing worldwide, which has caused many environmental problems, such as soil hardening, air and water pollution [1]. As an agricultural country, China's dependence on pesticides and chemical fertilizers is stronger than that of other countries. While using pesticides to control pests and diseases, problems such as pesticide residues in food, vegetables and other agricultural products frequently occur. In addition, most pesticide residues are not easy to biodegradation, which brings great harm to the health of humans and other organisms and the environment. A large number of experiments have shown that the development and use of microbial fertilizer plays an extremely important role in improving crop yield and quality, creating a good ecological environment, improving soil structural components, improving soil fertility, degrading pesticide residues and reducing the use of chemical reagents, etc. It is one of the most attractive substitutes for pesticides and fertilizers [2].

2. Introduction to microbial inoculant

Microbial inoculant is a kind of active microbial preparation that takes the life activities of microorganisms as the core and enables crops to obtain specific inoculant effects [3]. Microbial fertilization can promote material transformation in soil, thereby improving soil outcome and soil fertility. Secondly, it can stimulate and regulate the growth of crops, so that plant yield is stable and increased. Third, it can also control plant diseases and pests, reduce the use of pesticides, and degrade pesticide residues, thereby promoting plant production and reducing environmental problems caused by excessive use of chemical pesticides [4].

The core of microbial inoculants is active microorganisms, which have the characteristics of microorganisms. According to the different types of microorganisms, they can be divided into bacterial inoculants, fungal inoculants, actinomycetes inoculants, complex microbial inoculants, algae inoculants, etc. In addition, the mechanisms of pesticide degradation can be divided into two types: one is direct degradation of

pesticides through enzymatic reaction; The other is indirectly acting on pesticides by changing the chemical and physical environment [5]. Compared with conventional chemical fertilizers, microbial fertilizers have the advantages of improving soil structural components, improving soil fertility, increasing the yield and quality of crops, fruits and vegetables, degrading pesticide residues, and protecting the ecological environment. Microorganisms with specific functions in microbial inoculum promote the transformation of substances in soil through their own life activities, so as to improve the structural composition of soil, increase soil fertility, promote and assist plants to absorb nutrients, further improve the nutrient level of plants, stimulate and regulate plant growth, and effectively control plant diseases and pests. To increase crop yield and improve crop quality [6].

3. Mechanism of microbial inoculants

The mechanism of action of microbial inoculants is fundamentally different from that of chemical inoculants. The role of microbial inoculum is mainly to provide "microbial community" that is beneficial to crop growth, rather than "nutrient elements". When these beneficial microorganisms are applied to the soil, they can have a variety of effects. At the same time, the life and activity of microorganisms in soil can produce many metabolites or secretions, which can stimulate the growth of crops. In general, the role of microbial fertilizer is the fixation, decomposition and secretion of bacteria, which affects the change of nutrients in the soil. As the nutrients in the soil change, so does the growth of the crops that grow in the soil. Therefore, the role of microbial fertilizer is to "act" in the soil and "react" on the crop.

3.1. Improve soil structure and soil fertility

The application of microbial inoculant can decompose insoluble components in soil, such as phosphorus and potassium, change soil physical and chemical properties, and improve the utilization rate of plant inoculant, so as to improve soil fertility. For example, microbial inoculum mainly composed of nitrogen-fixing bacteria can fix nitrogen in the air through the activity of bacteria, which can be

absorbed and utilized by crops when they grow -- that is, "nitrogen fixation" [7]. Microbial fertilizers mainly composed of phosphate-solubilizing bacteria decomposes inorganic phosphorus or organic phosphorus in the soil that cannot be absorbed by crops through the activities of bacteria, so that phosphorus is decomposed from the soil for absorption and utilization by crops when growing -- that is, "phosphate-solubilizing" [8]. The main role of microbial fertilizers mainly composed of potassium-solubilizing bacteria is to decompose mica and feldspars in the soil that cannot be absorbed by crops through the activity of bacteria, so as to promote the decomposition of potassium elements from the soil for absorption and utilization by crops during growth -- that is, "potassium solubilizing" [9].

3.2. Promote plant growth and improve crop yield

Microbial inoculants regulate the growth and development of plants and other life activities, especially the growth and development of plant roots, by producing plant hormones or other physiologically active substances such as auxin, cytokinin, indoleacetic acid, gibberellin and so on by living microorganisms. A well-developed root system can improve the ability of plants to absorb nutrients and thus accelerate the growth and development of plants [10]. In particular, some microbial fertilizers containing photosynthetic bacteria preparations can be sprayed on the leaves of plants, which will make plants flourish and increase the leaf area, significantly enhance the photosynthetic capacity of plants, and accelerate the growth rate of plants, with early flowering, more fruits and high yield [11].

3.3. Reduce pests and diseases and enhance crop disease resistance

The beneficial growth-promoting bacteria in microbial inoculants can not only promote plant growth and improve crop yield, but also improve plant disease and insect resistance [12]. The beneficial microorganisms in the microbial fertilizer grow and reproduce in large numbers around the plant roots to form dominant bacteria, occupy the living space of pathogenic microorganisms, rob the nutrients of pathogenic microorganisms, and then block the invasion of pathogenic microorganisms to plants. Secondly, insecticidal and antibacterial substances secreted by some microorganisms, such as antibiotics, siderophils, hydrocyanic acid and wilting acid, have certain insecticidal and antibacterial effects. These substances can enhance the resistance of plants to diseases and pests, or inhibit the growth and reproduction of pathogenic microorganisms, so that plants can avoid the invasion of soil-transmitted pathogenic microorganisms. Thirdly, some pro-growth bacteria can also induce the formation of disease resistance system in the plant itself to develop resistance to pathogenic microorganisms and reduce the morbidity of the plant.

3.4. Improve the quality of plant products

For example, the application of microbial inoculant in the soil adjusts the nutrient structure in the soil due to the activities of beneficial microorganisms contained in it, so that the plant can prevent excessive absorption of nitrogen fertilizer; The improvement of protein, sugar, vitamins and other nutrients and the reduction of nitrate content can also significantly improve the quality of crop products, such as the improvement of appearance, better taste, increase of nutrient

content, and extension of fruit period [13].

3.5. Reduce pollution and improve the ecological environment

Microbial inoculants not only have good fertilizer effect, but also can enhance plant disease resistance. The use of microbial inoculants can reduce the amount of chemical fertilizer and the use of pesticides, thereby reducing environmental pollution and pesticide residues, and ultimately promoting the sustainable development of agriculture [14].

4. Research progress on application of microbial inoculants in plant growth promotion

4.1. Microbial inoculants are applied to promote the growth of grain plants

There are relatively many studies on the application of microbial fertilizers to corn, wheat, rice and other food crops to promote their growth and development. Studies by some scholars have shown that the absorption and utilization of soil nutrients by maize can be promoted through the role of microorganisms in the microbial fertilizer, such as phosphorus solubilization, potassium solubilization and nitrogen fixation, so that its root system becomes more developed and its growth rate is accelerated [15-20]. Many researchers have studied the effects of microbial inoculators on the growth and development of wheat, and found that the application of microbial inoculators in the rhizosphere of wheat can effectively dissolve insoluble phosphorus in the soil, improve the utilization of phosphorus in the soil, and thus promote the growth and development of wheat [21-25]. Of course, many researchers have found through experiments that the application of microbial fertilizers containing growth regulators such as secreted indoleacetic acid can regulate the main growth and development hormones in rice plants, so as to promote it to better absorb nutrients in the soil, promote its rooting, sprouting and affect the development of organs (such as roots, stems, etc.) [26-30]. In addition, Wang Qianqian et al. [31] proved through experiments that the use of microbial fertilizer containing 1-aminocyclopropane-1-acid deaminase to promote the rapid germination of sorghum seeds under salt stress environment. In 2019, Su Qun et al. [32] found in the research and development of liquid composite microbial inoculant that microbial inoculant containing beneficial bacteria such as *Bacillus subtilis* could improve soil quality and enhance the activity of soil organisms. If the concentration of liquid microbial inoculant used was appropriate, the growth of crops such as small rape could be promoted to the maximum extent. In 2022, in the study of Guo Zhen et al. [33], it was found that the dry weight, total root length and root surface area of soybean could be increased when microbial fertilizer was applied to the soybean rhizosphere.

4.2. Microbial inoculants are applied to promote the growth of vegetable plants

The research and application of microbial inoculants in promoting growth of vegetables are also very extensive. Wang Wei et al. [34], when studying the effect of microbial inoculants containing low-temperature adaptive microorganisms on plants, found that after the application of

developed microbial inoculants, both plant height, root length and fresh mass of the experimental plant-vegetables were significantly increased, and the growth promotion effect was very obvious, especially in root length. Some studies have also shown that microbial inoculum can promote the growth and development of cucumber, which can not only improve the germination rate of cucumber seeds, but also significantly improve the plant height, above-ground dry mass and root activity of cucumber, so as to improve the quality and yield of cucumber [35-36]. When Zhang Zhi et al. [37] and Zhang Yao et al. [38] explored the effect of rhizosphere growth-promoting bacteria on eggplant and pepper, they found that the application of microbial inoculants containing microorganisms that can secrete hormones and solubilize phosphorus in the roots had a good promoting effect on seed germination and seedling growth of eggplant and pepper. Many scholars have also studied the effect of application of microbial fertilizers on tomato. Their experimental results show that the application of appropriate microbial fertilizers can not only significantly increase the root length, plant height, above-ground fresh mass, above-ground dry mass and underground dry mass of tomato seedlings, but also advance the flowering of tomato and improve the yield [39-42].

4.3. Microbial inoculants are applied to promote the growth of fruit trees

In recent years, the application of microbial fertilizers in promoting the growth of fruit trees has also made some progress. Zhao Baixia et al. [43], when providing excellent strain resources for the development and production of microbial inoculants for sweet cherry, found that the root growth and dry matter accumulation of fruit trees were improved after applying microbial inoculants containing *Bacillus ascheri* which can produce indoleacetic acid to the rhizosphere of sweet cherry fruit trees. Xu Weihui et al. [44] found that the root length, root surface area, root volume, root tip number and root dry mass of watermelon seedlings were significantly increased after the watermelon seedlings were treated with the microbial fertilizer containing the microbial agent that secreted the inDA-acetic acid. Fei Xixuan et al. [45] applied microbial fertilizer containing bacteria with 1-aminocyclopropane-1-carboxylate deaminase activity in the rhizosphere of jujube, and the height, biomass, leaf nitrogen and phosphorus contents of fruit trees were significantly increased. Liu Lufeng et al. [46] found that after applying microbial fertilizer containing endophytic *Bacillus subtilis* to the rhizosphere of sugarcane, its root length, vitality and biomass were significantly improved.

4.4. Microbial inoculants are applied to promote the growth of other plants

In addition to being widely used in promoting the growth and yield of many agricultural plants, microbial inoculants are also used in promoting the growth of many other plants. For example, it has also attracted much attention in the application of growth promotion in medicinal and ornamental plants. For example, the growth of medicinal plants such as forsythe [47], *Radix codoginseng* [48], *Astragalus membranaceus* [49] and *Angelica sinensis* [50] can be promoted after the application of microbial fertilizers containing bacteria that can efficiently hydrolyze organic phosphorus, secrete plant hormones such as 1-aminocyclopropane-1-carboxylic acid deaminase, or change enzyme activities in the soil. For example, root diameter, root dry weight, or root growth were significantly

increased. In addition, many scholars have applied microbial inoculants to promote the growth of other plants. For example, Gao Ya et al. [51] applied microbial inoculants to promote the growth of ash trees. The survival rate of ash trees with microbial inoculants increased by 20%, and the stem diameter and chlorophyll content also increased significantly. Lu Jun et al. [52] applied microbial fertilizer containing highly effective *Burkholderia phosphate-solubilizing bacteria* to *Pinus massoniana*, which significantly increased seedling height, primary root length, lateral root number, shoot (stem, branch, leaf) fresh weight and dry weight, root fresh weight and dry weight.

5. Concluding

Nowadays, microbial fertilizer is gradually becoming the main force of the application of green, organic agricultural products base and other places, and the economic benefits, social benefits and ecological benefits brought by it are also getting higher and higher. From the perspective of the development trend of modern agricultural production, both at home and abroad are actively advocating green agriculture, ecological agriculture, the development of green food, pollution-free microbial fertilizer, will play an important role in future agricultural production. However, the deficiency of microbial inoculants is also obvious. For example, some strains contained in microbial inoculants have low ability to solubilize potassium and phosphorus. It is necessary to further explore efficient bacteria with higher ability to give full play to the due effect of microbial inoculants. The research scope of microbial inoculant needs to be further expanded, especially for the research and development of functional microbial inoculant, such as soil-borne disease control, soil pollution remediation, desertification soil remediation, water retention and drought resistance, and saline-alkali soil improvement. At the same time, as an ideal inoculant to protect the ecological environment and maintain human health, how to make it more substitute for chemical fertilizers and pesticides and play its special role more stably is one of the main research contents in the future.

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