

## Role of Beneficial Microorganisms in Soil Health Management

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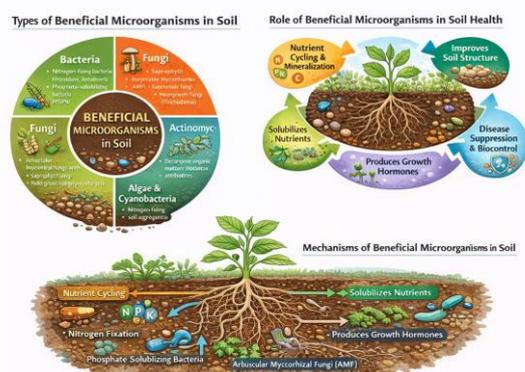
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### INTRODUCTION

Soil is a cool thing because it is always changing and it is home to a huge variety of tiny living things. These tiny living things are super important for keeping the soil healthy and making sure the environment is okay. You can find billions of these things in just one gram of good soil. Each one of these things does something special to help plants grow and keep the ecosystem running smoothly. The tiny things in the soil break down plant material turn nutrients into something plants can use and keep plants safe from bad guys like pathogens. Soil microorganisms do all these things and more which's really important for plant growth and ecosystem functioning. The soil microorganisms are really good at their jobs. They are essential, for keeping the soil fertile and healthy. Modern farming methods are not good for the soil. These methods include tilling the soil a lot growing the crop every year and using too many chemical fertilizers and pesticides. This has hurt the living things in the soil and the way they work. So the soil is not as healthy as it used to be. That is a big problem. The good news is that beneficial microorganisms can help make the soil healthy. They are a sustainable way to fix the soil while still growing a lot of crops. Beneficial microorganisms are good, for the soil. They can help farmers grow crops without hurting the soil.



## 2. Beneficial Microorganisms in Soil

Soil has microorganisms that're good for it. These microorganisms are like helpers that make the soil better. They do this by doing their thing and working with plants. This helps the soil and the plants in ways.

These beneficial microorganisms can be put into groups based on what they do for the soil and plants. Beneficial microorganisms are very important, for soil and plant growth because of what beneficial microorganisms do.

### 2.1 Bacteria

Soil bacteria are really good at growing in lots of places. They are the common kind of tiny living thing in the soil. Some of these bacteria like Rhizobium, Azotobacter and Azospirillum are very good at taking nitrogen from the air and turning it into something that plants can use. This means we do not need to use many synthetic nitrogen fertilizers.

Other kinds of bacteria like Bacillus and Pseudomonas are good at breaking down phosphorus compounds in the soil that plants cannot use. This makes it easier for plants to get the phosphorus they need.

Soil bacteria, like Plant growth-promoting rhizobacteria help plants grow by giving them nutrients, producing hormones and stopping diseases from hurting the plants. Soil bacteria are really important, for the health of the soil and the plants that grow in it.

### 2.2 Fungi

Soil fungi are really important for helping plants grow. They do this by breaking down plants and animals in the soil, which makes the soil better for plants to grow in. Some soil fungi, like mycorrhizal fungi work with plant roots to help them get the nutrients they need like phosphorus and water.

Other soil fungi, like fungi help get rid of old dead things in the soil. Then there are soil fungi like Trichoderma that help keep plants from getting sick by fighting off bad things in the soil. Soil fungi like these are very good, for the plants and the soil.

### 2.3 Actinomycetes

Actinomycetes are a type of bacteria that look like fungi when they grow. They are really good at breaking down things like cellulose and lignin. Actinomycetes make antibiotics that help stop microorganisms from growing which is great for the soil because it helps prevent disease. Actinomycetes are very important, in this process.

## 2.4 Algae and Cyanobacteria

Algae and cyanobacteria are really important in soils that are flooded and in paddy soils. Algae and cyanobacteria help to fix nitrogen in the soil naturally which is a deal. They also make the soil stick together better. Add more organic matter to the soil. The cyanobacteria even make things that help plants grow and make the soil more fertile, for algae and cyanobacteria to thrive.

## 3. Mechanisms of Action of Beneficial Microorganisms

Good microorganisms are really good for the soil. They help the soil in ways. These microorganisms make the soil healthy. They do this through a lot of biochemical things that they do. All of these things together help plants grow and make the soil fertile. The microorganisms are very important, for plant growth and soil fertility. They make sure that the soil is healthy and that plants can grow well in it.

### 3.1 Nutrient Cycling and Mineralization

Microorganisms break down stuff like the leftovers from crops, manure and compost. They take organic compounds and turn them into simpler things that plants can use. This process of breaking things down is always happening, which means plants always have the nutrients they need. The microorganisms make sure that the soil has a supply of nutrients so the plants do not run out of food. This is very important for the microorganisms and the plants because the microorganisms help the plants by breaking down the residues and the plants need the nutrients, from the microorganisms to grow.

### 3.2 Biological Nitrogen Fixation

Plants need nitrogen to grow. Nitrogen is around us in the air.. Plants cannot use the nitrogen in the air. That is where nitrogen-fixing microorganisms come in. These nitrogen-fixing microorganisms are very helpful to plants. They convert the nitrogen in the air into a form that plants can use. This is really good for plants because they can then make their food.

Nitrogen-fixing microorganisms are really good for the earth too. They help reduce the need for nitrogen fertilizers. Synthetic nitrogen fertilizers are not good for the earth. They can pollute the air and the water. Nitrogen-fixing microorganisms are a way to help plants grow. They help plants use nitrogen efficiently. This means that plants can grow strong and healthy without harming the earth. Nitrogen-fixing microorganisms are very important for

nitrogen use efficiency. Nitrogen use efficiency is important, for plants and the earth.

### 3.3 Solubilization of Insoluble Nutrients

There are good microorganisms that help plants. These microorganisms make it possible for plants to use phosphorus, potassium, zinc and iron that're not normally usable. They do this by releasing helpers like organic acids and enzymes. This means plants can get the nutrients they need to grow strong and healthy. The microorganisms also release compounds that grab onto these nutrients, which's really good for plant nutrition. This is very helpful because plants need these nutrients to grow well. The microorganisms are very good, at helping plants get the nutrients they need from phosphorus, potassium, zinc and iron.

### 3.4 Production of Plant Growth Regulators

Soil microorganisms are really good for plants. They make things like acetic acid and other stuff that helps plants grow. Indole acetic acid, gibberellins and cytokinins are all important. These things help plants grow roots and more roots on the side. This means plants can get nutrients and water from the soil. Soil microorganisms and the things they make like acetic acid, gibberellins and cytokinins are really good, for plant growth.

### 3.5 Disease Suppression and Biocontrol

Microorganisms that are good for the soil help stop things from growing in the soil. They do this in a way. Microorganisms compete with the things for food and space. Microorganisms also make things that're bad for the bad things. Sometimes microorganisms even attack the things. Microorganisms help plants become stronger so they can fight off the bad things on their own. This means we do not need to use many chemical pesticides. Microorganisms are really good, at helping to control the things in the soil.

### 4. Role of Beneficial Microorganisms in Soil Physical Properties

Microbial activity really helps the soil. It makes the soil healthier by making the particles in the soil stick together. This happens because the microbes release helpers that act like glue. When the soil particles stick together it makes the soil more air. That helps the roots of the plants grow better. The roots can also breathe easier.

Microorganisms are also good at helping the soil hold water. This means the soil does not get too dry or too hard. When the soil is like this it is easier for plants to grow and for the microbes to multiply. All of these things make the soil a great

place for plants and microbes to live and grow. Microbial activity and microbes are very important, for the soil.

### 5. Role in Soil Chemical Properties

Beneficial microorganisms are really good for the soil. They help keep the soil healthy by keeping the balance of chemicals in it. These beneficial microorganisms do this by using helpers called biochemical reactions and by making organic acids. When beneficial microorganisms are active they make sure plants get the nutrients they need which makes the plants strong.

Beneficial microorganisms also make sure the soil has a lot of carbon in it which is good for the soil. They do this by stopping nutrients from getting washed or lost in the air. This is very important for the soil and for the plants that grow in it. Beneficial microorganisms are very helpful, to the soil.

### 6. Microorganisms and Soil Organic Matter Dynamics

Microorganisms are really important for making soil healthy. They help break down plants and animals into a kind of natural fertilizer that stays in the soil for a long time. This natural fertilizer is good for the soil because it helps the soil stay fertile and it also helps keep carbon out of the air. Microorganisms and the work they do are very important for keeping the soil strong and for fighting climate change. Microorganisms are central, to this process. They play a big part in making sure the soil can support plants and animals for a long time.

### 7. Interaction with Plant Roots: The Rhizosphere Effect

The area around plant roots is really important. This is where the roots and tiny living things like microbes interact with each other a lot. The plant roots give off chemicals that help the microbes grow and do their thing. The microbes then help the plant roots get the nutrients they need make things that help the plant grow and make the plant stronger so it can handle things that might happen to it. The plant roots and the microbes help each other out. This is called the rhizosphere effect. The rhizosphere is a deal because it is where all this helping and interacting happens between the plant roots and the microbes, in the rhizosphere.

### 8. Beneficial Microorganisms in Sustainable Agriculture

Beneficial microorganisms are really important for agricultural systems. They help reduce the

need for chemical fertilizers and pesticides. When we use microorganisms they make crops grow better and taste better. They also make the soil healthier.

Beneficial microorganisms help crops deal with conditions like drought too much salt and really high or low temperatures. This is why beneficial microorganisms are so valuable in natural farming systems. They are very good for these types of farming systems because beneficial microorganisms help the crops and the soil, in ways.

### 9. Role in Climate Change Mitigation

Microbial processes are really important for farming that's good for the climate. They help the soil hold onto carbon and use nutrients in a way. When microbes cycle nutrients efficiently they reduce things like nitrous oxide that come from the soil on farms. So microbial processes are crucial, for reducing the effects of climate change. Microbial processes do a lot of things for the earth.

### 10. Challenges in Harnessing Beneficial Microorganisms

Beneficial microorganisms are really good for us. There are some problems that stop us from using them properly. When we try to use microorganisms in the field they do not always work well because the soil is different the weather is different and people do things differently. Many beneficial microorganisms are sensitive to things, like temperature and chemicals which can make them not work well.

The thing is, a lot of farmers do not know about microorganisms they do not know how to use them and we do not have good ways to make sure they are good quality. This makes it hard for a lot of people to start using microorganisms. Beneficial microorganisms are still a thing but we need to figure out how to make them work better for everyone.

### 11. Future Prospects

There have been a lot of advances in ecology and molecular biology. These advances are really helping us make groups of microorganisms that work together. We can make these microbial consortia do things and they can handle tough conditions. When we combine these microorganisms with new farming methods, like precision farming and tools that give farmers

advice we can make the soil healthier. This will also help us deal with the effects of climate change on farming. Microbial consortia are going to be very important, for managing soil health.

## CONCLUSION

Beneficial microorganisms play a pivotal role in maintaining and improving soil health by regulating physical, chemical, and biological processes. Their effective management is essential for sustainable agriculture, food security, and environmental conservation. Promoting microbial-based soil health management strategies can lead to resilient agroecosystems, improved productivity, and long-term agricultural sustainability.

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