

Soil Biodiversity Conservation and Microbial Inoculants

Shyam Karan^{1*},
Rakesh Dawar²,
KM Babali Kumari³

¹Senior Technical Officer
(STO), ICAR RC NEH,
Meghalaya

²ICAR KVK North and Middle
Andaman

³Ph.D., Scholar, ICAR IARI,
New Delhi



Open Access

*Corresponding Author
Shyam Karan*

Available online at
www.sunshineagriculture.vitalbiotech.org

Article History

Received: 16. 1.2026

Revised: 21. 1.2026

Accepted: 26. 1.2026

This article is published under the terms of the [Creative Commons Attribution License 4.0](https://creativecommons.org/licenses/by/4.0/).

INTRODUCTION

Soil is more than dirt that plants grow in. It is a living thing that's full of life. A small amount of soil can have a huge number of tiny living things in it. I mean billions of them. These tiny living things are very important because they do jobs that help the soil. They help turn things into food for plants. They help keep the air clean. They help keep plants from getting sick.

Soil biodiversity conservation is a deal now. People around the world are talking about it. This is because soil is very important for growing food. It helps stop the earth from getting too hot. It helps keep the earth healthy. Soil biodiversity conservation is crucial for making sure we have food to eat and, for keeping the earth stable. Microbial inoculants are a way to help the soil. They make the soil a better place for good microbes to grow. This means we do not have to use many chemical fertilizers and pesticides. Microbial inoculants are good for the soil. Help us take care of it in a sustainable way. We can use inoculants to make the soil healthy and strong. Microbial inoculants are an eco-option, for farming.

2. Concept of Soil Biodiversity

Soil biodiversity is about all the living things that are in the soil. These living things interact with each other and with the world around them. Soil biodiversity includes living things like bacteria, fungi and algae. These tiny living things help change the soil by doing things like breaking down plants.

Soil biodiversity also includes living things like earthworms and termites. These living things help move air through the soil and make it easier for roots to grow. They also help move nutrients around the soil so that plants can use them. Soil fauna, which is a fancy way of saying the animals that live in the soil includes things like nematodes, mites and springtails. These animals are all part of soil biodiversity. They all play a role, in keeping the soil healthy. Soil has a lot of things living in it. Plant roots and the tiny organisms that live around them are a part of what makes soil so diverse. These tiny organisms and plant roots work together. They help decide how tiny microbes behave. They do this by sending out chemicals from the roots.

Plant roots and the tiny organisms that live around them are very important. They all work together to make a network of food that is in the soil. This network helps decide how many nutrients are available in the soil. It also helps decide how the soil is structured and how well plants grow. Plant roots and the tiny organisms that live around them are really important, for plant growth dynamics and soil structure and nutrient availability.

3. Importance of Soil Biodiversity

Soil biodiversity is really important for keeping the soil healthy and making sure crops grow well. The different living things in the soil like bugs and microbes help turn nutrients into something that plants can use. This means they break down plants and animals into a form that is good for the soil. They also help make the soil stronger and better at holding water. Soil biodiversity does a lot of things for the soil like making it less likely to wash away and giving plants more air. Some tiny living things in the soil even help turn nitrogen into a form that plants can use which's a natural way to give plants what they need. Soil biodiversity is essential for soil health and for growing crops. The living things in the soil, like microorganisms work together to make the soil a good place for plants to grow. Soil has lots of living things like microbes. These microbes are really good at fighting off things that can hurt plants. They do this by competing with them and being mean to them. At the time microbes help plants grow strong and deal with problems. This means the soil stays healthy for a time and we can keep growing crops in a way that is good for the earth. Microbes are really important for soil fertility and, for growing crops in a way.

4. Threats to Soil Biodiversity

Soil biodiversity is really important for the earth. The way we use land and farm nowadays is hurting it. When we dig up the soil much and plant the same things over and over it messes up the homes of the tiny living things in the soil. Using many chemicals to help plants grow can also be bad for the good bugs and tiny organisms that live in the soil.

The soil can get worn out. Broken down which makes it hard for the tiny living things to survive. Other things like much salt, not the right balance of acid, pollution from factories cutting down trees and changing how we use land can also change the soil in ways that make it bad, for the tiny living things that need to live there. Soil

biodiversity is getting threatened by all these things. Climate change is a problem and it is making really bad weather happen more often. This is messing up the water, in the soil. The temperature is getting all out of whack. Climate change is making this happen. It is causing us to lose more of the good things that live in the soil. We are talking about soil biodiversity and climate change is hurting it.

5. Soil Biodiversity Conservation Strategies

We need to take care of the soil. That means we have to do things that help the soil. The soil has a lot of living things in it and we have to protect them. To do that we have to manage the soil and the crops that grow in it in a way that's good for the soil. This is what soil conservation is about it is about keeping the soil healthy and full of life which is really important, for the soil biodiversity. Soil biodiversity is very important. We have to make sure we do things that help the soil and the tiny living things in it.

5.1 Conservation Agriculture

Conservation agriculture is really good for the soil. When we do not till the soil or till it little it helps keep the soil in good shape and it is good for the tiny living things in the soil.

When we leave the leftover crops on the soil it helps keep the living things in the soil safe from very hot or very cold temperatures and from losing water.

Conservation agriculture practices like growing different crops and growing different crops together are also very good because they help many different kinds of tiny living things grow in the soil. Conservation agriculture is important, for the health of the soil.

5.2 Organic Matter Management

Soil gets the energy and nutrients it needs from things like farmyard manure, compost and the leftovers from crops.

When we put these things into the soil on a regular basis it helps the tiny living things in the soil like microbes to grow and thrive.

It also makes the soil better by increasing the amount of carbon in it and helping the microbes break down plants and other stuff.

The use of inputs like farmyard manure, compost and crop residues is really good, for the soil.

5.3 Crop Rotation and Diversification

Crop rotation and diversified cropping systems are really good for the soil because they support a lot of soil microorganisms. This happens because Crop rotation and diversified cropping

systems give the soil microorganisms root exudates and organic residues.

Crop rotation and diversified cropping systems also help to break the cycles of pests and diseases that can hurt the soil. They improve the biological balance of the soil which is very important, for Crop rotation and diversified cropping systems to work well.

5.4 Integrated Nutrient and Pest Management

We need to take care of the soil when we are growing crops. This means using a mix of man-made things to help the crops grow. We want to make sure we do not hurt the things that live in the soil. These good things help the soil stay healthy. We also want our crops to grow well. So we use a balance of natural and man-made things to make this happen. This is what integrated nutrient and pest management practices are, about. Integrated nutrient and pest management practices help us use natural and manmade things in a way that does not hurt the soil or the good things that live in it.

5.5 Agroforestry and Sustainable Land Use

Agroforestry systems and sustainable land use practices are really good, for the earth. They help to make the soil healthier by adding types of roots and organic things to it. This also increases the amount of carbon in the soil. All of this makes the ecosystem stronger and better able to handle problems. Agroforestry systems do a job of making the soil more resilient.

6. Microbial Inoculants: Concept and Classification

Microbial inoculants are things that have microbes in them. These microbes are good for the soil. They help the soil have nutrients. They also help plants grow better. You can put inoculants on seeds or in the soil or, on the plants. This makes the soil fertile. Helps plants grow. Microbial inoculants have. Dormant good microbes that do all these things.

6.1 Types of Microbial Inoculants

Nitrogen is really important for plants. There are living things like Rhizobium, Azotobacter, Azospirillum and Frankia that help plants get the nitrogen they need from the air. These tiny living things convert the nitrogen in the air into a form that plants can use.

There are also tiny living things like Bacillus, Pseudomonas and Aspergillus that help make phosphorus available to plants. Phosphorus is hard for plants to get because it is stuck in the soil. These tiny living things help get the phosphorus out of the soil so plants can use it.

Some microbes also help plants get potassium and zinc. These are nutrients that plants need to grow. Nitrogen-fixing microorganisms like Rhizobium and Azotobacter are really good at helping plants get the nutrients they need.

There are also fungi called arbuscular mycorrhizal fungi that help plants get water and nutrients. These fungi work with plant roots to help plants grow. Arbuscular mycorrhizal fungi are really good, at helping plants get the nutrients they need from the soil. Plants grow better with the help of Plant growth-promoting rhizobacteria. This Plant growth-promoting rhizobacteria does a lot of things to help plants grow. There are also good things like Trichoderma and *Pseudomonas fluorescens* that help plants. These things stop the guys in the soil that can hurt plants. Plant growth-promoting rhizobacteria is really good, for plants.

7. Role of Microbial Inoculants in Soil Biodiversity Conservation

Microbial inoculants are really good for the soil. They help the good microbes in the soil to grow and be healthy. This is important because it makes the soil a better place for plants to grow. Microbial inoculants make the soil have different types of microbes, which is good for the soil. They also help the microbes to work better so the soil can get the nutrients it needs.

Microbial inoculants are good because they mean we do not need to use many chemicals on the soil. These chemicals can hurt the microbes that live in the soil. Microbial inoculants help plants and microbes to work together which makes the soil healthier. They help the plants to use the nutrients they need. They make the soil a better place.

Microbial inoculants help to fix soil that has been damaged. They help to keep the soil healthy for a time. Microbial inoculants are important, for soil health. They help to keep the soil in good condition. Microbial inoculants make the soil a better place for plants to grow. They help to keep the environment healthy.

8. Mechanisms of Action of Microbial Inoculants

Microbial inoculants work in a few ways. They take nitrogen from the air. Make it useful for plants. They also make nutrients that plants need easier to get to. Microbial inoculants make things like acetic acid and gibberellins that help plants grow.

Many microbial inoculants make special helpers called siderophores. These siderophores

grab onto iron. Keep bad germs from growing. Some microbial inoculants even help plants fight off diseases on their own. This means plants are stronger and can defend themselves better.

All of these things that microbial inoculants do help make the soil better for plants. They help plants grow and make crops healthier. Microbial inoculants really improve soil fertility and crop performance. They are good for plant growth and, for the crops that people grow.

9. Synergistic Effects of Soil Biodiversity and Microbial Inoculants

The native soil. The microbes that are added to the soil work really well together. This helps the soil to break down things it helps the soil to use nutrients more efficiently and it helps to increase the amount of organic carbon in the soil. When the roots of plants grow better and the plants can deal with stress easily this also helps to keep the ecosystem stable and it helps to make sure that farms can produce food in a sustainable way. The native soil biodiversity and the introduced microbial inoculants are very important, for this. They help the soil and the plants to work better.

10. Application Methods of Microbial Inoculants

Microbial inoculants can be put on seeds. You can dip the roots of seedlings in them or you can put them right in the soil. You can also use them with water and fertilizer. Spray them on the leaves especially when you are using PGPR microbial inoculants. If you do it the way the microbial inoculants will work well they will survive and you will see the benefits of microbial inoculants for a long time.

11. Challenges in the Use of Microbial Inoculants

Microbial inoculants have some things about them but they also have some problems. One of the issues with microbial inoculants is that they do not always work well in the field because of the soil and the weather. Microbial inoculants also have a short shelf life, which means they do not last long and they can be hard to store. This can affect the quality of the inoculants. Another issue, with inoculants is that they do not always work well with other farm chemicals.

Microbial inoculants are not widely used because many farmers do not know about them or do not know how to use them properly. The people who make inoculants also need to make sure they are good quality but this is not always the case, which makes it hard for microbial inoculants to be used on a large scale.

12. Role of Policy, Research, and Extension

The government makes rules that help take care of the soil and its tiny living things. Schools that study the soil and people who teach farmers also do a job. They make sure the good bacteria we put in the soil are safe to use. The government checks these products to make sure they are good.

People learn about these bacteria by going to classes and seeing how they work on farms. This helps farmers want to use them. When we use these bacteria as part of a bigger plan to keep the soil healthy and grow food in a way that is good for the earth it works even better. The government and farmers work together to make the soil healthy and strong, by using these bacteria and following good farming practices.

13. Future Prospects

Microbes that live in the earth are really important. New discoveries about these microbes and how to make them stronger are helping us create helpers for the soil. These helpers are made from different kinds of microbes that work well together and can handle tough conditions. When we use these helpers with farming methods that consider the climate and tools that give farmers exact advice we can really make the soil a healthy place. This is good for the earth. Helps us grow more food in a way that is sustainable. Microbial inoculants are getting better and better. This is great news, for soil biodiversity conservation and sustainable agricultural intensification. Microbial inoculants and these new farming methods will work together to make the soil a better place.

CONCLUSION

Soil biodiversity conservation is fundamental to sustainable agriculture, environmental health, and long-term food security. Microbial inoculants serve as powerful tools for restoring and maintaining soil biological diversity while enhancing nutrient availability and crop productivity. The combined adoption of biodiversity-friendly soil management practices and scientifically validated microbial inoculants

offers a sustainable pathway for improving soil health, agricultural resilience, and ecological sustainability.

REFERENCES

- Alori, E. T., Dare, M. O., & Babalola, O. O. (2017). Microbial inoculants for soil quality and plant health. In *Sustainable agriculture reviews* (pp. 281-307). Cham: Springer International Publishing.
- Ambrosini, A., de Souza, R., & Passaglia, L. M. (2016). Ecological role of bacterial inoculants and their potential impact on soil microbial diversity. *Plant and Soil*, 400(1), 193-207.
- O'Callaghan, M., Ballard, R. A., & Wright, D. (2022). Soil microbial inoculants for sustainable agriculture: Limitations and opportunities. *Soil Use and Management*, 38(3), 1340-1369.
- Singh, D. P., Singh, H. B., & Prabha, R. (Eds.). (2016). *Microbial inoculants in sustainable agricultural productivity* (Vol. 2, p. 308). New Delhi: Springer.
- Trabelsi, D., & Mhamdi, R. (2013). Microbial inoculants and their impact on soil microbial communities: a review. *BioMed research international*, 2013(1), 863240.