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Role of microbial consortia in enhancing disease resistance in tuber crops

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Abstract

Although tuber crops—such as potatoes, sweet potatoes, and yams—are essential for ensuring the world's food security, they suffer large yield losses due to their high susceptibility to numerous diseases. A viable way to improve disease resistance in these crops is through microbial consortia, which are intricate communities of advantageous microorganisms. By fostering nutrient uptake, inhibiting soil-borne diseases, and establishing systemic resistance, these consortia work in concert within the rhizosphere to enhance plant health. The processes by which microbial consortia provide disease resistance are highlighted in this review, along with recent achievements in their use and difficulties encountered in the field. Microbial consortia have the potential to revolutionize tuber crop disease management techniques by incorporating them into sustainable farming operations, guaranteeing both environmental health and food security.

Key words: Microbial consortia, disease resistance, nutrient uptake, sustainable farming, Rhizosphere

Introduction:

Millions of people around the world rely on tuber crops like potatoes, sweet potatoes, and yams for their sustenance and livelihood. However, environmental stressors and soil-borne diseases pose serious obstacles to their cultivation, endangering both quality and yield. Sustainable solutions are required since conventional approaches to treating these illnesses, such as the use of chemical pesticides, frequently provide health and environmental hazards.

A wide range of microorganisms with varying environmental preferences, including host plant, soil type, preferred colonization areas, and action against various pathogen species, can be found in microbial consortia (Dinis et al.,2020). Communities of helpful microorganisms known as microbial consortia have become a viable way to increase plant resistance to disease. Through the breakdown of organic matter in the rhizosphere soil, the microbial consortium also enhanced the enzymatic activity, accelerated the release of root exudates, sulfate and ammonium, and raised the soil's carbon content. A higher yield is the outcome of an improved crop antioxidant system.

By developing symbiotic interactions with plant roots, these microorganisms enhance nutrient intake, promote systemic resistance, and inhibit infections. In order to promote resilient tuber crop production and open the door for sustainable agriculture methods, this study examines the mechanisms, uses, and possibilities of microbial consortia.

Mechanisms of Disease Resistance:

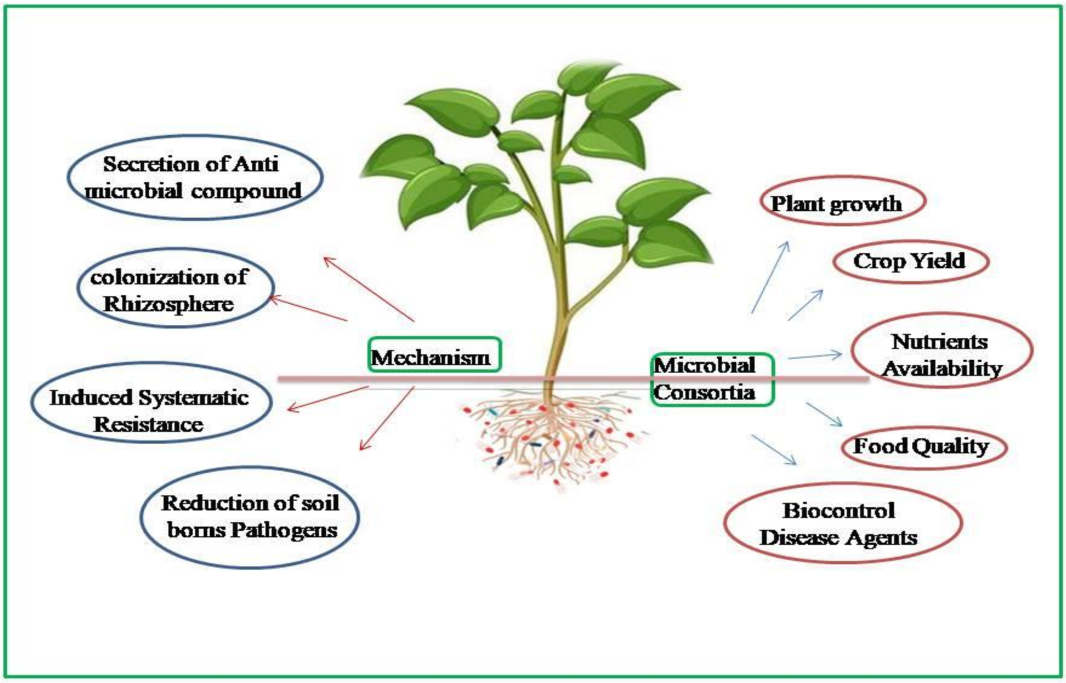
Microbial consortia enhance disease resistance in tuber crops by interacting with plant roots and triggering multiple defense mechanisms. These processes can be categorized as follows:

- **Colonization of the Rhizosphere**: *Pseudomonas fluorescens*, *Trichoderma*, and *Rhizobium*—play crucial roles in promoting plant health and resilience in the rhizosphere, which is the zone surrounding plant roots where intense microbial activity occurs. Here's a deeper look into how these microbes help protect plants (Vishwakarma et al.,2020). *P. fluorescens* is a well-known soil bacterium that acts as a biocontrol agent. It can produce antimicrobial compounds such as hydrogen cyanide, which inhibit the growth of pathogenic microbes. Additionally, *P. fluorescens* can enhance plant growth by producing growth-promoting substances like auxins, which help improve root development and nutrient uptake. *Trichoderma* is a genus of fungi that forms symbiotic relationships with plant roots. It acts as a biological control agent by producing enzymes that break down the cell walls of plant pathogens, such as fungi and bacteria, thereby inhibiting their growth. It also promotes plant growth through the secretion of growth-promoting hormones, improving root structure, and enhancing nutrient absorption. *Trichoderma* can outcompete pathogenic microbes in the rhizosphere and form a protective biofilm, providing an additional layer of defense against infections. Rhizobium is a group of nitrogen-fixing bacteria that form nodules on legume roots. While their primary role is to fix atmospheric nitrogen into a form usable by plants, they can also indirectly support plant health by improving soil fertility. These bacteria enhance plant growth, especially in nutrient-poor soils, and can compete with soil pathogens for resources, making it harder for harmful microbes to establish in the rhizosphere. Although Rhizobium is not directly antagonistic to pathogens, its role in enriching the soil and improving plant health boosts the plant's ability to resist infections. Together, these beneficial microbes create a healthier rhizosphere environment by outcompeting harmful pathogens, enhancing nutrient availability, and promoting plant growth.

- **Induction of Systemic Resistance**: Triggered by beneficial microbes, this response involves the production of phytohormones such as jasmonic acid (JA) and ethylene. These signals prime the plant's defense system without harming its normal growth. Some microbes can enhance resistance by stimulating salicylic acid (SA) pathways, leading to the accumulation of pathogenesis-related (PR) proteins. ISR strengthens cell walls by increasing lignin and callose deposition, forming physical barriers against pathogen invasion.
- **Secretion of Antimicrobial Compounds** : Beneficial microbes produce secondary metabolites such as antibiotics, lytic enzymes, and siderophores. These compounds inhibit pathogen growth directly or indirectly by depriving them of essential nutrients like iron. Microbes produce antibiotics (e.g., iturin, surfactin, and pyrrolnitrin) that directly inhibit pathogens. Compounds such as hydrogen cyanide (HCN) and 2,3-butanediol disrupt pathogen metabolism and inhibit their growth. Enzymes like chitinase, glucanase, and protease break down the cell walls of fungi and bacteria, leading to their death.
- **Reduction of Soil-Borne Pathogens**: Microbial consortia suppress soil-borne pathogens through competitive exclusion, nutrient deprivation, and modification of the soil microbiome. For instance, some bacteria produce biofilms around the root system, preventing the infiltration of harmful microbes. Consortia form protective biofilms around plant roots, creating a physical barrier that prevents pathogen colonization.

Fig 1 : Mechanism and Overview of Microbial Consortia

Applications in Tuber crops : When microorganisms are applied in a consortium, their effectiveness, dependability, and consistency may be enhanced across a variety of soil and environmental circumstances (Stockwell et al., 2011). Therefore, a consortium may have a greater effect on promoting plant growth or suppressing disease. Use of different species of microbes in combination may further have the advantage of enhancing biocontrol efficacies as different microbes occupy in the root zone.



- **Potatoes (*Solanum tuberosum*)** : Potatoes are highly susceptible to late blight caused by *Phytophthora infestans*. Microbial consortia comprising *Pseudomonas fluorescens*, *Trichoderma harzianum*, and *Bacillus subtilis* have shown remarkable efficacy in suppressing this pathogen by producing antifungal compounds and inducing resistance in plants.
- **Cassava (*Manihot esculenta*)** : Cassava bacterial blight, caused by *Xanthomonas axonopodis*, is a significant threat. A consortium of nitrogen-fixing bacteria and phosphate-solubilizing microbes has been effective in reducing disease incidence while promoting healthy growth.
- **Yams (*Dioscorea* spp.)** : Soft rot and anthracnose are common diseases in yams. Microbial consortia containing Azospirillum spp. and mycorrhizal fungi have demonstrated potential in minimizing these diseases by enhancing nutrient uptake and providing a protective shield against pathogens.
- **Sweet potato (*Ipomoea batatas*)** : Root rot caused by *Fusarium oxysporum* and scurf caused by *Monilochaetes infuscans*. A microbial consortium comprising *Trichoderma harzianum*, *Pseudomonas fluorescens*, and *Bacillus subtilis* effectively suppresses these pathogens by producing antifungal metabolites and enhancing plant defenses. Phosphate-solubilizing bacteria and mycorrhizal fungi improve nutrient uptake, promoting vigorous growth and resistance. Seed treatment

with microbial consortia significantly reduces disease incidence and enhances tuber yield. Post-harvest decay is minimized, improving storage quality and market value.

Conclusion: The integration of microbial consortia plays a pivotal role in enhancing disease resistance in tuber crops by improving soil health, promoting plant growth, and suppressing pathogenic organisms. These beneficial microbes, through synergistic interactions, strengthen the plants' immune responses, enabling them to withstand biotic and abiotic stresses effectively. Utilizing microbial consortia offers an eco-friendly and sustainable alternative to chemical pesticides, reducing environmental impact while maintaining crop productivity and quality. By adopting microbial consortia, farmers can not only protect their crops from diseases but also contribute to a healthier environment and a more sustainable agricultural system.

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