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The Role of Rhizosphere to Produce Biofertilizer for Nitrogen Enrichment in Plant

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ABSTRACT:

Rhizosphere is definitely the most complex microhabitat and it is comprised of an integrated network of plant roots, soil, and a diverse association of bacteria, fungi, eukaryotes, and archaea. The rhizosphere conditions have a direct impact on plant growth and yield. Rhizodeposits, root exudates, and root border cells are the important components of the rhizosphere that significantly affect root colonization capacity and multiplication of rhizosphere microbes as well as secretion of organic bioactive compounds. Nitrogen is one of the important nutrients of plants and it has a significant impact on plant productivity and microbial function but many Plants have a nitrogen deficiency. In order to avoid these deficiencies in plants, rhizosphere microorganisms can be utilized as biofertilizers to enrich the nitrogen content in plants. In this article, the use of rhizosphere microorganisms as biofertilizers to enrich the nitrogen content in nitrogen-deficiency plants can be reviewed and summarized.

Keywords: Rhizosphere, Nitrogen, Biofertilizer

INTRODUCTION:

The term “Rhizosphere” was first coined by *Hiltner* as the area of microbiology activity around the roots [1]. The rhizosphere is home to a prosperous diversity of microorganisms. Many of these support plants by suppressing pathogenic invasion. It also helps us to acquire nutrients from the soil [2,3]. The endo-rhizosphere, or the endodermis and cortical layers inside the root, is one of the three rhizosphere zones Lynch hypothesized. This zone is also known as "internal root colonization." The ectorhizosphere (soil particles past the root surface that are affected by root exudates) and the rhizoplane (the root surface with mucilaginous polysaccharide layer) [4]. The rhizosphere can also be defined as an area of the soil which is instantly surrounding the root and is directly influenced by plant root exudates [5]. Root exudates include a scope of organic acids, amino acids, sugars, and other small molecules discharged by the plant roots that can act as strong chemoattractants of the soil microbiota and the roots can produce differences in the chemical composition of exudates that can attract a particular microbial diversity depending on the plant species or variety [6,7]. One of the important approaches that can be used to solve some current problems of agriculture is the use of beneficial microorganisms that are naturally associated with plants which are environment-friendly alternatives that do not have secondary effects on the animals, human health, and the environment [8-10]. This biota is referred to as the” plant microbiome,” and unique benefits have been linked to it, including the promotion of plant growth and disease defense [11,12]. The production and modulation of phytohormones, solubilization and increasing the bioavailability of vital nutrients, production of antibiotics, and improvement of the physical and chemical properties of the soil are just a few of the numerous ways that these microbes are used to benefit the plant [13,14]. Prokaryotes (bacteria, viruses, and archaea) and eukaryotes (fungi, oomycetes, protozoa, algae, and arthropods) are among the microbial taxa that rhizosphere. Out of these, bacteria and fungi are the most prevalent species [15,16]. Plant growth-promoting rhizobacteria PGPR are microbes that reside in the rhizosphere of diverse plants and have a variety of beneficial impacts on the host plant in a variety of ways [17,18]. In addition to fixing atmospheric nitrogen, PGPR also produces siderophores, phytohormones (auxins, gibberellins, and cytokinins), solubilizes phosphorous (P), and synthesizes stress enzymes [19]. PGPR is resistant to harsh environmental circumstances such as water scarcity, salt stress, weed invasion, nutritional deficiency, and heavy metal contamination [20]. Natural stability and sustainability agriculture may benefit from the usage of PGPR. These are associated with roots (in the rhizosphere) and promote plant development when pathogens are absent or migrate the negative impacts of pathogens on crop yield through antibiosis, competition, induced systemic resistance, and siderophore synthesis [21-23]. Due to the impressive advancements made in the research of the relationship between microorganisms and plants over the past 20 years, the terms "biofertilizer" and "bioinoculant" have taken on a variety of meanings. The most common definition of a biofertilizer is "a substance that contains living microorganisms that, when applied to seed, plant surfaces, or soil, colonises the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant."[24]. The microorganisms found in biofertilizers use a variety of techniques to benefit agricultural plants. They may be proficient at all three processes—nitrogen fixation, phosphate solubilization, and plant growth promotion—or they may combine all three [25-28]. The microorganisms in biofertilizers employ a range of strategies to promote plant life in agriculture. They might excel at any of the three processes—nitrogen fixation, phosphate solubilization, and plant growth promotion—or they might combine them all [29,30]. Further, when applied as seed or soil inoculants, biofertilizers can multiply, participate in nutrient cycling, and help in crop production for sustainable farming [31-34].

RHIZOSPHERE AND ITS COMPONENTS:

The rhizosphere is a small area of soil that is close to plant roots and a breeding ground for numerous bacteria. Rhizodeposits, which are released or secreted by the plant and primarily include carbohydrates, secondary metabolites, organic acids, and amino acids, have an impact on the soil in the area. Hence, rhizosphere soils that encourage the expansion of microbial communities are referred to as mesotrophic. Many microbial species that carry out different tasks and have a variety of effects on plant growth are found in the rhizosphere. They participate in the cycling of nutrients, provide defense against phytopathogens, protect plants from biotic and abiotic stresses, and some may even behave as plant diseases. The composition, quality, and quantity of the root exudate that the plants emit change as a result of these microbial activities in the rhizosphere, which in turn alters the microbial component. According to the theory behind the phenomena known as "rhizosphere," plants alter the microbial community composition in the rhizosphere through rhizodeposition, which subsequently affects the productivity and growth of plants. Such a connection implies that the rhizosphere may be used and/or modified to aid in plant growth, nutrient uptake, and production. Three essential elements of the rhizosphere are soil, plants, and microorganisms.

BIOFERTILIZER:

A biofertilizer is something that has living microorganisms in it and can be used on seeds, and plant surfaces and it helps the host plant grow by increasing the supply or availability of primary nutrients. By a biological nitrogen fixation process, biofertilizers may fix nitrogen from the atmosphere. Moreover, it secretes compounds that encourage plant growth, such as different hormones, and solubilizes nutrients the plants need, such as phosphate, zinc, and potassium. Moreover, this biofertilizer can multiply and take part in the nutrient cycle when used as a seed or soil inoculant. It also aids in higher crop production.

PLANT GROWTH PROMOTING RHIZOBACTERIA:

Rhizobacteria that promote plant development make up the majority of the biofertilizers and biocontrol agents now in use. Many different plant species allow this PGPR to colonize their rhizospheres, where they produce more advantageous effects for the host. For instance, enhanced plant development and decreased susceptibility to illness brought on by plant pathogens like nematodes, fungi, bacteria, and viruses. The most advantageous effects of PGPR may include accelerated seed germination, root growth, yield, chlorophyll content, nutrient uptake, protein content, hydraulic activity, resistance to abiotic stress, shoot and root weights, and postponed senescence. As a result, these PGPR are frequently used as biofertilizers. *Arthrobacter, Azospirillum, Azotobacter, Bacillus, Enterobacter, Pseudomonas, Rhizobium, and Serratia* make up the majority of the most well-known PGPR that fall under these genera.

RHIZOSPHERIC FUNGI:

Many fungi that are found in soil can be used in agriculture to boost crop yields. For instance, like mycorrhizal fungi, *Penicillium bilabiate* is a type of rhizospheric fungus that aids plants in acquiring phosphorus. Rhizospheric and epiphytic members Due to their ability to lessen the biotic and abiotic stress on their host plants, Trichoderma spp. can be used in a wide variety of goods. They will, for instance, manage numerous plant pathogens. *Fusarium, Sclerotium* Rhizoctonia, and Pythium are just a few of the soil-borne diseases that *Trichoderma viride* is hostile to. The same fungal infections can be controlled *by Trichoderma harzianum*, which can also encourage the development, flowering, and secondary metabolism of host plants. The same fungal infections can be controlled by Trichoderma harzianum, which can also encourage the development, flowering, and secondary metabolism of host plants. Combining Trichoderma harzianum and Trichoderma polysporum increases the effectiveness against diseases brought on by fungi.

IMPORTANCE OF NITROGEN IN PLANTS:

One of the most essential elements, nitrogen is essential for several metabolic processes, including plant growth. Although 78% of all atmospheric gases are composed of nitrogen, plants cannot use them. Biological nitrogen fixation is the process by which specific bacteria and archaea convert nitrogen to ammonia using a nitrogenase protein complex. One of the most important elements that influence crop growth and yield formation is nitrogen. Nitrate and ammonium salts are the inorganic forms of nitrogen that plants continuously absorb. The root system is one of a plant's most crucial organs for absorbing nutrients and water, and the health of the root system directly influences the development of plant shoots. The uptake and use of nitrogen by plant roots are crucial for the production of yield.

APPLICATION OF RHIZOSPHERE:

The rhizosphere, the region of soil immediately surrounding a plant root, is where the root influences the biology and chemistry of the soil. By moving through the soil, plant roots release the majority of the water-soluble material, including amino acids, sugars, and organic acids, feeding the soil's microbial population. Two benefits of studying the rhizosphere include the use of organisms that encourage plant growth and the use of biocontrol agents to eliminate weeds and plant diseases. Rhizosphere organisms are also employed to increase the development of stable soil aggregates and as bioremediation agents for damaged soils. Rhizosphere: the ecosystem in which microorganisms, plants, and soil coexist Rhizobacteria and mycorrhizal fungi, which promote plant growth, are the types of microorganisms utilized to make bio-fertilizer Positive effects of biofertilizer on plant output, soil nutrients, and photosynthetic rate.

CONCLUSION:

Chemical contamination is currently harming the environment. In order to guarantee that the next generation will live in a healthy environment, fast implementation of efficient solutions is required. Microbes have shown to be a crucial tool in field studies that aim to minimize or do away with the usage of chemicals in agricultural production. The rhizosphere's driving forces for promoting plant development and biological control activities are rhizodeposits, root exudates, and root border cells. Today's plants likewise have very little nitrogen in them. Future sustainable food production will require the development of biofertilizers and biocontrol agents as well as their greater use. Nitrogen-deficient plants' nitrogen content will rise with the usage of biofertilizers. In this overview, various significant roles played by microbes in the competition, colonization, and establishment of the plants' rhizosphere have been reviewed.

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