GreenariA
Go Green, Learn Green
An Agricultural Monthly e-Magazine

Volume 02, Issue 02, 2024
e-ISSN: 2584-153X
Article ID: G-24-0202

ENDOSYMBIONTS IN PLANT NUTRITION

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INTRODUCTION

Plants, being sessile organisms, heavily rely on their ability to form symbiotic associations with various microorganisms to fulfil their nutritional requirements. Among these symbiotic relationships, endosymbionts have gained considerable attention due to their direct involvement in nutrient acquisition processes. Endosymbionts are microorganisms residing within plant cells or tissues, where they establish mutually beneficial interactions with their host plants. Endosymbionts play a crucial role in plant nutrition by establishing mutually beneficial relationships with their host plants. These symbiotic associations involve the presence of microorganisms, such as bacteria and fungi, residing within the plant tissues. In this review, we will explore the diverse roles and benefits of endosymbionts in plant nutrition, focusing on nitrogen-fixing bacteria, mycorrhizal fungi and other key associations.

TYPES OF ENDOSYMBIONTS

Endosymbionts in plant nutrition can be broadly classified into two main groups: mycorrhizal fungi and nitrogen-fixing bacteria. Mycorrhizal fungi form associations with the roots of most plant species, enhancing nutrient uptake, particularly phosphorus, in exchange for carbon compounds from the host. Nitrogen-fixing bacteria, such as rhizobia, form nodules on the roots of leguminous plants and convert atmospheric nitrogen into a usable form for the host plant.

NITROGEN-FIXING BACTERIA

Nitrogen is an essential nutrient for plant growth and development, but atmospheric nitrogen (N_2) is largely inaccessible to plants. Nitrogen-fixing bacteria, such as *Rhizobium* and *Bradyrhizobium*, form a symbiotic relationship with leguminous plants. The bacteria colonize specialized structures called root nodules and convert atmospheric nitrogen into ammonium through nitrogen fixation. The plant provides the bacteria with carbohydrates, while the bacteria supply the plant with usable nitrogen compounds. This symbiosis significantly enhances the nitrogen nutrition of legumes and reduces the need for synthetic fertilizers.

MYCORRHIZAL FUNGI

Mycorrhizal associations are widespread and involve the mutualistic relationship between plant roots and fungi. These symbiotic fungi form an intricate network of hyphae that extend into the soil, enhancing the plant's nutrient uptake capabilities. There are two main types of mycorrhizal associations: arbuscular mycorrhizae (AM) and ectomycorrhiza (EM).

a. Arbuscular Mycorrhizae (AM): AM fungi, belonging to the Glomeromycota phylum, colonize the roots of the majority of plant species. They facilitate the uptake of nutrients, especially phosphorus, by increasing the root surface area through the formation of branching structures called arbuscules. AM fungi also improve the plant's resistance to pathogens and environmental stresses.

b. Ectomycorrhiza (EM): EM associations are mainly formed by fungi belonging to the Basidiomycota and Ascomycota phyla. They form a sheath around the root tips, known as the mantle, and extend hyphae into the surrounding soil. EM fungi primarily enhance the plant's uptake of nutrients like nitrogen, phosphorus, and micronutrients. Additionally, they contribute to soil structure and play a vital role in forest ecosystems.

OTHER ENDOSYMBIOTIC ASSOCIATIONS

Apart from nitrogen-fixing bacteria and mycorrhizal fungi, other endosymbiotic associations also contribute to plant nutrition:

a. Actinobacteria: Certain actinobacteria form associations with plants and assist in phosphate solubilization, making phosphorus more accessible to the plant roots.

b. Endophytes: Endophytic microorganisms reside within plant tissues without causing harm. They can enhance nutrient uptake, produce growth-promoting substances, and confer resistance to pathogens and abiotic stresses.

MECHANISMS OF INTERACTION

Endosymbionts employ diverse mechanisms to facilitate nutrient acquisition in plants. Mycorrhizal fungi extend their hyphae into the soil, increasing the root surface area for nutrient absorption. These fungi also enhance the solubility and uptake of nutrients, particularly phosphorus and micronutrients. Nitrogen-fixing bacteria, on the other hand, convert atmospheric nitrogen into ammonia, which is subsequently assimilated by the host plant. These interactions are mediated by signalling molecules and molecular dialogues between the plant and the endosymbiont.

IMPACTS ON PLANT GROWTH AND DEVELOPMENT

The presence of endosymbionts significantly influences plant growth and development. Mycorrhizal associations enhance plant biomass, improve nutrient uptake efficiency, and enhance tolerance to various stresses, including drought and salinity. Nitrogen-fixing bacteria provide a steady supply of nitrogen to host plants, promoting vigorous growth, increased yield, and improved protein content. Furthermore, endosymbionts can enhance plant defence mechanisms against pathogens and pests.

APPLICATIONS IN SUSTAINABLE AGRICULTURE

Harnessing the potential of endosymbionts in sustainable agriculture is an area of active research. Utilizing mycorrhizal fungi and nitrogen-fixing bacteria as biofertilizers can reduce the reliance on synthetic fertilizers, mitigate environmental pollution, and improve soil health. Additionally, endosymbionts have shown promising results in enhancing plant tolerance to abiotic stresses, minimizing crop losses, and ensuring food security.

ROLE IN PLANT RESILIENCE

Endosymbionts play a crucial role in enhancing plant resilience to environmental stresses. They promote root system development, improve nutrient uptake efficiency, and enhance plant water relations. Moreover, endosymbionts can modulate plant hormone levels, activate stress-responsive genes, and induce the synthesis of protective compounds, thereby enabling plants to withstand challenging environmental conditions.

CONCLUSION

Endosymbionts represent a fascinating aspect of plant nutrition, providing significant benefits to their host plants. Understanding the mechanisms underlying their interactions and harnessing their potential in sustainable agriculture holds great promise for improving crop productivity, reducing environmental impacts, and ensuring global food security. Further research is required to unravel the intricate molecular mechanisms governing endosymbiotic associations and to explore their full potential in agricultural and ecological contexts. Endosymbionts, including nitrogen-fixing bacteria, mycorrhizal fungi, and other microbial associates, significantly influence plant nutrition. These symbiotic relationships enhance nutrient acquisition, improve plant growth and development, increase resistance to stressors, and reduce the reliance on external inputs like fertilizers. Understanding and harnessing the potential of endosymbionts in plant nutrition holds promise for sustainable agriculture and environmental conservation. Further research is needed to explore the intricate mechanisms underlying these associations and their application in optimizing plant productivity while reducing the environmental footprint of agriculture.