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Editorial

Endophytes in plant disease management

Endophytic microorganisms grow in the intercellular spaces of higher plants, are recognized as one of the most promising groups of microorganisms in terms of diversity and pharmaceutical potential. Beneficial endophytic microorganisms comprise especially fungi (*Acremonium* sp., *Aspergillus flavus, Cladosporium cladosporioides, Paecilomyces varioti, Nigrospora oryzae* etc.) and bacteria (*Streptomyces* sp., *Pseudomonas* sp., *Enterobacter, Acetobacter* etc.) that colonize internal plant tissues without causing visible damage to the hosts. Endophytes are microorganisms that reside in the tissues of living plants, are relatively unstudied and potential sources of novel natural products for exploitation in agriculture. That is, plant is thought to provide nutrients to the microbe, while the microbe may produce factors that protect the host plant from attack by animals, insects or microbes .

Endophytes are different from phytopathogenic microorganisms because they are not detrimental, do not cause diseases to plants and are distinct from epiphytic microorganisms which live on the surface of plant organs and tissues. Endophytic bacteria are able to penetrate and systemically disseminated in the host plant followed by actively colonizing the apoplast, conducting vessels, and occasionally the intracellular spaces. This colonization presents an ecological niche similar to that occupied by plant pathogens and this endophytic bacteria can, therefore, act as biological control agents against pathogens.

Root endophytic microorganisms are seen as promising alternatives to replace chemical pesticides and fertilizers in sustainable and organic agriculture systems. The capability of colonizing internal host tissues has made endophytes as a tool to improve crop performance in agriculture. This association is often mutualistic. Endophytes provide the plant with antagonism against diseases. Inside the plant, an endophyte occupies a niche with relatively low competition from other microorganisms, provided the endophyte gets there first.

In this context, the suppression of plant diseases due to the action of endophytic microorganisms has been demonstrated in several pathosystems. Several mechanisms may control this suppression, either directly on the pathogen inside the plant by antibiosis and competition for nutrients, or indirectly by induction of plant resistance response and more recently, their potentiality for enhanced degradation of several pollutants. There are many reports demonstrating that many bioactive compounds are produced by endophytic microorganisms .

Endophytes usually occur in above-ground plant tissues, but also occasionally in roots (for example, dark septate endophytic fungi have been isolated from various plants) and are different from mycorrhizae by lacking external hyphae. Although some root endophytic fungi require host cell death for proliferation during forming mutualistic symbiosis with plant, it is universally hypothe-sized that endophyte-host interactions involve a balance of antagonism and exhibit great phenotypic plasticity compared to plant pathogens.

Only few reports refer to the plant secondary metabolism mediated by the fungal endophytes. Currently, endophytes are viewed as an outstanding source of bioactive natural products because many of them occupying literally millions of unique biological niches (higher plants) growing in so many unusual environments. Thus, it appears that these biotypical factors can be important in plant selection, since they may govern the novelty and biological activity of the products associated with endophytic microbes. In addition, endophytic actinomycetes may also affect plant growth either by nutrient assimilation or enhanced secondary metabolites (anthocyanin) synthesis. Furthermore, the production of antimicrobial substances such as antibiotics or HCN, is an important mechanism to fight against phytopathogens.

A number of isolates found capable of suppressing fungal pathogens of wheat including *Rhizoctonia solani*, *Pythium* spp., and *Gaeumannomyces graminis* var. *tritici* indicating their potential use as biocontrol agents.

Endophytes are a poorly investigated group of microorganisms that represent an abundant and dependable source

of bioactive and chemically novel compounds with potential for exploitation in a wide variety of medical, agricultural and industrial arenas. They play important roles for protecting plants against diseases.

Several anticancer, antibiotic, antimycotic, antiviral, antioxidant, nematicide, insecticide and immunosuppressive compounds have been derived from endophytes, such as cytochalasines, ambuic acid, oocydin, jesterone, cryptocandin, lolitrem B and 3-hydroxypropionic acid etc. Many of them produce some toxic alkaloids and protect their hosts from herbivores. They also improve the growth and yield of crops under various stressed conditions.

The need is to carry out more detailed studies to understand the ecology, physiology, environmental activity profiles and modes of action of endophytes and complex interactions in and on root and above ground plant tissues .

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