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Editorial

Endophytes: Beneficial fungi associated with plants

Endophytic fungi (EF) are asymptomatic living partners within the host and are associated with broad varieties of plant species. The occurrence of endophytes has been reported for over 400 million years ago.Literature survey indicates that the maximum mangrove-associated fungi have been reported from South-East Asia compared to other parts of the world. These symbionts grow in the internal plant tissue by modulating the secondary metabolite production that positively helps both the living partners to grow and multiply *via* chemical signaling.While residing and reproducing inside the healthy tissue in an intimate mutualistic manner, presumable gene recombination/or the precursor molecule interaction with the host indicates enhanced biosynthetic capabilities in the endophytes.Such metabolites in turn trigger host survival rate. The microbial association within the plant species greatly provides a positive role in maintaining the steady growth and development of the host plant. Additionally assemblage of micro-biota involved in mediating CO_2, CH_4, N_2 and N_2O gases trigger adaptive mechanism in host plants. After penetration in the host, it is assumed that endophytes undergo three different life stages: neutralism /quiescent stage (at this stage endophytes undergo a latent stage which maybe even for a lifetime), mutualistic stage (at this stage the host and the endophyte share mutual benefits from each other without any harm), and the antagonistic stage. Endophytes are reported to be present in almost all the plant parts and contribute to nutrient uptake and fitness to the host plant.

It becomes crucial for endophytes to continuously modify their secondary metabolites, to penetrate the host plant through its chemotactic process. To overcome such responses, endophytes secrete certain detoxifying enzymes like cellulase, lactase, xylanase which match with the plant's enzymes to achieve colonization. Such adaptive mechanism has helped endophytes to produce therapeutically important bioactive compounds, exclusive to those of host plants. This is why over 80% of the endophytes exhibit positive activity in testing for antimicrobial and biological control.These symbionts are chemical synthesizers within hosts that provide resistance against various stresses. Literature suggests that such endophytic associations have a major role in providing host resistance towards pathogens thereby enhancing growth and nutrient uptake. Evidence reveals the contribution of endophytes in increasing the auxin and cytokinin production, promoting the growth and development of the host. Such endophytes facilitate nutrient exchange and enhance enzymatic activity by stimulating the plant growth-promoting hormones. *Aspergillus*, *Fusarium*, and *Penicillium* attracted the attention of the scientific community because of their potent chemical compounds. These compounds have diverse applications in plant growth, production of secondary metabolites, and in plant's defense mechanisms. Endophytic colonization has a direct impact on seed germination, root elongation, and has a potent role in phosphate (P) solubilization.The behavioral mechanism to arrest the attack of microbial pathogens has been a positive plant endophyte interaction impacting the adaptive mechanism and in the growth of the plant species. The endophytic organisms, therefore, provide a major role in the plant system benefiting the host from the deleterious effect of the pathogen by competing for colonization site, nutrient exchange through the production of antibiotics. They enhance plant growth through the production of phytohormones by increasing the susceptibility of the host towards pathogens that lowers the harm to the parent species.It is known that phytopathogens induce disease in the plant system and therefore endophytic organisms can be used as an alternative source of biological control. Literature indicates that few endophytic species when introduced within the host triggers the host biomass that would provide additional benefit to the agriculture industry.

Endophytes are known symbionts that help host plants in fixing environmental nitrogen (N) and inorganic P. Plant colonizers like endophytic fungi trigger the solubilization and mineralization of inorganic P into soluble forms. The microbial endophytes mobilize the insoluble P and enhance N accumulation within the plant system. It has been stated that the isolation, identification of endophytic mycobiota is crucial also to the ethnobotanical profile of the plant since the medicinal properties of a plant can be due to the endophytes harboured within. This was proved in the case of the anticancer drug taxol by isolating taxol producing endophyte *Taxomyces andreanae*. Approximately 140 novel potent drugs of natural origin have been isolated from endophytic fungi between the years 1987 till 2000. For example,tetramic acid is isolated from endophytic fungus *Cryptosporiopsisquercina*, having anti-inflammatory and antifungal properties. The production of metabolites, useful in pharmaceutical and agricultural industries is widespread among the endophytic fungi. Fungal endophytes are a novel source of drugsthat includes terpenoids, steroids, xanthones, chinones, phenols, isocoumarins, benzopyranones, tetralones, cytochalasines, and enniatines.Besides, they are a prolific source of novel antibiotics, anticancer, antiviral, antioxidant, insecticide, anti-diabetic, and immunosuppressant compounds. Pharmacological compounds produced byfungal endophytes comprises diverse bioactive compounds such as antimycotic steroid 22-triene-3b-ol, anticancer cajanol, podophyllotoxin, and kaempferol, anti-inûammatory ergo ûavin, antioxidant lectin, insecticidal heptelidic acid, immune-suppressive sydoxanthone A, B, and cytotoxic radicicol. Apart from these compounds, endophytes bring about stereoselective biotransformation of chemicals, involved in drug modifications. Given the global drug resistance problem, the need to discover novel drug sources particularly antibiotics cannot be over-emphasized.

Endophytes have been reported to play an important role in the biodegradation of oil and can be used as oil degraders. Most of these are filamentous fungi that play a significant role in the degradation of hydrocarbons because of their fast growth and extensive hyphal network. Petroleum degradation in the presence of hydrocarbon-degrading micro-organisms is a complex process of biodegradation that depends upon bacteria, yeast, and fungi. Fungi like *Aspergillus, Cladosporium, Corollasporium, Fusarium*, and *Penicillium* are reported to possess a beneficiary role in the degradation of hydrocarbons, which is mediated by the action of certain enzymes systems like oxygenases and hydroxylases. It is reported that these hydrocarbon-degrading micro-organisms detoxify the plant system by stimulating secondary metabolites.PAHs (Poly Aromatic hydrocarbons) have been reported as ubiquitous xenobiotic environmental pollutants. A diverse group of fungi such as Zygomycetes (*Cunninghamella elegans*), Ascomycetes (*Aspergillus niger* and *Penicillium* sp.), and white-rot Basidiomycetes (*Trametes versicolor, Pleurotusostreatus*) is known to oxidize and degrade PAH's. Although several physical and chemical techniques are employed to resolve the issue, they are expensive and time-consuming.Hence bioremediation using micro-organisms can be used as an alternative to degrade a wide range of hydrocarbon molecules.

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