ENDOPHYTIC FUNGI AND ITS ROLE IN PLANT LIFE CYCLE

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ABSTRACT

Endophytes are group of microbes which are associated with plants and play very important role in defense mechanism and production of secondary metabolites. This group generally contains bacteria and fungi. Fungal endophytes are more important than bacterial once because of their larger role in plant metabolism. They have been isolated from large number of plant families all over the world. Reports are available in the literatures related to the production of large number of useful compounds in plants by endophytic fungi. Some researchers have even pointed out that the some medicinal chemicals produced by plants are infects produced by the fungal endophytes of that plant. They also play important role in plant defense mechanism by producing some toxic substance which hampers the growth of pathogens. Therefore this group needs to be discussed in detail to know about its nature and its role in plants life cycle

Keyword: *Endophytes, Fungi, Metabolite, Plants*

1. INTRODUCTION

Fungi are one of the most important organisms on earth, serving as decomposers of organic matter. Since they lack chlorophyll they live either on dead organic matter as saprophytes or on living organic matter as parasites. As a sister group of animals and part of the eukaryotic crown group that radiated about a billion years ago, the fungi contribute an independent group equal in rank to that of plants and animals. The organisms of the fungal lineage include mushrooms, rusts, smuts, puffballs, truffles, morels, molds and yeasts as well as many other well-known organisms. More than 70,000 species of fungi have been described; however, some estimates of total numbers suggest that 1.5 million species may exist [1]. Based upon the mode of sexual reproduction, fungi are usually classified in four divisions: the Chytridiomycota (chytrids), Zygomycota (bread molds), Ascomycota (yeasts and sac fungi), and the Basidiomycota (club fungi). The shape and internal structure of the Sporangia, which produce the spores, are the most useful character for identifying these various major groups [2].

However, many fungi are biotrophs, and member of certain groups form symbiotic associations with plants (including algae), animals (especially arthropods), and prokaryotes. Examples are lichens, mycorrhiza and endophytes [2].

Fungi are also prominent source of pharmaceuticals and are used in many industrial fermantive processes, such as the production of enzymes, vitamins, pigments, lipids, glycolipids, polysaccharides and polyhydric alcohols. Fungi are extremely useful in making high value products like mycoproteins and acts as plant growth promoters and disease suppressor. Fungi also produce various beneficial secondary metabolites such as benzopyranones, chinones, flavonoids, phenolic, quinones, steroids, terpenoids, tetralones, xanthones etc. [3] and some harmful metabolites like aflatoxins that may be potent toxins and carcinogens in food of birds, fishes, humans, and other animals.

Some fungi colonize living tissues of plants as symbiont without producing any apparent symptom or negative effects. Such fungi are termed as endophytes. They are non-aggressive and have a mutualistic role within their hosts and are not affected by surface sterilization. The endophytic fungi appear to be highly coevolved with their host. Fossil records indicates that plants have been associated with endophytic fungi for more than 400 million years and were likely associated when plants colonized land, thus having an important role in driving the evolution of life on land. This group reproduces through vegetative mode as well as by means of spores. The vegetative phase remains inside the plant tissue which never produces the external structures or fruiting bodies on the host plant. Therefore, the reproduction is completely internal [4]. Reproduction which occurs through vegetative growth of hyphae in the developing ovules of the host causes infection to seeds, thus are transmitted to next generation [5].

Initially the endophytes include from virulent foliar pathogen to mycorrhizal root symbionts and fungi that produce the visible symptoms of plant disease are not included in endophytes [6]. Mycologists also include fungi that inhabit plant organs as some point in their life cycle without carrying apparent harm to their host as well as remained internal pathogen in the endophyte category [7].

Studies on endophytic fungi started nearly two hundred years ago, when Person (1772) [8] described the species *Sphaeria typhinia*, now called as *Epichloe typhinia* (pers.) Tul. Almost all plant species harbor one or more endophytic organisms [3]. Till now only a few plants are investigated for their endophytic diversity. It is estimated that there may be at least one million species of endophytic fungi alone which form symptomless infections within healthy plant tissues found in nearly all plant families of different climate regions of the world [9, 10].

2. ENDOPHYTE DIVERSITY

Endophytes have received considerable attention after they were found to protect their host against insects, pathogens, and even domestic herbivores [10, 11]. Interaction of plants with fungal endophytes which colonize and grow asymptomatically within healthy aerial tissues of all plants sampled to date i.e. mosses, liverworts, ferns, conifers and angiosperms are poorly known [7, 12]. In last century most studies about the endophytic fungi were performed on population biology and limited to three plant families, viz. Coniferaceae, Ericaceae and Gramineae [13]. Recently the knowledge about endophyte biodiversity is becoming more apparent, even from single plant; usually several to hundreds of endophytic fungal species can be isolated [3]. In 1992, Hirsch and Braun [14] defined endophytic fungi as; fungi colonizing living tissues of plants as symbiont without producing any apparent symptom or negative effects. Studies have been conducted at different parts of the world about the endophytic biodiversity, taxonomy, reproduction, host ecology and their effect on the host organism [7, 15, 16, 4]. Endophytes have been found in healthy tissues of all plant texa as reported by various researchers[7, 17]. They were also reported from various habitats ranging from coastal mangroves [18] to north temperate evergreen forests and temperate pastures, grasslands [19] and from tropical forests [20, 21, 22]. Studies were also carried upon temperate grasses which specifically inhabit Clavicipitaceous fungi [23]. However, the diversity, geographic distribution and host specificity of endophytes remain largely unknown and most are yet to be discovered [24]. Several authors have view that majority of undiscovered endophyte diversity occurs in leaves of tropical trees [25].

ROLE IN PRODUCTION OF SECONDARY METABOLITES

Fungi are the largest group of living organism present on the earth that has economic importance to human being, whether involved in production of various diseases in animals and plants as pathogen or as a source of various therapeutic compounds for the treatment of various diseases. A large number of compounds are produced by various genera of fungi that are used in day to day life besides serving as food. Endophytic fungi are also one such group which is emerging as a new and unexplored field for the isolation and production of medicinally important compounds [3]. As it is evident from the literature that, this group is involved in enhancement of the bioactive compounds of medicinally important plants with which they are associated [26].

ENDOPHYTES AND MEDICINAL COMPOUNDS

Endophytic fungi are unexplored field for potential novel natural products of medicinal and agricultural importance [3] and have a potential to produce bioactive compounds similar to those of host plants which may have therapeutic potential [27, 28]. The scientific community searching for new therapeutic alternatives has studied and found variable bioactive metabolites in endophytes such as antiviral, anticancer and anti diabetic compound . Endophytic fungi have been found to protect plants against various pathogens [29]. Screening of this diverse group of fungi is a promising approach for obtaining medicinal plant products on commercial scale [30]. Plants growing in unique environmental habitat, ethnobotanical uses, extreme age, interesting locations generally produce novel endophytes.

There are various reports related to isolation of large number of endophytic fungi from the different plant species. In this regard, Pimentel *et al*. (2006) [31] isolated endophytic fungi from soyabean (*Glycine max* (L.) Merril under different environmental conditions and reported that there is no difference between the number of fungal isolates obtained from stems and leaves of field grown and greenhouse grown plants. Selvanathan *et al*., (2011) [32] isolated endophytic fungi from *Calotropis gigantea* (L.) and observed that mature leaves have high frequency of endophytic colonization. Rezwan *et al*., (2007) [33] studied the biodiversity of endophytic fungi from *Calotropis procera*, and isolated nine endophytic fungi which belong to class ascomycetes and deuteromycetes among this Phoma *sp*. was found most prominent endophyte. Kaushal *et al*., (2010) [34] isolated leaf inhabiting endophytic species of *Aspergillus* and *Nigrospora* from *Melia azedarach* . A red listed endangered medicinal plant *Coscinium fenestratum* was also studied for their endophytic mycoflora by Goveas *et al*., (2011) [35].

.Petrini(1991) [36] studied effects of environmental condition on the colonization frequency of endophytic fungi. Jalgaon *et al*. (2011) [37] have isolated tissue specific fungal endophytes from fifteen medicinal plants and reported that microbial endophytes from medicinal plants namely *Aloe vera, Curcuma longa, Eucalyptus globules, Osimum sanctum, Pongamia glabra, Vinca rosea, Sphaeranthus indicus* have a great ability to synthesize natural products. Li *et al*. (2005) [38] screened the endophytic fungus isolated from the medicinal plants against various phytopathogenic fungi: *Aspergillus niger*, *Collectotrichum gloeosporioides*, *Fusarium* sp. *Phytophthora nicotianae*, *Scopulariopsis, Trichoderma* and *Verticillium* sp. Yuan *et al*., (2009) [39] studied the molecular phylogeny of the endophytic mycobiota in the roots of rare wild rice *Oryza granulate* and reported high diversity of endophytic fungi in a wide range of plant species as compared to the mycorrhizal fungi and among them dark septate endophytes are ubiquitous and cosmopolitan. Endophytic fungi were found to switch their endophytic life style to saprobic with the progression of leaf decomposition [40]. Endophytic fungi have also been reported to produce various therapeutic compounds in association with the host plants. The production of secondary metabolites by an endophyte is not random, but seems to be correlated with its ecological niche [41]. Endophytes provides a broad variety of bioactive secondary metabolites with unique structure, including alkaloids, benzopyranones, chinones, flavonoids, phenolic, quinones, steroids, terpenoids, tetralones, xanthones, and others [3]. A number of wide-ranging applications of these bioactive metabolites as agrochemicals, antibiotics, immune-suppressants, antiparasitics, antioxidants, and anticancer agents have been reported by [42]. Among the 12 secondary metabolites produced by the endophytic fungi *Aspergillus fumigatus* CY018 isolated from the leaf of *Cynodon dactylon*, "asperfumoid", "fumigaclavine C","fumitremorgin C", " physcion", and "helvolic acid" were shown to inhibit the growth of *Candida albicans* [43]. *Pestalotiopsis theae*, an endophytic fungus of an unidentified tree on Jianfeng Mountain, China, was capable of producing "Pestalotheol C" with anti-HIV properties [44].

ENDOPHYTES AND PLANT DEFENSE MECHANISM

Endophytes were also found to provide resistance in plant against herbivores and tolerance to stressful conditions and are also involved in changes in various physiological activities through the production of various chemicals, [16, 45, 46] and also have significance in evolution, adaptation and plant biodiversity [16, 47]. Some endophytes were reported to protect their host from insects;[48] Schulzt *et al*. (1999) [49] showed that host plant and endophyte relationship is able to balance pathogen host antagonism where as Arnold *et al*.(2003) [50] have view that leaves carrying fungal endophytes decreases both leaf necrosis and leaf mortality. Gundel *et al*. (2006) [51] observed that

in case of low availability of water, the endophyte infected seeds exhibits superior germination than non infected seeds. Le *et al*. (2009) [52] observed that endophytic fungi *Fusarium* sp. isolated from cultivated rice roots proved to be effective in biocontrol of a root knot nematode.

CONCLUSION

Fungal endophytes are going to play very important role in futures by showing a new path for production of novel active molecules. These new molecules can play important role as medicine to save the life of human beings. This group needs more exploration so that its potential can be utilized for the welfare of human beings.

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