ENDOPHYTIC MICRO-ORGANISMS AS EMERGING TREND OF SECONDAARY METABOLITE

Sucheta S.Tikole[a], Dr.Bapurao Tarate[a], Pournima Shelar[b],

[a] Alard college of Pharmacy, Pune, Maharashtra, India

[b] Institute of Pharmaceutical Education and Research, Limb, Satara, Maharashtra, India

ABSTRACT - Endophytes are defined as microorganisms that colonize living internal tissues of plants for all or part of their life cycle without causing apparent harm to the host. Due to long period of mutualistic relationship, co-evolution and association there is a possible intergeneric exchange of genetic information between host plants and endophytes. As a result it is assumed that endophytes may have the ability to produce similar secondary metabolites or bioactive compounds as that of their host plants thus triggering the expectation that endophytic fungi can serve as an alternative source of important plant secondary metabolites. Hence, there is worldwide-renewed scientific effort to isolate endophytes. Endophytic microbes may also have evolved to protect the plant from pathogens, insects, and harmful effects of irradiation, oxidation, and other natural events. Many endophytes are reported to have antimicrobial, insecticide, antioxidant and other biological activities.

Keywords- Endophytic fungi, Antimicrobial activity, Antioxidant activity,, Insecticidal.

INTRODUCTION

Endophytes are defined as “Microbes that colonize living internal tissues of plants without causing any immediate, overt negative effects, or all organisms inhabiting plant organs that at some time in their life can colonize internal plant tissues without causing apparent harm to the host.”[1] By definition, these microorganisms have a mutualistic relationship between the host plant and live in the intercellular spaces of plant tissues.[2,3] It is assumed that because of long period of co-evolution and association, there is a possible intergeneric exchange of genetic information between host plants and endophytes. As result endophytes may have the ability to produce the same or similar bioactive compounds as those originated from their host plants[4]. Plant endophytic fungi have proven to be an important and unusually rich source of bioactive natural products with their potential applications in agriculture, medicine and food industry[5]. Many valuable bioactive compounds with antimicrobial, pharmacological, insecticidal, cytotoxic and anticancer activities have been successfully discovered and reported from the endophytic fungi in the past two decades[6]. Some endophytes are rare. Many of the biologically active substances isolated from endophytic fungi are reported to be novel. Therefore, there is a world wide renewed scientific effort to isolate endophytes and study their natural products.[7]

PLANTS, ENDOPHYTES AS SOURCE OF SECONDARY METABOLITES

Natural products have played a fundamental role in drug discovery and development processes for a long time. Medicinal plants and their endophytes are important resources for discovery of natural products[7]. Many useful pharmaceutical agents are derived from plants and microbes. Technical improvements in screening programs, separation and isolation techniques, led to discovery of more than 1 million natural compounds. Of these 50–60% is discovered from plants which include alkaloids, flavonoids, terpenoids, steroids, carbohydrates, etc. and 5% are from microbial origin. 20–25% of the reported natural products have been shown to have biological activity. Furthermore, 45% of biologically active compounds that are obtained so far from microbes, are produced by actinomycetes, fungi and unicellular bacteria.[8]

Plant metabolites are often classified as either primary or secondary metabolites. Primary plant metabolites are substances widely distributed in nature, occurring in one form or another in virtually all organisms. Secondary metabolites are organic compounds that are not directly involved in the normal growth, development, or reproduction , or other "primary" functions of an organism. Absence of secondary metabolities does not result in immediate death, but rather in long-term impairment of the organism's survivability, fecundity, or aesthetics, or perhaps in no significant change at all. Secondary metabolites often play an important role in plant defense against herbivores and other interspecies defenses. Secondary plant metabolites are compounds biosynthetically derived from primary metabolites. Secondary metabolites are frequently accumulated by plants in smaller quantities than primary metabolites. They are often restricted to a narrow set of species within a phylogenetic group and are more limited in distribution in the plant kingdom. Each plant family, genus, and species produces a characteristic mix of these chemicals, and they can sometimes be used as taxonomic characters in classifying plants. Secondary metabolites are explored for many pharmacological, medicinal, agricultural and industrial applications. Secondary plant metabolites are extremely diverse present a broad range of medicinal properties.

Many secondary metabolites were identified as lead compounds. Further the structural complexity of these has inspired synthetic organic chemists to chemically modify and improve their pharmacological activity[9].

IMPORTANCE OF ENDOPHYTIC MICROORGANISMS[10]

Microorganisms also have been proven to be a valuable source of bioactive natural compounds. Microbial metabolites are being explored for various pharmaceutical, medicinal, foods, agricultural and industrial applications. It has been estimated that the pharmaceutical industry has screened on the order of more than 10,000,000 microbes of tremendous diversity for natural products over the past 50 years. Throughout the past 50 years many of the new drugs approved were either natural products or derivatives of natural compounds and 60 to 80% of new antibacterial and anticancer drugs are derived from natural products. The use of natural antimicrobial agents to treat infectious diseases has been one of the most significant successes in medicine as it is estimated that the use of antibiotics has saved more lives than any another medical therapy. There is a need for new drugs with a larger scope of action and less toxicity. Natural selection has been found to be superior to combinatorial chemistry for discovering novel substances. There is considerable interest in screening of novel potent and selective secondary metabolites and lead compounds having biological activities from extracts of plants and microorganisms.

Effective screening of microbial diversity for new molecules is hampered by the constantly repeated discovery of known natural products produced by dominant microorganism groups or because of lack of focus on isolating rare and novel microbial group. One crucial aspect to be considered for a successful discovery and screening of useful novel natural products is the selection of the source of the compounds to be studied. It is important to take into account that untapped sources of biological diversity that are often related to new chemical diversity. In the past few decades, plant scientists have begun to realize that plants may be serving as a reservoir of untold numbers of organisms known as endophytes. Endophytes are considered to be co-evolved as a friendly and mutualistic relationship with host plant. It is assumed that because of long period of co-evolution and association, there is a possible intergeneric exchange of genetic information between host plants and endophytes. As a result Secondary metabolites obtained from endophytes may have the ability to produce the same or similar bioactive compounds as those originated from their host plants thus triggering the expectation that endophytic fungi can serve as an alternative source of important plant secondary metabolites. By encouraging the endophytes to grow outside the plant in nutrient rich media, it is possible to harvest the bio-active compounds that plants produce. Chemical synthesis of secondary metabolites is difficult owing of their complexation with the available techniques of fermentation; it is possible to produce large quantities of these secondary metabolites Environmental factors and location influence the biology and metabolism of the endophytes. It is also expected that a greater number and diversity of classes of biological derived molecules possessing a range of biological activities may be produced by endophytes. Isolation of bioactive metabolites from endophytes known to possess antimicrobial, antiviral, anticancer and antidiabetic compounds is reported in literature. A significant number of interesting bioactive molecules have been found and reported to be produced by endophytes which include antibiotics, alkaloids, steroids, terpenoids, isocoumarins, quinones, flavonoids, phenylpropanoids, lignans, peptides, phenolics, aliphatics, and volatile organic compounds. Endophytes are an outstanding source of small novel molecules and represent a huge reservoir source of enormous potential for exploitation for producing antibiotics, pigments, toxins, pheromones, enzyme inhibitors, immunomodulating agents of medicinal, agricultural and industrial use.[11]

Table no. 1: Endophytic fungi and their biological activity[11,12,13,14]

Endophytic Fungi	Plant species	Biological activity
Colletotrichum spp.	*Artemisia annua*	Antimicrobial activity
Tubercularia spp	*Taxus mairei*	Taxol, Anticancer
Pestalotiopsis spp and Monochaetina spp.	*Taxus baccata and Taxus wallichiana*	Ambuic acid, Antimycotic and antifungal activity.
Paecilomyces sp. and Aspergillus clavatus	*Taxus mairei and Torreya grandis*	Brefeldin A, anticancer and antibacterial activity.
Muscodor albus	*Cinnamomum zeylanicum*	Antimicrobial activity
Phomopsis spp	*Urobotrya siamensis* and *Mesua ferrea*	3-Nitropropionic acid, Antimycobacterial
Penicillium spp.	*Aegiceras corniculatum*	Cytotoxicity
Pullularia pullulans	*Culophyllum spp.*	Cyclohexadepsipeptides, antiplasmodial and antiviral
Chaetomium spp and *Colletotrichum spp.*	*Nerium oleander L*	Antioxidant
Xylaria sp	*Ginkgo biloba L*	Antibacterial activity
Ampelomyces Spp.	*Urospermum picroides*	Cytotoxic and antimicrobial activity
Phomopsis species	*Erythrina crista-galli*	Antiinflamatory

PLANT-MICROBE INTERACTIONS

Most of the endophytes are fungi and bacteria. The symbiotic interactions between endophytic microbes and their hosts offer benefit to both of them. Symbiosis between a fungus and a plant is a widespread phenomenon in nature, which has been prevalent, ancient, evolutionary consequential in promoting diversity and plays a major role in structuring plant communities by affecting colonization, competition, co-existence and soil nutrients dynamics. The endophyte/host relationship is believed to be complex and variable from host to host and microbe to microbe. Currently, key elements for the evolution of the endophytic life style involve multiple levels of causation. These relationships are saved by biotic and abiotic environmental conditions, influenced by genetic factors, and have traits related to mutual exploitation. Endophytes, especially fungi are increasingly recognized as an important mediator of interactions between plants and their competitors, seed dispersers, herbivores and pathogens. Endophytes colonized plants often grow faster than non-colonized ones. Biodiversity of endophytes suggests that they can also be aggressive saprophytes or opportunistic pathogens.[15]

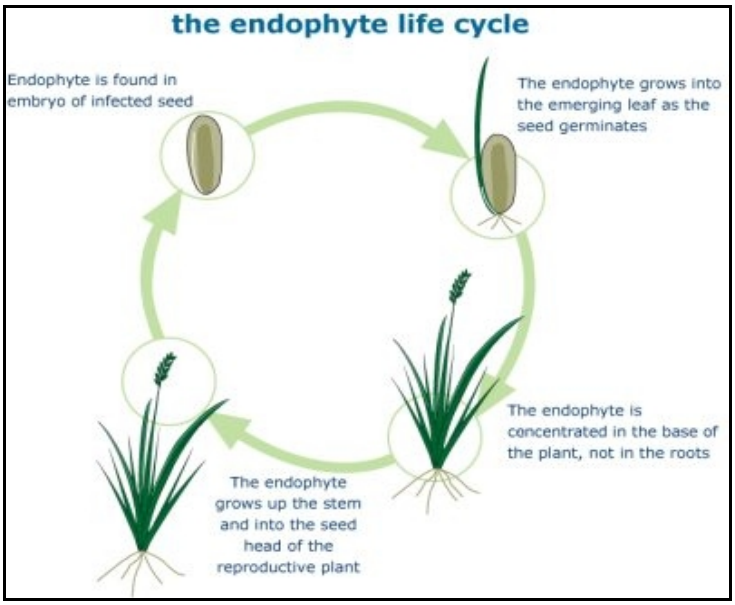

Fig No.8-The endophytic life cycle

Botanists have carried out much research into the plant/endophyte relationship, especially for grasses such as tall fescue, where they have shown that endophyte produces toxins that discourage insects and other grazing animals.[15]

The molecular and biochemical basis for the switch from endophytic to parasitic lifestyle are characterized by an imbalance in nutrient exchange that can explain why colonization of different hosts can cause a fungus to adopt contrasting lifestyles.It is likely that because of these long-held interactions, some endophytic microbes may have devised genetic systems allowing the transfer of information between themselves and the host plant.[15]

CONCLUSION

These results indicate endophytes can be potential sources for antimicrobial,anticancer, siderophore, biopigment secondary metabolites and for production of organic acids.

It is assumed that endophytes because of their symbiotic association and possible intergeneric exchange of genetic information with host plants may have the ability to produce the same or similar bioactive compounds as host plants. Endophytic fungi are potential sources of secondary metabolites and worthy of further investigation. We expect that the combined knowledge of microbial biodiversity, rational and random mutagenesis, along with bioprocess knowledge will provide the necessary tools to identify and culture endophytes that produce novel, potent pharmaceuticals on an economically viable scale.

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