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Plant Growth - Promoting Endophytes

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ABSTRACT

Endophytes are a group of plant associated microorganisms that infects to different plant tissues but does not show any visual symptoms, attracted a great interest of different researchers in the field of Agriculture. Microorganisms like bacteria, fungi and actinomyces can be a potential agent of endophytes in different plant species. Due to its great impact on the different crops, it is considered as a best alternative of different agro-chemicals used in the field of Agriculture. Endophytic microorganisms may promote plant growth by direct and indirect mechanisms. Endophytes promote plant growth and yield, suppress pathogens, may help solubilize phosphate and contribute assimilable nitrogen to plants. Some endophytes are seed borne, but others have mechanisms to colonize the plants that are being studied. Endophytes are useful for sustainable agriculture and help to reduced chemical use in agriculture and hence reduced pollution problem and increase soil health for better production.

Key words: *Microorganisms, Endophytes, Soil, Agriculture.*

INTRODUCTION

Microorganisms that reside within the plant tissues without doing substantive harm or gaining benefits other than securing the residency are considered as endophytes. Plants are gifted by nature with the diversified population of beneficial bacteria, including endophytes. Endophytes are the best example of the positive plant-microbe interaction, association of different plant species with microbes including bacteria and fungi. The interaction is such a complex that it is not fully understood. Endophytic microbes spend their whole or part of their life cycle living inside the plant causing no visual symptoms of disease[14]. Association of such positive plant associated microbes is increasingly gaining interest among scientific community and at the view point of industries due to their ability to improve plant quality and growth[5,25]. Current research is giving insight about the usefulness of endophytes in the production of various bioactive substances which have great value in ecology, medicine and pathology[31]. Researcher got the promising results in the application of such microbes in developing medicine resource and preventing disease and insects in agriculture practices. Isolation of endophytic microbes from the plant species was explained by Hallmann *et al*.,[14]. Briefly, plant tissue is surface sterilized with sodium hypochlorite solution. Since, the residual sodium hypochloride is toxic for microorganisms, it is necessary to rinse plant tissue with distilled water several times. After surface sterilization, tissue is crushed with sterilized

blade or other sharp tool. The suspension can be streaked on general or selective medium for the isolation of endophytic microbes. However, conformation of true endophytes requires not only the isolation from surface-disinfected tissues but also microscopic evidence to visualize "tagged" bacteria inside plant tissues[21]. True endophytic microbes must have the additional capacity to cause infection in disinfected seedling and other vegetative planting materials. Use of DNA sequencing technique from DNA of plant tissues can eliminate the laborious process of isolation and culturing of endophytes in the laboratory medium[8,10,22].

CLASSIFICATION:

Different microorganisms are associated with different plant species and it is largely influenced by the physical and chemical conditions prevailing. Several classification systems are available for the diversified microbial population present in the plant tissues. According to popular classification systems, bacteria, fungi and actinomycetes are the true endophytes[29].

Bacteria:

Different endophytic bacterial isolates have been isolated from different plants *Viz*. Cotton, corn and pea. Bacteria are associated with vascular and intracellar spaces parts of the plant. Both Gram positive and Gram negative bacteria are associated with plant, major families include pseudomonadaceae and Enterobacteriaceae[19]. Many endophytic isolates have capacity to tolerate salinity and alkalinity[15].

Fungi:

A first endophytic fungus was isolated by Strobel (1993) from a medicinal plant-*Taxus brevifolia*[17]. Plant generally harbour the vast diversified fungal population, majority of them are un-identified[2]. More than 80 genera of endopytic fungi are applied widely in the grass species for the promoting plant growth and minimizing disease and pest attack.

Actinomyces:

Most studied endophytic actinomyces is the *Streptomyces*, found to be associated with all the parts of plant, roots, stems and leaves of plant with highest in root[31]. This isolate was obtained from the medicinal plants which can induce secondary metabolite production which is of very important value. Research on the endophytic actinomyces is more at the view point of medicine but agricultural application point of view it is limited. *Streptomyces* isolate NRRL 3052 obtained from Australian native medicinal plant *Kennedia nigriscans* releases munumbicins B which is effective against a MRSA (Methicillin Resistant Staphylococcus aureus), and also demonstrated activity against *Bacillus anthracis* and multidrug-resistant *Mycobacterium tuberculosis*[7].

MECHANISM OF ACTION

Endophytic microorganisms confer the plant fitness by different mechanism of action. The main action includes:

Increase availability of nutrients

Different microbes have the capacity to fix, solubilise, mobilize the micro and macro nutrients and made it available to the plant. Application of such microorganisms in the plant can reduce use of chemical fertilizers. Phosphate solubilisation among endophytic microbes isolated from soyabean was reported by Kuklinsky-Sobral *et al*.[16]. Several nitrogen fixing microbes associated with sugarcane can fix atmospheric nitrogen in the range from 30 to 80 kg N/ha/year[4]. Different grasses growing in the nitrogen deficient soil harbours several nitrogen fixing endophytic bacteria *Viz*. *Pseudomonas, Stenotrophomonas* and *Burkholderia* that can fix atmospheric nitrogen to ammonia.

Suppression of plant pathogens and insects:

Plant diseases and pests are considered as major factor for restraining agricultural development. Conventionally diseases and pests are managed by the use of toxic chemical pesticides. Application and overuse of such chemicals in the agriculture can cause environmental pollution as well as animal and

human health related problems. Biocontrol organisms have the superior ability to control such harmful organisms in the agriculture and ultimately solves environmental and health related issues by reducing or minimizing use of toxic chemicals in the agriculture[2]. Different researchers have proposed different possible mechanism of action of endophytes. However, the knowledge for the mechanism behind endophytic plant pathogen suppression is still in the early age. The possible mechanism includes direct effect, indirect effect and ecological effects. In the case of direct effect, endophytes directly suppress pathogens by antibiosis, secreting lytic enzymes. However, the direct interactions between fungal endophytes and pathogens are complex and sensitive to species-specific antagonism[1]. Application of several endophytic bacterial isolates in banana seedling at earlier age can reduce the 60 percent incidences of banana bunchy top viruses as compared to control[7]. Several endophytic fungi (Clavicipitaceae, Ascomycetes) can produce organic molecules such as alkaloids during plant association period. This activity greatly reduced plant infection, reducing the survival and the development of *S. frugiperda* in Graminae and Cyperaceae. Infection of endophytic fungi to flour beetles *Tribolium castaneum* resulted in a reduction of infested seeds and insect growth[9]. Systemic acquired resistance (SAR) and induced systemic resistance (ISR) are two different mechanisms for induced resistances in the plant immunity. SAR, induced by pathogen infection, is mediated by salicylic acid (SA) and pathogenesis-related (PR) proteins. ISR, induced by some Plant Growth Promoting rhizobacteria (PGPR), is mediated by jasmonic acid (JA) or ethylene but no accumulation of PR proteins[30]. These PR proteins are a group of enzymes, such as chitinases and glucanases[11]. Accumulation of PR protein inside plant may cause lyses and death of fungus and other parasites. *Citrullus lanatus* and *Cucumis sativus* exposed to a nonpathogenic mutant of *Colletotrichum magna* exhibited high levels of lignin deposition, peroxidase activity and phenylalanine ammonialyase activity and obtained the protection against disease caused by *Colletotrichum orbiculare* and *Fusarium oxysporum*[20].

Phyto-hormone production

Role of different microorganisms in the production of phytohormoes is well documented aspects in the plant-microbe relationship studies. Endophytic microorganisms have the capacity to produce plant growth promoters i.e. IAA and gibberellins. Several microbes have ACC (1-aminocyclopropane-1-carboxylate) deaminase activity that degrade immediate precursor of ethylene (ACC) to ammonia and alpha-ketobutyrate and thereby reduces level of plant growth regulator ethylene. High level of IAA and low level of ethylene increases root and shoot length as well as weight of the plant[12]. Different bacteria such as *Enterobacter spp., Pseudomonas spp.,* and *Azospirillium spp.* are associated with ACC deaminase and plant growth promotion activities[27].

Degradation of toxic molecules:

Many endophytic microorganisms possess genetic machinery for the degradation of toxic and recalcitrant molecules present in the rhizosphere region and other contaminates sites. Bacteria degrading recalcitrant compounds are more abundant among endophytic populations than in the rhizosphere of plants in contaminated sites[26], indicated role of endophytes in the process of bioremediation. Application of genetically modified *Burkholderia cepacia* improved phytoremediation and promoted plant tolerance to toluene[3].

Draught tolerance

Draught tolerance is the adaptation that can provide plant tissues to withstand water deficits[6]. Different plants have different mechanisms for draught tolerance. Mechanisms have been categorized in three major groups

1. Accumulation and translocation of assimilates
2. Maintenance of cell wall elasticity
3. Osmotic adjustment

All the three mechanisms are affected by the endophytic microorganisms. Endophyte infected plant produced more soluble sugars such as glucose and fructose in their leaf blades, indicated evidence of first mechanism[23]. Additionally, endophyte may drive the plant metabolism for the secretion of soluble sugars, amino acids such as proline, polyols, alkaloids etc. that confers wall elasticity and osmotic adjustment during draught condition. Many microbes have the capacity to secrete enzyme ACC deaminase that reduces level of ethylene, a plant growth suppressing hormone which is more during draught.

Endophyte and pathogenicity:

Most of the fungal and bacterial endophytes are considered as mutually beneficial partners with the plants. Endophytes may promote the plant growth by direct or indirect mechanism and in turn microbes will get nourishment from the host plant. As a living organism, microbes are also facing the ever changing growth conditions; it may turn endophyte to pathogen. It is observed especially in fungus that the organism may become plant pathogen depending on the developmental stage of host and fungus, environmental factors, and host defense responses[24]. Several researchers reported that endophytes may become latent pathogen due to changes in environmental conditions such as CO_2 accumulation or O_2 depletion[18].

Several endophytes have been also reported as a cause of human diseases. Association of endophytic *salmonella* in raw fruits and vegetables can cause severe outbreaks and health related issues[13]. Similarly, presence of bacteria *Burkholderia* can cause pulmonary disease and *Nocardia* can lead to nocardiosis in human. Even, may plants harbour *Mycobacterium* as an endophyte, although it possess pathogenicity gene or not it is not clear.

Limitations of endophytes application:

Availability of the competent endophytic microorganisms that could perform its function under diverse ecological situation and under the influence of complex rhizosphreic plant microbe interaction is the area need to be explored. Several problem associated with the applications are complex microbial community-plant interaction, poor rhizosphere competence with endogenous microorganisms[28]. Bacterial population is also affected by the changing environmental conditions and prevailing soil physical, chemical and biological properties. In such conditions, viability of particular endophytic microbial population is somewhat questionable. Apart from the functionality of endophytic microbes, proper formulation, marketing, production methodology are also considered as major constraints in the use of such beneficial microbes in the agriculture. Some of the plant associated endophytes are opportunistic plant, animal or human pathogen and use of such microbes can cause mild to severe illness and some time disease outbreak.

CONCLUSION

Endophytic microorganisms are the best partner of plant and can accelerate plant growth by different mechanism of action, direct and indirect. The major impact of adoption of such beneficial microorganisms in the field of agriculture is the reduction of use of different agro-chemcials such as pesticides, chemical fertilizers, other artificial chemicals etc. that would make agriculture more productive and sustainable. However, there are many limitations and constraints are the major hurdles in the effectiveness of such eco-friendly technology in the Agriculture. Reseacher should focus to overcome such constraints and make the technology more viable to retain sustainability of Agriculture.

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