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Mini Review

Actinomycetes: Dependable Tool for Sustainable Agriculture

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Abstract

In fast developing countries, especially in countries like India where there is always huge demand for food grains, the most important question that arises is whether we are running towards depletion or growing towards sustainable future. The balance towards more sustainable future could be attained only by finding and employing most efficient and multi-faceted alternate farming techniques instead of completely depending upon chemicals. One of the most efficient tools in achieving this is organic farming especially the usage of rhizobacteria with multiple PGPR traits. Actinomycetes are one of the most important groups of the rhizosphere colonizing bacteria with multiple growth promoting traits. They are already well-known for their ability to produce broad spectrum antibiotics. In recent years Actinomycetes are widely studied for their plant growth promoting activities and few are commercialized. This article shows the importance of this group of bacteria as potential tools for more eco-friendly and sustainable agriculture.

Keywords: Actinomycetes; PGPR; Streptomyces; Plant growth; Phytopathogens; Agriculture

Introduction

In modern agriculture, there are a lot of challenges especially in developing countries, where the fast growing population increases the demand for food grains and the need for trading and economic development increase the demand for various cash crop products. Another challenge the modern agriculture faces is the emergence of many phytopathogens that pose serious threat to productivity and quality of the products produced. These challenges are contained to a great extent by the usage of fertilizers and chemical agents like fungicides, insecticides, etc. While on one hand these chemicals help farmers reap benefits, there is always a negative side to excessive usage of chemicals in agricultural fields. The major downside is that the chemicals often deplete the soil of its fertility and natural composition, thereby making it sterile and lose its natural biodiversity and beneficial microorganisms. Also bio-magnification and residual activity of these chemicals pose serious threats to human health. So there is a pressing urgency to reduce these harmful chemicals and improve the soil fertility by embracing eco-friendly practices. In order to replenish the soil with its natural fertility, it is essential to reintroduce the beneficial bacteria in the soil. Usage of this plant growth promoting rhizobacteria can be helpful in two ways that is they can act as biofertilizers as well as biocontrol agents [1]. Among these bacteria, Actinomycetes have a very special place because of their ability to inhibit the growth of wide range of bacterial and fungal phytopathogens by producing different bioactive compounds that are toxic to phytopathogens but do not give any toxic effect to humans or environment [2,3]. These traits make Actinomycetes an attractive alternate for chemical use.

Plant Growth Promotion by Actinomycetes

The most abundantly occurring Actinomycete in soil is *Streptomyces*. The genera, *Nocardia, Micromonospora* and *Streptosporangium* are less abundant Actinomycetes. Actinomycete species can grow in close association with plant roots and they are one of the most important root colonizing organisms, especially *Streptomyces*. Their thread-like filamentous colonial morphology helps them to colonize the rhizosphere area efficiently, which in turn enables to establish host – rhizobacteria symbiosis very

effectively [4]. After they establish effective colonization, the Actinomycetes are able to produce many organic compounds and enzymes that are beneficial to plants (Table 1). The ability to produce these compounds enables the actinomycetes to break down complex organic matter in the soil into simpler forms for the plants to absorb easily. Also they have many pathways to produce plant growth promoting compounds such as IAA, Siderophores, etc. [5-9]. It has been reported that around 60% of insecticides and bioactive compounds were discovered in the past 5 years from Actinomycetes especially *Streptomyces* sp. [10,11].

Table 1: Enzymes and compounds produced by various Actinomycete species [7-10].

Enzymes and compounds	Actinomycete species
Chitinase	*Streptomyces viridificans, S. coelicolor, S. griseus, S. albovinaceus, S. caviscabies, S. setonii, S. viginiae*
Cellulase	*Thermonospora spp. Actinoplanes philippinensis, A. missouriensis Streptomyces clavuligerus*
Peptidases	*Nocardia spp.*
Proteases	*Nocardia spp.*
Xylanases	*Microbiospora spp.*
Lignases	*Nocardia autotrophica*
Amylases	*Thermomonospora curvata*
Lipases	*Streptomyces spp.*
β-1-3-glucanase	*Streptomyces spp.*
Indole Acetic Acid (IAA)	*S. olivaceoviridis, S. rimosus, S. rochei, S. griseoviridis, S. lydicus, S. viridis, S. coelicolor, S.olivaceus, S.geysiriensis*
Phenazines	*Streptomyces fulvorobeus, S. luridiscabiei, S. fimicarius, S. griseus, S. mediolani, Micromonospora matsumotoense*
Siderophores	*Streptomyces spp.*
Catechol – type Siderophores	*Streptomyces, Actinopolyspora, Nocardia, Saccharopolyspora, Pseudonocardia, Micromonospora*
Novel Anti-Fungal metabolites	*Streptomyces cavurensis., Saccharopolyspora spp., Nocardiopsis spp., Nocardia spp.*
Plant hormone – like compounds	*Streptomyces hygroscopicus*
Nitrogen fixation	*Frankia spp.*
Phosphate Solubilization	*Micromonospora endolithica*

This makes Actinomycetes efficient as biocontrol agents against a wide range of fungal and bacterial phytopathogens (Table 2). The isolate *Streptomyces gresioviridis* is commercialized as biofungicide [12,13]. Many researchers have demonstrated the Plant Growth Promoting efficacy of Actinomycete species in various plants such as pea, beans, tomato, wheat and rice under field conditions [14-16]. Moreover they also interact synergistically with beneficial vesicular arbuscular mycorrhizal (VAM) fungi which are considered very important in plant uptake of nutrients from the soil. Actinomycetes also help in nutrient cycling and degradation of complex organic matters in the soil into simpler forms and play important role in the bio-geo cycles and help maintain equilibrium in the soil environment. Thus they also play a crucial role in maintaining a healthy ecosystem. One more desirable trait in this group of bacteria is the ability of many Actinomycete isolates to form spores, so they can survive through draught or salinity and they can resume their growth in favorable conditions, so that their population in soil environment will not dwindle, as in the case of non-spore-forming eubacteria [17].

Table 2: Various Actinomycete species showing biocontrol activity against phytopathogens [9,10,14,15].

Biocontrol Activity	Actinomycete Isolate
Biocontrol of Rice fungal pathogen	Streptomyces vinaceusdrappus
Biocontrol of Verticillium sp. in cotton	Streptomyces netropis
Biocontrol of Phytophthora cinnamomi in Snapdragon and Banksia	Actinomadura sp., Micromonospora carbonacea
Biocontrol of Fusarium udum in cotton	Micomonospora globosa
Biocontrol of Pythium ultimum causing damping off disease	Streptomyces griseus
Biocontrol of Fusarium oxysporum wilt disease	Nocardia levis
Biocontrol of Phytophthora megasperma in soybean	Actinoplanes Missouriensis, A. utahensis, Amorphosporangium auranticolor
Biocontrol of Pythium aphinidermatum	Actinoplanes sp.
Biocontrol of Alternaria alternata leaf blight disease in groundnut	Streptomyces violarus

Conclusion

Actinomycete isolates have proved to be effective in a multi-dimensional way. They involve in various plant growth promoting activities such as IAA production, siderophore production, phosphate solubilization, Nitrogen fixation, complementing VA Mycorrhizal fungi and also balancing out the ecological balance in the soil system. Moreover there are great numbers of evidences that prove Actinomycetes as potential biocontrol agents. All these qualities of this special group of bacteria make them inevitable tools in increasing agricultural productivity and quality. Considering all these aspects, it is high time that we focus on Actinomycetes as alternative tool for reducing harmful chemical usage to promote eco-friendly and sustainable farming practices.

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