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Marine Streptomycetes: Characteristics and Their Antifungal Activities.

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ABSTRACT

Marine microorganisms widely distributed on our oceans of the earth and emerging as the great source for the discovery of natural products. Marine Actinomycetes are virtually unlimited sources of novel compounds with many therapeutic applications and hold a prominent position due to their diversity and proven ability to produce novel bioactive compounds. Actinomycetes represent a high proportion of the soil microbial biomass and hâve the capacity to produce a wide variety of antibiotics and of extracellular enzymes. Several strains of actinomycetes hâve been found to protect plants against plant diseases. This review focuses on the potential of marine actinomycetes as (a) source of agroactive compounds and biocontrol tools of plant diseases.

Keywords: Microbial metabolites; Bioactive compounds; actinomycetes.

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INTRODUCTION

Marine microorganisms have become an important source of study in the search for novel microbial products (Gulve and Deshmukh 2011). Today both academic and industrial interest in marine microorganisms is on the rise. Marin eactinomycetes are useful and suitable source of new bioactive natural products. The discovery of new bioactive natural products from marine sources has become an important research area due to the extraordinary chemical diversity and novelty found in marine natural products and their potential applications as lead compounds in drug development (Molinski *et al*., 2009 and Mayer *et al*., 2011). The ocean covers approximately 70% of the Earth's surface and has the potential to provide a treasure trove of largely unexplored biodiversity. In the past 30 years, bioprospecting for new marine natural products has yielded several thousand chemically diverse compounds ; in 2009 to 2010 alone 2,014 novel marine natural products were discovered (Blunt *et al.,* 2011 and 2012). Clearly, such recent discoveries suggest that marine microorganisms have the potential to be a massive resource for bioactive natural product discovery. The genus *Streptomyces* is represented in nature by the largest number of species and varieties, which differ greatly in their morphology, physiology, and biochemical activities. Streptomyces is a genus of 500 species of gram positive, filamentous bacteria in the Phylum Actinobacteria, Order Streptomycetales, Family Streptomycetaceae. Streptomyces are ubiquitous in soil habitats and aquatic sediments (Gontang *et al*., 2007). *Streptomyces* are a group of prokaryotes that are usually found in all types of ecosystems including water and soil. Among their most notable features is their capacity to produce an extraordinary diversity of antibiotics. Streptomyces have been estimated to produce up to 100,000 distinct antimicrobial compounds, of which only a small number have been identified to date (Watve *et al*., 2001). Marine actinomycetes are a potential source of novel compounds as the environmental conditions of the sea are entirely different from the terrestrial conditions (Meiying and Zhicheng, 1998). Marine sediments represents rich in nutrition and moisture, provides main source for producing antimicrobial metabolites (Takuji Nakashima *et al.,* 2009).

Actinomycetes as source of Agroactive compounds

Actinomycetes are widely distributed group of microorganism in nature and have the capacity to synthesise many biologically active secondary metabolites (*Rao et al.* 2013). The marine actinomycetes produce variety of enzyme inhibitors, antibiotics and anticancer compounds. Many researchers have isolated novel antibiotics from the marine environment (Sujatha *et al*., 2005; Charan *et al*., 2004). The marine actinomycetes are the good source of enzyme inhibitors (Imade, 2005 and Pimentel-Elardo *et al*. 2010). Some of the novel secondary metabolites from marine actinomycetes have been isolated recently include Abyssomicin C, from *Verrucosispora* sp., a secondary metabolite with potent inhibitory action on para aminobenzoic acid synthesis (Riedlinger *et al*., 2004). Salinosporamide A, an anticancer compound from *Salinispora* sp. (Fehling *et al*., 2003) and a novel marinopyrroles from *Streptomyces* sp. (Hughes *et al*., 2008) have been isolated. Sea water dependent actinomycete *Salinispora* sp. (Maldonado *et al*., 2005) proved that the marine environment is still an untapped source of diverse group of actinomycetes with unique biological functions. However, the reports on biodiversity of actinomycetes are very limited. Almost 60% of the antibiotics discovered in the year 1990 and most of the antibiotics (Streptomycin related antibiotics) are from the genus *Streptomyces* (Ramesh and William 2012). Further they are developing as therapeutic agents for various plant diseases. Antibacterial (Ramesh and Mathivanan 2009, Berdy 2005), antifungal (Ramesh and Mathivanan 2009; Prabavathy, *et al*.,2006), anti-parasitic (Pimentel-Elardo et al. 2010), antiviral and anti-infective (Rahman *et al.* 2010 and 2012), insecticidal (Sacramento et al.2004), antitumor (Ramesh and Mathivanan 2009), antiinflammatory, antioxidant (Teppei 2012) and herbicidal compounds (Sousa , 2008).

It is possible to isolate strains which substrates are pollutants which contribute to environmental protection. Primarily, the advantage is a possibility of isolation a strain which metabolite product high value product or finds a new metabolite which leading to the development of new products (Atta and Ahmad 2009 and Selvameenal *et al*., 2009). Actinomycetes have been a source of a numerous useful products including pharmaceuticals, agrochemicals, enzymes for use in a number of industrial applications from food industry to papermaking (Rao *et al.* 2013). About three quarters of all the known commercially and several agriculturally important compounds were obtained from the streptomycetes. Further, they are well known for their capability of producing various extracellular hydrolytic enzymes including ribonucleases (Brunakova et al., 2004, Ramesh et al., 2009, Ramesh and Mathivanan, 2009 and Hong et al., 2009). The cellulolytic activity of marine actinomycetes was described by Chandramohan *et al.* (1972), chitinolytic actinomycetes were reported by Pisano et al. (1992) and various industrially important enzyme producing actinomycetes have

been reported (Ramesh and Mathivanan 2009). Actinomycetes are also reported to contribute to the breakdown and recycling of organic compounds (Goodfellow and Haynes 1984). In addition, they play a significant role in mineralization of organic matter, immobilization of mineral nutrients, fixation of nitrogen, improvement of physical parameters and environmental protection (Goodfellow and Williams 1983).

Streptomycetes as biofungicide

Fungal phytopathogens cause serious problems worldwide in the cultivation of economically important plants. Chemical fungicides are extensively used in current agriculture. However, excessive use of chemical fungicides in agriculture has led to deteriorating human health, environmental pollution, and development of pathogen resistance to fungicide. Because of the worsening problems in fungal disease control, a serious search is needed to identify alternative methods for plant protection, which are less dependent on chemicals and are more environmentally friendly. Microbial antagonists are widely used for the biocontrol of fungal plant diseases. *Streptomyces* have ability to produce extracellular antifungal metabolite(s) against pathogens has been reported. Several members of the streptomycetes family have been reported as potential biocontrol agents and as the potent producers of antifungal compounds (Haggag Wafaa and Elham Abdallh 2012 ; Haggag Wafaa and Abdall, 2011 ; Hagga, Wafaa *et al*., 2012)., indicating that these filamentous bacteria possess a vast potential for producing antifungal metabolites. In search for antifungal agents, *Streptomyces* strains have been isolated from various types of soils, including rice paddy, lake mud and water, deciduous forest, tropical forest, wasteland, and cave soils (Jiang, and Xu, 1996, Kim, et al., 1998 and Shomura, 1993).

Their natural habitat soil is nutritionally, biologically and physically complex and variable, demanding their fast adaptation. As a consequence, they are able to perform a broad range of metabolic processes and to produce an immense diversity of bioactive secondary metabolites. The antifungal potential of extracellular metabolites produced by soil-borne *Streptomyces* isolates could be exploited for its future use as a biofungicide. The chitinolytic actinomycetes were reported and various industrially important enzyme producing actinomycetes have been reported (Ramesh and Mathivanan 2009). According to Peela *et al*., (2005) numerous marine actinomycetes have been isolated from the samples collected from Andaman coast in Bay of Bengal and the majority of isolates belong to the genus *Streptomyces* with antibacterial and antifungal activity.

A total of 160 isolates of marine actinomycetes were isolated from the sediment samples drawn from mangroves, estuary, sand dune, and industrially polluted coast. Of these, mangrove sediments were rich sources of marine actinomycetes. Each isolate was tested against four phytopathogenic fungi*, viz. Rhizoctonia solani, Pyricularia oryzae*, *Helminthosporium oryzae* (causing sheath blight, blast and leaf spot diseases of rice) and *Colletotrichum falcatum* (causing red rot disease of sugar cane) (Kathiresan *et al.,* 2005). These isolates appeared to produce high antifungal compounds at 120 hrs of incubation period of production medium culture. These strains may prove to be the potent source for isolation of agrobased fungicides. (Gunasekaran Mohanraj and Thangavel Sekar 2013**)** . Marine sediments were collected from 28 points in the Bay of Bengal and totally 52 actinomycetes were isolated using different isolation media. All the above isolates were characterized and identified by microscopical and macroscopical observations. Identification of the isolates revealed that all isolates belong to the genus *Streptomyces*. The isolated marine actinomycetes were screened for their antimicrobial activity against the human bacterial pathogens *Salmonella typhi, Escherichia coli, Bacillus cereus, Staphylococcus aureus* and *Klebsiella pneumonia* and fungal phytopathogens *Rhizoctonia solani, Macrophomina phaseolina, Fusarium udum* and *Fusarium oxysporum f.* sp. *lycopersici*. Shantikumar singh *et al.* (2006) reported 37 actinomycetes from lake sediments, out of them 21 isolates exhibited antimicrobial activity especially 12 active isolates exhibited good antifungal activity. Among 52 isolates performed for antifungal activity test, a total of 20 isolates possess antifungal activity, of which 2, 12, 8 and 10 are active against the *Rhizoctonia solani*, *Fusarium udum*, *Fusarium oxysporum f.* sp. *lycopersici* and *Macrophomina phaseolina* respectively whereas 32 isolates showed no activity. Kathiresan *et al*. (2005) isolated 160 marine actinomycetes and 31% of them are proved to be potential against *Rhizoctonia solani*.

Streptomyces capable of producing growth regulators or Indole Acetic Acid (IAA). Another mechanism by which disease suppression occurs in foliage by rhizosfer bacteria is induced systemic resistance or ISR (Choudhary *et al*., 2007). Plant resistance mechanism in this way involves the translocation of plant signal from roots to foliage that activates plant resistance. Application of *Streptomyces* through seed coating may

induce systemic resistance. Early colonizing roots of germinated seeds may activate natural plant resistance mechanisms that will increase the capacity of plant defenses against multiple pathogens that will attack later. Soaking seeds in *Streptomyces* suspension further increase the population of *Streptomyces* that can colonize the roots.

Therefore, these *Streptomyces* can be considered for isolation of novel secondary metabolites which may be of importance for various biocontrol and applications. Use of biocontrol agents such as these broad-spectrum *Streptomyces* isolates will probably be one of the important tactics for plant disease management in the near future as they allow the reduced use of pesticides and fertilizers that are potential pollutants of the environment.

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