# Review on: Actinomycetes as a Biological Control

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***Abstract-*** **Actinomycetes are recognized as able to improve plant growth direct by producing some phytohormones and increasing soil nutrient availability and by indirect mechanisms by producing bioactive compounds against the phytopathogens. Different isolates are obtained from the samples drawn from the rhizospheric plant soil. The isolates are then tested against the two phytopathogenic fungi i.e., *Sclerotium rolfsii* and *Cercosporidium personatum.* The isolates if able to inhibit the growth of phytopathogen are then checked for their bioactive compound. Starch and casein proves to be the best carbon and nitrogen source. Based on the morphological and cultural characteristics, the potent strains producing antifungal compound are to be identified and these strains may prove to be the potent source for prodution of agro-based fungicides. The antifungal potential of metabolites produced by soil-borne actinomycetes could be exploited for its future use as an antifungal compound.**

***Key words:Actinomycetes*, phytopathogens, antifungal activity, bioactive compounds, fungicides.**

## INTRODUCTION:

Especially in tropical and subtropical areas, fungal phytopathogens are the source of several plant illnesses as well as significant crop output losses. The most useful prokaryotes in terms of both economics and biotechnology are actinomycetes, which are capable of producing a broad variety of bioactive secondary metabolites, including enzymes, anticancer agents, antibiotics, and immunosuppressive compounds. Antibacterial, antifungal, neutritogenic, anticancer, antifungal, antimalarial, and anti-inflammatory properties are known to be possessed by these metabolites. The rhizosphere of plants contains *Streptomyces*, and it has been suggested that these fungi may shield roots from potential infections by preventing the growth of certain fungi. The synthesis of antifungal substances or enzymes that break down the fungal cell wall can accomplish this. Prokaryotes called actinomycetes have a hyphal shape, which makes them resemble fungi. Most of the actinomycetes that have been reported are microorganisms found in soil.

Actinomycetes, formerly referred to as *actinobacteria*, are classified as filamentous, Gram-positive, spore-forming bacteria with DNA that typically contains between 57 and 75% G+C. Actinomycetes are thought to be a distinct class of microorganisms that lie between true fungi and true bacteria. 50% of *actinobacteria* are made up of the *Streptomyces* genus, which also produces 75% of the antibiotics that are used commercially. The enzymes that the actinomycetes produce include pectinase, amylase, lipase, protease, cellulose, and xylanase. These are all important industries. Microbes produced over 22,500 bioactive chemicals, of which 17%, 38%, and 45% were extracted from actinomycetes, unicellular bacteria, and fungus, respectively. A significant problem in agricultural crops is fungus-related disease. (8)

The fungicides that are now in use are either very environmentally hazardous or less effective.(1-3) Therefore, the development of effective and ecologically safe natural fungicides is imperative. It has been anticipated that microbial metabolites will reduce the harmful side effects of synthetic fungicides. Given that actinomycetes are known to produce powerful antibiotics, further research on them is warranted.

Athlete's foot, ringworm, and several other deadly diseases affect both plants and animals, and fungal phytopathogens are major global health issues. Fungi can produce rusts, smuts, rots, and other plant diseases that can seriously harm crops. Some of the largest and possibly oldest organisms in the earth are fungi. Mycotoxins are produced by certain fungal species and are extremely poisonous to humans. For example, ergot poisoning is brought on by the fungus *Claviceps purpurea*. A mycotoxin-infected person develops gangrene, blood flow problems in his limbs, and hallucinations.

Actinomycetes are filamentous Gram-positive bacteria that belong to the phylum Actinobacteria, one of the largest taxonomic groups among the 18 major lineages that are currently recognized under the Domain Bacteria. They are distinguished by a complex life cycle. (1)

These days, a lot of uncommon actinomycetes are isolated from plants. For instance, the culture broth of a novel endophytic actinomycete strain K07-0460T has been revealed to contain novel antitrypanosomal chemicals called spoxazomicins (*Streptosporangium oxazolinicum sp. nov.).* This strain was isolated from the roots of several different orchids and was determined by phylogenetic analysis to belong to the genus *Streptosporangium*. The same researchers also discovered two new genera: *Actinophytocola oryzae* GMKU 367T and *Phytohabitans suffuscus* K07-0523T. Thus, it's possible that recently found actinomycetes could be found in plant roots.(2)

Actinomycetes can be found in many groups that are stable in both rhizosphere plants and bulk soil. Many plants depend on actinomycetes for growth, and rhizospheric streptomycetes in particular can shield plant roots from fungal pathogens by preventing their growth. This ability stems from actinomycetes' capacity to generate antifungal drugs in vitro.(3)

It has long been known that actinomycetes have some general properties. But in the past few years, additional information regarding their diverse natural roles has become available. *Micromonospora* and *Actinoplanes* were found in the first half of the 20th century, while two genera, *Streptomyces* and *Frankia*, were found in the second half of the 19th century.(5)

With almost 700 species, the *Streptomycetaceae* family (order *Actinomycetales*) is led by the genus *Streptomyces*. They are neutrophilic and Gram-positive, facultative aerobic, mesophilic filamentous bacteria with a DNA content of more than 70% that thrive at a temperature of 25 to 35 °C. The life cycle of *Streptomyces* microorganisms is intricate. Spore-producing bacteria are called *streptomyces* species. Spore germination marks the beginning of the bacterial life cycle.

The hyphae's terminals stretch to form the germ tubes, which subsequently branch. The vegetative mycelium eventually takes the form of a thick network of vegetative cells. The growth cycle of *streptomyces* consists of three stages: sporulation, aerial hyphae production, and vegetative growth.

***Nitrogen fixation:***

*Actinobacteria* have evolved a variety of lifestyles and are widely spread in both aquatic and terrestrial environments. One of the genus *Frankia's* unique characteristics is its capacity to form symbiotic relationships with a wide range of plant hosts, known as actinorhizal plants. It was discovered that this genus is the only actinobacterium that fixes nitrogen. (6) Prokaryotes that can use the nitrogenase system to convert $N_2$ into ammonia. Biological nitrogen fixation is the process by which bacteria assist in the reductive conversion of air elemental nitrogen into ammonia. Actinomycetes, bluegreen algae, and some eubacteria are among these microorganisms.(6)

The finest example of this type that can fix atmospheric nitrogen is *Azotobacter* since it possesses many nitrogenase enzyme types.(7) The primary agent of the symbiotic nitrogen fixation in legume crops is Rhizobium.(7)

***Structure of actinomycetes:***

Actinomycetes have a stiff cell wall that keeps the cell from bursting from high osmotic pressure and preserves the cell's form. Polysaccharides, peptidoglycan, teichoic and teichuronic acid, and other complex substances make up the wall. The peptidoglycan, which is specific to prokaryotic cell walls, is made up of glycan (polysaccharides) chains that alternate between N-acetyl-d-glucosamine (NAG), N-acetyl-d-muramic acid (NAM), and diaminopimelic acid (DAP). Peptidoglycan is chemically linked to teichoic and teichuronic acid. Although the chemical makeup of their cell wall is comparable to that of gram-positive bacteria, actinomycetes are thought to be a distinct group from other common bacteria due to their well-developed morphological (hyphae) and cultural traits.(4)

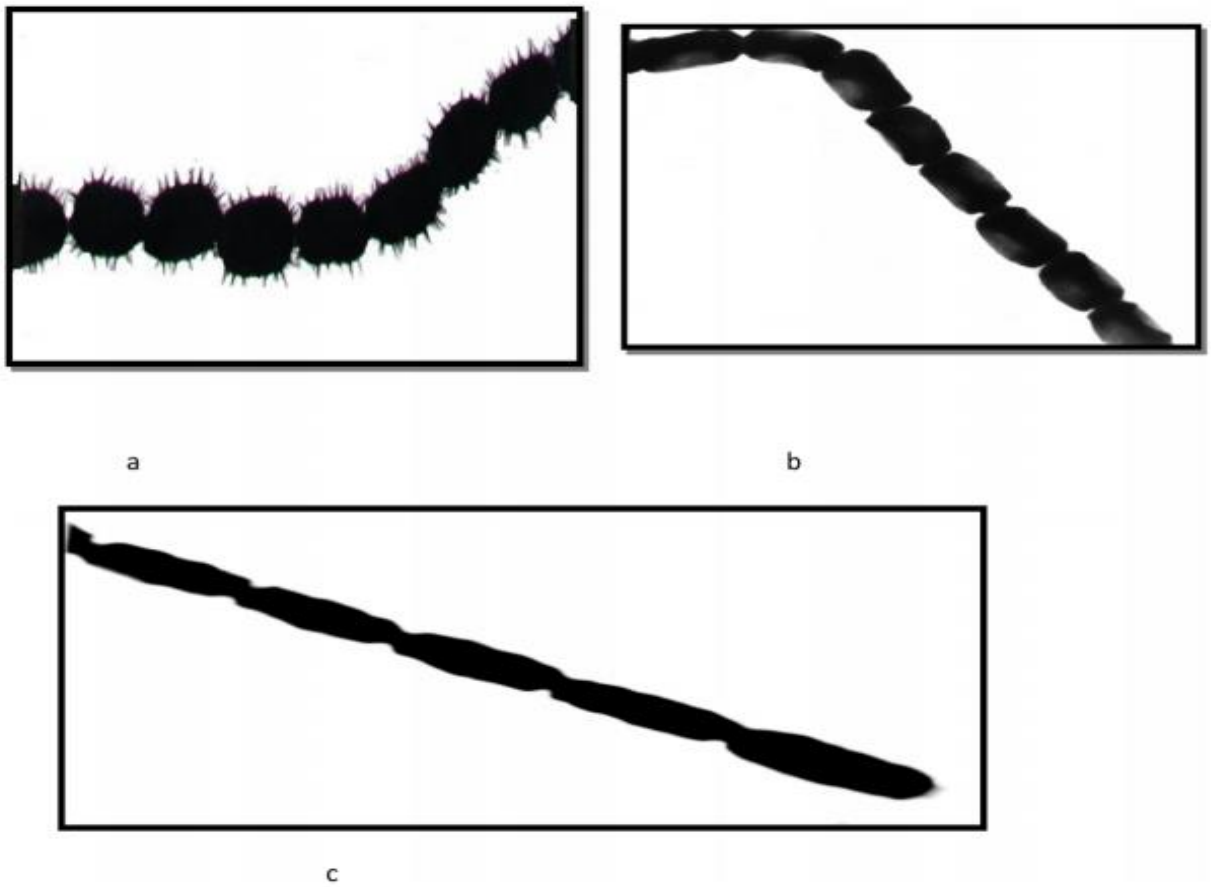


**Fig.1.** Different types of spore surface of *streptomyces* sp. **a.**spiny, **b.** Smooth, **c.**warty

***Secondary metabolites from actinomycetes:***

***Antibiotics:***

Low molecular weight chemical substances made by microorganisms are known as antibiotics. Actinomycetes are the primary producer of around 75% of antibiotics, which are primarily antibacterials. Numerous antibacterials exhibit a wide range of functions and different modes of action.Polyketides have numerous pharmaceutical uses, making them highly significant natural compounds. Examples of these polyketides are the antibacterial erythromycin, the antifungal nystatin, and the antiparasitic avermectin. *Streptomyces* sp., which is regarded as the primary creator of antibiotics, created all of the prior antibiotics.

***Plant growth hormone:***

Enhancement of plant growth through the synthesis of plant growth hormones, such as gibberellin-like substances and auxins. The primary auxin form, indole-3-acetic acid (IAA), is produced by actinomycetes and is involved in cell division, elongation, and differentiation.

***Pigments:***

The synthesis of colours on natural or manufactured media varies among actinomycetes. Typically, blue, violet, red, rose, yellow, green, brown, and black pigments are used. The pigments may remain within the mycelium or they may disperse throughout the media.These organisms' ability to create pigments can be considerably enhanced or completely lost depending on the different diet and growing conditions. Therefore, it is critical to enhance the ideal balance of various cultural circumstances in order to promote development and pigment production.

***Single cell protein feed:***

You can use marine actinomycetes as fishmeal. Certain secondary metabolites that actinomycetes can make may help young fish and prawns develop more effectively. Among these metabolites are normal amino acids such as azaleucine, 4-oxalysine, amino dichlobutyric acid, and boromycin and aplasmomycin.

***Biosurfactant:***

A surface-active chemical mostly generated by microorganisms is called a biosurfactant. The phrase describes substances that affect surfaces in some way. Surface tension measurements are used to assess the effectiveness of biosurfactants. The terms "emulsifier" and "surfactant" are commonly used synonymously in the literature. Because they are less harmful, biodegradable, and particular, biosurfactants have many benefits. Additionally, how well these biosurfactants function in harsh pH, salinity, and temperature environments. The creation of bioemulsifiers depends heavily on actinomycetes. Certain actinomycetes, such as Nocardia sp., produce trehalose dimycolates.

***The Phytopathogens:***

Phytopathogenic bacteria can be classified as biotrophs, hemibiotrophs, or necrotrophs based on how they live on plants. Necrotrophs first destroy host cells before feeding on dead tissues, whereas biotrophs feed on living cells and actively preserve the survival of their hosts. A necrotrophic phase comes after an early biotrophic phase for hemibiotrophs.It is necessary to create new antimicrobial drugs to prevent the dangerous phenomenon of phytopathogenic bacteria becoming resistant to certain agrochemicals. Presently, numerous researchers worldwide are attempting to find novel natural medications derived from plants or microorganisms. Numerous plants and microorganisms generate various bioactive secondary metabolites, which may find application in the agro-pharmaceutical sector as effective substitutes for a number of chemical pesticides.(9)

Actinomycetes isolation and biochemical characterisation may make it possible to discover novel bioactive compounds for use in agriculture and medicine. The current study's main goals were to: (i) isolate and identify new Actinomycetes strains from various soil habitats; (ii) assess the tested isolates' antagonistic effect in vitro against common phytopathogens; and (iii) assess the most bioactive isolates' growth-promoting effect in vivo as well as their antifungal activity against *Sclerotium rolfsii* on ground nut plant.(10)

Stem, root, and pod rot in peanuts is one of the most significant soil-borne fungal diseases resulting from *Sclerotium rolfsii* which can infect over 500 plant species. The soil-borne pathogen *Sclerotium rolfsii Sacc.* is typically found in warm temperate regions, the subtropics, and the tropics regions of the world that affect about 500 plant species, nearly all agricultural and horticultural crops, causing root rot, stem rot, wilt, and foot rot The phytopathogen known as *Sclerotium rolfsii* was initially identified by Rolfs in 1892, and Saccardo later confirmed this identification in 1911. Higgins (1927) conducted extensive research on *S. rolfsii*'s physiology and parasitism.

***Effect of Chemical control on the phytopathogen:***

Fungicides like banodenil and pentachloronitrobezene work well to prevent root rot disease and apple seedling blight. The high concentration of benzaldehyde and velvet bean suppresses *Sclerotium rolfsii's* mycelial growth and sclerotial germination. Six fungicides, namely benomyl, sancozeb, thiovit, dithane M-45, carbendazim, and topsin-M, were found to be effective against *Sclerotium rolfsii* by Yaqub and Shahzad (2006)[55]. At low concentrations, no fungicide was able to stop *Sclerotium rolfsii* from growing, but at high concentrations, sancozeb and dithane M-45 dramatically stopped the growth of *Sclerotium rolfsii*[56]

According to Mohamedy et al. (2014), substances like potassium sorbate (7.5%), salicylic acid (100mM), sorbic acid (7.5%), and $K_2HPO4$ (400mM) regulate root tomato rot disease brought on by *Fusarium solani*, *Rhizoctonia solani*, and *Sclerotium rolfsii*, which also has a beneficial influence on tomato plant growth, yield, and fruit quality when grown in fields for two cropping seasons.[57]

***Effective Biological control of the phytopathogen:***

According to Abd-Allah (2005), *Bacillus subtilis* controls *Sclerotium rolfsii* in peanuts grown in greenhouses by 92%. An antifungal secreted by *Bacillus subtilis* material that is extremely hostile to *S. rolfsii*. *Trichoderma harzianum* and *Trichoderma hamatum* were shown to be the most effective in inhibiting the growth of *Sclerotium rolfsii* mycelial by 79%, according to a study by Radawan et al. (2006)[58].

As *Streptomyces sp.* produces antifungal and antibacterial chemicals that inhibit *Sclerotium*, it has the biological control action of root and stem rot[59]. For an example the growth of two phytopathogen species named *Sclerotium rolfsii and Ralstonia salanacearum* were inhibited under in vivo conditions in the plant i.e., chilli peppers.

Actinomycetes are known to generate the enzyme chitinase, which inhibits the growth of *S. rolfsii* in vitro, regulates stem rot, and speeds up the growth of chillies.[60]

*Pseudomonas cf. montelii* produces volatile metabolites, hydrogen cyanide, siderophores, and diffusible antibiotics that inhibit *Sclerotium rolfsii* in vitro and speed up groundnut germination, shoot length, root length, leaf count, and chlorophyll content.[61]


**Fig.2.** Application of actinomycetes

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