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The Need for Research on Soil Actinomycetes in India

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Introduction: Though actinomycets are of universal occurrence in nature, their existence was noticed only two centuries after Antoni van Leeuwenhoek, who is considered to be the Father of Microbiology, first observed bacteria in his 'microscope'. The first report on an actinomycete was made by Ferdinand Cohn in the year 1875 and since then several reports have appeared on their occurrence in soil, composts and manure heaps and also as plant, animal and human pathogens and detailed investgations have been carried out. As a result it occupies at present a very prominent position in industrial and agricultural microbiology. Studies on actinomycetes started in the United States when Dr. Selmen A. Waksman, at present Director of the Institute of Microbiology, Rutgers University, entered this field. In the spring of 1914, Waksman, while studing different groups of microorganisms in the soils of New Jersey Agricultural Experimental Station, came across the interesting but little-known group of 'ray fungi'. The reason for this neglect was brought out in his first paper on the subject in the following words: "The actinomycetes grow very slowly; they begin to develop from the bottom of the plate, and to the casual observer the colonies formed look like those of bacteria, even after 5–6 days' incubation; only the somewhat mealy or rough surface will disclose the fact that they are not bacteria. It requires careful observation to tell whether those white, pink or grey colonies are bacteria or not. Many counts of bacteria might have been confused, when this point was not known, and the fungi and actinomycetes were not taken into consideration". Intensive studies on the occurrence of actinomycetes in soil, their classification, physiological properties and their economic importance followed and his contributions to our present knowledge of actinomycetes as a taxonomically and industrially important group of microorganisms are invaluable. The knowledge available on the organisms at the time pencillin was rediscovered by Florey and his associates in England in 1941 was put to use by him for evaluating their use as antibiotic-producing agents and new techniques for isolation and study of these antibiotics were developed, as a result of which remedies for various deadly diseases have been found and thousands of lives

saved. In the place of a dozen or so laboratories working on actinomycetes throughout the world before 1940, nearly a thousand laboratories are doing intensive research on this group of organisms in the United States alone at present and perhaps another thousand or more laboratories are engaged in this work in other parts of the world.

It is to be regretted that this important group of organisms has so far been very much neglected in India. It is the intension of the author to bring out in this article the economic importance of actinomycetes and to make some suggestions for their study in India.

Actinomycetes as microorganisums: Actinomycetes form an important group of microorganisms intermediate between bacteria and fungi. Because of their filamentous nature earlier workers were inclined to include them under fungi, but the knowledge obtained now show that they are more closely related to bacteria than to fungi and the latest edition of Bergey's Manual of Determinative Bacteriology has included them under the class *Schizomycetes* and order *Actinomycetales* with three families, *Mycobacteriaceae*, *Actinomycetaceae* and *Streptomycetaceae*. The family *Mycobacteriaceae* includes acid-fast bacteria of which *Mycobacterium tuberculosis*, is the most important. The true filamentous actinomycetes are included under the other two families. *Actinomycetaceae* includes the aerobic and microaerophilic pathogens belonging to the genus *Actinomyces* and the aerobic, mostly soil-dwelling forms, to the genus *Nocardia*. The last family *Streptomycetaceae* is economically and industrially the most important and the members of this family are known to be present in large number in soil, in dust, in manures and composts, in fresh-water lakes and river beds and in food products. Some of them are known to cause important plant diseases and food spoilage. There are two genera under this family viz., *Streptomyces* and *Micromonospora* of which *Streptomyces* is by far the most important.

Saprophytic Forms: Actinomycetes are distributed in various types of soil and at different soil depths as well as in other natural substrates in saprophytic form and they play a very important role in the decomposition of plant and animal residues and the formation of humus under condions which are unfavourable for the decomposition of organic matter by bacteria and fungi in general. Further, the important part played by the thermophilic forms, which grow in compost heaps at 60–65°C and decompose organic matter at that temperature where most of the bacteria and fungi do not function, is of great significance. The nature of their interrelationships with other microorganisms under natural conditions in soil and their significance in soil fertility is however not clearly understood.

Pathogenic Forms: Actinomycets are known from very early days to cause human, animal and plant diseases. *A. bovis* was the first

pathogenic form isolated from cattle in 1877 and since then aerobic and anaerobic forms of *A. bovis* have been isolated from infections on various parts of the animal body. The disease caused by this organism is commonly known as 'actinomycosis'. *A. israeli*, *N. asteroides* and *N. madurae* are known to be associated with animal diseases, sometimes resulting in serious troubles, but so far no epidemics due to these pathogens have been reported.

Potato scab or the common scab of potatoes is the most important of the plant diseases caused by actinomycetes. The disease is known since 1890, even though the causal organism was not recognized as a streptomycete at that time. Potato scab is one of the serious diseases of this crop. It is widely distributed throughout the world and has been extensively studied. The pathogen attacks young tubers and causes lesions in the form of small, brown spots which increase in size, leaving a shallow depression with irregularly ruptured skin and thick, corky outgrowths. The organism persists in the soil in saprophytic form for a long period. Among the other pathogenic forms known, *S. ipomoea* causing sweet potato pox and some species of *Streptomyces* causing scab of sugar beet and mangolds are important.

Actinomycetes in Industry: Actinomycets were known for long to produce various pigments in synthetic and complex organic media, but little was known about the chemistry of these substances. With the recognition of their ability to produce antibiotic substances the physiology and biochemical activities of the organisms have been studied in detail. It is now established that actinomycetes are by far the best microbial agents for the production of antibiotics as compared to bacteria and fungi. More than 200 antibiotics have so far been isolated from them, of which nearly ten have found industrial use and several more appear to be promising. *S. griseus* is the first of the series of actinomycetes which went into commercial utility in 1945 and in 1953 more than 4,00,000 lb. of streptomycin, valued at $ 48 million (about Rs. 23 crores) was produced in the United States alone and during 1954–55 there has been a further increase in production, due to its use as animal feed-supplement and for plant disease control. The sale of other actinomycete antibiotics in the United States was estimated as $ 160 million (about Rs. 77 crores) in 1953 and during the past two years several industrial concerns throughout the world have started using actinomycetes for antibiotic production, involving large investments. The evidence accumulated so far indicate that the antibiotics very greatly in their chemical composition and antimicrobial property with an ever-expanding field of applicability, which in turn widens the scope for commercial expansion.

Besides producing antibiotics, actinomycetes are known to synthesise vitamins, especially vitamin B_{12}. *S. griseus*, the organism

producing streptomycin is also known to produce vitamin B_{12} when cobalt is added to the medium. Among the various enzymes produced by actinomycetes, protease, amylase, invertase, pectinase, and oxidase, particularly some of these produced by the thermophilic forms, are considered to be of great importance. Several species of *Streptomyces* and *Nocardia* have been studied for this purpose. Some of the faster growing species like *S. griseus* and *S. lavendulae* are known to produce lactic acid, succinic acid, acetic acid, ammonia etc. under specific conditions. The uneconomic quantity of these substances produced in the broth, however, prevents the industrial applicability of the organisms for the present.

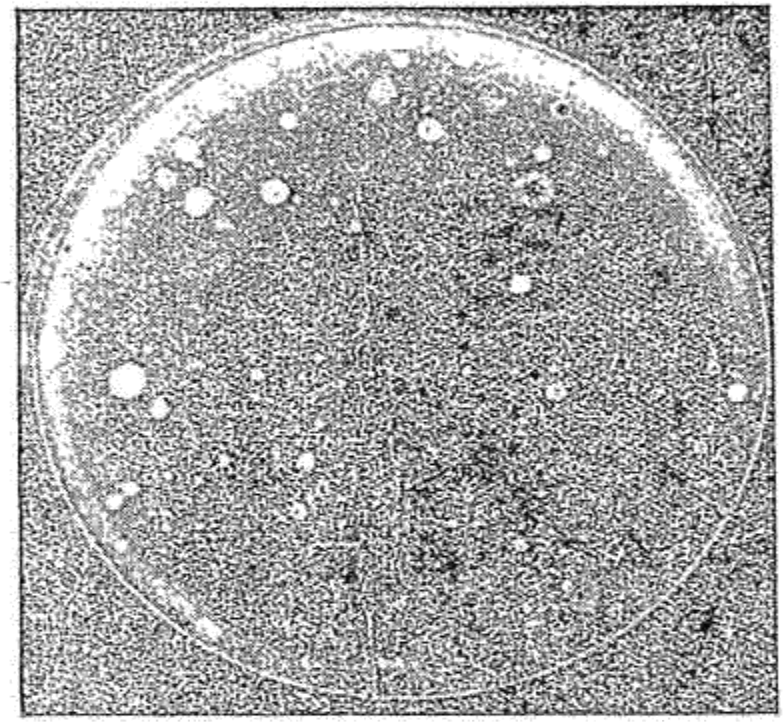

FIG. 1

Predominant development of actinomycete colonies in Ken Knight's agar medium plated with a soil sample at a dilution of 1 : 100,000.

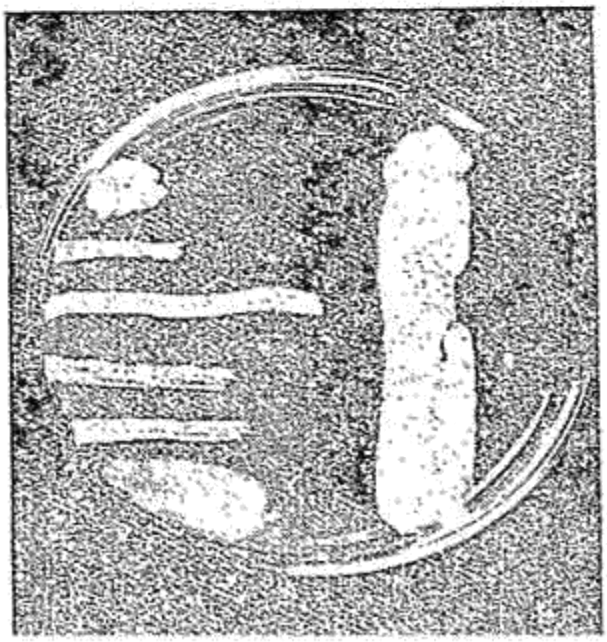

FIG. 2

Antagonistic property of a strain of *Streptomyces lavendulae* producing a new antibiotic, Mycothricin, recently isolated by the author. The organisms inhibited are: (1) *Bacillus subtilis* (2) *Escherichia coli*, (3) *Pseudomonas fluorescens*, (4) *Candida tropicalis*, (5) *Saccharomyces cerevisiae* and (6) *Aspergillus niger*.

Actinomycetes in Agriculture: Large populations of actinomycetes are known to exist in soil and only a handful of species are reported to be plant pathogens, whereas others are, though indirectly, beneficial to the growth and development of plants. They play an important part in the decomposition of organic matter and humus formation. Another very significant function of actinomycetes is their antagonistic property which prevents the growth and spread of plant pathogenic organisms added to the soil. Though several actinomycetes have been known to be inhibitory to soil-borne plant pathogenic bacteria and fungi, they have not been advantageously utilized so far because of several difficulties involved. Recently antibiotics of actinomycete origin have come into use in agriculture as animal-feed-supplements and plant disease sprays. Some streptomycin preparations (Agrimycin, Agristrep, Strep-Nitrate etc.) are being put to use on a commercial scale. The inhibitory power of some of the metabolites of actinomycetes against plant virus infection seems very promising and probably the only effective remedy for some of the unsolved problems in plant pathology like soil-borne fungal diseases and virus diseases is in actinomycetes and the antibiotics derived from them.

Past work in India: The work done so far on actinomycetes in India is very little and comparatively insignificant. The first report on an actinomycete in India seems to be that of Joshi (3) in the year 1915. While studying nitrifying organisms in soil, he isolated a 'new type' of organism differing morphologically from other known ones at that time and called it a 'nitrite-forming organism'. The photomicrographs and the descriptions of the organism given by him show that he was dealing with an actinomycete. An organised attempt to study soil actinomycetes was made by Norris, Subrahmanyan and Ganesha Rao (5) in the year 1929. These authors collected soil samples from different places in India (some of them now in Pakistan and Ceylon) and isolated actinomycetes, using a starch-agar medium with minimum amount of nitrogen. The total number of colonies obtained per gram of soil varied from zero to four million. According to them 1 to 15 types of colonies were observed in each sample and a majority of them were chromogenic. In their concluding remarks they said: "With our present knowledge it is not possible to define the exact role of actinomycetes in relation to soil fertility and plant nutrition. Much work still remains to be done on the physiology of the more prominent varieties commonly occurring in the soil, particularly under conditions similar to those obtained in the depths of forest areas and the interior of manure heaps, before their importance can be properly assessed."

Since then a good deal of work has been done in other parts of the world and various aspects of the role of actinomycetes in soil fertility and plant nutrition worked out, but not much has been done in India.

It is not known how far the results obtained in other countries are applicable to Indian soils. Some attempts, however, have been mada by a few microbiologists in recent years, to study the soil actinomycetes and some of the isolates have been reported to possess antibiotic properties (2). Studies made on the rhizosphere microflora of some of the important crop plants of South India have revealed that there is a greater accumnlation of actinomycete population in the rhizosphere of Sorghum than in other plants investigated (1). *S. scabies*, the organism responsible for potato scab has been reported to be a serious problem in some parts of India (4) but no detailed study on the disease has been made so far.

Suggested methods of approach: As has been already pointed out, the main reason for not paying enough attention to the study of actinomycetes in the difficulty involved in the isolation, identification and classification of the organisms, as they are slow-growing, require special media for growth and special technical knowledge on the part of the investigator for these studies. A large volume of literature on the subject has accumulated and some excellent books have been written in recent years, but because of the small number of persons working in microbiology in India, knowledge on this subject is not much. Considering the importance of this group of organisms in the agricultural and industrial development of our country it is essential to start intensive research in this field immediately. It is not possible in this article to go into all the details of work to be done in India to overcome the deficit, but the following suggestions are made as a beginning:

1. A thorough survey of the actinomycete population in different types of soils and at various depths throughout India. The microflora of soil types like rice puddles, garden-land soils, tank and riverbeds etc. are bound to contain species of beneficial actinomycetes, as the climatic conditions in India are very conducive to their growth and development all round the year, in most parts of the country. It is also needless to say that this potential resource in soil is no less important than the mineral resources for which extensive surveys are being made at present.

2. Screening of actinomycetes for antibiotic production, vitamin production and for other industrial and agricultural utility.

3. Study of the part played by actinomycetes in the decomposition of organic matter, humus formation and soil fertility in general. Since actinomycetes play a great role in the decomposition of organic matter in compost heaps, special attention should be paid to study this aspect in different original methods of composting followed in India.

4. Study of the interrelationships of actinomycetes with other microorganisms in soil and to explore the possibilities of controlling the

injurious microorganisms by favouring the processes brought about by the beneficial actinomycetes.

5. Identification and classification of actinomycetes and of the soil types in particular.

These suggestions are in no way exhaustive, but are of immediate importance. With the increase in our knowledge on soil actinomycetes in India, further studies on some of the fundamental aspects like genetics and cytology, physiology and biochemical reactions of actinomycetes, actinophage and its relationship with actinomycetes etc. and some of the applied aspects like utilizing agricultural and industrial waste products for the production of antibiotics, vitamins etc. can be taken up. Since the study of actinomycetes forms a great part of microbiology, it is important that students of microbiology in Indian Universities should all be taught the subject in detail and trained for future work in this field.

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REFERENCES:

1. Agnihothrudu, V. — 1953 Soil conditions and root disease. VIII. Rhizosphere microflora of some of the important crop plants in South India. *Proc. Indian Acad. Sci., Sect. B. 37* : 1–13.
2. Bhide, V. P., Moniz, L. & Patil, R. B. — 1952 Actinomycetes antibiotic to plant pathogenic bacteria. *Curr. Sci. 21* : 70—71.
3. Joshi, N. V. — 1915 A new nitrite–forming organism. *Mem. Dept. Agrl. India Bact. S. 1* : 85—96.
4. Nandi, H. K. — 1945 Potato in Assam. *Indian Farmg. 5* : 51—554.
5. Norris, R. V., Subrahmanyan, V, & Ganesha Rao, M. — 1929 Soil Actinomycetes. *Agrl. J. India. 24* : 232—234.
6. Pearlman, D. & Kroll, C. L. — 1954 Fermentation. *Ind. & Eng. Chem. 46* : 1809—1826.
7. Waksman, S. A. — 1950 "The Actinomycetes", Waltham Mass., U. S. A.
8. — — 1953 Biology of Actinomycetes and their economic importance. 'Symposium: Actinomycetales', Fondazione Enamelo Paterno, Roma.
9. — & Lechevalier, H. B. — 1953 "Actinomycetes and their antibiotics", William and Wilkins, Baltimore, U. S. A.