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INAUGURAL ADDRESS

International Symposium on Role of Fungi and Microbes in the 21st Century- A Global Scenario

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Mr. President, Ladies and Gentlemen! As we know, the Indian Mycological Society, established in 1954 at the Department of Botany is celebrating its Diamond Jubilee, the 125th Birth Aniversary of Prof. Sahay Ram Bose and also the Centenary of the Department of Botany, University of Calcutta by organizing this important symposium. Over decades, contribution of all the three i.e. the Society, Prof. Bose and the Department has been path breaking.

Ladies and Gentlemen! Now with everyday growing, there is a paradigm shift in our understanding of the biology, evolution, gene, genetics, genomics and proteomics of organisms. Further, combination of novel tools and techniques has opened new vistas. Genome enabled microbiology and biotechnology have brought about new insight into the co-evolutionary arms race in the diamond mines of microorganisms. Accordingly, this conference has contemplated to address recent developments in our understanding of the enormous genetic wealth, microbiological functions, relations and adaptations to our changing environment and to discover their ever increasing role in providing benefits to science and society. I am happy to note that in conjunction, there would be a series of Memorial Lectures on subjects of topical importance. I am sure it would help enormously to develop our understanding further,

Curiosity to know more about fungus and microorganisms have led to many explorations. The genetic resource collections of these organisms have always highlighted the challenges associated with their diversity. Based on the figure of 2,70,000 plant species available worldwide and the influence of higher plants on fungal diversity, the number of fungi are estimated to be 1.5 million species. This estimate is second only to insect species which is about 30 million species, Only 5- 10% of the world's fungi have so far been described. Most of the undescribed fungi are in tropical forests and unexplored habitats, including those lost or hidden species. Most prokaryotic microorganisms are invisible to the human eyes but constitute an important component of the earth's biomass. Their abundance has been estimated to be 4-6 x 10^{30} cells. Their cellular carbon content is about 350-550 Pg of C (1 Petagram = 10^{15} g), which is equal to 60-100% of plant carbon. These prokaryotes also contain about 85-130 Pg of N and 9-14 Pg of P; the pools of these nutrients are about 10-fold more than those of higher plants. Thus, these organisms are one of the largest pools for these nutrients. Interestingly, the annual production rate of these organisms is about 1.7 x 10^{30} with 6-25 days of turnover time. Both population size and rapid growth even make these organisms an interesting pool of genetic diversity.

Please recall, the soil which is basic to life, in itself is a living legend and its health is defined as: "the capacity of soil to function as a living system. Healthy soils maintain a diverse community of soil organisms that help to control plant disease, insect and weed pests, from beneficial symbiotic association with plant roots, recycle essential plant nutrition, improve soil structure with positive repercussions for soil water and nutrient holding capacity, and ultimately improve crop production". To that definition, an ecosystem perspective can be added: A healthy soil does not pollute the environment rather, it contributes to mitigating climate change by maintaining or increasing its carbon content. As such, incentives for restoration of soil organic carbon and agriculture-based soil carbon sequestration are imperative to improve agricultural productivity and sustainability. The possibility of incentives for environmental services can be used to encourage the adoption of more sustainable land use systems and soil management practices and for enhancing the economic viability of the production systems. Soil biodiversity determines the resource use efficiency, as well as the sustainability and resilience particularly of low-input agro-production systems.

When it comes to the soils, the first and foremost intention of mankind is to improve and sustain the soil's natural capacity for biological productivity and to increase its effective fertility. Agriculture has tremendous impact on the soils' fertility. Although only t2% of the land surface is cultivated worldwide, there is a continuing and accelerated loss of organic carbon. Within the last 10,000 years of agricultural activities, the loss is estimated to be about 15.8% of the initial organic carbon stock. To restore the carbon status and sustain life in soils, we need to know more about the habitants of soils and their lifestyles. The microbial biomass of soils is very large, which amounts to 1-2 tonnes per hectare. In a gram of soil mass, there may be about 10^9 cells with 6000 different bacterial genomes. All these organisms determine 80-90% of the soil processes. Among all those diverse microbial activities, the organic matter decomposition is critical in order to decompose the dead materials, unlock nutrients from the soil minerals, and make many of these nutrients available for plant growth and development. All those associated microbes in:fact act as store-house of nutrients, enzymes and biologicals for human utilization. Besides these processes in soils, they also interact with plants in numerous ways.

The symbiosis between plants and fungi merits our attention. Mycorrhizae in plants are more of a rule than exception in nature. The benefits of mycorrhizal association include the agronomic benefits of making P available to the plants and water absorption. Not only to the plants, this symbiosis benefits indirectly by improving the soil structure, more stabilized and strengthened. The exploratory studies on mycorrhizal symbiosis suggest that there are many undescribed species of arbuscular mycorrhizal and ectomycorrhizal fungi in nature. Only when they are identified, their interactions and numerous benefits plants derive from them such as drought tolerance and resistance to plant pathogens can be understood.

Prokaryotes are the only biological agents which are capable of fixing atmospheric nitrogen. Globally, the nitrogen fixation amounts to 413 Tg (1Teragram = 10^{12} gram) of reactive nitrogen (Nr.) in a year. The anthropogenic nitrogen fixation through chemical fertilizers alone is about 210 Tg of Nr. Since the losses from chemical fertilizers lead to atmospheric, soil and water pollution, increasing the efficiency of biological nitrogen fixers such as *Rhizobium, Bradyrhizobium* and *Frankia* and making the reliance of plants other than leguminous species more on biological nitrogen fixers will make agriculture eco- friendly. Almost all plant species have microorganisms within their tissues, in addition to those which colonize the surfaces. Even the so-called 'sterile' callus tissues of micropropagted plants are found to have many microorganisms within, commonly referred to 'endophytes'. Because of the association of these endophytes, plants are now considered as 'metaorganisms." The interactions of these endophytes with host plants are mutualistic. The survival of many plants in extreme environments depends on these endophytes. Interestingly, many plant species derive resistance to plant pathogens from their endophytes and other beneficial microorganisms in their rhizosphere. Generally, the microorganisms in soils are carbon starved and plants by providing nearly 40% of their photosynthates recruit many beneficial microorganisms selectively in their rhizosphere. In turn, these endophytes and beneficial microorganisms induce resistance to pathogens directly or produce pathogen-inhibitory compounds such as 2,4-diacetylphloroglucinol (DAPG).

The most significant microbial interaction with plants which we have known for long is pathogenicity. Many fungal pathogens destroy the agricultural production to a greater extent. At least 125 miltion tons of rice, wheat, maize, potatoes and soybeans are lost due to fungal infections every year. The global agricultural losses about 60 billion US dollars annually to fungal damage. In a recent survey, the scientists rate the rice blast fungus as the number one destructive pathogen among the ,fungal pathogens. But the microbial involvement in soil processes and plant growth and development suggest the ecological services provided by fungi and microorganisms. The stability and resilience of ecosystems including agroecosystems are largely due to the benefits obtained from diverse microorganisms. Recent studies have clearly shown that the microbiome of human gut determine the health of individuals beyond the influences of known pathogens.Dysbiosis in guts can cause autoimmune diseases and colon cancer. The changes in microbiological perspectives are due to the tools and approaches with which the science of microbiology is pursued. Going beyond the microscopy and laboratory culturing of microorganisms, the microorganisms are now detected and catalogued using molecular approaches. The use of molecular information on the 1.65 rRNA sequences have made easier with the improvements in DNA sequencing capabilities and computing advances in bioinformatics. The "black box" of soil is now getting opened with these tools to understand the numbers, kinds and functions of many unknowns and the knowns once again.

The survey and census of microorganisms from different environments have many surprises and have even forced to change the environmental limits we have considered for life on earth. The new release of ribosomal database project (RDP Release 11, Update 1 on October 16, 2013) has information on 2,809,406 bacterial (165 rRNAs) and 62,860 fungal (28S rRNAs) sequences, respectively. Tough environmental conditions may have less diversity but unique microorganisms with newer capabilities. For example, the microorganisms such as *Pyrolobfus fumarii* have been found to grow at 90-113°C. Similar exploratory studies conducted in extreme environments within India suggest that there is a huge potential of genetic resources to be tapped. Besides their high adaptive potential, they have remarkable capabilities to get distributed in diverse geographical regions. The clouds of desert dust make the global dispersion easier. In fact, the new knowledge on microbial biogeography will aid in tracking many plant pathogenic fungi.

Fungi and microbes not only support our agricultural activities. They even make use of all our wastes, including those from industries. For example, there exists an enormous avenue for making useful chemicals from food waste. The diverse nature of waste from agriculture provides a world of possibilities for making the microorganisms as workhorses for producing chemicals. The ever growing industrial microbiology is a billion $ business. Mushrooms have reached now to most of our households. Gene discovery and allele mining have opened enormous opportunities for tailor made novel products across plant and animal kingdoms. In fact, on a broader scale, microbes are being considered extremely vital for food, nutrition and environmental security in the posterity, It is fortifying old saying that smallest is the most powerful.

Soil organisms filter and detoxify chemicals and absorb the excess nutrients that would otherwise become pollutants when they reach groundwater or surface water. There is, therefore, a need to recognize these multiple benefits to promote effective actions that enhance and maintain soil biodiversity. Nutrient cycling, decomposing organic matters, mediating carbon sinks, maintaining and improving soil structure and water regimes, and biological control of pests that affect plant and animal health would be imperative. These are the vital functions performed by agriculturally important microorganisms.Hence, soil biota and their genetic resource collections should be brought at the centre stage in our research and development efforts.

Realising the importance, ICAR has established a National Bureau on Agriculturally Important Microorganisms in the country. Also a mega project on Gene Discovery and Allele Mining costing over Rs. 50 Cr. is put in place. In addition, a Phonemics Platform costing about Rs. 60 Cr. is in operation. To complete the chain of events, a super computer costing over Rs. 60 Cr. is in operation since January, 20t4 to analyse enormous data getting generated every day. These initiatives need further impetus as we go along. As there is no barrier to gene flow across plant and animal kingdoms, microorganisms appear to be the best bet for managing the likely climate change. The kind of biotic and a-biotic pressures which are likely to be there on meeting our ever growing requirements, we must invest heavily on institution building, human resource development, transgenic research, genomics, bioinformatics and putting policies in perspective. Before doing all this existing microbial diversity must be adequately sampled, evaluated and valuated.

I am happy to know that this conference is addressing several vital issues with a force to reckon with. I hope that the recommendations emanating from this conference would help programme planners and policy setters to take our country to new heights. With these words I have a great pleasure inaugurating this important conference.

Thanks and thanks a lot to one and all.