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Editorial

Fungal World: Challenges and Issues

Diversity is the variation among living organisms in morphology, genera species, genes, biochemical and physiological aspects and in other related characters. Fungi are second species rich organisms group after insects. It is more challenging to complete the fungal inventory as compared to other organisms such as plants. Fungi play key role in ecosystem as decomposers, mutualists and pathogens besides playing important role in industry, agriculture, medicine, biotechnology and others related to human welfare. The role of individual fungi in nature is still unknown. Hawksworth and Lucking (2017) has stated that there may be 2.8 – 3.8 million of fungi as an estimate. Wu et.al, (2019) have made an estimate of 13 million of fungi which may be occurring in the world. Around 1,40,000 fungal species have been identified in the world. In order to identify 13 million of fungi it may take around 10000 years. In India around 29000 fungal species are reported (Manoharachary et.al., 2009). To identify the probable number of 4 lakhs or more which may be occurring in India may take around 20 years. There is a hidden wealth of fungi underneath different ecological niches in nature which needs to be identified while keeping the mankind in view. IUCN Red Data indicates that around 1512 species are facing threat in the world. In india such data is not available with reference to fungi.

Biodiversity of plant pathogens and disease diagnosis

Host-Pathogen interaction under favorable environmental variables results in disease syndrome followed by symptom production. Interaction between virulent gene product and resistant gene product which triggers a series of signaling responses. There are different symptoms produced by plant pathogenic fungi namely necrosis, hypertrophy and hyperplasia and also hypotrophy and hypoplasia. Identification of fungal pathogen and their classification is an important aspect to be dealt. Most of the pathogenic fungi are either obligate parasites or biotrophs. The non culturable obligate parasitic fungi and disease symptoms are important in understanding disease incidence, detection of plant pathogen and management of diseases. Since 1/3 of global fungal biodiversity occurs in India, hence there is need to discover the fungi occurring in different ecological niches and also on crop plants. Around 30,000 plant pathogenic fungi have been reported in the world and of which 5000-7000 pathogenic fungi do occur on various crop plants and forest plants in India. No plant pathologist or agriculture scientist will be interested to conserve the pathogenic fungi and they will be focusing their attention in eliminating the pathogen. Early detection of plant pathogenic fungi and disease diagnosis are the important components that help in disease management. Morpho-taxonomy and molecular tools are employed in the identification of the plant pathogenic fungi. Establishment of relevant disease forecasting systems and models are important for early prediction of the outbreak of plant diseases. In view of the expected climate change there is need to get prepared for the disease epidemics that are going to occur on crop plants and necessary precautions be taken up for disease management. Young plant pathologists, extension plant pathologists and educated farmers need to be trained about symptom identification, disease forecasting and disease management practices so that they act in time to save the crops from disease incidence. Still in India agriculture forms the backbone for the country's economy besides offering food security and nutritional security to the growing population.

Fungi and agriculture

Spectacular progress has been made by India towards ensuring food security by unprecedented production of 300 million tonns of food grains and 300 million tonns of horticultural commodities in the last ten years and achieved steady growth in food production by enhancing crop productivity required for the estimated population of 1.5 billion people by 2030. After first green revolution, there has been loss of soil fertility and crop damage due to occurrence of 32-40% of pests and diseases and also due to non-judicious use of fertilizers, and spraying of chemicals to ward off the diseases. Therefore, there is a necessity of enforcing Integrated Disease Management Strategies to control pest and diseases besides bringing out disease resistant varieties.

Edible mushrooms for next generations

Edible mushrooms are considered more nutritious than many other vegetables and their nutritive value is almost equivalent to milk, fish, meat, pulses and others. Edible mushrooms are rich in proteins (32%) and possess all essential amino acids, more fiber, less fat and carbohydrates, vitamins, minerals, besides possessing biochemicals of increasing immunity and also anti cancer properties. Around 2000 mushrooms have been found to be edible and 60 of them have attained commercial status. In many European countries edible mushrooms have achieved multi-billion dollar market status. In China the caterpillar fungus (*Cordyceps sinensis)* is often used as a traditional medicine including in North Eastern states of India. Many of the mushrooms are considered as magic for sustainability. Some foreign companies have shown that the mushrooms are more than just fungi and food. Fungal mycelium spread to several kilometers and the entire ecosystem on earth is dependent on fungal mycelium and mycorrhizae. Fungi like mushrooms are used as biomaterials for packaging, insulation and others. Normally pollution by plastic brings problems while the mycelial mats avert pollution. Myco-composite is now used in many of the companies to offer strength and density. Some of the companies like Nexloop has incorporated the mycelium to deliver water to plant roots into aqua-web system helpful in capturing atmospheric water. In recent times fungi are also used to meet the energy needs.

Taxonomy and classification of fungi

Taxonomy is the mother of all sciences. As on today, 1,40,000 fungal species have been identified upto species level against the back drop of fungal estimate of 13 million of fungi. In India, around 29000 fungal species are reported against the possible estimate of 2 or 3 lakhs of fungi. Morpho-taxonomy and molecular sequencing including barcoding have helped in the exploration and identification of culture dependent and culture independent fungi including the identification of cryptic species. Classification follows the hierarchal system earlier the fungal nomenclature were dependent on ICBN, which got changed by IBC under Melbourne code in 2013 followed by Shanzuin 2017 code. There is a need to classify fungi and identify them upto species level. Many of the fungi are known to be important to the human welfare through their secretion of metabolites, chemical compounds, medicines, biotechnological products and others. As per the recently envisaged classification fungi has been raised to the level of kingdom, which includes Chytridiomycota, Zygomycota, Ascomycota and Basidiomycota. Hyphochytridiomycota and Oomycota are included under kingdom Chromista. However, Myxomycetes and Plasmodiophoromycetes are included under protista. There are number of classifications, however the recent ones include Whittaker classification of five kingdoms (1969), Hibbet et al AFTOL classification of Fungi (2007) and Leho Tedersoo et al – High Level Classification of the Fungi (2018). In my opinion taxonomists have to propose simple system of classification and identification criteria so as to help the researchers, teachers, students and others.

Mycorrhizae and potential biostimulants

Fungi form an important part of life on Earth. Mycorrhizae, the symbiotic associations of plant roots help in the plant growth, offer immunity to the plants, plant nutrition, delays the effect of global warming, elaborate elicitors like Jasmonic acid which offers defense to the plants, increases plant productivity, enhances alkaloid content in medicinal plants, transport water, minerals, particularly phosphorus and others. These fungi also release plant growth hormones which act as biostimulant. The mycorrhizal fungal existence have been known 400 million years ago in rhizome fossil remnants of *Rhynia*. In recent times because of their role in enhancing plant growth, many companies have been trying to manufacture mycorrhizal biofertilizers. Equally it is important to mention that fungi like *Trichoderma, Gibberella*, PGPR have been found to be important in the production of biostimulants in larger scale by some commercial companies.

Fungi as biocontrol agents

Many fungi such as *Trichoderma* spp. Entomogenous fungi, hyperparasitic fungi and also some saprophytic fungi have been considered as important in the disease control, as they elaborate antifungal and antibacterial substances. Further several compounds have been elaborated by these biocontrol agents and some of them have been sold in the market. The biocontrol process includes antagonism competition, antibiosis, and other mechanisms. The test conducted under laboratory conditions, glass-house condition and in the field condition proved highly beneficial to control pests and diseases of crop plants in several countries. Further it is important

to mention that raw materials are not available for manufacturing of chemical fertilizers, fungicides, insecticides and others. These chemicals have also become hazardous to soil health, plant health and farmers. Therefore the biocontrol agents have gained the momentum for maintaining soil and plant health. Nature is a treasure house of several microbes and fungi which have properties of biocontrol agents.

Microbiome

Microbiome includes actinomycetes, bacteria, fungi and other microscopic organisms including Yeasts surviving under different ecological niches and habitats. The habitats include soil, water, litter, air, rhizosphere, leaf surface, fruit surface, root surface, plant secretions and extremophilic habitats. Microbiome plays an important role in nutrient cycling, plant growth and productivity, plant protection, stress management and several other functions. Some small interventions in agro-ecosystems have become import6ant in maintaining soil and plant health. Since the agricultural practices have damaged the ecological functions along with loss of beneficial microbes, resulted in emphasizing the importance and role of microbiome in agro-ecosystems.

Fungal biotechnology

Fungal biotechnology is the need of the hour to boost economy of every country. Fungi have wide range of applications in agriculture, medicine, pharmaceuticals, industry, environment management, textile industry, dye production, food sector, and other biotechnological innovations. 16 billion dollars worth of fungal products are sold in the market every year. Fungi have become important in biochemical genetics and Omic sciences are employed in understanding fungi. Fungi because of their ecological and metabolic versatilities have attracted the attention of biotechnologist and bioengineers.

Challenges and issues

1. Studies on diversity of fungi have to be strengthened
2. Techniques for early detection for plant disease diagnosis have to be evolved which have to be easy and implementable at field level. Recently some foreign researchers have developed a new techniques that uses micro needle patches to collect DNA from plant tissues in one minute.
3. DNA extraction is the first step in identifying plant diseases and this method holds promise for the development of on site plant disease detection
4. There is a need to impart training on fungal and microbial taxonomy to youngstars using morpho-taxonomy and molecular techniques, so as to enrich fungal taxonomy status and enhance the possibilities to discover new fungi.
5. Microbiome studies have to be made with indepth analysis
6. Germplasm collections have to be increased and managed both for culturable and non culturable fungi and microbes.
7. Indigenous fungi and bacteria have to be isolated and commercialized so as to employ them as biostimulants, biofertilizers and biocontrol agents.
8. Importance has to be given to analyse extremophilic microorganisms which are of biotechnological potential.

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