



Indian Forests : A Natural Paradise for Biodiversity of Foliar Fungi

(with reference to North-Eastern U.P. Forests)

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Forest and Biodiversity

The United Nations General Assembly has declared 2011 to be the International Year of Forests to raise awareness on conservation, sustainable management and development of all types of forests. Forests, provide shelter to people and habitat to biodiversity; are a source of food, timber, herbal medicine, and clean water; and play a vital role in maintaining a stable global climate and environment. All of these elements taken together reinforce the message that forests are vital to the survival and well being of people everywhere on this planet. Forests represent some of the most diverse ecosystem on Earth. With growing awareness of the role of forests in the global carbon cycle, interests in the World's forest have grown to unprecedented heights. Forests provide employment and livelihood for a large proportion of the World's population acting as safety net in times of need. The World's total forest area is just over 4 billion hectares, which corresponds to an average of 0.6 ha per capita. India has 69.09 million ha. of forests as per the report of (FSI 2009).

India shares 2% biodiversity of the world. It also shares 6.5% fauna and 7% flora, 18% human population and 17% livestock population of the world. India can be divided into 20 biogeographic zones of 25 provinces which represents major ecosystem of the world. Earlier Indian forests used

to be a major source of revenue to the Government.. Several industries are associated with these and provide employment to crore of people. The forests also provide habitat for bacteria, viruses, phytoplasmas, algae, fungi, nematodes, birds, reptiles, amphibians, insects and mammals.

Status of forests in Uttar Pradesh

After creation of Uttrakhand state, Uttar Pradesh has total geographical area of 2, 40, 928 sq.km or 7.33% of the land area of the country. It is the fifth largest state of India, lies between latitude 23° 52' N and longitude 77° 5 to 84° 38' E. The human population of the state is maximum in India. More than 87.39% of the total geographical area of the state is under agriculture. The forest cover and productivity of India's forests is very low ($0.68 \text{ m}^3/\text{ha}/\text{yr}$) as compared to world average of $2.1 \text{ m}^3/\text{ha}/\text{yr}$ and for U.P., it is even less than half of the country productivity. The U.P. forests cover an area of 5.86% (14,127 km sq.) of its geographical area (FSI report 2005). The FSI 2009 report shows its forest covers to be 5.95% (14,541 km sq) of state's geographical area. Forests are disappearing partly because they are undervalued and our market economy fails to recognize ecosystem services provided by intact forests. To stop losing the earth planet's living treasure, we must understand and appreciate its importance for human well being and development.



The forests of Terai belt of Uttar Pradesh

There is urgent need to restore the degraded forests in order to save forest biodiversity.

Forests being of immense importance to man in view of their major and minor productivity as well as their ability to conserve and maintain the environmental stability, their leaf spot diseases merit our greater concern. This need is fortified by the probability of many of these stray plants serving as reservoirs of a variety of foliar pathogens which, on getting opportunity, may also spread to cultivated plants. This probability becomes more possible with the current concept of agro forestry, involving the multiuse of land.

The forests of terai belt of Uttar Pradesh

The topography

As regards the topography of the area (Terai Belt of north-eastern Uttar Pradesh), because of the industrial development being in rudimentary stage, vegetation can be found in its natural forms. Almost all the forest regions in question are flanked to the north by the foot hill regions of Nepal. The maximum altitude of the area from the sea level is not more than 400 meters and there is a gentle slope from North-West to South-East leading to an altitude of 100 meters only. Some big rivers like Ghaghra, Gandak and Rapti along with their tributaries and many rivulets flow through this

region. In addition, some big, perennial lakes and numerous low lying areas are present acting as seasonal water reservoirs.

The soil

The soil of the area is alluvial, deposited by the rivers emanating from lofty Himalayas. This alluvial soil containing large amount of minerals and minor humus derived from the silt brought down by the rivers is fertile for plant growth. Profile development, however, is not distinct.

Climatic conditions

This part of Uttar Pradesh experiences humid sub-tropical climatic conditions. Meteorological parameters have been so distinct and have such regular impact that a year can be divided climatologically into three different seasons along with two transitional periods.

Winter season is generally marked with very low and scanty rainfall, moderately humid air and fairly low temperature, as low as 6-10°C during December -January, at night. In summer, the temperature sometimes reaches as a high as 40-45°C in May and June. Rainfall is generally negligible to scanty and sporadic, humidity of the air being fairly low. In rainy season, however, the temperature is moderate, rainfall is maximum and consequently humidity is very high. The seasonal periodicity has a greater impact



on the distribution and development of micro-organisms in general and foliar forms of fungi in particular.

The humidity

The humidity of the area is generally high due to high rainfall. The seasonal variations, however, are marked in the relative humidity. The climatic conditions favour the growth of various types of phanerogamic vegetation along with seasonal and annual crops and other plants. Moreover, during major part of the year, the temperature also assumes such values that are very favourable for almost all kind of fungi not only on living leaves but also on a variety of other substrates. Thus, these two most important climatic factors, the temperature and the humidity combined together, foster the existence of one or the other type of foliar fungi all the year round.

Vegetations

Vegetationally, the area of the north-eastern Uttar Pradesh is very affluent. A large part of our land is under cultivation for various crops and horticultural plants; the other large part is covered by the forests, the planned as well as natural. The third, but sizable part constitutes abandoned as well as low lying areas supporting rich growth of wild herbaceous, shrubby and hydrophytic vegetations. Due to favourable climatic conditions, this comes to be one of the best regions for the rich and varied occurrence of parasitic fungi particularly of hyphomycets representing Cercosporoid forms.

The fungi and foliar fungi

Fungi are unique among the living organisms and have become omnipresent in biosphere. They represent the group of thalloid, eucaryotic, achlorophyllous, entirely heterotrophic microorganisms that are spore producing and usually reproducing asexually, sexually or both. In somatic organization they range from very simple, short-lived

unicellular forms whose single cell functions as sex organ for reproduction to massive perennial mesh of mycelia giving rise to sizable fructification.

The kingdom fungi are characterized by vast diversity in its own. According to Ainsworth (1966), it has been divided into two broad divisions; the Myxomycota encompassing the plasmodial forms and the Eumycota including the non plasmodial forms. The latter, some generic segregates of which are point at issue for the present investigation, is divided into five sub-divisions, Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina. Sub-division Deuteromycotina, reproducing only asexually, is a dust bin group which has been in state of flux from the very beginning. Except mastigomycotina, remaining four sub kingdoms includes foliar forms but Duteromycotina are found more dominant.

This sub-division, Deuteromycotina, includes three distinct classes, Blastomycetes, Hyphomycetes and Coelomycetes. Of these, the Hyphomycetes produce well-developed mycelia, which bear spores directly or on special branches (Sporophores) which may be variously aggregated like sporodochia or synnemata but not in pycnidia or acervuli. The conidia are born on the exterior of the substratum on which their somatic bodies are growing.

Alongwith other fungi, Hyphomycetes have profoundly influenced the human life both as friend and foes, since the antiquity. In recent years, however, some Hyphomycetes appeared as of immense biotechnological importance due to fantastic array of metabolites, enzymes and antibiotics etc. produced by them. The ecology of streams and ponds has acquired new dimension with the discovery that fungi are vital intermediaries in energy flow in these ecosystem. It was once assumed that bacteria do the most in sewage treatment but we now know that there is an enormous fungal biomass at work in these natural processes. They play also a great role in decompo-



sition processes with consequent recycling of basic natural resources and their role in biodeterioration and sometime consequent mycotoxicosis. Medical Mycology has undergone resurgence in recent years because of universal use of antibacterial antibiotics and the consequent recognition of certain mycoses as troublesome residuum. Growing concern with environmental toxicology has led to increased interest in biological control. The toxicologists have recently become aware that the growth of some common moulds on food stuffs leads to their contamination with dangerous fungal metabolites, such as aflatoxins.

We also known that the vast majority of higher plants with the exception of a few weedy families are mycorrhizal and that the fungi involved materially assist the plants to obtain some nutritionally necessary elements which are not available to them otherwise. Fungi are being increasingly exploited by industries for enzymes, organic acids, vitamins, antibiotics and other helpful substances, which they produce. Some fungi such as Agaricales, Truffels and Morels have been delicacies since the time immemorial. The pathogenic activities of fungi on man's crop plants have been important since the dawn of agriculture. But with increasing mechanization and concomitant spread of monoculture over huge areas, the harmful potential of fungal plant diseases has automatically been augmented.

As stated earlier fungi naturally do not posses photosynthetic pigments, they depend, for their food some sort of relation with other organisms. Nutritionally, the foliar hyphomycetes show a whole range of behavior from saprotrophy to necrotrophy and to biotrophy. Their ability to colonize substrates, decompose and utilize them and to interact with or parasitise other organisms i.e. plants, animals and their own kind, is remarkable and is achieved through the armory of a variety of enzymes, toxins, antibiotics and through their genetic diversity. One

of the parasitic categories is of the form, technically referred to as "Foliicolous" which incite an array of foliar diseases of plants.

The forest living leaves and their fungal symptoms

The leaves are the most important part of the body due to photosynthetic activity largely inherent to them. Plant leaves provide a very suitable habitat for the growth and development of fungal organisms especially as paratrophs such leaf inhabiting fungi are known as folicolous/foliar. Actually, the fungal pathogens attack the living leaves and reduce their productivity of photosynthates (foods and other valuable substances) by damaging photosynthetically active regions and also by bringing about quantitative reduction and qualitative rearrangement of living tissues of the host in multiple ways. The area of leaf invaded by foliicolous hyphomycetes usually becomes distinct due to the presence of fungus itself resulting in various kinds of local host responses ranging from discoloration to necrosis. Such diseased areas of the leaves are called "Leaf spots". The leaf spots vary in colour, shape, size and other features of appearance depending upon the degree and type of host-parasite interaction and association.

The cercosporoid fungi

Cercosporoid fungi are a heterogeneous assemblage of hyphomycetous forms of fungi imperfecti. The Cercosporoid hyphomycetes invade not only the horticultural and crop plants but also the weeds and forest plants equally. However, their best manifestation is seen in subtropical forests where almost every host species shows some or the other kind of fungal leaf spots and blights. Forests being of immense importance to man in view of their major and minor productivity as well as their ability to conserve and maintain the environmental stability, their leaf spot diseases lead to our greater concern. This indeed is fortified by the probability

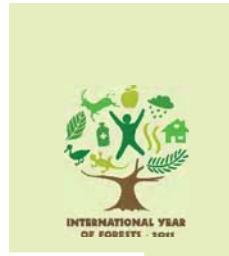


The fungal symptoms on leaves of host plants

of many of these stray plants serving as reservoirs of a variety of foliar pathogens which, on getting opportunity, may also spread to cultivated plants. This probability becomes more possible with the current concept of agro forestry, involving the multiuse of land.

Fresenius (1863) established the genus *Cercospora* while describing *Cercospora apii*. This type species was characterized by distinct features such as stromatic, coloured conidiophores with rimlike, thickened conidial scars and hyaline, acicular,

phragmosporic (vermiform) conidia bearing hila at the base corresponding to scars on the conidiophores. However, Fresenius himself and later workers did not follow these generic limits. Consequently, all the *Cercospora* like, foliicolous fungi were included in this genus which was inflated to more than 2000 species (Chupp, 1954). However, this genus was considered as a complex, with the upsurge of new information about host-parasite relationship including symptomatology, reappreciation of morphotaxonomic features and better understanding of conidial ontogeny. A further resolution



has resulted in two complexes, each represented by segregates of independent generic rank, the genus *Cercospora* being retained to represent those coming under the circumscription of the type species, *C. apii*. All the segregates are together referred to as Cercosporoid fungi.

The *Cercospora* like (Cercosporoid fungi) fungi are grouped into two complexes, the *Cercospora-Passalora* complex represented by *Cercospora*, *Pseudocercospora*, *Passalora*, *pheoaramularia*, *Phaeoisariopsis*, *Mycovellosiella*, *Stenella*, *Distocercospora*, *Corynespora* and a few other and the *Cercosporella-Ramularia* complex represented by *Cercosporella*, *Mycocentrospora*, *Ramularia*, *Ramulariopsis*, *Thedgonia*, *Pseudocercosporella*, *Phloeoospora*, *Neoramularia*, *Phacellium* and a few others. These complexes are also called as *Passaloroid* and *Ramularoids* complex respectively. The former complex is characterized by coloured conidial apparatus with hyaline or coloured conidia while the latter is characterized by hyaline conidial apparatus as well as conidia, the possibility of overlapping not being overruled as the colour is a polygenic character and is always subject to modification to some extent due to environmental conditions.

Crous & Braun (2003), upon examination of hundreds of type collections and thousands of non-type collections, assigned to *Cercospora*, deposited in various mycological herbaria of the world and analysis and correlation of molecular data have changed the entire scenario of Cercosporoid fungi followed by Kamal (2010).

This forest region is natural paradise for diversity of foliar fungi in general and hyphomycetous fungi in particular. Among foliicolous fungi, *Cercosporoid hyphomycetes* fungi have been found abundantly predominate throughout this region. A large number of genera and species of foliicolous fungi in general and *Cercosporoid hyphomycetous* fungi in particular have been encountered from this forest region of Uttar Pradesh. This forest region of Uttar Pradesh embodies most

of the factors which are congenial for the incidence of fungal diseases of plants particularly foliar diseases counting. Nevertheless, the end is still not in sight.

The taxonomy of parasitic fungi is, however, the first priority of study, since the knowledge about the correct identity of fungi involved in diseases is of vital importance for any study in applied aspects.

Conclusion

The Sub-tropical forests in the terai region of eastern Uttar Pradesh (Gorakhpur, Mahrajganj, Basti, Siddhatha Nagar, Gonda, Balrampur, Bahraich, Strawasti and Tulsipur) provide habitats to diverse lives such as various animal species, insect, bird, reptiles including variety of fungi, bacteria, viruses, lichens along with large number of parasitic phenerogams (*Cassytha* and *Cuscuta*) including beautiful epiphytic Orchids (*Vanda*). They also form the source of livelihood for rural and tribal settlements. Prevailing humidity throughout the year in the area makes area very ideal for fungal infection. The green leaves of trees in forests are natural site for occurrence of diversity of foliar fungi. Tree leaves can fall victim to many different fungi that can deform, discolor or destroy them, nevertheless, occasionally damage the trees completely or functionally. Generally, these diseases are not considered to be economic problems. Leaf diseases cause leaves to fall prematurely, leaving trees and shrubs without the green factories that produce food for them. Repeated defoliation of trees or shrubs makes them progressively weaker. Most deciduous plants can withstand several defoliations without serious damage. Being situated in terai region having humid climate, the area is very suitable for fungal infection because most fungi and bacteria that cause leaf diseases require a wet leaf surface for an extended time, usually about 24 hours. The wet leaf surface allows the fungal spores to swell, germinate and penetrate the plant and the bacteria to swim to a natural opening in the leaf surface, such as stomata.



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Consequently, the forests of North East part of Uttar Pradesh are the paradise for diverse species of foliar fungi. Over the past half century, about half the world's original forest cover has been lost, the most significant cause for that being unsystematic use of its resources. Nevertheless, some fungi and bacteria are also responsible for considerable damage. However, in recent year some biotechnological importance of fungi has been recognized. Large number of enzyme and antibiotics are being produced for variety of fungi. It was once assumed that only bacteria do the most in sewage treatment but recent researches have proved that there is enormous fungal biomass at work in these natural

processes. They also play a great role in decomposition processes by recycling the basic natural resources, bio deterioration and mycotoxicosis.

Sufficient biodiversity is required for ecosystem functions. The question is how we can assess required biodiversity. The species diversity of higher plants and animals usually can be assessed in most terrestrial environments. In contrast, microbial diversity is often ignored although the number and genetic diversity of microbes is enormous, and are profoundly important as plant and animal. Thus, it is the urgent need of the day that biodiversity as whole (higher and lower plants and animals) should be conserved for healthy and balance ecosystem.

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