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COLLECTION, IDENTIFICATION, DOCUMENTATION, EXPLORATION AND CONSERVATION OF BIODIVERSITY OF PARASITIC FOLIICOLOUS HYPHOMYCETOUS FUNGI FROM TERAI FORESTS FLORA OF UTTAR PRADESH

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Final Report of Research Project (KFRI RP: 729/2016)

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ABSTRACT OF PROJECT PROPOSAL

Project Number	**:**	**KFRI RP 729/2016**
Project title	**:**	**Collection, Identification, Documentation, Exploration and Conservation of parasitic foliicolous hyphomycetous fungi from Terai forest flora of Uttar Pradesh**
Objectives	**:**	**I. Biodiversity& Taxonomy of foliicolous hyphomycetous fungi:** ❖ Collection of specimens of parasitic foliicolous fungal forms at regular intervals from Terai forests of Uttar Pradesh and processing of specimens in the form of dried Herbaria as well as preservation in FAA and other such preservatives. ❖ Identification to sorting out hyphomycetous foliicolous forms. ❖ Documentation of hyphomycetous foliicolous fungi. ❖ Exploration of unexplored hidden parasitic foliicolous hyphomycetous biodiversity. **II. Conservation:** ❖ Conservation cum preservation of parasitic foliicolous hyphomycetes fungi in the form of dried herbaria (Fungaria). ❖ Indication for site conservation for foliicolous fungal biodiversity habitat.
Project period	**:**	**24 October 2016 – 02 October 2017 (at KFRI)**
Funding agency	**:**	**SERB, DST, Govt. of India**
Investigator	**:**	**Dr. Shambhu Kumar**

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Finally, I take this opportunity to express my gratefulness to all who have helped in any way towards the completion of this project.

(Shambhu Kumar)

Abstract

Extensive survey was conducted during 2014–2016 from Terai forests of Uttar Pradesh for the collection, identification, exploration, documentation and conservation of parasitic foliicolous hyphomycetous fungi. A total of 400 foliicolous fungal specimens showing different kinds of leaf diseases were collected in the entire period of study. Based on microscopic observation and morphological examination of collected foliicolous fungal specimens, 250 fungal specimens showing leaf spots were found belonging to hyphomycetous fungi and remaining 150 were belonging to the other groups (non hyphomycetous fungi). The identified 250 foliicolous hyphomycetous fungi were belonging to 30 genera, among them 233 were found already been reported while total 17 foliicolous hyphomycetous fungal specimens were proved as new taxa (species) for science, after critical morphological examination and comparison with closely similar taxa. The newly discovered foliicolous hyphomycetous taxa were belonging to 9 genera, represented by 5 species of *Corynespora* Gussow, 1 species of *Curvularia* Boedijn, 1 species of *Exosporium* Link, 1 species of *Monilochaetes* Halsted, 1 species of *Parapyricularia* Ellis, 1 species of *Passalora* Fr., 2 species of *Periconia* Tode ex Fries, 4 species of *Pseudocercospora* Speg. and 1 species of *Zasmidium* Fr. The novel taxa were morpho-taxonomically described, illustrated and discussed as per new ICN's rule. The dried and preserved Mycological herbarium (Fungarium) specimens of 17 novel taxa have been deposited as holotype in internationally recognized herbaria, Ajrekar Mycological Herbarium (AMH), ARI, Pune and Herbarium Cryptogamae Indiae Orientalis (HCIO), Indian Agricultural Research Institute (IARI), New Delhi and duplicate of the same as isotypes have retained in the departmental Mycological herbarium of the institute for future reference. Based on survey and collected foliicolous hyphomycetous fungi from different forest sites of eleven districts, it was found that the sites of Gorakhpur district and Mahrajganj district have more hyphomycetous fungal diversity. Hence, it is recommended that these areas need to be conserved.

1. INTRODUCTION:

Fungi are unique, ubiquitous and have their own monophyletic Kingdom Fungi (Eumycota). They are eucaryotic, achlorophyllous, heterotrophic, having a unique mode of nutrition, spore bearing organism reproduces asexually, sexually or both. Fungi are cryptic, understudied and hyperdiverse (morphologically, ecologically, phylogenetically and metabolically) organisms. Globally, fungi have estimated to range from 1.5 to more than 5.1 million species (Hawksworth 1991, O'Brien et al. 2005, Bass & Richards 2011, Blackwell 2011(, but only a small fraction of these species)approx .100000 (have so far been described)Kirk et al . 2008 .(Hawksworth (2004) reported that only 20% were being deposited in culture collections (BRC). The discovery of an average of 1200-1250 fungal species per year, suggests that it will take more than 1170 years to reach the most accepted milestone of 1.5 million species (Hibbett et al. 2011). From India, 27,000+ fungal species have been reported (Manoharachary et al. 2005). The systematic study of fungi in general and hyphomycetes, in particular revolves around certain basic steps including collection, macroscopic and microscopic examination along with need based molecular investigation. In term of diversity, season, climate, altitude and vegetational composition of an area plays a pivotal role. As time moved and in view of rapid race of allied branches of biological science ahead of taxonomic mycology, the publications on fungal diversity and taxonomy and thereby understanding of fungi of India steadily slowed down. Many countries similar to ours, viz. China, Taiwan, Thailand, etc. in the neighborhood; have clearly laid down their roadmap and future version of taxonomic mycology.

Fungi are both friend and foe and have profound impacts on human society and ecosystem function. They play an essential roles in ecological systems in terms of global chemical cycling, decomposition, nutrient acquisition in symbiosis and pathogenicity (Martin et al. 2011, Fisher et al. 2012, Read at al. 2004, Taylor et al. 2012). Fungi cause damage many millions of dollars in each year through food spoilage, destruction or degradation of materials used by humans, and diseases of plants and animals (including humans). Fungal species can also act as bioindicators of habitat status and type, and indicate sites with long ecological continuity (Lonsdale et al. 2008).

Fungi which inhabit on living leaves of plants are called Foliicolous, because the leaves are the most important part of the plant body due to photosynthetic activity largely inherent to them. Also, the plant leaves provide a very suitable habitat for the growth and development of fungal organisms.Most of them are plant biotrophs pathogens, but few are necrotrophs and or saprotrophs. The foliicolous fungi mainly include leaf spots, black mildews, rusts, smuts, powdery mildews, downy mildews, sooty moulds etc. Among foliicolous, the hyphomycetous fungi are heterogeneous assemblage of asexual fungi (Ascomycota), cause leaf spot diseases in both forests and crop plants and produced their spores on a special structure called conidiophores. Earlier they were considered under the Deuteromycotina (Fungi imperfecti). Actually these fungal pathogens attack the living leaves and reduce their productivity of photosynthates (food and other valuable products) by damaging photosynthetically active regions, and also by bringing about quantitative reduction as well as qualitative dearrangement of living tissues of the host in multiple ways. Because of these fungal infestations and infections sometimes result in colossal loss in biomass production by green plants. However their best manifestation is seen in tropical and subtropical forests. In hyphomycetes, cercosporoid fungi or *Cercospora s. lat.* belonging to *Mycosphaerellaceae* (Capnodiales), include numerous economically significant plant pathogens causing leaf spots on a wide variety of woody and herbaceous plants, but also can cause necrotic

lesions on flowers, fruits, bracts, seeds and stems (Goodwin et al. 2001, Crous & Braun 2003, Agrios 2005). They are found in different geographical and climatic zones across the world, and are especially abundant and diverse in tropical and subtropical areas (Braun et al. 2013, 2014). The frequent association of cercosporoid fungi with plant diseases has stimulated substantial interest in this group, and much of this attention has been focused on the systematics of species and genera in this complex (Deighton 1976, Pretorius et al. 2003, Braun & Crous 2005, Crous et al. 2006, Arzanlou et al. 2008, Nakashima et al. 2011, Braun et al. 2013). In the first monograph published by Chupp (1954), almost all of the cercosporoid taxa concerned were assigned to a single genus, viz. *Cercospora* Fresen. Deighton (1967, 1973, 1976) divided many *Cercospora* species into segregate genera such as *Cercosporella* Sacc., *Passalora* Fr. and *Pseudocercosporella* Deighton. Cercosporoid fungi include over 30 morphologically similar anamorphic genera. Crous and Braun (2003) published an annotated checklist of *Cercospora* and *Passalora* names with 5720 taxa. In Indian context, the Cercosporoid fungi of India has compiled by Kamal (2010).

These parasitic foliicolous hyphomycetous fungi have attracted the attention of mycologists since the very beginning of mycology due to distinct and sometimes beautiful symptoms produced on the leaf surfaces and its ecological importance. However, taxonomic studies of such fungal forms have been generally considered as only of academic interest, although there is growing acceptance now that taxonomic treatment of a fungal organism is the first requirement for any studies concerning its biology. Likewise, the correct identification of a fungus free from ambiguities is vital for its implement in applied disciplines in general and is more significant so far for Plant Pathology where precision of details about the biology of the pathogen is primarily conditioned by its identity. Infact, without being equipped for ascertaining the correct identification of a fungal pathogen, all studies concerning phytopathological aspects would simply be misleading. Foliicolous hyphomycetous fungi (for example host-specific species known only on rare endemic plants) are often treated as part of the problem (a threat to the plant) rather than recognized as themselves being in need of protection. Foliicolous fungi strictly depending on the plant species may be on the verge of co-extinction. Therefore, we can think that, in the forest of Uttar Pradesh, many plants are under the RET of IUCN's category and if a host plant is lost the associated host-specific fungus will also be lost simultaneously.

After the Rio de Janeiro Convention on Biological Diversity in 1992, exploration of biodiversity became more important than ever to know the cause of rapid depletion of biodiversity, their conservation management and to study the effects of climate change. In addition to this, the updated list of plants of a particular region helps to prevent bio-piracy and knowledge of indigenous fungi for future prospection. In this perspective, the forests of Uttar Pradesh were selected for its proper exploration, documentation, conservation and assessment of parasitic foliicolous hyphomycetous fungi. Hence, we had taken an initiative to explore the foliicolous fungal diversity in general and parasitic hyphomycetous fungi in particular of Terai forests of U.P. because, forests of U.P. is nurtured under diverse set of climatic conditions and is adorned with rich phanerogamic vegetation and this climatic conditions further add to the luxuriant growth of various such vegetations. The forest region (subtropical forest) of U.P. is natural paradise for biodiversity of foliar fungi in general and foliicolous fungi in particular. The climatic conditions as rainfall, soil and humidity are very much favourable for the thriving growth and development of the hyphomycetous fungi which affects the plants life greatly. The phytopathogenic foliicolous hyphomycetous fungi have been found abundantly predominate throughout this region. Thus, the Terai forest region of U.P. in India embodies most of the factors

which are congenial for the incidence of fungal diseases of plants particularly foliar diseases caused by hyphomycetous fungi. Most of the forest areas of U.P. have been surveyed extensively by the school of Mycology and Plant Pathology of D.D.U. Gorakhpur University for exploration of foliicolous fungi in general and cercosporoid fungi in particular (Kamal, 2010). Nevertheless, new surveys continue to reveal a vast number of undescribed fungi.In this background, the study was undertaken with the following objectives:

I. Biodiversity& Taxonomy of foliicolous hyphomycetous fungi:

- Collection of specimens of parasitic foliicolous fungal forms at regular intervals from forests of Uttar Pradesh and processing of specimens in the form of dried Herbaria as well as preservation in FAA and other such preservatives.
- Identification to sorting out hyphomycetous foliicolous forms.
- Documentation of hyphomycetous foliicolous fungi.
- Exploration of unexplored hidden parasitic foliicolous hyphomycetous biodiversity.

II. Conservation:

- Conservation cum preservation of parasitic foliicolous hyphomycetes fungi in the form of dried herbaria (Fungaria).
- Indication for site conservation of the foliicolous fungal biodiversity habitat.

2. MATERIALS AND METHODS:

Survey of the Terai forest Areas:

The area selected for the present study was Terai forests of Uttar Pradesh, due to congenial combination of topography, vegetations, climatic and environmental conditions. The low lying land stretch in the north of Indo-Gangatic Plain along the foothills of Central Himalaya is known as 'Terai' (Chauhan et al. 2010). It is dispersed in three Northern Indian States namely Uttarakhand, Uttar Pradesh and Bihar and the southern Nepal (Rodgers et al. 2002). It forms an ecotone where the Sub-Himalayan foothills encounter the plain region. Due to the edge effect this region exhibits the vegetation of both the contiguous regions and becomes one of the highly diverse regions of the country (Shukla 2009); and is one of the most diverse eco-regions of the world (De 2001; Kumar et al. 2002). The region in Uttar Pradesh spreads fromSaharanpur to Deoria covering 21 districts of the State, but we had chosen only 11 districts (Bahraich to Deoria). It is situated between 28°45′–26°15′ N and 079°51′–084°24′ E. The study area comes under themonsoon type of climate which witnesses three different seasons: winters (November–February), summers(April–June) and rains (July–September)with onemonth spring (March) and autumn (October). The mean minimum temperature varies from 4–5°C in December– January and maximum 40–45°C in May–June. The average annual rainfall varies from 1,085–1,228 mm. The forest type of the areas is subtropical. The humidity of the area is generally high due to high rainfall. The climatic conditions favour the growth of various types of phanerogamic vegetation (herbs, shrubs and trees) which favoursthe growth and development of foliicolous hyphomycetous fungi.Most of plants are very common in all the sites of the Teraiforests. As regards the topography of the area (belt of Uttar Pradesh) because of the industrial development being in rudimentary stage, vegetation has found in its natural forms. Almost all the forest regions in question are flanked to the north by the foot hills region 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, there are also present some big, perennial lakes and numerous low lying areas, the latter acting as seasonal water reservoirs.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.

Sample collection and infield visual examination:

The collection of foliicolous hyphomycetous fungal specimens were carried out at regular intervals during 2014–2016 from the forest (sub-tropical forests) of U.P. including different forest sites of the eleven districts (Bahraich, Shrawasti, Gonda, Balrampur, Basti, Sant Kabir Nagar, Siddharth Nagar Gorakhpur, Mahrajganj, Kushinagar, Deoria). The photographs of the host, infection spots on host leaves were taken at the time of collection by using a digital camera. The host plants were identified by visual examination, with the help of experts, online database and literature was used when required. The relevant primary information such as biological and vernacular names of host plants, symptomatology, locality and date of collection etc. were recorded in field diary at the time of collection for later reference to avoid any possible confusion.

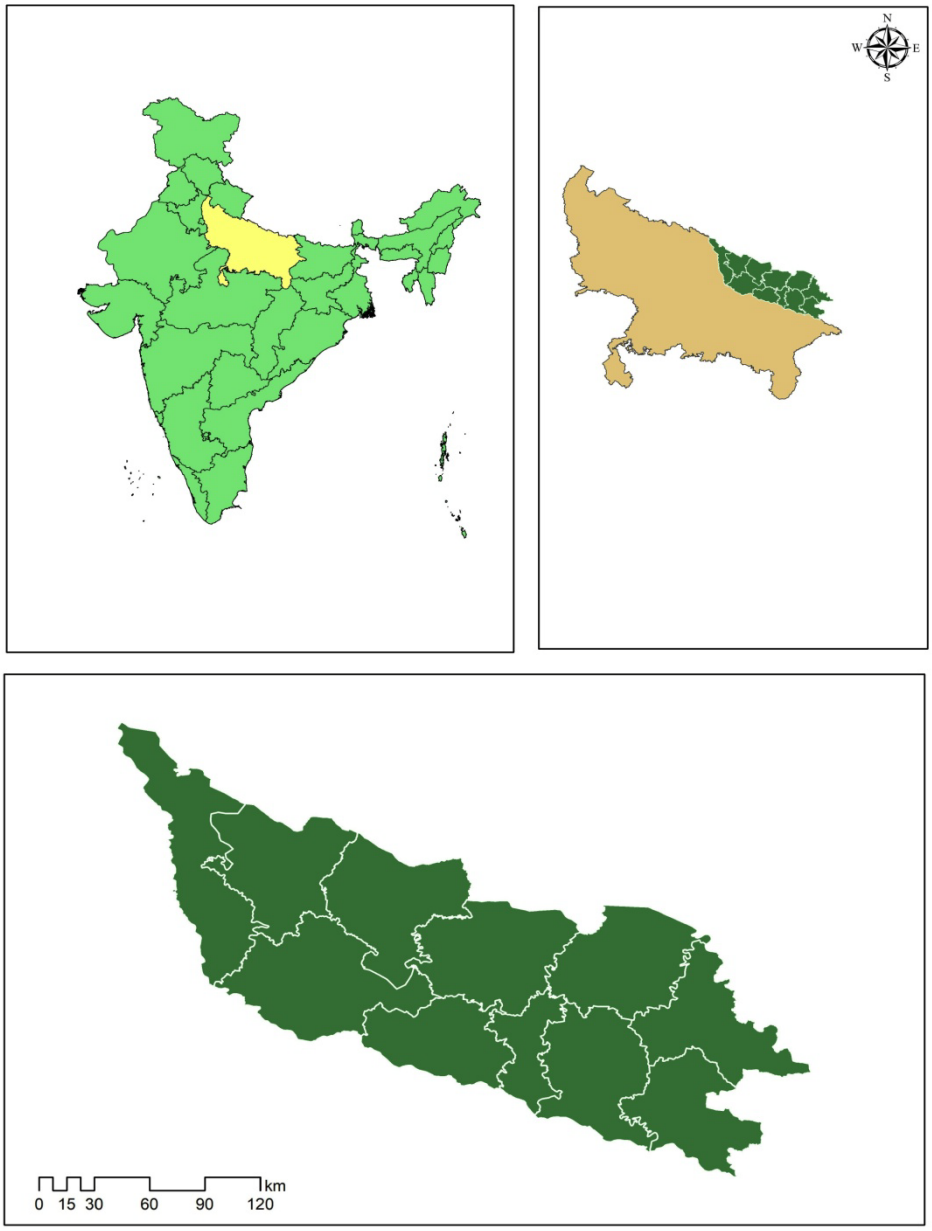

Figure 1. Study Area map: Terai forests of Uttar Pradesh, India

Processing of the collected specimens:

The collected fresh foliicolous fungal specimens were kept in zip-lock polyethene bags and brought to the laboratory for the detailed study. The selected specimens were pressed by routine herbarium techniques (Savile 1962, Hawksworth 1974, Castañeda-Ruiz 2005). After satisfactory drying and pressing specimens were sprayed with or 0.2% Sodium hypochlorite (NaOCl) and FAA in order to check microbial degradation.The sun dried and pressed specimens (herbarium specimens) were placed in air tight zip-lock polyethylene bags along with blotting paper and then kept in paper envelops along with collection details. The dried and pressed fungal herbarium specimens (Fungarium) were kept in two packets. The first packets of novel discovered taxa were deposited as holotype to the internationally recognized Ajrekar Mycological Herbarium (AMH), ARI, Pune and HCIO, IARI, New Delhi with accession number and second packets stored as isotype in the departmental mycological herbarium for future reference.

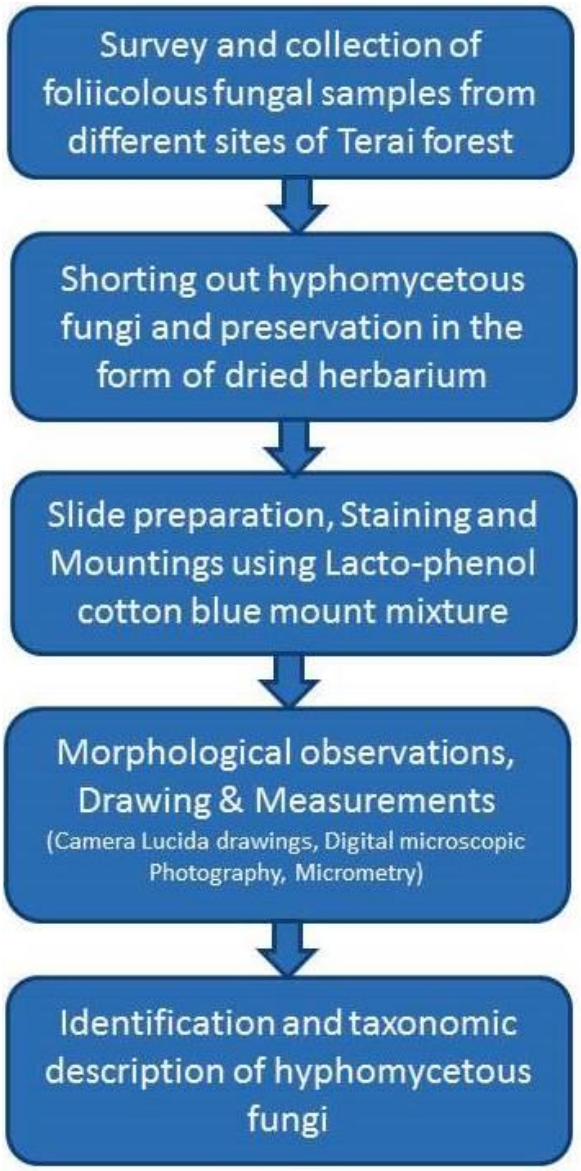

Figure 2: Schematic representation of methodology used in the study

Laboratory processing and preliminary examination:

Preparation of slides:

- **Hand cut section preparation:** A hand cut section of infected leaf tissue was made with sharp razor/blade to immersed or semi immersed foliicolous hyphomycetous fungi study.
- **Scrap mount:** The superficially attached organisms with the host tissue were studied by scrap mounts with the help of sharp razor or blade or scalpel.
- **Squash preparation:** The fruiting body was mounted, cleared and examined. Then the preparation was tapped vigorously and reheated. In this way the fruiting body was broken and content was released.

Staining and mounting:

- **Lacto-phenol cotton blue:** The lacto-phenol mounting fluid is used for mounting colored fungi. For locating cytoplasm, septa, guttules other structures and hyaline forms 0.05 – 0.01% cotton blue was added.

Observations, digital microscopic photography, drawing & measurement:

- **Observations, digital microscopic photography and measurements:** Observations andmicrophotography was made under Olympus BX51 compound microscope with attached high resolution camera at different magnifications (10X, 20X, 40X, 100X).
- **Camera Lucida:** Lucida drawings were made of the distinctly different taxa of species rank so as to show the morphotaxonomic features of vital importance.
- **Scanning Electron Microscopy:** SEMs were taken as far as possible for selected fungal specimens.
- **Measurement:** For taking measurements as many as 20 to 30 structures depending on fungi were taken and considered for measurements. The measurement was calculated by using following formula:

$$\bar{X} = \frac{\Sigma^{M}}{n}(\mu m),$$ where, m = is size of each components, n = is number of components

Morphotaxonomic identification and presentation of hyphomycetous fungi:

The morphological identification, taxonomy and description of hyphomycetous fungi were made with the help of literatures, including monographs, reviews, books, indices and recently published research papers. The hyphomycetes were identified mainly with the help of Monograph of the fungus genus *Cercospora* (Chupp 1954), Indian Cercosporae (Vasudeva 1963), Dematiaceous hyphomycetes and More Dematiaceous hyphomycetes (Ellis 1971, 1976); *Cercospora* and similar fungi from Taiwan (Hsieh & Goh 1990), The genus *Pseudocercospora* in China (Guo & Hsieh, 1995), Hyphomycetes and Hyphomycetes-Taxonomy and Biology (Subramanian 1971, 1983), The fungi (Ainsworth et al. 1973), Mycological papers (Deighton 1974, 1976, 1979). In addition to the above mentioned literature, Index of fungi published regularly from Commonwealth Mycological Institute, Kew, England; and Fungi of India (Bilgrami et al. 1979, 1981, 1991; Sarbhoy et al. 1980, 1986, 1996; Jamaluddin et al. 2004) were also considered as reference sources.

Besides above literature, some important references were also found very useful e.g. Introductory Mycology (Ainsworth and Bisby 1961), Morphology and Taxonomy of fungi (Bessey 1968), The Whole Fungus (Kendrick 1979 a,b), The Fifth Kingdom (Kendrick 1985), Crous et al. (2000), M*ycosphesella* & its Anamorphs (Crous & Braun, 2003), Fungal Families of the World (Cannon and Kirk 2007); Dictionary of Fungi (Kirk et al. 2008); Hyde et al. (2010), Cercosporoid fungi of India (Kamal, 2010); Phengsintham et al. (2010, 2013); Genera of hyphomycetes (Seifert et al. 2011); Host-Fungus Distribution Database (Farr & Rossman 2016), Mycosphaerellaceae – Chaos or clarity? (Videira et al. 2017), Index Fungorum (www.indexfungorum.org), etc. The nomenclatural details of the novel taxa were deposited in Mycobank (www.mycobank.org), a recognized database mycological repository. The newly recognized taxa were described as per new ICN rule (McKnill et al. 2012). Taxonomy and nomenclature of plant families, genera and species were identified based on the "Angiosperm Phylogeny Website" (http://www.mobot. org/mobot/research/apweb/), Tropicos database (http://www. Tropicos.org/) and The Plant List (http://www.theplantlist.org).

3. RESULTS AND DISCUSSION:

In the present study, total 400 fungal specimens showing various kinds of foliar symptoms were collected from different sites of Terai forest of Uttar Pradesh during 2014 to 2016. Based on microscopic examination of collected foliicolous fungal specimen, 250 fungal specimens were found belonging to 30 genera of hyphomycetous fungi and remaining 150 were belonging to other groups of fungi (non hyphomycetous fungi). Based on detailed morphotaxonomic study, 233 species of hyphomycetes were found already been reported, while total 17 foliicolous hyphomycetes were proved as new species for science after critical morphological examination and comparison with similar taxa. These newly recognized taxa were morpho-taxonomically described, illustrated and discussed as per new ICN's rule. The newly discovered hyphomycetous taxa were belonging to 9 genera represented by *Corynespora* Gussow (5 spp.), *Curvularia* Boedijn (1 sp.), *Exosporium* Link (1 sp.), *Monilochaetes* Halsted (1 sp.), *Parapyricularia* Ellis (1 sp.), *Passalora* Fr.(1 sp.), *Periconia* Tode ex Fries (2 spp.), *Pseudocercospora* Speg. (4 spp.), and *Zasmidium* Fr. (1 sp.). The details of novel taxa are as follows (Table-1):

Table 1: List ofnewly discovered taxa of foliicolous hyphomycetous fungi

SN	Name of fungus	Name of Host	Host family	Collection Place	Accession No.
1.	*Corynespora aristolochiae**	*Aristolochia indica*L.	Aristolochiaceae	Gulara Forest, Shrawasti	AMH-9687 SK-078
2.	*Corynespora celastri*#*	*Celastrus paniculatus* Willd.	Celastraceae	Paniyara Forest, Mahrajganj	AMH 9687 SK-094
3.	*Corynespora gmelina**	*Gmelina arborea* Roxb.	Verbenaceae	Kakadari Forest, Shrawasti	AMH-9870 SK-080
4.	*Corynespora sidae*#*	*Sida acuta L.*	Malvaceae	University Campus, Gorakhpur	AMH-9706 SK-119
5.	*Corynespora tremiicola*#*	*Trema orientalis* (L.) Blume	Ulmaceae	University Campus, Gorakhpur	AMH-9703 SK-143
6.	*Curvularia martyniicola**	*Martynia annua* L.	Martyniaceae	Buddha Men's Hostel Gorakhpur	AMH-9701 SK-148
7.	*Exosporium albizicoloum**	*Albizia lebbek* (L.) Benth.	Fabaceae	Kakadari Forest, Shrawasti	AMH-9871 SK-151
8.	*Monilochaetes dracaeniicola**	*Dracaena fragrans* (L.) Ker Gawl.	Dracaenaceae	University Campus Gorakhpur	AMH-9702 SK-158
9.	*Parapyricularia leptadeniicola**	*Leptadenia reticulata* (Retz.) Wight & Arn.	Asclepidaceae	Nichlool Forest, Mahrajganj	AMH-9522 SK-160
10.	*Passalora caesalpiniicola*#*	*Caesalpinia bonduc* (L.) Roxb.	Caesalpiniaceae	Nichlaul Forest, Mahrajganj	HCIO-48665 SK-165
11.	*Periconia palmivora*#*	*Phoenix dectylifera* (Roxb.) Wight & Arn.	Arecaceae	Bhinga Forest, Bahraich	AMH-9520 SK-171
12.	*Periconia pergularigena*#*	*Pergularia Pallida* L.	Asclepiadaceae	University Campus, Gorakhpur	AMH-9521 SK-172

13.	*Pseudocercospora ampelocissicola**	*Ampelocissus indica* (L.) Planch.	Vitaceae	Chook Forest, Mahrajganj	HCIO-48668 SK-178
14.	*Pseudocercospora aristolochium**	*Aristolochia indica* L.	Aristolochiaceae	Gulara Forest, Shrawasti	AMH-9866 SK-179
15.	*Pseudocercospora bischofigena *#*	*Bischofia javanica* Blume	Euphorbiaceae	Nichlaul Forest, Mahrajganj	HCIO-48669 SK-183
16.	*Pseudocercospora glochidiicola **	*Glochidion velutinum* Wight	Euphorbiaceae	Nichlaul Forest, Mahrajganj	HCIO-48672 SK-199
17.	*Zasmidium dregiicola**	*Dregea volubilis* L.f.) Benth. ex Hook.f.	Apocynaceae	Kuwana Forest, Balrampur	AMH-9876 SK-242

*# Novel taxa discovered and published

* Novel taxa discovered and to be published

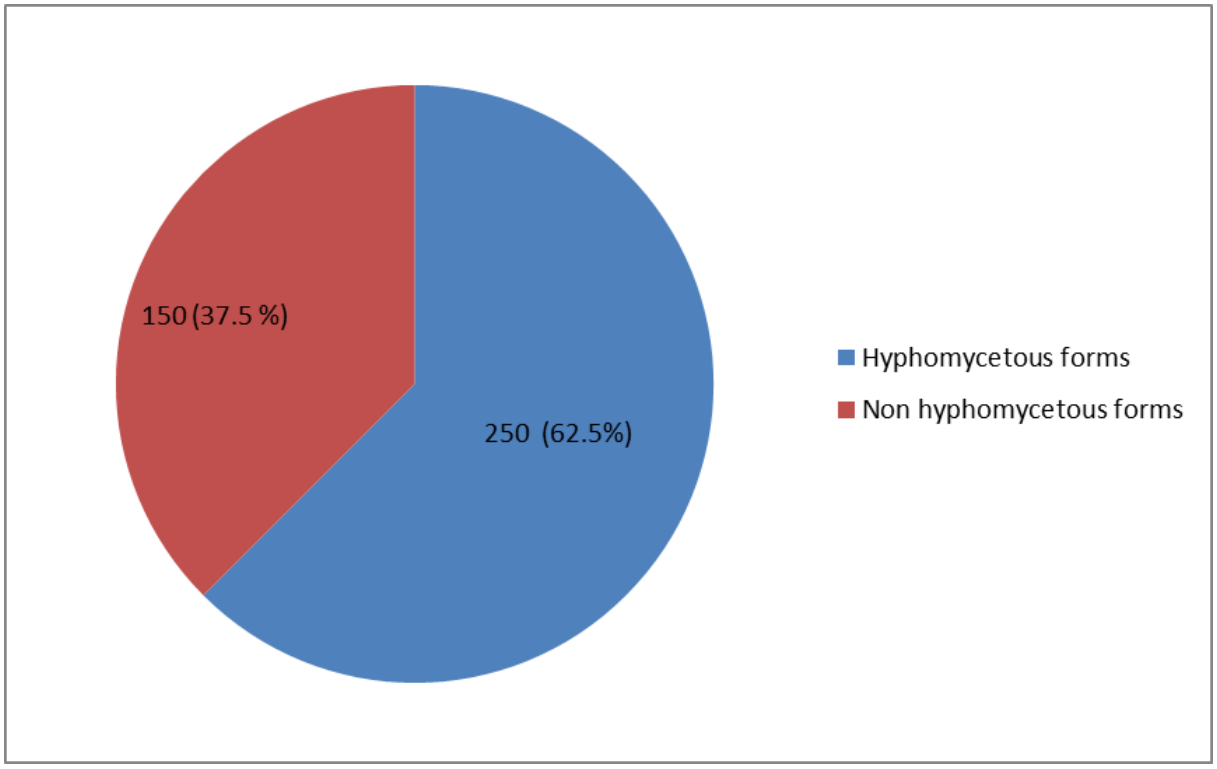

Figure 3. Number of hyphomycetous forms and non hyphomycetous forms in collected 400 foliicolous fungal specimens

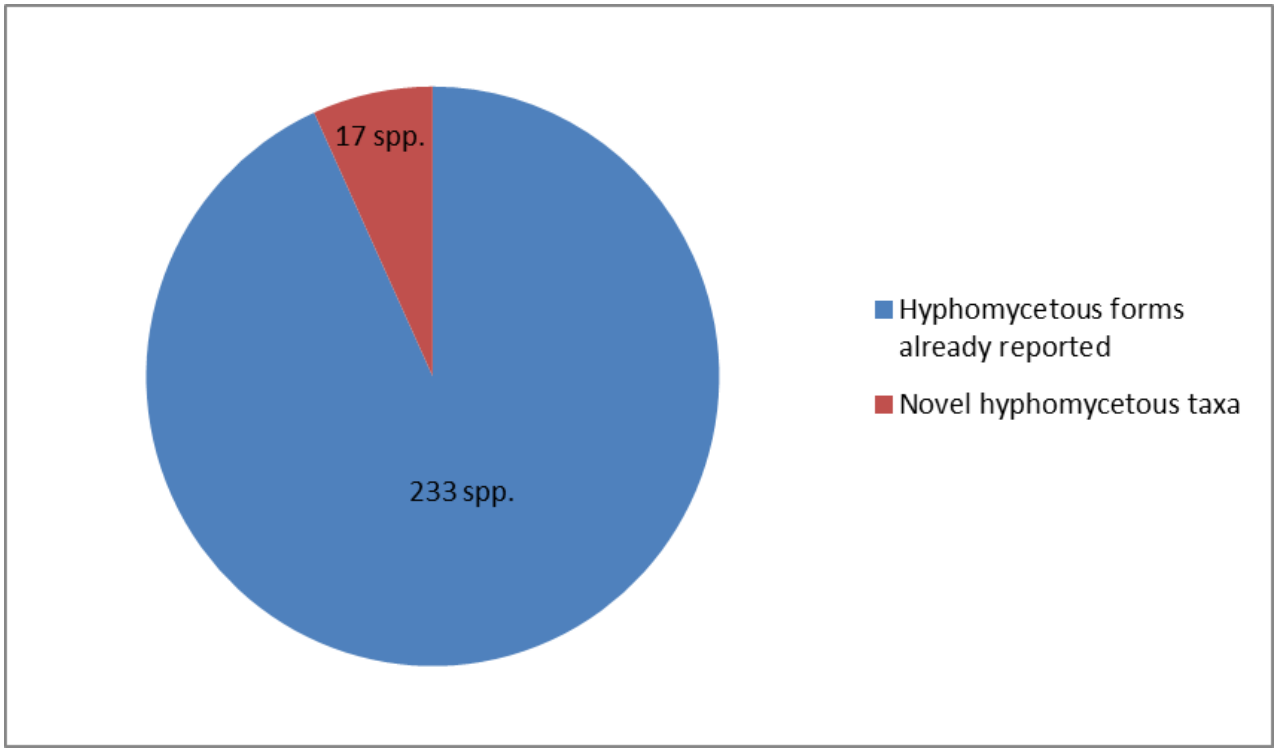

Figure 4. Number of novel hyphomycetous taxa, in identified 250 hyphomycetous forms

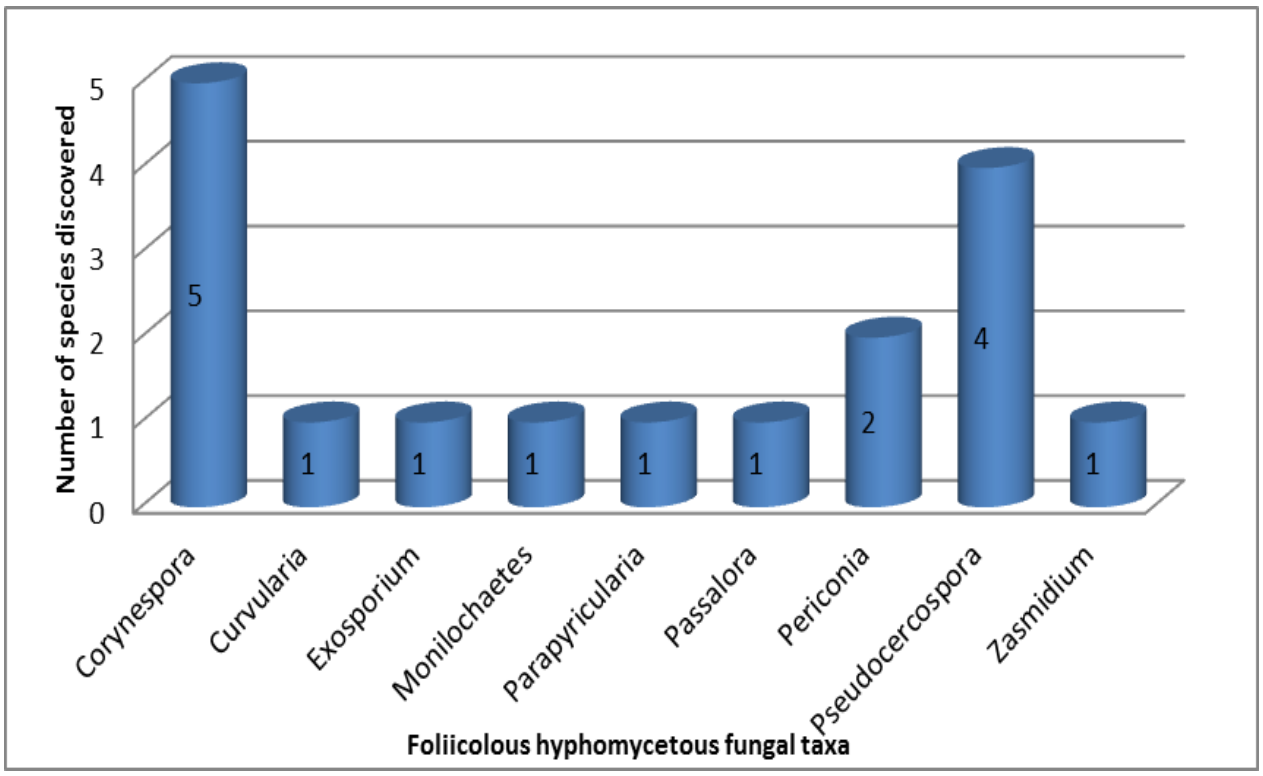

Figure 5. Graphical representation of newly discovered foliicolous hyphomycetous fungal taxa

After detailed study, the dried, pressed and preserved fungal herbarium (Fungarium) specimens of 17 novel taxa have been deposited as holotype in internationally recognized, Ajrekar Mycological Herbarium (AMH), ARI, Pune and Herbarium Cryptogamiae Indiae Orientalis (HCIO), Indian Agricultural Research Institute (IARI), New Delhi. The duplicate of the same as an isotypes are retained in the departmental mycological herbarium of Kerala Forest Research Institute, Peechi for future reference. Based on floristic survey, collection, morphological observations, laboratory examination and documentation of collected foliicolous hyphomycetous fungi from different forest sites of eleven districts of Uttar Pradesh, it was found that sites of Gorakhpur district and Mahrajganj district have more hyphomycetous fungal diversity. Hence, it is recommended that these forests areas need to be conserved as habitat for foliicolous hyphomycetous fungi.

4. CONCLUSION AND RECOMMENDATIONS:

In this study, the survey was made during 2014–2016 for the collection of foliicolous fungal specimens from the Terai region of Uttar Pradesh including different forest sites of eleven districts. A total 400 living leaf specimens of mostly angiospermic plants exhibiting disease symptoms (leaf spots and leaf blights) were collected based on natural morphological symptoms. In the collected 400-foliicolous fungal specimens, 250 fungal specimens were found belonging to 30 genera of hyphomycetous fungi and remaining 150 fungal specimens were found belonging to other groups (non hyphomycetous fungi) based on microscopic examination. After detailed critical morphological identification and comparison with similar taxa, 233 hyphomycetous forms were found already been reported, while total 17 foliar hyphomycetous fungal specimens were proved as new species for science. The dried herbarium specimens of 17 novel taxa were treated as holotype, have been deposited in internationally recognized herbaria, Ajrekar Mycological Herbarium (AMH), ARI, Pune and Herbarium Cryptogamiae Indiae Orientalis (HCIO), IARI, New Delhi for future reference. Based on survey, collection, morphological observations and laboratory examination of collected fungal specimens from Terai forests of U.P. including different forest sites of eleven districts, it was found that sites of Gorakhpur district and Mahrajganj district have more hyphomycetous fungal diversity. Hence, it is suggested that these forests areas need to be conserved as habitat for foliicolous hyphomycetous fungi.

After the Rio de Janeiro Convention on Biological Diversity in 1992, exploration of biodiversity became more important than ever to know the cause of rapid depletion of biodiversity, their conservation management and to study the effects of climate change.In this regards, we had taken an initiative for collection, identification, exploration and documentation of hidden foliicolous hyphomycetous fungal wealth and added 17 spp. to Mycoscience and Indian mycoflora from Terai forests.

With the result of outputs of this work, we can say, the Terai forest of U.P. is a natural paradise for foliicolous fungi in general and hyphomycetous fungi in particular. The potential for discovering foliicolous hyphomycetous fungiin the Terai forest of U.P. is high. Therefore, this is an open area for research, and researchers can work on biodiversity exploration, conservation and prospection of these unexplored fungi, because fungi have wide source of potentially bioactive compounds and secondary metabolites, etc.

From biological conservation point of view, its an urgent need to conserve the host plants and its associated foliicolous fungi as well as their occurrence sites (habitat) also for future generation, because in the Teraiforest, many plants are under the RET of IUCN's category and if a host plant will lost the associated host-specific fungus will also be lost simultaneously. This can be achieved only through creation and protection of forest reserve areas, preservation of fungi habitat and ex-situ conservation. It is therefore essential to include fungal biodiversity conservation in forest management policies in our country. In addition to this, we can also work on most hot problems of the decade impact of climate change on the occurrence of fungal biodiversity as well as the indicator species of foliar fungi.

With the result of project from phytopathological point of view, the correct and authentic identification of plant pathogenic fungi is extremely important for management of plant diseases, in formulating quarantine policies and thus can have an immense impact on trade and global bio-security. Also, the hyphomycetous fungi can be used as biocontrol agents who can be helpful for management of plant diseases without ill effects to plant and ecosystem health.

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Appendix

Publication

1. **Shambhu Kumar** and Raghvendra Singh (2015). *Pseudocercospora bischofigena*, a new anamorphic fungus from northeastern Uttar Pradesh, India.***Czech. Mycology,*** **67**(1):39–44.

2. **Shambhu Kumar** and Raghvendra Singh (2015). Taxonomy of asexual microfungus*Periconia* on *Phoenix* in India. ***Mycologia Iranica,*** **2**(1):65–68.

3. **Shambhu Kumar** and Raghvendra Singh (2016). *Passalora caesalpiniicola* sp. nov. from India on Caesalpinia bonduc. ***Mycotaxon,*** **131**(1): 25–30.

4. **Shambhu Kumar** and Raghvendra Singh (2016). Diversity, Distribution and Taxonomy of *Corynespora* associated with *Cannabaceae* and *Ulmaceae.* ***Pathology & Quarantine,*** **6**(2): 225-231.

5. **Shambhu Kumar** and Raghvendra Singh (2016). *Corynespora celastri* sp. nov. on Celastraceae from India. ***Studies in Fungi,*** 1(1):125–129.

6. **Shambhu Kumar** and Raghvendra Singh (2016). Biodiversity, Distribution and Taxonomy of Conidial Fungus *Corynespora* (Corynesporascaceae) associated with Malvaceae. ***J. Biodivers Endanger Species,*** **4**:166.

7. **Shambhu Kumar** and Raghvendra Singh (2016). Diversity of conidial fungus *Periconia* associated with Asclepiadaceae. ***Journal on New Bio. Reports,*** **5**(1): 71–74.

8. **Shambhu Kumar** and Raghvendra Singh (2018). *Curvularia martyniicola*, a new species of foliicolous hyphomycetes on *Martynia annua* from India. ***Studies in Fungi,*** **3**(1): 27–33.