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Fungal diversity associated with bamboo litter from Bambusetum of Rain Forest Research Institute, Northeast India

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ABSTRACT

Kumar R, Tapwal A, Pandey S, Rishi R. 2013. Fungal diversity associated with bamboo litter from Bambusetum of Rain Forest Research Institute, Northeast India. Biodiversitas 14: 79-88. Fungi play an important role in leaf litter decomposition due to their ability to break down the lignocelluloses matrix, which other organisms are unable to digest. Diversity of bamboo leaf litter fungi from fallen leaves and undergoing active decomposition leaves in different season and different depth was carried out in 2009-10. Twenty four samples were collected from Bambusetum of Rain Forest Research Institute (RFRI), Northeast India. The moist chamber, direct isolation and dilution plate methods were used to assess the diversity of fungal species. Fungi were cultivated on 3% malt extract agar and half strength potato dextrose agar. The litter was divided into freshly fallen senescent leaves (grade 1) and leaves already undergoing active decomposition (grade 2). Moist chamber incubation of the litter revealed 45 fungal taxa belonging to 22 genera. fungal taxa were found on grade I and 39 fungal taxa found on grade II litter. Although 24 fungal taxa were common to both grades, Differences were observed in percentage occurrence of fugal species between the two grades of litter. Periodic surveys were carried out to collect macrofungi. Young and matured carpophores of 16 macro fungi species were collected in different seasons. Out of these macrofungi, 3 species belongs to family Entolomataceae and Agaricacea, two species belongs to Tricholomataceae and Geoglossaceae one species belongs to each family Dacrymycetaceae, Pluteaceae, Coprinaceae, Marasmiaceae Lycoperdaceae and Phallaceae. The bamboo leaf-litter was selected for the present syudy because of the dominance and great economic value of bamboo vegetation in North-east India.

Key words: carpophores, decomposition, leaf litter, RFRI

INTRODUCTION

Fungi are one of the most important organisms in the world, because of their vital role in ecosystem functions and human-related activities (Mueller and Bill 2004). Fungi play a significant role in the daily life of human beings besides their utilization in industry, agriculture, medicine, food industry, textiles, bioremediation, natural cycling and decomposing the dead organic matter present in soil and litter. (Molina et al. 1993; Keizer 1998; Pilz 2001; Cowan 2001; Chang and Miles 2004, Hunt 1999; Gates 2005). The peak mushrooms and macrofungi season for each region vary with ecological climate (Arora 1991). The number of existing fungi worldwide has been estimated to 1.5 million species (Hawksworth 2004). One-thirds of the fungal diversity of the globe exists in India and of this, only 50% are characterized yet (Manoharachary et al 2005). The number of fungi recorded in India exceeds 27,000 species, the largest biotic community after insects (Sarbhoy et al. 1996).

Macrofungal biodiversity also play an important role in balancing ecological services. Fungi are one of the key functional components of forest ecosystems (Brown et al. 2006). They are omnipresent but drawing less attention than animal and plants. They are highly diverse in nature (Piepenbring 2007). Having a stable and estimate of taxonomic diversity for fungi is also necessary to enable fungi to be included in considerations of biodiversity conservation, land-use planning and management (Mueller and Schmit 2007). Decomposition on the forest floor is a very complex phenomenon and is achieved by different groups of microorganisms. The major component of the top soil consists of different parts of plant materials. These are immediately colonized by diverse groups of microorganisms as they fall on the soil surface and soon after the processes of decomposition starts. Litter decomposition is also an important link in nutrient cycling of the forest (Grigal and McColl 1977). During the last few years various workers have developed interest to understand the nature of fungi both in forest and cultivated fields. The study on diversity of leaf litter fungi from various host plants were reported earlier (Bills and Polishook 1994; Saravanan 2004; Tokumasu et al. 1997).

Some fungi were found to be common on leaf litter in previous studies, while many new fungal taxa have been described from decaying leaves and dead wood (Hughes 1989). A total of 26 genera, 31 species of Hyphomycetes, 8 species of Coelomycetes and 5 species of Ascomycetes were reported in Thiland. Two leaf litter fungi, *Myrothecium verrucaria* and *Ciliochorella* sp. were found to supress the growth of *Alternaria alternata*, *Colletotrichum capsici*, *Curvularia lunata* and *Fusarium oxysporum* under *in vitro* conditions (Manoch et al. 2006). In addition, morphological study of 42 genera 48 species leaf litter fungi was reported using light microscope (Manoch et al. 2006). Six new species of dematiaceous hyphomycetes from dead wood

and bark in New Zealand were also illustrated and described (Hughes 1989).

Alternaria, *Aspergillus*, *Cladosporium*, *Penicillum* and *Trichoderma* were reported as dominant fungi on decomposing bamboo litter. Deka and Mishra (1982) and Schmit et al. (1999) reported 30 species from bamboo litters. (Osono and Takeda 2002) observed the ability of 79 fungal isolates on litter decomposition of deciduous forest in cool temperate in Japan, and reported 6 species of Basidiomycetes causing 15.10 to 57.67% of weight losses, 14 species of *Xylaria* and *Geniculosporium* causing weight losses upto 14.4%. Some ectomycorrhizal fungi associated with Sal forest are *Astraeus hygrometricus*, *Boletus fallax*, *Calvatia elata*, *Colletotrichum dematium*, *Corticium rolfsii*, *Mycena roseus*, *Periconia minutissima*, *Russula emetica*, *Scleroderma bovista*, *S. geaster*, *S. verrucosum* and *Scopulariopsis alba* were documented by (Soni et al. 2011).

Keeping the above facts in mind, the present study was focused on the isolation and identification of fungi associated with decomposition of litter of bamboo in different seasons and in different depths from Bambusetum of RFRI, Jorhat, Northeast India. Bamboo leaf-litter was selected for the present study because of the dominance of bamboo vegetation and its great economic value in North-east India.

MATERIALS AND METHODS

Study area

The study was conducted in 2009-2010 at Bambusetum of Rain Forest Research Institute (RFRI), which is situated in the Northeastern part of India having longitude of 95°17´ E and latitude 26°46´ N and at an altitude of 107 m above the sea level. The climate of the region is semi arid. It is warm and moist from May to September. December and January are usually the colder months. The area receives an average mean annual rainfall of 2029 mm, average temperature 26ºC in summer and minimum temperature is 10ºC in the month of January. The soil is lateritic sandy loam of pH 4.5-5.0. Bambusetum was established in the year 2002, occupying an area of about 1 hectare. At present, it houses 39 species of bamboo (green gold) under 13 generic heads. Out of these special attention has been given on the exotic, endangered, rare and ornamentals that were collected from different regions of the Indian sub-continent (Figure 1).

Study on litter decomposing fungi

The fungi were isolated from leaf litter on culture media, then purified and identified as per methods briefly described below.

Direct observation

Twenty four samplings were made during the period of study. Litter samples were collected at random from the study site and brought to the laboratory in sterile polythene bags. The litter was sorted into two grades representing the two stages of decomposition. These were 'grade 1' representing freshly fallen and senescent leaves and 'grade 2' representing leaves in an advanced stages of decomposition, usually thin, fragmentary and tightly compressed. Leaf litter samples were cut into 5x5 mm^2 small pieces with a sterile parallel razor at random from the base, middle and apex. These pieces were cleaned, stained ,observed under stereo-microscope and fungal colonization were recorded (Shipton and Browns 1962).

Moist chamber incubation technique

Twenty five leaves of each grade of leaf litter were randomly selected and incubated in sterile moist chambers at 25±2°C. Petri plates (20 cm diam.) were sterilized **(**Keyworth 1951) and used as moist chambers with sterilized filter paper and periodically moistened with sterile distilled water. Leaves were incubated for 48 hours and then examined under a binocular stereomicroscope for the fungal fructifications. All fungi found sporulating were isolated, examined and identified to species level. Isolation frequency and percentage occurrence were used to explain the colonization efficiency of the microfungi on the leaf litter (Table 1, Figure 2). Isolation frequency denotes the number of samplings in which a particular fungus was recorded as against the total number of samplings (24).

Figure 1. Bambusetum of RFRI, Jorhat, Assam, India

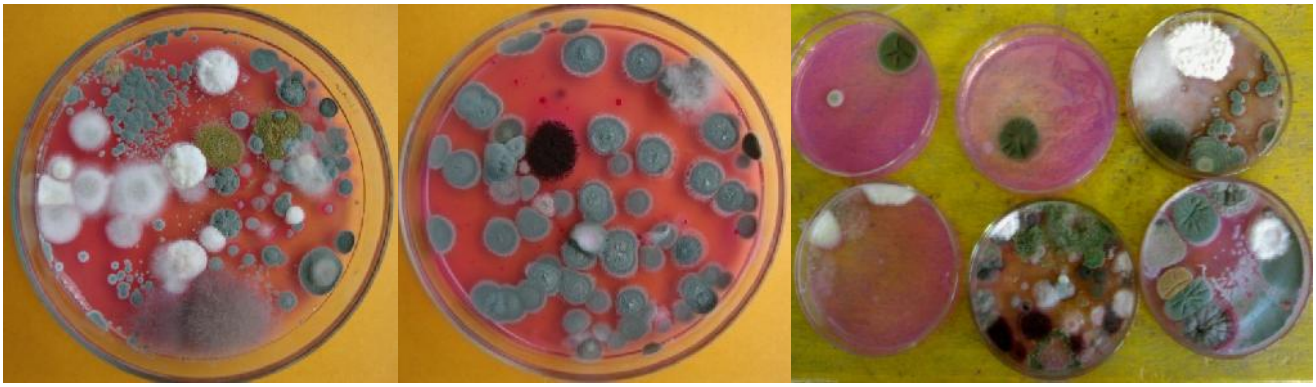

Figure 2. Micro fungal colony of *Mucor, Aspergillus, Penicillum, Rhizopus, Cunninughumella* and *Trichoderma*, from leaf litter culture of Bambusitum of RFRI, Jorhat, Assam, India**.**

Based on this, the fungi were categorized into 5 groups; most common(81-100%);common(61-80%); frequent(41-60%); occasional (21-40%) and rare(1-20%). Percentage occurrence was used to denote the number of leaves on which a particular fungus was present as against the total number of leaves (25) examined per grade by moist chamber incubation.

Leaf litter washing technique

In addition to the moist chamber incubation, a second technique of washing fresh leaves removed from the plant and leaf litter was performed (Subramanian and Vittal 1979). Fifteen fresh leaves and fifteen litter leaves were randomly selected from each grade of litter. From each leaf, five 1 cm^2 pieces were cut with a pair of sterile scissors. The samples were washed in 100 mL of sterile water in a 250 mL Erlenmeyer flask for 30 minutes on a shaker. From this initial suspension, serial dilutions were prepared. One mL of the required dilution (1/1000) was pipetted into each of six replicate plates. Potato dextrose agar (potato 200 g, dextrose 20 g, Agar 20 g, distilled water 1 L) with streptomycin sulfate (300µg/mL) was cooled to 45°C and poured into each Petri dish. The plates were incubated at room temperature in glass chambers under aseptic conditions for 4 days and examined for fungal growth. All fungal colonies were recorded and the fungi were sub-cultured and identified.

Identification of fungi

Fungi were identified on the basis of their growth characteristics, morphological characteristics and ontogeny with the help of manuals, monographs and taxonomic papers of various authors (Gilman 1957; Grove 1967; Subramanian 1971; Ainsworth et al. 1972; Barnett and Hunter 1972; Ellis 1971, 1976; Sutton 1980; and von Arx 1981). Identification was based on morphological study examined under stereo, light, microscopes (Olympus BX 50 F4, Japan and Axio Scope A, Carl Zeiss). Frequency of occurrence and percentage contribution were calculated as per the procedures described by (Saksena 1955). Where frequency of occurrence refers to the number of samplings in which a fungus was recorded out of the total number of samplings made during the period of study. This was converted to a percentage and on this basis the fungi were classified as most common (8-100%); common (61-80%); frequent (41-60%); occasional (21-40%); rare (1-20%).

Collection of macro fungal and diversity analysis

The periodic surveys were made for the collection of macrofungi during rainy season (June to September) and winter (October to December) in 2009-2010. The collected samples were wrapped in wax paper and brought to the laboratory for identification and proximate analysis. The taxonomy has been worked on the basis of macro and microscopic characteristic following available literatures (Zoberi 1973; Alexopolous et al. 1996; Purakasthya 1985). The soft textured specimens were preserved in 2% formaldehyde and leathery textured were preserved in 4% formaldehyde and kept in museum of Forest Protection Division, Rain Forest Research Institute, Jorhat, Assam by assigning identification number. The frequency and density of different species has been determined by the following formulas:

$$\text{Freq. of fungal sp. (\%)} = \frac{\text{No. of site in which the sp. is present}}{\text{Total no. of sites}} \times 100$$

$$\text{Density} = \frac{\text{Total no. of individual of a particular species}}{\text{Total no. of species}} \times 100$$

RESULTS AND DISCUSSION

The rapid bamboo leaf litter decomposition can be attributed mainly due to the soft cuticle, low lignin content, high moisture content and suitable temperature. Many workers have reported that changes in the relative proportions of chemical constituents of litter may influence the rate of decomposition (Frankland 1966; Van Cleve 1974). In grade 1 litter, 29 species belonging to 22 genera were isolated. Thirty nine species belonging to 17 genera were isolated from grade 2 litter (Table 1). Significant variation in microbial quantity was recorded in different seasons of the year. Our study revealed that the highest micobial population in all the sampeling sites was recorded in the month of September and second highest number of fungal propagules.was recorded in the month of March and April. The lowest microbial population in all the sampling sites

Table 1. Average percentage occurrence and isolation frequency of species isolated from two grades of bamboo litter

Species	Phyllum	Average % occurrence		Isolation frequency	
		Grade 1	Grade 2	Grade 1	Grade 2
Acropkialophora nainiana Edward	Ascomycota	1.65	0.45	R	R
Alternaria brassicae (Berk) Sacc.	Ascomycota	-	3.32	-	C
Arthrinium phaeospermum (Corda) M.B. Ellis	Ascomycota	2.07	0.66	R	R
Aspergillus flavus Johann Heinrich Friedrich Link	Ascomycota	3.17	4.08	O	MC
Aspergillus fumigates Fresenius	Ascomycota	-	3.62	-	C
Aspergillus nidulans G Winter	Ascomycota	-	3.57	-	C
Aspergillus niger van Tieghem	Ascomycota	4.69	4.39	O	MC
Aspergillus tamari Kita.	Ascomycota	4.14	4.44	O	MC
Aspergillus terreus Thom	Ascomycota	5.24	3.32	O	C
Aspergillus wentii Wehmer	Ascomycota	4.55	3.18	O	C
Bipolaris maydis (Y. Nisik. & C. Miyake) Shoemaker,	Ascomycota	2.30	-	R	-
Chaetomium bostrychoides Zopf and. C. crispatum	Ascomycota	-	1.71	-	O
Chaetomium globosum Kunze ex Fr.	Ascomycota	-	2.21	-	F
Cladosporium berbarum (Pers.) Link	Ascomycota	1.65	0.66	R	R
Cladosporium cladospoides Link	Ascomycota	-	2.72	-	F
Cladosporium cladosporioides Link	Ascomycota	1.93	0.80	R	R
Cladosporium oxysporum (Schlecht.) Snyder & Hansen	Ascomycota	1.24	1.71	R	O
Curvularia eragrostidis (Henn.) J.A. Mey.	Ascomycota	2.76	1.92	R	R
Fusarium concolor Reinking	Ascomycota	5.66	1.71	F	R
Fusarium equiseti (Corda) Sacc.	Ascomycota	7.04	2.97	F	
Fusarium solani (Mart.) Sacc.	Ascomycota	6.07	2.77	F	F
Fusarium solenoid Sacc.	Ascomycota	-	1.71	-	O
Humicola grisea (Traaen) Mason	Ascomycota	4.14	-	O	-
Myrothecium verrucaria (Alb. & Schwein.) Ditmar	Ascomycota	1.24	-	R	-
Nigrospora sphaerica (Sacc.) E.W. Mason	Ascomycota	1.93	-	R	-
Penicillium funiculasum, Thom,	Ascomycota	4.69	1.96	O	R
Penicillium nigricans Thom	Ascomycota	-	2.31	-	F
Penicillium ulaiense Thom,	Ascomycota	-	2.21	-	F
Penicillium vermiculatum P. A. Dang.	Ascomycota	-	2.41	-	F
Periconia digitata (Cooke) Sacc.,	Ascomycota	1.79	-	R	-
Pestalotiopsis theae (Sawada) Steyaert,	Ascomycota	2.90	1.10	O	O
Pestalotiopsis versicolor (Speg.) Steyaert	Ascomycota	3.17	-	O	-
Tetraploa aristata Scheuer.	Ascomycota	1.10	0.66	R	R
Trichoderma harzianum Rifai	Ascomycota	-	4.23	-	MC
Trichoderma koningii Oudem.	Ascomycota	-	4.44	-	MC
Trichoderma virens Miller, Gidden and Foster	Ascomycota	-	3.88	-	C
Trichoderma viride Pers	Ascomycota	7.59	3.57	F	C
Volutella concentric Penz. & Sacc.	Ascomycota	1.24	1.20	R	O
Choanephora cucurbitarum (Berk. & Ravenel) Thaxt.,	Zygomycota	2.07	1.31	R	O
Cunninghamella echinulata (Thaxt.) Thaxt. ex Blakeslee	Zygomycota	-	1.96	-	O
Cunninnghumella elegans (Lendner) Lunn & Shipton	Zygomycota	4.55	2.21	O	F
Mucor circinelloides Tiegh.	Zygomycota	4.69	3.72	O	C
Mucor mucedo de Bary & Woron.	Zygomycota	-	3.88	-	C
Rhizopus nodosus (Namysl.) Hagem,	Zygomycota	4.55	3.32	O	C
Rhizopus stolonifer (Ehrenb. & Fr.) Vuill.	Zygomycota	-	3.52	-	C

Table 2 Frequency of occurrence and density of macrofungi associated with bamboo leaf litter

Species name	Family	Frequency of occurrence (%)	Density	ID number
Agaricus augustus Fr.	Agaricacea	25.0	18.75	RFRI/000336
Cystoderma carcharias (Pers.) Fayod	Agaricacea	41.6	37.5	RFRI/000343
Termitomyces albuminosus (Berk.) R.Heim	Agaricaceae	8.30	6.25	RFRI/000330
Coprinus plicatilis (Fr.) Fr.	Coprinaceae	33.3	12.25	RFRI/000299
Dacryopinax spathularia (Schwein.) G.W.Martin	Dacrymycetaceae	41.0	31.25	RFRI/000339
Entoloma cetratum (Fr.) M.M. Moser	Entolomataceae	58.3	56.25	RFRI/000337
Entoloma lividoalbum (Kühner & Romagn.) Kubicka	Entolomataceae	66.6	62.50	RFRI/000335
Entoloma rhodopolium (Fr.) P. Kumm	Entolomataceae	33.0	25.0	RFRI/000340
Geoglossum defforme (Fr.) Durand	Geoglossaceae	25.0	18.75	RFRI/000295
Geoglossum fallax Durand	Geoglossaceae	41.6	56.25	RFRI/000296
Morganella pyriformis (Schaeff.) Kreisel & D. Krüger	Lycoperdaceae	25.0	12.25	RFRI/000334
Marasmius siccus (Schwein.) Fr.	Marasmiaceae	16.6	37.5	RFRI/000294
Dictyophora indusiata (Vent) Desv.	Phallaceae	8.30	6.25	RFRI/000329
Volvariella murinella (Quél.) M.M. Moser	Pluteaceae	33.3	25.0	RFRI/000338
Clitocybe nuda (Fries) Bigelow & Smith	Tricholomataceae	8.30	6.25	RFRI/000292
Clitocybe phyllophila (Fr.) Kummer	Tricholomataceae	8.30	12.25	RFRI/000302

was recorded either in May or June. It was observed that 70-85 % of the total population was shared by Ascomycota, 1-10% by Zygomycota and other by the macrofungi. The major groups of fungi in order of their dominance were the genera *Aspergillus, Penicillium, Fusarium, Trichoderma* and *Cladosporium.* In total, 7 species of *Asperqillus* and 4 species of each *Penicillium, Fusarium, Trichoderma* and *Cladosporium* were recorded. Among them *A. terreus, A. tamari* and *A. wentii* occasionally occurred in grade 1 litter isolation plates. Most common members of the group were *A. niger, A. tamari and A. flavus* in grade 2 litter isolation plates. Similarly, *Trichoderma viride* frequently present in litter1 and *T. harzianum* and *T. koningii* were the most common in litter 2. *A. terreus, A. tamarii* and *A. niger. A. fumigatus* were isolated in greater numbers during summer months, whereas, *A. tamarii* and *A. nidulans* in winter months. Although, *A. niger and A. flavus* were recorded regularly throughout the year but they were more prominent during June to October after the monsoon break. The second dominant group was the genus *Penicillium* which shared 10-15 % of the *Deuteromycetes* population. It was isolated in good numbers during winter months extending from November to March. Frequently isolated species were *P. funiculasum, P. nigricans P. vermiculatum* and *Penicillium ulaiense*. The genus *Fusarium* were quite frequent in rainy and winter months which comprised about 5 % of the population. Winter months were also favourable for *Cladosporium* but in summer it was recorded infrequently. Second dominant class was the *Phycomycetes* which shared 15-20 % of the total population. Rainy season was highly congenial for their occurrence. Frequently listed members were *Choanephora cucurbitarum, Cunninghamella echinulata* and *Cunninghamella elegans. Mucor mucedo, M. circinelloides, Rhizopus nodosus* and *R. stolonifer* are the common occurrence fungi and the rarely noted ones were *Acropkialophora nainiana, Cladosporium cladosporioides, Tetraploa aristata, Curvularia eragrostidis, Bipolaris maydis* and *Arthrinium phaeospermum* (Fugure 3 and 4). The fungal community composition was found to be distinct at each stage of succession (Promputtha et al. 2002). The method used for assessing the phylloplane mycota of green as well as litter leaves in the present study was also used by several earlier workers (Dickinson 1965, 1967; Hering 1965; Hogg and Hudson 1966; Tokumasu 1980; Shirouzu et al. 2009). The reason for using these techniques was to establish if any fungi that were missed by the direct observation would be found. Environmental variables exert great influence on their occurrence in different seasons. Therefore, some members were predominantly isolated in one season rather than other seasons. But certain fungi which consistently occurred throughout the year perhaps did not suffer much from such extremes as the soil environment is physically better buffered than subaerial environment to support them (Garrett 1955). The occurrence and distribution of microfungi studied in different seasons in bamboo leaf litter of RFRI were mostly governed by the temperature and moisture contents of soils. The abundance of fungi in different soils depends on the organic and nitrogen contents together with the other nutrient factors. The surface layer always exhibits maximum population, isolates and species numbers which gradually decline with depth increased. The periodic surveys were made for the collection of macrofungi, young and matured carpophores of 16 macro fungi species were also collected in different seasons. (Table 2.) The description of the collected specimens recorded as follows:

Entoloma rhodopolium (Fr.) P. Kumm (Figure 1A, 2A). The cap is 5-12 cm; convex, sometimes with a slight central bump, becoming broadly convex, broadly bell-shaped, or nearly flat; sticky when fresh; tan to yellow-brown or grayish brown, fading and drying out to grayish or almost whitish; the margin lined, at least by maturity. The gills are attached to the stem; close or nearly distant; white at first, becoming pink with maturity. The stem is 4-10 cm long; 6-12 mm thick; more or less equal; fairly dry; smooth, or very finely hairy at the apex; white; becoming hollow. The spore print is pink. The spores measure 6.5-11 x 7-9 µm, angular and inamyloid. Cystidia absent. Clamp connections present. It is inedible.

Dacryopinax spathularia (Schwein.) G.W.Martin (Figure 3B,4B). The fruit bodies of *Dacryopinax spathularia* are spatula-shaped, usually 1-1.5 cm (0.4-0.6 in) tall and between 0.5-3 mm wide. The color is orange when fresh, but it darkens to orangish-red when dry. The spore print is white. Spores are ellipsoid, smooth-surfaced, translucent, and measure 7-10 by 3-4 µm. It has four-spored basidia that are 25-35 by 3-5 µm. It is edible.

Cystoderma carcharias (Pers.) Fayod (Figure 3C, 4C). The cap is 2-5 cm across, sometimes white but usually shaded with pinkish or, more rarely, pale lilac, convex, flat, often umbonate, covered with minute granules, with appendiculate margin or cap edge. The gills are white, crowded, adnate. The stipe is 3-6 x 0.4-0.8 cm long, cap colored below ring and covered with small, pointed warts, white higher up, slightly enlarged at base and slightly narrower at top. Ring of the same color, smooth on interior, like the lower part of the stipe externally. The flesh is whitish or ochreous, strong fetid smell and unpleasant flavor. The spores measure 4-5x3-4 µm, white, elliptical, smooth, microns, and amyloid. It is edible.

Volvariella murinella (Quél.) M.M. Moser (Figure 3D, 4D). The cap is 3.5 cm across oval becoming convex to broadly convex to nearly flat; whitish, sometimes very slightly darker over the center; the margin lined; slightly sticky when fresh but soon dry. The gills are free from the stem; whitish becoming pink to salmon; close or almost distant. The stem is 1-5 cm long; 1-3 mm thick; more or less equal; dry; white; smooth; without a ring; the base encased in a thick, white to grayish, sack-like volva which may be buried. The spore print is Salmon pink. The spores measure 5.5-8 x 4-6 µm, elliptical and smooth. Clamp connections absent.

Entoloma cetratum (Fr.) M.M. Moser (Figure 3E, 4E). The cap is 2-5cm across, domed to bell-shaped with a nipple, transparently striate, yellowish-brown darker when wet. The stem is 4-8x2.5mm long, same colour as the cap. The gills are whitish at first then ochraceous-pink. The spores measure 11-12.5x6.5-7.5 µm. The spore print is pink. It is inedible.

Figure 3. A. *Entoloma rhodopolium*, **B.** *Dacryopinax spathularia*, **C.** *Cystoderma carcharias*, **D.** *Volvariella murinella*, **E.** *Entoloma cetratum*, **F.** *Agaricus augustus*, **G.** *Entoloma lividoalbum*, **H.** *Morganella pyriformis*, **I.** *Termitomyces albuminosus*, **J.** *Dictyophora indusiata*, **K.** *Clitocybe phyllophila*, **L.** *Geoglossum defforme*, **M.** *Geoglossum fallax*, **N.** *Coprinus plicatilis*, **O.** *Marasmius siccus*, **P.** *Clitocybe nuda*

***Agaricus augustus* Fr.** (Figure 3F, 4F). The cap shape is hemispherical in button stage, and then expands, becoming convex and finally flat, with a diameter of up to 22 cm. The cap cuticle is dry, and densely covered with concentrically arranged, brown-color scales on a white to yellow background. The gills are crowded and pallid at first, and turn pink then dark brown with maturity. The gills are free from the stem. The stem is clavate up to 20 cm tall, and 4 cm thick. In mature specimens, the partial veil is torn and left behind as a pendulous ring adorning the stem. Above the ring, the stem is white to yellow and smooth. Below, it is covered with numerous small scales. Its flesh is thick, white and sometimes has a narrow central hollow. The stem base extends deeply into the substrate. The spores measure 7-10 by 4.5-6.5 µm, ellipsoid and smooth. The basidia are 4-spored. It is edible.

Entoloma lividoalbum (Kühner & Romagn.) Kubicka (Figure 3G, 4G). The cap is 5-9 cm across; convex

becoming broadly convex or broadly bell-shaped; dry to greasy; smooth; yellow-brown, fading with age. The gills are attached to the stem; nearly distant; at first white, becoming pink with maturity. The stem is 7-20 cm long; 1-2.5 cm thick; more or less equal; dry; smooth but finely lined longitudinally; white, often discoloring and bruising brownish near the base. The flesh is thin; fragile; white. The spore print is pink. The spores measure 7-12 x 5-12 µm; mostly 5-and 6-sided; angular; inamyloid. Cystidia is absent. Clamp connections present. It is inedible.

Morganella pyriformis (Schaeff.) Kreisel & D. Krüger (Figure 3H, 4H). The fruiting body is pear shaped, 1.5-5 cm wide; 2.5-5 cm high; dry; often covered with tiny white spines when young and fresh, but the spines usually disappearing by maturity; typically with a pinched-off stem base; by maturity developing a central perforation through which spores are liberated by rain drops and wind currents; whitish to yellowish brown; with a white, fleshy interior at

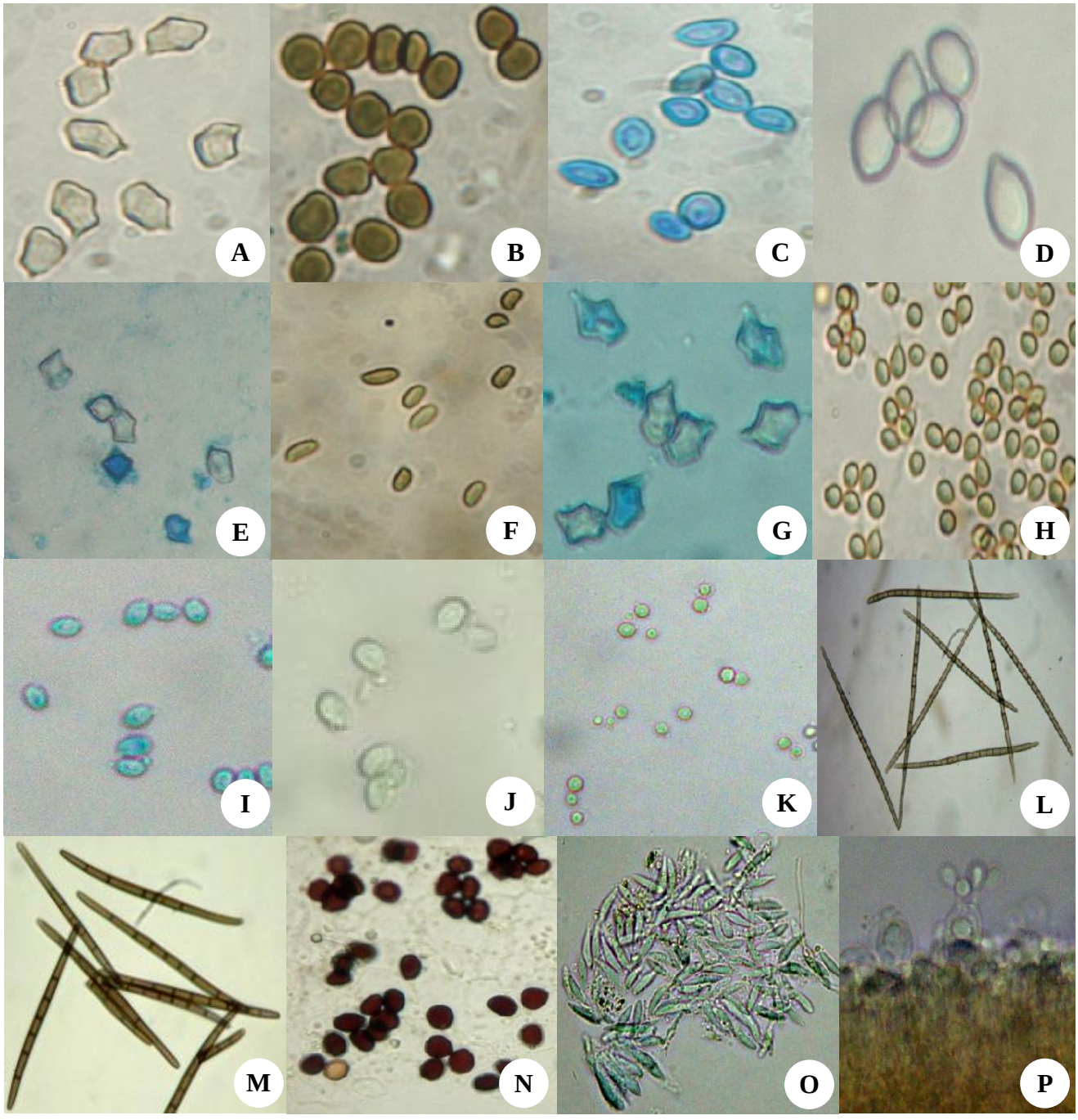

Figure 4. A. *Entoloma rhodopolium*, **B.** *Dacryopinax spathularia*, **C.** *Cystoderma carcharias*, **D.** *Volvariella murinella*, **E.** *Entoloma cetratum*, **F.** *Agaricus augustus*, **G.** *Entoloma lividoalbum*, **H.** *Morganella pyriformis*, **I.***Termitomyces albuminosus*, **J.** *Dictyophora indusiata*, **K.** *Clitocybe phyllophila*, **L.** *Geoglossum defforme*, **M.** *Geoglossum fallax*, **N.** *Coprinus plicatilis*, **O.** *Marasmius siccus*, **P.** *Clitocybe nuda*

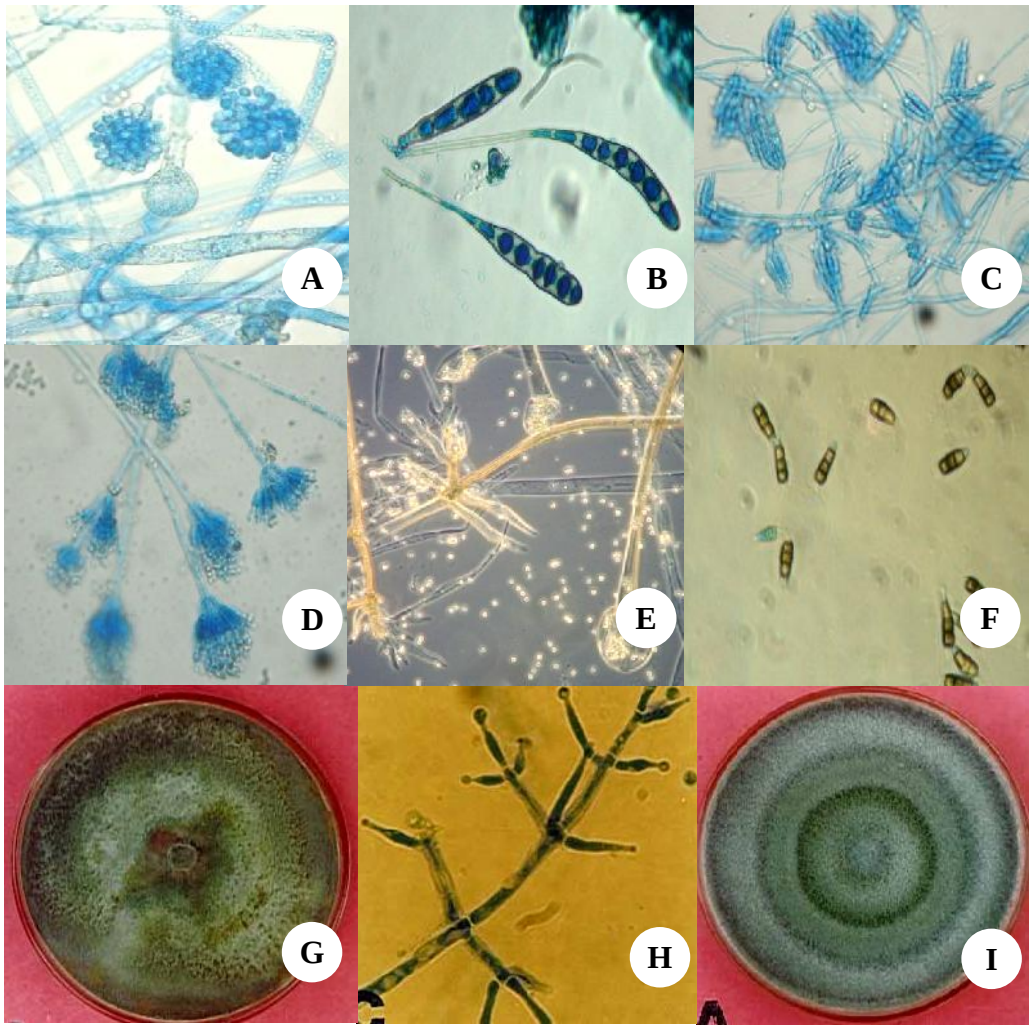

Figure 5. A. Micro fungal spores and colony of **A.** *Cunninghamella elegans,* **B.** *Alternaria brassicae,* **C.** *Fusarium equiseti,* **D.** *Penicillum funiculasum,* **E.** *Rhizopus stolonifer,* **F.** *Pestalotiopsis theae,* **G. & H.** *Trichoderma harzianum,* **I.** *Trichoderma virens*

first; later with yellowish to olive granular flesh and eventually filled with brownish spore dust. The spores measure 3.5-4.5 µm; round; smooth; without a pedicel. Capillitial threads measure 3-6 µm wide.

Termitomyces albuminosus (Berk.) R.Heim (Figure 3I, 4I). The cap is 5-11 cm, flat, acutely umbonate, pale brown to brown, glabrous, cracked, striate. The gills are free, crowded of several lengths, white to pale brown. The stem is central, 7-16 × 1.2-1.5 cm long, solid, white, glabrous, base enlarged with black brown rhizomorphs. The spores measure 6-10 × 4-5 µm, elliptical, hyaline, smooth, Cystidia broadly clavate, hyphae with clamps. It is edible.

Dictyophora indusiata (Vent) Desv. (Figure 3J, 4J). Egg 5 cm in diameter, globose, ovoidal, white or grayish. Carpophore 15-20 x 2.5-3.5 cm, fusiform or cylindrical, barbed toward the top, white, porous, hollow, head ogival for a short time, then bell-shaped, yellowish under the gleba, white if stripped, with rugose surface, reticulate with apex perforated and delimited by a raised and distnict collar. Veil white, hanging almost to the ground, with wide polygonal chains formed by elliptical strands. Gleba olive-green, mucilaginous, not very fetid. The spores measure 3.5-4.5 x1.5-2 µm colorless, elliptical, and smooth. It is reportedly eaten at the egg stage but not recommended.

Clitocybe phyllophila (Fr.) Kummer (Figure 3K, 4K. The cap is 3-10cm broad, funnel-shaped with a wavy margin. The stem is 20-60 x 5-13mm, swollen at the base, whitish or light tan, hairy. The gills are decurrent, crowded, moderately broad; whitish to flesh-colored. The spores measure 3.5-4.5 x 3-3.5µm, white to cream, ovoid to ellipsoid and smooth. It is inedible.

Geoglossum defforme (Fr.) Durand (Figure 3L, 4L). The fruit body is 4-12 cm high, club-shaped, compressed; black, smooth and sticky. The spores measure 5-7 x 90-125µm, asci up to 245 x 270µm, mostly 15 septate, Light to dark brown, smooth, club-shaped to cylindrical, packed with eight spores. The spore print is black. It is inedible.

Geoglossum fallax Durand (Figure 3M, 4M). It grows scattered or in small groups, occurring on soil in well drained areas. The sporocarp measures up to 3-7 cm high, club-shaped, upper part 0.1-0.3mm broad the length of the fruitbody, flattened and dark brown to black. The stem is

0.06-0.3 cm wide, slender, dark brown to black, viscid, bald and minutely downy. The ascospores measure (40)60-78(90) x 4.6-6.7 um, straight or somewhat curved, dark brown; asci mostly 8-spored. paraphyses colorless to brown. The spore print is brown. It is inedible.

Coprinus plicatilis (Fr.) Fr. (Figure 3N, 4N). The cap is 10-30 mm, bell shaped, grooved from the margin, yellow to light brown, gray in the groves. The stem is 30-90 mm long and 2.5 mm thick, fragile, hollow and white. The gills are white at first, becoming gray, free from the stem. The spore print is black. The spores measure 9-15 x 7-11 µm, ellipsoid to almond shaped, large, and have an eccentric pore. It is Inedible.

Marasmius siccus (schwein.) Fr. (Figure 3O, 4O).. The cap up to 0.4-3cm across, bell-shaped with deep wide radial pleats; rust-orange to rust-brown, minutely velvety. The stem is 2.4-6.5 cm long, 1 mm thick, equal, yellowish above, brown toward the base; smooth basal. The spore print is white. The spores measure 14-20 x 3-4.5 µm, spindle-to club-shaped, smooth, often curved. It is inedible.

Clitocybe nuda (Fries) Bigelow & Smith (Figure 3P, 4P). The cap is 3-20 cm; convex to nearly flat, surface smooth, dull purple, flesh-colored, tan. The stem is 2.5-9 cm long, 1-2 cm In diameter, pale purple colored like the gills, base covered with buff mycelium. The gills are attached to the stem, crowded, lilac, pinkish-buff. The spore print is pinkish. The spores measure 4.5-7 x 4.5-5 µm; ellipsoid and smooth. It is edible.

CONCLUSION

It is clear that in different grades of litter shifts in activity of the various species of the mycota occurred. As assessment of such activity is based on percentage occurrence of these fungi in different grades of litter, computed on the basis of sporulating colonies on the litter, and not on dilution plate counts, the data so obtained may be considered sufficiently reliable. It is obvious that the fungi colonizing the phylloplane or litter must be already present in that area. The phylloplane serves as a settling area for propagules of numerous fungi, several of which are components of the air spora. The host leaf allows the development of only a few species and inhibits others. Those fungi which are able to establish on living leaves are foliicolous. These can, in turn, be classified in to: (i) those whose activity is confined to living leaves and (ii) those that continue to be active after colonizing a living leaf even after it is shed. The true litter fungi are perhaps those that colonize the leaves after they are shed and show activity for varying periods.

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