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SCREENING OF MACRO-FUNGI RESPONSIBLE FOR POST HARVEST DECAY OF BAMBOO CULMS IN STORAGE

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ABSTRACT
Post harvest decay of bamboo culms by fungi in storage is one of the major problems of bamboos. The present investigation is an attempt to screen the macro-fungi mainly responsible for deterioration of stored bamboo culms. The investigation was carried out in 5(five) major bamboo producing districts of Assam, India. Few macro-fungi (*Auricularia auricula*, *Boletus* sp., *Clitocybe fragrans*, *C. infundibuliforme*, *Collybia conigena*, *Clavaria cristata*, *Cyathus striatus*, *Daedalea* sp., *Fomes lignosus*, *Ganoderma applanatum*, *G. lucidum*, *Laetiporus sulphureus*, *Lentinus sp*, *Lenzites* sp., *Marasmius putillus*, *Polystictus* sp., *Polyporus squamosus*., *Phellinus* sp., *Pycnoporus sanguineus*, *Rhizopogon* sp., *Schizophyllum commune*, *Xylaria polymorpha*, *Xylaria* sp.) associated with post harvest decay of bamboo were documented. Excepting *Xylaria* sp. (Ascomycetes) rest of these macro-fungi belongs to the class Basidiomycetes.

INTRODUCTION

Bamboos are a unique group of giant arborescent grasses of agro-economic importance in which the woody culms arise from underground rhizomes. Bamboo belongs to the family Poaceae, one of the largest of the families of flowering plants ranking third in number of genera (600) and fifth in number of species (7,500) and form tribe Bambuseae of the subfamily Bambusoideae (Dransfield and Widjaja, 1995; Moulik, 1997; Gould, 1968). There are an estimated 1000 species of bamboo belonging in 80 genera worldwide, and about 200 species are found in South-East Asia (Dransfield and Widjaja, 1995). Bamboo occurs in tropical, subtropical, and temperate regions of all continents, but with limited occurrence in Europe. In India bamboo are of major economic, ecological and cultural importance and mostly found in the forests. As per Forest Survey of India (1999) estimates, 9.6 million hectares forest area of the country contains bamboo amounting to 12.8% of the forest cover. India has the largest area under bamboo in the world, which is estimated around 11.36 million hectares. India is also very rich in bamboo diversity and it is the second richest country in the world in terms of genetic resources**,** after China (Balaji, 1991). Sharma (1988) reported 136 species of bamboos, across 22 genera, occurring in India. Out of these, nineteen are indigenous and three are exotic.

More than 1100 species of fungi have been described or recorded world-wide from bamboo and include 630 Ascomycetes, 150 Basidiomycetes and 330 mitosporic taxa (100 Coelomycetes and 230 Hyphomycetes) (Hyde *et al*., 2002). Bamboo is being exposed to attack by microorganisms and insects., often succumbs to fungal decay and biodeterioration during storage. During storage for up to 12 months, about 20-25% damage of culms has been reported in India (Varma and Bahadur 1980).

Decay and biodeterioration of culms are caused mainly by fungi and these include: soft rot, white rot and brown rot. Colonization by the microorganisms and the severity of attack depend on the moisture content and nutrient status (starch content) in the culm, ambient temperature, humidity, etc. High fungal diversity on stored bamboo culms is found in tropical and subtropical Asia (Dransfield and Widjaja, 1995). Decay and deterioration has been considered a serious problem in bamboo culms stored for making pulp and in simple term fungal attacks increase pulping costs (Singh, 1977). Decay fungi seriously affect the pulp yield (up to 25% loss over one year storage) and pulp strength is reduced by 15-40% (Guha and Chandra, 1979; Bakshi *et al*., 1960). Whilst a number of traditional methods and treatment approaches derived from wood preservation technology have been applied to bamboos, there have been only few detailed reports of the fundamental aspects of colonization and decay of bamboo by fungi (Purushotham, 1963; George, 1985; Murphy *et al*., 1991; Jayanetti and Follett, 1998; Ashaari and Mamat, 2000).

Limited work had been reported on fungal infection of stored bamboo with most studies of a taxonomic nature (Rehm, 1913, 1914; Sydow and Sydow, 1913, 1914; Eriksson and Yue, 1998; Zhou and Hyde, 2001). The associations of macrofungi with the post harvest decay of bamboo culms were reported time to time from India (Banerjee and Ghosh, 1942; Mathur, 1936; Patel *et al*., 1949; Subramaniam, 1956; Bakshi *et al*., 1960; Kar and Maity, 1971; Sutathip, 1988; Arunee, 1989; Shojiro *et al*., 1989; Subramaniam, 1956). There are however, no reports available on macrofungi associated with post

harvest decay of bamboo culms under storage from north eastern region of India.

The present study is an attempt to enumerate the macrofungi responsible for decay of stored bamboo culms of Assam.

MATERIALS AND METHODS

Survey area

Survey and collection of macrofungi associated with stored bamboo culms was carried out in 5 (five) different districts of Assam, India. Assam is a northeastern state of India, located south of the eastern Himalayas and comprises the Brahmaputra and the Barak river valleys and the Karbi Anglong and the North Cachar Hills with an area of 30,285 miles^2 (78,438 km^2) with a collective representation of the various climatic condition with highest levels of humidity. The different sites of survey and sample collections were Balipara (Sonitpur district), Amsoi (Nagaon district), Khetri (Kamrup district), Nonoi (Udalguri district), Balikuchi (Darrang district). These areas lie in between 26°52 N and 27°N latitude and 91°52 E and 93°E longitude.

Macrofungi in stored bamboo

Collection of macrofungi associated with stored bamboo culms was carried out from forest land, household cultivation site and mill yards/depot of various sites of 5 (five) districts of Assam. Light microscopic studies of macrofungal decay in bamboos revealed that the initial fungal pathways for penetration are via the vascular bundles and the mycelium spreads characteristically in an axial direction in the parenchyma adjacent to the vessel elements. The colonization of the ground tissue occurs much more slowly and is restricted to the intercellular spaces between the round-shaped parenchyma cells and in the later stages of invasion the decay process continues.

Frequency study

$$\text{Frequency of fungal species (\%)} = \frac{\text{N no. of sites in which the species is present}}{\text{Total number of site}} \times 100$$

Collection, preservation and identification

The fructifications were collected during the rainy months (April to September) in 2007-2009. The bamboo in the yards was considered, and the associated fungi with the bamboos were collected carefully. The fruiting bodies with leathery texture were preserved in 4% formaldehyde solution whereas the fungi with soft texture were preserved in 2% formaldehyde solution for further study. Dried specimens were also preserved for identification, characterization and documentation. The habitat, colour, shape and size, growth, texture, odour and adaptation to the environment considered prior to the preservation of the collected macro fungi. Identification of the specimens was carried out by standard microscopic methods (Roy and De, 1996), and also considering various morphological and anatomical features into account (Overholt, 1953; Bondarstev, 1953; Zoberi, 1972; Nilson and Persoon, 1978; Higgins, 1972; Ryvarden and Johansen, 1980; Dickinsion and Lucus, 1982; Roy and De, 1996; Garnweidner, 1996; Sharma, 2000). Environments were considered prior to the preservation of the collected macro fungi. Identification of the specimens were carried out by standard microscopic methods (Roy and De, 1996), and also considering various morphological and anatomical features into account (Overholts, 1953; Bondarstev, 1953; Zoberi, 1972; Nilson and Persoon, 1978; Higgins *et al*., 1972; Ryvarden and Johansen, 1980; Dickinsion and Lucus, 1982; Garnweidner, 1996; Sharma, 2000).

RESULTS AND DISCUSSION

Macrofungi associated with the decay of stored bamboos numbering 50 were collected and documented. Out of these 50 morphotypes, 23 species could be identified and which were belonging to 20 genera and 11 families (Table 1). Excepting *Xylaria* species (Ascomycetes) rest of the species belongs to Basidiomycetes. Out of 23 species identified 8 belongs to family Polyporaceae, 2 belongs to Ganodermataceae, 4 belongs to Tricholomataceae, 1 belongs to Boletaceae, 1 belongs to Clavariaceae, 1 belongs to Hymenochaetaceae, 1 belongs to Rhizopogonaceae, 1 belongs to Shizophyllaceae (all Basidiomycetes) where as 2 belongs to Xylariaceae (*i*.e., Ascomycetes).

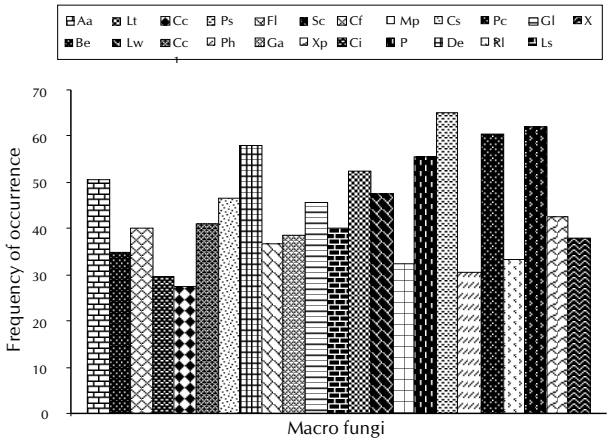

Figure 1: Frequency of occurrence of different macro fungi associated with post-harvest decay of *Bamboo culms*

Aa-*Auricularia auricula* (Hook) Underwood; Be *Boletus edulis* Bull. Ex Fr.; Cf-*Clitocybe fragrans* (With) P. Kumm; *Ci-Clitocybe infundibuliforme;* Cc-*Collybia conigena;* Clc-*Clavaria cristata;* Cs-*Cyathus striatus* Persoon; De-*Daedalea elegans* Spreng ex Fries; Fl-*Fomes lignosus* (Kl) Bresadola; Ga-*Ganoderma applanatum* Pers. Pat*;* Gl-*Ganoderma lucidum* (Leys ex Fr) Karsten; Ls-*Laetiporus sulphureus* (Bull.) Murril; Lt-*Lentinus tigrinus* Bull: (Fr); Lw-*Lenzites warnieri* Duriem and Mont.; Mp-*Marasmius putillus;* P-*Polystictus* sp.; Ps-*Polyporous squamosus;* Ph-*Phellinus* sp.; Pys-*Pycnoporus sanguineus* (L. ex Fr.) Murril; Rl-*Rhizopogon lutiolus* (Fr.) Nordholm; Sc-*Schizophyllum commune* Fries; Xp-*Xylaria polymorpha*(Pers, ex Merat)Greville; X-*Xylaria* sp.

This study revealed that in this area of the state majority of fungi associated with decayed bamboo is from the family Polyporaceae, followed by Tricholomataceae, Ganodermataceae, Xylariaceae, Schizophyllaceae, Nidulariaceae, Clavariaceae, Boletaceae, Hymenochaetaceae. Amongst the species studied *Polyporus squamosa* (Polyporaceae, 65%) and *Schizophyllum commune* (Schizophyllaceae, 62%) were found to be highest in comparison to other species involved in decay of stored

Table1: Frequency of occurrence of Macrofungi associated with the decay of stored bamboo culms in five districts of Assam

Name of the species	Class	Family	Frequency of occurrence (%)
Auricularia auricula (Hook) Underwood	Basidiomycetes	Auriculariaceae	50.5
Boletus edulis Bull. Ex Fr.	Basidiomycetes	Boletaceae	35
Clitocybe fragrans (With) P. Kumm	Basidiomycetes	Tricholomataceae	40
*Clitocybe infundibuliforme*Quél	Basidiomycetes	Tricholomataceae	29.5
Collybia conigena(Pers)P.Kumm	Basidiomycetes	Tricholomataceae	27.5
Clavaria cristata (Pers) (Holmsk)	Basidiomycetes	Clavariaceae	41
Cyathus striatus Persoon	Basidiomycetes	Nidulariaceae	46.5
Daedalea elegans Spreng ex Fries	Basidiomycetes	Polyporaceae	58
Fomes lignosus (Kl) Bresadola	Basidiomycetes	Polyporaceae	36.5
Ganoderma applanatum Pers. Pat	Basidiomycetes	Ganodermataceae	38.5
Ganoderma lucidum (Leys ex Fr) Karsten	Basidiomycetes	Ganodermataceae	45.5
Laetiporus sulphureus (Bull.) Murril	Basidiomycetes	Polyporaceae	40
Lentinus tigrinus Bull: (Fr)	Basidiomycetes	Polyporaceae	52.5
Lenzites warnieri Duriem and Mont.	Basidiomycetes	Polyporaceae	47.5
Marasmius putillus(Fr.)Fries	Basidiomycetes	Tricholomataceae	32.5
Polystictus sp.	Basidiomycetes	Polyporaceae	55.5
Polyporous squamosus(Huds),:Fr.	Basidiomycetes	Polyporaceae	65
Phellinus sp.	Basidiomycetes	Hymenochaetaceae	30.5
Pycnoporus sanguineus (L. ex Fr.) Murril	Basidiomycetes	Polyporaceae	60.5
Rhizopogon lutiolus (Fr.) Nordholm	Basidiomycetes	Rhizopogonaceae	33.5
Schizophyllum commune Fries	Basidiomycetes	Schizophylaceae	62
Xylaria polymorpha(Pers, ex Merat)Greville	Ascomycetes	Xylariaceae	42.5
Xylaria sp.	Ascomycetes	Xylariaceae	38

Figure 2: *Laetiporus sulphureus* (Bull.) Murril

Figure 3: *Cyathus striatus* (Pers.)

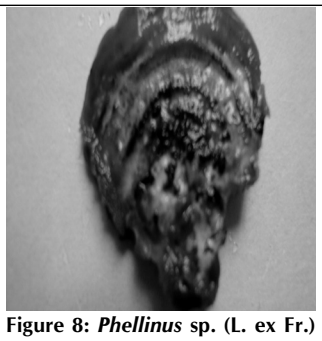

Figure 8: *Phellinus* sp. (L. ex Fr.)

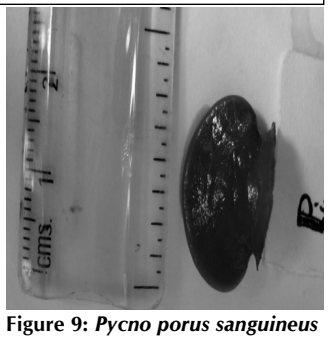

Figure 9: *Pycno porus sanguineus* Murril

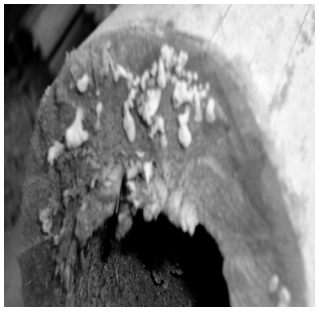

Figure 4: *Schizophyllum commune* Fries

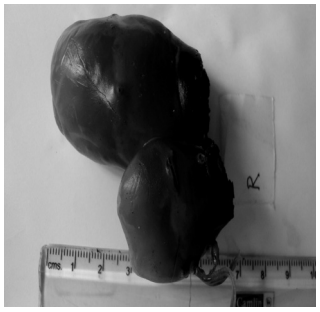

Figure 5: *Schizophyllum commune* Fries

Figure 10: *Ganoderma lucidum* (Leys ex Fr) Karsten(Dorsal view)

Figure 11: *Ganoderma lucidum* (Leys ex Fr) Karsten (Ventral view

Figure 6: *Rhizopogon lutiolus* (Fr.) Nor

Figure 7: *Xylaria polymorpha* (Pers, ex Merat)Greville

bamboo (Fig. 1). The higher frequency of infection and availability of these species was probably due to high humidity and moderate temperature (which is favourable for their growth) during the rainy season in the state of Assam. Most fungi on bamboo are not pathogens, and therefore, are unlikely to be host-specific. They may, however, exhibit a host recurrence, *i.e.* occur repeatedly on the same host, but be absent or rare on adjacent hosts of the same family (Zhou and Hyde, 2001).

The present study also establishes that a high diversity of fungi growing on *Bambusa* indicates that the fungi on bamboo is

extremely diverse in Assam. Such high species diversity at the subfamily level (Bambusoideae) would have a significant impact on species numbers. Hyde *et al*., (2001) also found high fungal diversity on Bambusa.

Though they are responsible for the decay and deterioration of bamboo culms some of them have got immense importance from Ethnomedicinal or Ethnomycological point of view. *Ganoderma lucidum* (Leys ex Fr) Karsten is reported to have medicinal property with luxuriant growth (Mizuno, 1996). *G.lucidum* also has been reported to have antidiabetic properties (Teow, 1997). Pycnoporus is used as a dye (Zoberi, 1972).

The association of fungi in stored bamboo is seemed to be incomplete. There is an urgent need for extensive collection and identification of fungal strains associated with decay of bamboo. The study of their infecting conditions and other relevant factors responsible for the growth of Macrofungi are also important. Isolation, identification and screening of fungi from stored bamboo will pave the way for better understanding of the ecosystem communities as well as for further research on the development of post harvest technology to control these fungal species.

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