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Succession of fungi on decomposing rice stubbles in a rice-wheat cropping system

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ABSTRACT

Forty fungal species were isolated from decompsing rice stubbles. Aspergillus flavus, A. niger, Penicillium citrinum, Curvularia lunata, Trichoderma harzianum, Fusarium semitectum and Alternaria alternata were preponderant and present almost throughout the decomposition process while common fungi species like Humicola grisea, P. rubrum, Aspergillus luchuensis, dark mycelium were more frequent and abundant. The species of Duteromycetes were regnant while species of Mastigomycetes, Zygomycetes, Ascomycetes, Mycelia Sterilia were insignificant. Abundance and frequency of species were affected by environmental conditions. Among Deuteromycetes species of the family Moniliaceae and Dematiaceae were dominant.

Key words: *Rice, stubble, decomposition, fungi*

The rice and wheat cropping system is practised on 9.6 x 10^6 ha annually in Indo Gangetic plains of India. Wheat crop is sown immediately after harvest of rice crop. There is hardly any turning around time between the harvest of rice and wheat sowing. Residue of rice left after harvest poses considerable problems in cultivation of wheat. Burning of crop residue is most common practice. In addition to the loss of nutrients like nitrogen, phosphorus, sulphur and boron (Biederbeck *et al.*, 1980), residue burning creates health and environmental problems (Prasad and Power, 1991) and lower microbial population (Raison, 1979) and organic carbon content of the soil. On the other hand incorporation of rice residue increases organic carbon and nitrogen (Mukharjee *et al.*, 1990) phosphorus (Forse *et al.*, 1988) and microbial biomass. Crop residues just after incorporation in soil is metabolised by an array of organisms (Wood, 1976). Among these fungi play immense role in decomposition (Hudson, 1971) and have successive phase of colonization, exploitation and exhaustion of organic substrate during decomposition (Nandi *et al.*, 1996).

Fungi including phyllosphere colonizers (*Alternaria alternata*, *Epicoccum nigrum*, and other common fungi species of *Cylindrocarpon*, *Fusarium*, *Mucor* and *Phoma* decompose sorghum residue (Beare *et al.*, 1993). Phycomycetes and Duteromycetes such as *Trichoderma*, *Aspergillus* and *Alternaria* were found throughout the decomposition process of maize (Dkhar, 1980). Information on fungal species colonizing rice residue *in situ* in rice-wheat cropping system is meagre in literature. In light of the above, fast decomposing mycoflora in the rice-wheat cropping system will be beneficial to reduce the decomposition period of crop residue. Therefore, the present study was undertaken to characterise the succession of fungi decomposing rice stubbles.

MATERIALS AND METHODS

In order to study the decomposition of rice stubbles by soil mycoflora, the materials were collected from the Experimental Farm of Banaras Hindu University, Varanasi after a week of harvest of rice crop. Decomposition was studied by nylon net bag technique. All stubble samples were mixed and cut into small pieces (2-3 cm). Fifty grams of air-dried rice stubble were filled in each nylon net bag (30 cm x25 cm) with mesh size of 1-2 mm^2. A trench with an area of 4x4x1m was dug in the field where rice wheat cropping system was practised and it was filled with soil. All nylon net bags were kept in the trench at a depth of 10 cm. Samples were drawn from October, 2001 to August, 2002 at monthly intervals.

Isolation and determination of fungal population

were done by dilution plate technique proposed by Warcup, (1960). Stubble samples were powdered and one gram of it was suspended into 10ml. sterilized distilled water further dilution series ($1:10^3$,$1:10^4$,$1:10^5$) were prepared from it. Five replicas with 1ml of each dilution were incubated on Czapek's dox agar with 100ppm streptomycin at 25±2°C for a week and fungi were recorded at monthly interval. Total number of fungi in onegram of oven dried stubble was calculated. The fungal species were identified with the help of literature available (Thom and Raper, 1945; Ellis, 1971; Barnett and Hunter, 1972). Meteorological data e.g. maximum and minimum temperature, relative humidity and rainfall were obtained from the meteorological observatory situated at Experimental Farm, Banaras Hindu University, Varanasi.

Frequency and abundance of fungi were determined with the help of the following formula (Saksena, 1955)

$$\text{Frequency (\%)} = \frac{\text{No. of occurrence of a species}}{\text{Total no. of Petridishes}} \times 100$$

$$\text{Abundance} = \frac{\text{Total no. of colonies of a species}}{\text{Number of plates of occurrence}}$$

The frequency values are further modified into five frequency classes as follows. Class 1: Species occurring in 1-20% of Petridishes, Class 2: Species occurring in 21-40% of Petridishes, Class 3: Species occurring in 41-60% of Petridishes, Class 4: Species occurring in 61-80% of Petridishes, Class 5: Species occurring in 81-100% of Petridishes,.

Only class values of frequency and absolute values of abundance are given in the nearest whole numbers in the tables.

RESULTS AND DISCUSSION

From the decomposing rice stubble forty fungal species were isolated (Table 1). All these species never colonized simultaneously anytime during decomposition period and differed numerically. Colonization was not similar in all the months. It was in the descending order of October, November and February March, June and July December and August April and May. Among the species isolated *Aspergillus flavus, A. niger, Penicillium citrinum, Curvularia lunata, Trichoderma harzianum* and *Alternaria alternata* were preponderant and were present throughout the decomposition process. *Fusarium semitectum, Humicola grisea, Penicillium rubrum* and *Aspergillus luchuensis* were most common and occurred frequently. The rest of the species listed in Table 2 were rare and spasmodic. Colonization pattern varied markedly. The common fungal species occurred frequently in early and a few in late stages of decomposition process. Occurrence of rare species was irregular in nature. Species of class Deuteromycetes, Mastigomycetes, Zygomycetes, Mycelia sterilia were observed during decomposition process (Fig. 1). About 80 per cent of the species were of Deuteromycetes. Among these species of Moniliaceae and Dematiaceae were dominant (Fig. 2). Meteorological data during the

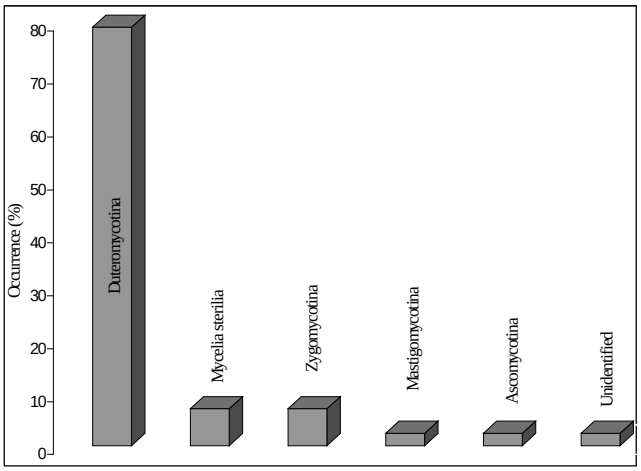

Fig. 1. Classwise distribution of decomposing fungal species

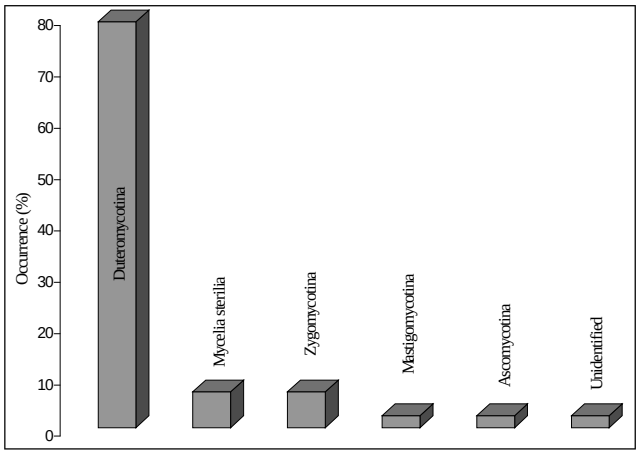

Fig. 2. Distribution of dominant order and families of decompsoing fungal species

Table 1. Frequency and abundance of fungi in decomposing rice stubble

Fungal species	2001						2002															
	October		November		December		January		February		March		April		May		June		July		August	
	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A
Pythium aphanidermatum	-	-	1	1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Rhizopus stolonifer	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	-	-
Mucor raecemosus	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaetomium globosum	1	1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phoma hibernica	-	-	-	-	-	-	1	1	-	-	-	-	2	2	-	-	-	-	-	-	-	-
Pestalotia mangiferae	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aspergillus flavus	3	3	2	2	5	5	2	1	4	4	5	5	2	1	1	2	1	1	4	4	2	2
Aspergillus niger	4	4	1	1	1	1	4	4	3	3	2	2	1	1	1	1	1	1	2	2	1	1
Aspergillus candidus	1	2	4	4	1	3	1	1	-	-	-	-	-	-	-	-	4	4	1	1	4	4
Aspergillus luchuensis	-	-	-	-	1	1	1	1	-	-	1	1	-	-	-	-	1	1	1	1	-	-
Aspergillus terreus	1	1	1	1	-	-	2	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-
Aspergillus fumigatus	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	1	1	-	-	-	-
Aspergillus sydowi	-	-	-	-	1	1	-	-	1	1	-	-	-	-	-	-	-	-	1	2	-	-
Aspergillus sulphuricus	-	-	1	1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Penicillium citrinum	2	3	3	4	2	3	3	3	4	2	2	2	2	2	1	1	4	4	5	5	4	2
Penicillium rubrum	-	-	2	2	1	2	-	-	2	3	2	2	-	-	-	-	4	4	3	2	1	1
Penicillium chrysogenum	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichoderma harzianum	3	4	3	3	2	3	1	2	2	2	2	2	1	2	1	1	3	4	5	5	1	1
Trichoderma viride	1	2	1	1	2	2	1	2	-	-	1	1	-	-	-	-	1	1	-	-	-	-
Trichoderma koningii	1	1	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Gliocladium sp.	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alternaria alternata	1	2	3	3	-	-	3	3	3	4	5	5	3	4	1	2	2	2	2	3	2	3
Alternaria solani	-	-	-	-	-	-	1	1	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Alternaria clamydospora	-	-	-	-	-	-	-	-	2	2	1	2	-	-	-	-	1	1	-	-	-	-
Curvularia lunata	4	4	2	2	1	2	2	2	3	4	3	3	1	2	1	1	2	2	2	3	1	2
Curvularia pallescens	1	1	1	1	-	-	-	-	1	2	1	1	-	-	-	-	-	-	1	1	1	1
Dreschlera avanacea	1	1	-	-	-	-	-	-	-	-	1	1	1	1	-	-	-	-	-	-	-	-
Humicola grisea	2	3	-	-	1	1	-	-	1	1	2	2	3	3	2	2	5	4	4	4	4	5
Nigrospora sphaerica	-	-	1	1	-	-	-	-	1	1	1	1	-	-	-	-	-	-	-	-	-	-
Torula graminis	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	2	2	3	2	2	3
Cladosporium cladosporioides	2	2	1	1	3	2	1	1	1	1	-	-	-	-	-	-	1	1	2	2	1	1
Helminthosporium oryzae	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bipolaris sp.	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fusarium semitectum	1	1	1	1	-	-	1	1	3	4	2	5	-	-	1	1	4	5	3	3	4	4
Fusarium oxysporum	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
Fusarium sp.	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White sterile mycelium	1	1	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	1	1	1	1
Pink sterile mycelium	-	-	1	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dark sterile mycelium	2	2	2	3	2	3	1	1	1	1	3	2	-	-	-	-	-	-	-	-	-	-
Unidentified	1	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Frequency – Class number; Abundance – Absolute number

period of study are presented in Table 2.The population of fungal species were affected markedly by environmental extremes (Table 2).

The results of the present study demonstrated that after incorporation of rice residue in the soil it was colonized by large number of fungal species. Barkenkamp *et al.* (2002) reported that decomposition of added organic matter started at the moment of residue incorporation. The microbial colonization and utilization of commuted litter results in chemical degradation and utilization of tissue and production of complex phenolic polymers (humic acid) and formation of stable organo-mineral complexes (Wood, 1976). Fungal species e.g. *Aspergillus flavus, A. niger, Penicillium citrinum, Curvularaia lunata,Trichoderma harzianum, Fusarium semitectum* and *Alternaria alternata* were preponderant and present throughout the decomposition process indicating thereby their active participation in metabolism of rice residue. The commonly occurring species *Humicola grisea, Penicillium rubrum* and *Aspergillus luchuensis* having high frequency and abundance might have hastened the process of decomposition.

Sarojini and Mathur (1994) in their study found rapid decomposition of paddy straw with *Trichoderma reesci, T. viride, Pleurotus sajor caju* and *Coplinium cinereus* while Chatterjee and Nandi (1980) reported that *Verticillium albo-atrum, Aspergillus wentii* and *Penicillium pupurogenum* were dominant on wheat stubble six weeks after harvest of crop. Beare *et al.* (1993) reported that *Alternaria alternata* and *Epicoccum nigrum* were dominant and species of *Cylindrocarpon, Fusarium, Mucor* and *Phoma* were common on sorghum residue. Occurrence of preponderant species and common species on rice stubble may be assigned to their preference for disaccharide cellobiose polysaccharide source of cellulose in rice residue. Hobbie *et al.* (2003) reported that *Aspergillus flavus* and *Fusarium oxysporum* had higher metabolic activity on glucose containing disaccharide cellobiose owing to their potential ability to use the cellulose.

Table 2. Monthly meteorological data of Banaras Hindu University during 2001-2002

Months	Rainfall (mm)	Temperature [°C]		Relative humidity [%]	
		max.	min.	max.	min.
2001					
October	28.4	32.2	21.7	85.0	61.4
November	0.0	29.1	15.0	83.5	40.0
December	0.0	18.9	10.3	88.2	56.7
2002					
January	2.3	22.6	9.8	87.8	47.8
February	9.5	26.3	13.9	87.7	49.7
March	2.3	32.5	16.6	75.5	30.0
April	0.0	37.8	23.0	67.2	26.4
May	10.4	38.4	26.2	65.2	39.0
June	15.3	37.3	27.4	74.5	49.7
July	31.9	36.0	27.8	74.4	55.0
August	76.3	32.7	26.1	87.7	69.5

Colonization pattern by fungi was not alike throughout the decomposition period. Abundance and frequency of preponderant fungi varied markedly. In early stages it was higher than later stages. Some common fungi inhabited more in early stage compared to later stages of decomposition process. They observed *Trichoderma, Fusarium* and *Penicillium* as early decomposer, whereas genus Aspergillus and class Mucorales (Zygomycotina) as late decomposer. Rosenbrock *et al.* (1995) found *Mucor, Alternaria* and *Epicoccum* as early decomposer and *Fusarium* as late decomposer.

Species of Deuteromycetes were major decomposers (Fig. 1). Among the Deuteromycete species of Moniliaceae and Dematiaceae were dominant (Fig. 2). Similar colonization pattern was observed by Mehrotra and Aneja (1979). The distribution of higher percentage of Deuteromycetes fungi suggests that the fungi belonging to this class are strong colonizers of the decaying rice residue *in situ* with better adoptability and higher competitive ability. Poor colonization by species of groups Ascomycetes, Zygomycetes, Mastigomycetes and Mycelia sterilia may be attributed to their poor competitive ability. Similar was the findings of Pathak and Sinha (1995), Sinha (1992) and Rai *et al.* (2001).Fungal population was affected due to variation in environmental conditions. It was higher in the month of October, November and February and it may be assigned to favourable soil moisture and favourable temperature (Table 2) (Rai and Srivastav, 1982; Webb *et al.*, 2003). The lower population in the month of April, May and June may be attributed to lower temperature and inappropriate soil moisture. Rai and Srivastava also reported that during winter month's low

temperature and moisture creates an environment not conducive to fungal growth.

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