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Diversity of aeromycoflora in fruit and vegetable markets of Barpeta, Assam, India and their sustainable management

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Abstract

Air-borne fungi are responsible for producing several diseases in fruits and vegetables and allergic disorders in human beings. An aeromycological study of fruit and vegetable markets of Barpeta town and Sonkuchi Colony of Barpeta district, Assam was conducted from January to December, 2018 to analyze different fungal species exhibit in the environment using Culture Plate exposure method. A total of 30 different fungal species belonging to 19 genera were isolated from Barpeta town fruit and vegetable market, while 27 species belonging to 19 genera were from Sonkuchi Colony market. A total of 3609 and 2963 fungal spores were isolated from Barpeta town and Sonkuchi Colony market respectively throughout the year. The most and least dominating fungal species in Barpeta town market were recorded to be *Aspergillus niger* and *Drechslera* sp. respectively, while in the Sonkuchi Colony market, they were *Cladosporium herbarum* and *Botrytis* sp. respectively. The number and types of fungal species varied between the two markets. The maximum number of fungal spores was recorded in the month of August and the minimum was in January 2018. The growth of the fungal population is influenced by season and meteorological factors, which play a vital part in the composition and concentrations of aeromycoflora. There was a definite relationship found between the fungal spores and the markets. So, proper management of the waste is needed in the markets by the Municipality Board. The vegetable-market solid wastes can be used for preparing vermicomposting and biogas for minimizing environmental pollution and maintaining sustainable management.

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Introduction

Air-borne fungal spores are ubiquitous in nature. Most of the air-borne microbes originate from natural sources like soil, water bodies and animals, including man (Zobell, 1964). Mishra and Bhandari (2006) reported that our environment is full of a variety of dangerous fungal propagules comprising allergens, phytopathogens and saprophytes. Air-borne fungi are considered to act as an indicator of the level of atmospheric bio-pollution. The presence of fungal spores, volatile and mycotoxins in the air can cause health hazards in all segments of the population (Kakde *et al.*, 2001). The spores are liberated in the air in massive concentrations and remain for a long time in the air. Fungal spores in the air are markedly seasonal because of their sensitivity to weather changes (Kurkela, 1997; Stepalska and Jerez, 2005). Air-borne fungal counts increase with temperature and decrease with rainfall and relative humidity (Kasprzyk, 2008). Many of the air-borne fungal spores are the potential allergen. Therefore, indoor and outdoor aeromycological surveys help considerably to locate the sources of spores, their identification, concentration and seasonal variation (Tilak, 2009).

The leftover rotting fruits and vegetables are the habitat for various pathogens which cause different diseases in fresh fruits and vegetables and also affect the working atmosphere of the market. The concentration and range of occurrence of these microorganisms depend on various factors such as the season and time, rainfall, moisture, temperature and wind (Sharma *et al.*, 2017). Air-borne pathogenic fungi could cause allergies or infections and become a severe health risk for both consumers as well as workers on the markets (Vermani *et al.*, 2014). According to Ahire and Sangale (2012) that the airspora in the market area are affecting directly on the health of the people working in the market, consumers and sellers, because the fungal propagules in the ambient air are regularly and continuously inhaled by human beings that may cause different respiratory diseases. Many human health disorders can be caused by *Alternaria* species which grow on the skin and mucous membrane, sinus cavities, nails and respiratory tract (Vennealad *et al.*, 1999).

The deterioration of raw vegetables may be caused by physical damage, the action of their own enzymes, microbial action, or a combination of these factors. As a general rule, vegetables become more susceptible to infection by post-harvest pathogens as they ripen. Vegetables and fruits are perishable products with active metabolisms during the post-harvest period (Eckert, 1975). Therefore, proper handling and environmental conditions after harvesting are essential in maintaining product quality. Most of the fungi found on vegetables and fruits originate in the field or develop during transportation. In the market areas, the presence of rotten vegetables and fruits, gunny bags, paper bags, packaging materials, straw, discarded leaves and stems are the main substrates for the growth of air-borne fungi. Vegetable and fruit markets are of varied types like completely closed, partly closed, or in sheds or open, which influences the spore load (Tilak, 2009).

Spoilage of stored vegetables and food materials plays an important role in determining the number and nature of fungi present in the air. Over 30% of fruit and vegetable produce is wasted during harvest, grading, packing, transport, marketing and storage (Surendranathan, 2005). Vegetable-market solid waste is produced in millions of tones in urban areas and creates a problem of safe dispersal. It has been reported by Suthar (2009) that vegetable-market solid waste can be used for preparing vermicomposting, which enhances the earthworm growth and decomposition rate. He also reported that vermicomposting could be an efficient technology to convert negligible vegetable-market solid wastes into nutrient-rich biofertilizers.

Barpeta district is one of the major producers and suppliers of different types of vegetables in Assam. Barpeta town and Sonkuchi colony vegetable and fruit markets are the largest markets among other markets of Barpeta district due to the availability of different varieties of fresh vegetables and fruits. A little is known about the aeromycoflora of other vegetable markets of Barpeta district, but no information is available in the present study area hitherto. Hence, the present study was undertaken to analyse the qualitative and quantitative incidence of fungal spores in the extramural environments of the two markets in different seasons of the year of Barpeta district of Assam, India.

Materials and methods

The aeromycological study was carried out in two fruit and vegetable markets of Barpeta district viz., Barpeta town and Sonkuchi Colony vegetable and fruit markets. The experimental work was carried out for one year from January 2018 to December 2018, comprising the three main seasons- summer, monsoon and winter. Culture Plate exposure method was adopted for trapping the aeromycoflora. Air samples for culturable fungi were collected by uncovering culture petriplates separately in vegetable and fruit markets. Three petriplates containing Potato Dextrose Agar medium supplemented with chloramphenicol (1 mg/liter) were exposed for 10 minutes at the height of 1.5 meters over the ground level at 15 days intervals. The sampling was done while the market was the most active during the morning hours between 10.00 a.m. to 2.00 p.m. After the exposing time, the petriplates were brought to the laboratory in pre-disinfected polythene bags and incubated at 27±1^{o}C for 5–7 days.

The fungal colonies were observed after incubation and counted as well as fungus isolated sub-cultured on PDA slants and identified subsequently. On the basis of colony characters, morphological and reproductive structures, some of the fungi were identified up to generic level and some were identified up to species level and were confirmed as per the keys of the manuals of Gilman (1957); Barnett and Hunter (1972) and Funder (1968).

Results and discussion

The results (Table 2 & 4) showed that a total of 30 different fungal species belonging to 19 genera were isolated from Barpeta town fruit and vegetable market while 27 different fungal species belonging to 19 genera were from Sonkuchi Colony fruit and vegetable market.

Table 1. Meteorological data for the year 2018.

Months	Average Temperature (0^{o}C)	Average Relative Humidity (%)	Rainfall (mm)	Average wind speed (kmph)	Average air pressure (mbr)
January	18.1	76.0	10.16	3.8	1013
February	20.4	64.3	17.78	4.4	1009
March	23.4	64.1	50.8	5.2	1011
April	25.9	69.1	170.18	5.3	1006
May	26.9	78.3	231.14	5.0	1008
June	29.5	84.5	314.96	4.7	1009
July	30.4	83.5	317.5	4.4	1012
August	30.2	84.2	264.16	4.0	1011
September	29.2	81.5	203.2	3.8	1008
October	26.4	80.4	96.52	3.7	1009
November	22.4	81.3	43.18	3.8	1012
December	19.3	80.7	7.62	3.7	1011

Source: www.timeanddate.com.

The results also revealed that a total of 3609 different fungal spores were isolated from Barpeta town fruit and vegetable market and 2963 fungal spores were isolated from the Sonkuchi Colony fruit and vegetable market throughout the year. Some of the most dominating air-borne fungal species isolated from Barpeta town fruit and vegetable market were *Aspergillus niger* (224, 6.21%), *Penicillium citrinum*

(215, 5.96%), *Cladosporium herbarum* (213, 5.90%), *Fusarium moniliformae* (204, 5.65%), *Penicillium oxysporum* (194, 5.38%), *Aspergillus fumigatus* (186, 5.15%) and *Fusarium oxysporum* (185, 5.13%) while the lowest was recorded by *Drechslera sp.*(22, 0.61%) followed by *Botrytis sp.* (25, 0.69%). In the case of Sonkuchi Colony fruit and vegetable market, the most dominating air-borne fungal species isolated were *Cladosporium herbarum* (208, 7.02%), *Aspergillus niger* (188, 6.35%), *Fusarium moniliformae* (187, 6.32%), *Penicillium citrinum* (179, 6.04%), *Trichoderma viride* (174, 5.87%) and *Penicillium oxysporum* (168, 5.67%) while the lowest species was recorded by *Botrytis sp.* (24, 0.81%) followed by *Drechslera sp.*(27, 0.92%).

The present findings are similar to the findings of Toqeer *et al.* (2009), Das and Talukdar (2016), Upadhyay *et al.* (2018) and Sitara *et al.* (2020). Toqeer *et al.* (2009) isolated allergic microorganisms viz., *Alternaria solani, Aspergillus candidus, A. terreus, A. wentii, A. flavus, A. fumigatus, A. niger, Drechslera dertioiclea, Curvularia clavata,* and *Penicillium notatum* at different site of Karachi.

Table 2. Seasonal variation of aeromycoflora in the air over Barpeta town fruit and vegetable market from January, 2018 to December, 2018 (average of 3 replica plates).

Fungal types isolated	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Total	Individual % contribution	% Frequency
Alternaria alternata	12	8	6	4	4	-	10	15	-	8	10	6	83	2.30	83.33
A. tenuis	10	8	4	-	-	-	8	-	-	-	4	4	38	1.05	50.00
A. solani	8	10	6	6	-	-	6	10	8	8	6	8	76	2.11	83.33
Aspergillus flavus	12	8	10	8	8	10	16	22	20	18	14	12	158	4.38	100.00
A. fumigatus	6	8	6	8	12	15	18	28	25	24	18	18	186	5.15	100.00
A. nidulans	-	4	-	4	2	-	8	12	12	8	4	6	60	1.66	75.00
A. niger	14	14	12	15	14	16	20	30	26	25	20	18	224	6.21	100.00
Aspergillus sp.	8	6	4	6	6	8	10	12	10	10	8	6	94	2.60	100.00
Botrytis sp.	-	4	2	-	-	-	6	-	6	3	-	4	25	0.69	50.00
Chaetomium globosum	-	4	2	4	6	-	6	10	8	8	-	-	48	1.33	66.67
Cladosporium herbarum	8	10	14	16	12	14	22	26	25	24	22	20	213	5.90	100.00
Colletotrichum sp.	8	10	8	8	8	10	12	18	16	18	15	10	141	3.91	100.00
Curvularia lunata	6	8	8	-	6	6	10	10	12	10	8	8	92	2.55	91.67
Drechslera sp.	-	4	4	2	-	-	-	5	4	3	-	-	22	0.61	50.00
Fusarium moniliforme	12	12	10	14	10	12	20	28	25	23	20	18	204	5.65	100.00
F. oxysporum	10	14	16	14	10	8	18	24	22	18	18	13	185	5.13	100.00
F. roseum	6	8	10	12	10	10	16	24	20	20	12	12	160	4.43	100.00
F.semitactum	-	6	10	13	16	18	20	20	22	15	-	-	140	3.88	75.00
Helminthosporium sp.	6	8	10	8	10	8	15	22	20	15	8	8	138	3.82	100.00
Mucor hiemalis	10	8	8	10	8	-	12	22	16	14	10	12	130	3.60	91.67
Nigropora sp.	-	4	2	-	-	-	10	-	8	4	6	-	34	0.94	50.00
Penicillium sp.	8	8	4	6	6	6	10	16	12	8	6	8	98	2.72	100.00
Penicillium oxysporum	8	10	14	16	10	12	15	25	24	24	18	18	194	5.38	100.00
P. citrinum	12	14	14	15	14	10	20	28	25	25	20	18	215	5.96	100.00
Phoma sp.	6	-	4	-	-	2	-	6	6	-	4	4	32	0.89	58.33
Phytophthora sp.	6	8	6	-	-	-	8	6	-	-	6	4	44	1.30	58.33
Rhizoctonia solani	4	6	6	8	6	8	10	20	16	18	14	16	132	3.66	100.00
Rhizopus nigricans	10	10	8	8	10	6	12	20	18	16	12	10	140	3.88	100.00
Trichoderma viride	10	8	6	8	12	10	20	25	22	22	18	15	176	4.88	100.00
Verticillim sp.	4	-	-	8	12	16	18	16	-	14	-	6	94	2.60	66.67
Unidentified sp.	3	2	4	2	2	3	4	3	4	2	2	2	33	0.91	100.00
Total no. of fungi	207	232	218	223	214	208	380	503	432	405	303	284	3609		
% occurrence of fungal spores	5.74	6.43	6.04	6.20	5.93	5.76	10.53	13.94	11.97	11.22	8.40	7.87			

They also reported that the contamination of airborne fungi is more in summer than in the winter season in Karachi. Das and Talukdar (2016) isolated the most dominating fungal species of the genus, such as *Alternaria, Aspergillus, Fusarium, Helminthosporium, Mucor, Penicillium, Phytopthora* and *Trichoderma* from the indoor vegetable markets such as Barpeta Road, Bahari and Howly of Barpeta district of Assam. Upadhyay *et al.* (2018) recorded 28 kinds of contagious fungal species belonging to 12 genera and they isolated the most dominant fungal types belong to *Aspergillus flavus*, *Cladosporium herbarum*, *Aspergillus niger*, *A. ochraceus*, *Rhizopus nigricans*, *Penicillium citrinum* and several other genera from fruit and vegetables market environment of Morar, Gwalior, M. P., India. Sitara *et al.* (2020) reported 31 fungal species belonging to 17 genera from major fruit and vegetable markets of Karachi city, Pakistan and they had isolated the most dominating fungal species such as *Alternaria alternata, Aspergillus flavus, A. candidus, A. niger, Fusarium oxysporum, Penicillium digitatum* and *Rhizopus stolonifer*. From the results (Table 2 & 4), it was found that there was a marked variation that occurred both qualitatively and quantitatively in the areomycoflora during different months of the year. The results also showed that there was a close relationship between the areomycoflora of fruit and vegetable markets and the incidence of post-harvest diseases.

Table 3. Analysis of Variance of aeromycoflora in the air over Barpeta town fruit and vegetable market from January, 2018 to December, 2018.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10238.909	28	365.675	.843	.680
Within Groups	867.944	2	433.972		
Total	11106.853	30			

In the case of Barpeta town fruit and vegetable market, the highest percentage of fungal contamination was observed in the month of August (13.94%), whereas the lowest was in January (5.74%).

In Sonkuchi Colony fruit and vegetable market, the highest percentage of fungal contamination was observed in the month of August (14.42%), whereas lowest in January (5.70%).

Table 4. Seasonal variation of aeromycoflora in the air over Sonkuchi Colony fruit and vegetable market from January, 2018 to December, 2018 (average of 3 replica plates).

Fungal types isolated	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Total	Individual % contribution	% Frequency
Alternaria alternata	8	8	6	6	-	-	8	10	10	-	12	6	74	2.50	75.00
A. tenuis	-	6	4	4	-	-	6	6	-	-	4	8	38	1.30	58.33
A. solani	8	8	6	8	6	-	-	8	8	-	6	6	64	2.20	75.00
Aspergillus flavus	8	8	12	8	10	10	12	20	18	18	12	8	144	4.90	100.00
A. fumigatus	6	4	6	8	10	14	14	22	20	18	16	18	156	5.30	100.00
A. nidulans	4	4	4	-	2	-	6	8	10	8	4	8	58	1.96	83.33
A. niger	10	14	8	12	14	15	16	25	23	21	16	14	188	6.35	100.00
Aspergillus sp.	4	6	4	6	-	8	6	14	10	10	6	5	79	2.67	91.67
Botrytis sp.	3	4	2	-	-	-	-	-	6	3	-	6	24	0.81	50.00
Chaetomium globosum	-	5	-	4	-	-	6	12	8	8	-	-	43	1.50	50.00
Cladosporium herbarum	12	14	12	18	12	12	20	26	24	22	20	16	208	7.02	100.00
Colletotrichum sp.	4	10	8	4	8	8	12	20	14	12	12	8	120	4.05	100.00
Curvularia lunata	-	8	-	-	6	4	8	12	12	10	6	6	72	2.43	75.00
Drechslera sp.	3	4	4	2	-	-	-	6	4	4	-	-	27	0.92	58.33
Fusarium moniliforme	10	12	10	12	10	12	20	25	22	20	18	16	187	6.32	100.00
F.roseum	6	10	10	12	10	8	16	25	20	20	12	10	159	5.37	100.00
Helminthosporium sp.	8	8	10	8	12	8	14	24	20	18	12	8	150	5.06	100.00
Mucor hiemalis	8	8	8	12	-	-	12	20	18	16	10	8	120	4.05	83.33
Nigropora sp.	3	4	2	3	-	-	8	6	6	-	4	-	36	1.21	66.67
Penicillium sp.	6	8	4	6	6	6	12	14	14	6	6	4	92	3.10	100.00
Penicillium oxysporum	8	12	13	15	10	14	18	22	20	12	14	10	168	5.67	100.00
P. citrinum	10	14	16	15	10	10	14	22	20	18	16	14	179	6.04	100.00
Phoma sp.	-	8	4	-	-	2	6	6	6	-	4	8	44	1.48	66.67
Phytophthora sp.	10	8	6	8	-	-	6	6	-	-	4	8	56	1.89	66.67
Rhizoctonia solani	6	6	6	8	6	8	12	20	18	22	12	10	134	4.52	100.00
Rhizopus nigricans	12	10	8	6	14	6	12	22	16	18	14	12	150	5.06	100.00
Trichoderma viride	10	10	6	6	14	10	20	24	20	20	18	16	174	5.87	100.00
Unidentified sp.	2	2	4	2	-	3	-	2	2	-	-	2	19	0.65	66.67
Total no. of fungi	169	223	183	193	160	158	284	427	369	304	258	235	2963		
% occurrence of fungal spores	5.70	7.60	6.23	6.10	5.40	5.33	9.58	14.42	12.45	10.26	8.72	7.94			

The results indicated that fungal contamination was gradually increased from January till September and after September, the decline was observed till December in both the markets in the fungal spores' pattern. The peak concentration of fungal contamination was recorded in the period of July, August, September and October 2018, the second peak was recorded in the month of February to May.

The analysis of variance showed that there is no significant difference of seasonal variation of aeromycoflora in the air over Barpeta town fruit and vegetable market at a 5% level (Table 3). The analysis of variance showed that there is a significant difference of seasonal variation of aeromycoflora in the air over Sonkuchi Colony fruit and vegetable market at a 5% level (Table 5).

Table 5. Analysis of Variance of aeromycoflora in the air over Sonkuchi Colony fruit and vegetable market from January, 2018 to December, 2018.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8571.310	25	342.852	4.935	.182
Within Groups	138.944	2	69.472		
Total	8710.254	27			

It was found that high relative humidity and moderate temperature favoured the contagious development of fungi. It was due to moderate temperature and high relative humidity which favors the growth of fungi in the month of August and September. In the winter months, the reasons for low fungal counts may be due to low humidity and temperature, which are unfavorable for fungal growth. The present findings are similar to the findings of Kakde *et al.* (2001), Arya and Arya (2007), Pandey *et al.* (2012), Shamsi *et al.* (2014), Upadhyay *et al.* (2018) and Sitara *et al.* (2020). Kakde *et al.* (2001) isolated the most frequent and predominant fungal genus was *Aspergillus* and the fairly abundant genus were *Cladosporium, Penicillium* and *Alternaria* spores which are well known as allergenic and pathogenic while they worked on the seasonal variation of fungal propagules in fruit market environment, Nagpur, India. Pandey *et al.* (2012) reported that air-borne fungi were copious during summer and monsoon season, while in January month they occurred with low concentration. They also recorded 51 fungal species from the air and most of the species belong to the genus *Alternaria* sp., *Aspergillus* sp., *Cladosporium* sp. and *Curvularia* sp. These fungal spores settled down on the surface of fruits and vegetables, which causes rot and reduced economic value. Arya and Arya (2007) studied the aeromycoflora of fruit markets of Baroda, India and associated diseases of certain fruits and they observed a direct correlation between the percentage of rot fruits and the occurrence of fungal spores in different months. Shamsi *et al.* (2014) worked on the seasonal variation of aeromycoflora in the vegetable market of Karwan bazar, Dhaka, Bangladesh and they recorded 31 fungal species belonging to 18 genera of which maximum fungal pollutants were recorded in the month of July, minimum in January and moderate in February and March.

They further reported that *Aspergillus niger* was the highest occurrence and prevalence of fungal types isolated and the lowest colony count was recorded by *Aspergillus ustus, Drechslera* sp. and *Nigrospora* sp. Upadhyay *et al.* (2018) recorded the peak concentration of fungal spores in July, August and September and the second peak was recorded in February and March. Sitara *et al.* (2020) have also reported that fungal contamination was gradually increased from the month of January and the highest peak was noticed in the month of August. Our results also indicated that some fungi viz., *Aspergillus sp., Aspergillus flavus, A. fumigatus, A. niger, Cladosporium herbarum, Colletotrichum sp., Fusarium moniliformae, F. oxysporum, F. roseum, Helminthosporium sp., Penicillium sp., P. oxysporum, P. citrinum, Rhizoctonia solani, Rhizopus nigricans and Trichoderma viride* were present in all the months of the year in all fruit and vegetable markets (Table 2 & 4 and Fig. 1).

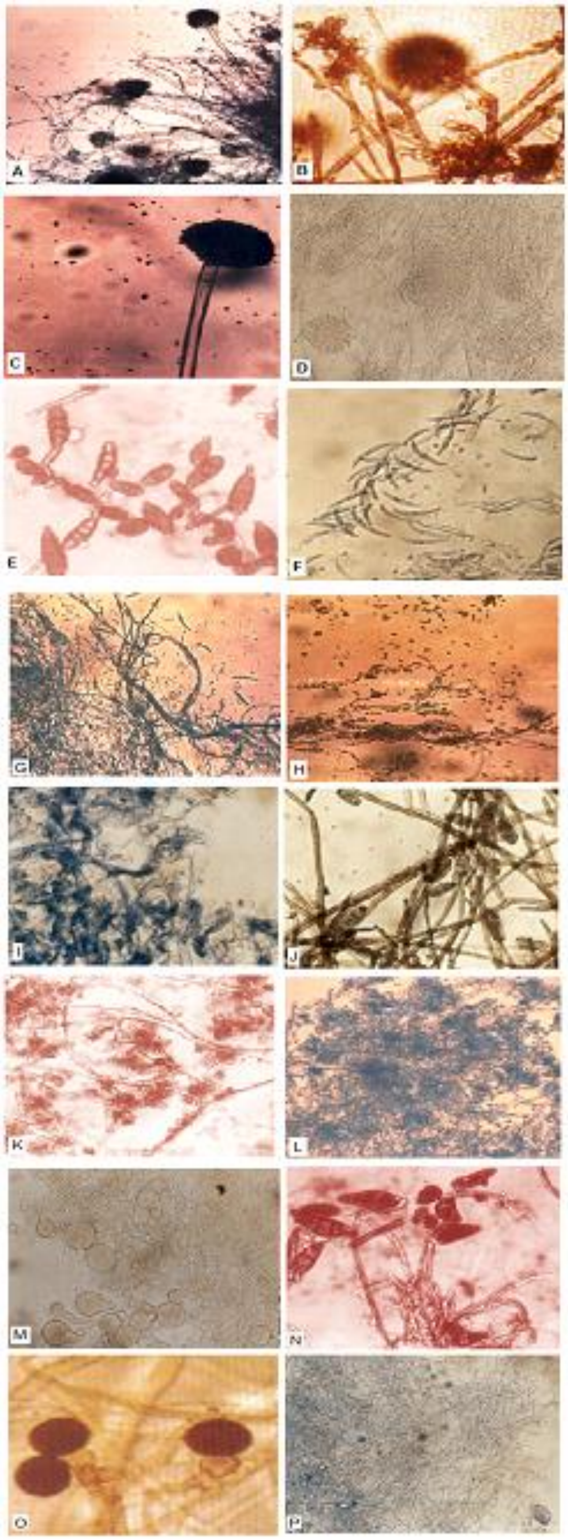
Fig. 1. (A) *Aspergillus fumigatus,* (B) *Aspergillus flavus,* (C) *Aspergillus niger*, (D) *Aspergillus* sp. (E) *Alternaria alternata*, (F) *Colletotrichum* sp., (G) *Fusarium oxysporum,* (H) *Trichoderma viride,* (I) *Mucor hiemalis,* (J) *Curvularia lunata,* (K) *Penicillium citrinum,* (L) *Penicillium oxysporum,* (M) *Fusarium* sp., (N) *Helminthosporium* sp., (O) *Nigrospora* sp. and (P) *Rhizoctonia* sp.

The species of *Alternaria, Aspergillus, Cladosporium, Fusarium, Penicillium* and *Rhizopus* were trapped in all fruit and vegetable markets of Barpeta town and Sonkuchi Colony markets which are known as allergen during the whole year and exposure to the verity of such aeromycoflora may result in serious asthma, respiratory infection and chronic obstructive pulmonary diseases. In our study, it is also noticed that the predominance of such air-borne mycoflora in all fruit and vegetable markets is due to variation in weather patterns such as moderate temperature and high humidity along with poor sanitation conditions of fruit and vegetable markets. *Aspergillus* sp. is the agent of aspergilloses that has the ability to invade the arteries of the lung and brain (Marcoux *et al.,* 2009). *Rhizopus* sp. may cause rhino cerebral, thoracic and gastrointestinal problems while ergot alkaloid is also produced, which is toxic to humans (Mulac *et al*., 2011). The different species of *Penicillium* may damage the lung (Rick *et al*., 2016).

It has been reported by Garg and Singh (2016) that *Alternaria alternata* produce a number of mycotoxins. Baxi *et al.,* 2016; Khan and Karuppayil, 2012 and Inal *et al.,* 2007 reported that high levels of air-borne fungal spores cause respiratory infections, immunomodulatory reactions and skin problems. Baxi *et al.* (2016) reported that species of *Cladosporium* can cause asthmatic reactions in children.

It was observed from the results that the growth of the fungal population is influenced by season and meteorological factors such as temperature, rainfall, relative humidity, wind speed and wind pressure, which play a vital part in the composition and concentrations of aeromycoflora (Table 1). Our observation was in accordance with the observation made by Jones and Harrison (2004), who worked on the effects of meteorological factors on atmospheric bioaerosol concentrations and they have reported that these factors affect the initial release of biological materials and their dispersal once air-borne, temperature and water availability affect the size of the source and control the release of some actively released fungal spores. Among the most dominating fungi isolated from both the markets, the species of *Aspergillus* and *Cladosporium* were prevailing commitment of aeromycoflora display in such sort of conditions. The dominating fungi were likewise connected with post-harvest natural product decay. Kakde and Kakde (2012) reported that various things were present in fruit and vegetable markets such as rotten fruits and vegetables, unwanted paper bag and packaging material, etc., as a substrate for dispersing the saprophytic and pathogenic spores of fungi in the atmosphere. The present study on atmospheric fungal spore concentration over the fruit and vegetable markets certainly would help to understand the dissemination of post-harvest pathogens prevailing in the air and evolve a forecasting system for storage diseases of fresh fruits and vegetables. So, proper management of the waste is needed in the markets by the Municipality Board. The vegetable-market solid wastes can be used for preparing vermicomposting and for producing biogas for minimizing environmental pollution and maintaining sustainable management.

Conclusion

The present study indicated that the fruit and vegetable market sites have been badly contaminated by a heterogeneous type of airborne fungal species. Among the different fungal types isolated, *Aspergillus niger* and *Cladosporium* sp. were the most dominating fungal types. Besides, *Aspergillus sp., Aspergillus flavus, A. fumigatus, A. niger, Cladosporium herbarum, Colletotrichum sp., Fusarium moniliformae, F. oxysporum, F. roseum, Helminthosporium sp., Penicillium sp., P. oxysporum, P. citrinum, Rhizoctonia solani, Rhizopus nigricans and Trichoderma viride* took active part in post-harvest decaying of fruit and vegetable. The species of *Alternaria, Aspergillus, Cladosporium, Fusarium, Penicillium* and *Rhizopus* were trapped in all fruit and vegetable markets of Barpeta town and Sonkuchi Colony markets which are known as allergen during the whole year and exposure to a variety of such aeromycoflora may result in serious asthma, respiratory infection and chronic obstructive pulmonary diseases. The post-harvest decaying fruit and vegetable wastes can be used for preparing vermicomposting and for producing biogas for reducing environmental pollution and maintaining sustainable management.

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Declaration of interest

The authors of this paper had no personal or financial conflicts of interest.

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