



Short communication

Seasonal variation of fungal propagules in a fruit market environment, Nagpur (India)

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Abstract

The concentration of airborne fungal spores in a market environment was examined to provide basic information needed to evaluate the importance of varying levels and heterogeneity. Sampling has been carried out by rotorod sampler and exposed Petri plate method to obtain the quantitative and qualitative estimations respectively. *Aspergillus* was the most frequent and predominant genus detected. *Cladosporium*, *Penicillium* and *Alternaria* spores were also fairly abundant which are well known as allergenic and pathogenic. The high concentration of airborne spores was recorded during December–January. While the maximum concentration of *Aspergillus* was found during summer months in the market environment.

Introduction

Molds are frequent contaminants of fresh vegetables and fruits. A significant role of air-borne molds in affecting or damaging the vegetables and fruits, in transit and storage is well established. Airborne fungi are also considered as a key factor and as indicator of the level of air pollution. The presence of fungal propagules, volatiles and mycotoxins in air can cause a health hazards in all segments of the population (Salvaggio, 1986; Tilak, 1982).

The study of fungal aerospora of market may have some implications on the health of the people working in the market, customers, sellers etc. Fungal propagules in the ambient air are regularly and continuously inhaled by human beings. Consequently, it is understandable that the high concentration of most of the fungal spores present in the market environments may be causative agents of respiratory diseases in humans and infections to various perishable commodities. The adverse effects of inhaled fungal propagules on the immune system have been

well documented by various workers (Day, 1986; Salvaggio, 1986; Burge, 1989; Lacey, 1991).

Mold concentrations in the ambient air of the busiest markets exhibit immense importance in order to study the dissemination of post-harvest pathogens found in the air and in evolving the forecasting system for post-harvest and storage diseases of fresh fruits and vegetables. It is a high time when we must become acutely aware of the incidious alternation in the quality of the air around us which is essential for health. Bio-pollution is a source – transport effects phenomenon and is analogous to the development of plant diseases.

Considering the various hazards of bio-aerosols on workers, consumers, and sellers as well as on market commodities, the present study was undertaken in one of the major fruit markets of Nagpur City. In the present study the qualitative and quantitative assessment of fungal propagules was studied.

Materials and methods

The present investigation includes the qualitative and quantitative analysis of the aerospora of a fruit market environment. It is one of the main outdoor markets of Nagpur City (M.S.) from which number of fruits are marketed and transported out to various other markets. This market is situated in the heart of the city and surrounded on all sides by schools, residential quarters, garden, railway station etc.

Aeromycoflora was monitored by operating both rotorod sampler and exposed culture plates to ensure the quantitative and qualitative measurements of fungal spores respectively.

The rotorod sampler was used to analyze the total spore counts. The sampler was operated for 15 min. at one meter above the ground level at eight days intervals. The sampling was done during peak hours of market activities i.e. 10 a.m. to 2 p.m. Exposed cellophane tapes were mounted with glycerin jelly and examined under microscope. The trapped spores were identified with the help of available standard literature (Ainsworth et al., 1973; Tilak, 1989; Nair et al., 1986).

Air samples for culturable fungi were collected by exposing culture Petri plates. Two Petri plates of each medium containing Potato dextrose agar, Czapek's Dox agar and Rose bengal streptomycin agar were exposed for 3 min. at 15 days interval. The Petri plates were kept at different heights (0.5–1 m) above the ground level. After the exposure to air the Petri plates were brought to the laboratory in the pre-sterilized polythene bags and incubated at 25 °C for 5–7 days. Colonies were counted and identified. The identification of colonies was based on the color, size, and shape of the colonies and other morphological features aided by published literatures. (Gilman, 1957; Barnett, 1960; Raper and Fenell, 1965; Raper and Thom, 1968; Smith, 1969).

Results and discussion

There was no spore free season during the study. A total of 47,565 spores were recovered on the exposed cellophane tape of rotorod sampler. Thirty-three identifiable spore taxa belonging to various categories were recovered. Of these Zygomycetes and Oomycetes were represented by one spore of type each, Ascomycetes with six, Basidiomycetes with three while rest of the spore types were of Deuteromycetes. Besides few unidentified spores, the hyphal fragments,

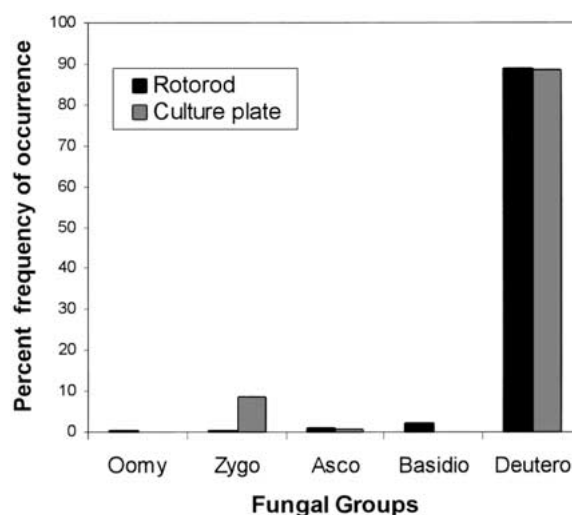


Figure 1. Relative contribution of fungal groups in the fruit market environment.

algal filaments, insect's scales, protozoan cysts, pollen grains etc. were also trapped and categorized separately. Relative contribution of fungal spore types in the fruit market environment is given in Table 1.

The spores of *Aspergillus-Penicillium*, *Cladosporium*, Smuts, Uredospores, *Alternaria*, *Drechslera*, *Helminthosporium*, and *Nigrospora* trapped with varying frequencies throughout the year. *Aspergillus-Penicillium* spores trapped in the range of 975–5275 spore/m³, which is followed by *Cladosporium* 450–3560 spores/m³. The spores of Smut, Uredospores, *Alternaria*, *Curvularia*, *Drechslera*, *Helminthosporium*, *Nigrospora* ranged between 0–125, 0–165, 65–820, 90–510, 25–200, 50–570, 0–200 spores/m³, respectively (Table 2).

The spores of *Aspergillus-Penicillium* group viz., *Aspergillus*, *Penicillium*, *Trichoderma*, *Mucor*, *Rhizopus* etc. were predominant and contributed 35.5% to the total air-spores, followed by *Cladosporium* (21.9%), *Alternaria* (10.4%) and the other spores like *Helminthosporium*, *Cercospora*, Uredospores, *Fusarium*, Smuts which occurred in varying frequencies. Spores of *Cunninghamella*, *Chaetomium*, *Diplodia*, *Pithomyces*, *Torula* were also trapped once or many times during the period of investigation. The other type contributed 6.7% of the total aerospora including different unidentified spores.

Deuteromycetes spores registered an average of 88.9% of the total trapped spores and were most common throughout the year followed by Basidio-

Table 1. Relative contribution of fungal spores trapped by Rotorod sampler in fruit market environment.

Spore Type	Total spore count	%
OOMYCETES		
<i>Albugo</i>	105	0.2
ZYGOMYCETES		
<i>Cunninghamella</i>	145	0.3
ASCOMYCETES		
<i>Chaetomium</i>	220	0.5
<i>Cucurbitaria</i>	145	0.3
<i>Didymosphaeria</i>	75	0.1
<i>Lophiostoma</i>	40	0.1
<i>Pleospora</i>	45	0.1
<i>Sporormia</i>	35	0.1
BASIDIOMYCETES		
<i>Ganoderma</i>	60	0.1
Smuts	500	1.0
Uredospores	435	0.9
DEUTEROMYCETES		
<i>Alternaria</i>	4,935	10.4
<i>Aspergillus/</i> <i>Penicillium*</i>	16,895	35.5
<i>Bispora</i>	220	0.5
<i>Botrytis</i>	90	0.2
<i>Cercospora</i>	595	1.2
<i>Cladosporium</i>	10,425	21.9
<i>Curvularia</i>	2,530	5.3
<i>Dicoccum</i>	75	0.1
<i>Diplodia</i>	290	0.6
<i>Drechslera</i>	920	1.9
<i>Epicoccum</i>	45	0.1
<i>Fusarium</i>	480	1.0
<i>Helminthosporium</i>	2,820	5.9
<i>Heterosporium</i>	20	0.0
<i>Macrophoma</i>	65	0.1
<i>Nigrospora</i>	925	1.9
<i>Periconia</i>	105	0.2
<i>Pithomyces</i>	310	0.6
<i>Torula</i>	215	0.4
<i>Trichoconis</i>	55	0.1
<i>Trichothecium</i>	80	0.2
Hyphal fragments	410	0.9
Other Type	3,255	6.8
Total	47,565	—

*small, spherical and similar type of spores viz., *Aspergillus*, *Penicillium*, *Trichoderma*, *Mucor*, *Rhizopus*

Table 2. Mean concentration of fungal taxa or taxonomic groups most frequently isolated in the fruit market environment.

Taxa	Mean concentration (spore/m ³)	Range
Smut spores	42	0–125
Uredospores	30	0–165
<i>Alternaria</i>	411	65–820
<i>Aspergillus- Penicillium</i>	2020	975–5275
<i>Cladosporium</i>	865	450–3560
<i>Curvularia</i>	210	90–510
<i>Drechslera</i>	75	35–200
<i>Helminthosporium</i>	235	50–570
<i>Nigrospora</i>	70	0–200
Unidentified	270	50–500

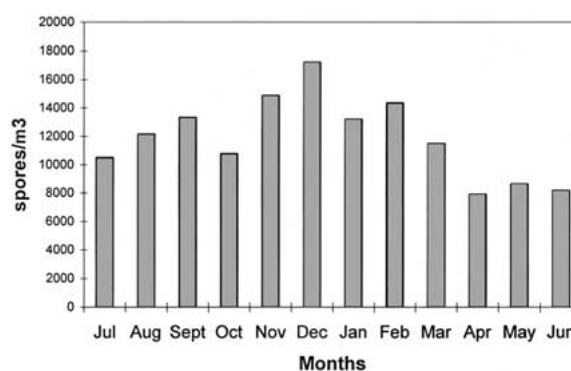


Figure 2. Mean concentration of fungal spores/m³ in different months (1993–1994).

mycetes (2.1%), Ascomycetes (1.2%), Zygomycetes (0.3%) and Oomycetes (0.2%) (Figure 1).

The fungal spores showed significant seasonal variations. The highest incidence of spores was observed during November–December while April–June was the lean period. The maximum daily incidence of fungal spores were recorded in December (17205 spores/m³) when the temperature and relative humidity ranged between 22 °C to 27 °C and 75 to 80% respectively; and the lowest was found in April–June (7905–8175 spore/m³) when maximum temperature and relative humidity were ranged between 43–48 °C and 25–40% respectively (Figure 2).

A total of 144 culture plates were analyzed. Altogether 4382 fungal colonies of sixty-five species belonging to twenty-five genera were isolated. The maximum colonies identified were of Deuteromycetes

Table 3. Relative contribution of culturable fungal species in fruit market environment (July, 1993–June, 1994).

Fungal Species	Total Colonies	%
ZYGOMYCETES		
<i>Actinomucor repens</i>	22	0.5
<i>Cunninghamella echinulata</i>	52	1.2
<i>C. elegans</i>	78	1.8
<i>Mucor globosus</i>	20	0.4
<i>M. hiemalis</i>	20	0.4
<i>M. racemosus</i>	30	0.7
<i>Rhizopus oryzae</i>	11	0.2
<i>R. stolonifer</i>	141	3.2
<i>Syncephalastrum racemosum</i>	10	0.2
ASCOMYCETES		
<i>Chaetomium funicola</i>	12	0.3
<i>C. globosum</i>	25	0.6
DEUTEROMYCETES		
<i>Alternaria brassicae</i>	98	2.2
<i>A. humicola</i>	14	0.3
<i>A. solani</i>	138	3.1
<i>A. tenuis</i>	100	2.3
<i>Aspergillus candidus</i>	95	2.2
<i>A. flavipes</i>	32	0.7
<i>A. flavus</i>	232	5.3
<i>A. fumigatus</i>	122	2.8
<i>A. humicola</i>	39	0.9
<i>A. nidulans</i>	101	2.3
<i>A. niger</i>	286	6.5
<i>A. ochraceous</i>	191	4.3
<i>A. repens</i>	12	0.3
<i>A. sydowi</i>	13	0.3
<i>A. tamarii</i>	15	0.3
<i>A. terreus</i>	18	0.4
<i>A. versicolor</i>	23	0.5
<i>A. wentii</i>	17	0.4
<i>Botrytis cinerea</i>	18	0.4
<i>Candida albicans</i>	30	0.7
<i>C. tropicalis</i>	26	0.6
<i>Cladosporium epiphyllum</i>	103	2.3
<i>C. herbarum</i>	227	5.2
<i>C. lignicola</i>	119	2.7
<i>Colletotrichum sp.</i>	35	0.8
<i>Curvularia geniculata</i>	16	0.4
<i>C. lunata</i>	76	1.7
<i>C. oryzae</i>	26	0.6
<i>C. tetramera</i>	35	0.8
<i>C. tuberculata</i>	6	0.1
<i>Drechslera australiensis</i>	35	0.8
<i>D. hawaiiensis</i>	56	1.3
<i>Epicoccum sp.</i>	8	0.2
<i>Fusarium chlamydosporum</i>	30	0.7
<i>F. moniliforme</i>	100	2.3

Table 3. Continued

Fungal Species	Total Colonies	%
<i>F. oxysporum</i>	37	0.8
<i>F. solani</i>	200	4.6
<i>Helminthosporium nodulosum</i>	40	0.9
<i>H. oryzae</i>	45	1.0
<i>Monilia candida</i>	51	1.2
<i>Nigrospora sphaerica</i>	51	1.2
<i>Penicillium citrinum</i>	202	4.6
<i>P. chrysogenum</i>	190	4.3
<i>P. digitatum</i>	18	0.4
<i>P. italicum</i>	187	4.3
<i>P. nigricans</i>	120	2.7
<i>P. oxalicum</i>	27	0.6
<i>Phoma lingam</i>	48	1.2
<i>Sporotrichum roseum</i>	26	0.6
<i>Trichoderma lignorum</i>	63	1.4
<i>T. koningi</i>	42	0.9
<i>T. viride</i>	25	0.6
<i>Trichothecium roseum</i>	13	0.3
<i>Verticillium glaucum</i>	7	0.2
STERILE MYCELIA		
Black sterile	15	0.3
Orange sterile	05	0.1
White sterile	18	0.4
Unidentified colonies	39	0.9
Total	4382	—

(88.6%) followed by Zygomycetes (8.8%) and Ascomycetes (0.8%) (Figure 1). *Aspergillus* dominated the entire mycoflora, being represented by 14 species, and predominated by *Aspergillus niger* contributing 6.5% to the total viable fungi followed by *A. flavus* (5.3%) and *A. fumigatus* (2.8%). The other major viable taxa were *Penicillium*, *Cladosporium* and *Fusarium*. In general the higher frequency of mycoflora was registered during winter (November–February) and monsoon (July–August) which gradually decreased at the onset of summer (March–June).

The sterile fungi and yeasts were also significant during the period of investigation and categorized separately. The maximum colony counts were obtained in December when the colonies of *Cladosporium*, *Penicillium* and *Alternaria* were most common, while minimum was noted in June with highest concentration of *Aspergillus* species.

The quantitative and qualitative analysis revealed that the investigation site (Fruit market environ-

ment) was contaminated with variety of conidial fungi. *Aspergillus* was found to be dominant by both methods. It is reported that *Aspergillus* makes a large contribution to the air-spora in tropical regions (Santra and Chanda, 1989; Rosas et al., 1992). Organic materials, such as plant debris have been reported to be sources of *Aspergillus* spores (Mullins et al., 1976). The most common *Aspergillus* species were *A. niger*, *A. flavus* and *A. fumigatus* (Table 3). These species were also recorded as common in the various environments of different parts of the world (Abdel-Hafez et al., 1989; Rosas et al., 1992). *Aspergillus* followed a seasonal trend, with high numbers in the dry and hot months (April–June). It may be due to small spherical spores (3 μ m), which can be easily disseminated in the air during dry periods, while in rainy periods the spores may settle down with rains.

The spores of *Penicillium*, *Cladosporium* and *Alternaria* were also most common at concentration in the air of market environment probably due to abundant organic matter availability such as infected materials, plant debris, packaging leaves etc. Fungi growing on these materials are dispersed by wind. The taxa like *Aspergillus*, *Penicillium*, *Cladosporium*, *Alternaria*, *Fusarium* etc. are opportunistic pathogens. The dominance of *Cladosporium* spore has been reported in the majority of airborne data in the temperate and tropical zones (Davies, 1969; Shaheen, 1992). The growth, sporulation and dispersal of *Cladosporium* was found very sensitive to changes in climate. It was found abundant during winter and rainy period (Larsen et al., 1991). In the present investigation *Cladosporium* occupied the second position.

The routine market activities like transportation, loading and unloading and handling of various types of fruits and vegetables augmented the number and type of air-borne molds in the market environment. Dry air with greater wind speed and turbulence further helped in liberation and dissemination of spores.

The considerable concentration of Smuts and Uredospores was also recorded. These spores were passively dispersed by wind and were common components of the dry air-spora (Levetin, 1991). Detection of Basidiomycetes spores was not possible in the culture. However, these spores are important components of the atmosphere. They have also been reported to be climatically significant and also known to be allergenic (Salvaggio et al., 1971; Brown and Jackson, 1979; Gaur and Kala, 1984; Burge, 1985).

Deposits of waste or organic matter in the market places generates and liberates microorganism

to the ambient air in high concentrations and may cause health hazards to people working or living near such environments. The spores of *Aspergillus*, *Cladosporium*, *Fusarium* and many others are reported to be pathogenic and allergenic (Mallea et al., 1972; Gravesen, 1979; Al-Doory et al., 1984; Santra and Chanda, 1989).

Apart from the human health hazards, the dispersal of microorganisms from the various source could give technical problems like biodegradation and biodegradation of various perishable commodity in the market environment transport and in storage. Number of species such as *Aspergillus flavus*, *A. fumigatus*, *Fusarium* spp, *Alternaria* spp. and many other fungal species produce mycotoxins in various foods which may cause carcinogenic effects and other disorders (Kramer et al., 1960; Hudson, 1969; Bullerman, 1979; Wicklow and Shottwell, 1983; Miller, 1992).

Conclusions

The analysis of data indicates that concentration of airborne fungi in fruit market environment is very high and quite variable depending on the climatic conditions. The spores of *Aspergillus*, *Penicillium*, *Cladosporium* were found to be predominant, probably due to their wide host range and opportunistic nature. Seasonal variation of the various types was highly related to the availability of the substrates needed for the fungal growth. The seasonal climate had positive variations of the influence on occurrence of aeromycoflora. Winter and rainy months registered maximum frequency and concentration of fungal spores due to favorable growth and sporulating conditions for fungi and availability of suitable substrates.

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