

Chapter III

**PHYLLOPLANE STUDIES OF THE
CROPS UNDER AIR SURVEY**

INTRODUCTION

Plant leaves are the natural inhabiting surface sheltering various microorganisms. These include mainly fungi, bacteria and actinomycetes. According to Kerling (1958), an active population of fungi exists on the surface of physiologically active green leaves. These mycoflora from plant surfaces are disseminated (Gregory 1973) through air spreading diseases to other plants (Singh and Dorycanta 1992; Govi 1992) in neighbouring areas. In the agricultural fields as well as farm houses, the agricultural practices viz. harvesting, threshing, shredding cause an enormous local rise of spore load (Atluri *et al.* 1988, Uddin and Chakraverty 1994) releasing from the plant parts particularly foliage due to mechanical disturbances. The spores are hazardous not only from plant pathogenic point of view but also cause allergy or other ailments to the farmers and farm animals. Phylloplane studies including antagonistic effect on various plants have been reported by a number of workers (Dickinson 1965, Hogg and Hudson 1966, Pugh and Mulder 1971, Sinha 1971, Ruscoe 1971, Abdel-Wahab 1975, Abdel-Hafez 1984b, Bopaiah 1982, Kuter 1986, Bhaskar Rao and Mallaiah 1988, Varadavakis 1988, McLean and Sutton 1992, Golubev 1992). Reports on economic crop plants are comparatively less (Dickinson 1967, Abraham and Balasundaran 1977, Abdel-Hafez 1981, Sharma and Gupta 1985, Chandel and Chandel 1993). Hence, along with the aerobiological investigations, systematic studies on the phylloplane mycoflora were conducted simultaneously.

MATERIALS AND METHODS

Along with the aerobiological investigation, studies on the leaf surface mycoflora was conducted in the "Aman" and "Boro" variety of paddy, wheat, jute, mustard, winter vegetables, banana and potato. The fresh green vegetative as well as the diseased and decayed leaves were collected at random at different stages of crop growth starting from the very seedling stage till harvesting, generally at 13 days intervals simultaneously with the air samples. The surface sterilised leaf disc method (Dickinson 1967, Abdel-Hafez 1981 and Vardavakis 1988) was applied with some modifications. The leaves were cut into pieces with sterile scissors measuring 5 x 5 mm² area i.e. 25 mm² leaf area. After having washed once with sterile distilled water, 4 pieces (100 mm² area) were inoculated within a

petridish containing malt extract agar (2%) with streptomycin (40 µg/ml). The mature and immature grains of rice were similarly plated on petriplates. The inoculated plates were incubated at 28°C ± 1°C for 12 d followed by colony counting and identifications.

The meteorological data viz. temperature, relative humidity and rainfall were simultaneously recorded from Dum Dum Station, of the Regional Meteorological Centre, Alipore, Calcutta, a place nearest to the crop fields, similar with the air samples.

1. STUDIES ON THE LEAF SURFACE MYCOFLORA IN "AMAN" VARIETY OF PADDY

CROP SEASON

The leaves were sampled from 28th July 1991 in seedling stage till 18th December 1991 (at harvest time).

RESULTS

The total count and per cent distribution of phylloplane mycoflora recovered from various types of leaves sampled at different growth stages are represented in Table 17. Among the isolated fungal types, *Aspergillus*, *Curvularia*, *Nigrospora*, *Penicillium*, *Cladosporium* and *Helminthosporium oryzae* were the dominant flora. *Aspergillus* and *Penicillium* were the major inhabitants of leaf surface from seedling to late vegetative growth stages during rainy season; gradually declined with the onset of winter (November and December) and at late phases totally disappeared; although *Penicillium* was isolated once from the infected mature grains in mid-November. *Cladosporium* mainly invaded the leaves during flowering in winter, gradually rising and reaching peak (42.1%) at late senescent stage prior to harvesting of the standing crop. *Curvularia* was observed in early as well as later stages infecting also the mature and immature grains. Except the seedling stage, *Nigrospora* spp. represented by *N. sphaerica* and *N. oryzae* were present on leaf surface throughout the crop's lifetime, with significant amount during actively growing state. *Helminthosporium oryzae*, a virulent rice pathogen infected the leaves during flowering with

Table 17. Total colony count and percentage frequency of phylloplane mycoflora in "Aman" variety of paddy during the crop season, 1991

Date of leaf plucking (1991)	July 28		Aug 11		Aug 25		Sep 22		Sep 22		Oct 6		Oct 20		Nov 3		Nov 17		Nov 29		Dec 18	
	Seeding Transplant	Seeding Vegetative	Seeding F. Gr.	Vegetative Growth	Massive Veg. Gr.	Massive Veg. Gr.	Lowermost Diseased	Uppermost Fr. Gr.	Max. Veg. Growth	Pathogenic Spotted	Both Upper Fresh & Lower	Flowering Both Upper & Lower	Grain Maturity	Infected Leaves	Leaves full of pathogenic spots	Pre-harvesting	Harvesting	Senescent Leaves				
Nature of leaves	Fresh Vegetative Leaves	Green Veg. Growth	Healthy Fresh	Lowermost Diseased	Uppermost Fr. Gr.	Max. Veg. Growth	Pathogenic Spotted	Both Upper Fresh & Lower	Flowering Both Upper & Lower	Grain Maturity	Infected Leaves	Leaves full of pathogenic spots	Pre-harvesting	Harvesting	Senescent Leaves							
Leaf area covered (mm ²)	300	300	200	100	200	200	100	300	300	300	200	200	200	200	200	300	300					
% Occurrence																						
1. <i>Aspergillus</i> spp.	9.45	22.38	-	-	7.27	5.00	9.67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>A. fumigatus</i>	2.70	10.44	4.16	-	-	-	3.22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>A. niger</i>	4.05	32.83	4.16	-	-	-	12.90	1.23	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>A. flavus</i>	5.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>A. luchuensis</i>	-	-	1.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>A. sydowii</i>	-	-	9.43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>A. ochraceous</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Penicillium</i> spp.	12.16	7.46	-	9.09	16.36	-	3.22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Cladosporium herbarum</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>C. cladosporioides</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Curvularia</i> sp.	5.40	1.49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>C. lunata</i>	12.16	2.98	8.33	-	3.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>C. pallescens</i>	2.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>C. geniculata</i>	9.45	-	1.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Helminthosporium oryzae</i>	6.75	-	3.77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Sclerotium roffsii</i>	-	-	8.33	-	30.90	-	40.00	6.45	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Nigrospora sphaerica</i>	1.35	2.98	8.33	36.36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>N. oryzae</i>	-	-	8.33	13.63	-	1.81	5.00	12.90	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Cephalosporium</i> spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Epicothium purpurascens</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Pulularia pululians</i>	-	8.95	4.16	-	-	-	-	9.67	-	-	-	-	-	-	-	-	-	-	-	-	-	
Yeast	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Rhizoctonia solani</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Graphium</i> sp.	2.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Spicaria</i> spp.	1.35	-	-	-	-	-	-	3.22	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>S. griseola</i>	1.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Alternaria</i> sp.	1.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Trichoderma lignorum</i>	-	-	1.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Acremonium</i> sp.	-	-	4.16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Geotrichum candidum</i>	-	-	-	4.54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Torula herbarum</i>	-	-	-	4.54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Stachybotrys atra</i>	-	-	-	-	-	-	-	3.22	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Thielavia terricola</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Fusarium</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Brachyosporium</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Cercospora</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Cordana musae</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Humicola fuscoatra</i>	-	-	4.16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Unidentified Types	4.05	1.49	4.16	9.09	-	-	-	3.22	-	-	-	-	-	-	-	-	-	-	-	-	-	
Sterile forms (White)	2.70	1.49	4.16	4.54	-	-	-	9.67	-	-	-	-	-	-	-	-	-	-	-	-	-	
Sterile forms (Orange)	16.21	7.46	16.66	13.63	40.00	50.00	22.58	16.04	13.33	16.88	16.88	13.33	8.55	8.55	13.33	8.55	8.55	13.33	8.55	8.55	8.55	
Total colony count	74	67	53	24	22	55	20	31	81	77	90	90	152	152	90	152	152	90	152	152	152	

the causation of massive leaf damage at the later stages of crop growth, with peak concentration (19.73%) during harvesting. Other pathogens i.e. *Alternaria*, *Fusarium*, *Sclerotium* and *Cercospora* were recovered rarely from rice leaves. The rare isolates were *Spicaria*, *Trichoderma*, *Acremonium*, *Geotrichum candidum*, *Torula*, *Graphium*, *Stachybotrys atra*, *Thielavia terricola*, *Rhizoctonia*, *Brachysporium*, Yeast, *Humicola fuscoatra* and *Cordana musae*. Sterile mycelia, failing to produce spores were found to be present in significant numbers in the whole leaf sampling period, irrespective of growth stages and meteorological parameters.

Table 18 represents the total and percentage frequency of fungi associated with the growing seeds in the existing crop. *Curvularia* spp. were the main dominant type occurring in high frequency (37-57%). In the immature seeds, apart from *Curvularia* the other genera isolated were *H. oryzae*, *Aspergillus*, *Penicillium*, *Nigrospora* and *Rhizoctonia*. Prior to harvesting the seeds were contaminated with *Curvularia* spp., *Cladosporium* spp., *H. oryzae*, *Sclerotium rolfsii*, *Nigrospora sphaerica* and *Rhizoctonia solani*. Sterile mycelia predominated the immature grains rather than the grains ready for harvesting.

2. PHYLLOPLANE STUDIES IN "BORO" VARIETY OF PADDY

CROP SEASON

The crop season extended from January to April. Leaf sampling was started on 20th January 1991 and continued up to 28th April 1991, during harvesting stage.

RESULTS

The results obtained in "Boro" variety of paddy are represented in Table 19. A remarkable rise in colonisation was observed from massive vegetative growth stages onwards. A number of fungal types recovered from the leaf samples were represented by *Curvularia*, *Penicillium*, *Pullularia*, *Aspergillus*, *Helminthosporium*, *Alternaria*, *Nigrospora*, *Cephalosporium*, *Fusarium*, *Chaetomium*, *Epicoccum*, *Rhizoctonia*, yeast, *Arthrobotrys*, *Trichoderma*, *Stemphylium*, *Cladosporium*, *Sordaria*, *Mucor*, *Brachysporium*, *Monilia*,

Table 18. Mycoflora associated with the seeds in the standing crop of rice

Date of grain collection (1991)		Nov 3		Nov 17		Nov 29	
Crop growth stage		Flowering		Grain Maturation		Pre-harvesting	
Nature of grain		Immature grains		Infected Mature Grains		Mature Grains	
Sl. No.	Fungal Organisms	Total	%	Total	%	Total	%
1.	<i>Aspergillus</i> sp.	1	4.34	-	-	-	-
2.	<i>Penicillium</i> spp.	1	4.34	3	12.5	-	-
3.	<i>Curvularia</i> spp.	3	13.04	-	-	-	-
	<i>C. lunata</i>	8	34.78	8	33.33	10	24.39
	<i>C. geniculata</i>	1	4.34	-	-	5	12.19
	<i>C. pallescens</i>	1	4.34	1	4.16	-	-
4.	<i>Cladosporium herbarum</i>	-	-	2	8.33	9	21.95
	<i>C. cladosporioides</i>	-	-	1	4.16	4	9.75
5.	<i>Helminthosporium oryzae</i>	2	8.69	-	-	7	17.07
6.	<i>Nigrospora sphaerica</i>	1	4.34	-	-	1	2.43
7.	<i>Rhizoctonia solani</i>	1	4.34	-	-	1	2.43
8.	<i>Chaetomium globosum</i>	-	-	2	8.33	-	-
9.	<i>Sclerotium rolfsii</i>	-	-	-	-	1	2.43
10.	White Sterile forms	-	-	2	8.33	-	-
	Brown Sterile forms	4	17.39	5	20.83	3	7.31
Total		23	100%	24	100%	41	100%

Table 19. Phylloplane mycoflora in "Boro" variety of paddy

Date of leaf sampling (1991)	Jan 20	Feb 3	Feb 24	Mar 10	Mar 24	Apr 7	Apr 21	Apr 28	
Crop growth stage	Transplanting	Plants' attachment	Vegetative growth	Massive veg. Gr.	Maximum Veg. Gr.	Flowering	Ripening	Harvesting	
Leaf area covered (mm ²)	300	300	300	300	300	300	300	300	
Types of leaves sampled	Fresh green vegetative leaves	Yellow discoloured veg. leaves	Fresh green veg. leaves	Veg. leaves	Both Fresh & diseased leaves	Diseased leaves	Diseased 1/2 senescent leaves	Senescent leaves	
Sl. No.	Fungal types		% Occurrence						
1.	<i>Aspergillus</i> spp.	11.11	-	-	15.00	-	2.32	-	1.02
	<i>A. niger</i>	2.77	5.61	-	-	-	-	3.50	-
2.	<i>Penicillium</i> spp.	2.77	2.24	4.30	27.77	6.08	10.85	7.01	6.15
3.	<i>Cladosporium herbarum</i>	-	-	3.22	3.88	-	6.97	7.01	1.02
4.	<i>Curvularia</i> spp.	-	3.37	-	0.55	-	-	2.63	-
	<i>C. lunata</i>	8.33	10.11	12.90	6.66	15.65	10.07	15.78	15.38
	<i>C. pallescens</i>	-	3.37	7.52	3.33	6.06	5.42	4.38	3.07
	<i>C. geniculata</i>	-	4.49	3.22	1.66	2.60	0.77	-	-
5.	<i>Cephalosporium</i> spp.	5.55	-	2.15	3.33	0.86	7.75	6.14	-
6.	<i>Epicoccum purpurascens</i>	-	-	4.30	-	4.34	3.87	5.26	3.58
7.	<i>Helminthosporium oryzae</i>	8.33	6.74	3.22	-	-	-	1.75	3.07
	<i>H. sativum</i>	-	4.49	25.80	0.55	1.73	-	0.87	1.53
8.	<i>Alternaria</i> spp.	5.55	3.37	6.45	6.11	6.08	4.65	2.63	2.05
	<i>A. tenuis</i>	-	3.37	2.15	-	-	7.75	-	-
	<i>A. humicola</i>	-	-	3.22	1.11	3.47	10.85	-	12.30
	<i>A. tenuissima</i>	-	-	1.07	-	-	-	0.87	2.56
9.	<i>Fusarium</i> spp.	11.11	12.35	-	-	-	-	-	-
10.	<i>Sclerotium rolfsii</i>	-	-	-	0.55	1.73	-	3.50	3.58
11.	<i>Nigrospora sphaerica</i>	5.55	3.37	3.22	-	-	-	-	-
	<i>N. oryzae</i>	-	-	-	2.22	1.73	-	1.75	2.56
12.	<i>Chaetomium</i> sp.	5.55	8.98	-	2.22	-	-	-	1.02
	<i>C. indicum</i>	2.77	6.74	-	-	-	-	-	-
	<i>C. globosum</i>	-	3.37	-	1.66	5.21	-	-	-
13.	<i>Rhizoctonia solani</i>	-	-	6.45	1.11	3.47	-	-	-
14.	<i>Stemphylium piriforme</i>	-	-	2.15	-	-	6.20	-	-
15.	<i>Sordaria fimicola</i>	-	-	-	2.22	0.86	0.77	-	0.51
16.	<i>Arthrotrichum superba</i>	-	6.74	-	-	2.60	0.77	-	-
17.	<i>Mucor</i> sp.	5.55	1.12	-	-	-	-	-	0.51
18.	<i>Trichoderma lignorum</i>	2.77	-	-	5.00	-	-	-	-
19.	Yeast	-	-	-	-	0.86	-	-	-
20.	<i>Monilia</i> sp.	-	-	-	1.11	17.39	3.10	1.75	1.02
21.	<i>Brachysporium</i> sp.	-	2.24	-	6.11	-	1.55	4.38	2.56
22.	<i>Pullularia pullulans</i>	-	-	-	-	-	7.75	7.01	16.92
23.	<i>Cordana musae</i>	-	2.24	-	-	-	-	-	-
24.	<i>Humicola grisea</i>	-	-	-	0.55	-	-	-	-
25.	<i>Papularia sphaerosperma</i>	-	-	-	1.11	-	-	-	-
26.	<i>Trichocladium opacum</i>	-	-	-	-	2.60	-	-	-
27.	Unidentified types	8.33	2.24	-	2.22	0.86	-	1.75	1.02
28.	White sterile forms	5.55	3.37	-	1.11	1.73	1.55	-	-
	Brown sterile forms	8.33	-	8.60	2.77	13.91	6.97	21.92	18.46
Total colony count		36	89	93	180	115	129	114	195

Humicola, Cordana, Papularia, Trichocladium. "Sterile forms" contributed throughout.

Aspergillus was a frequent phylloplane mycoflora. *Penicillium* was isolated regularly from all types of leaves, reaching peak (27.77%) during massive vegetative growth stage. While a high level of *Curvularia* was maintained in all the leaf samples, *Cladosporium* was mainly observed in later stages. Of the other non-pathogenic fungi *Cephalosporium*, *Chaetomium*, *Nigrospora* and *Epicoccum* were recorded frequently. *Trichoderma*, *Sordaria*, *Mucor*, yeast, *Arthrotrichum*, *Brachysporium*, *Cordana*, *Papularia*, *Monilia*, *Humicola*, *Trichocladium* and *Pullularia* were among the very rare types.

Among the pathogenic fungi, *Helminthosporium* was very predominant and maximum (29.03%) during earlier stages. *Alternaria* was observed regularly with a more or less gradual rise with a peak (23.25%) during flowering and another peak (16.92%) at harvest time. *Sclerotium* was reported in later stages while *Fusarium* in early stages. *Rhizoctonia* and *Stemphylium* were observed only occasionally.

3. PHYLLOPLANE STUDIES ON WHEAT

CROP SEASON

The wheat seeds were sown in the field in late December, 1991 and harvested in late March, 1992. Hence, the leaves were collected from the very early vegetative growth stage on 31st December 1991 till 30th March 1992.

RESULTS

The phylloplane studies of wheat (Table 20) revealed that the amount of fungal colonisation was same up to maximum vegetative growth as measured by total CFUs in 300 mm² leaf area. Colonisation gradually rose from inflorescence towards the senescence with the ageing of the standing crop reaching peak colony production (244 CFUs) at pre-harvesting stage.

Table 20. Phylloplane mycoflora of wheat and their relative incidence

Date of leaf sampling	Dec 31, 1991	Jan 12, 1992	Jan 26	Feb 9	Feb 9	Feb 23	Feb 23	Mar 8	Mar 22	Mar 30
Crop growth stages	Early Vegetative Growth	Veg. Gr.	Max. Veg. Growth	Inflorescence		Grain maturation		Late grain matur.	Ripening	Harvesting
Nature of leaves [area covered (mm ²)]	Fresh green vegetative (300)	Green vegetative (300)	Green vegetative (300)	Green Veg. (200)	Lower yellow (100)	Upper Gr. vegetative (200)	Lower 1/2 senescent (100)	Half senescent (300)	Senescent (300)	Senescent dry (300)
Sl. No. Fungi	% occurrence of recovered genera									
1. <i>Cladosporium herbarum</i>	43.47	22.64	37.31	61.44	46.03	58.16	46.98	0.51	3.27	0.85
<i>C. cladosporioides</i>	5.79	16.98	14.92	3.61	14.28	8.16	8.08	-	-	-
2. <i>Culvularia</i> spp.	-	-	-	-	-	-	-	0.51	1.63	1.70
<i>C. lunata</i>	4.34	-	4.47	-	7.93	-	-	-	14.34	8.93
<i>C. geniculata</i>	-	-	-	-	-	-	-	1.53	6.55	3.40
<i>C. pallescens</i>	-	-	4.47	-	4.78	2.04	1.51	1.02	2.45	4.25
3. <i>Nigrospora sphaerica</i>	1.44	3.77	5.97	1.20	-	4.08	-	-	-	1.70
<i>N. oryzae</i>	14.49	5.68	5.97	-	-	-	1.51	-	-	5.95
4. <i>Epicoccum purpurascens</i>	2.89	5.68	4.47	4.81	9.52	6.12	12.12	-	-	-
5. <i>Cephalosporium</i> spp.	1.44	-	5.97	3.61	-	-	-	0.51	-	-
6. Yeast	1.44	5.68	1.49	-	-	-	-	-	2.45	2.55
7. <i>Aspergillus</i> spp.	-	-	-	-	-	-	-	-	0.40	1.70
8. <i>Penicillium</i> spp.	-	-	-	1.20	1.58	-	-	2.55	2.45	3.82
9. <i>Alternaria</i> spp.	1.44	7.54	1.49	2.40	-	2.04	-	0.51	0.40	0.85
<i>A. humicola</i>	1.44	3.77	-	6.02	1.58	-	3.03	2.04	12.29	18.57
<i>A. tenuissima</i>	-	-	-	-	-	-	-	1.53	9.01	7.85
<i>A. brassicae</i>	-	-	-	-	-	-	-	-	0.40	-
10. <i>Drechslera</i> spp.	-	-	-	-	-	4.08	19.69	80.10	32.37	16.17
11. <i>Fusarium</i> spp.	-	1.88	-	1.20	-	-	-	-	-	-
12. <i>Sclerotium rolfsii</i>	1.44	3.77	1.49	1.20	4.78	-	-	1.02	1.22	4.67
13. <i>Helminthosporium oryzae</i>	-	-	-	-	-	-	-	0.51	-	-
14. <i>Rhizopus oryzae</i>	-	-	-	-	-	2.04	-	-	-	2.97
15. <i>Sordaria fimicola</i>	2.89	3.77	1.49	-	-	-	-	-	-	-
16. <i>Papularia sphaerosperma</i>	2.89	3.77	-	-	-	-	-	-	-	-
17. <i>Brachysporium</i> sp.	-	-	-	-	-	-	-	-	0.40	2.97
18. <i>Rhizoctonia solani</i>	1.44	-	-	-	-	-	-	-	-	-
19. <i>Botrytis cinerea</i>	2.89	-	-	-	-	-	-	-	-	-
20. <i>Arthrobotrys superba</i>	-	-	-	-	1.58	-	-	-	-	-
21. <i>Mucor</i> sp.	-	-	-	-	-	-	1.51	-	-	-
22. <i>Stemphylium</i> sp.	-	-	-	-	-	-	-	-	0.40	-
23. <i>Spicaria</i> sp.	-	-	-	-	-	-	-	-	-	0.42
24. <i>Acremonium</i> sp.	-	-	-	-	-	-	-	-	-	0.42
25. Unidentified Types	2.89	-	1.49	1.20	3.17	1.02	1.51	3.06	-	1.27
26. Sterile Forms	7.24	15.09	8.95	12.04	4.76	12.24	6.06	4.59	9.83	8.08
Total Colony Count	69	53	67	83	63	98	66	196	244	235

Cladosporium was the dominant leaf surface fungus contributing 40-66% to the total spora up to late February so long the winter prevailed and with the onset of summer (in March) it disappeared abruptly. On the contrary, *Aspergillus* and *Penicillium* (except in early February) were absent totally on leaves in winter and showed a heavy colonisation during summer. *Nigrospora sphaerica* and *N. oryzae* were mainly recovered from fresh green leaves during vegetative growth stages and also at harvest time. Predominance of *Epicoccum purpurascens* was restricted in winter season. *Curvularia* was isolated in huge number during ripening (25.00%) and during harvesting (18.29%) from the leaves at senescent stages. A number of "sterile forms" were observed throughout the period. Yeasts were found in early and late stages only, while *Cephalosporium*, *Sordaria*, *Papularia*, *Brachysporium* and *Rhizopus* were recorded occasionally.

Phytopathogenic *Alternaria* (represented mainly by *A. humicola* and *A. tenuissima*) although present on leaf surface from early vegetative growth, it was predominantly isolated in later stages with peak (28.08%) during harvesting, showing massive leaf infection. *Drechslera* infected the plants heavily from "grain maturation" stage with peak spore production (80.10%) at late "grain maturation" with a gradual fall afterwards. Except for "grain maturation", *Sclerotium* was regularly recovered unlike *Helminthosporium*. *Stemphylium* and *Fusarium* which were observed only very rarely.

4. PHYLLOPLANE MYCOFLORA OF JUTE PLANTS

CROP SEASON

Jute seeds are sown in late April and the mature plants are cut for retting in late July of the year covering the summer and early rainy season. Leaf sampling was conducted from 5th May during seedling to 28th July at harvest time in 1991.

RESULTS

Table 21 shows the data of phylloplane studies of jute crop. *Curvularia* was regularly isolated with huge numbers (20.00%) at pre-harvesting and harvesting stages. *Aspergillus*

Table 21. Phylloplane studies on jute plants

Date of leaf sampling (1991)	May 5		May 19		June 2		June 16		July 7		July 28		July 28	
	seed-ling (17)	Early Veg- etative Growth (31)	Upper veg. leaves (45)	Veg. Gr. (45)	Lower most yellow leaves (45)	Upper veg. Fr. leaves (59)	Lower yellow leaves (59)	Pre har- vesting (80)	Upper Half senes- cent leaves (101)	Lower Senes- cent leaves (101)	Harves- ting (101)	Rotten stem & attached leaves (101)		
Nature of leaves	Fresh green leaves	Upper veg. leaves	Upper fresh veg. leaves	Lower most yellow leaves	Upper veg. Fr. leaves	Lower yellow leaves	Both Upper & lower leaves	Upper Half senes- cent leaves	Lower Senes- cent leaves	Rotten stem & attached leaves				
Leaf area covered [mm ²]	300	300	200	100	200	100	300	200	100	300				
1. <i>Curvularia</i> spp.	8.82	14.86	-	-	7.69	-	5.60	3.33	-	-	-	-		
<i>C. lunata</i>	-	-	1.26	12.06	3.84	5.55	14.40	13.33	12.24	69.65	-	-		
<i>C. pallidus</i>	-	-	-	-	-	-	-	3.33	2.04	-	-	-		
2. <i>Aspergillus</i> spp.	17.64	-	2.53	-	-	5.55	-	-	-	-	-	-		
<i>A. niger</i>	-	-	27.84	6.89	-	-	-	1.66	-	-	-	-		
<i>A. fumigatus</i>	-	-	-	-	-	-	-	3.33	-	-	-	-		
3. <i>Penicillium</i> spp.	11.76	18.91	2.53	-	15.38	16.66	19.20	11.66	12.24	1.38	-	-		
4. <i>Cephalosporium</i> spp.	2.94	5.40	-	8.62	19.23	16.66	8.00	20.00	6.12	-	-	-		
5. Yeast	5.88	-	1.26	-	-	-	-	-	-	1.38	-	-		
6. <i>Pullularia pullulans</i>	11.76	9.45	62.02	55.17	7.69	-	-	-	-	-	-	-		
7. <i>Rhizopus oryzae</i>	-	-	-	-	-	-	-	-	-	-	-	-		
8. <i>Cladosporium</i> sp.	2.94	1.35	-	3.44	3.84	16.66	24.80	6.66	18.36	7.59	1.38	-		
9. <i>Alternaria</i> spp.	-	-	-	-	-	-	-	3.33	6.12	1.38	-	-		
<i>A. tenuis</i>	-	-	-	-	-	-	-	3.33	8.16	6.20	-	-		
10. <i>Fusarium</i> sp.	2.94	4.05	-	5.17	1.92	-	8.00	5.00	2.04	40.00	-	-		
11. <i>Macrophomina phaseolina</i>	-	6.75	-	-	21.15	33.33	-	-	-	-	-	-		
12. <i>Humicola</i> sp.	2.94	5.40	-	-	-	-	-	1.66	-	-	-	-		
13. <i>Chaetomium</i> sp.	2.94	2.70	-	-	-	-	-	-	-	2.76	-	-		
14. <i>Stemphylium</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-		
15. <i>Spicaria</i> sp.	-	-	2.53	-	-	-	-	-	-	-	-	-		
16. <i>Brachyosporium</i> sp.	-	-	-	-	-	-	11.20	-	4.08	-	-	-		
17. <i>Helminthosporium</i> sp.	-	-	-	-	-	-	2.40	-	2.04	-	-	-		
18. <i>Geotrichum candidum</i>	-	-	-	-	-	-	-	1.66	2.04	-	-	-		
19. <i>Nigrospora sphaerica</i>	-	-	-	-	-	-	-	1.66	-	-	-	-		
20. <i>Epicoccum</i> sp.	-	-	-	-	-	-	-	-	4.08	1.38	-	-		
21. <i>Pleospora</i> sp.	8.82	18.91	-	-	-	-	3.20	-	4.08	-	-	-		
22. Unidentified Fungi	11.76	-	-	-	5.76	-	-	5.00	8.16	8.97	-	-		
23. White sterile forms	8.82	12.16	-	8.62	13.46	5.55	3.20	13.33	8.16	17.93	-	-		
Brown sterile forms	-	-	-	-	-	-	-	-	-	-	-	-		
Total Colony Count	34	74	79	58	52	18	125	60	49	145	-	-		

% distribution

Sl. Fungal organism No.

niger was found predominating in early June over green vegetative leaves. In general, *Aspergillus* spp. were more frequent on the leaf surface in earlier stages. Twelve to 19% *Penicillium* was found regularly except in June. *Cephalosporium* was a frequent type observed in later stages of crop growth. *Pullularia* was observed in very high concentration in June. During mid-June, *Cladosporium* was observed over the yellow leaves. Yeast, *Rhizopus*, *Nigrospora*, *Humicola*, *Chaetomium*, *Brachysporium*, *Pleospora*, *Geotrichum candidum* and *Epicoccum* were observed very rarely.

Fusarium and *Alternaria* spp. represented by *A. tenuis* and other species were observed during early seedling, pre-harvesting and harvesting stages. *Macrophomina phaseolina* were observed in very high values during late vegetative growth stages and during harvesting, associated with heavy stem damage. The other pathogens, i.e. *Stemphylium* and *Helminthosporium* were recorded only occasionally.

5. MYCOFLORA ASSOCIATED WITH THE MUSTARD LEAVES

CROP SEASON

The mustard seeds are broadcast in December and the matured plants are harvested in early February. Leaf sampling was started on 18th December 1991 and continued till harvesting on 9th February 1992.

RESULTS

The remarkable increase in total recovered colonies was recorded with the start of flowering in comparison to early vegetative growth. The heavy colonisation over leaves was maintained until harvesting (Table 22).

Colonisation of *Cladosporium* was abruptly increased from "vegetative growth" stage to early flowering. A very high concentration was maintained till harvesting particularly on senescent leaves. *Aspergillus* and *Penicillium* were almost absent on the leaves of mustard. Amongst other saprophytic forms, *Curvularia*, *Nigrospora* and *Epicoccum* were regularly

Table 22. Leaf surface mycoflora of mustard

Date of Leaf sampling (1991-92)	Dec 18	Dec 31	Dec 31	Jan 12	Jan 12	Jan 26	Jan 26	Feb 9	
Crop growth stage	Vegetative growth	Veg.Gr.& EarlyFlow-ering	Veg.Gr.& EarlyFlow-ering	Flowering	Flowering	Pod Matu-ration	Pod Matu-ration	Harves-ting	
Types of leaves sampled	Fresh green veg. leaves	Upper most fresh leaves	Lower senescent leaves	Upper green leaves	Lower diseased	Topmost fresh leaves	Diseased and decayed	Senescent leaves	
Leaf area covered (mm ²)	300	200	100	200	100	100	200	300	
Sl. No.	Fungal organism		% Occurrence						
1.	<i>Cladosporium herbarum</i>	8.10	22.76	52.56	26.13	36.53	18.46	20.14	15.52
	<i>C. cladosporioides</i>	5.40	8.94	11.53	8.52	-	10.76	10.07	9.74
2.	<i>Curvularia lunata</i>	22.97	4.06	2.56	2.27	0.96	7.69	-	0.72
	<i>C. pallens</i>	-	2.43	5.12	0.56	1.92	-	2.87	-
3.	<i>Aspergillus</i> sp.	1.35	-	-	-	-	-	-	-
4.	<i>Penicillium</i> sp.	2.70	-	-	0.56	-	-	-	-
5.	<i>Epicoccum purpurascens</i>	-	10.56	2.56	13.06	8.65	9.23	12.23	7.94
6.	<i>Alternaria</i> sp.	8.10	1.62	3.84	6.25	12.50	9.23	6.47	9.38
	<i>A. brassicicola</i>	-	4.87	6.41	15.90	19.23	12.30	11.51	18.05
	<i>A. brassicae</i>	-	0.81	-	-	2.88	4.61	5.75	9.74
	<i>A. humicola</i>	-	-	-	1.13	-	-	3.59	-
	<i>A. tenuis</i>	-	-	-	1.13	-	-	1.43	1.44
7.	<i>Fusarium</i> spp.	13.51	-	-	1.13	0.96	4.61	1.43	2.52
8.	<i>Sclerotium rolfsii</i>	2.70	11.38	-	-	-	3.07	-	1.44
9.	<i>Nigrospora sphaerica</i>	4.05	4.06	-	7.95	5.76	1.53	4.31	1.08
10.	<i>Helminthosporium</i> sp.	4.05	-	-	-	-	-	-	-
11.	<i>Cephalosporium</i> sp.	5.40	-	-	0.56	-	-	-	0.72
12.	Yeasts	-	1.62	1.28	-	-	-	1.43	1.44
13.	<i>Rhizopus oryzae</i>	-	4.87	6.41	-	-	-	3.59	-
14.	<i>Stemphylium</i> sp.	2.70	-	-	0.56	-	-	-	0.36
15.	<i>Mucor</i> sp.	2.70	-	-	-	-	1.53	-	2.88
16.	<i>Humicola fuscoatra</i>	1.35	-	-	1.13	-	-	-	-
17.	<i>Chaetomium</i> sp.	12.16	-	-	-	-	-	-	-
18.	<i>Sordaria fimicola</i>	-	-	-	3.40	-	-	0.71	-
19.	<i>Pullularia pullulans</i>	-	-	-	-	-	4.61	4.31	-
20.	<i>Cordana musae</i>	-	1.62	-	-	-	-	-	-
21.	<i>Graphium</i> sp.	-	-	-	2.27	-	-	-	-
22.	<i>Cercospora</i> sp.	-	-	-	-	0.96	-	-	-
23.	<i>Brachysporium</i> sp.	-	-	-	-	-	-	-	0.36
24.	<i>Trichoderma lignorum</i>	2.70	-	-	-	-	-	-	-
25.	Unidentified Types	-	0.81	-	1.70	0.96	1.53	-	-
26.	White Sterile forms	-	-	1.28	-	0.96	1.53	-	-
27.	Brown Sterile forms	-	19.51	6.41	5.68	7.69	9.23	10.07	16.60
	Total colony count	74	123	78	176	104	65	139	277

isolated. In contrast, *Humicola*, *Cephalosporium*, yeast, *Rhizopus oryzae*, *T. lignorum*, *Brachysporium*, *Mucor*, *Sordaria fimicola*, *Chaetomium*, *Cordana musae*, *Graphium* and *Pullularia pullulans* were recovered occasionally. Sterile forms were as usual present.

Alternaria species represented by *A. brassicicola*, *A. brassicae*, *A. tenuis* and *A. humicola* were the main pathogenic fungal types appeared on the phylloplane from the very beginning. It increased gradually with the ageing of the crop plant reaching peak value (38.62%) in the senescent leaves at harvesting time. Next to *Alternaria*, *Fusarium* was more commonly isolated from leaves unlike *Sclerotium* and *Stemphylium*. Fungi, like *Helminthosporium* and *Cercospora* were found only in one sample each in the sampling period.

6. LEAF SURFACE FUNGI OVER THE LEAVES OF WINTER VEGETABLES

CROP SEASON

The seed plants are transplanted in October-November and the mature vegetables are harvested in December-January. Sampling of leaves was done throughout the crop growth period (i.e. from 3rd November 1991 to 21st January, 1992).

RESULTS

The most dominant leaf surface flora recovered from various leaves of cauliflower were *Cladosporium*, *Curvularia*, *Nigrospora*, *Alternaria* and *Epicoccum* (Table 23). *Aspergillus* was observed at the earlier stages only. *Cladosporium* was present regularly with peak colonisation in the leaf litter. *Curvularia* was found to be present in high values in the earlier stages, while *Nigrospora* was during mid-season. *Epicoccum* was isolated with the start of flowering onwards. *Alternaria* represented by 4 species was very common and predominant from flowering and peak colonisation was recorded in the leaves of harvesting period. In the fallen decayed leaves, it was also present in high concentrations. *Penicillium*, *Pullularia*, *Sclerotium*, *Stemphylium*, *Cephalosporium*, *Sordaira fimicola*, *Graphium* and yeasts were the rarely occurring leaf surface fungi. The fungi appeared only once during

Table 23. Phylloplane mycoflora of winter vegetables (Cauliflower)

Date of Sampling (1991-92)	Nov 3	Nov 21	Dec 18	Dec 31	Dec 31	Jan 21
Growth stage of the crop	Early vegetative growth	Vegetative Growth	Early Flowering	Harvesting	Harvesting	Post-harvesting
Nature of leaves samples	Green veg. leaves	Fresh veg.	Both fresh & lower yellow	Green leaves	Diseased spotted	Fallen decayed leaf litter
Leaf area covered (mm ²)	300	300	300	100	200	300
Sl. No.	Fungal organism		% Occurrence			
1.	<i>Cladosporium herbarum</i>	6.66	12.12	3.22	11.11	21.96
	<i>C. cladosporioides</i>	-	-	-	12.67	6.93
2.	<i>Aspergillus</i> sp.	6.66	9.09	1.61	-	-
	<i>A. niger</i>	6.66	-	3.22	-	-
	<i>A. parasiticus</i>	3.33	-	-	-	-
	<i>A. fumigatus</i>	-	6.06	-	-	-
3.	<i>Penicillium</i> spp.	-	-	12.90	3.70	-
4.	<i>Curvularia lunata</i>	20.00	12.12	3.22	-	3.46
	<i>C. pallenscens</i>	-	6.06	4.83	-	1.40
5.	<i>Puffularia pullulans</i>	3.33	9.09	-	-	-
6.	Yeasts	6.66	-	-	-	1.73
7.	<i>Nigrospora sphaerica</i>	-	6.06	25.80	14.81	4.22
8.	<i>Epicoccum purpurascens</i>	-	-	4.83	11.11	2.81
9.	<i>Alternaria</i> spp.	-	-	4.83	3.70	2.81
	<i>A. brassicae</i>	-	-	6.45	7.40	4.62
	<i>A. brassicicola</i>	-	-	-	11.11	19.07
	<i>A. tenuis</i>	-	-	-	7.04	2.89
10.	<i>Sclerotium rolfsii</i>	-	-	-	3.70	0.57
11.	<i>Stemphylium piriforme</i>	-	-	4.83	-	1.73
12.	<i>Chaetomium</i> sp.	6.66	-	-	-	-
13.	<i>Pestalotia truncata</i>	-	9.09	-	-	-
14.	<i>Helminthosporium oryzae</i>	-	-	3.22	-	-
15.	<i>Cephalosporium</i> spp.	-	-	4.83	-	0.57
16.	<i>Graphium</i> sp.	-	-	-	7.40	1.40
17.	<i>Spicaria</i> sp.	3.33	-	-	-	-
18.	<i>Sordaria fimicola</i>	-	-	-	-	4.22
19.	<i>Papularia sphaerosperma</i>	-	-	-	-	0.57
20.	<i>Mortierella</i> sp.	-	-	-	-	1.73
21.	Unidentified types	3.33	-	4.83	3.70	2.81
22.	Sterile forms (White)	10.00	3.03	-	-	0.57
	Sterile forms (Brown)	23.33	27.27	11.29	22.22	20.80
	Total Colony	30	33	62	27	71

the sampling period were represented by *Spicaria*, *Chaetomium*, *Pestalotia truncata*, *Helminthosporium oryzae*, *Papularia sphaerosperma* and *Mortierella*. The sterile mycelia were observed predominantly at the earlier stages.

7. PHYLLOPLANE STUDIES ON BANANA

CROP SEASON

In banana plantation, the crop remains standing throughout the year. The leaves were sampled from 19th May 1991 till 23rd February 1992. In the months of March-April, generally no new vegetative plants are produced due to shortage of water. The mother plants are left only in remnant stage. For this reason, no leaves were sampled during these two months.

RESULTS

The per cent contribution of different genera obtained from the leaf surface of banana is represented in Table 24. *Curvularia*, *Aspergillus*, *Cladosporium*, *Cephalosporium*, *Nigrospora* and *Sclerotium* were found to occur frequently. A clear seasonal periodicity was observed in cases of *Aspergillus* and *Cladosporium*, the former predominating in summer and monsoon, while the latter during winter. *Curvularia*, a regular isolate occurred in huge numbers showing no trend of seasonality. *Pullularia* was mainly isolated during May-June but *Epicoccum* and *Nigrospora* were very common in winter. *Sclerotium* was common in monsoon and persisted till the end of winter. *Fusarium* was frequently recorded from leaves excepting the months of September to November. *Zygosporium oscheoides* was found inhabited on leaves of banana from late December to February (in winter). *Alternaria*, *Helminthosporium* and *Cordana musae* were recorded from leaves only occasionally. While "sterile forms" were found all through; a number of genera (Table 24) were recorded to be present on leaves very rarely.

8. THE STUDIES ON THE LEAVES OF POTATO PLANTS

CROP SEASON

The seed potatoes are planted within the prepared soil of land in the field in mid-December and after maximum tuber formation and maturation, the tubers are harvested during early February. The leaf sampling was continued from very early "vegetative growth" stage (December 29, 1992) till prior to harvesting (February 7, 1993).

RESULTS

The major genera isolated regularly and in high values (as revealed in Table 25) were *Cladosporium*, *Penicillium*, *Curvularia*, *Alternaria*, *Sclerotium*, *Epicoccum purpurascens*, *Nigrospora* in sequential order with a fair number of "sterile forms". *Aspergillus*, yeasts, *Spicaria*, *Brachysporium*, *Rhizoctonia*, *Stemphylium* and *Cercospora* were recorded occasionally. The other rarely occurring genera were *Trichoderma lignorum*, *Rhizopus*, *Papularia sphaerosperma*, *Cephalosporium*, *Pyricularia*, *Pestalotia truncata*, *Chaetomium globosum*, *Drechslera*, *Cunninghamella elegans* and *Phytophthora infestans*. Peak (57.31%) *Cladosporium* concentration was recorded from fresh leaves during late January. *Curvularia* was isolated in very high concentration (57.14%) in spotted as well as diseased leaves, in early January. A fair percentage of *Penicillium* was being reported to be present all through. *Nigrospora* (except for one sample), *Epicoccum purpurascens* and *Sclerotium* were the regular constituents on leaf surface. A gradual rise of *Alternaria solani* was observed with the ageing of the crop plant with the production of leaf spots and showed peak concentration (14.19%) at harvesting time. The causal agent of late blight disease, *Phytophthora infestans* was recorded on leaves very rarely, i.e. during harvesting (2.43%).

DISCUSSION

The specificity of fungal colonisation on leaves of various plants depends upon a number of factors viz. suitable host plant especially for pathogenic fungi, crop season for cultivated plants, plants' lifetime (i.e. whether ephemerals, annuals, biennials or evergreen perennials), leaf texture, position of the leaf on the stem (i.e. whether exposed horizontally

Table 25. Phylloplane mycoflora of potato plants

Date of Leaf Collection (1992-93)	Dec 29	Jan 10	Jan 10	Jan 24	Jan 24	Feb 7	
Growth stage of the crop	Early vegetative growth	Vegetative Growth & starting of tuber formation	Tuber formation	Pre-Harvesting	Pre-Harvesting	Harvesting	
Types of leaves sampled	Fresh green vegetative	Upper green veg.	Lower spotted & diseased	Uppermost fresh green	Diseased spotted	Senescent leaves	
Leaf area covered (mm ²)	300	200	100	100	200	300	
Sl. No.	Fungal organism		% Occurrence				
1.	<i>Cladosporium herbarum</i>	11.45	12.50	7.14	50.60	28.69	21.72
	<i>C. cladosporioides</i>	3.12	5.55	-	6.70	3.55	3.99
2.	<i>Nigrospora sphaerica</i>	4.16	-	-	-	-	0.66
	<i>N. oryzae</i>	-	-	5.35	1.21	2.95	-
3.	<i>Aspergillus niger</i>	1.04	1.38	-	1.82	-	-
	<i>A. fumigatus</i>	3.12	5.55	-	-	-	-
	<i>A. ochraceous</i>	1.04	-	-	-	-	-
	<i>A. nidulans</i>	1.04	-	-	-	-	-
4.	<i>Penicillium</i> spp.	8.33	8.33	3.57	3.04	14.49	5.09
	<i>P. funiculosum</i>	2.08	4.16	1.78	0.60	2.07	0.66
5.	<i>Curvularia lunata</i>	7.29	20.83	48.21	4.87	3.84	9.31
	<i>C. pallens</i>	5.20	6.94	7.14	1.21	5.02	3.76
	<i>C. tuberculata</i>	-	1.38	-	-	0.59	-
	<i>C. geniculata</i>	-	-	1.78	-	0.59	0.66
6.	Yeast	1.04	-	-	4.87	6.21	6.87
7.	<i>Epicoccum purpurascens</i>	1.04	1.38	1.78	3.65	1.77	5.32
8.	<i>Alternaria</i> spp.	-	-	-	-	-	4.87
	<i>A. solani</i>	1.04	4.16	5.35	3.65	6.21	14.19
	<i>A. tenuissima</i>	-	-	-	-	-	7.31
	<i>A. brassicae</i>	-	-	-	-	-	1.54
9.	<i>Sclerotium</i> sp.	4.16	4.16	1.78	2.43	3.55	1.10
10.	<i>Rhizoctonia solani</i>	1.04	-	-	-	0.59	-
11.	<i>Pyricularia oryzae</i>	1.04	-	-	-	-	-
12.	<i>Pestalotia truncata</i>	-	-	-	0.60	-	-
13.	<i>Stemphylium</i> sp.	-	-	-	0.60	0.59	-
14.	<i>Cercospora</i> sp.	-	-	-	-	0.29	0.66
15.	<i>Drechslera</i> sp.	-	-	-	-	0.29	-
16.	<i>Phytophthora infestans</i>	-	-	-	-	-	2.43
17.	<i>Brachysporium</i> sp.	-	1.38	5.35	0.60	-	-
18.	<i>Spicaria sylvatica</i>	1.04	-	-	0.60	-	-
19.	<i>Trichoderma lignorum</i>	10.41	-	-	-	-	-
20.	<i>Rhizopus arrhizus</i>	5.20	-	-	-	-	-
21.	<i>Papularia sphaerosperma</i>	2.08	-	-	-	-	-
22.	<i>Cephalosporium</i> sp.	3.12	-	-	-	-	-
23.	<i>Cunninghamella elegans</i>	-	-	-	-	1.47	-
24.	<i>Chaetomium globosum</i>	-	1.38	-	-	-	-
25.	Unidentified types	2.08	4.16	-	1.82	0.88	0.66
26.	Sterile forms (White)	3.12	1.38	1.78	2.43	0.29	-
	Sterile forms (Brown)	15.62	15.27	8.92	8.53	16.01	9.09
	Total colony count	96	72	56	164	338	451

or perpendicularly or obliquely perpendicular), age of the leaves as well as the plant, amount of leaf exudates, climatic conditions and even on the plants or plant parts producing toxic organic metabolic compounds.

A number of fungi (both saprophytic and parasitic), bacteria and actinomycetes can be detected to be present in all the plants. Antagonistic effect of certain isolates may cause the variation in amount of leaf surface flora. Abraham and Balasundaran (1977) reported that some actinomycetes were capable of inhibiting the growth of certain leaf pathogenic fungi. *Epicoccum nigrum* was reported to be a strong antagonist against plant pathogens (Dhingra and Khara 1973, Sharma *et al.* 1988). Singh (1985) reported a significant control of *Macrophomina phaseolina* and *Colletotrichum capsici* by *Epicoccum nigrum*. Some common phylloplane fungi like *Penicillium oxalicum*, *Fusarium semitectum*, *A. niger* and *A. luchuensis* showed the antagonistic effect on *Cercospora canescens*, an important pathogen of black gram (Bhaskar Rao and Mallaiah 1988).

The "Aman" variety of paddy is widely cultivated during monsoon in Kharif season and harvested in December covering the entire rainy season (July to October) till the middle of winter (November-December). The leaves of rice are exposed in obliquely perpendicular position with rough texture, hairy and stiff. Even it harbours a number of saprophytic and pathogenic fungal flora, their quality and quantity are changed with the changing environmental conditions and with different growth stages of the crop. *Aspergillus* and *Penicillium* were regularly isolated from leaves during rainy season, declining gradually in winter. In contrast, *Cladosporium* was preponderant in cold climate; gradually reaching peak (42.10%) at late senescent stage as also observed by Dickinson (1967). *Cladosporium* was reported by a number of workers (Pugh and Mulder 1971, Abdel-Wahab 1975, Abdel-Hafez 1981, McLean and Sutton 1992) as one of the dominant phylloplane fungus. The seasonal periodicity of *Aspergillus* and *Cladosporium* was supported by a number of air survey studies (Sinha *et al.* 1984, Sen *et al.* 1991, Ballero *et al.* 1992).

In the vegetative growth stages, the fresh green rice leaves were colonised by few fungal isolates, as compared to the excessive colonisation from flowering to senescence by the pathogenic as well as saprophytic fungi. Similarly, Dickinson (1967) recorded a dramatic increase in the activity of several fungi especially *Cladosporium*, *Stemphylium* and *Alternaria* on *Pisum* leaves at the senescence stage. During the studies on the leaf surface microorganisms, Bopaiah (1982) reported that a large number of microorganisms were present on older leaves.

A virulent rice pathogen, *Helminthosporium oryzae* causing brown spot disease was recorded first in the leaf surface in flowering stage, while it was isolated from the air during vegetative growth in the same crop (Uddin and Chakraverty 1995). It colonised at a faster rate and caused severe crop damage reaching peak (19.73%) at harvest time. *Sclerotium* was recorded more or less frequently unlike other pathogens (*Alternaria*, *Fusarium* and *Cercospora*); although *Alternaria* was already reported as a dominant isolate on wheat leaves (Abdel-Hafez 1981). At the period of harvesting of paddy, the seeds were observed to be contaminated with *Curvularia*, *H. oryzae*, *Cladosporium*, *Sclerotium*, *Nigrospora* and *Rhizoctonia*. Pathogenicity and transmission of *Alternaria padwickii* and *Curvularia lunata* on seeds of rice were evaluated by Costa (1991).

In the phyllosphere studies of fern plants (Abdel-Hafez 1984b), *Cladosporium herbarum*, *C. sphaerospermum*, *Alternaria alternata*, *Drechslera spicifera*, *Aspergillus*, *Penicillium*, *Cephalosporium roseo-griseum*, *Myrothecium verrucaria*, *Mucor racemosus* and yeasts were isolated.

In "Boro" variety of paddy as in "Aman" variety, *Cladosporium* was mainly isolated in the later stages of crop growth. *Aspergillus*, *Penicillium*, *Curvularia*, *Cephalosporium*, *Chaetomium*, *Nigrospora* and *Epicoccum* were the frequently occurring genera in order. Of these *Chaetomium* and *Cephalosporium* were almost absent in the leaves of "Aman"

variety. Although *Helminthosporium* was very high in earlier stages, *Alternaria* was found to be a regular isolate showing peak colonisation in later stages; caused crop damage and was a virulent pathogen for this variety in contrast to the "Aman" variety of paddy.

The dominant genera recorded in the phylloplane of wheat were *Cladosporium*, *Alternaria*, *Drechslera*, *Curvularia*, *Nigrospora*, *Sclerotium*, *Epicoccum* and sterile forms. The similarity between the air and phylloplane mycoflora were observed in case of *Cladosporium*, *Aspergillus*, *Penicillium*, *Alternaria*, *Curvularia*, *Epicoccum*, *Drechslera* and sterile forms. *Cladosporium* was the most dominant leaf surface flora upto February. Similar reports are also available from various workers (Hogg and Hudson 1966, Kuter 1986). Abdel-Hafez (1981) reported *Cladosporium* as the most common, occurring in 100% of the samples contributing 37% of the total phylloplane spora in wheat. In the phyllosphere studies of wheat plants (Abdel-Hafez 1981), the most frequent genera recorded were *Cladosporium*, *Aspergillus*, *Alternaria* and *Penicillium* followed by *Rhizopus*, *Drechslera*, *Fusarium*, *Epicoccum* and *Curvularia*; and in the phylloplane the most frequent fungi were *Cladosporium herbarum*, *A. niger*, *A. ochraceous*, *Alternaria alternata* and *A. fragmospora*. In the present study, *Aspergillus*, *Penicillium*, *Rhizopus* and *Fusarium* were not frequently isolated probably due to the variable environmental conditions and so also the *Cladosporium*, not found in the samples after February. Mazen *et al.* (1984) isolated *Aspergillus*, *Alternaria alternata*, *Cladosporium herbarum* and *Fusarium oxysporum* from wheat grains and their lemmae and paleae. As in our studies, *Alternaria* was reported to be present on a number of host plants (Pugh and Mulder 1971, Abdel-Wahab 1975, McLean and Sutton 1992). *Drechslera* caused massive leaf infection at the time of "grain maturation" during which it was isolated in huge amounts. Except for "grain maturation" stage, *Sclerotium* was isolated from leaves throughout and was not so severe as reported in other plants (Bowen *et al.* 1992).

Previously, Dickinson (1967) reported that at the onset of senescence, colonisation proceeded rapidly with *Cladosporium*, *Aureobasidium* and actinomycetes becoming

dominant on the yellow leaves and during senescence *Alternaria* and *Stemphylium* increased in frequency with *Cladosporium* dominated on newly dead leaves. In the present studies on wheat it was observed that up to "grain maturation" stage, both lower yellow and upper fresh green leaves were colonised mainly by *Cladosporium* followed by *Epicoccum*, *Nigrospora*, *Sclerotium* and *Alternaria*. From late "grain maturation" onwards *Cladosporium* disappeared and heavy colonisation of *Drechslera*, *Alternaria*, *Curvularia*, *Aspergillus* and *Penicillium* in accordance were recorded.

In the succession of colonisation pattern in jute leaves, in the earlier stages the dominant fungi recorded were *Curvularia*, *Aspergillus*, *Penicillium*, *Pullularia*, *Fusarium* and *Alternaria*. In the later stages *Curvularia* and *Penicillium*, continued; and *Aspergillus*, *Pullularia*, *Fusarium* and *Alternaria* disappeared and replaced by *Cephalosporium* and pathogenic *Macrophomina phaseolina* causing stem rot disease.

A similarity in the quality and quantity of leaf surface mycoflora was recorded in mustard and in winter vegetables (cauliflower). *Cladosporium*, *Curvularia*, *Nigrospora*, *Alternaria* and *Epicoccum* were the dominant flora in both the host plants. But only difference is that while in mustard *Aspergillus* was absent, it was found to be present in earlier stages in cauliflower. In both types of plants *Cladosporium* was the most dominant saprophyte throughout till senescence and even in the litter of cauliflower; and *Alternaria* with 4 species i.e. *A. brassicicola*, *A. brassicae*, *A. tenuis* and *A. humicola* was the most virulent pathogen causing damage in later stages of crop growth. Kuter (1986) reported that *Aureobasidium pullulans*, *Cladosporium cladosporioides*, *Phoma exigua*, *Coniothyrium ferckelii* and *Alternaria alternata* accounted for the majority of the samples of both foliage and litter.

Besides the main 5 genera recovered from the leaf of mustard and cauliflower, *Penicillium* and *Sclerotium* were also frequent genera found in another winter crop, i.e. potato. In later stages of crop growth *Alternaria solani* showed its maximum activity and

were isolated heavily during harvesting time with a simultaneous rise in the airspora in that period (Table 15). The activity of *Phytophthora infestans*, causing late blight of potato was negligible.

A close similarity in the air mycoflora and phylloplane flora was observed in case of banana. The seasonal periodicity of *Aspergillus*, *Cladosporium*, *Fusarium*, *Epicoccum*, *Nigrospora*, *Pullularia*, *Sclerotium*, *Zygosporium oscheoides* and *Cordana musae* was recorded during the phylloplane studies with banana (Table 24) and are similar with the air samples. No seasonal trend was recorded in *Curvularia* and *Cephalosporium*. These observations were in contrast with Bopaiah (1982) who reported that season had little influence on the composition of phylloplane microflora.

Thus, it can be concluded that the phylloplane mycoflora in the crop plants differ one from another in general. The crop season and type of host are the main factors in "Aman" and "Boro" varieties of paddy, wheat, jute and potato. As being winter crop and the plant under Brassicaceae i.e., mustard and cauliflower showed a similarity in their qualitative and quantitative phylloplane mycoflora. A seasonwise change of phylloplane flora was observed in case of banana. These leaf surface mycoflora determined mainly the typical airspora of a particular crop in spite of that some spores in the airspora may come from distant places. However, a close similarity in the airspora and phylloplane flora in a particular environment strengthens that the phylloplane is the reflection of crop field airspora. Pasanen and Fritze (1992) suggested that dominant fungi in phylloplane could be used as a biomonitor for assessing the air quality.