ACTA SOCIETATIS
BOTANICORUM POLONIAE
Vol. 51, nr 3-4: 493-501
1982

Studies on the rhizosphere mycoflora of certain trees

INDER JEET JOSHI

School of Studies in Botany, Jiwaji University, Gwalior 474011, India

(Received: January 22, 1982)

Abstract

Two soil types, one supporting *Prosopis juliflora* and another supporting *Dalbergia sissoo* were selected to study the mycoflora associated with soil, rhizosphere and rhizoplane during winter and rainy seasons. Variations in the fungal population and variety of soil, rhizosphere and rhizoplane in relation to the nature of the plant and season were studied. Similarities between the soil, rhizosphere and rhizoplane fungeal flora in relation to plant species and season were studied. Differences in the dominant fungal species are also described.

INTRODUCTION

Extensive investigations on the rhizosphere fungal flora of various plant species have been carrried out. Most of the workers have noted maximum rhizosphere populations during the flowering period (Timonin 1940, Ivarson and Katznelson 1960) when the plant shows maximum vegetative growth. Most of the earlier studies, however, were confined to herbaceous plants (Srivastava and Mishra 1971, Mishra and Srivastava 1974), where studies may conveniently be performed within a shorter time. Fewer studies have concerned the rhizosphere mycoflora of trees (Mishra and Kanaujia 1973, Peno and Veselinovic 1973, Karimbaeva and Sizova 1976) and greater attention has not been paid to the seasonal variation in the rhizosphere fungal flora of trees, owing to their very long life cycle and difficulties in handling their root system. It was, threfore, considered worthwhile to elaborate the soil, rhizosphere and rhizoplane mycoflora of two angispermic tree species viz., *Prosopis juliflora* (SW) DC and *Dalbergia sissoo* Roxb. in relation to various seasons and to study the variations and extent of similarities between the fungal soil flora, rhizosphere and rhizoplane along with the response of rhizosphere fungi to the flowering period.

MATERIALS AND METHODS

This investigation was performed on two angispermic tree species viz., *Prosopis juliflora* (SW) DC and *Dalbergia sissoo* Roxb. growing in two different soil types viz., sandy loam and clayey loam soils, respectively in the Chambal ravines of Bhind, M. P. (India). These two plant species are planted here by the forest depertment to check the soil erosion of those ravinous areas. The soil is alluvial and the climate is semi-arid.

The mycoflora assosiated with the soil, rhizosphere and rhizoplane of these two tree species was studied during winter and rainy seasons. For soil mycoflora, soil samples were taken from the upper 15 cm of the soil wide apart from the roots and the mycoflora was isolated on Martin's rose bengal streptomycin medium (Martin 1950) by the soil plate method (Warcup 1950). Rhizosphere mycoflora was isolated by the dilution plate method (Timonin 1940) on modified Martin's medium (Papavizas and Davey 1959). Rhizoplane mycoflora was isolated by the serial root washing technique (Harley and Waide 1955) on Czapek's Dox+Yeast extract medium (Stover and Waite 1953).

Frequency and abundance of the individual fungal species were calculated by the method suggested by Saksena (1955) and the species exhibiting higher frequency and abundance were treated as dominant. The fungal flora of soil, rhizosphere and rhizoplane was compared by the similarity quotient (Sorensen 1948) for finding the extent of similarity among them.

Among the edaphic factors, mechanical composition of the two soil types was evaluated by the Bouycous hydrometer method. Soil moisture and carbon were determined by the method suggested by Piper (1944) whereas nitrogen was estimated by the semimicrokjeldahl method (Jackson 1958). Data were statistically analysed for significant conclusions.

RESULTS

The two soil types, selected for study, differed as regards their mechanical composition. The soil texture of the *P. juliflora* field was sandy loam (sand = 51.56%, silt = 15.04%, clay = 12.40%. $CaCO_3$ = 1.00%) whereas that of the *D. sissoo* field was clayey loam (sand = 35.34%, silt = 32.92%, clay = = 23.24%, $CaCO_3$ = 8.50%). Soil moisture and carbon and nitrogen contents of the two soil types showed appreciable variable variations during the rainy season (Table 2).

A total of 87 fungal species were isolated from the soil, rhizosphere and rhizoplane of *P. juliflora* and *D. sissoo* during the winter and rainy seasons (Table 1). Six of them belonged to *Phycomycetes*, 8 to *Ascomycetes*, 69 to *Fungi Imperfecti*, 3 were sterile colonies and one an unidentified colony. During the winter season 49 species were isolated form the *P. juliflora* field (33 from soil, 24 from rhizosphere and 5 from rhizoplane), whereas during

Table 1

Distribution of fungi in soil, rhizosphere and rhizoplane of P. juliflora and D. sissoo during winter and rainy season

Fungal species	Soil				P. juliflora				D. sissoo			
	winter		rainy		winter		rainy		winter		rainy	
	P	D	P	D	Rs	Rp	Rs	Rp	Rs	Rp	Rs	Rp
PHYCOMYCETES												
Actinomucor elegans	-	-	-	-	-	-	-	-	+	-	-	-
Candida sp.	-	+	-	+	-	-	-	-	-	-	-	-
Mortierella camargensis	-	+	-	-	-	-	-	-	-	-	-	-
Mucor hiemalis	-	-	+	+	-	+	-	+	-	-	-	-
M. racemosus	+	+	-	-	-	-	-	-	-	-	-	-
Rhizopus oryzae	-	-	-	+	-	+	-	+	-	-	+	-
ASCOMYCETES												
Chaetomium cochliodes	-	-	-	-	+	-	-	-	-	-	-	+
C. jodhpurense	+	+	+	+	-	-	-	-	-	-	-	-
C. spirale	-	-	+	-	-	-	-	-	-	-	-	-
Chaetomium sp.	-	-	-	+	-	-	-	-	-	-	-	-
Khuskia oryzae	+	+	+	+	-	-	-	-	-	-	-	-
Neocosmospora vesinfecta	-	+	-	-	-	-	-	-	-	-	-	-
Thielavia sepedonium	-	-	+	-	-	-	-	-	-	-	-	-
T. terricola	-	-	+	-	-	-	-	-	-	-	-	-
FUNGI IMPERFECTI												
Acremonium kiliense	+	-	-	-	-	-	-	-	-	-	-	-
A. restrictum	-	-	-	+	-	-	-	-	-	-	-	-
Acrophialophora fusispora	+	+	+	+	-	-	-	-	-	-	-	-
Alternaria alternata	+	+	+	-	+	-	+	+	-	-	+	+
Alternaria sp.	-	-	-	-	-	-	-	-	-	+	+	+
Aspergillus sculestus	-	+	-	-	+	-	-	-	-	-	-	-
A. flavipes	+	-	-	-	-	-	-	-	-	-	-	-
A. flavus /strain I/	+	+	+	+	+	+	+	-	+	-	+	-
A. flavus /strain II/	-	+	-	+	-	-	-	-	-	-	-	-
A. fumigatus /strain I/	+	+	-	+	-	-	-	-	-	-	-	-
A. fumigatus /strain II/	+	+	+	+	-	-	-	-	-	-	-	+
A. fumigatus /strain III/	+	+	+	+	-	-	-	-	-	-	-	-

Fungal species	Soil				P. juliflora				D. sissoo			
	winter		rainy		winter		rainy		winter		rainy	
	P	D	Rs	Rp	P	D	Rs	Rp	P	D	Rs	Rp
A. nidulans /strain I/	+	+	+	+	+	-	-	-	+	-	-	-
A. nidulans /strain II/	-	+	-	-	-	-	-	-	-	-	-	-
A. niger /strain I/	+	+	+	+	+	-	-	-	-	+	+	-
A. niger /strain II/	+	+	+	+	-	-	-	-	-	-	-	-
A. niveus /strain I/	-	+	-	-	+	-	-	-	+	+	-	-
A. niveus /strain II/	-	-	-	-	+	-	-	-	-	-	-	-
A. ochraceous	-	-	-	+	+	-	-	-	-	-	-	-
A. quercinus	-	-	-	-	+	-	-	-	-	-	-	-
A. stellatus	+	+	+	+	-	-	-	-	-	-	-	-
A. terreus	+	+	+	+	+	-	-	-	+	-	-	+
A. ustus	+	+	+	+	+	+	-	-	-	-	-	-
Cladosporium oxysporum	-	-	-	+	+	-	+	-	+	-	+	+
Coleophoma empetri	+	+	+	+	-	-	-	-	-	-	-	-
Coniothyrium fuckelii	-	-	-	+	-	-	-	-	-	-	-	-
Curvularia lunata	+	+	+	+	-	-	-	-	-	+	-	+
C. verruculosa	-	-	+	-	-	-	-	-	-	-	-	-
Cylindrocladium floridanum	-	+	-	+	-	-	-	-	-	-	-	-
Drechslera state of Cochliobulus carbonus	-	-	-	+	-	-	-	-	-	-	-	-
Fusarium dimerum	-	-	-	+	-	-	-	-	-	-	-	-
F. equiseti	-	-	-	-	+	+	-	-	-	-	-	-
F. moniliforme	-	-	-	-	+	-	-	-	+	-	+	+
F. oxysporum	+	+	+	+	-	-	+	+	+	-	-	-
F. solani /strain I/	+	+	+	+	+	-	-	-	+	+	-	-
F. solani /strain II/	-	-	-	+	-	-	-	-	-	-	-	-
F. tabacinum	-	-	-	+	-	-	-	-	-	-	-	-
Helminthosporium sativum	+	-	+	-	-	-	-	-	-	-	-	-
Humicola fusco-atra /strain I/	+	+	+	+	+	-	-	-	-	-	-	-
H. fusco-atra /strain II/	-	+	-	-	-	-	-	-	-	-	-	-
Macrophomina phaseolina	-	-	-	-	-	-	-	+	-	+	-	+
Microscus trigonosporus	-	+	-	-	-	-	-	-	-	-	-	-
Monocillium constrictum	+	+	-	+	-	-	-	-	-	-	-	-

Fungal species	Soil				P. juliflora				D. sissoo			
	winter		rainy		winter		rainy		winter		rainy	
	P	D	P	D	Rs	Rp	Rs	Rp	Rs	Rp	Rs	Rp
Monodictys fluctuata	+	+	+	+	-	-	-	-	-	-	-	-
Myrothecium leucotrichum	+	-	-	-	-	-	-	-	-	-	-	-
M. verrucaria	+	+	+	+	+	-	+	+	-	-	-	-
Nersimhella hyalinospora	-	-	+	-	-	-	-	-	-	-	-	-
Paecilomyces lilacinus	-	-	+	-	+	-	-	+	-	-	-	+
P. variotii	-	-	+	-	-	-	-	-	-	-	-	-
Paecilomyces sp.	-	+	-	-	-	-	-	-	-	-	-	-
Penicillium canescens	-	-	-	-	+	-	-	-	-	-	-	-
P. chrysogenum	-	-	+	-	+	-	+	-	-	-	-	-
P. funiculosum	-	+	-	-	+	-	-	-	-	-	+	-
P. oxalicum	+	+	-	+	-	-	-	-	+	+	+	+
P. spiculisporum	+	-	-	-	-	-	-	-	-	-	-	-
Penicillium sp.	-	-	-	+	-	-	-	-	-	-	-	-
Periconia sp.	-	+	-	-	-	-	-	-	-	-	-	-
Phialophora cyclaminis	-	+	-	-	-	-	-	-	-	-	-	-
Phoma exigua	-	-	-	-	-	-	-	-	-	-	-	+
P. herbarum	+	+	-	-	-	-	-	-	-	-	-	-
P. pomorum	-	+	-	-	-	-	-	-	-	-	-	-
Polyschema sp.	-	-	+	+	-	-	-	-	-	-	-	-
Pyrenochaeta sbutilonis	-	-	-	+	+	-	-	-	-	-	-	-
Scolecobasidium constrictum	-	-	-	+	-	-	-	-	-	-	-	-
S. terreus	-	+	+	+	-	-	-	-	-	-	-	-
Stachybotrys atra	-	+	+	+	-	-	-	-	-	-	-	-
S. bisbyi	+	+	-	-	-	-	-	-	-	-	-	-
Trichoderma sureoviride	+	+	+	+	+	-	-	-	-	-	-	-
Zalerion sp.	-	+	+	+	-	-	-	-	-	-	-	-
Sterile colony I /white/	+	-	-	-	-	-	-	-	-	-	-	+
Sterile colony II /black/	+	-	-	-	-	-	-	-	-	-	-	-
Sterile colony III /brown/	-	-	-	+	-	-	-	-	-	-	-	-
Unidentified colony	-	-	+	-	-	-	-	-	-	-	-	-

\+ indicates 'Presence'; - indicates 'Absence'

P = P. juliflora field ; D = D. sissoo field

Rs = Rhizosphere ; Rp = Rhizoplane

the rainy season only 39 species were isolated (36 from soil, 6 from rhizosphere and 8 from rhizoplane). On the other hand, from the *D. sissoo* field, 51 species were isolated during the winter (46 from soil, 10 from rhizosphere and 7 from rhizoplane) and 53 during the rainy season (44 from soil, 9 from rhizosphere and 13 from rhizoplane).

Table 2
Population of fungi in soil, rhizosphere and rhizoplane and certain edaphic factors in relation to plants and seasons

	Factors	Winter	Rainy season
P. juliflora	soil population/g soil	84465	32699
	soil moisture (%)	4.68	6.99
	carbon (%)	0.665	0.353
	nitrogen (%)	0.096	0.048
	rhizosphere population/g soil	376670	17363636
	rhizoplane population/g root	104	247
D. sissoo	soil population/g soil	50309	26595
	soil moisture (%)	4.29	21.78
	carbon (%)	0.637	0.580
	nitrogen (%)	0.114	0.066
	rhizosphere population/g soil	133055550	13424658
	rhizoplane population/g root	300	524

The fungal population in soils under *P. juliflora* and *D. sissoo* did not differ significantly, though, its marked decline in both soil types was noted during the rainy season (Table 2 and 3). The rhizosphere fungal population of *P. juliflora* exhibited a significant increase, whereas that of *D. sissoo* showed a significant decline. During both the seasons, statistically, highly significant differences were observed betweeen the rhizosphere populations of *P. juliflora* and *D. sissoo*. The fungal population in the rhizoplane

Table 3
Statistical analysis of fungal populations and values of "t"

Factor	*P. juliflora*	*D. sissoo*	Winter	Rainy season
Soil	9.325^{x}	4.498^{x}	0.344	1.164
Rhizosphere	13.152^{xx}	25.570^{xx}	28.350^{xx}	12.364^{xx}
Rhizoplane	1.811	1.873	4.423^{xx}	2.036

^{x} Significant at 5% level
^{xx} Significant at 1% level

of both plants did not exhibit any significant seasonal variation. During winter *D. sissoo* showed a significantly higher rhizoplane population as compared with *P. juliflora*, though, during the rainy season, no appreciable variations were observed between them.

The extent of similarity among soil, rhizosphere and rhizoplane fungal floras varied with plant and season (Table 4). A higher extent of similarity was observed between the soil mycoflora of *P. juliflora* and *D. sissoo* during both the seasons. The root surface mycoflora (rhizosphere+rhizoplane) showed a greater diversity than the soil mycoflora. The rhizosphere and rhizoplane fungal flora of both *P. juliflora* and *D. sissoo* exhibited a higher extent of similarity during the rainy than the winter season.

Table 4
Similarity quotients (S.Q.) between fungal flora

Combinations compared	S.Q. (%)
Soil fungi:	
Winter — *P. juliflora* × *D. sissoo*	68.35
Rainy — *P. juliflora* × *D. sissoo*	62.50
P. juliflora — winter × rainy season	60.87
D. sissoo — winter × rainy season	57.78
Soil and root surface fungi:	
Winter — soil × *P. juliflora*	34.48
Winter — soil × *D. sissoo*	30.00
Rainy — soil × *P. juliflora*	28.00
Raily — soil × *D. sissoo*	26.23
Rhizosphere and rhizoplane fungi:	
P. juliflora — rhizosphere × rhizoplane	20.69
P. juliflora — rainy — rhizosphere × rhizoplane	57.14
D. sissoo — winter — rhizosphere × rhizoplane	35.29
D. sissoo — rainy — rhizosphere × rhizoplane	45.45

Different fungal species dominated the soil, rhizosphere and rhizoplane of both plants during both seasons (Table 5). On the *P. juliflora* field during winter, *Aspergillus flavus* I and *A. fumigatus* III dominated in soil; *Penicillium canescens, P. chrysogenum* and *Aspergillus terreus* dominated the rhizosphere, whereas *Fusarium solani* I and *Aspergillus niger* I dominated the rhizoplane, whereas during the rainy season, *A. fumigatus* III, *A. niger* II and *Humicola fuscoatra* I were dominant in the soil; *P. chrysogenum* and *Cladosporium oxysporum* dominated in the rhizosphere, whilst *P. chrysogenum, Fusarium oxysporum, Alternaria alternata* and *Macrophomina phaseolina* dominated in the rhizoplane. On the other hand, on the *D. sissoo* field, during winter the dominant fungal species were *A. fumigatus* I, *A. niger* I and *F. solani* I in the soil; *Penicilium oxalicum, A. terreus* and *A. niveus* I in the rhizophere; and *P. oxalicum* and *Fusarium moniliforme* in the rhizo-

Table 5

Percent al frequency and abundance /in parentheses below/ of some dominant fungi in soil, rhizosphere and rhizoplane of two plants during winter and rainy season

Fungal species	Prosopis juliflora field						Dalbergia sissoo field					
	winter			rainy season			winter			rainy season		
	soil	rhizo-sphere	rhizo-plane	soil	rhizo-sphere	rhizo-plane	soil	rhizo-sphere	rhizo-plane	soil	rhizo-sphere	rhizo-plane
Alternaria alternata	3.67 /0.23/	25.00 /0.16/	- -	8.33 / 1.13/	100.00 /7.07/	100.00 /17.28/	7.33 /0.26/	- -	- -	- -	50.00 /0.51/	100.00 /18.45/
Alternaria sp.	- -	- -	- -	- -	- -	- -	- -	- -	100.00 /18.10/	- -	100.00 /4.85/	83.00 /18.45/
Aspergillus flavus /strain I/	100.00 /14.75/	75.00 /0.49/	17.00 /2.17/	3.00 /0.57/	50.00 /0.52/	- -	29.33 /1.28/	25.00 /0.21/	- -	50.00 /15.93/	100.00 /2.81/	- -
A. fumigatus /strain II/	44.33 /2.03/	- -	- -	- -	- -	- -	51.67 /13.21/	- -	- -	8.33 /1.02/	- -	- -
A. fumigatus /strain III/	77.67 /12.78/	- -	- -	53.00 /26.02/	- -	- -	7.33 /0.20/	- -	- -	2.67 /0.16/	- -	- -
A. nidulans /strain I/	7.33 /1.00/	50.00 /0.82/	- -	13.67 /1.81/	- -	- -	81.67 /9.54	100.00 /1.83/	- -	14.00 /0.98/	- -	- -
A. niger /strain I/	55.67 /2.50/	100.00 /1.97/	83.00 /13.04/	25.33 /2.04/	- -	- -	70.33 /10.36/	- -	82.00 /12.93/	41.67 /7.26/	25.00 /0.26/	- -
A. niger /strain II/	48.00 /2.63/	- -	- -	27.00 /10.47/	- -	- -	48.33 /4.53/	- -	- -	8.33 /2.47/	- -	- -
A. niveus /strain I/	- -	100.00 /9.35/	- -	- -	17.00 /2.17/	- -	22.00 /0.68/	100.00 /10.44/	100.00 /18.97/	- -	- -	- -
A. terreus	33.33 /4.43/	100.00 /24.14/	- -	25.00 /4.01/	- -	- -	37.00 /2.12/	100.00 /36.53/	- -	27.67 /6.19/	- -	33.00 /1.94/
A. ustus	14.67 /2.17/	75.00 /0.66/	17.00 /4.35/	2.67 /0.13/	- -	- -	33.33 /10.20/	- -	- -	5.33 /0.41/	- -	- -
Cladosporium oxysporum	- -	75.00 /1.15/	- -	- -	100.00 /9.42/	- -	- -	25.00 /0.21/	- -	19.67 /2.37/	75.00 /2.04/	17.00 /0.97/

Fungal species	Prosopis juliflora field						Dalbergia sissoo field					
	winter			rainy season			winter			rainy season		
	soil	rhizo-sphere	rhizo-plane	soil	rhizo-sphere	rhizo-plane	soil	rhizo-sphere	rhizo-plane	soil	rhizo-sphere	rhizo-plane
Curvularia lunata	18.33 /0.78/	- -	- -	35.67 /5.60/	- -	- -	7.33 /0.26/	- -	50.00 /2.59/	2.67 /0.16/	- -	17.00 /0.97/
Fusarium equiseti	- -	75.00 /0.49/	67.00 /8.70/	- -	- -	- -	- -	- -	- -	- -	- -	- -
F. moniliforme	- -	75.00 /0.82/	- -	- -	- -	- -	- -	25.00 /0.21/	- -	- -	100.00 /16.32/	100.00 /18.45/
F. oxysporum	14.67 /0.74/	- -	- -	28.67 /4.61/	25.00 /0.52/	100.00 /22.22/	14.67 /0.51/	25.00 /0.21/	- -	19.67 /3.18/	- -	- -
F. solani /strain I/	22.22 /2.68/	100.00 /3.78/	100.00 /54.35/	8.33 /0.63/	- -	- -	66.67 /11.25/	75.00 /1.46/	100.00 /27.59/	16.33 /4.93/	- -	- -
Humicola fusco-atra /strain I/	33.33 /2.09/	25.00 /0.16/	- -	33.67 /10.67/	- -	- -	29.33 /1.73/	- -	- -	5.67 /0.49/	- -	- -
Macrophomina phaseolina	- -	- -	- -	- -	- -	83.00 /14.81/	- -	- -	50.00 /2.59/	- -	- -	17.00 /0.97/
Penicillium canescens	- -	100.00 /29.89/	33.00 /6.52/	- -	- -	- -	- -	- -	- -	- -	- -	- -
P. chrysogenum	- -	100.00 /17.57/	- -	9.00 /4.60/	100.00 /81.94/	100.00 /35.80/	- -	- -	- -	- -	- -	- -
P. oxalicum	22.22 /0.78/	- -	- -	- -	- -	- -	22.00 /1.17/	100.00 /46.56/	100.00 /16.33/	22.33 /9.45/	100.00 /71.43/	100.00 /18.45/
Trichoderma sureoviride	70.67 /8.41/	25.00 /0.16/	- -	5.67 /1.36/	- -	- -	44.33 /2.86/	- -	- -	25.33 /4.67/	- -	- -

plane, whereas during the rainy season in the soil dominated *A. flavus* I and *A. niger* I; in the rhizosphere—*F. solani* I, *A. niveus* I, *Alternaria sp.* and *P. oxalicum;* whereas *Alternaria sp., A. alternata, P. oxalicum* and *F. moniliforme* were the dominant fungal species of the rhizoplane.

DISCUSSION

The two soil types under *P. juliflora* and *D. sissoo* did not differ significantly as regards their soil fungal population during both the seasons (Tables 2 and 3) in spite of differences in their soil texture, the soil under *P. juliflora* being sandly loam and that under *D. sissoo* being clayey loam. Besides these insignificant defferences in their fungal population, the fungal communities also exhibited a very high degree of similarity during both the seasons (Table 4). This can be explained on the basis of similar climatic conditions in these two adjoining soil types selected for study and the cosmopolitan nature of fungi. Seasonally, however, both the soil types exhibited a significant decline in their fungal population (Tables 2 and 3) during the rainy season. A. perusal of Table 2 reveals that there were marked variations in moisture, carbon and nitrogen contents in the soil during the rainy season. Excessive moisture during the rainy season (Stover 1955) and a marked decline in the carbon and nitrogen contents of the soil (Saksena 1955. Kiem et al. 1975. Zoberi 1979, Joshi and Chauhan 1981) may be responsible for the significant decline in the soil fungal population during the rainy season.

In the soil, colonization of the root surface by fungi has been shown to be brought about by successive lateral colonization from the soil (Taylor and Parkinson 1961, Natrajan 1976). Thus appreciable variation between the fungal population of the soil and the root surface (rhizosphere+rhizoplane) mycoflora (Table 2) coupled with the wider diversity (Table 4) between their fungal communities (S.Q. varying from 26.23% to 34.28%) indicate the diversity between the soil and root surface (rhizosphere+rhizoplane) microenvironments.

As seen from Tables 2 and 3 maximum fungal population was observed in the rhizosphere, next come the soil and last the rhizoplane, whereas the maximum number of fungal species were isolated from soil, followed by those of the rhizosphere and lastly of the rhizoplane (Table 1). These findings are in accordance with earlier reports (Chesters and Parkinson 1959, Srivastava 1973, Gangawane and Deshpande 1977). Greater variations in the soil, rhizosphere and rhizoplane microfungi are abvious because of the differences in the nutritional level of their microenvironments. A higher nutritional level due to root exudation and addition of cast off root cell debris in the rhizosphere may be responsible for the larger population in the rhizosphere, whereas specificity in the available nutrients

may be responsible for restricting the fungal variety. On the other hand, a maximum number of species in the soil may be due to the wide heterogeneity, of both nutrition and habitat, in the soil where different fungi utilizing various nutrients are encouraged. The conditions in the rhizoplane appear to be more specialized owing to root leakage and the chemical composition of the root surface itself, thus favouring only proliferation of specific forms and therefore showing the smallest population and minimum number of fungal species in the rhizoplane.

Significant differences were observed between the rhizosphere and rhizoplane microfungi. On both the plants, during both the seasons the fungal population in the rhizosphere was appreciably higher than in the rhizoplane (Tables 2 and 3), and consequently the fungal flora also exhibited a wider diversity (Table 4). The quantitative parametres of the rhizosphere and rhizoplane microfungi, however, behaved seasonally in different way the rhizosphere population of *P. juliflora* showing a significant increase during the rainy season, whereas that of *D. sissoo* exhibited a significant decline (Tables 2 and 3). On the other hand, the rhizoplane population of both the plants did not exhibit any statistically significant variation during various seasons, though there was a slight increase in the fungal population during the rainy season. The role played by environmental conditions in affecting the root surface microflora trought changes in growth, metabolism and plant exudated has been well reviewed by Rovira (1965). Some workers (Timonin 1940, Ivarson and Kartznelson 1960, Srivastava and Mishra 1971, Mishra and Srivastava 1974) have reported a maximum rhizosphere population during the flowering period when the plants exhibit maximum vegatative growth. The present investigation also reveals the same, and thus the response of rhizosphere fungi to various seasons can be explained on the basis of the flowering periods. In *P. juliflora* flowering occurs during September (rainy season) and thus correspondingly the maximum population in the rhizosphere was also observed during this season. On the other hand, in *D. sissoo*, since the foliage begins to appear during February and the flowers open during March and April (winter season), the rhizosphere fungal popualation was also maximum during the winter season. For both plants, however, an interesting trend was noted in the seasonal variation as the fungal flora of the rhizosphere and rhizoplane exhibited a greater similarity (Table 4) during the rainy season (*P. juliflora* = 57.14%, *D. sissoo* = 45.35%) as compared with winter (*P. juliflora* = 20.69%, *D. sissoo* = 35.29%).

In the present investigation (Table 1) on continual presence of any fingal species was noted in the soil, rhizosphere and rhizoplane of *P. juliflora* and *D. sissoo* during winter and rainy seasons. This again suggests the specificity of these microenvironments in respect to the nature of the plant and season. It was, however, observed that of the 49 species isolated from the *P. juliflora* field during winter, only *Aspergillus flavus* I and *A. ustus* were common to soil, rhizosphere and rhizoplane whereas during the rainy

season, of the 39 isolated species, *Alternaria alternata, Fusarium oxysporum, Myrothecium verrucaria* and *Penicillium chrysogenum* were the common species. On the other hand, in the *D. sissoo* field, of the 51 species isolated during winter, *Aspergillus niveus, Fusarium solani* and *Penicillium oxalicum* were common to soil, rhizosphere and rhizoplane, whilst during the rainy season, of the 53 isolated species, *P. oxalicum* and *Cladosporium oxysporum* were common to them.

Different plants growing under the same environmental conditions have been reported to have a different root surface mycoflora, their nature being primerily controlled by root exudates and cast off root cell debris (Rovira 1965), thus providing a specific dominant fungal flora for each (Panwar and Panwar 1972). In the present investigation also (Table 5) different fungal species dominated the soil, rhizosphere and rhizoplane microenvironments of both the plants during both the seasons. *Chaetomium jadhpurense, Khuskia oryzae, Acrophialophora fusispora, Aspergillus fumigatus* II, *A. fumigatus* III, *A. niger* II, *A. stellatus, Coleophoma empetri* and *Monodictys fluctuata* seem to be the typical soil inhabitants as they were isolated from both soil types during both seasons (Table 1). *A. fumigatus* III was the most characteristic fungal species in the soil of the *P. juliflora* field where it exhibited very high frequency and abundance in the *D. sissoo* soil, it showed very poor growth. In spite of very high frequency and abundance shown by *A. fumigatus* III in the soil of the *P. juliflora* field, it was completely absent from the rhizosphere and rhizoplane of *P. juliflora* as well as *D. sissoo*. Some workers (Bartoli et al. 1978, Mishra 1979) mention *Aspergillus* as a typical rhizosphere inhabitant. In the present investigation, however, it was only during winter, that the rhizosphere of *P. juliflora* and *D. sissoo* was dominated by *Aspergilli* along with *Penicillia*. Among the *Penicillia* dominating the rhizosphere and rhizoplane, a specificity was also noted in respect to the nature of the plant and season. *P. chrysogenum* dominated the rhizosphere and rhizoplane of *P. juliflora* during both seasons except in the rhizoplane during winter, whereas it was completely absent from the *D. sissoo* rhizosphere and rhizoplane. On the other hand, *P. oxalicum* dominated the rhizosphere and rhizoplane of *D. sissoo* during both seasons, whereas it was absent on *P. juliflora*. Taylor and Parkinson (1961), Wastie (1961) and Srivastava (1973) have reported an abundance of *Fusarium spp.* in the rhizoplane. Because of its higher degree of saprophytic ability, in the present study the rhizoplane was also always found to be badly infested with *Fusarium spp.* as *F. solani* I dominated the rhizoplane of *P. juliflora* and *D. sissoo* during winter, while during the rainy season, the rhizoplane of *P. juliflora* was dominated by *F. oxysporum* and that of *D. sissoo* by *F. moniliforme*.

Acknowledgements

The autor is grateful to Dr R. K. S. Chauhan, School of Studies in Botany, Jiwaji

University, Gwalior for guidance, to Prof. S. B. Saksena, F.N.A., Visiting Professor for suggestions and to Prof. R. R. Das, Head, School of Studies in Botany, Jiwaji University, Gwalior for providing laboratory facilities. Thanks are due to Dr A. Jahnston, Director, CMI, Kew, England for help in the identification of fungal species. Financial assistance provided by the University Grants Commission in the form of a fellowship is also gratefully acknowledged.

REFERENCES

Bartoli A., Maggi O., Albonetti S. G., Puppi G., Rambelli A., 1978. Research on the rhizosphere of *Loudetia simplex* C. E. Hubbard, typical grass of Ivory Coast: Final report. G. Bot. Ital. 112: 75-96.

Chesters C. G. E., Parkinson D., 1959. On the distribution of fungi in the rhizosphere of Oats. Plant and Soil 11: 145-156.

Gangawane L. V., Desphpande K. B., 1977. Seasonal variation in rhizosphere mycoflora of groundnut. J. Indian Bot. Soc. 56: 289-295.

Harley J. L., Waide J. S., 1955. A method of studying active mycelia on living root and on other surfaces in the soil. Trans. Br. Mycol. Soc. 38: 104-118.

Ivarson K. C., Katznelson H., 1960. Studies on the thizosphere mycoflora of yellow birch seedlings. Plant and Soil 12: 30-40.

Jackson M. L., 1958. Soil chemical analysis. Printice Hall. Englewood Cliffs. New Jersey.

Joshi I. J., Chauhan R. K. S., 1981. Soil fungal ecology of cultivated areas of Chambal ravines. Proc. Indian Natn. Sci. Acad. 47: 248-254.

Karimbaeva L. Y., Sizova T. P., 1976. Fungal flora of the rhizosphere of some woody species. Vestn. Mosk. Univ. Ser. VI Biol. Pochvoved. 31: 24-29.

Kiem R., Webster R. K., Wick C. M., 1975. Quantitative effects of incorporating rice residue on populations of soil microflora. Mycologia 67: 280-291.

Martin J. P., 1950. Use of acid, rose bengal and streptomycin in the plate method for estimating soil fungi. Soil Sci. 69: 215-232.

Mishra R. R., 1979. Root decomposition. Proc. Indian Natn. Sci. Acad. 45: 648-659.

Mishra R. R., Kanaujia R. S., 1973. Investigations into rhizosphere mycoflora XII. Seasonal variation in the mycoflora of certain gymnosperms. Sydowia 27: 302-311.

Mishra R. R., Srivastava V. B., 1974. Effect of yellow mosaic virus on rhizosphere and rhizoplane mycoflora of *Acalypha indica*. Entomologie et Phytopathologie Appiliquies 37: 6-10.

Natrajan K., 1976. A simple device to study the role of seed mycoflora in root region of crop plants. Plant and Soil 45: 287-289.

Panwar K. S., Panwar S., 1972. Rhizosphere mycoflora in the sand dunes of Western Rajasthan, India. Proc. Nat. Acad. Sci. 42: 30-35.

Papavizas G. C., Davey C. B., 1959. Evaluation of various media and antimicrobial agents for isolation of soil fungi. Soil. Sci. 88: 112-117.

Peno M., Veselinovic N., 1973. Dinamika populacjia glijivicnih organizama a rizosferi *Pinus nigra* Arn., S. Posebnium Osvrtom no patogene *Fusarium* Vrste. Mikrobiologija (Belgr.) 10: 289-292.

Piper C. S., 1944. Soil and plant analysis. University of Adelaide S. Australia.

Rovira A. D., 1963. Interactions between plant roots and soil microorganisms. Ann. Rev. Microbiol. 19: 241-266.

Saksena S. B., 1955. Ecological factors governing distribution of soil microfungi in some forest soils of Sagar. J. Indian Bot. Soc. 34: 262-298.

Sorensen T., 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content. Dansk. Vidensk. Biol. Skr. 5: 1-34.

Srivastava V. B., 1973. Investigations into rhizosphere microflora IV. Fungal association in different root regions of some rainy season crops. Acta Soc. Bot. Pol. 42: 409-422.
Srivastava V. B., Mishra R. R., 1971. Investigations into rhizosphere microflora I. Succession of microflora on root regions of *Oryza sativa* L. Microbiol. Espan. 24: 193-205.
Stover R. M., 1955. Flood following for eradication of *Fusarium oxysporum f. cubense* III. Effect of oxygen on fungus survival. Soil Sci. 80: 397-412.
Stover R. H., Waite B. H., 1953. An improved method for isolating *Fusarium spp.* from plant tissue. Phytopathology 43: 700-701.
Taylor G. S., Parkinson D., 1961. The growth of saprophytic fungi on root surface. Plant and Soil 15: 261-267.
Timonin M. I., 1940. The interactions of higher plants and soil microorganisms I. Microbial population of rhizosphere of seedlings of certain cultivated plants. Can. J. Res. 18: 307-317.
Warcup J. H., 1950. The soil plate method for isolation of fungi from soil. Nature (London) 166: 117.
Wastie R. L., 1961. Factors affecting competative saprophytic colonization of the agar plate by various root infecting fungi. Trans. Br. Mycol. Soc. 44: 145-159.
Zoberi M. H., 1979. Ecology of some fungi in a termite hill. Mycologia 71: 537-545.

Badania flory grzybowej z ryzosfery niektórych gatunków drzew

Streszczenie

Do badań flory grzybowej związanej z glebą, glebą strefy korzeniowej (ryzosfery) i z powierzchnią korzeni (ryzoplany) wybrano dwa typy gleby: jeden spod roślin *Prosopis juliflora* i drugi — spod *Dalbergia sissoo*. Badania przeprowadzono w zimie i w porze deszczowej. Pomimo różnic w składzie mechnicznym dwóch badanych typów gleby, nie zaobserwowano istotnych różnic w składzie populacji grzybów glebowych. Różnice sezonowe w populacji grzybów glebowych były skorelowane z wahaniami wilgotności gleby oraz z zawartością w niej węgla i azotu. Flora grzybowa ryzoplany była bardziej urozmaicona niż gleby. Zanotowano wyraźne różnice między populacją grzybów glebowych, z ryzosfery i ryzoplany i ich rodzajem. U. *P. juliflora* maksimum populacji grzybów w ryzosferze zaobserwowano w porze deszczowej, podczas gdy u *D. sissoo* — w zimie. Wahania sezonowe w populacji grzybów w ryzosferze związane były z porą kwitnienia drzew. U *P. juliflora* kwitnienie rozpoczyna się porze deszczowej, również w porze deszczowej zaobserwowano maksimum populacji się w porze deszczowej, również w porze deszczowej obserwowano maksimum populacji grzybów. U *D. sissoo* okres kwitnienia przypada na zimę i tu maksimum populacji grzybów w ryzosferze wystąpiło również w zimie. Skład flory grzybowej w ryzosferze i ryzoplanie 87 gatunków grzybów nie wykazał ciągłej obecności w glebie, ryzosferze i ryzoplanie u obu gatunków drzew w obu porach roku. Inne gatunki grzybów dominowały w glebie, inne w ryzosferze a jeszcze inne w ryzoplanie poszczególnych gatunków drzew, w obu porach roku.