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Effects of edaphic conditions and flowering period on the rhizosphere mycoflora of *Adhatoda vasica* Nees

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Abstract

Non-rhizosphere, rhizosphere and rhizoplane mycoflora of *Adhatoda vasica* Nees growing in two different soil types was studied during winter and rainy seasons. The effect of edaphic conditions and flowering period on the non-rhizosphere, rhizosphere and rhizoplane mycoflora was studied. Qualitative as well as quantitative variations in the non-rhizosphere, rhizosphere and rhizoplane mycoflora were studied in relation to soil types and seasons. The dominance of different fungal species and specific fungal groups in the non-rhizosphere, rhizosphere and rhizoplane of *A. vasica* was described in relation to soil types and seasons.

Key words: Adhatoda vasica, mycoflora, rhizosphere, edaphic conditions, flowering period

INTRODUCTION

The rhizosphere mycoflora is known to affect the growth of soil borne plant pathogens, root respiration (Katznelson and Rouatt 1957), mineral nutrient uptake (Subba Rao et al. 1961), as well as plant growth (Pidoplichko et al. 1965). Most of the workers have noted maximum rhizosphere community during the flowering period when the plant shows luxurient growth (Srivastava 1973, Gangawane and Deshpande 1977, Shukla and Dwivedi 1981) and this has been attributed to the maximum root exudation during the flowering period.

Although considerable research has been done on the rhizosphere mycoflora of various plants with regard to their flowering periods, fewer studies have been performed on the rhizosphere mycoflora of trees and shrubs (Mishra and Kanaujia 1973, Peno and Veselinovic 1973, Karimbaeva and Sizova 1976) due to difficulties in handling their root systems. Consequently, very little is known about the rhizosphere mycoflora of woody plants with regard to their flowering periods. In an investigation on the rhizosphere mycoflora of certain trees (Joshi 1982), maximum rhizosphere mycocommunity was noted during their corresponding flowering periods. In view of these results, in the present study an attempt is made to investigate the rhizosphere mycoflora of *Adhatoda vasica* Nees which is an important medicinal shrub and is one of the dominant plants occurring in Chambal ravines of Bhind, India. The non-rhizosphere, rhizosphere nad rhizoplane mycoflora of *A. vasica* growing in two different soil types is studied during winter and rainy seasons to elaborate the effect of edaphic conditions and flowering period on the non-rhizosphere, rhizosphere and rhizoplane mycoflora of *A. vasica.*

MATERIALS AND METHODS

This investigation was carried out on *Adhatoda vasica* Nees growing in two different soil types of Chambal ravines of Bhind (M. P.), India. Soil type I was characterized by sandy loam soils and the other dominant plants growing in this soil type include *Dichrostachys cinerea* L., *Salvadora oleoides* DC., and *Grewia flavescens* Juss. Soil type II was clayey lam in texture and the other dominant plants of this soil type include *Prosopis juliflora* (SW) DC and *Dalbergia sissoo* Roxb both of which are being used for afforestation to reclaim these ravines. The non-rhizosphere, rhizosphere and rhizoplane mycoflora of *A. vasica* growing in the two soil types was studied during winter and rainy seasons.

The non-rhizosphere soil samples were collected upto a depth of 10 cm from the place 15 cm away from the roots and the mycoflora was isolated on Martin's rose bengal streptomycin medium (Martin 1950) using soil plate method (Warcup 1950). After the roots were carefully removed from the soil, the rhizosphere mycoflora was isolated on modified Martin's medium (Papavizas and Davey 1959) using dilution plate method (Timonin 1940). For rhizoplane mycoflora, serial root washing technique (Harley and Waid 1955) was used and the fungi was isolated on Czapek's Dox + Yeast extract medium (Stover and Waite 1953).

Fungal community was expressed as fungi per g dry soil in case of non-rhizosphere soil and rhizosphere soil; and fungi per g fresh root in case of rhizoplane. Besides this, frequency and abundance of individual fungal species was calculated by the method suggested by Saksena (1955) and the species with higher frequency and abundance were considered as dominants. Similarity Quotients (Sorensen 1948) were evaluated to compare the non-rhizosphere, rhizosphere and rhizoplane mycoflora.

The non-rhizosphere soil was analysed for certain edaphic factors. Mechanical composition of the soil was evaluated by Bouycous Hydrometer method (Piper 1944). Soil moisture was estimated by oven drying soil samples at 105 ± 1°C for 24 hrs. Water holding capacity and organic carbon were determined by methods suggested by Piper (1944). Total nitrogen was estimated by semimicro Khjeldahl method; exchangeable calcium nad potassium by flame photometer method; and available phosphorus by Olsen's colorimetric method (Jackson 1958).

The data were statistically analysed for Standard Deviations and Analysis of Variance.

RESULTS AND DISCUSSION

The results of present investigation are given in Tables 1-7. Table 1 reveals the mechanical composition and soil texture of the two soil types, whereas Table 2 deals with the edaphic factors of their non--rhizosphere soil. Table 3 shows the fungal community in the non-rhizosphere, rhizosphere and rhizoplane of *A. vasica,* whereas Table 4 deals with the distribution of fungal species. Table 5 deals with the similarly quotients, Table 6 deals with the frequency and abundance of some dominant fungi, whereas Table 7 shows percentage occurrence of specific fungal groups in the non-rhizosphere, rhizosphere and rhizoplane of *A. vasica.*

Table 1

Mechanical composition and soil texture of the two soil types (±SD)

Mechanical composition, %	Soil type I	Soil type II
Sand	61.78±2.01	48.34±5.72
Silt	17.02±1.80	22.82±2.26
Clay	15.62±2.04	18.73±3.66
$CaCO_3$	8.73±0.75	10.11±0.38
Soil texture	sandy loam	clayey loam

The two soil types selected for study did not differ significantly with regard to their non-rhizosphere soil fungal community during the rainy season (Table 3) due to statistically insignificant variations in the soil moisture, water holding capacity, carbon, nitrogen, calcium, potassium and phosphorus contents of two soil types (Table 2). However, during the winter season, although soil moisture, water holding capacity, nitrogen, calcium, potassium and phosphorus contents of the two soil types

Table 2

Edaphic factors of non-rhizosphere soil of both soil types in relation to seasons

Factors	Winter season		Rainy season		L.S.D.
	soil type I	soil type II	soil type I	soil type II	
Moisture, %	4.41	3.07	10.47	11.90	4.10*
Water holding capacity, %	37.67	39.65	49.04	47.71	4.00*
Organic carbon, %	0.271	0.506	0.386	0.464	0.089**
Total nitrogen, %	0.042	0.070	0.056	0.060	0.043
Exchangeable calcium, $mg \cdot 100\ g^{-1}$	134.03	135.42	122.89	146.53	42.09
Exchangeable potassium, $mg \cdot 100\ g^{-1}$	39.17	46.67	35.67	42.50	16.69
Available phosphorus, ppm	10.33	12.67	12.33	15.00	7.19

* Variations during seasons significant at 5% level.
** Variations between soil types significant at 5% level.

Table 3

Fungal community in the non-rhizosphere, rhizosphere and rhizoplane of *Adhatoda vasica* in relation to soil types and seasons

Season	Soil type	Non-rhizosphere soil fungal community $\cdot g^{-1}$ soil	Rhizosphere soil fungal community $\cdot g^{-1}$ soil	Rhizoplane fungal community $\cdot g^{-1}$ root
Winter	soil type I	45.87×10^3	0.15×10^5	18.53×10^2
	soil type II	66.59×10^3	4.47×10^5	1.12×10^2
Rainy	soil type I	22.22×10^3	4.55×10^5	12.67×10^2
	soil type II	40.98×10^3	94.05×10^5	1.72×10^2
L.S.D.		20.05*	15.06*	2.49*

* Variations significant at 5% level.

did not differ significantly, the carbon contents of the clayey loam soils of soil type II were significantly higher than that of sandy loam soils of soil type I and hence the non-rhizosphere soil fungal community of the soil type II was also significantly higher than that of soil type I. Earlier studies have also revealed a positive correlation between the fungal community and carbon contents of the soil (Kiem et al. 1975, Kanazawa 1979, Joshi and Chauhan 1982a). Seasonally, the non-rhizosphere soil fungal community of both soil types decreased significantly during the rainy season due to significantly higher moisture contents and water holding capacity. In earlier investigations also the soil fungal community has been negatively correlated with the excessively higher moisture contents and water holding capacity (Joshi and

Table 4

Distribution of fungi in the non-rhizosphere soil (NRs), rhizosphere soil (Rs) and rhizoplane (Rp) of Adhatoda vasica in relation to soil types and seasons

Fungal species	Winter season						Rainy season					
	Soil type I			Soil type II			Soil type I			Soil type II		
	NRs	Rs	Rp	NRs	Rs	Rp	NRs	Rs	Rp	NRs	Rs	Rp
	1	2	3	4	5	6	7	8	9	10	11	12
ZYGOMYCOTINA												
Cunninghamella echinulata (Thaxt.) Thaxt. ex Blakeslee	+	–	–	+	–	–	–	–	–	–	–	–
Mucor hiemalis Wehmer	+	+	+	–	–	–	–	+	+	–	–	–
M. racemosus Fresenius	–	–	–	+	–	–	–	–	–	–	–	–
Rhizopus oryzae Went & Prinsen Geerligs	+	+	–	+	–	+	+	–	–	+	–	+
ASCOMYCOTINA												
Candida sp.	+	–	–	+	+	–	–	–	–	+	–	–
Chaetomium globosum Kunze ex Fr.	+	–	–	–	–	–	–	–	–	–	–	–
C. jodhpurense Lodha	+	–	–	+	–	–	+	–	–	+	–	–
Chaetomium sp.	+	–	–	+	–	–	–	–	–	+	–	–
Cymnoascus zuffianus Morini	+	–	–	+	–	–	+	–	–	–	–	–
Khuskia oryzae Hudson	+	–	–	+	–	–	+	–	–	+	–	–
Narasimhella hyalinospora (Kuehn, Orr & Ghosh) Von Arx	–	–	–	+	–	–	–	–	–	–	–	–
Neocosmospora vasinfecta E.F. Smith	–	–	–	+	–	–	+	–	–	+	–	–
Petriella sordida (Zukal) Barron & Gilman	+	–	–	–	–	–	–	–	–	–	–	–
Thielavia spedonium Emmons	–	–	–	–	–	–	–	–	–	+	–	–
T. terricola (Gilman & Abbot) Emmons	+	–	–	+	–	–	–	–	–	+	–	–
DEUTEROMYCOTINA												
Acremonium kiliense Grutz	+	+	–	+	–	–	+	–	–	+	–	–
A. restrictum (Van Beyma) W. Gams	–	–	–	–	–	–	+	–	–	–	–	–
Acrophialophora fusispora (Saksena) Samson	+	–	–	+	–	–	+	–	–	+	–	–
Alternaria alternata (Fr.) Keissler	+	+	+	+	–	–	+	+	+	+	–	–
A. humicola Oudemans	–	–	–	–	–	–	+	–	–	–	–	–
Alternaria sp. I	+	–	–	–	–	–	–	–	–	–	–	–
Alternairasp. II	–	–	–	–	–	–	+	–	–	–	–	–
Aspergillus aculeatus Lizuka	–	–	–	+	–	–	+	–	–	–	–	–
A. flavipes (Bain & Sart.) Thom & Church	+	–	–	+	–	–	–	–	–	+	–	–
A. flavus Link ex Fr. (Strain I)	+	+	+	+	+	+	+	–	+	+	+	–
A. flavus Link ex Fr. (Strain II)	–	–	–	–	–	–	+	–	–	+	–	–
A. flavus Link ex Fr. (Strain III)	+	+	+	+	–	–	–	–	–	+	–	–
A. fumigatus Fres. (Strain I)	+	–	–	+	–	–	+	+	–	+	+	–
A. fumigatus Fres. (Strain II)	+	–	–	+	–	–	+	–	–	+	+	+
A. fumigatus Fres. (Strain III)	+	–	–	+	–	–	+	–	–	+	–	–
A. giganteus Wehmer	–	–	–	–	–	–	+	–	–	+	–	–
A. nidulans (Eidam.) Wint (Strain I)	+	+	–	+	–	–	+	–	–	+	–	–
A. nidulans (Eidam.) Wint (Strain II)	–	–	–	+	–	–	–	–	–	–	–	–
A. niger Van Tiegham (Strain I)	+	+	+	+	+	+	+	–	–	+	+	+
A. niger Van Tiegham (Strain II)	+	+	–	+	–	–	+	–	–	+	+	–
A. niveus Blockwitz (Strain I)	+	+	+	+	+	+	–	+	–	+	+	+
A. niveus Blockwitz (Strain II)	–	+	–	–	–	–	–	–	–	–	–	–
A. ochraceous Wilhelm	+	+	–	+	–	–	–	–	–	–	–	–
A. quercinus (Bainier) Thom & Church	+	–	–	–	+	+	–	–	–	–	–	–
A. stellatus Curzi	+	–	–	+	–	–	+	–	–	+	–	–
A. terreus Thom	+	–	–	+	–	–	+	–	–	+	+	–
A. ustus (Bainier) Thom & Church	–	–	–	+	–	–	–	–	–	+	–	–
A. versicolor (Vuillemin) Tiraboschi	–	–	–	–	–	–	–	–	–	+	–	–
Aspergillus sp.	–	–	–	–	–	–	+	–	–	–	–	–
Cladosporium oxysporum B. & C.	+	+	+	–	–	–	+	+	–	–	+	+
Coleophoma empetri (Rostrup) Petrak	+	–	–	+	–	–	–	–	–	+	–	–
Colletotrichum capsici (Syd.) Bulter & Bisby	+	–	–	–	–	–	–	–	–	–	–	–
Coniothyrium fucklii Sacc.	–	–	–	–	–	–	+	–	–	–	–	–
Curvularia borrerie (Viegas) M.B. Ellis	–	–	–	+	–	–	–	–	–	–	–	–
C. clavata Jain	–	+	+	–	–	–	+	–	+	–	–	–
C. lunata (Wakker) Boedijn	+	–	+	+	–	–	+	–	–	+	–	–
C. lunata (Wakker) Boedijn var. aeria (Batista, Lima & Vasconcelos) M.B. Ellis	–	–	–	–	–	–	+	–	–	–	–	–
C. verruculosa Tandon & Bilgrami	+	+	–	–	–	–	–	–	–	+	–	–
Cylindrocladium floridanum Sobers & Seymour	+	–	–	–	–	–	–	–	–	+	–	–
Diplodia state of Otthia spiraeae (Fuckel)Fuckel	–	–	–	+	–	–	–	–	–	–	–	–

Drechslera state of Cochliobolus carbonus Nelson	–	–	–	–	–	–	+	–	–	–	–	–
Drechslera state of Cochliobolus spicifer Nelson	–	–	–	–	–	–	+	–	–	–	–	–
Drechslera state of Trichometasphaeria pedicellata Nelson	–	–	–	–	–	–	+	–	–	–	–	–
Fusarium acuminatum Ell. & Ev.	–	–	–	–	–	–	–	–	–	+	–	–
F. dimerum Penz.	–	–	–	–	–	–	+	–	–	–	–	–
F. equiseti (Corda) Sacc.	–	–	–	–	+	+	–	–	–	–	–	–
F. moniliforme Scheld	–	–	–	+	–	–	–	+	–	+	–	–
F. moniliforme var. subglutinans Wollenw. & Reink.	–	–	–	–	–	–	+	–	–	–	–	–
F. oxysporum Schlecht	+	+	+	+	–	+	+	–	–	+	–	–
F. solani (Mart.) Sacc. (Strain I)	+	+	+	+	–	+	+	–	+	+	+	+
F. solani (Mart.) Sacc. (Strain II)	–	–	–	–	–	–	+	–	–	–	–	–
F. tabacinum (Beyma) W. Gams	–	–	–	–	–	–	–	+	+	–	+	+
Helminthosporium sativum Pammel, King & Bakke	+	–	+	+	–	–	+	–	+	–	–	–
Humicola fusco-atra Traeen (Strain I)	+	–	–	+	–	–	+	–	–	+	+	–
H. fusco-atra Traeen (Strain II)	–	–	–	+	–	–	–	–	–	+	–	–
Macrophomina phaseolina (Tassi) Goid.	+	–	–	+	–	–	+	–	+	+	–	–
Memnoniella subsimplex (Cda) Deighton	+	–	–	+	–	–	–	–	–	–	–	–
Microascus trigonosporus Emmons & B. Dodge	–	–	–	+	–	–	–	–	–	–	–	–
Monocillium constrictum W. Gams	+	–	–	+	–	–	+	–	–	+	–	–
Monodictys fluctuata (Tandon & Bilgrami) M.B. Ellis	+	–	–	+	–	–	+	–	–	+	–	–
Monodictys sp.	–	–	–	–	–	–	–	–	–	+	–	–
Myrothecium leucotrichum (Pk.) Tulloch	+	–	–	+	–	–	+	–	–	–	–	–
M. verrucaria (Alb. & Schw.) Ditm. ex Fr.	+	–	–	+	–	–	+	–	–	+	+	–
Paecilomyces lilacinus (Thom)Samson	–	+	+	+	–	–	+	–	–	–	–	–
Penicillium chrysogenum Thom	+	+	+	–	+	+	+	+	+	+	–	+
P. crustosum Thom	–	–	–	–	–	–	+	–	–	–	–	–
P. funiculosum Thom	+	–	–	+	+	+	+	–	–	–	+	–
P. implicatum Biourge	+	–	–	–	–	–	–	–	–	+	–	–
P. oxalicum Currie & Thom	–	–	–	+	–	–	+	–	–	+	–	–
P. spiculisporum Lehman	–	–	–	–	–	–	+	–	–	+	–	–
Periconia saraswatipurensis Bilgrami	+	–	–	+	–	–	+	–	–	+	–	–
Periconia sp.	–	–	–	+	–	–	–	–	–	–	–	–
Phialophora cyclaminis Beyma	+	–	–	+	–	–	–	–	–	+	–	–
P. fastigiata (Lagerberg, Lundberg & Melin) Conant	–	–	–	–	–	–	–	–	–	+	–	–
Phoma herbarum Westd.	+	+	–	+	–	–	–	–	–	–	–	–
P. multirostrata (Mathur, Menon & Thirum.) Dorenbosch & Boerema	+	–	–	–	–	–	+	–	–	–	–	–
P. pomorum Thum.	–	–	–	+	–	–	–	–	–	–	–	–
P. putaminum Speg.	–	–	–	–	–	–	+	–	–	–	–	–
Phoma sp.	–	–	–	+	–	–	–	–	–	–	–	–
Pleurophragmium sp.	–	–	–	–	–	–	–	+	–	–	–	–
Polyschema chambalensis Joshi, Chauhan & Saksena	–	–	–	+	–	–	–	–	–	+	–	–
Pyrenochaeta abutilonis Mathur, Verma & Chauhan	+	–	–	+	–	–	–	–	–	–	–	–
P. indica Vishwanathan	–	–	–	+	–	–	–	–	–	–	–	–
Scolecobasidum constrictum Abbott	–	–	–	+	–	–	+	–	–	–	–	–
S. terreus Abbott	+	–	–	+	–	–	+	–	–	+	–	–
Sphaeronaema allohabadense Chandra & Tandom	–	–	–	+	–	–	–	–	–	–	–	–
Sporotrichum roseum Link	–	–	–	–	–	–	+	–	–	–	–	–
Stachybotrys atra Corda	+	–	–	–	–	–	–	–	–	+	–	–
S. bisbyi (Srinivasan) Barron	–	–	–	+	–	–	+	–	–	–	–	–
Trichoderma aureoviride Rifai aggr.	+	+	–	+	–	–	–	–	–	+	+	+
T. harzianum Rifai aggr.	–	–	–	+	–	–	–	–	–	–	–	–
Ulocladium chartarum (Preuss) Simmons	–	–	–	–	–	–	–	+	+	–	+	+
Zalerion sp.	+	–	–	+	–	–	+	–	–	+	–	–
Sterile colony I	+	–	–	+	–	–	–	–	–	+	+	+
Sterile colony II	+	–	–	–	–	–	+	–	–	–	–	–
Sterile colony III	–	–	–	–	–	–	+	–	–	+	–	–
Sterile colony IV	+	–	–	–	–	–	–	–	–	–	–	–
Sterile colony V	–	–	–	+	–	–	+	–	–	–	–	–
Sterile colony VI	–	–	–	–	–	–	+	–	–	–	–	–
Unidentified colony I	–	–	–	+	–	–	+	–	–	+	–	–
Unidentified colony II	–	–	–	+	–	–	–	–	–	–	–	–
Unidentified colony III	–	–	–	–	–	–	–	–	–	+	–	–

– = Absent

+ = Present

Table 6

Percentage frequency and abundance (in parentheses below) of some dominant fungi in the non-rhizosphere (NRs), rhizosphere (Rs) and Rhizoplane (Rp) of A. vasica in relation to soil types and seasons

Fungal species	Winter season						Rainy season					
	Soil type I			Soil type II			Soil type I			Soil type II		
	NRS	Rs	Rp	NRs	Rs	Rp	NRs	Rs	Rp	NRs	Rs	Rp
	1	2	3	4	5	6	7	8	9	10	11	12.
Aspergillus flavus I	50.00 (9.15)	25.00 (0.26)	33.00 (3.96)	76.55 (10.00)	25.00 (0.31)	50.00 (24.32)	40.78 (11.45)	-	17.00 (2.08)	29.00 (9.64)	25.00 (1.27)	-
A. fumigatus I	77.22 (25.03)	-	-	67.56 (6.00)	-	-	13.89 (2.02)	25.00 (1.15)	-	9.00 (2.27)	25.00 (1.27)	-
A. fumigatus II	7.11 (1.72)	-	-	34.56 (5.70)	-	-	1.78 (0.24)	-	-	15.33 (3.49)	75.00 (3.80)	17.00 (2.78)
A. fumigatus III	25.56 (3.24)	-	-	35.22 (4.89)	-	-	2.78 (0.90)	-	-	15.45 (5.25)	-	-
A. niger I	41.67 (12.08)	100.00 (2.04)	67.00 (7.92)	54.67 (8.69)	100.00 (1.25)	83.00 (18.92)	24.45 (5.28)	-	-	56.67 (12.76)	25.00 (1.27)	17.00 (2.78)
A. niveus I	1.22 (0.06)	100.00 (29.08)	100.00 (12.87)	3.89 (0.31)	100.00 (11.60)	17.00 (2.70)	-	25.00 (1.15)	-	2.89 (0.50)	25.00 (1.27)	17.00 (2.78)
A. quercinus	3.11 (0.41)	-	-	-	100.00 (75.24)	17.00 (2.70)	-	-	-	-	-	-
Cladosporium oxysporum	4.89 (0.48)	100.00 (4.06)	33.00 (1.98)	-	-	-	25.33 (4.70)	100.00 (41.38)	-	-	25.00 (1.27)	50.00 (8.33)
Curvularia clavata	-	25.00 (0.26)	17.00 (0.99)	-	-	-	9.33 (1.06)	-	100.00 (27.08)	-	-	-
Fusarium moniliforme	-	-	-	4.89 (0.22)	-	-	-	100.00 (16.09)	-	0.89 (0.07)	-	-
F. oxysporum	10.89 (0.89)	75.00 (1.53)	83.00 (10.89)	24.78 (1.34)	-	17.00 (5.41	4.67 (0.82)	-	-	13.22 (1.90)	-	-
F. solani I	18.44 (1.57)	75.00 (8.16)	100.00 (25.74)	36.11 (2.74)	-	83.00 (27.03)	7.33 (1.16)	-	17.00 (2.08)	10.33 (2.29)	25.00 (2.53)	17.00 (5.56)
F. tabacinum	-	-	-	-	-	-	-	75.00 (5.75)	17.00 (2.08)	-	100.00 (73.42)	17.00 (2.78)
Penicillium chrysogenum	13.33 (1.05)	100.00 (43.11)	100.00 (14.85)	-	100.00 (10.97)	33.00 (5.41)	2.78 (0.30)	75.00 (4.60)	50.00 (12.50)	9.22 (1.57)	-	17.00 (2.78)
Rhizopus oryzae	15.45 (1.53)	50.00 (1.02)	-	1.22 (0.10)	-	17.00 (2.70)	23.00 (5.15)	-	-	5.56 (1.08)	-	17.00 (2.78)
Trichoderma aureoviride	23.33 (2.84)	50.00 (1.02)	-	39.11 (4.06)	-	-	13.00 (3.82)	-	-	12.11 (2.23)	25.00 (1.27)	33.00 (5.56)
Ulocladium chartarum	-	-	-	-	-	-	-	100.00 (14.94)	67.00 (22.92)	-	50.00 (2.53)	100.00 (61.11)

Table 5

Similarity Quotients (S. Q.) between non-rhizosphere, rhizosphere and rhizoplane mycoflora of *Adhatoda vasica* in relation to soil types and seasons

Fungal flora compared	S.Q., %
Non-rhizosphere mycoflora:	
Winter season — soil type I *vs* soil type II	69.23
Rainy season — soil type I *vs* soil type II	55.73
Soil type I — winter season *vs* rainy season	56.45
Soil type II — winter season *vs* rainy season	67.18
Rhizosphere mycoflora:	
Winter season — soil type I *vs* soil type II	28.57
Rainy season — soil type I *vs* soil type II	38.46
Soil type I — winter season *vs* rainy season	32.36
Soil type II — winter season *vs* rainy season	34.78
Rhizoplane mycoflora:	
Winter season — soil type I *vs* soil type II	50.00
Rainy season — soil type I *vs* soil type II	42.11
Soil type I — winter season *vs* rainy season	60.87
Soil type II — winter season *vs* rainy season	50.00
Rhizosphere mycoflora *vs* rhizoplane mycoflora:	
Winter season — soil type I	68.57
Winter season — soil type II	82.35
Rainy season — soil type I	57.89
Rainy season — soil type II	69.23

Chauhan 1981a, b, 1982a). Besides the significant quantitative decline in the non-rhizosphere soil fungal community of both soil types during the rainy season, qualitatively, the extent of similarity between the non--rhizosphere soil mycoflora also decreased considerably during the rainy season (Table 5). The restricted occurrence of certain fungal species in the non-rhizosphere soil of a particular soil type during a particular season (Table 4) indicates the specificity of each non-rhizosphere soil microenvironment which is known to be influenced by the climatic, edaphic and biotic factors (Joshi and Chauhan 1982b, Joshi 1983a). However, in general, higher extent of similarities (Table 5) between the fungal flora of the two soil types during the two seasons may be attributed, besides the similar edaphic conditions, to the similar climatic conditions of these two adjoining soil types and the cosmopolitan nature of the fungi.

Due to differences in the non-rhizosphere soil mycoflora of the two soil types, the rhizosphere mycoflora of *A. vasica* growing in the two soil types also differed during both the seasons (Table 3) as it is through the non-rhizosphere soil that certain fungi are preferentially stimulated in the vicinity of the roots largely on account of the exudation of metabolically active substances from the roots and sloughed off root cells

Table 7

Percentage occurrence of specific fungal groups in the non-rhizosphere (NRs), rhizosphere (Rs) and rhizoplane (Rp) of *A. vasica* in relation to soil types and seasons

Fungal groups	Winter season						Rainy season					
	soil type I			soil type II			soil type I			soil type II		
	NRs	Rs	Rp	NRs	Rs	Rp	NRs	Rs	Rp	NRs	Rs	Rp
Zygomycotina	1.83	1.28	0.99	2.66	—	2.70	6.16	9.20	4.17	1.89	—	2.78
Ascomycotina	4.03	—	—	3.83	—	—	4.42	—	—	4.37	—	—
Deuteromycotina												
Aspergillus	61.86	42.61	32.68	59.84	88.50	48.64	33.84	2.30	2.08	45.39	11.42	8.34
Penicillium	2.85	42.11	14.85	0.44	11.20	13.52	3.96	4.60	12.50	4.80	1.27	2.78
Fusarium	2.44	3.57	36.63	4.31	0.30	35.14	3.42	21.84	2.08	4.27	45.95	5.56
Rest of the hyphomycetes	22.11	9.41	14.85	21.55	—	—	43.56	62.06	77.09	37.97	38.33	24.82
Coelomycetes	2.61	1.02	—	7.05	—	—	3.85	—	2.08	0.66	—	—
Sterile colonies	2.27	—	—	0.32	—	—	0.79	—	—	0.65	2.53	5.36

— indicates absence

(Rovira 1965, 1969). Qualitatively, the rhizosphere mycoflora of *A. vasica* of both soil types during both the seasons was widely dissimilar (Table 5), whereas, quantitatively, during the rainy season, the rhizosphere fungal population of *A. vasica* of soil type II was significantly higher than that of soil type I (Table 3). The responses of rhizosphere mycoflora to the soil types and seasons were in sharp contrast when compared with the responses of non-rhizosphere soil mycoflora to the soil types and seasons. This suggests the specificity of the rhizosphere mycoflora imparted largely by the root exudates which is directly related to the physiological activities of the plant. Among the environmental conditions affecting the plant growth which consequently affects the root exudation, soil conditions are also known to influence the root surface microflora (Louw and Webley 1959). Despite the qualitative and quantitative differences in the root surface mycoflora of different sugarcane varities, Kamal Singh (1974) noted pronunced similarity in their rhizosphere mycoflora and attributed it to the common characteristics of plants and soils. In the present investigation significantly higher rhizosphere fungal community of *A. vasica* growing in soil type II during the rainy season point towards better growth of plant in soil type II and which, considering the uniform climatic conditions in these two soil types, may consequently be attributed to better edaphic conditions in soil type II. The improved and better soil conditions in the afforested areas of Chambal ravines, which corresponds to the soil type II in the present study, by retaining soil fertility due to afforestation of *P. juliflora* and *D. sissoo* in these areas have already been noted (Joshi 1979). Seasonally, *A. vasica* exhibit luxurient plant growth and flowering during the rainy season and, therefore, the rhizosphere mycoflora increased during the rainy season, although the differences were only significant in soil type II (Table 3). Studies on the rhizosphere mycoflora of *Prosopis juliflora* and *Dalbergia sissoo*, both of which undergo flowering at different seasons, also revealed maximum rhizosphere fungal community at their corresponding flowering periods (Joshi 1982). Mall (1979) studying the rhizosphere microflora of three varieties of potato noted that the rhizosphere microflora increased with the advancement of the plant growth and was maximum before initiation of tuber formation. It is believed that there is maximum exudation from roots during the flowering period which consequently results in higher rhizosphere fungal community during this period (Srivastava 1973, Saksena et al. 1982). The wider differences in the species composition of rhizosphere mycoflora of both soil types during both the seasons indicate the differences in their respective microenvironments which consequently result in the occurrence of certain specific fungal species for each.

During both the seasons, the rhizoplane fungal community of *A. vasica* growing in soil type I was significantly higher than that of soil type II (Table 3). Seasonally, the rhizoplane fungal community in soil type I decreased significantly during the rainy season. In contrast to the rhizosphere, the rhizoplane mycoflora showed greater similarity (Table 5) with respect to the soil types and seasons. Variations in the qualitative and quantitative parameters of rhizoplane mycoflora led to the specific occurrence of certain fungal species for each soil type and season.

A total of 117 fungal species were isolated during the course of investigation from the non-rhizosphere, rhizosphere and rhizoplane of *A. vasica* (Table 4). The qualitative and quantitative variations in the non-rhizosphere, rhizosphere and rhizoplane mycoflora were attributed to the wider differences in their respective microenvironments (Joshi 1982). In the present investigation maximum fungal community was always noted in the rhizosphere followed by non-rhizosphere soil and least in rhizoplane (Table 3), whereas, qualitatively, maximum number of fungal species were isolated from the non-rhizosphere soil (112 species) followed by rhizosphere (34 species) and lastly rhizoplane (24 species). These findings are in accordance with the studies of most of the workers (Peno and Veselinovic 1973, Srivastava 1973, Joshi 1982, 1983b, Joshi and Chauhan 1982c), although Gangawane and Deshpande (1977) noted higher fungal population in the rhizosphere but failed to find marked qualitative variations, whereas Odunfa and Iso (1979) and Shukla and Dwivedi (1981) recovered maximum number of fungal species from the rhizosphere soil rather than from the non-rhizosphere soil.

In view of the differences in the non-rhizosphere, rhizosphere and rhizoplane microenvironment of *A. vasica* of two soil types during both the seasons, different fungal species dominated in each type of microenvironment (Table 6). Earlier, Shukla and Dwivedi (1981) also noted variations in the percentage occurrence of individual fungal species in the rhizosphere and rhizoplane of primary, secondary and tertiary roots of *Trifolium alexandrinum* at early, pre-flowering, flowering and fruiting stages. Studies on the rhizosphere mycoflora of certain trees (Joshi 1982) and crop plants (Joshi and Chauhan 1982c, Joshi 1983b) have also revealed the same results.

Studies on the rhizosphere mycoflora of different plants revealed that different fungal groups dominate the rhizosphere and rhizoplane at various stages of development of plants. Odunfa and Oso (1979) studying the rhizosphere mycoflora of cowpea noted that with the increasing age some of the early colonizers, viz. *Rhizopus* spp. and *Pythium* spp. were replaced by *Curvularia* spp., certain ascomycetous forms and some drak sterile mycelia. In the present investigation in general, ascomycetous and coelomycetous fungi were mostly isolated from the non--rhizosphere soil (Table 7), whereas they showed poor growth in rhizosphere and rhizoplane. Mishra (1979) studying the fungal flora of certain crop plants also did not observe appreciable number of ascomycetous forms on roots. Some workers have shown *Aspergillus* to be a typical rhizosphere inhabitant (Bartoli et al. 1978, Mishra 1979). Studies on the rhizosphere mycoflora of certain trees (Joshi 1982), however, revealed the dominance of *Aspergillus* in the rhizosphere of *Prosopis juliflora* and *Dalbergia sissoo* only during the winter season but not during the rainy season. In the present study, in general, *Aspergillus* spp. were most abundant in the non-rhizosphere soil, followed by rhizosphere and lastly in rhizoplane (Table 7). Odunfa and Oso (1979) have also noted the abundance of *Aspergillus* spp. in the non-rhizosphere soil of cowpea in Nigeria. The dominance of *Aspergillus* spp. in the tropical and subtropical soils has already been reported (Domsch and Gams 1972) and they have already been found to be abundant in some other soil types of Chambal ravines (Joshi and Chauhan 1981a, 1982a). Besides *Aspergillus*, poor growth of *Zygomycotina* which are represented in the present study by only 3 genera (Table 4) indicate desert environment of the study area (Joshi and Chauhan 1982b, Joshi 1983a). Booth (1971) has found *Fusarium* spp. to be important rhizoplane fungi in many plants. Srivastava (1973), Mishra (1978), Joshi (1982) and Joshi and Chauhan (1982c) have also found *Fusarium* to be dominant rhizoplane fungi. Thomas and Parkinson (1967) opined that the infrequent isolation of *Fusarium* spp. from soil dilution plates, used for estimating rhizosphere mycoflora, is due to the fact that they are restricted in the soil to the fragments of the organic matter where they may be present as chlamydospores or as mycelia and that the dilution plate technique is unsuitable for isolating fungi associated with organic fragments in the soil. Odunfa and Oso (1979), therefore, noted considerably low frequency of *Fusarium* spp. in rhizosphere than in rhizoplane. In the present investigation, however, during the winter season *Fusarium* spp. dominated the rhizoplane of both soil types, whereas during the rainy season, they dominated the rhizosphere of both soil types (Table 7). Parkinson and Pearson (1967a, b) studied the occurrence and competitive ability of sterile dark fungi on barley root surface and found that sterile dark fungi were rapid colonizers on young roots and persisted there with increasing age. Mishra (1978) recorded occurrence of sterile dark mycelia on rhizoplane of certain fibre-yielding plants from seedling to fruiting age. Mall (1979) also noted abundance of sterile forms in the rhizoplane of three varieties of potato. In the present study, however, it was only during the rainy season that from the rhizosphere and rhizoplane of *A. vasica* growing in soil type II certain sterile mycelia were isolated.

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Wpływ warunków glebowych i kwitnienia na mykoflorę gleby strefy korzeniowej Adhatoda vasica Nees

Streszczenie

Badano mykoflorę *Adhatoda vasica* Nees, rosnącą na dwóch różnych typach gleby, ze strefy poza korzeniowej (poza-ryzosfery), w glebie strefy korzeniowej (ryzosferze) i z powierzchni korzeni (ryzoplany). Badania wykonywano w zimie i w porze deszczowej. Wyizolowano ogółem 117 gatunków. W zimie mykoflora z poza-ryzosfery z gleby II typu, zawierającej więcej węgla, była wyraźnie bogatsza w gatunki niż w glebie I typu. Mykoflora poza-ryzosferą w porze deszczowej znacznie zmniejszyła się, co było związane z wyraźnie większą wilgotnością gleby i z jej większą zdolnością zatrzymywania wody. Zbiorowiska grzybów z ryzosfery *A. vasica* podczas pory deszczowej różniły się w zależności od typu gleby. Maksimum zbiorowisk grzybów zanotowano w ryzosferze w porze deszczowej, kiedy roślina rosła najbujniej i kwitła. Mykoflora w ryzosferze *A. vasica* wyraźnie różniła się jakościowo w zależności od typu gleby i sezonu. Mykoflora ryzoplany również wykazywała różnice zależne od typu gleby i sezonu ale znacznie mniejsze. Najwięcej zbiorwoisk grzybów zanotowano w ryzosferze, następnie poza-ryzosferą, a najmniej w ryzoplanie, podczas gdy największą liczbę gatunków grzybów — w glebie poza-ryzosferą, następnie w ryzosferze i najmniejszą w ryzoplanie. Odmienne gatunki grzybów dominowały w glebie poza-ryzosferą, w ryzosferze i ryzoplanie *A. vasica* na obu typach gleby i w obu sezonach. *Aspergillus* spp. występował najobficiej w glebie poza-ryzosferą. W obu typach gleby *Fusarium* spp. dominowało w ryzoplanie w zimie i w ryzosferze w porze deszczowej.