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Diversity Spectrum of Soil Fungi in the Indian Thar Desert

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Abstract: Diversity analyses of soil fungi in four districts of Indian Thar Desert revealed higher alpha diversity in Jodhpur (69) and least at Jaisalmer (48). Jaisalmer and Barmer have higher similarity (Is = 89.81) followed by Jaisalmer-Bikaner (89.07). *Aspergillus fumigatus* mostly dominant in the study sites. Jodhpur had higher diversity ($\overline{H}$ = 3.57) and fair equitability (e = 1.94). Hyphomycetes formed the predominant (84.05) fungal community.

Key words: Diversity, soil fungi, Indian Thar Desert.

Indian Thar Desert covers north-west part of the Rajasthan State between 25'2 to 28'10 N and 69'3 to 74'0 E with an area of about 25,000 km^2. It includes the arid and semi-arid tracts of the districts of Jodhpur, Jaisalmer, Bikaner and Barmer, 100 m above the mean sea level. Most of area consisting dry undulating plain of hardened sand and remaining region is largely a rolling plain of loose sand, farming shifting sand dunes of longitudinal and transverse types, varying from 2-10 km in length and 30-80 m in height. Climate of this region is characterized by extremes of temperature, severe drought accompanied by high wind velocity; relative humidity mostly low, potential evapo-transpiration far exceeds precipitation, and too scanty a rainfall to support any appreciable vegetation. The vegetations are bushy, cacti, thorny and spinous shrubs, grasses and a few drought hardy slow growing tree species. Soil fungi are an important biotic component of the Thar Desert ecosystem.

Fungal biodiversity has been well studied for different agro-climatic regions of India (Beena *et al.*, 2000; Ananda and Sridhar, 2004) except the desert region. Therefore, the current study aims to understand the sol fungal diversity using the randomly collected soil samples from different locations of Thar Desert.

Materials and Methods

The areas surveyed in present study were Jodhpur, Jaisalmer, Barmer and Bikaner districts of Rajasthan. Soil samples were collected during July to October 2006; individually in sterilized polythene bags with the help of sterilized spatula and brought to the laboratory for fungal assessment. Twenty five soil samples were collected from each district representing different land uses viz., fallow land, agriculture land (open area as well as under tree canopy), grassland and pond banks; five samples at each site. All samples were taken from 5-10 cm depth of soil. The soil pH, soil moisture and temperature were recorded at the time of sampling (soil pH 7.9-8.2; moisture was low 2-5%, except pond sites wherein it was mostly 7-9%). The soil fungal diversity was estimated in these samples. Soil fungi were isolated by dilution plate method as described by Johnson *et al.* (1959) using Czapak's Agar medium and potato dextrose medium. Petri plates were incubated at 25°C±3°C and colonies were examined daily up to 10 days. For identification, temporary and semi-permanent mounts of fungi were made in cotton blue and lactophenol and were identified by the help of fungal identification key described by Gilman (1945), Barnett (1960), Ellis (1971 and 1976) and Barron (1972). Isolates were finally identified and authenticated by Prof. D.K. Purohit, Department of Botany JNV University, Jodhpur and Agharkar Research Institute, Pune. Cultures of all the fungal isolates have been deposited in the culture preservation center of Botany Department to get accession number.

Frequency, density and abundance were calculated using the following formulae:

$$\text{Frequency (\%)} = \frac{\text{No. of soil samples in which species occured}}{\text{No. of total samples}} \times 100$$

$$\text{Density} = \frac{\text{No. of colonies in all soil samples}}{\text{No. of total samples}}$$

$$\text{Abundance} = \frac{\text{No. of individuals in all the soil samples}}{\text{No. of samples in which species occurred}}$$

Species indices were assessed to quantify biological diversity (Biodiversity) of the soil fungi using Simpson Index (Simpson, 1949):

Table 1. Diversity spectrum (frequency, density and abundance) of soil fungi from four districts of Indian Thar Desert

Species	Jodhpur			Jaisalmer			Barmer			Bikaner		
	F	A	D	F	A	D	F	A	D	F	A	D
Alternaria alternata	22	3.95	0.087	0	0	0	0	0	0	0	0	0
Alternaria brassicicola	8	2.75	0.022	9	2.11	0.019	6	3.5	0.021	10	2.1	0.021
Alternaria porri	6	7.5	0.045	0	0	0	0	0	0	3	9.33	0.028
Alternaria solani	18	3.83	0.069	15	3.6	0.054	19	2.52	0.048	15	2.6	0.039
Alternaria sp.	10	3.3	0.033	0	0	0	0	0	0	0	0	0
Alternaria tenuis	5	6.2	0.031	2	9	0.018	3	8.33	0.025	5	9.6	0.048
Arthrobotrys superba	3	1	0.003	1	1.4	0.001	2	0.85	0.002	4	0.8	0.003
Aspergillus flavipes	12	8.83	0.011	10	9.5	0.095	11	9	0.099	15	8.13	0.122
Aspergillus flavus	41	10.36	0.425	45	9.62	0.433	38	10.78	0.41	36	10.83	0.39
Aspergillus fumigatos	46	10.63	0.489	42	10.52	0.442	47	10.12	0.476	35	11.85	
Aspergillus niger	34	11.76	0.4	33	11.96	0.395	30	13.5	0.405	31	12.25	0.38
Aspergillus ochraceus	16	10.43	0.167	14	11.57	0.162	13	11.07	0.144	15	10.33	0.155
Aspergillus sp.	6	6.5	0.039	0	0	0	0	0	0	0	0	0
Aspergillus tamarii	9	7.55	0.068	6	8.16	0.049	7	8.21	0.057	5	10.6	0.053
Aspergillus terreus	13	5.3	0.069	11	5.72	0.063	12	4.91	0.059	10	5.19	0.052
Aspergillus wentii	8	7	0.56	0	0	0	3	13.66	0.041	7	7.8	0.055
Botryotrichum piluliferum	1	1	0.001	1	1	0.001	1	1	0.001	1	1	0.001
Cephaliophora irregularis	2	2	0.004	0	0	0	0	0	0	1	2	0.002
Chaetomium caprinum	3	2.66	0.008	0	0	0	1	7	0.007	2	3.5	0.007
Chaetomium flavum	11	8.9	0.098	9	8.22	0.074	7	11.71	0.082	13	6.07	0.079
Chaetomium globosum	9	4.88	0.044	7	6	0.042	6	6.5	0.039	10	4.9	0.049
Chaetomium indicum	2	2.5	0.005	0	0	0	2	2	0.004	3	1.66	0.005
Cladosporium cladosporioides	8	7.62	0.061	4	7.5	0.03	5	6.4	0.32	7	8.2	0.057
Cladosporium macrocarpum	6	3.83	0.023	0	0	0	4	4.5	0.018	3	4	0.012
Colletotrichum capsici	9	4.11	0.037	8	4.25	0.034	7	4.57	0.032	9	4.05	0.036
Corynespora cassiicola	2	3.5	0.007	1	3	0.003	1	3.2	0.003	2	3.2	0.006
Cunninghamella sp.	8	3.12	0.025	6	3.66	0.022	0	0	0	7	2.71	0.019
Curvularia falcata	12	3.83	0.046	11	3.9	0.043	8	4	0.032	6	4	0.024
Curvularia lunata	16	9.06	0.145	10	9.5	0.095	14	7.85	0.11	15	8.66	0.13
Curvularia maculans	4	4.75	0.019	0	0	0	2	5.5	0.011	3	5	0.015
Curvularia pallescens	6	3.66	0.022	3	3.83	0.011	0	0	0	0	0	0
Drechslera tetramera	18	9.16	0.165	16	9	0.144	13	8.8	0.114	17	8.8	0.15
Drechslera tritici	3	2.66	0.008	0	0	0	1	3	0.003	3	2.25	0.007
Fusarium chlamydosporum	29	10.82	0.314	22	13.6	0.299	24	12.91	0.031	26	11.92	0.31
Fusarium lateritium	3	1	0.003	0	0	0	3	0.93	0.003	2	1.05	0.002
Fusarium moniliforme	14	8.85	0.124	11	10.45	0.115	12	10	0.12	13	9.07	0.118
Fusarium oxysporum	2	1	0.002	0	0	0	0	0	0	2	1	0.002
Fusarium solani	17	8.05	0.145	15	9.33	0.14	13	10.61	0.138	16	8.85	0.142
Fusarium sp.	3	2	0.006	0	0	0	0	0	0	0	0	0

Table 1 contd.....

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Species	Jodhpur			Jaisalmer			Barmer			Bikaner		
	F	A	D	F	A	D	F	A	D	F	A	D
Gliomastrix aterrima	2	1	0.002	0	0	0	0	0	0	1	1	0.001
Helminthosporium sativum	7	4.71	0.033	6	5.25	0.031	4	6.8	0.027	5	5.9	0.029
Helminthosporium turcicum	2	3.5	0.007	0	0	0	0	0	0	2	3.4	0.07
Macrophomina phaseolina	14	5.57	0.078	10	5.4	0.054	9	5.66	0.051	13	5.76	0.075
Memnoniella echinata	7	2.57	0.018	4	3	0.012	5	2.52	0.013	6	2.58	0.015
Monilia fructigena	1	2	0.002	1	1.8	0.002	1	2	0.002	1	1	0.001
Mucor racemosus	17	3.41	0.058	13	3.38	0.044	16	2.81	0.045	15	3.2	0.048
Myrothecium roridum	12	3.33	0.04	10	3	0.03	8	3.12	0.025	9	3.66	0.033
Nigrospora sphaerica	9	3.11	0.028	0	0	0	5	4.44	0.022	0	0	0
Oedocephalum glomerulosum	2	1	0.002	1	0.8	0.001	1	1	0.001	2	0.85	0.002
Papulospora sepedonioides	6	1.83	0.011	0	0	0	0	0	0	4	2	0.008
Penicillium chrysogenum	21	3.95	0.083	19	3.84	0.073	16	4.34	0.069	20	402	0.08
Penicillium citrinum	17	3.82	0.065	13	4.03	0.052	15	4.2	0.063	12	4.12	0.049
Penicillium sp.	6	2.83	0.017	4	3.75	0.015	3	4.33	0.013	5	3.1	0.015
Pestalotiopsis sp.	8	4.37	0.035	7	4.62	0.032	5	3.9	0.019	6	5.1	0.031
Phoma sp.	10	3.2	0.032	0	0	0	0	0	0	0	0	0
Rhizoctonia solani	20	4	0.08	16	3.75	0.06	14	3.92	0.055	17	4.11	0.07
Rhizopus nigricans	16	4.25	0.069	11	2.9	0.032	13	3.69	0.048	17	4.23	0.072
Rhizopus stolonifer	22	4.63	0.0102	15	5.66	0.085	24	3.75	0.09	20	2.5	0.05
Stachybotrys atra	15	4.6	0.069	10	4.2	0.042	9	4.56	0.041	12	4.41	0.053
Thielavia terricola	6	3.16	0.019	0	0	0	0	0	0	0	0	0
Torula herbarum	16	4.18	0.067	0	0	0	0	0	0	15	4.26	0.064
Trichoderma harzianum	21	4.66	0.098	20	4.77	0.095	17	5.26	0.089	14	5.57	0.078
Trichoderma koningi	12	5.08	0.061	10	5.75	0.057	11	5.5	0.06	8	5.25	0.042
Trichoderma virence	14	4.14	0.058	7	4.42	0.031	12	4.16	0.05	13	4.69	0.061
Trichoderma viridi	25	4.08	0.102	20	4.95	0.099	19	4.86	0.092	24	4.2	0.0101
Trichothecium roseum	17	3.17	0.054	14	3	0.042	15	3.14	0.047	12	3.25	0.039
Trichrus sp.	6	1.33	0.008	5	1.5	0.007	3	1.5	0.004	4	1.5	0.006
Trichrus spiralis	12	2.91	0.035	8	3.31	0.026	5	3.6	0.018	9	3.22	0.029
Ulocladium sp.	3	1	0.003	2	0.9	0.002	1	1.2	0.012	2	1	0.002

F= frequency, D= density, and A= abudence

$C = \sum pi^2$

where,

pi = ni/N

and Shannon and wiener index (Shannon and Wiener, 1949):

$$\overline{H} = -\sum pi.\log_e pi$$

Equitability was assessed using Pielou Index (Pielou, 1975)

$$e = \frac{\overline{H}}{logS}$$

Table 2. Species richness and diversity index of soil fungi from Indian Thar Desert

Location	Species richness	Diversity Index		
		Simpson	Shannon	Pielue
Jodhpur	69	0.0441	3.569	1.9411
Jaisalmer	48	0.0584	3.249	1.9325
Barmer	54	0.0587	3.314	1.9132
Bikaner	61	0.0491	3.418	1.9146

The similarity index was computed using the following function (Sorenson, 1948):

$$Is = \frac{2W}{A + B} \times 100$$

where, W is the sum of the lower values of density and A + B are the sum of density in the selected sites.

Results and Discussion

Diversity is a measure of the complexity of the community structure and is influenced by physical, chemical and biological factors. High diversity indicates the stable or equilibrium community. Low diversity occurs in an area where the community is dominated by a few species or the environment is harsh. Different diversity indices have been used to assess the mycofloral diversity. Altogether 69 fungal species were recorded from four districts of Indian Thar Desert (Table 1) with the composition of 5.79% Zygomycetes, 5.79% Ascomycetes, 84.05% Hyphomycetes and 4.34% Coelomycetes. Maximum fungal species were recorded from Jodhpur (69 species) followed by Bikaner (61 species), Barmer (54 species), and Jaisalmer (48 species) districts. *Aspergillus fumigatus* was more frequent in Jodhpur and Barmer districts, while *Aspergillus flavus* was more frequent in Jaisalmer and Bikaner districts. *Aspergillus niger* was more abundant in Jodhpur, Barmer and Bikaner, while *Fusarium chlamydosporous* in Jaisalmer district. *Aspergillus fumigatus* was more dense in all districts as compared to other fungi. Simpson Index varied between 0.0441 to 0.0587, maximum being in Barmer. Shannon and Wiener Index was maximum in Jodhpur followed by Bikaner, Barmer and Jaisalmer districts. Similarly, Pielou Index was maximum in Jodhpur and minimum in Barmer (Table 2). Moubasher and El-Dohlob (1970) reported *Aspergillus* species to be more frequent in warmer climate. The present study was from drier regions and it supports the earlier observation.

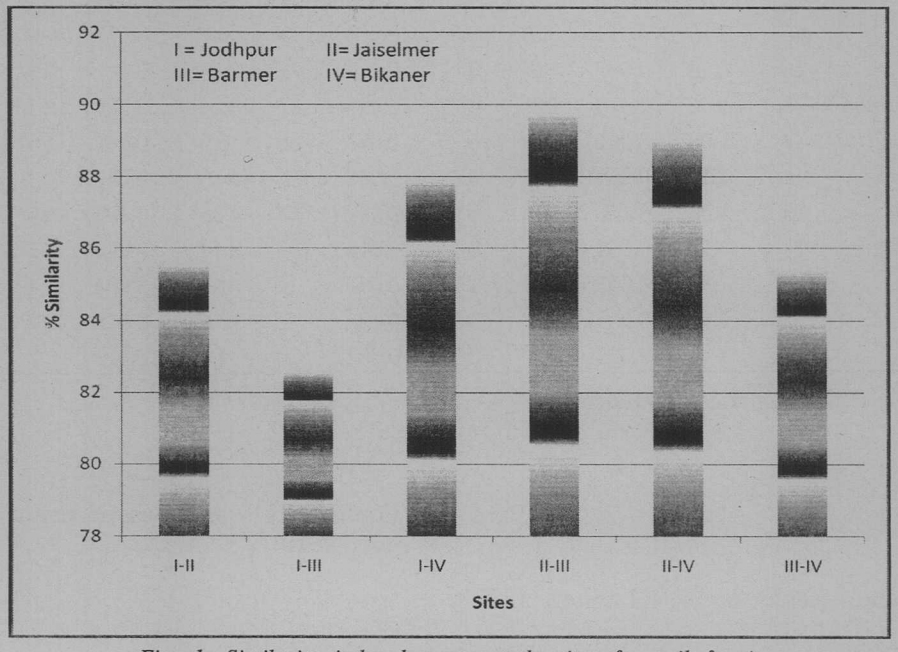

Fig. 1. Similarity index between study sites for soil fungi.

Similarity index evaluation (Fig. 1) revealed higher similarity between Jaisalmer and Barmer (89.81%) followed by Jaisalmer and Bikaner (89.07%). *Alternaria, Aspergillus, Chaetomium, Bipolaris, Cladosporium, Colletotrichum, Curvularia, Corynespora, Drechslera, Helmithosporium, Memnoniella, Myrothecium, Nigrospora, Penicillium, Rhizoctonia and Macrophomina* species are found in wide spectrum of colony colors in the cultures while *Fusarium* and *Cephalosporium* sp. possessed only in white color. Maximum numbers of soil fungi were reported pigmented conidia as compared to hyaline conidia. As per the conidial morphology is concerned the fragmented conidia were reported higher in number than the single cells spores.

In the present investigation very low number of soil fungal species have been reported as compared to tropical region. The harsh hospitable climatic conditions are the cause of such low alpha diversity. Fungal diversity in desert soils is highly dependent on temperature, moisture and availability of organic carbon (Gehlot, 2006). Soil fungi are not only responsible for the productivity, biogeochemical cycling of elements and ecosystem balance, but also for soil neogenesis and improvement of soil structure.

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