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Soil Fungal Ecology of Cultivated Areas of Chambal Ravines

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Three terraced up areas of Chambal ravines (Distt. Bhind, M P) supported by different vegetative covers, viz., *Triticum vulgare* Vill. (designated as soil 'A'); *Brassica compestris* L. (designated as soil 'B'); and *Cajanus cajan* (L.) Mill sp. (designated as soil 'C') were selected to study the ecology of soil microfungi as influenced by the plant cover and edaphic factors such as mechanical composition, soil temperature, moisture, water holding capacity, *p*H, humus, organic carbon, total nitrogen, C/N ratio, exchangeable calcium, exchangeable potassium and available phosphorous. Qualitatively 54 fungal species were isolated of which 24 were common to the three fields whereas 8 species were restricted to soil 'A', 7 to soil 'B' and 4 to soil 'C'. The fungal population was highest in soil 'C' and lowest in soil 'A'. *Aspergillus terreus* was the most widely distributed fungal species in the three fields. However, *Penicillium funiculosum* was dominant in soil 'A'; *Aspergillus niger* I and *Trichoderma aureoviride* in soil 'B'; and *Aspergillus nidulans* in soil 'C'. None of the edaphic factors showed any statistically significant correlation with fungal numbers except calcium carbonate which exhibited a significant negative correlation. The plant cover associated with the three soils and the edaphic factors affecting the soil microfungal population is discussed.

Key Words: Fungal population, Plant cover, Soil microenvironment, Edaphic factors, Interaction

Introduction

The qualitative and quantitative nature of the microorganisms inhabiting the soil is most important to the soil fertility. Both the microenvironment and the microorganisms of soil are largely influenced by the surface vegetation, edaphic conditions and climatic factors (Tresner et al. 1954, Saksena 1955, Pirozynski 1968). As the biotic and abiotic parameters of the environment govern the microbial distribution at a particular site, the microorganisms, in turn, also modify the composition of their surroundings through the metabolic products.

In the present investigation, an attempt has been made to understand the influence of edaphic factors and surface vegetation on the

soil microfungi of three different cultivated fields of Chambal ravines.

Topography and Climate

The present study is carried out in terraced or levelled up areas of Chambal ravines of 'Barhi forest range' of district Bhind (MP) situated on the southern bank of Chambal river. Geologically, the area is a meeting ground of Vindhyan systems and recent deposits of alluvium. The climate is semi-arid.

Materials and Methods

Three cultivated fields of Chambal ravines, designated as 'A', 'B' and 'C', were selected to study their mycoecology. The fields differ with regard to their vegetative cover viz., soil 'A' was characterized by *Triticum vulgare* Vill.; soil 'B' with *Brassica compestris* L.; and soil 'C' with *Cajanus cajan* (L.) Millsp. The soil sampling was done during February 1975. Fifteen soil samples were collected from each field. For fungal isolations, five plates were poured for each soil sample on Martin's medium (Martin 1950) using soil plate method (Warcup 1950). The fungal isolates were confirmed for their identity through CMI, Kew, England. Frequency and abundance of the individual fungal species was calculated as suggested by Saksena (1955).

The edaphic factors viz., soil temperature, moisture, water holding capacity, *p*H, and organic carbon were determined by methods suggested by Piper (1966). Mechanical analysis of soil was done by Boycous hydrometer method (Piper 1966). The soil humus was estimated by De Sigmond's method as described by Pandey et al. (1968). Total nitrogen, exchangeable calcium and potassium and available phosphorus were determined by methods suggested by Jackson (1967). The data were subjected to statistical analysis (Snedecor & Cochran 1967) for getting precise conclusions.

Results and Discussions

A total of 54 fungal species were isolated from the three fields of which 2 belonged to phycomycetes, 4 to ascomycetes, 44 to hyphomycetes, 2 to mycelia sterila and 2 unidentified colonies (table 1). The three fields differed with regard to their fungal population which was highest in *Cajanus cajan* field and lowest in *Triticum vulgare* field (table 2). However, the species spectrum was widest for *T. vulgare* field whilst *C. cajan* field exhibited the lowest number of fungal species. The variation in the soil fungi of three fields can be attributed to the difference in the type of vegetative cover whose importance has already been realized by numerous workers (Tresner et al. 1954, Saksena 1955, Ramakrishnan 1955, Ramarao 1970, Manoharachary 1977).

The present investigation reveals that the common soil fungi is represented by species of *Aspergillus*, *Penicillium*, *Fusarium*, *Rhizopus*, *Chaetomium*, *Curvularia*, *Helminthosporium*, *Monocillium* and *Monidictys*. The spectrum of fungal species (table 1) exhibits the dominance of Aspergilli in the tropical areas of the world as suggested by various workers (Waksman 1917, Peyronel 1955, Domsch & Gams 1972). Mucorales were represented by only two genera thus suggesting the desert soil conditions (Garrett 1963). Higher proportions of species from dematiaceae and sphaeropsidales further indicate the desert soil environment (Park 1968)

Of the 54 isolated fungal species, only 24 were found to be common to the three fields. Since the edaphic conditions (table 2), also differed markedly in the three fields, this led to specificity of certain fungal species in the fields. Thus, *Aspergillus pulverulentus*, *A. ustus*, *Cladosporium oxysporum*, *Humicola fusco-atra*, *Penicillium implicatum*,

Table 1 *Distribution of fungal species in the three soil types of Chambal ravines*

Name of fungal species	Soil 'A'	Soil 'B'	Soil 'C'
PHYCOMYCETES			
Mucor hiemalis Wehmer	—	+	+
Rhizopus oryzae Went and Prinsen Geerligs	+	+	+
ASCOMYCETES			
Chaetomium jodhpurense Lodha	+	+	+
Chaetomium sp.	+	+	—
Khuskia oryzae Hudson	+	+	+
Neocosmospora vesinfecta E.F. Smith	—	+	—
Thielavia terricola (Gilman & Abbot) Emmons	—	+	—
HYPHOMYCETES			
Acremonium kiliense Grutz	—	+	—
Acrophialophora fusispora (Saksena) Samson	+	+	+
Alternaria alternata (Fr.) Keissler	+	+	+
Aspergillus flavus Link ex Fr.	+	+	+
A. fumigatus Frees. (Strain I)	+	+	+
A. fumigatus Frees. (Strain II)	+	+	+
A. fumigatus Frees. (Strain III)	—	+	+
A. nidulans (Eidam) Wint.	+	+	+
A. niger Van Tiegham (Strain I)	+	+	+
A. niger Van Tiegham (Strain II)	+	+	+
A. niveus Blockwitz	+	+	+
A. ochraceous Withelm	—	+	+
A pulverulentas (Mc Alpine) Thom	+	—	—
A. quercinus (Bainier) Thom and Church	+	—	—
A. stellatus Curzi	+	+	+
A. terreus Thom	+	+	+
A. ustus (Bainier) Thom and Church	+	—	—
Cladosporium oxysporum B. & C.	+	—	—
Curvularia geniculata (Tracy & Earle) Boedijn	—	+	—
C. lunata (Wakker) Boedijn	+	+	+

Table 1 (*Contd.*)

Name of fungal species	Soil 'A'	Soil 'B'	Soil 'C'
Cylindrocladium floridanum Sobers and Seymour	−	+	−
Fusarium fusarioides (Frag. & Cif.) Booth	−	−	+
F. oxysporum Schlecht (Strain I)	+	+	+
F. oxysporum Schlecht (Strain II)	−	−	+
F. solani (Mart.) Sacc.	+	+	+
Gliocladium roseum Bain	−	+	−
Helminthosporium sativum Pammel, King and Bakke	+	+	+
Humicola fusco-atra Traaen	+	−	−
Monocillium constrictum W. Gams	+	+	+
Monodictys fluctuata (Tandon & Bilgrami) M.B. Ellis	+	+	+
Myrothecium leucotrichum (Pk.) Tulloch	+	+	+
M. verrucaria (Alb. & Schw.) Ditm. ex Fr.	+	−	+
Nigrospora oryzae Hudson	−	−	+
Paecilomyces lilacinus (Thom) Samson	+	+	+
Paecilomyces sp.	−	−	+
Penicillium funiculosum Thom	+	+	+
P. implicatum Biourge	+	−	−
P. lapidosum Raper and Fennell	+	−	+
P. oxalicum Currie and Thom	+	+	+
P. spiculisporum Lehman	+	+	−
Phoma multirostrata (Mathur, Menon & Thirum) Dorenbosch & Boerema	+	−	+
Stachybotrys atra Corda	+	−	+
Trichoderma aureoviride Rifai aggr.	+	+	−
Sterile colony I (White)	−	+	−
Sterile colony II (Black)	+	+	−
Unidentified colony I	+	+	−
Unidentified colony II	+	−	−
Number of species	40	38	34

\+ = Present
− = Absent
Soil 'A' = *Triticum vulgare* crop field
Soil 'B' = *Brassica compestris* crop field
Soil 'C' = *Cajanus cajan* crop field

Table 2 *Fungal numbers in relation to edaphic factors in three cultivated fields and their values for correlation coefficient*

Factors	Soil 'A'	Soil 'B'	Soil 'C'	Correlation coefficient 'r'
Fungal population/mg soil	41.425	49.439	70.732	
Sand %	13.79	71.68	58.00	+0.534
Silt %	25.73	9.60	19.51	—0.136
Clay %	52.08	11.62	17.99	—0.601
$CaCO_3$ %	8.40	7.10	4.50	—0.998*
Temperature °C	19.70	20.70	27.50	+0.989
Moisture %	8.88	6.39	4.00	—0.964
Water holding capacity %	58.76	39.15	35.34	—0.810
*p*H	7.5	7.2	7.1	—0.858
Humus %	2.73	2.09	1.69	—0.926
Organic carbon %	0.346	0.252	0.357	+0.106
Total nitrogen %	0.018	0.036	0.054	+0.968
C/N ratio	19.222	7.000	6.611	—0.730
Exchangeable calcium mg/100 gm soil	356.25	84.37	140.62	—0.560
Exchangeable potassium mg/100 gm soil	41.2	22.5	33.7	—0.153
Available phosphorus ppm	18	12	8	—0.932

*Significant at 5% level
Soil 'A' — *Triticum vulgare* crop field
Soil 'B' — *Brassica compestris* crop field
Soil 'C' — *Cajanus cajan* crop field

sterile colony II and unidentified colony II were exclusive to *Triticum vulgare* field; *Neocosmospora vesinfecta*, *Thielavia terricola*, *Acremonium kiliense*, *Aspergillus ochraceous*, *Curvularia geniculata*, *Cylindrocladium floridanum*, *Gliocladium roseum* and sterile colony I were isolated only from *Brassica compestris* field whereas *Fusarium fusarioides*, *F. oxysporum* II, *Nigrospora oryzae* and *Paecilomyces* sp. were confined to *Cajanus cajan* field. The restricted occurrence of certain fungal species in different soil microenvironments has also been noted by Wicklow et al. (1974), Litinov and Smirnov (1975) and Manocharachary (1977).

The three fields are characterized by different microbial communities (table 3), except *Aspergillus terreus* which was dominant and widely distributed fungal species in all the three fields. Certain forms were dominant exclusively to different localities (table 3). The dominance of certain fungal forms in a particular soil microenvironment and their poor growth in the other soils support the ideas of Alexander (1971).

The edaphic conditions of the three fields

Table 3 *Percentage frequency and abundance of some of the dominant fungal species in the three cultivated fields*

Fungal species	Soil 'A'		Soil 'B'		Soil 'C'	
	% frequency	% abundance	% frequency	% abundance	% frequency	% abundance
Aspergillus nidulans	27.27	2.47	32.14	2.38	65.85	20.02
A. niger I	71.43	8.07	60.71	7.14	48.78	4.54
A. terreus	89.61	27.09	57.14	27.31	87.80	24.05
Penicillium funiculosum	76.62	13.28	23.21	1.50	39.02	6.22
Trichoderma aureoviride	24.68	1.53	60.71	7.14	—	—

— indicates absence
Soil 'A' — *Triticum vulgare* crop field
Soil 'B' — *Brassica compestris* crop field
Soil 'C' — *Cajanus cajan* crop field

also varied (table 2). The mechanical analysis of the three fields revealed that the soil of *Triticum vulgare* field was clayey whereas that of the rest two fields were sandy loam in texture. Parr and Norman (1964) and Griffin (1969) assessed reduced fungal activity in soils with smaller particle systems due to poor aeration. The present study also reveals the same as the fungal population was lowest in clayey soils of *Triticum vulgare* field. This correlation, however, was not statistically significant (table 2). The present investigation reveals a significant negative correlation between fungal population and calcium carbonate contents of soil as the *Triticum vulgare* field showed the lowest fungal population and highest calcium carbonate contents whilst *Cajanus cajan* field exhibited the highest fungal population along with lowest calcium carbonate contents (table 2). Mishra (1966), however, failed to exhibit any such correlation.

The physico-chemical characteristics of the soil have been shown to play an important role in determining the microbial activity in soil (Tresner et al. 1954, Ramakrishnan 1955, Saksena 1955, Dwivedi 1965, Ramarao 1970, Manoharachary 1977) whereas the finding of some other workers differed (Jensen 1931, Ruschman & Pozdena 1942, Menon & Williams 1957, Orpurt & Curtis 1957). The present investigation reveals that the soil moisture, water holding capacity, *p*H, humus, C/N ratio, exchangeable calcium and available phosphorus exhibited a negative correlation with the fungal population which, however, was statistically insignificant (table 2). Soil temperature, on the other hand, showed a positive correlation with fungal population which, again was not statistically significant. The organic carbon contents and exchangeable potassium, however, failed to exhibit any clear correlation (table 2).

The complex microbiological system of the soil, since, is influenced by a variety of factors, it becomes difficult to elucidate the role played by individual factors. In the present investigation, the combined effect of various factors (Saksena 1955) seems to play the most important role in evaluating the microfungal distribution. It can, therefore, be concluded that it is the interaction of various factors which determines the extent

and nature of microbial population at a given site.

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References

Alexander M 1971 *Introduction to Soil Microbiology* (London, New York: John Wiley & Sons Inc.) 153 pp.

Domsch K H and Gams W 1972 *Fungi in Agricultural Soils.* (London: Longaman)

Dwivedi R S 1965 Ecology of soil fungi of some grasslands of Varanasi I. Edaphic factors and fungi; *Proc. natn. Acad. Sci. India.* **B35** 255

Garrett S D 1963 *Soil fungi and Soil fertility.* (Oxford: Pergamon Press) 165 pp

Griffin D M 1969 Soil water in the ecology of fungi; *Ann. Rev. Phytopothol.* **7** 289-310

Jackson M L 1967 *Soil chemical analysis.* (New Delhi: Prentice-Hall of India Pvt. Ltd,)

Jensen H L 1931 The fungus flora of the soil; *Soil Sci.* **31** 123–158

Litinov M A and Smirnov N V 1975 Mycoflora of the sand desert soils occupied by *Carex physodes* and *Haloxylen persicum* associations in Repetek reservation; *Mikol. Fitopatol.* **9** 377–380

Manoharachary C 1977 Microbial ecology of scrub jungle and dry waste land soils from Hyderabad district, A P (India); *Proc. Indian natn. Sci. Acad.* **43** 6–18

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

Menon S K and Williams L E 1957 Effect of crop, crop residues, temperature and moisture on soil fungi; *Phytopath.* **47** 559–564

Mishra R R 1966 Studies on ecological factors governing distribution of soil mycoflora; *Proc. natn. Acad. Sci. India* **B36** 205–222

Orpurt P A and Curtis J T 1957 Soil microfungi in relation to the prairie continuum in Wisconsin; *Ecology* **38** 628–637

Pandey S C, Puri G S and Singh J S 1968 *Research Methods in Plant Ecology* (Bombay: Asia Publ. House)

Park D 1968 The ecology of terrestrial fungi; in *The Fungi* eds. G C Ainswarth and A S Sussman Vol. III (London: Academic Press) pp 5–39

Parr J F and Norman A G 1964 Growth and activity of soil microorganisms in glass microbeads. I. CO_2 evolution; *Soil Sci.* **97** 361–366

*Peyronel B 1955 Allionia, 2, 357 (Cited by Griffin, D M 1972); in *Ecology of Soil Fungi* (London: Chapman & Hall Ltd.)

Piper C S 1966 *Soil and Plant Analysis.* (Bombay: Hans Publ.)

Pirozynski K A 1968 Geographical distribution of fungi; in *The Fungi* eds. G C Ainswarth and A S Sussman Vol. III (New York: Academic Press) 491 pp

Ramakrishnan K 1955 Some aspects of soil fungal ecology; *Proc. Indian Acad. Sci.* **B41** 110–114

Ramarao P 1970 Studies on soil fungi III. Seasonal variation und distribution of microfungi in some soils of Andhra Pradesh, India; *Mycopath. et Mycol. Appl.* **40** 277–298

*Ruschmann G and Pozdena L 1942 Beziehungen zwischen physikalisher und biologischer Bodenertragung; *Z. Bl. Bakt. Int. Acad.* **105** 213–233

Saksena S B 1955 Ecological factors governing distribution of soils microfungi in some forest soils of Sagar; *J. Indian bot. Soc.* **34** 262–298

Snedecor G W and Cochran W G 1967 *Statistical Methods* 6th edn. Iowa State Univ. Press 593 pp

Tresner H D, Backus M P and Curtis J T 1954 Soil microfungi in relation to hardwood forest continuum in Southern Wisconsin; *Mycologia* **46** 314–333

Waksman S A 1917 Is there any fungus flora in soil? *Soil Sci.* **3** 565–589

Warcup J H 1950 The soil plate method for isolation of fungi from soil; *Nature, Lond.* **166** 177

Wicklow M C Bollen W B and Denison, W C 1974 Comparison of microfungi of 40-yr old stands of pure alder, pure conifer and alder-conifer mixtures; *Soil Biol. Biochem.* **6** 73–78

*Originals not seen.