

ECOLOGY OF THE SOIL FUNGI OF UTTAR PRADESH

III. SOILS OF THE SUB-HIMALAYAN TRACT AND THEIR MICROFUNGI

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This paper deals with different forest soils of the sub-Himalayan tract (Gorakhpur), giving their chemical composition and distribution of fungi at various depths during different seasons. In all, 63 soil samples were collected from Ramkola, Deoria and Ghugli zones of the district Gorakhpur. Forty-five species of fungi were isolated and identified belonging to Phycomyetes, Ascomycetes and Deuteromycetes. Out of these *Circinella mucoroides* Saito, *Torula* sp. and *Paecilomyces puntonii* (Vuill.) Nannizzi were new records from Indian soils. The occurrence of *Penicillia* in the soil was poor as compared with that of *Aspergilli*. The maximum number of *Fusaria* was recorded during the summer in almost all the soils. In the winter season the occurrence of fungi was the maximum in Ramkola while the minimum was in Deoria zone. During the summer season the maximum number of microfungi was recorded in Ghugli and Deoria zones, while in the rainy season it was the maximum in Deoria zone.

INTRODUCTION

The sub-Himalayan tract comprises three distinct portions, viz. *Bhabhar* area immediately below the hills, *Tarai* and *Plains*. Three types of soil profile were found in the sugar-cane growing areas of Gorakhpur, Uttar Pradesh. This paper mainly deals with three different types of soils found in the Gorakhpur District, giving their chemical composition and distribution of fungi at various depths during different seasons and their possible interrelations. These comprise the second division of the soils found in Uttar Pradesh, India.

SOILS

The district of Gorakhpur occupies the extreme north-east corner of Uttar Pradesh and comprises a huge stretch of country lying to the north of the river Ghagra. The geographical limits of the district are determined by the parallels of 26° 5' and 27° 29' north latitude and 83° 4' and 84° 26' east longitude. The whole eastern side of the district consists of the Padrauna tahsil and Ramkola zone and its soil commonly known as *Bhat*. This is never irrigated and the crops grow under rain-fed condition. This soil is highly calcareous (pH 7.8) and has generally a high soluble salt content. Besides the Ramkola area are the Ghugli and Deoria zones, the soils of which are the

upland *Bangar* (local classification) and they form a stretch of extremely fertile soil. There are definite signs of leaching and the zones have lower content of soluble salts and lime, the pH lying between 7 and 7.6 and below 7 respectively.

CLIMATE

The climate of the sub-Himalayan tract is characterized by a delightful cold weather, a long and almost intolerable summer and a rainy season. The rainfall is about 45 inches.

Method for the collection of soil samples :

This was the same as mentioned by Saksena and Sarbhoy (1963). The soil samples were collected during the months of October, February and June 1962-64 from Ramkola, Ghugli and Deoria zones. The samples were packed in sterilized containers and brought to the laboratory. In all, 63 soil samples were taken in various seasons from different depths.

Soil analysis :

The pH values, moisture contents, carbon, nitrogen, nitrates, phosphorus and calcium of the soils were determined (Tables I, II and III). The methods used were the same as described in the previous paper (Saksena and Sarbhoy 1963).

Isolation of fungal flora from the soil samples :

The isolation of soil microfungi was made by four methods as described by Saksena and Sarbhoy (1963). Pure cultures of the fungi were obtained by single spore culture and sometimes by hyphal isolation methods (Warecup 1955a).

The different fungi identified are shown in Table II.

RESULTS AND DISCUSSION

A critical study of Table II shows that the dominant species were *Rhizopus stolonifer*, *Aspergillus niger*, *A. awamori* and *A. terreus* found in different seasons. Bacteria were also present universally in all the soils.

1. *Sugar fungi* (Phycomycetes):

In all, 14 species belonging to eight genera of sugar fungi (Garrett 1951) were isolated from these soils in various seasons. *Actinomucor elegans*, *Absidia ramosa*, *Helicostylum piriforme*, *Circinella mucoroides* and *C. muscae* showed some restricted distribution.

Three species of the genus *Rhizopus* were recorded during the present studies. *Rhizopus arrhizus* was recorded from Ghugli and Deoria soils during the rainy and winter seasons respectively while it was absent in Ramkola

TABLE I
 Showing results of mechanical and chemical analyses of the sub-Himalayan soils in various seasons

Soils	Seasons	Ghugli			Deoria			Ramkola		
		Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy	Winter
Moisture contents from different depths (in inches)	SS	13.5	19.7	10.5	19.0	13.5	8.5	14.0	10.0	12.5
	2"	13.8	16.0	10.8	17.0	14.7	10.5	16.0	12.0	14.4
	4"	14.7	17.6	12.6	20.0	15.2	12.5	11.0	16.7	16.2
	6"	15.7	18.3	13.8	12.0	22.6	12.8	10.0	15.9	16.5
	8"	14.8	18.6	14.6	16.0	27.5	12.8	10.0	12.0	17.6
	10"	14.2	20.0	16.8	16.8	29.5	13.9	12.5	10.0	18.5
Average pH	12"	14.0	21.2	17.5	17.0	31.2	14.2	14.0	9.4	18.5
	..	7.0-7.6	7.2-7.4	7.0-7.4	7.0-7.6	7.0-7.4	7.2-7.6	8.2-8.6	8.2-8.6	8.0-8.4
	Carbon (percentage)	0.84	1.35	0.80	0.66	0.54	0.65	0.90	1.56	0.90
	Nitrogen (percentage)	0.054	0.084	0.080	0.053	0.150	0.06	0.084	0.058	1.05
	Nitrate per acre (lb.)	32	150	24	42	75	42	22	100	32
	Phosphorus per acre (lb.)	100	80	100	75	12	75	50	81	100
Calcium (percentage)	0.45	0.18	0.25	0.42	0.42	0.26	0.82	0.82	0.19	

SS = surface soil.

TABLE II
Microfungi identified in different seasons at various depths

Name of the fungi	Ghugli			Deoria			Ramkola		
	Rainy	Summer	Winter	Rainy	Summer	Winter	Rainy	Summer	Winter
PHYCOMYCETES									
1. <i>Actinomyces elegans</i> (Eidam) Benj. and Hess.	—	—	—	—	10"	—	—	—	2"
2. <i>Absidia ramosa</i> (Lindt) Lendner	—	—	—	—	—	—	—	4"	2"
3. <i>Rhizoglyphus arrhizus</i> Fisch.	6"	4"	—	SS	2"	—	—	—	—
4. <i>R. stolonifer</i> (Ehrenb. ex Fr.) Lind.	10"	6", 4"	2"	10"	8"	10"	10"	8"	2", 4"
5. <i>R. oryzae</i> Went and Geerl.	—	—	—	—	—	12"	—	—	8"
6. <i>Mucor hiemalis</i> Wehmer	—	10"	SS	—	—	—	—	—	—
7. <i>M. luteus</i> L.	—	4"	—	—	8"	—	—	—	—
8. <i>M. racemosus</i> Fres.	—	—	—	—	—	—	—	—	SS
9. <i>Cunninghamella echinulata</i> Thaxt.	—	—	—	—	—	12"	2", 4"	2"	SS
10. <i>C. verticillata</i> Paine	—	—	—	6"	6"	2"	6"	—	2"
11. <i>Helicostylum pyriforme</i> Bain.	—	—	—	—	—	—	—	—	6"
*12. <i>Circinella mucoroides</i> Saito	—	—	—	—	—	—	—	—	—
13. <i>C. muscae</i> Smith	—	—	—	—	—	—	—	—	—
14. <i>Synecephalastrum racemosum</i> (Cohn) Schroet.	—	—	—	—	—	—	6", 4"	2", 2"	2"
ASCOMYCETES									
15. <i>Neocosmospora vasinfecta</i> E. F. Smith	—	—	4"	8"	—	—	2"	—	8"
16. <i>Chaetomium bostrychodes</i> Zopf	—	10"	—	—	—	—	—	—	SS
17. <i>C. globosum</i> Kunze ex Fr.	—	—	—	10"	—	—	—	—	SS

* = new records from soil.
 — = absence of the fungus.
 SS = surface soil.

TABLE II—(contd.)
Microfungi identified in different seasons at various depths

Name of the fungi	Ghugli				Deoria				Ranikola			
	Rainy	Summer	Winter		Rainy	Summer	Winter		Rainy	Summer	Winter	
FUNGI IMPERFECTI												
18. <i>Aspergillus faevis</i> Link ..	—	6", 4"	4"	—	—	—	—	—	—	—	—	12"
19. <i>A. niger</i> van Tieghem ..	10"	6", 4"	4"	—	—	—	—	—	—	—	—	SS
20. <i>A. awamori</i> Nakazawa ..	2", 4"	8"	10"	2", 12"	6", 4"	10", 2"	8"	4", 6"	8"	10", 2"	12", 2"	SS
21. <i>A. oryzae</i> (Ahlburg) Cohn ..	—	—	10"	—	—	—	10"	4"	6"	10"	10"	—
22. <i>A. terreus</i> Thom ..	10"	2"	4"	2"	—	10"	4"	4"	6"	8"	8"	—
23. <i>A. ustus</i> (Bain.) Thom and Church	—	4"	8"	—	—	—	—	—	—	—	—	—
24. <i>A. phoenicis</i> (Corda) Thom and Church ..	—	2"	—	—	—	—	—	—	—	—	—	—
25. <i>A. nidulans</i> (Eidam) Wint. ..	2"	10"	4"	4"	—	10"	—	—	—	—	—	—
26. <i>A. ruber</i> (Spieck. and Brem.) Thom and Church ..	—	4"	—	—	—	10"	—	—	—	—	—	—
27. <i>A. luchuensis</i> Inui ..	—	12"	—	—	—	—	—	—	—	—	—	—
28. <i>Penicillium frequentans</i> Westl. ..	4"	—	—	2"	—	—	—	—	—	—	—	—
29. <i>P. funiculosum</i> Thom ..	—	—	2"	6"	—	—	—	—	2"	—	—	—
30. <i>P. brefeldianum</i> Dodge ..	—	10"	—	—	—	12"	6"	—	—	—	—	SS
31. <i>Cladosporium herbarum</i> (Pers.) Link ex Fr. ..	10", 2"	—	—	4"	—	—	—	—	6"	4"	—	2"
32. <i>Trichoderma viride</i> Pers. ex Fr. ..	—	8"	12"	—	—	SS	—	—	—	—	—	SS
33. <i>Hemicola grisea</i> Traaen ..	—	—	—	4"	—	—	—	—	—	10"	—	8"
*34. <i>Torula</i> sp. ..	—	—	—	—	—	—	—	—	—	—	—	8"
35. <i>Gloeosporium</i> sp. ..	—	4"	—	—	—	—	—	—	—	—	—	—
36. <i>Papulospora</i> sp. ..	—	—	—	—	—	2"	—	—	—	—	—	—
37. <i>Fusarium ocyosporium</i> Schlecht ex Fr. ..	10", 6"	—	—	4"	—	12"	—	—	4", 6"	6", 2"	—	SS
38. <i>F. avenaceum</i> (Fr.) Sacc. ..	2"	—	—	—	—	4"	—	—	2"	4"	—	—

* = new records from soil.

— = absence of the fungus.

SS = surface soil.

TABLE II—(contd.)
Microfungi identified in different seasons at various depths

Name of the fungi	Ghugli				Deoria				Ramkola			
	Rainy	Summer	Winter		Rainy	Summer	Winter		Rainy	Summer	Winter	
39. <i>F. rose</i> (Peck) Wollenw.	—	2"	—	—	—	—	—	—	—	—	—	—
40. <i>F. solani</i> (Mart.) Appel and Wollenw.	—	4"	—	—	—	4"	—	—	—	—	—	—
41. <i>F. javanicum</i> Koord	2"	—	—	—	—	10"	—	—	—	—	—	—
42. <i>Fusarium</i> sp.	—	12"	—	—	—	—	—	—	—	—	—	—
*43. <i>Paeclomyces punttonii</i> (Vuill.) Nan-nizzi	—	SS	SS	—	—	10"	SS	8"	—	SS	—	—
44. Bacteria (1, 2, 3, spp.)	2", 4"	—	SS	—	SS	SS	2"	SS	SS	2", 4"	—	SS
45. <i>Mycelia sterilia</i>	10"	—	—	—	6"	—	—	—	—	—	—	—

* = new records from soil.
— = absence of the fungus.
SS = surfaco soil.

soil. *Rhizopus oryzae* was not available from Ghugli soil. Three different species of the genus *Mucor* were also recorded. *Mucor hiemalis* was isolated from Ghugli soil during the summer and winter seasons while it was absent from Deoria and Ramkola soils in all the seasons. *Mucor luteus* was recorded during the summer in Ghugli and Deoria soils only. This shows that high temperature favours the growth of this fungus. The most common species, *Mucor racemosus*, of the temperate region (Himalayan tract) was recorded from Ramkola soil only in the winter season while it was absent from the other two soils. *Cunninghamella echinulata* and *C. verticillata* were isolated during the rainy and summer seasons from Deoria and Ramkola soils while these were not present in Ghugli soil. The maximum number of genera was recorded from the Ramkola region while in the other two regions the number was absolutely the same. This shows that Ramkola soil is rich in sugar fungi. *Circinella mucoroides* is a new record from Indian soil.

2. Cellulose decomposing fungi (Ascomycetes and Fungi Imperfecti):

Ascomycetes.—Only two genera, viz. *Neocosmospora* and *Chaetomium*, were recorded during the course of the present studies. This shows their poor occurrence in Gorakhpur soils.

Fungi Imperfecti.—These constitute the most common fungal flora of cosmopolitan distribution.

The occurrence of *Penicillia* in the soil is poor as compared with that of *Aspergilli* (Waksman 1932; Warcup 1955*b*; Saksena and Sarbhoy 1963). Only three species of *Penicillium* were isolated, the most common being *P. brefeldianum* which was recorded almost in all the soils of Gorakhpur in different seasons.

During the present studies, 10 species of *Aspergillus* were encountered. *Aspergillus niger*, *A. awamori* and *A. terreus* were the most common and dominant species in almost all the seasons from Gorakhpur soils. *Aspergillus nidulans* and *A. ustus* were also isolated from Ghugli and Deoria soils while they were absent from Ramkola soil. *Aspergillus ustus* and *A. phoenicis* were isolated from Ghugli soil only.

Humicola grisea, *Torula* sp., *Gloeosporium* sp. and *Paecilomyces puntonii* were recorded very frequently from various soils. This shows their wide distribution in these soils. *Torula* sp. and *P. puntonii* were new records from the Indian soil.

Trichoderma viride was also obtained from these soils mostly during the winter season. This confirms its wide distribution in India in every type of soil as reported by other workers also (Saksena and Sarbhoy 1963).

The maximum number of *Fusaria* was recorded during the summer in almost all the soils. The authors agree in this respect with Stover (1953), who was of the opinion that a reduction takes place in the ability of *Fusaria* to

survive in soils held at high moisture contents, where the multiplication of soil bacteria is favoured at the expense of the nutrient and oxygen supplies of soil fungi.

Only one species of *Mycelia sterilia*, viz. *Papulospora* sp., was identified by the authors.

The maximum number of fungi was isolated by Warcup soil plate and dilution methods.

The pH of these soils generally ranged between 7.0 and 8.6. The authors isolated 45 different species of fungi in all the seasons. The maximum number of species was recorded during the summer and winter in Ghugli and Ramkola soils respectively.

Carbon, nitrogen, phosphorus, calcium, etc., were found important for the growth and sporulation of microfungi and in the absence of any one of these the soil population is markedly affected as reported by Waid (1957), Chesters (1960) and Saksena and Sarbhoy (1963), and the findings of the authors in the present study were similar.

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