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Plant Pathology

FUNGAL DECOMPOSITION IN RELATION TO CARBON DIOXIDE EVOLUTION IN A TROPICAL SAL FOREST BIOME*

by R. S. DWIVEDI *and* A.N. SHUKLA, *Department of Botany, Banaras Hindu University, Varanasi* 221 005

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Fungal decomposition of litter and the total soil respiration at monthly intervals were studied over one year in Chakia Sal forest of Varanasi, by placing litter in nylon-litter bags. Phycomycetes were isolated in the initial stages, which were later replaced by cellulose decomposing ascomycetous and deuteromycetous fungi. A white felt of basidiomycetous mycelium was frequently observed in litter layers. CO_2 evolution during the process of litter decomposition, was correlated with the temperature and the fungal population. Respiration rate from soil excelled that from litter in all the months except in August and September when the litter respiration exceeded.

INTRODUCTION

In a deciduous forest ecosystem the primary producers and the decomposers compose almost 95% of the total biomass (Odum, 1971). Misra (1969) estimated that in a tropical deciduous forest dominated by *Shorea robusta* (Gaertn.) the litter fall was 7000 kg^{-b}/year. The mycoflora plays an important role in the cycling of mineral nutrients from decomposing plant tissue. Their two-fold action i.e., breaking down of complex organic compounds and trapping of the released elements in the fungal bodies, prevents the elements from leaching and balances the ecosystem (Witkamp, 1969). Breaking down of litter during decomposition is followed by the release of CO_2 in aerobic conditions and rate of CO_2 evolution is generally accepted as a measure of metabolic activity in soil (Witkamp, 1966). There is little information on decomposition, succession of fungi and soil and litter respiration in natural forest conditions in this country. The present study was aimed at studying the decomposition by microfungi inhabiting Sal leaf litter and the evolution of CO_2 from forest floor in different seasons.

MATERIALS AND METHODS

The site of work was selected in a dense *Shorea robusta* forest about 90 km south-east of Varanasi in the Bhansora range. A pit of $150 \times 100 \times 10$ cm was dug

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and 40 nylon litter bags (mesh size 1 mm²) of 25 × 20 cm were filled with 100g air-dried Sal leaf litter and their openings closed by metal pins. The bags were arranged horizontally at the bottom of the pit. The litter bags were then closed with dried Sal litter, twigs and some soil to minimize the activities of biotic factors in the forest.

Samples of litter from nylon bags were collected at monthly intervals; 3 bags were picked at random basis, placed in plastic bags and brought to the laboratory. Some soil and litter collected from 50 different places in the forest was also brought to the laboratory in separate plastic bags. The microfungi were studied for a year starting from July 1973, employing the methods described by Hudson and Webster (1958), Dwivedi (1965), Hogg and Hudson (1966) and Ruscoe (1971) and designated under following heads:

(i) Direct observation of litter samples: The litter from the nylon bags and from the forest floor was observed under a binocular microscope and the fungi on the surface of the litter were recorded.

(ii) Damp chamber incubation: Five mm litter discs cut from the unsterilized litter by a cork borer, were placed in petridishes containing a wet and sterilized pad of blotting paper. The plates were incubated at 26°C for 15 days and fungi sporulating on the discs were recorded.

(iii) Dilution plate method : Dilution plate technique was employed for the isolation and identification of mycoflora on leaf litter. The litter from nylon litter bag was fragmented into small bits and 10 g of it was suspended in 100 ml sterilized distilled water. Further dilutions of this suspension upto 10^6 were prepared and 1 ml of each dilution was poured in sterilized Petri plates. Czapek-Dox-Yeast Extract agar (*p*H 5.5+ streptomycin 185 μg ml^{-1}) was used as nutrient medium. All the plates were incubated at 25±1°C for a week and fungi were recorded.

This experiment was done in triplicate and repeated at least twice.

Soil Respiration and CO_2 Measurement

Respiration studies were performed from July 1973 to June 1974. Inverted metal boxes (height 18 cm, diameter 14 cm) were used for trapping the flux of carbon dioxide from soil and decomposing litter fragments separately (Macfadyen 1973; Witkamp, 1969). Dishes containing 20 ml KOH solution were placed over the soil and litter fragments and were tightly covered with inverted boxes. Neutralization of KOH was allowed only upto 60 per cent, based on predetermination and the normality of the solution in each month was adjusted accordingly between 0. 1–0. 5N, which continued for 4 hr and the final conclusion was arrived at after titrating KOH against 0 1N HCl, using 1 per cent alcoholic phenolphthalein as an indicator. This experiment was set in three replicates each for litter and soil. The temperature of soil was measured by a soil thermometer. To avoid diurnal variations of temperature, all the experiments were dismantled at 16.00 hr.

RESULTS

A total of 8 fungi were recorded in direct observation of litter. White basidiomycetous mycelia were noted to be prevalent in all the months except in summer. In case of damp chamber incubation method, a total of 10 fungi were recorded from the average of 50 litter discs placed on damp blotting paper (Tables I and II).

TABLE I

Fungal colonies present on the litter as observed under binocular microscope (direct observation method)

Name of the fungi	Months											
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Dark fumegoid mycelium	+	+	+	−	+	+	−	−	−	−	−	−
White basidiomycetous mycelium	+	+	+	+	+	+	+	+	−	+	−	−
Chaetomium globosum	−	−	−	+	+	+	−	−	+	−	−	−
C. spirale	−	+	−	+	+	−	−	+	−	+	−	−
Memnoniella sp.	−	−	−	+	−	+	+	−	−	−	−	−
Aureobasidium pullulans	+	−	−	−	−	+	−	+	−	−	+	−
Beltrania rhombica	−	−	+	−	−	−	−	−	−	−	−	−
Gyrothrix circinata	−	+	+	−	−	−	−	−	−	−	−	−

A total of 54 fungi were isolated by the dilution plate technique and brought into pure culture (Table III).

Table IV depicts the measurements of CO_2 evolving from soil and litter in different months along with the soil temperature of the respective months.

DISCUSSION

Leaves before they fall on the ground are initially colonized by various saprophytic and parasitic phyllosphere fungi and further colonization by fungi depends mostly on climatic conditions and the nature of substrate. Tables I and II reveal only little colonization of fungi in March and April. Under dry weather conditions in May and June the litter remained more or less intact. As the moisture conditions became favourable, the litter was invaded by a large number of microfungi. Due to the activities of earthworms, termites and micro-arthropods, which were observed in the present study, the litter was transformed into moribund tissue.

TABLE II

The number of fungi recorded on an average of 50 litter discs by damp chamber incubation technique (in % frequency class)

Name of the fungi	Months											
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Dark fumegoid mycelium	1	—	1	2	—	1	—	1	—	—	—	—
White basidiomycetous mycelium	4	3	1	2	3	2	2	1	1	—	—	1
White unseptate mycelium	2	2	1	1	—	—	—	—	—	—	—	—
Chaetomium globosum	—	—	—	1	1	1	—	—	—	—	—	—
C. spirale	—	—	1	2	1	1	—	—	1	—	—	—
Aureobasidium pullulans	1	1	1	1	—	—	—	—	—	—	—	1
Pestalotia mangiferae	1	2	3	1	1	—	—	—	—	—	—	1
Gyrothrix circinata	—	—	1	—	—	—	—	—	—	—	—	—
Beltrania rhombica	—	1	1	—	—	—	—	—	—	—	—	—
Tetraploa sp.	1	—	1	—	—	—	—	—	—	—	—	—

In the initial stages the litter was colonized by non-septate white phycomycetous mycelia along with the white basidiomycetous ones and dark mycelial forms. Certain other genera viz., *Chaetomium globosum*, *Memnoniella* sp., *Aureobasidium pullulans*, *Beltrania rhombica*, *Gyrothrix circinata*, *Pestalotia mangiferae* and *Tetraploa* sp. were recorded by direct observation method (Tables I and II).

A comparatively large number of fungi were recorded by dilution plate technique on the litter amongst which some aspergilli and penicillia were the most prevalent ones throughout the year followed by some fusaria and sterile white and dark mycelia. Phycomycetes were represented by only *Rhizopus nigricans*, *Syncephalastrum racemosum* and *Cunninghamella elegance*. Certain deuteromycetous genera like *Vasudevella sporoboli*, *Pestalotia mangiferae*, *Dictyoarthrinium* sp., *Robillarda phragmitis*, *Pseudotorula* sp., *Humicola grisea* and *Curvularia lunata* were recorded by dilution plate technique, which could not be observed by direct observation method. *Aureobasidium pullulans*, a dominant common phyllosphere fungus, persisted throughout on the decomposing litter (Table III).

The increase of temperature from January onward kept pace with the increase in the soil respiration. The maximum value was recorded in August. In September, soil respiration was considerably reduced, which again increased in October, but later reduced with the decrease in temperature. The reduced soil respiration in May may be due to an increase in soil temperature which might have caused reduction in the microbial population (Table IV).

TABLE III

Frequency of the mycoflora inhabiting litter on nutrient medium by dilution plate technique

Name of the fungi	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Aspergillus niger	5	5	5	5	4	4	5	4	5	4	5	5
A. luchuensis	5	2	5	4	1	—	3	—	2	—	2	5
A. flavus	3	—	—	—	—	2	—	2	—	3	4	—
A. terreus	—	—	—	—	1	2	—	—	—	—	—	—
A. violaceofuscus	2	—	—	—	—	—	3	—	—	—	—	5
A. humiucola	2	3	—	—	—	1	—	2	—	—	—	—
A. chievalieri	3	5	5	4	5	5	5	5	5	—	—	2
A. candidus	—	3	—	2	—	—	—	—	2	—	—	—
A. variecolor	—	2	—	—	—	—	—	2	—	—	—	—
A. famigatus	—	—	—	—	—	—	—	—	4	2	3	5
Emericella nidulans	—	4	1	5	—	4	2	3	5	—	2	2
Trichoderma album	1	—	—	—	1	1	—	—	—	—	—	—
T. lignorum	4	2	5	5	4	1	4	—	5	—	—	5
T. koningii	5	2	5	5	3	1	5	—	2	—	—	1
Penicillium citrinum	—	3	2	1	—	—	—	—	—	—	—	—
P. rubrum	2	2	2	—	1	3	2	—	—	—	—	—
P. diversum	—	4	—	—	—	—	—	—	—	—	—	—
P. roseopurpureum	—	2	—	—	3	—	2	—	—	—	—	—
P. subtilissimus	—	2	—	—	—	—	—	—	—	—	—	—
P. purpurogenum	—	—	—	—	—	1	3	—	—	—	—	—
P. funiculosum	—	1	1	—	—	4	—	—	—	—	—	—
Penicillium sp.	—	2	—	—	1	1	2	—	—	—	—	—
Chaetomium globosum	—	—	—	1	2	—	1	—	—	—	—	—
C. spirale	—	—	—	2	1	1	1	—	—	—	—	—
Dictyoarthrinium sp.	—	—	—	1	—	—	—	—	—	—	—	—
Pestalotia mangiferae	—	3	1	—	1	5	3	2	3	—	—	—
P. macrotricha	—	—	—	2	4	—	3	2	2	3	—	—
Alternaria tenuis	—	2	—	1	—	—	—	—	—	1	—	—
Sarcinella sp.	—	2	—	—	—	—	—	—	—	—	—	—
Monilia brevis	—	2	—	—	—	1	—	2	—	—	—	—
Discosia sp.	—	3	—	—	—	2	4	—	3	—	—	—
Macrophoma sp.	—	2	—	—	1	—	—	—	—	—	—	—
Vasudevella sporoboli (Strain 1)	—	—	1	5	5	2	2	2	4	—	—	—
Vasudevella sporoboli (Strain 2)	—	—	—	2	1	4	3	—	—	—	—	—
Mucor mucedo	1	2	—	2	—	—	—	—	—	—	—	—
Rhizopus nigricans	1	1	—	—	—	—	—	—	—	2	—	—

TABLE III (*Contd.*)

Name of the fungi	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
R. oryzae	—	1	—	—	—	3	—	—	—	—	—	—
Syncephalastrum racemosum	1	2	—	1	—	—	—	—	—	—	—	—
Cunninghamella elegance	2	1	1	—	—	—	—	—	—	—	—	—
Phoma hibernica	—	—	—	—	—	—	—	4	—	—	—	—
Sphaceloma ampelinum	—	—	—	—	—	1	2	2	—	—	—	—
Curvularia lunata	—	—	2	—	1	—	—	2	—	—	—	—
Robillarda phragmitis	—	—	—	—	2	—	—	2	—	—	—	—
Pseudotorula sp.	—	—	—	—	—	—	2	—	3	—	—	—
Fusarium poae	—	—	—	—	2	—	—	—	—	—	—	—
F. roseum	—	—	—	—	—	1	—	—	2	—	—	—
F. chlamydosporum	—	—	—	—	1	—	—	—	—	—	—	—
Aureobasidium pullulans	—	—	—	—	1	—	—	—	2	2	3	—
Humicola brevis	—	—	—	—	1	—	—	—	—	1	—	—
H. grisea	—	—	—	—	1	—	—	—	—	—	—	2
White sterile mycelia	3	—	2	4	5	—	3	—	3	—	—	3
Dark sterile mycelia	2	4	2	—	3	3	2	2	5	1	—	3
Grey sterile mycelia	—	—	—	—	—	—	3	—	—	—	—	—
Total number of fungi	18	29	15	19	27	23	24	16	17	9	6	12

TABLE IV

Measurement of CO_2 $m^{-3}h^{-1}$ evolving from soil and litter layers during different months of decomposition

Month of sampling	CO_2 evolving from soil	CO_2 evolving from litter	Soil temp. (°C)	Number of fungi
July 1973	1040	1040	35·0	18
Aug. ,,	1152	1173	33·3	29
Sept. ,,	646	775	31·0	15
Oct. ,,	756	735	30·0	19
Nov. ,,	525	480	23·0	27
Dec. ,,	465	372	18·0	23
Jan. 1974	334	281	15·0	24
Feb. ,,	556	484	19·4	16
Mar. ,,	746	668	26·7	17
Apr. ,,	851	814	35·0	9
May ,,	756	740	38·8	6
June ,,	825	810	36·6	12

The highest peak of CO_2 evolution and fungal population was observed in August. The other peaks of CO_2 evolution and fungal population were recorded in October and November respectively. Table IV shows that there was always higher respiration rate in the soil layer than in the litter layer from January to June. In July respiration rate of soil and litter was almost the same while in August litter respiration surpassed soil respiration. This study provides an evidence of the possible role of mycoflora contributing in total CO_2 evolution and hence the total energy flow model between soil respiration and temperature.

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