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Soil Respiration and Microbial Population in Potato Field

A. K. Shukla, B. K. Tiwari and R. R. Mishra
Department of Botany, School of Life Sciences
N. E. Hill University, Shillong 793 014

Abstract

Physico-chemical factors, soil respiration, fungal and bacterial population of three potato field soils were estimated for two crop cycles at ten days intervals. Maximum fungal and bacterial population, soil respiration, organic carbon, total nitrogen, phosphorus were recorded in valley land soil. Soil respiration significantly correlated with microbial population. Mycoflora of three field did not differ significantly. **Mucor** spp., **Fusarium** spp., **Penicillium** spp. and **Trichoderma** spp. were dominant fungi in all the three agricultural systems.

Introduction

The microorganisms perform a vital role in the soil as they are responsible for the decomposition of the organic matter and they play an important role in the transformation of various nutrients from non-available to available forms. Thus, microorganisms hold a key position in the nutrient cycle and functioning of soil ecosystem. Soil respiration is another index of microbial activity (Chaney *et al.*, 1978), as most of the CO_2 evolved from soil comes from microbial respiration (Smith and Brown, 1932). It also provides a measurement of microbial number and the rate at which soil organic matter is broken down. A perusal of literature reveals that our knowledge on the ecology of soil microorganisms is largely based on research in forest and grassland soil (Lewis *et al.*, 1971 ; Widden, 1979). Microbiological studies of agricultural soils have received less attention and studies available on the subjects are mainly concerned with the effect of various agricultural practices namely tillage, manuring, fertilizer application and type of crop on the soil microbes (Soderstrom *et al.*, 1983 ; Bolten *et al.*, 1985).

The aim of present study was to survey the soil properties and assess the effect of these environmental factors on microbial population and soil respiration by calculating correlation coefficient in three different agricultural field soils.

Material and Methods

The study was carried out at Upper Shillong (altitude 1706-1730 m, latitude 25°34'N and longitude 91°56'E). Three different cultivation methods are prevalent

which are adapted by the farmers depending on the topography and availability of the land. In one type farmers adopt slash and burn type of shifting cultivation mostly on the hillocks (slope land). The second type is done on bench terraces, which made on hill slopes. Between the hillocks some plain land are found and on these lands permanent type of cultivation is done and it is known as valley land.

Soil samples were collected from three potato fields. Sampling was done at 10 days interval for two crop cycles from 10th September 1985 to 20th November 1985 and 10th September 1986 to 20th November 1986. The soil samples were collected from three depths (0-10, 10-20, 20-30 cm). All the estimations concerned with microbial population and activity were carried out within 24 hours of collection. Soil temperature was noted using soil thermometer at the time of collection. pH was measured by glass electrode (soil : H_2O, 1:5). The CO_2 evolution was measured by absorption and titration method using Phenolphthalein indicator (Macfadyen, 1970). A suitable control was also used for substraction of the atmospheric CO_2. Soil plate method was followed for the assessment of fungal population as it gives more precise information based on a wide range of fungal species. Martin's rose bengal agar medium was used for maintaining the culture. Dilution plate method was followed for estimation of bacterial population using nutrient agar medium. Organic carbon and total nitrogen were determined by Walkley and Black (1934) titration and microkjeldahl method (Allen, 1974) respectively. Sulphomolybdic acid method was followed for the estimation of phosphorus (Jackson, 1973). Potassium was determined by flame photometer method using ammonium acetate extraction solution (Jackson, 1973).

Results and Discussion

Maximum concentration of mineral nutrients was recorded in valley land soil followed by terrace and slope land soil (Table I). The number of fungi per gram dry soil was maximum in valley land and minimum in hill slope land soil. In depthwise studies the population was always highest in surface soil and it decreased along with depth. In valley land, a maximum of 3672 fungal propagules g^{-1} dry soil was recorded in the surface soil and a minimum of 1252 fungal propagules g^{-1} dry soil was recorded in the 20–30 cm deep soil. In terrace land soil surface layer contained maximum 3496 fungal propagules g^{-1} dry soil and minimum 760 fungal propagules g^{-1} dry soil in 20-30 cm deep soil. In hill slope land soil the fungal population ranged between 3093 and 930 fungal propagules g^{-1} dry soil. The number of bacteria per gram of dry soil was maximum in terrace land soil which was followed by the valley land and hill slope land soil (Table I). The fungal and bacterial population of soil decreased with increased in depth can be attributed to the less

TABLE I

Soil respiration, microbial population and physico-chemical characters of potato field

Soil		Soil temperature (°C)	Moisture content (%)	pH	Organic C(%)	Total N(%)	Available P(%)	Exchangeable K(%)	Fungi (g^{-1} dry soil)	Bacteria $1x10^5$ (g^{-1} dry soil)	CO_2 evolution (mg kg^{-1} dry soil)
Valley land	1985	16.9	41.8	4.5	3.1	0.11	0.04	0.01	2280	12.2	75.8
	1986	15.8	38.5	4.1	3.5	0.12	0.04	0.03	2330	11.8	71.8
Terrace land	1985	17.8	32.5	4.8	2.7	0.08	0.04	0.05	2270	13.3	66.5
	1986	18.6	35.1	4.2	2.7	0.09	0.04	0.06	1933	14.5	63.4
Slope land	1985	17.6	31.0	4.7	1.5	0.05	0.01	0.02	1988	11.3	66.0
	1986	17.8	22.8	4.2	1.0	0.06	0.01	0.04	1512	10.4	59.4

Results are overall means of 8 collections and three depths of soil, each composed of three replicate samples.

amount of nutrients and reduced aeration. Generally, total microbial population was highest in the month of October at the middle age of plants. It might be due to favourable factors (N, P, K) and also due to possible increase in the root exudation (Rovira, 1956). The maximum fungal population in valley land might be due to high concentration of organic carbon, nitrogen, phosphorus and potassium as compared to terrace and hill slope land.

Twenty six species of fungi were isolated from valley land soil (Table II). In valley land soil, *Absidia glauca*, *Rhizopus oryzae* and *Emmonsiella capsulata* were isolated only from the surface layer (0–10 cm), while *Alternaria alternata* and *Phoma* sp. were isolated only from the middle layer (10-20 cm). *Monilia* sp., *Penicillium funiculata* and *Trichoderma harzianum* were recorded only from 20–30 cm depth soil. *Fusarium* sp., *Mucor hiemalis*, *M. racemosus*, *Penicillium brevicompactum*, *P. chrysogenum* and *Trichoderma viride* were common in all the three depths. Twenty one species were isolated from terrace land soil. *Alternaria alternata*, *Humicola fuscoatra* and *Penicillium fellutanum* were isolated only from surface (0–10 cm). *Penicillium canescens*, *P. brevicompactum* and *Pythium* sp. were isolated from 20–30 cm depth soil. *Mucor plumbeus*, *Penicillium chrysogenum* and *Trichoderma viride* were dominant in middle layer soil. Twenty seven species were isolated from hill slope land soil. *Arthrobotrys arthrobotryodes*, *Oidiodendron echinulatum*, *Penicillium canescens*, *P. citrinum* and *Phoma* sp. were isolated only from middle layer (10–20 cm), while *Rhizopus oryzae*, *Trichoderma koningii* and *Verticillium chlamydosporum* were isolated only from 20–30 cm depth. *Trichoderma viride* and *Mucor racemosus* were dominant fungi in surface soil while *Mucor racemosus* was dominant in middle layer soil. Mycoflora of the three fields did not differ significantly. *Fusarium oxysporum*, *Mucor plumbeus*, *M. racemosus*, *Penicillium brevicompactum*, *P. chrysogenum* and *Trichoderma viride* were the common fungi in all the fields. Species of *Mucor*, *Pencillium* and *Trichoderma* seem to be tolerant to a wider range of environmental conditions as they were recorded from all the three different agricultural soils. *Penicillium*, *Fusarium*, *Trichoderma* and *Mucor* have been earlier reported to be the dominant fungi in cultivated soils (Mishra and Kanaujia, 1973).

Maximum output of CO_2 was recorded from valley land soil followed by terrace land and hill slope land soil. The highest soil respiration and fungal and bacterial population was noted in the month of October in all the three systems. In valley land soil respiration was significantly correlated with soil temperature, moisture content, nitrogen, phosphorus, fungal and bacterial population. In terrace land soil it correlated with soil temperature, moisture content, organic carbon, N, P, K and fungal population. In hill slope land soil correlated with soil temperature, moisture content, nitrogen, phosphorus, fungal and bacterial population. In terrace land soil it correlated with soil temperature, moisture content, organic carbon, N, P, K and fungal population. In hill slope land soil correlated with soil temperature, moisture

TABLE II

List of fungi and mean of 8 collections (10 Sep.-20 Nov.) for two crop cycles (1985-1986) per gram dry soil x 10^2 in valley land, terrace land and slope land soil

Fungal species	Valley land			Terrace land			Slope land		
	10cm	20cm	30cm	10cm	20cm	30cm	10cm	20cm	30cm
1	2	3	4	5	6	7	8	9	10
Aosidia corymbifera	—	—	—	1.8	4.8	2.2	3.0	4.0	3.3
Absidia glauca	2.3	—	—	—	—	—	—	—	—
Arthrobotrys arthrobotryoides	—	6.5	—	0.7	—	—	—	—	—
Aspergillus alulaceous	—	—	0.5	—	—	—	—	2.1	—
Aspergillus flavus	—	2.1	3.8	2.8	0.5	3.5	1.0	2.5	2.6
Aspergillus niger	0.5	3.3	0.3	6.6	4.0	6.7	3.8	3.8	—
Emmonsiella capsulata	1.6	—	—	—	—	—	—	—	—
Fusarium oxysporum	5.7	2.1	2.0	7.2	4.8	2.8	9.6	7.7	6.7
Fusarium poae	3.3	3.5	6.0	8.3	9.1	5.0	—	—	3.6
Fusarium solani	1.0	3.1	0.4	—	—	4.9	3.6	3.3	—
Humicola fuscoatra	—	—	—	1.8	—	—	—	—	—
Monilia sp.	—	—	0.3	4.7	5.8	7.3	3.8	2.7	2.8
Mortierella minutissima	4.1	6.0	1.9	—	1.0	2.5	1.5	1.5	3.6
Mucor cercenelloides	1.6	—	1.8	0.7	1.5	—	—	—	—
Mucor hiemalis	5.5	5.3	4.6	3.4	2.5	2.2	5.8	7.5	7.0
Mucor mucedo	—	0.4	1.3	0.7	—	6.6	—	—	—

(Table II continued)

1	2	3	4	5	6	7	8	9	10
Mucor plumbeus	10.6	5.0	5.0	10.1	10.3	7.7	9.4	4.5	4.2
Mucor racemosus	20.5	15.1	16.8	7.7	4.5	6.5	14.1	13.4	12.8
Oidiodendron echinulatum	—	—	—	—	—	—	—	1.0	—
Penicillium brevicompactum	10.5	3.5	—	6.0	12.1	13 6	4.1	4.3	3.9
Penicillium canescens	—	—	—	3.6	3.6	—	—	0.8	—
Penicillium chrysogenum	10.4	19.3	15.8	12.9	9.7	7.5	10.7	12.2	12.2
Penicillium citrinum	—	—	—	—	—	—	—	3.7	—
Penicillium fellutanum	—	3.3	3.2	10.0	—	2.7	—	2.2	7.1
Penicillium funiculata	—	—	0.2	—	—	—	—	—	—
Phoma sp.	—	2.7	0.5	—	0.6	0.6	2.0	2.9	—
Rhizopus oryzae	0.8	—	—	—	—	—	—	—	3.0
Trichoderma hamatum	—	—	—	—	—	—	—	1.8	1.5
Trichoderma harzianum	—	—	2.0	—	0.8	0.5	3.3	3.1	3.1
Trichoderma koningii	—	—	—	—	—	—	—	—	0.7
Trichoderma viride	4.9	8.9	11.8	11.8	10.1	8.8	15.5	9.3	10.6
Verticillium ehlamydosporum	—	—	—	—	—	5.2	1.5	—	—
Sterile soil	14.0	13.3	9.5	2.7	7.7	2.9	8.0	2.3	4.0

content, N, P, fungal and bacterial population (Table III). Soil respiration is influenced by microbial count, organic carbon and inorganic nutrients (Stroo and Jencks, 1982). Maximum soil respiration was recorded in upper soil and as depth increased the respiration decreased. The results showed that CO_2 evolution from soil is more related to the fungal population than bacterial population confirming the results of earlier workers (Baruah and Mishra, 1983). The organic carbon was found to be the strongest predictor of CO_2 evolution from soil by Stroo and Jencks (1982). However, in the present study the total nitrogen content of soil was the most important factor influencing the rate of soil respiration.

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TABLE III

Simple correlation coefficient (r) values between soil viable plate counts, respiration and soil properties

	Valley land			Terrace land			Slope land		
	Fungi	Bacteria	Carbon dioxide	Fungi	Bacteria	Carbon dioxide	Fungi	Bacteria	Carbon dioxide
Temperature	0.54*	0.47*	0.70*	0.35‡	N.S.	0.55*	N.S.	0.45†	0.49*
Moisture content	N.S.	N.S.	0.31‡	N.S.	N.S.	0.29‡	0.49†	N.S.	0.45†
pH	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	0.30‡	N.S.	N.S.
Organic C	0.79*	N.S.	N.S.	0.43†	0.53*	0.44†	0.28‡	N.S.	N.S.
Total N	0.79*	0.72*	0.65*	0.83*	0.30‡	0.80*	0.55*	0.85*	0.63*
Available P	0.75*	0.74*	0.68*	0.78*	0.62*	0.72*	0.56*	0.82*	0.58*
Exchangeable K	N.S.	N.S.	N.S.	0.44†	0.59*	0.28‡	N.S.	N.S.	N.S.
Fungi	—	0.69*	0.77*	—	0.40†	0.81*	—	N.S.	0.66*
Bacteria	—	—	0.58*	—	—	N.S.	—	—	0.72*

‡, †, * Indicate significance at the 0.05, 0.01 and 0.001 level, respectively.
Degrees of freedom, 47.

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