

Temporal and Depth-wise Variations in CO₂ Evolution and Microbial Population in Pineapple-Plantation Soils

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Abstract

Monthly variation and depth-wise distribution of microbial population and CO₂ evolution in pineapple-plantations were studied for a period of one year. The study was conducted on one year, 5 years and 10 years old plantations. Higher fungal and bacterial population and CO₂ evolution were recorded from surface (0-10 cm) soils in all the three plantations. Lower values of fungal population were recorded during the winter months. Two peaks in bacterial population, one in September and another in April or May were recorded. Surface soil generally showed higher values of fungal and bacterial population, and CO₂ evolution which decreased with increase in depth. Almost similar pattern of variation of fungal and bacterial population, and CO₂ evolution were observed in all the three plantation soils; CO₂ evolution was found maximum during winter season. Correlation coefficients among various parameters have been estimated. Soil moisture, temperature, pH and organic carbon were found to be the most important factors governing the temporal and depth-wise variation in fungal and bacterial populations and CO₂ evolution.

Introduction

Carbon dioxide evolution has been used as an index of microbial activity of agricultural and forest soils (Julia and Pedziwilk, 1985; Stotzky, 1960; Smith and Brown, 1932). CO₂ is usually the sole carbon source for chemoautotrophs and photoautotrophs, and is also required as a supplementary carbon source by most heterotrophs living in soils. Owing to the variations in the microbial activity the CO₂ concentrations in the soil environments also varies in space and time (Buyanousky and Wagner, 1983; Enoch and Dasberg, 1971). CO₂ content of soil affects the soil pH, nutrient availability, redox potential, species-composition and number of soil microbes (Bohn *et al.*, 1979; Alexander, 1977).

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CO₂ evolution has been found to be closely related to various soil characteristics *viz.*, organic carbon content, microbial population, nitrogen transformation, litter decomposition and enzyme activities (Singh and Gupta, 1977; Baruah and Mishra, 1983; Orchard and Cook, 1983; Singh, 1984; Keeney *et al.*, 1985; Cropper *et al.*, 1985). Das and Mishra (1986) found that the rate of CO₂ evolution is more precise index of microbial activity than that of the dehydrogenase activity. Most of the studies on CO₂ evolution and microbial populations were done in forest, grassland and agricultural soils (Keeney *et al.*, 1985; Evi and Pae, 1984; Kostva and Tsilosani, 1985). The soils of horticultural crops differ to a great extent from the above in physical, chemical and biological characteristics as neither of these soils are tilled annually nor left fallow for a very long time. Population and activities of the microbes of soils under horticultural crops have not received sufficient attention (Pavlenko, 1985).

The purpose of the present study was to work out temporal and depth-wise variations in microbial populations and CO₂ evolution, in pineapple plantations soils. Attempt has also been made to study the interrelationship among microbial activity estimates and physico-chemical characteristics of the soils.

Material and Methods

The study was conducted at the Pineapple Research Station, Nayabaunglow (Altitude 800 M, Latitude 25°44'N, Longitude 91°53'E). Soil was of sandy loam type containing 66.68 per cent sand, 15.77 per cent silt, 17.4 per cent clay. Ambient temperature, rainfall and humidity of the study area are given in Fig. 1.

The growers of this region quite often maintain the crop upto a period of ten years after plantation. It was thought desirable to study, whether soil microbial characteristics are altered with the continuous cultivation of pineapple for ten years. With this objective pineapple plantations of three ages *viz.*, 1 year, 5 years and 10 years old were selected for the study.

Soil samples from 0-10, 10-20 and 20-30 cm depth were collected at monthly intervals using a sterilized soil sampler. Soil temperature was noted at the time of soil sampling. Moisture content was estimated on W/W basis by drying soil at 105°C for 24 hours. pH was determined using electric digital pH meter in 1 : 5 soil water suspension.

Warcup's (1950) soil plate method was used for the estimation of the fungal population developing on Martin's (1950) rose bengal agar medium. Dilution plate method was followed for enumeration of the bacteria on nutrient agar medium

(Johnson and Curl, 1972). The CO₂ evolution was measured by absorption and titration method using phenolphthalein indicator and 0.1N KOH as absorbant (MacFadyen, 1970). Organic carbon of soil was determined by Walkley and Black's

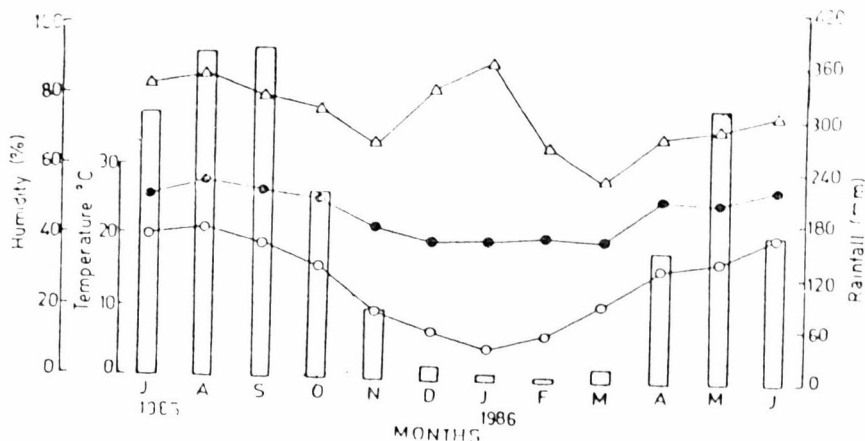


Fig. 1 Monthly variation in rainfall, ambient temperature and relative humidity of the study area. Rainfall : histogram. Maximum temperature : Closed circle, Minimum temperature : Open Circle relative humidity : Open triangle.

(1934) rapid titration method. Three replicates were maintained for each sample and analysis, and the values in tables and figures are the arithmetic means.

Results and Discussion

Higher soil temperature was recorded from surface soil. The soil temperature ranged between 14°C and 30°C (Fig. 2). Moisture content of the soil varied from 13 to 30 per cent (Fig. 2). Higher soil moisture was generally recorded from the surface soil. pH of different plantations varied between 4.2 and 5.9. Higher organic carbon was generally noted from the surface soils of all the plantations. Winter months showed lower organic carbon content. Values of organic carbon content ranged between 0.57 and 2.25 per cent (Fig. 4).

Higher fungal population was generally recorded from surface soil in all the plantations which decreased with increase in depth except during the months of December and January when higher fungal population was recorded from deeper soils (Fig. 3). Low populations were recorded during winter months in all three plantation soils. In many cases fungal populations increased in March which was followed by a drop in April and with a further increase in May.

Reversal in the depth-wise distribution of fungal population during winter (December and January) in all the plantation soil appears to be due to the effect of low temperature (Fig 2) during this period. The effect of low temperature was more pronounced in surface soils and probably due to insulation, fungi of deeper soils were least affected resulting into higher populations in deeper layers. Behera and

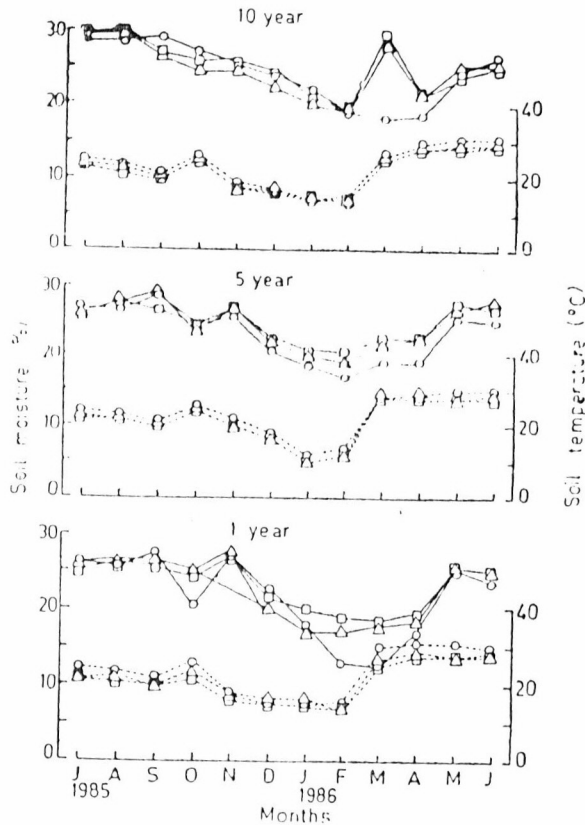


Fig. 2 Monthly variation in percentage soil moisture and soil temperature.
 Soil moisture : Unbroken line, Soil temperature : Broken line
 Circle 0-10 cm, Triangle : 10-20 cm, Rectangle : 20-30 cm depth

Mukerji (1985) ; Baruah and Mishra (1983) and Dwivedi (1965) also found that surface soils harboured higher population of fungi than the deeper layers. Results of the present study are also in concomitant with the observations of above authors except during the winter. Could be the above studies were conducted at lower altitudes where winter temperature did not drop beyond the tolerance limit of the fungi.

Seasonal variation of fungal population may be attributed to the change in soil organic matter, moisture, temperature and pH (Dwivedi, 1966 ; Mishra and Kanaujia, 1972).

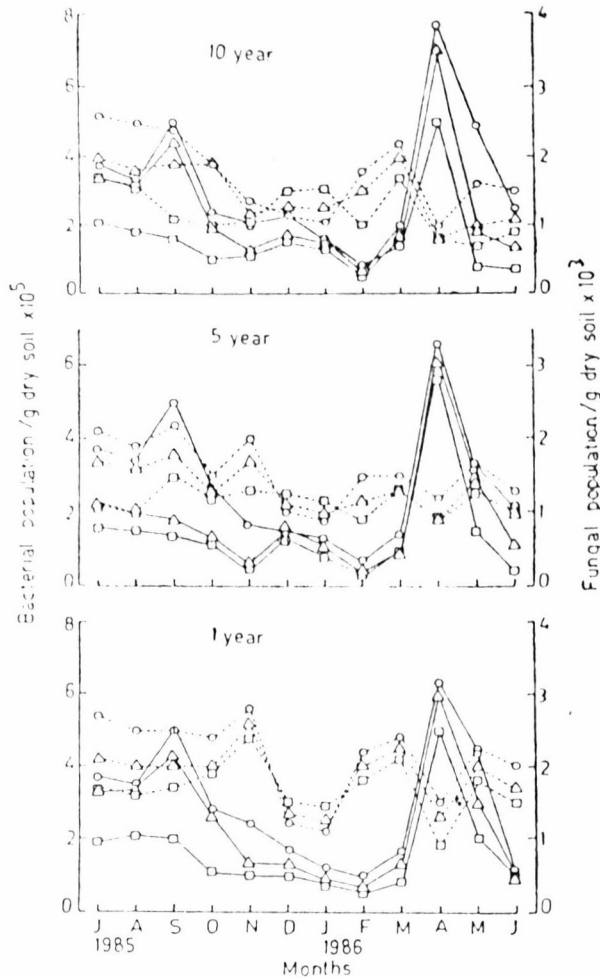


Fig. 3 Monthly variation in fungal and bacterial population of the soils. Unbroken line : Bacteria, Broken line : Fungi symbols as in Fig. 2.

A bimodal bacterial population was recorded during the study period one in September and another in March or April. During winter months the bacterial population depleted to a minimum (Fig. 3). Higher bacterial population was always noted from the surface soil which may be due to a higher organic carbon content and

favourable moisture level (Fig. 2, 4). The same observations were reported by Kauri (1982) and Tate and Terry (1980). In September the higher moisture level at surface soil of all the plantations might be responsible for the increased bacterial population. The drop in winter may be attributed to low temperature and/or depletion of the available soluble organic nutrients. During March and April the higher bacterial population may be due to onset of rains and increased moisture which may

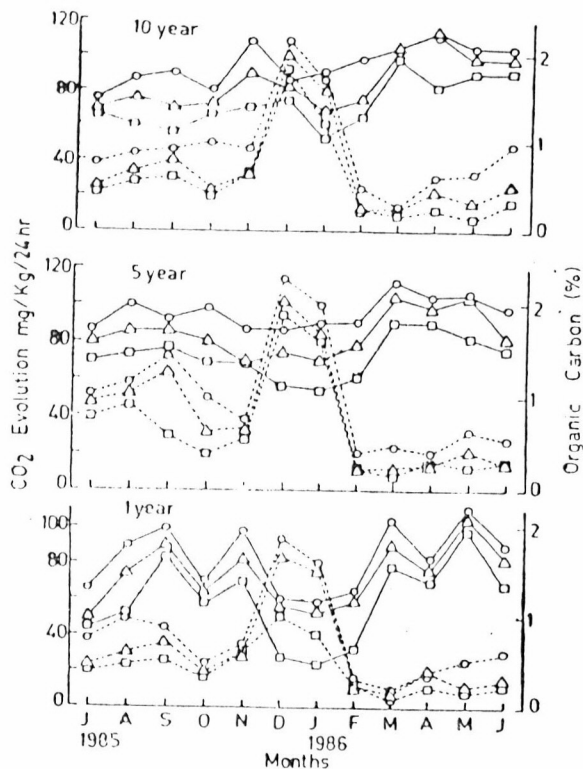


Fig. 4 Monthly variation in CO_2 evolution and organic carbon of the soils. CO_2 evolution : Broken line, Organic carbon : unbroken line, Symbols as in Fig 2.

transfer the soluble organic matter from decomposing plant litters (Fig. 4). Rise in temperature may also be responsible for the increased bacterial population during this period. Bacterial population was found to be positively correlated with soil temperature and pH (Table I).

CO_2 evolution was found to be highest in the surface of soils of all plantations and decreased with increasing depths (Fig. 4). Maximum CO_2 evolution was noted

TABLE I

Correlation coefficient (r) values among various parameters [1] 1 year old plantation, 2) 5 years old plantations and 3) 10 years old plantation]

Parameters		pH	Soil temperature	CO ₂ evolution	% Organic carbon	Bacterial population	Fungal population
% Moisture	1	NS	NS	.225*	NS	NS	NS
	2	NS	.440*	.217*	NS	NS	.557**
	3	.590**	.318*	NS	.525**	NS	.454**
pH	1	NS	NS	NS	.543**	.390*	NS
	2		.365	-.302*	.346*	-.275**	NS
	3		.298*	-.358*	.270*	.552**	NS
Soil temperature	1			-.632**	-.449*	.535*	NS
	2			-.366*	-.533**	.547**	NS
	3			-.405*	-.665**	.503**	-.237*
CO ₂ evolution	1				.452*	-.234*	-.516**
	2				.523**	NS	NS
	3				.358*	NS	NS
% Organic carbon	1					NS	-.491**
	2					.452*	NS
	3					.224*	.314*
Bacterial population	1						-.372*
	2						-.227*
	3						-.268*

Values marked with **, * are significant at 0.005 and 0.05 probability levels respectively.

NS = Not significant.

in December in all the plantation soils. Singh (1984) on the otherhand, reported maximum CO₂ evolution only during rainy summer.

During winter months, the moisture level dropped which increased the aeration of soil favouring the gaseous exchange. While during other periods, the soils contained higher moisture levels which did not allow the CO₂ to escape and may be a part of CO₂ produced during this period was absorbed by the soil water. CO₂ accumulated in the soil water may also evolve during dry winter. During high moisture conditions, the microbial populations might be predominantly composed of anaerobes or facultative aerobes which might have contributed to a low CO₂ output. During winter, bacterial and fungal population were minimum. A part of the carbon-dioxide evolved during winter might have come from the dead or decaying microbes. It appears that CO₂ evolution was not related with the fungal and bacterial populations estimated with the plate culture procedures as CO₂ evolution was maximum during the periods when microbial population was minimum.

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