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The influence of moisture regimes on the population and activity of soil microorganisms

S.C. TIWARI[1], B.K. TIWARI[2] and R.R. MISHRA[1]
[1] *Department of Botany, School of Life Sciences, North-Eastern Hill University, Shillong — 793014 India and* [2] *Department of Botany, St. Anthony's College, Shillong, India*

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Abstract

This paper deals with the influence of soil moisture on the fungal population, bacterial population, CO_2-evolution and dehydrogenase activity. Correlation coefficients of various parameters of the soil with different moisture regimes are given. It is demonstrated that soil moisture significantly alters the microbial population, its activity and the relationships between various parameters.

Introduction

Microbial populations, their activities and biochemical transformations differ widely in soils of various moisture contents. As well as biological characteristics, moisture also influences a number of physico-chemical properties of soil such as redox-potential, pH, O_2 and CO_2 levels *etc.* (Ponnamperuma, 1972) which in turn influence the microbial population and its activity. CO_2-evolution and dehydrogenase activity have been often used as indexes of soil microbial activity (Baruah and Mishra, 1983a, b). Most of the studies concerning soil moisture and microbial population relationships are conducted on monthly and seasonal sampling regimes (Mishra and Kanaujia, 1968). Very few studies are available dealing with the effect of moisture on population and activity of soil microbes over short term intervals. Recently attempts have been made to establish relationships between various microbial populations and activity measurement parameters by several workers (Baruah and Mishra, 1983a, b; Wong, 1975). However, contrasting reports occur in the literature which are mainly attributed to differences in the physico-chemical characteristics of the soils used in various studies. It was therefore, thought useful to study the microbial populations, their activity and relationship to various physico-chemical properties and microbial activity parameters in a soil with different moisture regimes.

Materials and methods

Surface (0–20 cm) soil was collected from the Pineapple Research Station, Nayabaunglow. The soil was air dried at room temperature (25 °C) for 5 days. Field capacity moisture adjustment was achieved by placing the soil of saturation moisture, in a bucket with a perforated bottom for 5 days after which the percentage moisture was determined. For 1/2 field capacity, the moisture was adjusted to half of the field capacity moisture. For waterlogged soil the soil was over saturated, leaving a 0.5 cm layer of water on the surface. Moisture content was estimated on a dry weight basis and it was 5% in air dried soil, 24% for 1/2 field capacity moisture soil, 48% for field capacity moisture soil and 71% in waterlogged soil. Moisture levels were adjusted before the commencement of the experiment. The soils were kept in covered glass containers in the laboratory. Evaporation loss of water was found to be negligible. Minimum and maxi-

mum temperatures of the laboratory were noted during the study period and were 24 °C and 27 °C. Fungal and bacterial population, dehydrogenase activity and physico-chemical characters of the fresh soil sample were determined before the adjustment of the various moisture treatments.

The experimental soil was a sandy loam, containing sand 66.8%, silt 15.74% and clay 17.40%. pH was determined in 1:5 soil water suspension, using a digital electric pH meter. The CO_2-evolution was measured by the method described by Macfadyen (1970). Dehydrogenase activity was assayed by the 2, 3, 5, triphenyl tetrazolium chloride reduction technique (Casida, 1977). Warcup's soil plate method was adopted for estimation of the fungal population using Martin's (1950) rose bengal agar medium. The dilution plate method was used for enumeration of bacteria on nutrient agar medium (Johnson and Curl, 1972). All the analyses were done in triplicate and mean values are given in Tables and Figures.

Results

The pH of the test soil samples remained fairly constant, the minimum value recorded was 4.82 while the maximum was 5.30. Figure 1 shows the variations in fungal and bacterial populations at 24 hours intervals. Higher fungal population was generally recorded in waterlogged soil and lower population was frequently noted in air dried soil except towards the end of the study when a minimum fungal population was recorded in the waterlogged soil. Soil with field capacity moisture and half field capacity moisture showed a more or less similar trend of variation. There was an initial increase in fungal population which stabilized later at a lower population level. The population of bacteria increased rapidly after 24 hours in all moistened soils, while in the case of air dried soil it remained unaltered. During the next 24 hours the bacterial population decreased in all the soils and thereafter remained at a fairly low level and the temporal variations were not statistically significant.

Figure 2 shows the temporal variations in dehydrogenase activity and the cumulative values of CO_2-evolution. It is evident that moisture has a profound influence on the dehydrogenase activity.

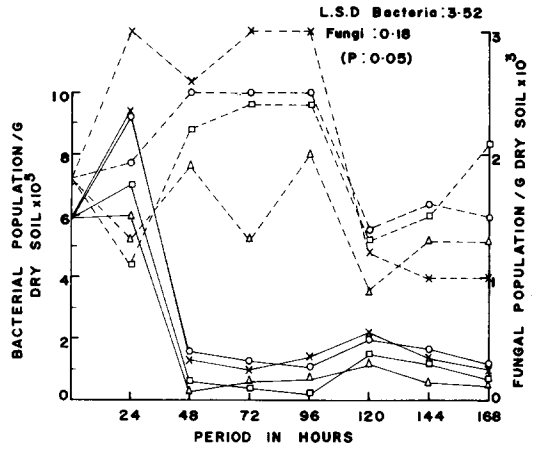

Fig. 1. Variation of fungal and bacterial population at 24-hour intervals in soils of different moisture contents. *Broken line*: fungi, *unbroken line*: bacteria.
△, air dried; □, 1/2 field capacity; ○, field capacity moisture; x, waterlogged.

While in the air dried and 1/2 field capacity soils the activity decreased and stabilized at a very low level, in case of field capacity and waterlogged soils it rose rapidly to a high level. Initially, the amount of CO_2 evolved from the soils was highest but decreased with time. In the case of the soil at field capacity the CO_2 was evolved upto 144 hours after the treatment, however, in other treatments CO_2-

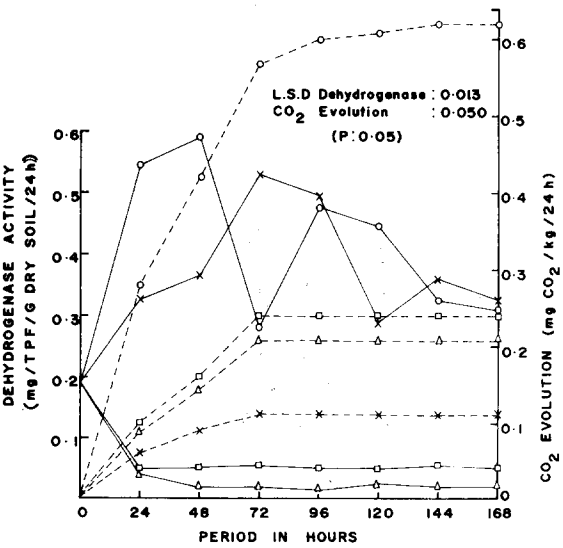

Fig. 2. Variation of CO_2-evolution and dehydrogenase activity at 24-hour intervals in soils of different moisutre contents. *Broken line*: CO_2 evolution, *unbroken line*: dehydrogenase activity. Symbols as in Fig. 1.

Table 1. Correlation coefficient (r) values of various parameters of Air Dried[1], 1/2 Field Capacity Moisture[2], Field Capacity Moisture[3] and Waterlogged[4] soils

		CO_2 evolution	Dehydrogenase activity	Bacterial population	Fungal population
pH	1	0.710**[a]	0.804***	0.803***	NS
	2	NS	NS	NS	NS
	3	NS	−0.791***	−0.638**	−0.728**
	4	NS	NS	NS	−0.707**
CO_2 evolution	1		0.641**	0.635**	NS
	2		NS	0.583*	NS
	3		NS	0.784***	0.831***
	4		NS	0.827***	0.560*
Dehydrogenase activity	1			0.942***	NS
	2			NS	NS
	3			NS	NS
	4			NS	0.679**
Bacterial population	1				NS
	2				−0.650**
	3				NS
	4				NS

[a] Values marked with ***, **, * are significant at 0.01, 0.05 and 0.1 probability levels respectively. NS: Not significant.

evolution was negligible after 72 hours. The largest amount of CO_2 was evolved from the soil with field capacity moisture, but the smallest amount from the waterlogged soil.

Correlation coefficients of various parameters are given in Table 1. It is evident that the correlation between various parameters varies with the soil moisure status, and is most pronounced in the case of the relationship of pH with microbial population and activity.

Discussion

The fungal population in soils varied with different moisture regimes. It appears that moisture has a profound influence on the fungal population and appreciable effects could be noted within a very short interval of time. Similar results were reported by Prakash and Khan (1972). In the case of wetted soils, increased moisture could bring into solution soluble organic matter which might be responsible for the increased bacterial population during the first 24 hours. The sudden decrease after this may be attributable to exhaustion of the easily available soluble organic nutrients. In the case of the air dried soil, the decrease may be because of the extreme dryness which became unfavourable for most bacteria and few could survive in the air dried soil.

The several fold increase in dehbyrogenase activity in the case of wet soils and low activity in the case of dry soils, shows that moisture plays a significant role in the regulation of dehydrogenase activity in soils. Similar results have also been reported by Dormaar *et al.*, (1984). Another important recommendation which arises from the present study is that as moisture amendments influence the dehydrogenase activity within a day or two and two or three fold variations may be recorded after 24 hours. Care should be taken when considering results from long interval sampling regimes as short term variations may confound the effects of monthly and seasonal variations. The present study also shows that the moisture level of soil profoundly influences the rate, as well as the quantity, of CO_2 evolved from the soils as is also reported by Orchard and Cook, 1983. Waterlogging as well as drying, of soils reduces the CO_2 evolution. Anaerobiosis developed in the waterlogged soils which inhibited aerobic respiration and the presence of surface water might have resulted in reduced gaseous exchange causing low CO_2 evolution. In the case of low moisture soils water probably became limiting and therefore, the CO_2 evolution remained quite low. Field capacity moisture appears to be the optimum moisture level for the CO_2 evolution (Fig. 2) and it is suggested that in comparative studies on soils using CO_2 evolution as an index of activity, the soils should be brought to the same moisture levels, preferably to field capacity, before the start of the experiment, in order to obtain comparable results.

The present study reveals that the interrelationships of various parameters are significantly influenced by the moisture content of the soil. Two parameters closely related at one moisture level, may not show any relationship at another moisture content (Table 1). Apparently soil moisture status not only regulates the population and activity of microbes but it also modifies the relationship between various parameters.

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