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Dehydrogenase and urease activities of maize (*Zea mays* L.) field soils

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Summary Dehydrogenase and urease activities, bacterial and fungal populations and physico-chemical characteristics of maize (*Zea mays* L.) field soils have been studied for one crop cycle. A comparison has been made among soils of three different agricultural systems *viz* permanent agriculture on plain lands in valleys, recently introduced terrace land agriculture and age old 'slash and burn' type of shifting agriculture on slopes. Results demonstrate that the enzyme activities, microbial population as well as most of the physico-chemical characteristics of soils followed the trend permanent agriculture on plain lands > terrace land agriculture > 'slash and burn' type of shifting agriculture. Moisture and nutrient levels and topography of the lands were found to be major factors responsible for the trend.

Introduction

Studies on different enzyme activities in soil are important as they indicate the potentiality of soil to carry out the biochemical processes which are important to maintain the soil fertility. Lenhard[9] introduced the concept of determining the metabolic activity of microorganisms in soil and other habitats by measuring dehydrogenase activity. Skujins and McLaren[19] studied the dehydrogenase activity in some air dried soils that had been stored for a few years. Ross and Roberts[15] investigated the enzyme activities and oxygen uptakes of pasture soil in relation to temperature and rainfall sequences. Ross[16] studied the estimation of dehydrogenase activity of pasture soils in New Zealand. In India, very little information is available on this aspect of soil biology. Viswanath *et al.*[24] estimated the contributions of bacteria surviving chloroform and toluene treatment in the dehydrogenase activity of some selected soils.

Urease is another important enzyme in soil which deserves attention. The increased use of urea as fertilizer has led many workers to study its fate in soil and its relationship with soil factors. Cropping history, soil amendments and environmental factors have greater influence on the activity of urease and other enzymes in soils[22]. Stojanovic[17] found marked seasonal variations in urease activity in Mississippi soils. Seasonal variations in the enzymatic activities of soil reported in a number of studies[4,6,7,14] are biologically important because they change the quantity and quality of substrates upon which they act and are responsible for altering the rate of various soil processes influenced by seasonal

changes. Proper evaluation of the urea-hydrolysing power of any soil is essential to improve the fertilizer use efficiency especially in the soils with low organic carbon and high pH in some tropical regions.

Despite a number of studies on enzyme activities of soils, little is known on dehydrogenase and urease activities of maize field soils under different agricultural systems. The paper presents the comparative account of the enzyme activities and microbial population of the maize field soils under three agricultural systems *viz.*, permanent agriculture on plain lands in valleys, terrace land agriculture and 'slash and burn' type of shifting agriculture of North-East India.

Description of sites

Three maize fields differing in agricultural systems were selected. They were (i) permanent agriculture at Polo (alt. 1350 m, lat. 25°34″N and long 91°56″ E) (ii) terrace land agriculture at Upper Shillong (alt. 1600 m, lat. 25°34″ N and long. 91°52″ E) (iii) 'slash and burn' type of shifting agriculture at Burnihat (alt. 200 m, lat. 26°N and long. 91°50″ E). Terrace land agriculture is prevalent in hill areas where cultivation is usually done on terraces. "Slash and burn' type of shifting agriculture locally known as 'Jhum' is extensively practised by the tribal population of N.E. hill region of India. This type of agriculture consists of felling of the forests at various stages of development on the hill slopes (20–40 angle), followed by drying and burning of the slash and the land is cultivated for 4–5 years. Slopes cause much loss of nutrients during cropping due to absence of crop cover at sowing.

Materials and methods

The surface soil samples (0–10 cm) were collected from five places at each study site for one complete crop cycle during May to September 1981 at monthly interval. The soil samples of each field were mixed to make the composite samples separately and the following studies were made.

Enzyme assay

Dehydrogenase activity was assayed by a method modified by Casida *et al*[3]. To 10 gram of soil in a sterile stoppered test tube, 0.1 g $CaCO_3$ and 1.0 ml of 1.5% (W/V) 2,3,5 – triphenyl tetrazolium chloride (TTC) were added. Blank contained all the amendments except the TTC. Each soil sample was extracted with methanol after 24 h incubation at 30°C. The extract was filtered through a Whatman No. 5 filter paper. The O.D. of the filtrate was read at 485 nm.

Urease activity was measured by the modified McGarity and Myers[11] method. To 10 gram of soil, one ml of toluene was added and left for about 15 minutes for penetration of toluene into the soil sample. 10 ml of buffer solution (pH 7.0) and 5 ml of urea (10%) were added and incubated at 37°C for three hours. Then the volume was made upto 50 ml with distilled water and filtered through Whatman No. 5 filter paper. Ammonia released as a result of urease activity was determined by indophenol blue method and O.D. was read at 630 nm in a spectrocolorimeter.

Microbial counts

The soil plate method[27] using rose-bengal agar medium[10] was followed for isolation of fungi. Inoculated Petri plates were incubated at 25°C for five days. Total population of bacteria was estimated by dilution plate method[25] using nutrient agar[8] medium. Petri plates were incubated at 30°C for 24 hours. The bacterial population was calculated on per gram dry soil basis.

Determination of physico-chemical characters of the soil

pH was measured in a 1:5 soil water suspension using electric digital pH meter. Moisture content of the soil was measured by drying a known amount of soil in an oven at 105°C for 24 hours. The soil used in the analyses of organic carbon, N, P and K was air dried and ground to pass through a 0.2 mm sieve. Soil organic carbon was determined by rapid titration method[26]. Total N and available P were determined by macro Kjeldahl's method and molybdenum blue method respectively. Exchangeable K was extracted in ammonium-acetate buffer (pH 7.0) and the same was read in a flame-photometer[1].

Results and discussion

Enzyme activities were always higher in the soils of permanent agriculture followed by terrace land while minimum activity could be observed in the soils under "slash and burn" type of shifting agriculture system. Dehydrogenase as well as urease activity followed the similar trend of monthly variations. The soil of permanent agriculture was rich in N, P, K and the soil organic carbon throughout the sampling period (Table 1). It appeared that the nutrient level and moisture played a dominant positive role towards the enzyme activities. Ramirez-Martinez and McLaren[14] and Dalal[5] showed that moisture had a positive influence on development of soil microorganisms. Ross and Roberts[15] observed that dehydrogenase activities were significantly correlated with soil moisture content. The enzyme activities in the soil were higher during the growing period of the plants. This may be attributed to the continual addition of enzyme released from the plant roots[18] and also due to associated microorganisms[13,21]. With increase in organic carbon content enzyme activities

Table 1. Physico-chemical characters of the maize field soils

Soil	pH	Moisture content (%)	Total N (%)	Available P (ppm)	Exchangeable K (mg g^{-1})	Organic C (%)
Permanent agricultural system	6.62 (5.5–7.96)	31.2 (30–33)	0.25 (0.18–0.38)	5.67 (3.94–7.86)	0.22 (0.07–0.23)	2.5 (0.75–3.48)
Terrace land agricultural system	5.52 (3.49–5.67)	22.5 (20–25.3)	0.06 (0.04–0.09)	4.19 (2.17–5.51)	0.06 (0.04–0.07)	1.27 (1.08–1.5)
'Slash and burn' type of shifting agricultural system	4.23 (4.0–4.4)	18.7 (18–20)	0.05 (0.03–0.05)	4.07 (2.76–5.51)	0.05 (0.04–0.06)	1.09 (1.05–1.2)

Results are overall means of 5 collections of soil from May to September 1981, each composed of three replicate samples. The range of the values are given in parentheses.

increased[12,20]. Beri *et al.*[2] found that soil urease activity is largely controlled by the organic carbon status of the various soils. The positive correlations of urease activity with organic carbon and total nitrogen suggested that organic matter content accounted for most of the variations in soil urease activity[28]. Tabatabai[22] also showed that urease activity was significantly correlated with organic carbon.

On most of the sampling dates, like enzyme activity estimates, the fungal and the bacterial populations were also maximum in the soils of permanent agriculture followed by terrace land and minimum in 'slash and burn' type of shifting agriculture (Fig. 2). A comparison of the microbial population data with physico-chemical characters (Table 1) of the soil showed that the population levels were also probably a function of the N, P, K, organic C and % moisture of

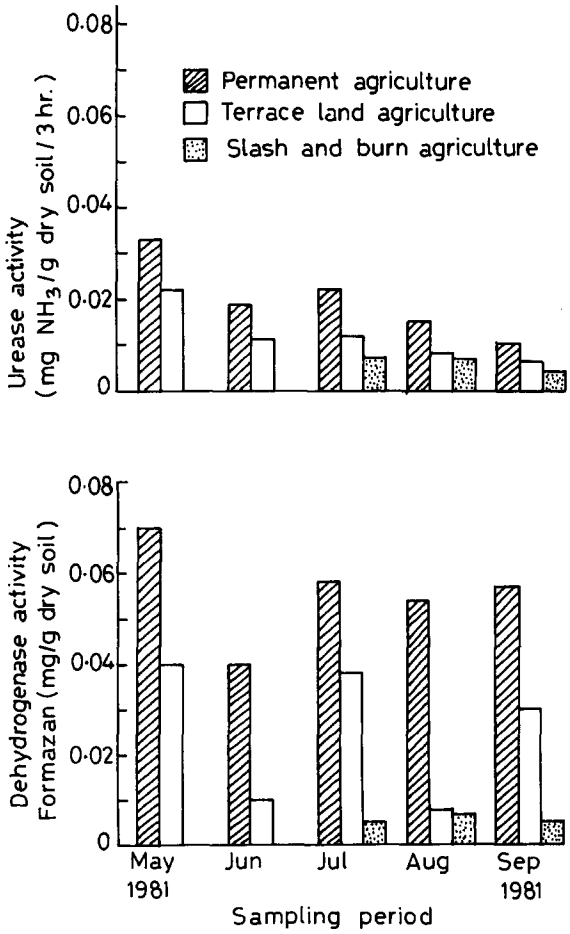

Fig. 1. Dehydrogenase and urease activities in maize field soils during the study period. (May-September 1981).

the soil. As with dehydrogenase activity, the increase in microflora may be explained by the increased facultative and anaerobic bacterial population. Tate and Terry[23] found positive correlation between bacterial population and soil moisture and concluded that moisture was generally limiting to the microbial activity. The increase in the population of decomposer microorganisms may be responsible for the post harvest increase in the enzyme activities. (Fig. 1, 2).

Significant monthly variations were observed in the enzyme activities as well as the microbial population. But no clear cut generalization emerged, which could be applicable for all the study sites.

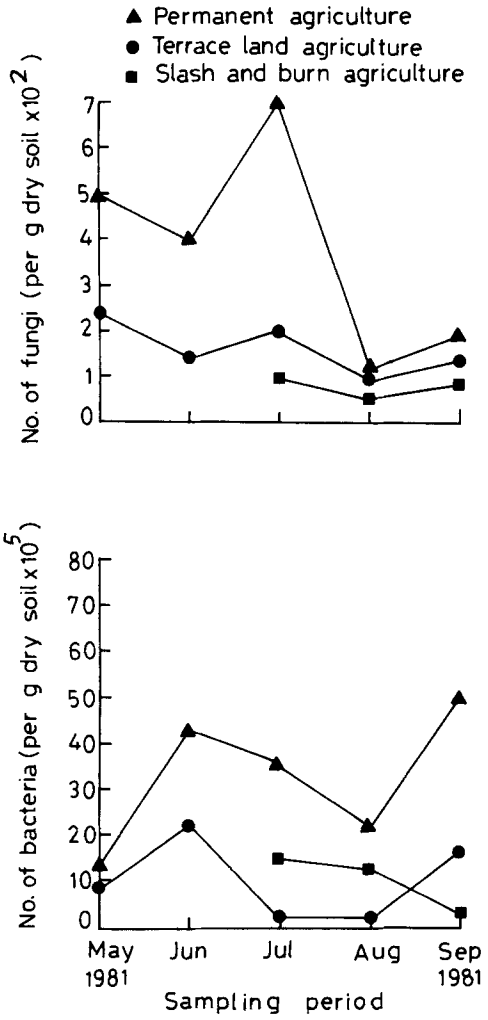

Fig. 2. Bacterial and fungal populations in maize field soils during the study period. (May-September, 1981).

Results of the present study demonstrate that enzyme activity is nutrient and moisture dependent. Soil with higher microbial population harboured higher enzyme activities which clearly depicted the positive relationship between the two. But the monthly variations in the microbial population were not related with the enzyme activities showing that temporal variations in the microbial population due to season, crop age and changes in soil physico-chemical properties are not simultaneously reflected in the changed enzymatic activities. There may be a time lag between the physico-chemical changes and their corresponding changes in microbial population and activity.

Considering enzyme activities and heterotrophic microbial population estimates as a nutrient release and decomposer activity function, it appears that the permanent agriculture is more stable and self sustainable. On the other hand the terrace land and the 'slash and burn' type of shifting agriculture systems seem to be fragile.

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