STUDIES ON SOME MICROBIOLOGICAL ENZYMES IN SOILS

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TO THE MEMORY OF
MY FATHER
&
MY SON

C O N T E N T S

...coOoo...

I N T R O D U C T I O N

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The most characteristic feature of all living organisms is the possession of a wide range of enzymes; catalysing specific chemical reactions. All soils contain living organisms and consequently enzymes. However, soil enzymes vary considerably in both type and number from soil to soil, and also with a great many factors in any particular soil.

For soils to remain highly productive, it is necessary that they have a well functioning drainage (excretory)system so as to prevent toxic accumulation of various substances. All biological action is bound up with the presence of enzymes. To use the materials in the soil, to assimilate or extract energy from them to fashion their own substances, organisms in the active state must produce a great variety of enzymes. The extent of the transformations they cause is a direct expression of the output and the global enzymatic activity may be presented as the integration of a great number of elementary activities, each depending upon one enzyme. All the biological processes occurring in soils are accomplished by enzymes that occur either intracellularly or extracellulary. These reactions fall into two main types : 1) hydrolytic and 2) oxidative-reducting.

Starch is the second only to cellulose as the most common hexose polymer in the plant realm. Starch serves the plant as a storage product, and as such it is the major reserve carbohydrate. This material occurs in large amounts in leaves carrying out photosynthesis and is the most common reserve foodstuffs of plants. It disappears rapidly when subjected to the activity of the soil population, and its decomposition proceeds at a greater rate than the microbiologically induced losses of cellulose and hemicelluloses. The final product of starch hydrolysis, maltose, is converted by α-glucosidase to glucose which is rapidly metabolised by soil micro-organisms. The process of degradation goes on at a good pace even under total anaerobiosis. Starch-hydrolysing enzymes are usually adaptive, also, because amylases are extracellular, the possibility exists that the enzymes are adsorbed and possibly inactivated by soil colloids.

In Egypt, only very limited work have been undertaken on the soil enzymatic activities. Furthermore, starches form a large part of the plant residues which are rapidly decomposed by a great many soil micro-organisms through the elaboration of the specific extracellular enzymes, known collectively as "amylases".

The present work was limited with regard to the enzymatic activity of some Egyptian soils, as a good indicator of soil biological activity and consequently its fertility. Two

major objectives. The first objective is to detect and measure the enzymatic activity of some types of soil with regard to amylase and invertase. The second objective is to study the mentioned enzymes concerning the possible factors affecting these activities. These factors include soil microflora, soil texture, moisture content and organic matter ... etc.

REVIEW OF LITERATURE

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Enzymatic activity of soil has presently become one of the most lively branches of soil microbiology. Much interest has grown in the last decade in the enzymology of soil, and a considerable amount of empirical data has been collected.

At present, the number of enzymes whose activity has been detected in soils approaches 50. However, not more than 10 of these enzymes have been fairly studied. These enzymes are primarily connected with the metabolism of carbohydrates and nitrogen and phosphorus-containing organic compounds (Kuprevich & Shcherbakova, 1971).

In spite of the voluminous literature accumulated in the past on the enzymatic activity of soils, this concept is still far from being completely developed. Among the questions which may be raised are the following. What are the precise origins of the enzymes in soil P. What is their distribution on a macro scale, and what is their localization with respect to other soil constituents ? What is the operation of enzymes as distinguished from microbial activity, in the decomposition of organic matter and in humus formation ? What is their significance in plant nutrition; that is, are there soil-enzyme-root interrelationships ? It is known that some inorganic

soil constituents exhibit catalytic properties; for example, some iron and manganese compounds catalyze the decomposition of H_2O_2 in a manner similar to that of catalase. Thus, it is also of interest to distinguish between enzymatic activity and the catalytic activity of inorganic matter.

I. The Origin of Soil Enzymes

Three types of sources of soil enzymes apparently exist: proliferating micro-organisms and dying micro-organisms (from which the enzymesare released because of the changing permeability of their cell-membranes), soil animals, and plant roots. Thus, some authors have concluded that soil enzymes are derived mostly from soil micro-organisms (Hofmann & Hoffmann, 1955; Hoffmann, 1959, 1963; Geller and Dobrotvors'ka, 1960, 1961; Kozlov, 1962 and many others) whereas others have emphasized the role of extracellular enzymes coming from either live or dead plant material present in soil (Koepf, 1954; Shumakov, 1960; Nizova, 1961; Gallopini et al., 1962; Nowak, 1964 and others). Animals have also been shown to contribute to the enrichment of enzymes in soils (Kozlov, 1965).

I.1. Soil Extracellular Enzymes :

The relative stability of enzyme activity in soils as contrasted with the wide fluctuations of their microbial populations, the lack of correlation observed between enzyme activity

and microbial numbers in soils, and the fact that enzymes are readily adsorbed by clay minerals and soils, have all been used in support of the hypothesis of an accumulation of free enzymes in soils.

Hofmann (1963a) has suggested that enzyme activity due to live microbial cells might be relatively small when compared to the total enzyme activity of the soil. Although, initially, he and his co-workers (Hofmann & Hoffmann, 1955) felt that enzyme activity portrayed only the microbial population at the time of sampling. He (1963a) recognized that most of the enzyme activity in soils is furnished by extracellular enzymes and enzymes adsorbed on soil colloids.

I.2. Microbial Extracellular Enzymes :

Numerous micro-organisms produce extracellular enzymes. Most of these enzymes catalyze the breakdown of high-molecular weight compounds, fulfilling the same function in microbial nutrition as the enzymes released in the digestive tracts of animals; by degrading the compounds they then assimilate through cell membranes.

Often it is difficult to decide whether an enzyme, even one in pure culture, is truly extracellular or whether it has been released upon autolysis of cells. Dox and Golden (1911) were the first to distinguish between intra- and extracellular phosphatases of Aspergillus sp. by testing separately mycelium