STUDIES ON POPULATION DYNAMICS AND ACTIVITY MEASUREMENT OF MICROBIAL COMMUNITIES OF PADDY FIELD SOIL

By

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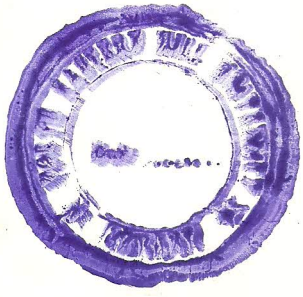

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I certify that the thesis entitled "STUDIES ON POPULATION DYNAMICS AND ACTIVITY MEASUREMENT OF MICROBIAL COMMUNITIES OF PADDY FIELD SOIL" submitted by Miss Manjumani Baruah, M.Sc. for the degree of Doctor of Philosophy of the North-Eastern Hill University, Shillong embodies the record of original investigation carried out by her under my supervision. She has been duly registered and the thesis presented is worthy of being considered for the award of the Ph.D. degree. This work has not been submitted for any degree of any other University.

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CONTENTS

GENERAL INTRODUCTION

The agriculture in North-Eastern India is unique due to uneven lands, high annual precipitation and type of agricultural practices. Agricultural activities of man greatly modify the distribution of soil microbes which constitute one of the most important component of the soil. The microbes are responsible for breakdown of organic matter and release of nutrients. The overall fertility of the soil is largely the result of the activity of the soil microbes. Changes in microbial communities are also brought about by the cultivation of the soil. For the proper management and exploitation of agricultural lands the knowledge on the microbial population and its activity is a fundamental requisite. The present day man made perturbations in the agroecosystems of this region (Toky and Ramakrishnan, 1981) has further added to the importance of such type of investigations.

Rice is the principal staple crop of North-Eastern India. Depending on the topography, human population pressure and reach of agricultural technology, three different agricultural practices are followed for the cultivation of rice. They are named as terrace land, valley land and "jhum" type of agriculture.

The terrace land cultivation has been suggested by the Indian Council of Agricultural Research as a substitute for 'jhum' agriculture. This type of cultivation has

been adopted by the farmers at high altitudes where the population pressure has increased much. Continuous cultivation of crops on the hill slopes make the land unfertile due to soil erosion. Also, these lands cannot hold sufficient water for the rice cultivation. Terracing of the lands helps in soil and water conservation and keeps the soil cultivable for a long period. The width of the terraces depends on the degree of slope i.e. higher the angle of slopes lesser the width of terraces. The terraces remain flooded during the rainy seasons and rice is grown during this period. The water table in these fields are far below the soil surface. The crop growth is fairly good and the farmers put chemical fertilizers for the sustained yield year after year.

Valley land agriculture, predominantly a monoculture of rice, is a sedentary and settled form of agriculture. Plain areas in the hilly terrain surrounded by hills from the sides are under this type of agriculture. These are lowland areas which for most part of the year remain flooded. Contrary to the terrace land fields, the water table of such fields is very shallow and generally it is only 1 to 3 feet below the soil surface. Field preparation is done in May and the seedlings are raised in nursery beds. The seedlings are transplanted in the month of June and the harvesting is completed by the end of November. Subsequently land is

fallowed between November and June. The soil of valley lands are generally fertile due to natural inflow of nutrients from adjoining hills. These lands are ideally suitable for the paddy cultivation. Crop yield in such fields is quite high. Typical valley land agriculture is at higher altitudes of Khasi hills for example in and around Shillong.

Shifting agriculture locally known as "Jhum" is extensively practised by the tribals of hill areas in the North-Eastern Region of India. This is most premitive type of agriculture. The system consists of cutting down of the forest at various stages of development on the hill slopes, allowing the slash to dry for a few months and burning it before cropping. During winter months (December-January) the undergrowth is slashed and small trees and bamboos are felled. The boles of the larger trees are not felled; only the lower branches are cut down. Before the onset of monsoon, towards the end of March and April, the dried debris is burnt <u>in situ</u>. After first shower of rains the paddy seeds are sown in the last week of May by dibbling using a long stick. Maize is also grown along with rice and harvested in the month of October. Semi perennial crops such as ginger, colocasia, tapioca, banana and castor are also sown intermittantly and at random throughout the growing season. The cultivation is done on hill slopes of 20-40°. At lower elevations of Meghalaya

this type of agriculture is still very common. The lands remain dry except during rainy season. Due to steep slopes the soil moisture remains quite low and the water table is very deep. The crop yield for rice is poor but it is compensated by the other crops grown mixed with it.

In valley land and terrace land fields rice cultivation is done in submerged condition; while in the jhum land the rice cultivation is done in dry land condition. In valley land rice is grown by transplantation method, in terrace land it is done by spread method whereas in the jhum land rice is sown by dibbling.

When a soil is submerged it becomes oxygen deficient and microorganisms bring about biochemical transformations that are unique to an anaerobic environment (Ponnamperuma, 1972). The paddy fields are waterlogged specially in valley land and terrace land systems for part of the year, which means that essentially anaerobic condition prevails in the soil below the top one or two centimeters. Important effects on soil nutrients result from the fact that while the soil is waterlogged, it develops reducing condition below the surface layer.

In jhum field, burning of the plants affects the microbial population and also the enzyme activities of the soil. According to De bano and Conrad (1978) fire affects soil in several ways. During burning, upper soil is exposed to very

high temperature. Even small rise in temperature of the soils significantly alters the fertility of the soil (Mukherjee, 1954). The soil becomes too much vulnerable to the erosion agencies. The rapid exhaustion of the soil fertility and its fast erosion from the slopes, often too steep to hold soil particles, are most important deletarious effects of fire on the agricultural lands.

The terrace land agricultural system is most prevalent in the higher elevations of the region. The field was therefore, selected at Upper Shillong (altitude 1540 m, latitude 25°34" N, longitude 91°56"E). Valley land agriculture is most common in the Shillong area and it was therefore selected at Polo, Shillong (altitude 1350 m, latitude 25°34"N, longitude 91°52"E). At lower elevation, the jhum type of agriculture is most common. The jhum field was selected at Burnihat about 90 km north of Shillong (altitude 100 m, latitude 26°N and longitude 91°50"E). The three different agricultural paddy fields were selected at places where they were most common and which represented the typical of each type.

The measurement of population and biological activities of heterotrophic microbes provides an index of various metabolic processes of the soils (Kjoller and Struwe, 1982). Two enzymes were selected on the basis of their affinity to the soil microbes. Dehydrogenases are catabolic enzymes and

therefore, predominantly associated with heterotrophic microbes. Urease enzyme is responsible for the hydrolysis of urea which is a principal agricultural nitrogen fertilizer and a metabolite of nucleic acid degradation. Both the enzymes are predominantly microbial in origin and they have been reported to be positively related to the soil microbial activity (Skujins, 1978).

Herbicides have great potential for increasing productivity in valley land and terrace land fields, as these lands are heavily infested with weeds and their weeding through manual labour is almost impossible due to high labour cost. Weeds are to a great extent responsible for the low crop productivity of these lands (Borthakur and Ghosh, 1978). Various government agencies are trying to popularize the herbicides in these areas. The effect of such agro-chemicals on the soil microflora and their activity warrants immediate attention.

Application of chemical fertilizers has been recently popularized in North-Eastern Hill region of the country. Still per hectare fertilizer use in this part of the country is far below the national average. Introduction of fertilizers to the soil significantly affects the microbial community and its activity (Trolldenier, 1981). The effect of fertilizers on soil microbes depends on the physico-chemical characters

and the species composition of the microbial community of the soils. Results obtained for one type of soil is quite often not repeatable for the other soils. This aspect of soil microbial ecology has received very little attention, therefore, it was thought necessary to investigate the effect of various fertilizers on the microbial community and their activity in the paddy field soils.

In North-Eastern part of the country a large quantity of rice straw and roots are left in the field after the harvest of the crop. With increasing crop varieties, disposal of crop residue is becoming a serious problem in the intensive rice growing areas. The left over plant parts are either burnt or puddled in the soil. While burning results into loss of energy and nutrient, the puddling causes reduced yield of crop during subsequent year. Decomposition of crop residue is one of the most important phenomenon in the ecosystem. Therefore, the studies relating to the role of microbes in the decomposition of paddy crop residue are of much importance.

Present study deals with population dynamics and activity of microbial communities of paddy field soil of three different agricultural practices common in North-Eastern region of India. The soils collected on monthly intervals have been analysed for various physico-chemical characteristics. The effect of common post emergent herbicides used in paddy

fields on the microbial communities of paddy field soils and their activities has been investigated. Laboratory experiments have been conducted on the effect of various chemical fertilizers on the microbial populations and their activities in paddy field soil. The process of paddy litter decomposition has also been studied both in field and laboratory condition. Various part of investigation has been dealt in separate chapters each having their own introduction, review of literature, materials and method, results and discussion.

CLIMATE AND SEASONS OF THE STUDY AREA