BIOMASS AND NITROGEN DYNAMICS IN AGRICULTURAL SYSTEM AND PROTECTED 'JHUM' FALLOW

By

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I certify that the thesis entitled **"Biomass and nitrogen dynamics in agricultural system and protected 'jhum' fallow"** submitted by **Shri Lakhi Boral,** for the degree of **Doctor of Philosophy** of the North-Eastern Hill University, Shillong, embodies the record of original investigation carried out by him under my supervision. He has been duly registered and the thesis presented is worthy of being considered for the award of the **Ph.D. Degree.** The work has not been submitted for any degree of any other University.

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CHAPTER I

GENERAL INTRODUCTION

Life on our planet is dependent on the cycle of nitrogen in the biosphere. It is no less important than oxygen and water for sustaining life. Nitrogen is one of the most important limiting nutrients for the vegetation growth and is required in large quantities because it is the chief constituent of proteins, nucleic acids and chlorophylls. It is very effective in increasing biomass and productivity of the vegetation, but the vegetation receiving inadequate amount of nitrogen show stunted growth (thus low productivity) with yellow or yellowish green leaves due to low protein and chlorophyll synthesis.

Most of the nitrogen in terrestrial ecosystem occurs in organic form in the soil. The organic N is not accessible to plant unless it is mineralized and released as NH_4^+ and NO_3^- ions by the micro-organisms. The mineral N are absorbed by the plants from the soil. The availability of mineral N directly influences the growth of the plants. Moreover, the nitrogen also determines the physical characteristics of the soils. Soils having low level of nitrogen status often relfects reduction in organic matter

content and associated lowering of water holding capacity and infiltration rates.

In all the natural terrestrial ecosystems the nitrogen is absorbed by roots from the soil nitrogen pool and translocated to different aboveground parts which after maturity return to the soil surface as litter. The aboveground litter and belowground dead roots are the source of organic matter in soil. The nitrogen bound in the organic matter is degraded through decomposition and mineralization and is re-used by the vegetation. In the natural ecosystems the amount of nitrogen absorbed by the roots from the soil pool is compensated for by the nitrogen release from decomposition and mineralization of dead organic matter because both the processes of uptake and release occur simultaneously. Hence, natural ecosystems are self sustaining However. in agroecosystems the available nitrogen and other resources, which are primarily supplied to the crop in order to get maximum yield, are also shared by weeds. Thus, the nitrogen gets partitioned into two major vegetational components, viz., the weeds and the crops. which represent two major biological nitrogen pools. A larger proportion of the biological nitrogen is removed from the system in weed biomass during weeding and in crop harvest. Thus, the bulk of nitrogen moves

across the system and only a small portion of it recycles within the system through crop straw or stubbles and weed residues. Hence, the cycling is rather weak in agroecosystem. Though the nitrogen release from the crop straw and weed residues assumes significance in nitrogen cycling, the amount of nitrogen release is not sufficient to compensate the loss due to constant removal of nitrogen through crop harvest and in weed biomass through weeding. As a result, the soil is gradually depleted of nitrogen, which causes reduction in agricultural production unless the nitrogen is supplied externally by artificial means. A complete knowledge of the nitrogen cycling in such an ecosystem may provide clues for effective and efficient utilization of added nitrogen or for better management of the ecosystems.

Nitrogen level in soil is also greatly influenced by the precipitation which has both positive and negative effects on the soil nitrogen. Though some amount of nitrogen is added to the soil through rain water, the rain water which flows over the surface and which percolates down to deep soil layer carries away a significant amount of nitrogen from the top soil layer. However, the losses of nitrogen through run-off and percolation depend on quantity of rainfall, vegetation cover and topography.

Usually the losses through run-off and percolation are greater from an agroecosystem than from a natural ecosystem due to perturbation of top soil layer and low vegetation cover. Mishra & Ramakrishnan (1983) reported that a significantly higher amount of nitrogen was lost from 'jhum' agroecosystem than the 'jhum' fallow. However, comparative studies pertaining to nitrogen loss from a settled terraced agroecosystem and that from natural ecosystem represented by older 'jhum' fallows have not yet been carried out.

The widely practiced method of cultivation in Meghalaya is 'jhum' cultivation (slash and burn agriculture). It is a primitive and destructive method of cultivation. In this method a plot of land on the hill is cleared by felling trees and slashing ground vegetation which is burnt later on, when dried up. Due to deforestation, and due to lack of control measures for water, soil and nutrient losses the land becomes infertile and unproductive (Mishra & Ramakrishnan, 1983, 1984). Therefore, the lands are left fallow for nutrient recovery and vegetation regeneration. This method of cultivation is not sustainable and therefore, in recent past Indian Council of Agricultural Research (ICAR) has recommended a sustainable settled agriculture on terraced land with a view to replace the 'jhum' agriculture. The terraces are constructed to check

the loss of resources such as water, soil and nutrients. However, to what extent the method of agriculture is sustainable in relation to conservation of nitrogen on the hill slope is yet to be analysed.

On the other hand, most of the uncultivated lands on the hills are abandoned 'jhum' fallows left after 'jhum' cultivation. A large number of ruderal weeds colonise the abandoned 'jhum' fallows paving the way for other secondary successional species to grow over there which eventually helps in the restoration of soil fertility of the degraded lands. However, no detail studies have been made to monitor the biomass dynamics and cycling of nitrogen in 'jhum' fallows covered by secondary successional plant communities. It would be very interesting to compare the dynamics of biomass and nitrogen on such fallows with that in adjacent agroecosystems representing the same topo-sequence.

Keeping the above facts in view the present study on **"Biomass and nitrogen dynamics in agricultural system and protected 'jhum' fallow"** was conducted on Barapani agricultural farm of the ICAR Complex to cover the following aspects:

1. Floristic composition and structure of the vegetation.

2. Biomass and productivity of the vegetation.
3. Nitrogen uptake by vegetation, its transfer from belowground to aboveground vegetation compartments, its return to the soil through litter and belowground biomass disappearance and its accumulation in vegetation.
4. Decomposition and the pattern of nitrogen release from the dead organic materials.
5. Loss of nitrogen through crop harvest, weeding, surface run-off and percolation water and its input through incident rain water and fertilizer to compensate the loss.
6. Balance of input and output or existing status of mineral nitrogen (i.e., NH_4-N and NO_3-N) and organic nitrogen in soil.

The data obtained from the field experiments on various aspects mentioned above have been presented in chapters IV to IX. The literature pertaining to various relevant aspects such as community structure, biomass and productivity, nitrogen cycling between vegetation and soil and within the vegetation components, decomposition and pattern of nitrogen release from decomposing materials, nitrogen input through rainfall and losses through run-off, leaching and through biological materials

have been briefly reviewed in chapter II (Review of Literature). Chapter III deals with the location, climate, soil and vegetation of the study sites. The results contained in chapters IV to IX have been critically discussed in the corresponding chapters. However, the major findings of the entire work have also been discussed in integrated manner in General Discussion (Chapter X).
