CHAPTER 1

INTRODUCTION

The concept of sustainability assumes vital significance in agriculture in view of the fact that modern agriculture has created a number of ecological and environmental problems. The sustainability in agriculture depends on the extent to which a balance could be created between human and livestock needs, and conservation of the environment. The existence of forests and grasslands in the surrounding areas is vital for a sustainable agriculture. However, forest and grassland ecosystems have been undergoing fast degradation in recent years owing to deforestation caused by shifting cultivation and other human disturbances in the whole of north-eastern hill region (Khan *et al.*, 1987; Singh & Prasad, 1987). Nearly 19 million t of soil is estimated to be eroded every year due to shifting cultivation in this region (Singh & Singh, 1980, 1981). This has resulted in a loss of 6 million t of organic carbon, 9.7 t of available P_2O_5, and 5,690 t of available K_2O (Borthakur *et al.*, 1985). Besides, a substantial amounts of Ca and Mg are also washed away and eventually, their deficiencies are being noticed in the crops grown on these soils (Prasad, 1987). The extent of degradation has already reached an alarming proportion in Meghalaya and according to a recent estimate, approximately 21 percent of the total geographical area of the state is in the form of wastelands (SPWD, 1995). Abandoned jhum-lands and barren hill ridges or rock outcrops form the major part of wastelands in the state. The ecological

implications of land degradation in these areas are evident now. The natural resource degradation is bound to adversely affect the economic growth, particularly in the rural areas and may trigger the migration of the population to the urban centres. The removal of forest biomass alters bio-geochemical cycles and modifies physical characteristics of the site (Johnson *et al.*, 1991). This impact may be more pronounced in agricultural systems. However, not much information is available on the soil fertility status on the hill slopes that have been brought under cultivation after clearing the forest vegetation growing on them. It is an urgent need to put back the abandoned areas under some kind of permanent vegetation for reasons of ecological reconstruction of the degrading resource- base as well as for meeting the food and fodder requirement of ever increasing human and livestock population in this region.

The significance of tree-based land use systems in general and agroforestry in particular, has been realized in improving the economy of farmers having small land holdings as well as in the restoration of soil fertility level (Alpizar *et al.*, 1986; Lal, 1986; Fassbender *et al.*, 1988; Chauhan & Dhyani, 1989; Beer *et al.*, 1990; Fisher, 1990). The fertility restoration capacity of the soils can be improved under the influence of tree cover which protects the soil from erosion, contributes to soil organic matter (SOM) content and continuously replenishes the nutrients through effective recycling mechanism. In the recent past ICAR Research Complex for NEH Region has evolved agri-horti-silvi-pastoral land use

as an alternative to shifting cultivation for high and sustained crop production systems in the hills (Prasad, 1990). Besides, different forms of inter-cropping including annual food crops in asoociation with trees, plantation crops and pastures not only optimize the natural resources but also ensure continuous food flow (Watson, 1990). Agroforestry is a special case of mixed cropping and it integrates the land-use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land-management unit (Leakey, 1996). The benefits accrued from agroforestry systems might be due to efficient nutrient recycling, nitrogen fixation by leguminous trees (if present), and accumulation of organic matter. It offers a practical means of achieving greater output and at the same time maintaining soil fertility which ultimately helps in increasing the productivity of agricultural crops and trees. This is so because maintaining high levels of available N and P, the two most limiting nutrients in soil, still remains a major challenge to ecologists and land managers. Investigating long term effects of cultivation on soils under different agroforestry systems is an important component of research efforts directed towards restoring the sustainability of agriculture in terms of maintaining soil fertility and optimum economic returns. Organic matter is the most dynamic constituent of soil and its input is a key factor governing the soil fertility. Besides, soil organic matter (SOM) greatly influences the physical, chemical and biological characteristics of soils (Lal & Kang, 1982; Adejuwan &

Adesina, 1990; Drechsel *et al.*, 1991). It is expected that inclusion of compatible and desirable trees in cropland situation would improve soil fertility (Okigbo *et al.*, 1980; Vergora, 1987; Young, 1989; Lal, 1989; Parrotta, 1990; Watson, 1990) through organic matter decomposition cycle. But it is impossible to answer the many questions on nutrient cycling until data are available for different agroforestry systems under different environments. In this context the need for quantitative determination of inputs, outputs and within-system transfers of nutrients and their storage in plant and soil compartments is evident. The collection of quantitative data on biomass production of the tree species, agronomic and biological productivity of crops and other plants and the influence of agroforestry systems on soil properties and nutrient dynamics, is a pre-requisite for a better understanding of the effects of agroforestry systems on productivity and soil characteristics. A review of literature reveals that studies on these aspects have been carried out with reference to natural forests, grasslands and agroecosystems by several researchers and a large amount of data is available, but no serious attempt has been made to study agroforestry systems on these lines.

The ICAR Research Complex for NEH Region has initiated a long term indepth study on various farming systems at Barapani Farm since 1987, wherein the analysis of agroforestry systems is also envisaged. The present study in conjunction with the efforts already made by the ICAR, may help in developing suitable agroforestry models for this region.

OBJECTIVES

The major objective of the present research is to **analyse the effects of a few agroforestry systems on crop yield and soil characteristics** in slopy land situation in Meghalaya. The specific objectives of the study are as follows:

1. To study the effects of agroforestry systems on agronomic productivity and biological productivity of crops, trees and weeds.
2. To study the effects of agroforestry systems on physical and chemical properties of soil.
3. To investigate nutrient dynamics under different agroforestry systems.

To achieve the above objectives, the following four agroforestry systems were selected for the study:

(1) Alder-based agroforestry system (AFS 1),

(2) Albizia-based agroforestry system (AFS 2),

(3) Cherry-based agroforestry system (AFS 3), and

(4) Mandarin-based agroforestry system (AFS 4).

Data on growth attributes, survival, timber volume, and above- and below-ground biomass production of the four tree species, distribution of tree roots in soil profile and fine root biomass of the four tree species, agronomic and biological productivity of crops and weeds and the influence of agroforestry systems on soil properties were collected in the four agroforestry systems. Besides, the uptake of nutrients and their retention and removal in vegetation compartment and soil pool were also estimated. Data collected on various aspects were analysed using appropriate statistical procedures and conclusions with regard to effects of agroforestry systems on crop and tree productivity, soil characteristics and

nutrient dynamics were drawn.

The thesis is divided into 10 chapters. The data collected on various aspects such as survival, growth attributes and litter dynamics of the tree species, biomass and productivity of tree, crops and weeds, soil properties as influenced by the four agroforestry systems and nutrient cycling are presented in Chapters 4-9. Chapter 1 gives a general introduction to the entire study. Chapter 2 presents the review of literature published on the subject matter of the thesis and related aspects. Chapter 3 includes the details pertaining to the study site, description of the selected agroforestry systems and physico-chemical properties of soil at the study site. Survival and growth of the four tree species have been discussed critically in Chapter 4. The details relating to biomass and productivity of the four tree species and of crops and weeds in the four agroforestry systems have been presented in Chapters 5 and 6. Litter dynamics of trees and physico-chemical characteristics of soil as influenced by the agroforestry systems have been presented and discussed in Chapters 7 and 8. A comparative account of nutrient cycling in the four agroforestry systems has been discussed in Chapter 9. The results presented in chapters 4-9 have been critically discussed in detail in individual chapters, however, the major findings of the whole study have been briefly discussed in an integrated manner in Chpater 10 (General Discussion). This is followed by a brief summary and references.
