Chapter 1

Introduction

Agroforestry has a long tradition in the northeastern region where trees are integrated in the crops and livestock production systems according to the agroclimatic and other prevailing conditions. For the traditional farmers, the system is closely interlinked with the forest, cropland and the household as the major components in organic relationship with each other that are critical for the ecological sustenance. These systems are essentially man-made and reflect the evolution of human culture with aspects of location, climate, and other ecological parameters carefully considered in their establishment. Schultz (1964) said ‘Farming based wholly upon the kinds of factors of production that have been used by farmers for generations can be called traditional agriculture’. Traditional societies in general are more conservation-oriented and follow basic narrow guidelines required for mutual co-existence with nature.

Traditional agroforestry systems are managed indigenously, with practices having been evolved by the farmers through trial and error over long periods of time (Rai and Proctor, 1986). Therefore, traditional cropping patterns also vary, since they have evolved in response to prevailing soil and climatic conditions and social and ethological preferences (Ruthenburg, 1976). A great number of different traditional grain crops, rhizomatous crops, pineapple, coffee, tea and vegetables are being grown with a number of fruits and other trees in the traditional agroforestry systems, which are valuable for the farmers’ everyday life as they provide a greater diversity of food and also act as a good source of commercial outlets in addition to household consumption. Farmer’s objective of introducing/maintaining woody perennials in their farming system is not only to cover the risk of crop failure but also to meet the demands for food, fruit, fuel, fodder, small wood and timber. Trees are also maintained for shelter and shade.

Northeastern India harbours rich floristic diversity in difficult terrain. The local people have tremendous traditional knowledge to use the natural resources. Basically the indigenous communities are farm-based and they have customary laws that
accommodate socio-cultural patterns, land tenure system and cultivation practices. Earlier, the local people used to be collecting their day-to-day requirements from the wild, but over time, they have developed a few traditional systems that can help in meeting their livelihoods. The traditional agroforestry system is one such system that can fulfill productivity, sustainability and adaptability criterions for the traditional farmers’ of this region. Yet, the adoption and relevance of tree farming practices varies by region and is habitually driven by local tradition, economic factors and land ownership patterns. In this region, a number of tree species viz, areca nut, coconut, citrus, guava, jackfruit, etc are generally grown with understorey crops such as vegetables (beans, cucumbers, squash, spices) and betel vine. However, the combination of trees and understorey crops varies from place to place and tribe to tribe due mainly to socio-cultural variations. ‘Kalitas’ and ‘Nyishis’ are the dominant ethnic communities in the foothill region of Arunachal Pradesh and its border area in Assam. The Kalitas of Assam are hard working and practices agroforestry to meet their daily household requirements as well as for the monetary gain. On the other hand, Nyishis of Arunachal Pradesh practices agroforestry since time immemorial, but earlier it was in the form of shifting cultivation and now they opt towards the settled cultivation. Both the communities are still maintaining their traditional needs and beliefs in their agroforestry systems. A great number of different traditional crops (e.g., trees, shrubs, herbs, medicinal plants, tubers, vines, spices and condiments, etc.) are grown in the traditional agroforestry systems of this region, which are valuable for the farmers’ everyday life, as they provide a greater diversity of food and also act as a good source of commercial outlets in addition to household consumption. People of Nyishi tribes of Arunachal Pradesh use wild plants for food and supplement their diet with Alpinia malaccensis, Angiopteris evecta, Calamus temuis, Cyathia gigantea, Dendrocalamus hamiltonii, Dioscorea bulbifera, Pinanga gracilis, Sphenoclea zeylanica and Wallichia densiflora (Maikhuri, 1991).

In agroforestry systems, both biotic and abiotic environments can be modified by the different crop/pasture-tree configuration (Chang et al., 2002; Yunusa et al., 1995). Trees under agroforestry system provide soil cover through their canopy and soil mulch through leaf litter, which may prevent the soil from erosion. These systems are expected to have nutrient input through litterfall, thus leading to the better
nutrient use efficiency in an ecosystem. So, besides yielding food, fodder, fuel, fruit and timber, and providing shade for crops and animals, the trees enhance soil fertility of agroforestry farms. Farmers generally consider indigenous species to be more suitable than exotic (Evans, 1987) in traditional agroforestry systems. The species selections for the agroforestry systems are very important when the goal is high organic matter production to protect soils and enhance nutrient recycling.

According to Nair (1993) agroforestry has the following characteristics:

- Combines production of multiple outputs with protection of resource base,
- Places emphasis on indigenous, multipurpose trees and shrubs,
- Suitable for low input conditions and fragile environments,
- More concerned with socio-cultural values than most other land-use systems,
- Structurally and functionally complex.

Agroforestry systems have long been considered as viable alternatives to degraded land use in the tropics (Nye and Greenland, 1960), though some have questioned this assertion (Sanchez et al., 1995). For instance, the farmers of Nigeria, as in other parts of the tropics, rely on the bush fallow component of agroforestry for the restoration of soil fertility after a cultivation cycle (Okeke et al., 1992). Agroforestry systems theoretically may duplicate many characteristics of undisturbed ecosystems and incorporate several soil conserving attributes of tree crops. Furthermore, Nair (1995) reported that tree-based agricultural systems are considered more efficient in nutrient cycling than many herbaceous systems because of the extensive and deeper root system of trees than herbaceous species. So, in specific, trees in agroforestry farms recycle the nutrient which effectively contributed in maintenance, and recovery of soil structure and fertility (Buresh, 1995; Buresh and Niang, 1997).

The role of litter in soil nutrient budget of agroforestry systems has been recognized, but yet remains underestimated. The incorporation of leaf biomass could be a very viable strategy in improving the soil nutrient status without adversely affecting the physico-chemical composition of soil. In traditional agroforestry
systems, the farmers primarily focus on the adoption of timber and horticultural trees and fuelwood and fodder species. So the litter of these species can be source of energy

The biological advantages of agroforestry are:

- Increased site utilization,
- Improved soil characteristics,
- Increased productivity,
- Reduced soil erosion,
- Reduced microclimate extremes,
- Positive use of microclimate changes (i.e. shade),
- Enhanced above- and belowground biodiversity (Ruark et al., 2003).

and nutrients to the soil decomposer subsystem. Phillipson et al. (1975) reported that much of the energy originating from the primary production is released during decomposition. During this release, plant nutrients become available for recycling within the ecosystem. In tropical ecosystems, where soils are of low natural fertility, soil nutrient status and tree or crop growth depend on litter decomposition for the release of plant nutrients sequestered in the litter layer. Thus, decomposition of plant litter in an agroforestry ecosystem has a crucial impact on growth and development of both agricultural and tree crops.

Plant roots comprise a substantial portion of total biomass in an agroforestry system. Trees and understorey species will compete strongly for resources if the fine roots of both are concentrated in the same soil layer; but if the fine roots of the species are distributed in different soil layers, there may be a minimal or no competition between the species (Ong, 1991). Thus, selection of understorey type should be an important consideration when the goal is to optimize tree growth under agroforestry conditions (Gautam et al., 2002). Beyond recognizing their role of anchorage in terrestrial plants and in uptake of water and nutrients, this component has been largely in the context of ecosystem analysis (Harris et al., 1980; Persson, 1978). Root studies in intercropped situations with multipurpose trees could provide a change of belowground environmental resource sharing in agroforestry systems. The architectural form, biomass, dynamics and nature of the growth of roots of different agroforestry
tree species generally fluctuate, therefore describing a typical root system for a particular root species is often difficult, because their inherent nature can be greatly modified by soil, climate and plant management, particularly with regards to the extent and depth of rooting and the within seasonal phonological phases they undergo. But still the belowground biomass production of a particular system gives an idea about the fertility and sustainability of the systems and for successful management of mixed cultivation in traditional agroforestry. According to the existing model of nutrient cycling, belowground inputs from fine-root turnover may contribute more to the organic matter decomposition cycle than the above ground litterfall (Shugart et al., 1977; Aber et al., 1983).

Although sporadic studies on litter and root mass accumulation and turnover in agroforestry tree species exist (Dhyani, 2000; Hauser, 1993), very little is known about the production and turnover of litter and fine root biomass in tree farming systems per se, which is maintained by the people traditionally. The present study, therefore, aims at understanding the role of litter and fine roots in soil organic matter and nutrient dynamics in traditional agroforestry systems practiced by ‘Kalitas’ and ‘Nyishis’ in northeast India.
Chapter 2

Review of Literature

Traditional agroforestry

Most traditional agricultural systems are poorly organized and managed and hence, yield low in northeast India in particular in the tropics, the pressure to clear new land for farming continues to increase. The traditional farmers have however responded to sustain production by selectively incorporating multipurpose woody species which they consider useful and effective in enriching the production system biologically (Obi and Tuley, 1973; Getahun et al., 1982; Kang and Ghuman, 1991). Despite the importance of woody species in traditional farming systems, only limited information is available on the potential contribution, when used in agroforestry systems of multipurpose woody species to the improvement and sustenance of crop production in the humid tropics. To improve traditional systems, alternative farming methods with improved soil management technologies are being investigated by various research institutions. Emphasis is being given to traditional agroforestry systems that promote sustainability and serve as intermediate steps to more permanent cultivation through soil conservation, crop rotation, and intercropping techniques. (Ref. needed)

There is still no general consensus about what agroforestry is? Lundgren and Nair (1985) use agroforestry as a collective name for land use systems and practices where woody perennials are deliberately used on the same land management unit as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. Agroforestry thus encompasses many land use systems that have been practiced for a long time in the tropics, including shifting cultivation and bush fallow systems that are predominant in the northeastern hilly states (Ramakrishnan, 1992).

Traditional agroforestry systems have evolved with time in response to population pressure and depletion or degradation of non-renewable resources. The possible evolution of traditional agroforestry, from a simple rotational sequence of temporal agroforestry to the intensive and complex multistory system was described by Kang and Wilson (1987). Although agroforestry is an age-old practice it is relatively a new science. The role of agroforestry is also capturing ever greater