PERFORMANCE OF TURMERIC IN THE LITCHI BASED AGROFORESTRY SYSTEM

A Thesis
By

SALINA HASAN
Student No. 0705015
Session: 2007-2008
Thesis Semester: January- June, 2008

MASTER OF SCIENCE (M.S.)
IN
AGROFORESTRY

DEPARTMENT OF AGROFORESTRY
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY
DINAJPUR

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Submitted to Department of Agroforestry, Hajee Mohammad Danesh Science and Technology University, Dinajpur in partial fulfillment of the requirements for the degree of

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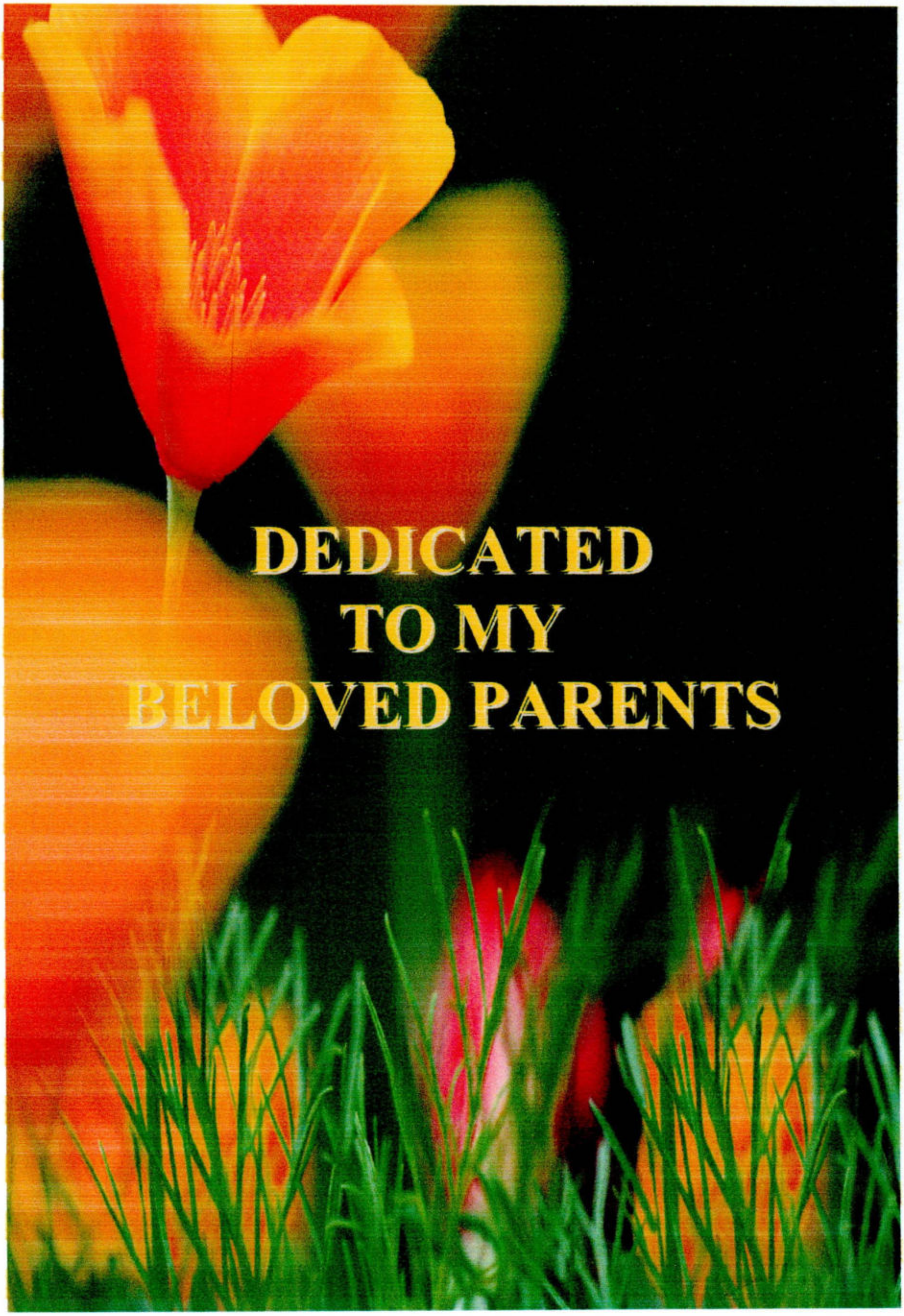
DEDICATED
TO MY
BELOVED PARENTS

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The Authoress

ABSTRACT

The experiment was conducted at the 30 years old litchi orchard of Agroforestry Research Farm, HSTU, Dinajpur during April to December 2007. The study was to conducted investigate the performance of turmeric (var.Dimla T-027) under litchi orchard on the basis of light intensity/ distance from the tree base. The litchi tree was planted in the field by 10m × 10m distance for plant to plant and line to line also. In the experiment, there were four treatments, i.e. T_1 (2.0-3.0 m distance from tree base and approximately light intensity 20-30%), T_2 (3.0-4.0 m distance from tree base and approximately light intensity 40-50%), T_3 (4.0-5.0 m distance from tree base and approximately light intensity 80-90%) and T_4 Open field, and light intensity 100%). Values of all growth parameters of turmeric were influenced by different shade levels created due to distance from tree base. The highest plant height was recorded from T_2 (156.43cm) followed by T_1 (142.30cm). On the other hand the lowest value was recorded in T_4 (115.20cm). Number of leaf per plant and number of tiller per plant were highest in T_3 (8.73and 3.33) followed by T_4 (7.53 and 2.73). On the other hand the lowest values were found in T_1 (5.53 and 2.23). But the value of all yield contributing attributes (number of fingers per plant, finger fresh weight per plant, finger dry weight per plant, rhizome fresh weight per plant and rhizome dry weight per plant) were the maximum in T_3 followed by T_4. Significantly the highest yield (23.59 t/ha) of turmeric was recorded in T_3 followed by T_4 (18.20 t/ha) while significantly the lowest yield was obtained in T_1 (10.7 t/ha). The study suggested that up to 3.0m distance from tree base could not be used for turmeric production.

ABBRIVIATIONS AND ACRONYMS

%	:	Percent
abst.	:	Abstract
AEZ	:	Agro-Ecological Zone
cm	:	Centimeter
et al.	:	And others
FAO	:	Food and Agriculture Organization
RCBD	:	Randomized Complete Block Design
g	:	Gram
i.e.	:	That is
m	:	Meter
kg/ha	:	Kilogram per hectare
viz.	:	Namely
BBS	:	Bangladesh Bureau of Statistics
BARC	:	Bangladesh Agriculture Research Council
DAP	:	Days after planting
Kg	:	kilogram
mm	:	Millimeter
Fig	:	Figure
LSD	:	Least significant difference
DC	:	Degree Celsius
*	:	1% level of significance
**	:	5% level of significance
&	:	And

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Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Bangladesh is an agrarian country enjoying tropical to sub-tropical climate. Her population is 134.3 millions in an area of 147570sq km with a growth rate of 1.54% (BBS, 2003). The total forest area of the nation covers about 13.36% of the land (BBS, 2001). However, according to the Forest Master Plan and surveys conducted by multinational donor agencies, only 6% or a total of 0.769 million hectares land of the territory has actual tree coverage (Anonymous, 1999). But to have benefits of the nature, any state should have at least 25% of her land covered with forests. So, the dominion is suffering from inadequate forest coverage coupled with over population for a limited land. The realm has neither the ability to increase command areas of agricultural crops nor to increase the forest area for ecological demands. Under these fatal situations, various agroforestry systems can address the stress of the day to considerable extents.

Common Bangladeshi people traditionally use various spices in curries in their daily life. Among them turmeric (*Curcuma longa)* is the most important one. Besides making curries, it is also used for medicine as a carminative and aromatic stimulant to the gastrointestinal tract

(Purseglove *et al.,* 1988) and many other purposes. In addition, turmeric is a high valued crop having good local as well as export potentials (Siddique, 1995). But total production of turmeric is 41.5 thousand metric tons from 16.06 thousand hectors (BBS, 2003). The demand of turmeric for home consumption is increasing day by day with the over increasing population of Bangladesh and their demand is world wide also.

Turmeric requires a warm and humid climate. It is cultivated in most areas of tropics and subtropics provided that rainfall is adequate or facilities for irrigation are available. So, it is usually grown in regions with a rainfall of 1000-2000 mm/annum. However cultivation has been extended into moist area with a yearly rainfall above 2000 mm (Purseglove et al., 1981). The humus rich virgin soils of hills and forests are also suitable for it.

All the above conditions are available in Bangladesh for turmeric productions. But most of Her lands are engaged to produce food crops. So, there is little scope to increase the area of turmeric production without Agroforestry systems. Hence, attempts should be taken to boost-up their culture through appropriate local techniques. Growing turmeric in association with trees and shrubs in and around homestead/farm land, which is called agroforestry systems, may be one of the ways in land constraint situations of Bangladesh. In this case, turmeric must face shade to some extent depending on the characteristics of the upper-storey tree species. Fortunately turmeric is traditionally known as shade loving spices and grown well under partial shade condition but their degrees of shade tolerance has not yet been standardized from the scientific point of view growing turmeric in the agroforestry system. For this, response of turmeric (var. Dimla T-027) under different light/shade conditions must be evaluated in scientific way. with that view, the present study was undertaken to meet the following objectives.

i) To investigate the performance of turmeric under Litchi (*Litchi chinensis*) orchard in different distance from tree base.

ii) To identify the suitable zone/area under Litchi tree for profitable turmeric production.

Chapter 2
Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

This study is concerned with abundance of different Agroforestry practices of a particular region of Bangladesh. The study is confined on different Agroforestry farming systems. The literatures relevant to the present study have been grouped as i) Primitive and Modern Agroforestry Practices, ii) Effect of Light on Plant Growth and Development iii) Effect of Light intensity on spices production iv) Homestead Agroforestry Practices, v) Farm land/ Crop land and other Agroforestry Practices.

2.1. Primitive and Modern Agroforestry Practices

The practice of Agroforestry varies considerably from place to place, region to region and country to country. Quite naturally, the word conveys a different meaning at different places. For example, Jhum cultivation is a primitive nature of shifting cultivation, which is a form of Agroforestry. While shifting cultivation is a sequential system of growing woody species and agricultural crops.

About 10,000 years ago, man discovered that seeds of certain grasses could be eaten. To obtain these seeds, he cleared forests and grew them. Subsequently he cleared larger tracts by felling trees and burning them. It was found that the productivity went down after some time and therefore, other areas were cleared and burnt to grow those seeds. Thus the practices of shifting cultivation began. Shifting cultivation gave ways to regular cultivation in due course of time (Dwivedi, 1992).

Agroforestry is an old system although its emergence as an academic discipline is quite new. Agroforestry practices combine agriculture and forestry on the same piece of land. Agroforestry system is defined as the sustainable management system for land that increases overall production, combines agricultural crops, trees and forest plants and/or animals simul-taneously or sequentially and applies management practices, which are compatible with the cultural patterns of a local population
(Bene *et al*., 1977)

Agroforestry has been practiced by many groups of people in various ways under different conditions over a long period of time such as bush fallowing, taungya, alley cropping, fringe planting, green hedge and fences, afforestation blocks, protein banks, woody perennials for shelter, soils and water conservation, as well as home gardens, cattle under woody perennials, aquaforestry, api-silviculture and many others (Torquaebiae, 1990).

According to Solanki (1998), agroforestry can significantly contribute in increasing demands of fuel wood, fodder and cash flows and infra-sturctures in many developing countries. He also stated that agroforestry has high potential to simultaneously satisfy 3 important objectives: (i) protecting and stabilizing the ecosystems, (ii) producing a high level of output of economic goods (fuel, fodder, small timber, organic fertilizer etc.) and (iii) producing stable employment, improved income and basic material to rural populations.

According to Lundgren and Rain tree (1982), agroforestry is a collective name for land use systems and technologies whereby woody perennials (trees, shrubs, palms, etc) are deliberately grown on the same land management unit as agricultural crops and /or animals either in spatial mixture or in temporal sequences.

Saka *et al.* (1990) stated that an agroforestry system can provide a sound ecological basis for increased crop and animal productivities, more dependable economic returns and greater diversities in social benefits on a sustained basis.

Ong (1988) reported that by incorporating trees with arable crops, biomass production per unit area could be increased substantially when the roots of trees exploit water and nutrients below the shallow roots of crops and when a mixed canopy intercepts more solar energy.

According to Nair (1979) Agroforestry is a land use system that integrates trees, crops and animals in a way that is scientifically sound, ecologically describe, practically feasible, and socially acceptable to the farmers.

In India, the word Agroforestry is often used as a synonym for farm forestry. Farm forestry is defined as the practice of forestry in all its aspects on farms or village lands generally integrated with other farm operations (NCA, 1976).

2.2 Effect of Light on Plant Growth and Development

According to Ong *et al.* (1991) shading due to trees is responsible for poor yield of associated crops. Limiting light is obviously the most imperative factor that causes poor performance of under storey crops.

Angeles and Mendoza (1988) reported that when intercropped with bananas and pineapples at Laguna, pawpaw cv. Smooth Cayenne plants were an average of 71.4 cm taller and thier average stem diameter was 4.7cm greater than when grown as a pure stand. Leaf production was also greater when intercropped, with longer petioles and greater laminar and petiolar DW being recorded. Intercropping also increased papaya fruit size, number and yield/tree from 0.9, 7.1 and 6.6 kg/tree, respectively, in pure stand to 1.7, 22.1 and 36. 7kg/tree, respectively. This was attributed to each pineapple plant in the intercrop and confirmed by increase in leaf N concentration of papaya when intercropped.

The yield of any crop (whether tree crop or field crop) is dependent on intercepted radiation energy. Excessive canopy density as well as excessive exposure to irradiation may depress economic yield (Jackson, 1987).

Zhong and Kato (1988) observed that decreasing in the light intensity also decreases dry weight. Moreover, low light intensity decreases the rate of exudation. Shading decreases starch and soluble sugar contents of root system too.

Singh (1988) reported that low light (25% of normal sunlight) produced by shading significantly decreased tuber yield due to reduction in tuber size apparently caused by uses partitioning (harvest index) of the lower biomass production.

Light plays the most vital role in photosynthesis but it carries out important functions in various biological processes of plant-life, viz. metabolism, growth and development. Plants grown at high irradiances had higher photosynthetic rate and stomatal conductance while intercellular CO_2 concentrations were lower than in plants grown at low irradiances (Sritharam and Lenz, 1992).

Sarkar and Saha (1997) studied the influence of light intensities on the growth and development of radish in a field trial at Baruipur, India and found that reduction of light intensity (to 75 or 50% of the full sunlight using the Muslin cloth supported on bamboo frames) adversely affected the elongation and thickening of radish hypocotyls. Yield of radish was also reduced by reducing light intensity.

Leonardi (1996) reported that shading (60% light reduction) reduced vegetative and fruit growths but increased plant height. It also reduced the chlorophyl1 content, stomatal density, transpiration as well as photosynthetic rate in peppers.

An agroforesty system incorporating a range of tree and crop species offers more scope for useful management of light interception and distribution than monoculture forests and agricultural crops (Miah, 1995)

Wang and Zhang (1998) conducted an experiment under reduced light by 0, 20, 60 and 80% and experienced that stem height was the greatest one with 80% shading while the leaf number was the maximum with 60% shading. Stomatal density was also noted without shading.

Battistelli *et al.*, (1998) stated that at low light levels, plant growth rate, leaf area and specific leaf dry weight were reduced, and the shoot: root ratio was increased compared to the plants grown at high light levels. Low light affected photosynthetic light driven reaction, the capacity of the Calving cycle, and starch and sucrose synthesis pathways enabling acclimatization to shaded conditions and thus promoting survival under those conditions too.

Contritto *et al.*, (1998) studies the effects of shades (0 or 30%) on growth and photosynthetic parameters of capsicum in Italy and noted that shaded plants exhibited better growth and higher yields than the control plants. Fruits from shaded treatments were of better class than those of the control treatment.

Light is an essential factor on plant growth and development. The major light factors affecting plant growth are light quality, light intensity, photoperiod and day/night cycle (Toto, 2003).

2.3 Effect of Light intensity on Turmeric production.

Singh *et al*. (2001) observed that the effect of three species namely eucalyptus (*Eucalyptus teretcorris*), acacia (*Acacia nilotica*) and poplar (*Populus deltoides*) on the performance of turmeric (*Curcuma longa* L.) was investigated in Kamal, Haryana, India. The mean germination of turmeric was maximum when grown in association with acacia and minimum in the control i.e. in open field. The mean height attained by turmeric after 90 days was highest under eucalyptus and lowest under poplar. The yield of turmeric was in the order: eucalyptus > control > poplar > acacia.

Sathish *et al.* (1998) evaluated the performance of 12 turmeric cultivars in a 20-year old coconut plantation. Plant crop cylle duration, yield and quality were assessed. The cv. Cuddapah prodrced the tallest plant (57.27 cm) and BSR-1 produced the greatest number of tillers (4.47 CLUMP).

Intercropping of turmeric with *Leucuena leucocephala, Eucalyptus camaldulensis.* Ghoraneem or Manilkara spp. were carried out in Madhya Pradesh, India. The hightest yield of turmeric was observed in the L. leucocephala treatment. The yiedl of turmeric decreased with increasing tree age and with increasing density of planting of trees (Mishra and Pandey, 1998).

Michon *et al.* (1986) stated that multistoried agroforestry system is characterized by intensive integration of forest species and commercial crops forming a forest like system. Agroforest is a profitable production system and provides a buffer between villages and protected forests.

Michon and Mary (1994) reported that multistoried village gardens in the vicinity of Bogor, West Java, Indonesia have long been essential multipurpose production system for low income households. However, they are being subjected to important conversion processes linked to socioeconomic changes presently found in over crowed semi urban zones.

Mishra and Pandey (1998) stated that intercropping of *Curcuma longa* with *Leuceaena leucocephala, Eucalyptus camaldulensis, Melia Azadirach*

2.4. Homestead Agroforestry Practices

Homestead Agroforestry is the traditional land uses system in Bangladesh. It provides basic needs of the people such as food, shelter, cash etc. Under this system, people plant or retain multipurpose trees in the homestead. Annual and perennial crops are planted in between the species. Livestock is an integral part of the system. So, homestead Agroforestry is the most important example of Agri-silvi pastoral system in Bangladesh.

According to Wiersum (1982), a home garden is a land use form on private lands surrounding individual houses with a definite fence, in which several tree species are cultivated together with annual and perennial crops, often with the inclusion of small livestock.

Hassan and Mazumder (1987) observed that 88.5% of wood and 48.9% of fuel wood would come from homestead forest.

Hossain and Shailo (1987) reported that the present annual demand of fuel wood in the country stands in 2.04 million m^3 and the timber at 0.92 million m^3 where as the supply is presently 0.61 million m^3 and 0.76 million m^3, resulting in a deficit of 1.42 million m^3 of fuel wood and 0.16 million m^3 of timber. There is possibility of meeting this deficit through the practice of homestead Agroforestry system.

Leuschner and Khaleque (1987) stated that the homestead Agroforestry systems are very important in the economy of Bangladesh. In fact, Agroforestry is a term that invariability brings up the homesteads to the forefront in a country like Bangladesh; the very act of concentration on the homestead areas would cover more than three forth of all matters concerned with Agroforestry at large.

About 30,400 hectare of homestead in Bangladesh provided 70 per cent of timber, 90 per cent of fuel wood and 90 per cent bamboo per year as estimated by Byron (1984). Further, he showed that the annual harvest from the village was estimated to be 8.9 per cent of the standing volume and this was double the rate that the forests could sustain. If this is true and is not compensated, there would be an ultimate extinction of these forests.

Dasgupta *et al.* (1988) reported that farmers grew various fruits and vegetables on their homestead and farms varied according to their size and categories. Large farmers prefer growing a wide range of fruits and vegetables. They also found that the potential of the homestead was great which could be improved by replacing the less productive plants with fast growing nitrogen fixing species to provide more fuel fodder and green manure.

Khaleque *et al.*, (1988) observed that homestead forests are being overcome to meet increasing demands for fuel wood and timber in Bangladesh. The study revealed that every homestead contained a combination of different tree species, a bamboo grove and shrubs. Farmers generally prefer to grow fruit trees because they are multipurpose and can also provide fuel, fodder and timber.

Lai (1988) mentioned that application of appropriate technology in relation to production and management of trees and crops in the homestead ensured better utilization of land with the creation of better living environment there.

Hassan and Mazumder (1990) stated that the homesteads in rural Bangladesh are clustered with nearly 25 species of fruit trees and 30 species of timber, fuel wood and industrial wood trees. There are the habitats, for many herbs, shrubs and creeper species. Thus, homestead is a complex ecosystem and it varies from location to with minor ecological changes.

Islam (1991) reported that village forest mainly covered by homesteads accounts only 0.27 million ha and out of 64 district as estimated 28 districts had no public forestland.

Ahmed and Ali (1993) reported that trees are used for fencing homesteads, controlling soil erosion both in homestead and crop field.

Misbahuzzaman and Ahmed (1993) conducted a survey on land use categories in the homesteads of a forest rich area of Bangladesh. They observed that farmers in the marginal, small, medium and large farm categories utilized substantial portions (27-35%) of their homesteads for planting trees. Farmers in the landless farm category utilized 30% of their homesteads for cultivation of vegetables. Other land uses measured were housing, cattle sheds, ponds, threshing and drying floors and utilized. Farmers in all of the farm categories showed more interest in planting fruit tree species than forest tree species. Woodlots were very poorly managed.

Linda (1990) mentioned that the high diversity of plant species in village home garden ensure continuous production of fruit and vegetables, fuel, timber, medicinal and ash crops.

Hossain and Bari (1996) conducted a study, which is based on information obtained from a field survey conducted with 120 households in four selected villages in Bangladesh. They reported that homestead forests were an important source for the rural poor to meet their contingency needs. The forests were facing increasing pressure form alternative uses, but their survival was crucial to the economic and social needs of the rural people, especially the poor.

Ahmed (1997) in his study reported that 31 minor fruits were found in homestead of Bangladesh. The minor fruits account for as many as two thirds of the total number of fruits found to grow in homestead.

Wickramasige (1997) reported that Agroforestry is important for income, nutrition and health, for reducing economic risk, and for improving food security at household level. Home gardens were seen as having potential role to play maintaining biological diversity at both species and subspecies level.

Ahmed *et al.* (1998) reported that farmers of the study area grown first growing tree species in homesteads and farmland for improving soil organic matter and supply of timber, fruits, fodder and raw materials for cottage industries. They also suggested that trees in homestead may be managed on a rotation of 2-3 years to produce fuel wood; fruit trees be retained for longer period to obtain, fruits and timber.

Salehuddin *et al.* (1998) reported that farmers in homestead preferred fruit tree species over fuel, timber species because most tree species present in homesteads had multiple uses though all the uses were not considered while planting the species. For this reasons people have adopted some exotic short rotation tree species, replacing some indigenous tree species.

Mosabber and Niar (1999) studied the floristic composition and socio-economic aspects of rural homestead forestry and reported that the proximity to natural forest and the availability of timber in local markets also seen to influence the propensity to plant timber and fuel wood in home gardens. Fruit trees dominate the gardens, followed by fuel wood species. Women play an intensive role in the management of home gardens.

2.5. Farm land/crop land and other Agroforestry Practices

According to the classification of Agroforestry system based on the nature and type of components most cropland are agrosilvopastoral system consisting of herbaceous crop (Nair, 1985).

Lagemann (1987) opined that the cropland Agroforestry system is very important in the economy of Bangladesh. In fact Agroforestry is a term that invariably brings up the homesteads to the forefront. Particularly in a country like Bangladesh.

Singh *et al.* (1987) observed that shifting cultivation, taungya, prosopis cineraria (Khejur) based systems, homestead systems, multipurpose tree planting in agricultural fields and agrosilvocultural use of trees on farmland, borders and boundaries in both unirrigated arid semi arid areas and irrigated sub-humid and humid areas were some of the traditional Agroforestry systems.

Fernandes and Nair (1990) reported that the intimate mix of diversification agricultural crops and multipurpose trees fulfils most of the fundamental needs of the total populations and their multi-storied configuration and high species diversity avoid the environmental deterioration commonly associated with monoculture production systems. Moreover, they have produced sustainable yields for centuries in a most resource efficient way. Thus, cropland is economically efficient, ecological sound and biologically sustainable Agroforestry system.

Abedin and Quddus (1991) reported that boundary and in-field plantation of *Phoenix sylvestris* are highly profitable compare to cultivating agricultural crops only which give a gross return of Tk. 10,000-12,000 per hectare with crops like rice, wheat, pulses and oilseeds, and Tk. 60,000-75,000 with sugarcane. As in *Phoenix sylvestris*, juice is the primary economic product of *Borassus flabellifer*. "Thus tree also gives a handsome income to the landowners as well as to the gacchi. About 20 kg Gur is prepared from the juice obtained from one tree in a season, which is sold at the rate of Tk. 10-15 per kg. From 130-150 trees per hectare, 2,600-3,200 kg gur can be produced which generate Tk. 26,000-48,000.

Shivaprakash and Gowda (1992) found that Eucalyptus performing better than its perennial counterpart Casuarina which did not fare any better than millet on the crop land.

Ahmed (2001) reported that Swiss Agency for Development and Co-operation (SDC) undertook a major cropland Agroforestry initiative in the North Bengal in 1996 through its village and farm forestry project (VFFP). This was an action-oriented program aimed at promoting production in non-forest area (cropland and home gardens). The main objectives were to generate cash, fuel wood and fodder from privately owned farmland for the subsistence and sustenance of landless, marginal and poor farmers through planning trees on cropland and home gardens.

Das and Oli (2001) observed that *Dalbeergia sissoo* was the most preferred tree species by farmers followed by Bakain (*Melia azadirach*), Kadam (*Anthocephalus cadamba*) and *Populus* spp. Bamboo (*Bambusa Dendrocalamus* spp.) planing was also considered as suitable species of growing on farmland.

Roy I, Siddiqui, A.R. and Azmal Huda, A.T.M. 1996. Village and Farm forestry Program : An analysis of trend to plan for VFFP phases (1997-2001) : An input for Evaluation cum planning Mission Village and Farm Forestry Project, Swiss Agency for Dev. Co-operation, Dhaka.

Roy (1997) observed that village and farm forestry project's (VFFP's) current emphasis tilts toward c\ropland, most of which are under traditional rice-wheat systems. Because this techno-economic niche is both challenging and far more promising in scope for VFFP to add further momentum to its tree planting afford. This is evident from a 66 percent annual increase in khetland plantings between 1994 and 1996. If in 1994 khetland accounted for 22.9 percent share of VFFP's total planting, then in 1996 this figure stands at 45.9 percent.

Abedin *et al.* (1998) noted that *Acacia nilotica, A. catechu, Artocarpus heterophyllus, Phoenix sylvestris, Broassus flabelifer* and *Mangifera indica* were the major tree species grown on the croplands of he low rainfall Ganges floodplain in Bangladesh for fruit, timber, fuel and building material.

Hocking and Islam (1998) observed that Eucalyptus affected crop yield by 12 % but the species had highest wood production while economic analysis was made the species showed most profitable compared to all other species. Agriculture contributes about 37% of he gross domestic product of Bangladesh of the total agricultural product, about 77.7% comes from various crops, 7.8% form livestock, 7.8% from fishes and 6.7 from forests (BBS, 1993).

Stirzaker *et al.* (2002) predicted that the success of a tree/crop mixture becomes less likely with declining crop season rainfall and increasing seasonal variability and more likely when the tree products have a direct economic benefit.

Chapter 3

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

The materials and methods used in conducting the experiment presented here under different headings including brief descriptions of the experimental site, soil and climates.

3.1 Location of the experimental plots

The present research works were carried out at the Agroforestry Research Farm, Department of Agroforestry, HSTU, Dinajpur. Thirty years old litchi orchard was used for the study. The study period was from April 2007 to December 2007. The site lies between 25^0 13' latitude and 88^0 23′ longitudes at the elevation of 37.5m above the sea level.

3.2 Soil characteristics

The experimental site belongs to the Old Himalayan Piedmont Plain AEZ. The soil texture was sandy loam with a pH of 3.5 The structure of soil was fine, details soil physical and chemical characteristics were given in Apendix-I

3.3 Structural Description of Litchi Orchard

The studies were done under 30 years old litchi tree, which was established at the eastern side of Agroforestry Research farm. The characteristics of litchi tree were as follows:

Tree	Characteristics	Values
Litchi	Height	17 m
	Base girth	2.35 m
	Tree to Tree distance	10 m
	Canopy diameter	10 m

3.4 Climate and weather

The climate of the study area is characterized by a heavy rainfall during kharif season (April to September) while a scanty rain fall during the rest period, i.e. during the Rabi season (October to March). The mean maximum temperature in the summer (March to September) was 35^0 C and the mean maximum temperature in the winter (November to March) 11.9^0C. The humidity was 87% in January and 88% in July. The mean annual rainfall was 1822 mm most of which occurred in short spells during May to September and light showers occur during the Rabi season (October to March). Monthly average temperatures, relative humidity, total rainfall of the experiment site during the period from

April to December 2007 are cited in Appendix-II. Light intensity was measured at different time at the day and then average light intensity was calculated in Appendix-III.

3.5 Experimental design

The experiment was laid out in the RCBD. The experiment was set with turmeric. Three different distances were compared as the four treatments in the experiment. There were three replication in each study. The size of each plot was 4 × 1m.

3.6 Treatments of the study

The four treatment combinations used in the study was-

T_1= 2.0-3.0 m distance from the tree base and light intensity was 20-30% (highest shade 80-90%)

T_2= 3.0-4.0 m distance from the tree base and light intensity was 40-50%, (Moderate shade 50-60%)

T_3= 4.0-5.0 m distance from the tree base and light intensity was 80-90% (Partial shade 10-20%) and

T_4= Open field light intensity 100% (No shade)

3.7 Land preparation

The land was opened in the first week of March 2007 and prepared throughly by spading to obtain a good tilth, which was necessary to get better yield of this crop (Ahmad,1969). All the weeds, stubbles and crop residues were removed from the field and bigger clods were broken into smaller pieces. Finally, the land was pulverized and leveled uniformly.

3.8 Experimental materials

The Dimla (T-027) variety of turmeric was used in the experiment as the test crop.

3.9 Crop establishment

The seed rhizome of turmeric was planted maintaining a row to row distance of 50cm, a plant to plant distance of 25cm and a depth of 10cm. The weight of each seed-rhizome was of 15-20g.

3.10 Intercultural operation

Weeding is done as felt necessary. Earthing-up was done thrice; the first one after 60, the second one after 90 and the final one after 110 days of planting. Some plants were rotten by water logging condition. This condition was controlled by drainage. Some turmeric plants were affected by leaf spot and rhizome rot disease, which were controlled by spraying Rovral and Dithane M-45 @ 4.5g/L at an interval of 15 days, respectively.

3.11 Application of manure, fertilizer and Dolochoon

The doses of fertilizers and manures and their methods of application as recommended by MD. Mamum Al Ahsan Chowdhury (2006) as follows:

Recommended fertilizer/manure rates and method of application for turmeric

Manure/ fertilizers	**doses per hectare**
Well decomposed cow dung	10 (ton)
TSP	45 (kg)
Mp	125 (kg)
Gypsum	105 (kg)
Zinc sulphate	3 (kg)
Dolochoon	240 (kg)

Cow dung and Dolochoon were applied seven days before planting. One half of N and other fertilizers were applied before planting of rhizome. Rest of the N fertilizer were applied in 3 splits between 2 rows after planting of rhizome at 50, 80 and 110 days of planting.

3.12 Harvesting

Turmeric were harvested on 30 December 2007 (after 260 days of planting) when the sheath were yellow and started drying up.

Plate 1: Sample of final harvest.

Plate 2: Showing the rhizome and finger produced from a single plant.

3.13 Sampling and data collection

Samplings were done before first time of data collection. First data were collected on 100 days after planting and second data collection was done on 180 days after planting. Fifteen plants were randomly selected from each plot for data collection and the following parameters were recorded.

i) **Plant height (cm):** This was measured from the ground level up to the tip of the longest leaf of the sample plants at 100 and 180 DAP.

ii) **Number of leaves per plant:** It was counted at 100 and 180 DAP.

iii) **Number of tillers per plant:** This was also recorded at 100 and 180 DAP.

iv) **Number of finger per plant:** It was counted at the time of harvest.

v) **Finger fresh weight per plant (g):** After harvest, fingers were moped with a handkerchief and then were weighed with a balance.

vi) **Finger dry weight per plant (g):** After harvest, fingers were dried in an electric oven for 24 hours at 70^0C till the constant weight was achieved.

vii) **Rhizome fresh weight per plant (g):** The weight of fresh rhizome per selected plant was recorded with the help of a balance at the time of harvest and their average was calculated as weight of individual plant.

viii) **Rhizome dry weight per plant (g):** After harvest, rhizome of 15 selected plants were weighed and dried in an oven for 24 hours at 70^0C till constant weight. After drying the dry rhizome weighed and mean weight was calculated in gram (g).

ix) **Total yield per hectare (ton/ha):** The yield of rhizome per plot was converted to yield per hectare.

3.14 Data analyses

The data on various growth and yield contributing parameters of turmeric was statistically analyzed to examine the variations of the results due to the four treatments compared. The analyses of variance for each trait were done by F (variance ratio) test following the RCBD design. The treatment mean was compared by the LSD test at 5 percent level of significance.

Chapter 4
Results and Discussion

CHAPTER 4

RESULTS AND DISCUTION

The episode is the presentation and discussion of the results obtained from the experiments carried out to study the performance of turmeric under litchi tree as practices of agroforestry system. The data are presented tables, plates and the summary of analysis of variance of all parameter. The results of each parameter discussed under the following headings.

4.1 Plant height

Plant height at different Days After Planting (DAP) was significantly influenced by different treatments. At 100 DAP the tallest plant was recorded from T_2 (99.67 cm) followed by T_1 (91.71) significantly the smallest plant was recorded from T_4 (83.72 cm) on the other hand the medium plant height was recorded from T_1 (91.71 cm) and T_3 (91.07cm) both were statistically similar (Table-1). At 180 DAP similar influenced was found on plant height by the different treatments. Significantly the tallest plant height was produced from T_2 (99.67) followed by T_1 (91.71). Significantly the smallest plant height was recorded in T_4 (83.72 cm), which was not similar to that of T_3 (123.05 cm).

Similar result was found by Meerabai *et al.* (2000). They noticed that turmeric responded for its plant height to highest level of shade than the open field conditions.

Table 1: Effect of shade on plant height (cm) and number of tiller/plant of turmeric at 100 and 180 DAP.

Treatment	Plant height (cm)		Number of tiller/plant	
	100 DAP	180 DAP	100 DAP	180 DAP
T_1	91.71 b	142.30 b	.00 c	.00d
T_2	99.67 a	156.43 a	1.25 b	2.23c
T_3	91.02 b	123.05 c	2.90 a	3.33a
T_4	83.72 c	115.20 d	2.53 a	2.73b

T_1= 2.0-3.0 m distance from the tree base and light intensity 20-30% (highest shade 80-90%); T_2= 3.0-4.0 m distance from the tree base and light intensity 40-50% (Moderate shade 50-60%); T_3= 4.0-5.0 m distance from the tree base and light intensity 80-90% (Partial shade 10-20%) and T_4= Open field light intensity 100% (No shade)

4.2 Number of tiller

Number of tiller/plant at different days (DAP) after planting was significantly influenced by different treatments (Table-). At 100 DAP the maximum number of tiller / plant was produced by T_3 (2.90) followed by T_4 (2.53) which was statistically similar. Significantly the minimum number of tiller/plant was obtained from T_1 (00) which was not similar to that of T_2 (1.25). At 180 DAP similar influenced was found on number of tiller/plant by different treatments. Significantly the maximum number of tiller/plant was obtained from T_3 (3.33) followed T_4. No tiller was produced by the plants of T_1.

Absent of tiller in T_1 might be due to heaviest shade. On the other hand Partial shade (10-20%) might be the causes of maximum number of tiller/plant.

4.3 Number of leaves

Number of leaf per plant of turmeric was influenced by the different shade conditions found at different distance from tree base. At 100 DAP the significantly heights number of leaf/plant was obtained from T_3 (7.89) followed by T_4 (6.96). Significantly the lowest number of leaf/plant was recorded from T_1 (5.36) (nearest treatment from tree base and heaviest shade), which was statistically identical to that of T_2 (5.96)

(Table-2). At 180 DAP similar influenced was found on number leaf/plant by different treatments. Significantly the highest number of leaf/plant was produced from T_3 (8.73) followed by T_4 (7.53). Significantly the lowest number of leaf/plant was recorded in (5.53) which was not similar to that of T_2 (7.03).

The lowest number of leaf/plant obtained from T_1 might be due to heaviest shade. Partial shade (10 -20%) might be the causes of highest number of leaf/plant.

Table 2: Effect of shade on Number of leaf/plant (cm), Length of leaf blade/ plant (cm) and Breadth of leaf blade/plant (cm) of turmeric at 100 and 180 DAP.

Treatment	Number of leaf/plant		Length of leaf blade/plant (cm)		Breadth of leaf blade/plant (cm)	
	100 DAP	180 DAP	100 DAP	180 DAP	100 DAP	180 DAP
T_1	5.36 c	5.53d	66.20 c	91.11b	11.50 c	11.92c
T_2	5.96 c	7.03c	77.43 a	105.22a	13.76 ab	14.17ab
T_3	7.89 a	8.73a	71.10 b	94.46 b	15.36 a	15.81a
T_4	6.96 b	7.53b	62.86 d	71.93c	13.23 bc	13.95bc

T_1= 2.0-3.0 m distance from the tree base and light intensity 20-30% (highest shade 80-90%); T_2= 3.0-4.0 m distance from the tree base and light intensity 40-50% (Moderate shade 50-60%); T_3= 4.0-5.0 m distance from the tree base and light intensity 80-90% (Partial shade 10-20%) and T_4= Open field light intensity 100% (No shade)

4.4 Length of leaf blade:

Length of leaf blade of turmeric was influenced by deferent shade conditions found at different distance from tree base. (Table-2) At 100 DAP the significantly the largest length of leaf blade was obtained from T_2 (77.43) followed by T_3 (71.10). Significantly the lowest length of leaf blade was recorded from T_4 (62.86), which was not similar to that of T_1 (66.20 cm). At 180 DAP similar influence was found on length of leaf blade by different treatments. Significantly the largest length of leaf blade was obtained from T_2 (105.22 cm) followed by T_3 (94.46), which was statistically similar to that of T_1 (91.11 cm). Significantly the lowest length of leaf blade was recorded in T_4 (71.93 cm).

The lowest length of leaf blade obtained from T_4 might be due to no shade. Moderate shade (50-60%) might be the causes of largest length of leaf blade.

4.5 Breadth of leaf blade:

Breath of leaf blade of turmeric was influenced by different shade conditions found at different distance from tree base. At 100 DAP, significantly the largest breadth of leaf blade was obtained from T_3 (15.36 cm) which was statistically similar to T_2 (13.76 cm). Significantly the lowest breadth of leaf blade was recorded from T_1

(11.50 cm), which was statistically similar to T_4 (13.23cm). But T_2 (13.76cm) and T_4 were statistically similar respectively. At 180 DAP similar influence was found on breadth of leaf blade by different treatments. Significantly the largest Breadth of leaf blade was produced by T_3 (15.81 cm), which was statistically similar to T_2 (14.17cm). Significantly the lowest breadth of leaf blade was recorded in T_1 (11.92 cm), which was statistically similar to T_4 (13.95cm). T_2 (14.17cm) and T_4 (13.95cm) were statistically similar.

The lowest breadth of leaf blade obtained from T_1 might be due to heaviest shade. Partial shade (10-20%) might be due to the largest breadth of leaf blade.

Plate 3: Vegetative phase of turmeric at 180 DAP (T_1)

Plate 4: Vegetative phase of turmeric at 180 DAP (T_2)

Plate 5: Vegetative phase of turmeric at 180 DAP (T_3)

Plate 6: Vegetative phase of turmeric at 180 DAP (T_4) Open field.

4.6 Number of finger:

Number of finger per plant is an important yield contributing character. Number of fingers among the for treatment i.e. for different light levels were significant where the highest number of finger counted from T_3 (13.38) the minimum number of finger was obtained from T_1 (9.96). But the moderate number of finger counted from T_2 (11.29) and T_4 (11.44), which were statistically similar.

The minimum number of finger obtained from T_1 might be due to heaviest shade. The highest number of finger per plant produced in $T_{3,}$ Partial shade (10-20%). It indicated that partial shade enhanced the translocation of photosynthetic materials to rhizome, which might be causes of maximum number of finger per plant.

4.7 Finger fresh weight

Finger fresh weight per plant was significantly influenced by different treatments. The highest finger fresh weight was recorded from T_3 (225.72 g) The lowest finger fresh weight was recorded from T_1 (105.89g). On the other hand the medium finger fresh weight was obtained from T_2 (185.86g) and T_4 (186.86g) under open field conditions. The T_2 and T_4 were statistically similar.

The smallest number of finger fresh wt. obtained from T_1 might be due to heaviest shade. T_3 Partial shade (10-20%) might be due to the causes of height finger fresh wt. per plant.

Table 3: Effect of shade on Number of finger/plant (g), Finger fresh weight/plant(g),Rhizome fresh weight/plant(g), Fresh yield/plant(g) and Total fresh yield (t/ha) of turmeric.

Treatment	Number of finger/plant (g)	Finger fresh Weight/ plant (g)	Rhizome fresh Weight/ plant(g)	Fresh yield/ plant (g)	Total fresh yield (t/ha)
T_1	9.96 c	105.89 c	36.86 d	142.75c	10.7 c
T_2	11.29 b	185.86 b	55.16 c	241.02b	18.07 b
T_3	13.38 a	225.72 a	88.88 a	314.60a	23.59 a
T_4	11.44 b	186.86 b	55.86 b	242.72b	18.20 b

T_1= 2.0-3.0 m distance from the tree base and light intensity 20-30% (highest shade 80-90%); T_2= 3.0-4.0 m distance from the tree base and light intensity 40-50% (Moderate shade 50-60%); T_3= 4.0-5.0 m distance from the tree base and light intensity 80-90% (Partial shade 10-20%) and T_4= Open field light intensity 100% (No shade)

4.8 Fresh rhizome weight

The highest rhizome fresh weight was obtained from T_3 (88.88g) followed by T_4 (55.86g). The lowest rhizome fresh weight was recorded from T_1 (36.86g). But the moderate value was counted from T_2 (55.16g) and T_4 (55.86g). But they were not statistically similar.

The lowest rhizome fresh wt. obtained from T_1 might be due to heaviest shade. T_3 Partial shade (10-20%) might be due to the causes of height rhizome fresh wt. per plant.

4.9 Total fresh yield

The yield contributing character statistically influenced by shade level from the tree base. The maximum yield recorded from T_3 (23.59 t/ha) which was followed by T_4 (18.20 t/ha) and statistically similar to T_2 (18.07 t/ha). Oppositely the lowest value was found from T_1 (10.7 t/ha).

Relatively the better yield of turmeric under partial shade T_3 (10-20% shade), might be due to better photosynthetic efficiency and faster translocation of photosynthates to the storage organ of turmeric plants. It has been postulated that partial shading enhanced the quantity of chlorophyll and thus enhances the photosynthetic efficiency of the plants (Collard *et al.*, 1977; El-Aidy *et al.*, 1983). Nayak *et al.*, 1979 reported that translocation is enhanced under lightly reduced light (70% of normal light), but further reduction in light (below 70%) normal light), affect translocation due to limitation in energy supply.

Plate 7: Sample turmeric of final harvest from different treatments.

Plate 8: Cross section of turmeric (rhizome and finger) of different treatments.

Plate 9: Cross section of rhizome
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Plate 10: Cross section of finger.

4.10 Finger dry weight

The fingers dry weight/ plant also influenced by shade levels like finger fresh weight. The maximum value was counted from T_3 (43.66g) and the minimum value was recorded from T_1 (18.88g). On the other hand the medium values were counted from T_2 (36.87g) and T_4 (37.87g), which was statistically similar.

Table 4: Effect of shade on finger dry weight/plant (g), Rhizome dry weight/plant(g), Dry yield/plant(g) and Total dry yield (t/ha) of turmeric.

Treatment	Finger dry Weight /plant (g)	Rhizome dry Weight /plant (g)	Dry yield/ plant (g)	Total dry yield (t/ha)
T_1	18.88 c	8.86 d	27.74d	2.08 d
T_2	36.87 b	14.16 c	51.03c	3.82 c
T_3	43.66a	24.86 a	68.52a	5.14 a
T_4	37.87 b	14.88 b	52.75b	3.96 b

T_1= 2.0-3.0 m distance from the tree base and light intensity 20-30% (highest shade 80-90%); T_2= 3.0-4.0 m distance from the tree base and light intensity 40-50% (Moderate shade 50-60%); T_3= 4.0-5.0 m distance from the tree base and light intensity 80-90% (Partial shade 10-20%) and T_4= Open field light intensity 100% (No shade)

4.11 Rhizome dry weight

Rhizome dry weight/plant influenced by shade than other parameters. The maximum rhizome dry weight was counted from T_3 (24.86g). The minimum rhizome dry was obtained from T_1 (8.86g). But the T_4 (14.88g) show the moderate performance. T_2 (14.16g) also show similar performance. But T_2 and T_4 were not statistically similar.

The minimum Rhizome finger dry weight obtained from T_1 might be due to heaviest shade. T_3 Partial shade (10-20%) might be due to the causes of highest Rhizome finger dry weight/ plant.

4.12 Total dry yield

The dry yield significantly varied by shade levels the highest dry yield was obtained from T_3 (5.14 t/ha) followed by T_4 (3.96 t/ha). On the other hand the lowest yield was recorded from T_1 (2.08 t/ha) which was not similar to that of T_2 (3.82g).

The similar result was found by Miah et al. (2005), they observed that significantly lowest dry matter yield of turmeric and ginger was found under 25% PAR level.

Relationship between distance from tree base and fresh yield per plant (g):

Linear relationship was found between distance from tree base and fresh yield. The equation is y= 85.93 x -67.95, $R^2 = 0.99$. The yield of turmeric gradually increased with the increased of distance from tree base.

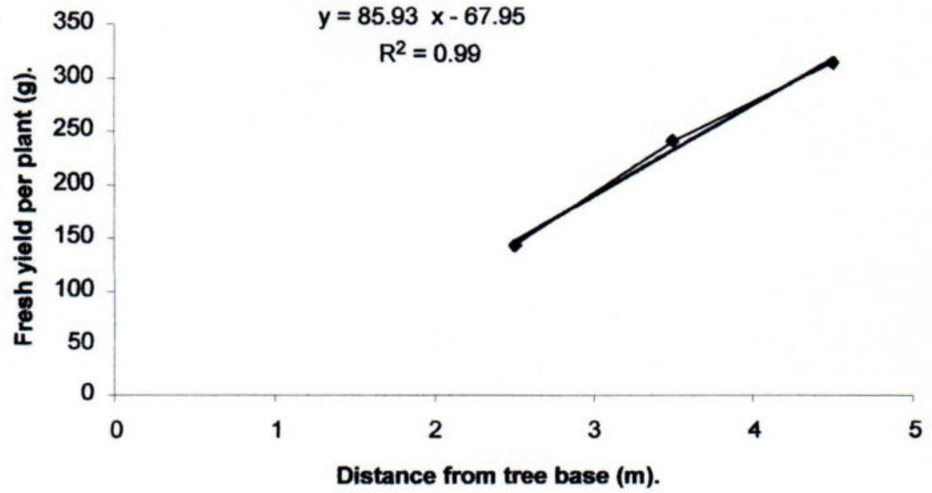

Figure: 1 Relationship between distance and fresh yield g/plant

Chapter 5

Conclusion and Recommendations

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

Irregular variation of plant height was found under Litchi orchard. The shortest plant height under Litchi orchard was found at nearest treatment (2-3 m distance) as the shade level was severe. The plant height increased up to 4m distance. After 4m distance from tree base the plant height of turmeric was turned to decrease. i.e. The plant height of turmeric at 2-3, 3-4 and 4-5m distances were 142.30, 156.43 and 123.05 respectively. But the shortest plant height was recorded under full sunlight (115.20 cm). All other vegetative parameters of turmeric was found highest at 4-5m distance from tree base and significantly the lowest values were recorded in the nearest treatment (2-3m distance). In case of yield contributing characters the highest yield of turmeric was found at T_3 treatment (4-5m distance, Partial shade 10-20%). Significantly the lowest yield was recorded at 2-3m distance, the yield obtained from open field T_4 (18.20 t/ha), was statistically similar to that of T_2 (18.07 t/ha) which was 3-4m distance from tree base.

The study suggested that up to 3m distance from tree base of turmeric production was not profitable. Hence it can be concluded that middle 6m alley (avoiding 3m from each tree base), was suitable for turmeric production.

The findings can be used for mature Litchi orchards that are similar (age, canopy and arrangement) to the experimental orchard. Before final comments another one year same experiment is needed.

References

REFERENCES

Abedin, M.Z. and Quddus, M.A. 1990. Household fuel situation, Homegarden and Agroforestry practice at six agro-ecologically different locations of Bangladesh. *In:* Homestead plantation and Agroforestry in Bangladesh. Abedin, M.Z.; Lai, C.K. and Ali, M.O. (eds). Proc. Nat. Work. July 17-19, 1998 Gazipur, 1701, Bangladesh. pp. 19-34.

Abedin, M.Z. and Quddus, M.A. 1991. Agroforestry systems in Bangladesh with particular reference to economics and tenorial issues. *In:* Agroforestry Reference in Asia and the Pacific. Mellink *et al.* (eds) RAPA/FAO, Winrock Int. Inst. Agric. Dev., Bangkok. pp. 13-33.

Ahmed, F.U. 1997. Minor fruits in homestead Agroforestry. In Agroforestry: Bangladesh perspective. Alam, M.K., Ahmed, F.U. and Amin, S.M.R. (Eds.) APAN-NAWG-BARC, Dhaka, Bangladesh. pp. 165-169.

Ahmed, K. 1969. Phul Phat O Shank-Shabji (in Bangla). 2nd Ed, Alhaj Kamisuddin Ahmad, Banglo No. 2, Sher-E-Bangla Nagar, Dhaka-15. pp. 438-439.

Ahmed, M. and Ali, M.H. 1993. Agroforestry-environmental linkages. Lecture Note Agrof. Train. Work. Feb. 77-March 4, 1993, BARC, Dhaka.

Angeles, D.E and Mendoza, D. B. 1988. Performance of papaya grown as monocrop and as intercrop with pineapple and banana. Philippine Agriculturist. 71 (2): 173-177

Anonymous, 1999a. Fruit Production Manual, HRDP/DAE/BADC, Dhaka. 252p.

Anonymous, 1999a. Fruit Production Manual, HRDP/DAE/BADC, Dhaka. 252p.

Battistelli. A.S., Moscatello, Proietti, S., Salvini, D. Scartazza Augusti, A. And Garab G. 1998. Growth light intensity affects photosynthetic carbon metabolism in spinach photosynthesis: mechanisms and effects. Volume V. Proceeding of the X1th International Congress on Photosynthesis, Budapest, Hungary, 17-22 August, 1998.

BBS (Bangladesh Bureau of Statistics). 2001. Statistical yearbook of Bangladesh. Stat. Div. Ministry Plan. Govt. People's Rep. Bangladesh, Dhaka.

BBS, 2003. Monthly Statistical Bulletin Bangladesh Bureau of Statistics Stat. Div. Ministry of Planning, Government Peoples Republic of Bangladesh.

BBS, 2003. Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics. Ministry of Planning, Government Republic of Bangladesh.

Bene, J.G., Beall, H.W. and Cote, A. 1977. Trees, Food and People. IDRC. Ottawa.

Byron, N. 1984. Status, trend and proposed direction of Bangladesh forestry paper presented at the forest. Ext. Seminar, Forest Dev. Train Cent. Kaptai, Bangladesh.

Byron, R.N. 1984. Peoples forestry. A novel perspective of forestry in Bangladesh. ADAB News 11(2): 28-42.

Chowdhury, M.A. 2006. Effect of fertilizer and soil amendment on the performance of turmeric and ginger in ghoraneem based agroforestry system. M.S. Thesis, HSTU, 29 pp.

Collard R.C., Joiner J. N., Conver C.A. and McConnell D.B. 1977. Influences of shade and fertilizer on light compensation point of Ficus benjamian L. J. Amer. Soc. Hort. Sci 102 (4): 447-449.

Contritto, M., Dolphion, S., Villain, M.C., Aluino, A. and Marco, G.D. 1998. Improved growth of pepper under reduced light intensity, photosynthesis, mechanism and effects. Proc. of the Eleventh International Congress on photosynthesis. Budapest, Hungary, 17-22 August 1998, 3773-3776.

Das, A.N. and Oil, B.N. 2001. Tree growing practices on farmland: an option for sustaining rural livelihood. Banko-Janakari. 11: (2) 8-12.

Dasgupta, S., Azam, A.K., Rahman, M. and Islam, K.D.K.M. 1988. Agroforestry status homestead area on vaskarkhills farming system research site, Kishoregonj (Bangladesh), Proc. Nat. Work.. *In:* Homestead Plantation and Agroforestry in Bangladesh. BARI, PIC, Great Britain. 17(8): 1159-1172.

Dwivedi, A.P. 1992. Agroforestry: Principles and practices. Oxford and IBH Pub. New Delhi.

El-Aidy, Moustafa F S and El-Afry M. 1983. Influence of shade on growth and yield of tomato cultivated in summer season in Egypt. Plasticulture. 59: 33-36.

Fernandos, E.C.M. and Nair, P.K.R. 1990. An evaluation of the structure and function of tropical Agroforestry. *In:* Kathleen, L. and Mark, B. (ed.). tropical home garden. United Nations Univ. Press.

Hassan, M.M. and Mazumder, H.M.H. 1987. An exploratory Survey of Tress on Homestead and Wasteland of Bangladesh. ADAB News, March-April. 1990. pp. 26-32.

Hassan, M.M. and Mazumder, H.M.H. 1990. An Exploratory Survey of Trees on Homestead and Wasteland of Bangladesh. ADAB News March-April. 1990. pp. 26-32.

Hocking, D. and Islam, K. 1998. Tress on farms in Bangladesh : 5. Growth of top and root pruned trees in wetland rice fields and yields of under story crops. Agroforestry System. 40(1): 98-109.

Hossain, A. and Shailo, I. 1987. Deforestation in Bangladesh : Towards an Ecological Infer. ADAB News. Vol. XVII. No.2.

Hossain, S.M.A. and Bari, M.N., 1996. Agroforestry farming system. *In:* Haque M.A. (ed.). Agroforestry in Bangladesh, Mymensingh.

Islam, M.N. 1991. Towards Sustainable Development : Energy and Mineral Resources of Bangladesh. National Strategy, BARC, Dhaka.

Jackson. J. E. 1987. Tree and crop selection and management to optimize overall system productivety, especially light utilization in agroforestry. Meteorology and agroforestry. ICRAF, WMO and UNEP.

Khaleque, K., Withington, D., MacDicken, K.G., Sastry, C.B. and Adams, N.R. 1988. Growing Multipurpose fruit trees in Bangladesh : Farmers perceptions of opportunities and obstacles. Department of Social., Univ. Dhaka, Bangladesh.

Lagemann, J. 1987. Traditional farming system in Eastern Nigeria. African Studies. Special series 98. Weltforum, Verlag.

Lai, C.J.K. 1988. Design of Agroforestry system with special Reference to Bangladesh. In: Proc. Work. Homestead and Agrof. Bangladesh Agric. Res. Inst. Gazipur, Bangladesh.

Leonardi C. Effect of shading on peppers, Cotures-Protette (ITALY); 25 (7): 61-65 (Cited from CAP Abst., 1996-98).

Leuschner, W.A. and Khaleque, K. 1987. Homestead Agroforestry, Bangladesh. Agroforestry System. 5: 139-151.

Linda, C. 1990. Home garden in the tropical Asia, with special reference to Indonesia. In: Tropical Home garden Kathleen, L. and Mark, B.(ed.). U.N. Univ. Press. pp. 9-21.

Ludgren, B.O. and Raintree, J.B. 1982. Sustained Agroforestry. In: Agric. Re. for Dev. Potentials and Challenges in Asia, (Nestel B. ed.) ISNAR. pp. 37-49.

Meerabai, M., B. K. Jayachandran and K. R. Asha. 2000. Boosting spice production under coconut gardens of Kerala maximizing yield of turmeric with balanced fertilization. Better Crops Inter., 14 (2): 10-12

Miah, M.G., Garrity, D.P. and agron, M.L. 1995. Light availability, to the understrrey annual crops in an Agroforestry system. In: Sinoquet, H. and Cruz, P. (ed) Ecophysiology to tropical inter cropping. IRNA Editions, Paris, France.

Michon, G. and Mary, F. 1994. Conversion of traditional village gardens and new economic strategies of rural households in the area of Bogor Indonesia. Agroforestry systems, 25 (1): 31-54

Michon, G., F. Mary and J. M. Bompard 1986. Multistoried Agroforesrty garden systems in West Sumatra, Indonesia. Agrofor. System, 4 (4): 315-338.

Misbahuzzaman, K. and Ahmed, M.R. 1993. Homestead land utilization for tree husbandry in a forest-rich area of Bangladesh. Chittagong Univ. Stud. 17(1): 37-43.

Mishra, R. K. and Pandey, V. K. 1998. Intercropping of turmeric under different tree species and their planting patter in agroforestry system. Zonal Agricultural Research Station, Ambikapur, M. P., India. Range Management and Agroforestry, 19 (2): 199-202.

Mosabber, A.S. and Niar, A.K. 1999. Floristic composition and socio-economic aspects of rural homestead forestry in

Chittagong : A case study Bangladesh J. Forest. Sci. 28(2): 94-101.

Nair, P.K.R. 1979. Agroforestry Research : A Retrospective and Prospective Appraisal Proc. Intl. Conf. Int. Coop Agroforestry. ICRAF, Nairobi, pp. 275-296.

Nair, P.K.R. 1985. Classification of Agroforestry systems. Agroforestry System. 3: 97-128.

NCA. 1976. Report of the National Commission on Agriculture, Part IX. Forestry Govt. India. Ministry of Agric. and Irrigation, New Delhi.

Ong C.K. 1988. The interaction light, water and nutrients in agroforestry system. Chapter for book on "Application of Biological Research on Asin Agroforestry". J. A., 885.

Ong, C. K., Corlett. , J. E., Singh, R.P. and Black, C.R. 1991. Above and below ground interactions in Agroforestry systems. Forest Ecology and Management, 45: 45-57.

Purseglove, J. W. 1988 Papaya in: Tropical crops Dicotyledons, the English Language Book Society. pp. 45-51.

Purseglove, J. W. G. Brown, C. L. green and S.R. J. Robbins. 1981. Spices. Longman scientific & Technical Co-published in the united states with John weley & sons, Inc., New York. vol., 2: 457.

Roy I, Siddiqui, A.R. and Azmal Huda, A.T.M. 1996. Village and Farm forestry Program : An analysis of trend to plan for VFFP phases (1997-2001) : An input for Evaluation cum planning Mission Village and Farm Forestry Project, Swiss Agency for Dev. Co-operation, Dhaka.

Roy, I. 1997. Cropland Agroforestry: The Experience of the village and Farm Forestry Program. In: Agroforestry Bangladesh Perspective. Alam *et al.* (eds.) APAN/NAWG/BARC.

Salehuddin, G., Miah, M.D. and Aktes, S. 1998. Social attitude towards homestead forestry in Narsingdi district, Bangladesh. South Asian Anthrop. 19(2): 99-106.

Saka. A. r. , Bunderson, W.T., Mbekeani, Y. and Itimu, O. A. 1990. Planning and implementing Agroforesrty for small holder farmers in Malawi. In: Planning for agroforesrty, Budd et al. (Eds) Elsevier Applied Sci. London.

Sarkar, band Saha A. 1997. Note on Effect of light intensity on growth and yield on radish (Raphanus sativus L.) Indian Agric., 41 (4): 295-298.

Sathish, H, Venkatesha, J., H. Chandrappa, S. Hegde, N. M. Mathew (ed): (1998) performance of promising turmeric cultivars under coconut cropping systems. Division of Hort., Univ. of Agril. Sci., Bangalore, India. Development in plantation crops research. Proc. of the 12th symposium on plantation crops. India 27-29 November 1996, 220-222.

Shivaprakash, A.R. and Gowda, M.V.S. 1992. Comparative economics of eucalyptus, casuarinas and ragi. Agricultural Situation in India. 46(12): 931-933.

Siddique A.B. 1995. Importance of vegetables and spices production. Horticulture Research and Development project, Dhaka.

Singh, G.B.. Steppler, H.A. Nair, P.K.R. 1987. Agroforestry in the Indian subcontinent : past, present and future. Agroforestry : a decade of dev. pp. 117-138.

Singh, H., Gurbachan. S., Singh, H., Singh, G. 2001 Performance of turmeric in association with multipurpose tree species. Central Soil Salinity Res. Institute, Karnal, Haryana, India, Applied Biol. Res., 3 (1-2): 57-60.

Sing, L. 1988 Adoption and yield of potato under low light intensity. Indian J. Plant Physiolo., 31 (1): 114-116.

Sritharam, R. and R. Lenz. (1992). Effect of light regime on growth, carbohydrates and nitrate concentration in kohlrabi Angewandte Botanik. 66: 3-4, 130-134.

Stirzaker, R.J., Lefroy, E.C., Ellis, T.W., Turner, N.C. and Ward, P.R. 2002. An index for quantifying the trade of between drainage and productivity in tree crop mixtures. Special Issue: The role of Agroforestry and perennial pasture in mitigation water logging and secondary salinity. Selected papers form a symposium held at Albany, Western Australia. 13-14 June 2000. Agricultural-Water-Management. 53(1-3): 187-199.

Torquaebiae, E. 1990. The concept of Agroforestry Lect. Notes. 2nd ed. ICRAF, Nirobi, Kenya.

Wang, S. H. and Zhang, Z. X 1998. Effect of shade on growth and yield of ginger. China vegetables, 5: 5-8.

Wickramasinge, A. 1997. The evaluation of Kanadyan (Sri Lanka) homegarden. An Intewrgenous strategy of conservation of biodiversity out side the protected area, IUCN, 1997.

Wiersum, K.F. 1982. Tree garden and Taungya on Java. Examples of Agroforestry in the humid tropics. Agroforestry System. 1: 53-67.

Zong, L. F. and Kato, T. 1988. The effect of sunlight intensity on growth, yield and chemical composition of xylem exudates in solanaceous fruits. Research r\Reports of the Kochi University: Agril. Science 37: 39-40.

Appendices

APPENDIX

Appendix I. The properties of soil of the experimental Litchi orchard

Soil characters	Physical properties
Sand (%)	65
Silt (%	30
Clay(%	5
Texture	Sandy loam
CEC (meq/ 100g)	8.07

Soil characters	Chemical properties
p^H	5.35
Organic matter (%)	1.06
Total nitrogen (%)	0.10
Sodium (meq/ 100g)	0.06
Calcium (meq/ 100g)	1.30
Magnesium (meq/ 100g)	0.40
Potassium (meq/ 100g)	0.26
Phosphorus (µg/g)	24.0
Sulphur (µg/g)	3.2
Boron (µg/g)	0.27
Iron (µg/g)	5.30
Zinc (µg/g)	0.90

Source: Soil Resources Development Institute, Dinajpur (2007).

Appendix II. Distribution of monthly average temperature, relative humidity, total rainfall of the experiment site during the period from April to December 2007.

Month	Air temperature (^0C)		Relative humidity (%)	Total rainfall (mm)
	Max.	Min.		
April	32.8	21.1	83	54
May	30.9	21.5	77	213
June	33.2	23.2	82	333
July	32.0	25.8	85	369
August	32.4	26.2	84	466
September	32.0	25.0	89	97
October	31.6	21.0	90	0
November	27.5	15.5	72	0
December	26.6	11.9	85	0

Source: Wheat Research Center, Dinajpur.

Appendix-III. Monthly average light intensity during the period from May to December 2007.

Month	Date	Light intensity at different time of the day (LUX)			Total light intensity(LUX)	Average light intensity (LUX)	Monthly mean light intensity (LUX)
		10.00 AM	12.00 PM	4.00 PM			
May	8-5-07	32200	38300	33100	103600	34533	34499
	15-5-07	30600	33500	30000	94100	31366	
	22-5-07	38200	42300	37600	118100	39366	
	29-5-07	31200	33700	33300	98200	32733	
June	6-6-07	36200	37600	35700	109500	36500	28891
	14-6-07	29700	37200	32400	99300	33100	
	18-6-07	22000	23200	22600	67800	22600	
	28-6-07	23800	24700	21600	70100	23366	
July	4-7-07	30200	33300	22800	86300	28766	40191
	11-7-07	42200	47300	41600	13100	43700	
	18-7-07	38800	47700	40100	126600	42200	
	25-7-07	40700	56200	41400	138300	46100	
August	01-8-07	41100	50800	42200	134100	44700	44624
	8-8-07	40700	48100	43300	132100	44033	
	15-8-07	41000	50200	40900	132100	44033	
	28-8-07	42200	52000	43000	137200	45733	
September	5-9-07	41400	49900	43200	134500	44833	41291
	12-9-07	40500	47600	39700	127800	42600	
	18-9-07	39200	45100	38500	122800	40933	
	26-9-07	36400	42200	36600	115200	38400	
October	03-10-07	35900	41100	36000	113000	37666	36383
	17-10-07	35200	40000	33600	108800	36266	
	24-10-07	34900	39600	33800	108300	36100	
	31-10-07	34700	38600	33200	106500	35500	
November	7-11-07	34100	37500	35900	107500	35833	34116
	14-11-07	33600	36300	34000	103900	34633	
	22-11-07	33100	35500	31400	100000	33333	
	28-11-07	32500	34700	30800	98000	32666	
December	06-12-07	39300	31700	28200	99200	33066	30266
	12-12-07	37200	30500	28000	95700	31900	
	24-12-07	28600	30300	27600	86500	28833	
	30-12-07	27500	28200	26100	81800	27266	

Source: Department of Agroforestry, records of light intensity observation, HSTU.