PERFORMANCE OF MAIZE UNDER IPIL-IPIL AND GHORA NEEM BASED AGROFORESTRY SYSTEMS

A Thesis

By

Md. Shahazada Ibrahim

Student no.: 1005010

Session: 2011-2012

Thesis Semester: March - August, 2012

Masters of Science (MS)

in

Agroforestry

DEPARTMENT OF AGROFORESTRY, HAJEE MOHAMMAD DANESH SCIENCE & TECHNOLOGY UNIVERSITY, DINAJPUR.

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August, 2012

DEDICATED TO
MY BELOVED
PARENTS

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The Author

ABBREVIATION AND ACRONYMS

AEZ	: Agro-ecological Zone
AGFs	: Agroforestry Systems
BARC	: Bangladesh Agricultural Research Council
BBS	: Bangladesh Bureau of Statistics
BCR	: Benefit Cost Ratio
DAP	: Days After Planting
DMRT	: Duncan's Multiple Range Test
MP	: Muriate of Potash
MPTs	: Multipurpose Tree Species
N	: Nitrogen
RCBD	: Randomized Complete Block Design
TSP	: Triple Supper Phosphate

PERFORMANCE OF MAIZE UNDER IPIL-IPIL AND GHORA NEEM BASED AGROFORESTRY SYSTEMS

Abstract

An experiment was conducted in the Agroforestry Research Field, Hajee Mohammad Danesh Science and Technology university, Dinajpur, during 15 January 2011 to 22 may, 2011 in order to investigate the performance of different maize variety under Ipil-ipil (*Leucaena leucocephala*), and Ghora neem (*Melia azedarach*) woodlot. The experiment was consisted of RCBD two factors with four replications. Between the two factors, one factor was three production systems: S_0=Sole cropping of maize, S_1=Ipil-ipil +maize, S_2= Ghora neem+ maize; another factor was three maize variety: V_1= Hero, V_2= Kanok, V_3= Super. So, there were nine treatment combinations and those were: V_1S_0= Sole cropping of Hero maize variety V_1S_1= Ipil-ipil + Hero maize variety, V_1S_2= Ghora neem +Hero maize variety, V_2S_0= Sole cropping of Kanok maize variety, V_2S_1= Ipil-ipil + Kanok maize variety, V_2S_2= Ghora neem + Kanok maize variety, V_3S_0= Sole cropping of Super maize variety, V_3S_1= Ipil-ipil + Super maize variety and V_3S_2=Ghora neem + Kanok maize variety.

The experimental results revealed that the main effect of variety on growth, yield contributing characters and yield of maize were significantly varied each other. The highest yield (14.37tha^{-1}) was recorded in Hero maize variety whereas lowest yield (8.74tha^{-1}) of maize was recorded in Super maize variety. Again, maize grown in open sunlight condition exhibited considerably highest plant height & maximum number of leaves than other two production system. Longest length of leaves was observed (42.25 inch) in sole and shortest length of leaves (41.83 inch) was observed in Ghora neem + maize based Agroforestry system. Highest leaf breadth (3.16 inch) was found in sole cropping system and the shortest leaf (3.03 inch) was recorded in Ipil-ipil + maize based Agroforestry system. Again, the yield of maize was also significantly influenced by the main effect of different production systems. The highest yield (11.55tha^{-1}) was recorded under sole cropping of maize. Significantly, the lowest yield (10.07tha^{-1}) was recorded in Ghora neem+ maize based Agroforestry system.

The interaction effect of different maize variety and production systems on the yield of maize was found significantly different among each other. The highest yield 16.74 tha^{-1} in sole cropping with Hero maize variety and the lowest 7.35 tha^{-1} was found under Ghora neem based Agroforestry system with Super maize variety. Finally it can be concluded that Hero maize variety is the best Maize variety for production in the floor of Ipil-ipil woodlot.

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Chapter I

Introduction

1.1 Background and justification

Maize (*Zea mays L.*) is one of the important staple food crops of the world and ranks next only to wheat and rice as a third most important crop in the world. In Bangladesh, maize is grown on an area of 6.6 million ha with an annual production of about 12 million tones and a productivity of 1.67 tones per ha. (Anon, 2004).

Maize is a multipurpose crop, providing food and fuel for the human beings, feed for animals and poultry and fodder for livestock. Maize grains have great nutritional value and are a rich source of raw material for manufacturing industrial products. Maize plays an important role in the economy of the country. Per hectare yield of maize has not increased despite introduction of high yielding varieties / hybrids (Anonymous 2006). It is one of the world's major food crops, feeding the humanity since ages. The expanded use of maize in industry gives this crop a prominent place in agricultural economy. Increased productivity in staple food, such as maize, is critical to raising rural incomes and stimulating broad-based economic growth (Eicher & Byerlee 1997). The demand for maize in developing countries, arguably, surpasses the demand for both wheat and rice. This is as a result of the growth in meat and poultry consumption, which consequently, have led to the rapid increase in the demand for maize as livestock feed. Thus, the exploding demand for maize presents an urgent challenge for most developing countries (Pingali & Pandey, 2000).

In the present day agriculture, emphasis is being laid on the maximization of agricultural productivity per unit area per unit time through multiple cropping systems. But this approach of continuous cropping exhausts the nutrients from the soil. Good yield on a sustainable basis can be obtained, provided soil quality and health is maintained with adequate supply of macro and micronutrients. Fertilizers and different types of bulky organic manures such as, farmyard manure, compost and green manures are normally used to increase the productivity of the land. But inadequate supply of these bulky organic sources of nutrients in required quantities is the major constraint in their large-scale use in agriculture to build up soil fertility. Green manuring being a low cost practice is an alternate way to improve soil fertility status. It has received a new impetus in recent years with an urgent need for increased food production in the country (Virdi *et al.*, 2003). Complete dependence on chemical fertilizers is making the soil infertile and less productive in absence of organic materials. Among the different organic manures, green manuring is the most important (Meisheri *et al.*, 1997). The nitrogen reserves in the soil are limited. Chemical fertilizers are expensive and non-renewable. Hence, renewable biological nitrogen fixation is a very good alternative. Green manure crops ensure ecological sustainability maintaining the productivity of the soil over a long period by protecting soil from erosion. Depending upon the species and locations, green manure crops supply 40 to 120 kg N/ha (Shivaram *et al.*, 1991). Substantial information is available on the benefits of green manuring with legumes in increasing the irrigated low land rice and improving the conditions for enhanced and sustained production.

Leguminous plants are largely used for green manuring due to their biological nitrogen fixing ability, drought tolerance, quick growth and adaptation to adverse conditions. Green manuring is useful in minimizing the ill effects of intensive agriculture particularly on natural resources. Plant nutrients are provided in a better form and over a longer period for the crops grown after green manuring. However, the choice of green manuring crops has to be made in relation to soil, climate and time available to raise the green manure crop and the facility for irrigation. Leguminous green manuring crop fixes the atmospheric nitrogen in the soil in the available form, improves the soil health, physical structure, prevents leaching and consumes excess soil moisture (Virdi *et al.*, 2003).

1.2 Objectives of the study:

The overall activities showed that we have no way to expand crop production in horizontal. So, multi-cropping system is one of the best way for providing food, fuel, and income generation. Considering the above factors the present study was done according to the following objectives:

1. To measure the performance of maize as inter crop with Ipil-ipil & Ghora neem based Agroforestry system.
2. To evaluate the varietals performance of maize in association with Ipil-ipil & Ghora neem based Agroforestry system.
3. To find out the suitable maize-tree combination in Agroforestry system.

Chapter II

Review of Literature

Good amount of literature is available where efforts have been made to understand various aspects of Agroforestry systems, although information is inadequate with respect to quantification of biological interactions among the components in Agroforestry systems. Keeping this in view, an attempt has been made to review findings of Agroforestry practices with particular emphasis on potato in association with trees. The relevant literatures pertaining to the present study have been reviewed in this chapter under the following heads:

2.1 Agroforestry: A sustainable land use technology
2.2 Benefits from Agroforestry system
2.3 Effect of light on plant growth and development
2.4 Performance of maize in Agroforestry system
2.5 Benefits of Maize

2.1 Agroforestry: A sustainable land use technology

Agroforestry is an age-old and ancient practice. It is an integral pad of the traditional farming systems of Bangladesh. The concept of Agroforestry probably originate from the realization that trees play an important role in protecting the long range interests of agriculture and in making agriculture economically viable. The emergence of Agroforestry was mainly influenced by the need to maximize the utilization of soil resources though the "marriage of forestry and agriculture" (PCARRD, 1983). This was brought development by the increasing realization that Agroforestry can become an important component of ecological, social and economic development efforts.

Harou (1983) stated that Agroforestry is a combined agriculture-tree crop farming system which enables a farmers or land user to make more effective use of his land which may yield a higher net economic return on a sustainable basis. Again, Saxena (1984) pointed out that agroforestry utilizes the inter spaces between tree rows for intercropping with agricultural crops and this does not impair the growth and development of the trees but enable farmers to derive extra income in addition to benefits accrued from the use of fuel and timber from trees.

Agroforestry is a dynamic, ecologically based, natural resources management system that through the integration of trees in farmland and range land, diversities and sustains production for increased social, economic and environmental benefits for land users at all levels (Michon *et al.,* 1986). While Akter *et al.* (1989) originated that in traditional agroforestry systems of Bangladesh; Farmers consider trees as saving and insurance against risk of crop failure or compensate low yields of crops.

Agroforestry is considered as an efficient and sustainable land use option specially suited for poor farmers. On the other hand, Mac Dicken and Vergara (1990) stated that agroforestry in a means of managing or using land (i.e., a land use system) that combines trees or shrubs with agricultural,/horticultural crops and/or livestock.

Rang *et al.* (1990) stated agroforestry as an economic enterprise which aims to produce a combination of agricultural and forest crops simultaneously on the same land area while the trees which are grown in the crop land, homestead, orchard not only to produce foo4 fruits, fodder, fuel wood or to generate cash for various purpose (Chowdhury and Satter, 1993) but also gives better living environment (Haque, 1996).

Agroforestry is an age-old practice but modem concept is now being developed. It is a sustainable management system for land that combines agricultural crops, trees, forest plants and/or animals simultaneously or sequentially and applies management practices that are compatible with the cultural patterns of the local population (Raintree, 1997), whereas Solanki (1998) considered agroforestry as an technology which can significantly contribute in protecting and stabilizing the ecosystems' producing a high level output of economic goods (fuel fodder, small timber' organic fertilizer etc) and providing stable employment, improved income and ensure sustainable use of land resources.

2.2 Benefits from Agroforestry system

In an experiment conducted by Bhuva *et al.* (1989), mango cv. Rajapuri was planted in l97g at 6x6 t1 and was inter planted from 1980 with (a) banana, (b) cassava, (c) tomato followed by cluster bean (*Cyamopsis tetragonoloba*), or (d) brinjal followed by cowpea (*Vigna unguiculata*) They reported that mango grown with tomato and cluster bean as intercrops gave the greatest financial return per hectare.

Atta-Krah (1990) reported that application of *Leucaena* pruning and 60 kg/ha, N fertilizer into alley cropping plots resulted in a maize yield, 40% higher than that of conventional cropping with the same input. Consequently in the recent year's public interests in planting trees in croplands have increased greatly in the southwest Bangladesh' In addition to planting traditional species, *Dalbergia sissoo* in croplands is one of the salient reasons behind such a practice was to reduce the risk of total crop failure (Akter *et al.* 1990). On the other hand, York (1991).observed that, deep-rooted trees in agroforestry system absorb nutrients from great soil depths and deposit them on the surface as organic matter, thus making nutrients more available to shallow rooted crops.

Wannawong *et al.* (1991) studied the combinations of eucalyptus (*Eucalyptus camaldulensis*), Ipil-ipil (*Leucaena leucocephala*), or acacia (*Acacia auriculiformris*) intercropped with cassava (*Manihot esculenta*) or mung bean (*Vigna radiata*), Parameters considered were tree growth, charcoal production and crop yield. Evidence from trials at short, 3-yr rotations, demonstrates that early supplementary and complementary relations between some system components can imply synergistic financial gains. Although these biological interactions become competitive over time, in this case, the gains should be sufficient to make early adopters consider agroforestry (intercropping) systems financially preferable to traditional mono-crops. Consequently, Kass *et al.* (1992) observed higher bean and maize yield in alley cropping systems using *Gliricidia sepium* both in on-station and farmers' field conditions. Soriano (1991) found that the grain yield of maize was generally higher in hedgerow plots than that in monoculture plots.

Marz (1992) stated that the introduction of alley cropping systems based on neem (*Azadirachta indica*) may have strong impacts on the traditional cropping pattern and economic performance of small farms in the Sudano-Sahelian Zone of West Africa- The analysis shows &at the farm income and liquidity of farms in particular are increased significantly by integrating neem (for the production of wood and fruits) into the traditional cropping pattern. The potential benefits as a result of combining field crop with trees are so obvious from consideration of the waste of light resources while, (Haque *et al.,* 1992) claimed that the practice of producing trees in crop fields is pre-historic in Bangladesh but due to tremendous increase in cropping intensity many farmers are now reluctant in planting tree in crops fields, as they believe that the trees significantly reduce crop yield by shading and root competitions' There are possibilities to raise various species of trees in crop fields in such a fashion not much affecting the yield of field crops.

An experiment was conducted by Korikanthimath *et at.* (1997) to find out the suitability of mixed cropping of areca nut (*Aleca catechu*) + *Elettaria cardamonn* on comparison with monoculture of *A. catechu.* The cost of cultivation was higher (Rs.40683/ha) in mixed cropping than under monoculture (Rs.27571/ha) and the net return (Rs.161837/ha) realized in mixed cropping was 1.56 times higher than in monoculture (Rs.103626/ha).

Afzalur and Islam (1997) conducted research under the government-initiated Community Forestry Project at Madhyapara, Dinajpur. Under this project the participants were promised a 50% share from the sales proceeds of the final tree harvest in addition to 100% of all other benefits generated from agricultural crops' thinning materials and pruning' The plots were planted with mixed tree species (mainly *Eucalyptus camaldulensis* and *Acacia mangium*) at i.5x1.5 m spacing in double rows' with 9 m alleys between the rows, in which rice, sugarcane, maize' pulses, vegetables and sesame were grown as intercrops whereas, due to pruning of shoot and root the tree yield was reduced by 4lo/o and crop (rice, wheat, jute and pulses) yield by 7%.It was observed that eucalyptus affected crop yield by 12% but the species had the highest wood production. While economic analysis was made, the species showed the most profitable compared to all other species (Hocking and Islam, 1998). On the other hand, Chauhan (2000) inferred that *Tagetes minuta* can be successfully grown at 50x75 cm spacing with 40 kg N/ha under eight year old Poplar, resulting in monetary gains (net profit) of about Rs.52000/ha/year.

2.3 Effect of light on plant growth and development

Sunlight is the primary source of energy for all biological activities. The fundamental food for all living organisms, plants and animals, is prepared through the process of photosynthesis in which light is essential. Light not only plays the most vital role in photosynthesis but it carries out important functions In various biological processes of plant life, such as metabolism, growth and development. Intensity, quality and duration of light influence different photo-physiological processes in different ways. Optimal level of light is essential for normal structures and necessary physiological functions of all green plant (Leopold. I964).

Crookston *et. al.* (1975) reported that shading reduced leaf number, area and thickness of two dry bean (*Phaseolus vulgaris*) cultivars. Photosynthesis per unit area of leaf was decreased by 38 per cent whereas the effect on transpiration was non-significant. Under low light conditions, dry matter, photosynthetic rate, relative growth rate, net assimilation rate and specific leaf weight were reduced in rice, whereas leaf area, height, leaf area ratio and relative leaf growth rate were increased (Janardhan and Murthy , 1980) but in mixed stands more efficient use of light resource by plants of different heights and canopy structures as one of the advantage to be gained by growing crops in agroforestry system (Okigbo and Geenland,1976; Okigbo, 1980).

Light interception by monoculture never be achieved 100% and there are periods before and during canopy development and after harvest, where and under storey crop can utilize these lights that might be lost otherwise, even light can pass through the gaps of fully developed canopy. Solar radiation is a very important resource for production because it is the energy source for photosynthesis and transpiration, hence growth and development of plants. The yields of crops (whether tree crops or ground crops) are dependent on solar radiation (light) which is intercepted (Jackson, 1987) The yield advantage of conventional intercropping has been explained in terms of improved capture of utilization of growth resources such as light, water, nutrient etc. (Willy *et al.* 1986). The resource capture by agroforestry systems will probably be greater than in sole crops (Ong *et al.* 199t).

One of the major constraints of microclimate and growth in agroforestry practice is solar radiation. Interaction among the trees and solar geometry produce the particular solar climate of a tree/corm system. These interaction and effects include interception of radiation by tree stands of various densities, effect of canopy structure, effect spacing, effect of latitude and time of year on solar paths, shade from single crowns and spectral quality of sunlight under partial shade (Reifsnyder, 1987).

Srininvasan *et al.* (1990) while examining the resource sharing ability of multipurpose trees in an intercropping ping system reported reduced crop yields due to competition with the trees for light but in under high temperature and dry days in summer, suitable shading increased the photosynthetic efficiency. He stated that the photosynthetic efficiency was 16, 16.5, 9,5 mg/dm2/h for spring tea, 5, 8, 18, 7 mg/dm2/h for summer tea and 17, 18, 20, 12 mg/dm^2/h for autumn tea against at 0, 30, 50, 70 per cent shading rate, respectively(Huang *et al.* 1991).

Limiting light (Shade) is obviously the most important factor that causes poor performance of under storey crops. The key to the development of compatible tree crop combination in agroforestry is greater light interception by under storey crops. In India, it is widely believed that shading by trees is responsible for poor yields of associated crops (Ong *et al.* 1992). Light not only plays the most vital role in photosynthesis but it carries out important function in various biological processes of plant live, such as metabolism, growth and development. Plants grown at high irradiances, photosynthetic rate and stomata conductance were higher and intercellular CO2 concentrations lower than in plants grown at low irradiances (Sritharam and Lenz, 1992).

Miah (1996) stated agroforestry system incorporate a range of tree and crop species offer much more scope for useful management of light interception and distribution that do monoculture forests and agricultural crops but the competition in agroforestry system, ultimately crop yield is dependent upon the partitioning of resources, primarily of light and water between tress and crops (Howard *et. al.* 1995).

Shade created by upper storey tree canopies has several positive benefits to under storey annual crops. Wallace (1996) described these benefits as (i) tree shading may significantly reduce soil evaporation which allows for an increase in the amount of water available to the soil and ultimately to the crops, (ii) shading of the crop may reduce its transpiration without a proportional decrease in photosynthesis. This occurs if the under storey crops become "light saturated" at relatively low radiation levels which is typically in C3 species, (iii) shading of a crop by a tree canopy may reduce surface soil and air temperature that create beneficial effects on crop growth. Generally crop growth and rates of development increase with temperature up to an optimum level and decline thereafter. It is widely believed that partial shade improves the quality of some crops such as tea, coffee etc. Wainwright (1995) described that another advantages of shade in a multilayered system is that it may lead to a reduction in photorespiration in C3 crops due either to lower temperature or to a rapidly flickering rather than a constant light source. Maize, Sorghum, Green gram (*Vigna radiate*), groundnut and okra were unshaded, shaded to 65% normal light at ambient temperature (33^0 C or 38^0 C + high humidity). With the exception of okra where seed yield was not affected, shading decreased grain or seed yield in the other crops. Shading combined with high temperature and humidity resulted in failure in grain formation in maize and sorghum and produced parthenocarpic fruit in okra. Green gram seed yield was decreased further but that of groundnut was not (Singh, 1997).

Thakur and Singh (2002) in a recently conducted study in *Morus* based agroforestry system reported that solar radiation transmission through unmanaged canopies of 5 year old *Morus* trees was 9.6 per cent. However, 25 %, 50% and 75% crown removal allowed 21.6; 36.8 and 52.7 per cent transmission of photo-synthetically active radiation beneath canopies, respectively. Solar radiation transmission between 9- 36.8 per cent have adversely affected yield of both *Morus* and pea.

2.4 Performance of maize in Agroforestry system

In the temperate zones maize must be planted in the spring, as it is cold intolerant. Its root system is generally shallow, so the plant is dependent on oil moisture. As a C4 plant (a plant that uses C4 carbon fixation), maize is a considerably more water-efficient crop than C3 plants (plants that use C3 carbon fixation) like the small grains, alfalfa and soybeans. Maize is most sensitive to drought at the time of silk emergence, when the flowers are ready for pollination. Maize provided support for beans, and the beans provided nitrogen derived from nitrogen-fixing rhizobia bacteria which live on the roots of beans and other legumes; and squashes provided ground cover to stop weeds and inhibit evaporation by providing shade over the soil. This method was replaced by single species hill planting where each hill 60–120 cm (2.0–3.9 ft) apart was planted with three or four seeds, a method still used by home gardeners. A later technique was "checked maize", where hills were placed 40 inches (1.0 metre) apart in each direction, allowing cultivators to run through the field in two directions. In more arid lands, this was altered and seeds were planted in the bottom of 10–12 cm (3.9–4.7 in) deep furrows to collect water. Modern technique plants maize in rows which allows for cultivation while the plant is young, although the hill technique is still used in the maize fields of some Native American reservations.

2.5 Benefits of Maize

Maize is commonly known as corn and is the most cultivated crop on Earth. Globally, maize is the most cultivated staple crop and is used as a primary source of nutrition. Many people also use it as fodder. Some other benefits are given below:

Nutritious and highly appetizing

Maize flour is used to make nutritious bread which is highly palatable, and is easily broken down in the body. When taken at intervals, bread helps to clean the colon and the dextrose produced is commonly used for medicinal purposes.

Human food

Maize and cornmeal (ground dried maize) constitute a staple food in many regions of the world. Introduced into Africa by the Portuguese in the 16th century, maize has become Africa's most important staple food crop. Maize is a major source of starch. Cornstarch (maize flour) is a major ingredient in home cooking and in many industrialized food products. Maize is also a major source of cooking oil (corn oil) and of maize gluten. Maize starch can be hydrolyzed and enzymatically treated to produce syrups, particularly high fructose corn syrup, a sweetener; and also fermented and distilled to produce grain alcohol. Grain alcohol from maize is traditionally the source of Bourbon whiskey. Maize is sometimes used as the starch source for beer. Within the United States, the usage of maize for human consumption constitutes about 1/40th of the amount of grown in the country. In the United States and Canada, maize is mostly grown to feed for livestock, as forage, silage (made by fermentation of chopped green cornstalks), or grain. Maize meal is also a significant ingredient of some commercial animal food products, such as dog food. Maize is also used as a fish bait, called "dough balls". It is particularly popular in Europe for coarse fishing.

Prevents constipation

Popcorn is a wholesome staple food made by heating small grains. It is easily digested by the body. In addition, it is practically starch-free and not fattening, and is converted into intermediate carbohydrates and dextrine, which is easily absorbed in the body. It promotes peristalsis and is also beneficial in preventing constipation.

Reduces stomach acidity

Corn facilitates the removal of toxic food substance and also accelerates the passage of faces through the intestine. Additionally, it protects the digestive tract thus promoting function of the gall-bladder and reducing stomach acidity.

Combats the symptoms of certain cancers

Cereals generally wheat, rice, millet, oatmeal and corn should be eaten in large quantities since they are sources of carbohydrates and starch.

According to recent studies, the use of corn helps to combat the effects of certain cancers, as it reduces the development of cancer.

Reduce the risk of diabetes and heart diseases

Corn is low in cholesterol and fat content. Cereal or whole grains are great sources of vitamins and minerals, magnesium, fiber and complex carbohydrates. The fiber in whole grains helps to prevent the risk of heart diseases and diabetes, and all its nutrients boost the immune system.

The main shortcoming is that most people are not aware of the numerous health benefits of maize, hence fail to include it in their nutrition.

Alternative medicine

Stigmas from female maize flowers, popularly called corn silk, are sold as herbal supplements.

Chemicals

Starch from maize can also be made into plastics, fabrics, adhesives, and many other chemical products. The corn steep liquor, a plentiful watery byproduct of maize wet milling process, is widely used in the biochemical industry and research as a culture medium to grow many kinds of microorganisms.

Biofuel

"Feed maize" is being used increasingly for heating specialized corn stoves (similar to wood stoves) are available and use either feed maize or wood pellets to generate heat. Maize cobs are also used as a biomass fuel source. Maize is relatively cheap and home-heating furnaces have been developed which use maize kernels as a fuel. They feature a large hopper that feeds the uniformly sized maize kernels (or wood pellets or cherry pits) into the fire. Maize is increasingly used as a feedstock for the production of ethanol fuel.

Ethanol is mixed with gasoline to decrease the amount of pollutants emitted when used to fuel motor vehicles. High fuel prices in mid-2007 led to higher demand for ethanol, which in turn lead to higher prices paid to farmers for maize. This led to the 2007 harvest being one of the most profitable maize crops in modern history for farmers. Because of the relationship between fuel and maize, prices paid for the crop now tend to track the price of oil.

Ornamental and other uses

Some forms of the plant are occasionally grown for ornamental use in the garden. For this purpose, variegated and colored leaf forms as well as those with colorful ears are used. Size-superlative types, reaching 40 ft (12 m) tall, cobs 2 ft (61 cm) long, or 1 in (2.5 cm) kernels, have been popular for at least a century. Corncobs can be hollowed out and treated to make inexpensive smoking pipes, first manufactured in the United States in 1869.

Fodder

Maize makes a greater quantity of epigeous mass than other cereal plants, so can be used for fodder. Digestibility and palatability are higher when ensiled and fermented, rather than dried.

Commodity

Maize is bought and sold by investors and price speculators as a tradable commodity using corn futures contracts. These "futures" are traded on the Chicago Board of Trade (CBOT) under ticker symbol C. They are delivered every year in March, May, July, September, and December.

Chapter III

Materials and Methods

In this section the materials and methods have been presented which include brief description of location of the experimental site, soil, climate, materials used and methodology followed in the experiment. The details of these sections are described below.

3.1 Location of the study

The experiment was conducted in Agroforestry Research Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur. The site was between 25° 13' latitude and 88° 23' longitude and about 37.5 m above the sea level.

3.2 Soil characteristics

The experimental plot was in a medium high land belonging to the old Himalayan Piedmont Plain Area (AEZ No. 01). Land was well-drained and drainage system was well developed. The soil texture was sandy loam in nature. The soil pH was 5.1. The details soil properties are presented in Appendix-I.

3.3 Climate and weather

The experimental site was situated under the tropical climate characterized by heavy rainfall from July to August and scanty rainfall in the rest period of the year. Monthly maximum and minimum temperatures, rainfall and relative humidity recorded during the experimental period (15 January 2011 to 22 may, 2011) are presented in the Appendix-II.

3.4 Experimental Period

15 January 2011 to 22 may, 2011

3.5 Experimental materials

It consists of two tree species and three maize varieties.

The tree species were –

i) Ipil-ipil (*Leucaena leucocephala*)

ii) Ghora Neem (*Melia azedarach*)

The spacing for all the tree species was 3m x 3m and the age years. The present status of the tree species in the research field are-

Table-1: Status of the existing tree species in there research field

parameters / Trees	Plant height (m)	Clean bole height (m)	Base girth (cm)	Bole girth (cm)	Diameter at breast height (cm)
Ipil-ipil	15.5	6	76	67.5	64
Ghora neem	12.5	4.5	83	62	68

Brief descriptions f the species and the reasons their selection are given below:

A) Ipil-ipil (*Leucaena leucocephala*)- *Leucaena leucocephala* is a fast growing deciduous tree with a short clear bole to 5 m upright, angular branching and open crown maximum height 20 m. Bole diameter 10- I 5 cm bark on young branches smooth, grey-brown, rustly orange-brown vertical tissues and deep red inner bark on older branches and bole. The deep rooted plant often has a combination of flowers, immature and mature pods, all presents on the tree at the same time. Flowering time: March-April and August-October; Fruiting time: December-February.

Functional uses:

Pods, seeds and leaf tips have been used as food, although mimosine toxicity makes this practice risky. Seeds can also be prepared as a coffee substitute. *Leucaena leucocephala* is one of the highest quality and most plantable fodder trees of the tropics. But livestock feed should not contain more than 20% of *L. leucocephala* as the mimosine can cause hair loss and stomach problems. It is an excellent firewood species with a specific gravity of 0.45-0.55 and a high colorific value of 4600 k cal/kg. The tree makes excellent charcoal with a heating value of 29 mj/kg and good recovery value (25-30%). Its pulping properties are suitable for both paper and rayon production. *L. Ieucocephala* has hard heavy wood (about 800 kg/m) with a pale yellow sap wood and light reddish- brown hard wood. The wood is known to be of medium density and to dry without splitting or cheeking. It is strong medium iexture4 close grained and easily workable for a wide variety of carpentry purposes.

Services:

Different services like erosion control, shade reclamation, it forms symbiotic relationship with *Rhizobium loti* (Halliday and Somasegaran, 1983), soil improvement by the addition of organic matter (Pathak and Gupta 1987), decoration and boundary, barrier or support can get from this tree.

B) Ghora neem (*Melia azedarach*)- A handsome deciduous tree up to 45 m tall with wide spreading branches. The bark is smooth greenish brown. Leaves are bipinnate, sometimes tripinnate, 20-50 cm long. Pinnae usually opposite, 3-7 leaflets are found in each pinnae. Flowers are small liliac blue, Inflorescences long auxiliary panicle up to 20 cm long. Fruit a small, yellow drupe round about 1.5 cm in diameter, seed oblonged, 3.5 mm x 1-6 mm (Nagveni *et. al.* 1987). Flowering time: March to May. Fruiting time: December to January.

Functional uses

Leaves and young shoots are lopped for fodder and are highly nutritious. The fruits are consumed by goat, sheep and birds. Fuel wood is a major use of it. It has calorific value of 5100 kcal/ kg. The wood is extensively used for toys, small box, house building different furnitures etc. Aqueous and alcoholic extracts of leaves and seed reportedly control many insects, mite nematode pest. The fruits of *M. azedarach* are highly toxic to warm blooded (Attri, 1982). It is well known for its medicinal uses. Its various parts have antihelmintic, antinalarial and emmenegogic properties and are also used to treat skin disease.

Services:

Widely planted as a shade tree in coffee plantation as an avenue tree, fruit scented flowers and shady crown, *M. azedarach* is useful flowers shady for growing with crops like wheat. The foliage can be used as green manure and mulch. The seed cakes can be proceeded 1o produce bio-fertilizer (Tiwari, 1983). This is mainly used against attacks of insects on dry fruit.

3.6 Experimental design and treatments

The experiment was laid out following the two factors RCBD with four replications. Each plot size was 2.5m x 1.5m. The treatments of the experiment were-

Factor A: Three maize varieties, i.e.

V_1= Hero

V_2= Kanok

V_3= Super

Factor B: Three production systems, i.e.

S_0= Sole cropping of maize

S_1= Ipil-ipil+ maize

S_2= Ghora neem+ maize

So, there were nine treatment combinations like,

V_1S_0=Sole cropping of Hero maize variety

V_1S_1= Ipil-ipil+ Hero maize variety

V_1S_2= Ghora neem +Hero maize variety

V_2S_0= Sole cropping of Kanok maize variety

V_2S_1=Ipil-ipil + Kanok maize variety

V_2S_2=Ghora neem + Kanok maize variety

V_3S_0= Sole cropping of Super maize variety

V_3S_1=Ipil-ipil + Super maize variety

V_3S_2=Ghora neem + Kanok maize variety

In case of S_0, maize varieties were planted without any shade i.e. in open condition whereas, in case of both S_1 and S_2, maize varieties were planted under Ipil-ipil and Ghora neem tree, respectively.

Plate1: Maize in Open field system.

Plate 2: Maize + Ipil-ipil based AGF

Plate 3: Maize + Ghora neem based AGF.

3.7 Land preparation

The land of experimental plot was opened in the first week of January 2011 with a power tiller and it was made ready for planting on 14 January 2011. The comers of the land were spaded and visible larger clods were hammered to break into small pieces. All weeds and stubbles were removed from the filed. The layout was done as per experimental design. All basal dosages of fertilizers as per scheduled of the experiment was incorporated in the soil and finally the plots were made ready for planting (Plate4).

Plate4: Land preparation.

Plate 5: Seed sowing

3.8 Application of fertilizers and Manures

Half of Urea and full doses of TSP, MP, were applied as the basal dose in furrows made on both sides of the seed rows and mixed properly with soil at planting. The doses were according to BARC rate i.e. 150 kg N/ha, 100 kg P_2O_5 /ha and 160 kg K_2O/ha. On the other han4 the remaining urea was applied at 40 DAP during the second earthing-up at the side of the rows and covered with soil.

3.9 Planting of maize seeds

The well- seeds were planted on 15 January 2011 at a depth of 05 cm in the furrows. The furrows were 75 cm apart with the spacing of 25 cm in each line. Thus 96 seeds were shown in each plot (Plate5).

3.10 Intercultural operations

Weeding and Mulching

Manual weeding was done as and when necessary to keep the Plots completely free from all weeds. After each irrigation, the soil was mulched by breaking the crust for aeration and to conserve soil moisture.

Eerthing-up

Earthing-up was made twice during the growing period at 25 days and 40 days after planting. The second one was preceded by top dressing of the remaining half of urea.

Irrigation

Three irrigations were provided throughout the growing period. The first one was done at 30 days after planting. Subsequently two irrigations were given at 20 days interval.

3.11 Plant Protection Measures

Furadan 5G @10 kg /ha was applied control ant, mite, cutworm and other. As a preventive Duo 66.8 WP (Iprovelicarb 5.5%, measure against late blight Melody Propineb 61.3%) was sprayed at the rate of 2.5g litter water when the weather was cloudy. During the final land preparation to soil borne insects.

3.12 Harvesting

The crop was harvested on 24th April 2011 at 100 days after planting when 90% plants showed leaf senescence. At first ten sample plants were harvested from each plot and later on the rest plants were harvested.

3.13 Sampling and Data collection

The experimental plots were observed frequently to record various changes in plant characteristics at different stages of their growth. Ten plants were selected at random from each unit plot to collect experimental data. The plants in the outer rows and at the extreme end of the two middle rows were excluded to avoid the border effects. The observations were made on the following parameters during plant growth phase and harvest, which were noted for different treatments of the experiment.

Plant height (inch) at different Days after Planting (DAPs)

The heights are measured from the ground level to the tip of the longest shoot at an interval of 10 days starting from 50 DAP till 80 DAP.

Number of leaves per plant at different DAPs

It was recorded at an interval of 10 days starting at 50 DAP and 80 DAP.

Leaf length (inch) at 50 DAP

The length of the leaf was obtained with the help of inch scale at 50 DAP.

Leaf breadth (inch) at 50 DAP

The breadth of the leaf was obtained with the help of inch scale at 50 DAP.

Number of cobs/plant

It was recorded at the time of final harvest.

Yield of maize (kg/plot)

This was recorded during the time of harvest.

3.14 Data analysis

Data were statistically analyzed using the (ANOVA), Analysis of Variance technique with the help of the computer package MSTAT program. The mean differences were adjusted by the Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Chapter IV

Results and Discussion

This episode is the presentation and discussion of the results obtained from the experiment carried out to study the performance of maize under different tree based agroforestry systems. The data are presented in tables, plates and the summary of analysis of variance of all the parameter. The summaries of analysis of variance for all yield contributing characters and growth parameters studied have been presented in Appendix. The results of each parameter discussed under the following headings.

4.1 Main effect of variety on growth, yield contributing characters and yield of maize.

4.1.1 Plant height

Plant height at different Days After Planting (DAP) was significantly influenced by three different maize varieties (Table-2). In initial stage i.e. at 50 DAP the tallest plant was observed in Hero (V_1) (28.67 inch) which was statistically significant with the variety Super (V_3), while the shortest plant (23.17 inch at 50 DAP) was recorded in Kanok (V_2). Consequently, in 80 DAP the tallest plant was (103 inch) found in Hero (V_1) and the shortest plant was (86.58 inch) recorded from the variety Super (V_3).

4.1.2 Number of leaves per plant

Numbers of leaves per plant of maize were also significantly disposed by three different maize varieties. The maximum number of leaves (9.75 at 50 DAP and 17 at 80 DAP) was recorded in Hero (V_1) in compare to Kanok (V_2) & Super (V_3). The lowest number of leaf was (8.25 at 50 DAP) observed in Kanok (V_2) and at 80 DAP lowest number of leaf (16) observed in both Kanok (V_2) & Super (V_3).

4.1.3 Length of leaves (inch)

Leaf length of maize was increased gradually with the increase of sun light. The longest leaf at 50 DAP (24.42 inch) was recorded from the Hero (V_1) followed by Kanok (V_2) & Super (V_3). The leaf with shortest length at 50 DAP (22 inch) was recorded from Kanok (V_2). The longest leaf at 80 DAP (48.67 inch) was recorded from the Hero (V_1) followed by Kanok (V_2) & Super (V_3). The leaf with shortest length at 80 DAP (38.83 inch) was recorded from Kanok (V_2) & Super (V_3).

4.1.4 Breadth of leaf

Leaf width of maize was also influenced by sun light intensity. The widest leaf (3.18 inch at 50 DAP and 3.72 inch at 80 DAP) was recorded at Hero (V_1). On the other hand the lowest widths of leaf (2.95 inch at 50 DAP) was observed in Kanok (V_2) and at 80 DAP the lowest leaf breadth (3.6 inch) was observed in both Kanok (V_2) & Super (V_3).

Table-2: Main effect of variety on the growth parameters of maize

Treatments	Plant height (inch)		No. of leaves per plant		Leaf length (inch)		Leaf breadth (inch)	
	50 DAP	80 DAP	50 DAP	80 DAP	50 DAP	80 DAP	50 DAP	80 DAP
Hero (V_1)	28.67 a	103 a	9.75 a	17 a	24.42 a	48.67 a	3.18 a	3.72 a
Kanok (V_2)	23.17b	91.83 b	8.25 b	16 b	22 b	38.83b	2.96 b	3.60 b
Super (V_3)	27.92 a	86.58 c	9.67 a	16 b	24.08 a	38.83b	3.12 a	3.60 b
Level of Sig.	**	**	**	**	**	**	**	**
CV (%)	3.70	6.92	2.87	2.92	1.71	0.00	0.98	0.12

Note: ** = Significant at 1% and 5% level of significant. Means with the same letter are not significantly different

4.1.5 Cob per plant

Cobs per plant of maize vary significantly in respect of varieties. Significantly, highest number (1.25) of cobs is recorded in Hero (V_1) while lowest number of cobs (1) was recorded in Kanok (V_2) and Super (V_3).

4.1.6 Length of cobs (inch)

Cob length of maize was increased gradually with the increase of sun light. The longest cob (8.73 inch) was recorded from the Hero (V_1) followed by Kanok (V_2) & Super (V_3). The cob with shortest length (6.317 inch) was recorded in Super (V_3).

4.1.7 Diameter of cobs (inch)

Cob diameter of maize was also increased gradually with the increase of sun light. The highest diameter of cob (1.971 inch) was recorded from the Hero (V_1)

followed by Kanok (V_2) & Super (V_3). The cob with shortest diameter (1.7 inch) was recorded in V_3.

4.1.8 Yield tha^{-1}

Yield of maize varies significantly with different variety of maize. The maximum (14.37 tha^{-1}) yield of maize was recorded in Hero (V_1) followed by Kanok (V_2) & Super (V_3). Significantly lowest (8.744 tha^{-1}) yield was recorded in Super (V_3).

Table-3: Main effect of variety on the yield and yield contributing characters of maize

Treatments	No. of cobs per plant	Cob length (inch)	Cob diameter (inch)	Yield (tha^{-1})
Hero (V_1)	1.250 a	8.73 a	1.97 a	14.37 a
Kanok (V_2)	1.000 b	6.93 b	1.76 b	9.59 b
Super (V_3)	1.000 b	6.32 c	1.70 c	8.74 c
Level of Sig.	**	**	**	**
CV (%)	26.27	5.39	2.72	9.94

Note: ** = Significant at 1% and 5% level of significant. Means with the same letter are not significantly different.

4.2 Main effect of production system on growth, yield contributing characters and yield of maize.

4.2.1 Plant height

Maize grown in open sunlight condition was most vigorous than those other Agroforestry system (Table-4). It exhibited considerably highest plant height (27.58 inch) at 50 DAP was recorded in open condition and the lowest plant height was observed in Ghora neem based AGFs. At 80 DAP the plant height was found not significant.

4.2.2 Number of leaves per plant

Numbers of leaves per plant of maize were found not significant disposed by the diverse Agroforestry systems. Numerically, maximum number of leaves (9.33 at 50 DAP and 16.33 at 80 DAP) was recorded in sole cropping system and the minimum number of leaves were recorded in Ghora neem + maize based Agroforestry system.

4.2.3 Length of leaves (inch)

Lengths of leaves of maize were found not significant at 50 DAP but at 80 DAP the length of leaves was found significant. Longest length of leaves at 50 DAP was observed (23.58 inch) in sole cropping system and the shortest leaf was recorded in Ghora neem + maize based Agroforestry system. At 80 DAP, longest length of leaves was observed (42.25 inch) in sole and shortest length of leaves (41.83 inch) was observed in Ghora neem + maize based Agroforestry system.

4.2.4 Breadth of leaf

At 50 DAPs highest leaf breadth (3.16 inch) was found in sole cropping system and the shortest leaf was recorded in Ipil-ipil + maize based Agroforestry system. At 80 DAPs the breadth of leaves found not significant.

Table-4: Main effect of production system on the growth parameters of maize

Treatments	Plant height (inch)		No. of leaves per plant		Leaf length (inch)		Leaf Breadth (inch)	
	50 DAP	80 DAP	50 DAP	80 DAP	50 DAP	80 DAP	50 DAP	80 DAP
S_0 (Sole cropping)	27.58 a	93.75a	9.33 a	16.33 a	23.58 a	42.25 a	3.16 a	3.64 a
S_1 (Ipil-ipil + Maize)	26.50 b	93.42 a	9.17 a	16.33 a	23.42 a	42.25 a	3.03 b	3.64 a
S_2 (Ghora neem + Maize)	25.67 c	94.25 a	9.17 a	16.33 a	23.50 a	41.83 b	3.05 b	3.63 a
Level of Sig.	**	ns	ns	ns	ns	ns	**	ns
CV (%)	3.70	6.92	2.87	2.92	1.71	0.00	0.98	0.12

Note: ** = Significant at 1% and 5% level of significant and ns = not significant. Means with the same letter are not significantly different.

4.2.5 Cob per plant

Cobs per plant of maize found not significant in respect of production system. Consequently, only one cob per plant of maize was recorded in each and every production system.

4.2.6 Length of cobs (inch)

Cob length of maize was increased gradually with the increase of sun light. The longest cob (7.58 inch) was recorded from Ipil-ipil + maize based Agroforestry system followed by in Sole cropping (S_0) while the shortest cob was recorded in Ghora neem + maize based Agroforestry system.

4.2.7 Diameter of cobs (inch)

Cob diameter of maize was also increased gradually with the increase of sun light. The highest diameter of cob (1.852 inch) was recorded from open condition while the cob with shortest diameter (1.792 inch) was recorded in both Ipil-ipil + Maize (S_1) & Ghora neem + Maize (S_2).

4.2.8 Yield tha^{-1}

Yield of maize varies significantly with different production system of maize. The maximum (11.55 tha^{-1}) yield of maize was recorded in sole cropping of maize followed by in Ipil-ipil + maize based Agroforestry system while the minimum (10.07 tha^{-1}) yield of maize was recorded in Ghora neem + maize based Agroforestry system.

Table-5: Main effect of production system on the yield and yield contributing characters of maize.

Treatments	No of cobs per plant	Cob length (inch)	Cob diameter (inch)	Yield tha^{-1}
S_0 (Sole cropping)	1.083	7.52 a	1.85 a	11.55 a
S_1 (Ipil-ipil + Maize)	1.083	7.55 a	1.79 b	11.10 a
S_2 (Ghora neem +Maize)	1.083	6.89 b	1.79 b	10.07 b
Level of Sig.	ns	**	**	**
CV (%)	26.27	5.39	2.72	9.94

Note: ** = Significant at 1% and 5% level of significant and ns = not significant. Means with the same letter are not significantly different.

4.3 Interaction effect of variety and production system on growth, yield contributing characters and yield of maize.

4.3.1 Plant height

The interaction effect of variety and production system on the plant height of maize was found significantly different at different Days After Planting (DAP). At 50 DAP the tallest plant of maize (30 inch) was recorded in V_1xS_0 i.e. Hero in sole cropping where as the shortest plant of maize (21.5 inch) was recorded in V_2xS_2 i.e. Kanok under Ghora neem Agroforestry system. However V_1xS_1, (Hero + Ipil-ipil), V_1xS_2, (Hero + Ghora neem), V_3xS_0, (Super + Sole cropping), V_3xS_1, (Super + Ipil-ipil) and V_3xS_2 (Super + Ghora neem) were statistically similar. Again at 80 DAP the tallest plant of maize (103.3 inch) was recorded in V_1xS_2 i.e. Hero under Ipil-ipil based AGFs. On the other hand shortest plant of maize (85.75 inch) was observed in V_3xS_0 i.e. Super in sole cropping. Plant height depends on a number of factors such as availability of required quality of water, mineral nutrients, quantity, quality and duration of light, temperature, area of growing space and genetic set-up of the plants. Hillman (1984) reported that, plant grown in low light levels was found to be more apical dominant than those grown in high light environment resulting in taller plants under shade.

4.3.2 Number of leaves per plant

The interaction effects of variety and production system on the numbers of leaves per plant of maize were also significantly disposed. The maximum number of leaves (10 at 50 DAP) was recorded in V_1xS_0 Sole cropping with Hero AGFs which was statistically identical to that of V_1xS_1 (Hero + Ipil-ipil), V_1xS_2 (Hero + Ghora neem), V_3xS_0 (Super + sole cropping), V_3xS_1 (Super + Ipil-ipil), and V_3xS_2 (Super + Ghora neem) Agroforestry system. Again at 80 DAP the maximum number of leaves of maize (17) was recorded in V_1xS_0 (Hero + sole cropping) and V_1xS_1 (Hero + Ipil-ipil), V_1xS_2 (Hero + Ghora neem) AGFs. This finding was in agreement with the findings of Benoit et al., 1986 who stated that, cooler temperatures promote lower number of total leaf and numbers of branches.

4.3.3 Length of leaves (inch)

Leaf length of maize was increased gradually with the increase of sun light and the interaction effects of variety and production system. The longest leaf (24.5 inch at 50 DAP) was recorded from V_1x S_1 (Hero + Ipil-ipil) Agroforestry system followed by Ghora neem + Maize AGFs. The leaf with shortest length (21.5 inch at 50 DAP) was recorded in V_1x S_1 (Hero + Ipil-ipil) AGFs. On the other hand the longest leaf (48.75 inch at 80 DAP) was recorded from V_1x S_0 (variety + Sole cropping) AGFs and the leaf with shortest length (38.5 inch at 80 DAP) was recorded in V_3x S_2 (Super + Ghora neem) AGFs. This might be attributed due to the situation of cellular expansion and cell division of leaves under shade condition (Schoch, 1972).

4.3.4 Breadth of leaf

Leaf breadth of maize was also increased gradually with the increase of sun light and the interaction effects of variety and production system. The widest leaf (3.215 inch at 50 DAP) was recorded from V_1x S_0 (Hero + Sole cropping) Agroforestry system followed by Ghora neem + Maize and Ipil-ipil + Maize AGFs. The leaf with shortest breadth (2.85 inch at 50 DAP) was recorded in V_2x S_2 (Kanok + Ghora neem) AGFs. On the other hand the widest leaf (3.717 inch at 80 DAP) was recorded from V_1x S_0 (variety + Sole cropping) AGFs and the leaf with shortest breadth (3.6 inch at 80 DAP) was recorded in V_3x S_2 (Super +Ghora neem) AGFs. This might be attributed due to the situation of cellular expansion and cell division of leaves under shade condition (Schoch, 1972).

Table-6: Interaction effect of variety and production system on growth, yield and yield contributing characters of maize

Treatments	Plant height (inch)		No. of leaves per plant (inch)		Leaf length (inch)		Leaf breadth (inch)	
	50 DAP	80 DAP	50 DAP	80 DAP	50 DAP	80 DAP	50 DAP	80 DAP
$V_1 x S_0$	30.00 a	103.0 a	10.00 a	17.00 a	24.25 a	48.75 a	3.215 a	3.717 a
$V_1 x S_1$	28.50 b	102.8 a	9.750 a	17.00 a	24.50 a	48.75 a	3.150 ab	3.717 a
$V_1 x S_2$	27.50 b	103.3 a	9.500 a	7.00 a	24.50 a	48.50 a	3.175 a	3.715 a
$V_2 x S_0$	25.00 c	92.50 b	8.250 b	16.00 b	22.25 b	39.00 b	3.100 ab	3.600 b
$V_2 x S_1$	23.00 d	91.50 b	8.000 b	16.00 b	21.50 b	39.00 b	2.925 cd	3.600 b
$V_2 x S_2$	21.50 e	91.50 b	8.500 b	16.00 b	22.25 b	38.50 b	2.850 d	3.600 b
$V_3 x S_0$	27.75 b	85.75 c	9.750 a	16.00 b	24.25 a	39.00 b	3.175 a	3.600 b
$V_3 x S_1$	28.00 b	86.00 c	9.750 a	16.00 b	24.25 a	39.00 b	3.025 bc	3.600 b
$V_3 x S_2$	28.00 b	88.00 c	9.500 a	16.00 b	23.75 a	38.50 b	3.150 ab	3.600 b
Level of Sig.	**	**	**	**	**	**	**	**
CV (%)	3.70	6.92	2.87	2.92	1.71	0.00	0.98	0.12

Note: ** = Significant at 1% and 5% level of significant. Means with the same letter are not significantly different.

4.3.5 Cobs per plant

Cobs per plant of maize found not significant in terms variety and production system.

4.3.6 Length of cobs (inch)

The longest cob (9.425 inch) was recorded from $V_1 x\ S_1$ (Hero + Ipil-ipil) Agroforestry system followed by Ghoraneem + Maize AGFs. The cob with shortest length (5.8 inch) was recorded in $V_3 x\ S_2$ (Super + Ghoraneem) AGFs.

4.3.7 Diameter of cobs (inch)

The highest dia. of cob (6.276 inch) was recorded from V_1x S_0 (Hero + Sole cropping) Agroforestry system followed by Ghora neem + Maize AGFs. The cob with shortest dia. (2.757 inch) was recorded in V_3x S_2 (Super + Ghora neem) AGFs.

4.3.8 Yield tha^{-1}

Yield of maize varies significantly with different Agroforestry system and their interaction with each other. The maximum yield (16.73 tha^{-1}) of maize was recorded in V_1x S_0 (Hero + sole cropping) AGFs followed by Ipil-ipil + Maize and Ghora neem + Maize AGFs. The maximum yield was gained in the treatment of Ipil-ipil + Maize variety combination in respect of Ipil-ipil + Maize variety and Ghora neem + Maize variety due to favorable condition prevailed during the growing period because Ipil-ipil is a leguminous & semi-deciduous tree. Significantly lowest (7.352 ton) yield was recorded in V_3x S_2 (Super + Ghora neem) AGFs.

Table-7: Interaction effect of variety and production system on yield and yield contributing characters of maize

Treatments	No. of cobs per plant	Cob length (inch)	Cob diameter (inch)	Yield (tha^{-1})
V_1x S_0	1.250 a	8.56 b	2.02 a	16.74 a
V_1x S_1	1.250 a	9.43 a	1.95 a	13.65 b
V_1x S_2	1.250 a	8.20 b	1.95 a	12.77 b
V_2x S_0	1.000 a	6.95 c	1.78 b	9.10 c
V_2x S_1	1.000 a	7.15 c	1.76 bc	9.61 c
V_2x S_2	1.000 a	6.68 cd	1.76 bc	10.06 c
V_3x S_0	1.000 a	7.05 c	1.76 bc	8.82 cd
V_3x S_1	1.000 a	6.100 de	1.67 c	10.06 c
V_3x S_2	1.000 a	5.80 e	1.67 c	7.35 d
Level of Sig.	ns	**	**	**
CV (%)	26.27	5.39	2.72	9.94

Note: ** = Significant at 1% and 5% level of significant and ns = not significant. Means with the same letter are not significantly different.

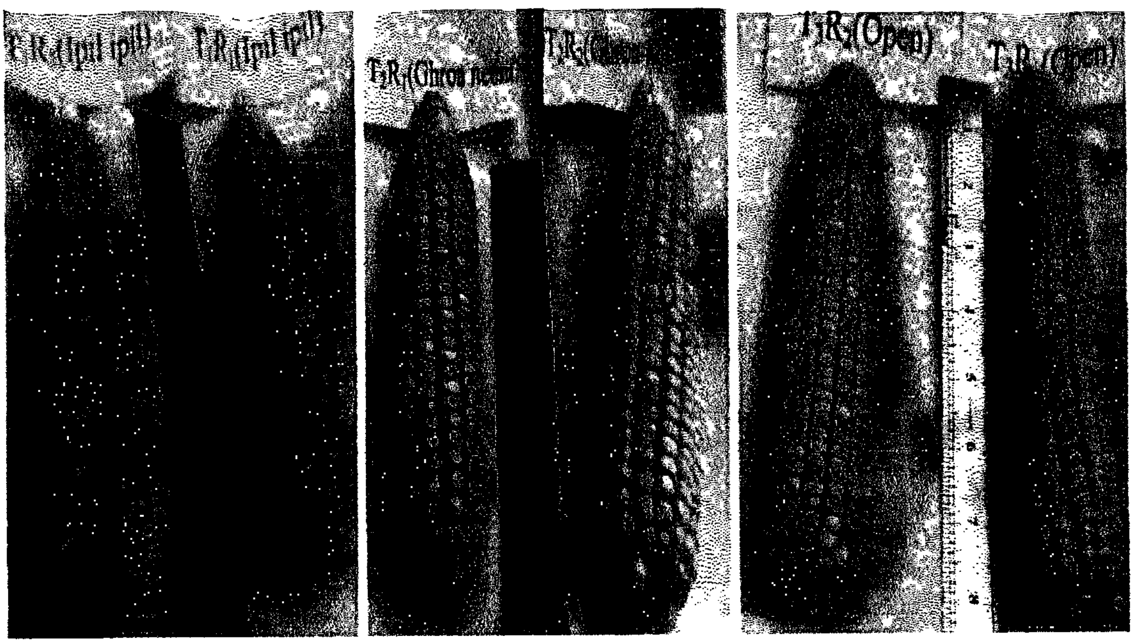

Plate-6: Harvested maize of Ipil-ipil, Ghora neem and sole cropping Agroforestry system respectively.

Chapter V

Summary and Conclusion

5.1 Summary

The experiment was conducted in Agroforestry Research Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur from 15 January 2011 to 22 may, 2011. The experiment was conducted to evaluate the possibilities of growing maize under different agroforestry systems. The experiment was conducted in an established seven years old different tree based agroforestry system. The trees, which are used as over storey, are Ipil-ipil and Ghora neem and under storey crop was maize. The maize variety used was hybrid. There were three treatments in this experiment viz. T1: Maize (Open), T2: Maize + Ipil-ipil, T3: Maize + Ghora neem. The tree-to-tree spacing was 3 m x 3 m. Maize was planted as intercrop in the alleys between the two tree rows according to their cultural schedules. The plots of the ground layer crops were fertilized with fertilizers and manures according to the BARC fertilizer recommendation guide.

The experimental results revealed that the Main effect of variety on growth, yield contributing characters and yield of maize was found significant in respect of plant height at 50 DAP the tallest plant was observed in Hero (V_1) (28.67 inch) which was statistically significant with Super (V_3) while the shortest plant (23.17 inch at 50 DAP) was recorded in Kanok (V_2). Consequently, in 80 DAP the tallest plant was (103 inch) found in Hero (V_1) and the shortest plant was (86.58 inch) recorded from Super (V_3). Again The maximum number of leaves (9.75 at 50 DAP and 17 at 80 DAP) was recorded in Hero (V_1) in compare to Kanok (V_2) & Super (V_3). The lowest number of leaf was (8.25 at 50 DAP) observed in Kanok (V_2) and at 80 DAP lowest number of leaf (16) observed in both Kanok (V_2) & Super (V_3). In case of Length of leaves, the longest leaf at 50 DAP (24.42 inch) was recorded from the V_1 followed by Kanok (V_2) & Super (V_3). The leaf with shortest length at 50 DAP (22 inch) was recorded from Kanok (V_2). The longest leaf at 80 DAP (48.67 inch) was recorded from the Hero (V_1) followed by Kanok (V_2) & Super (V_3). The leaf with shortest length at 80 DAP (38.83 inch) was recorded from Kanok (V_2) & Super (V_3). On the other hand the widest leaf (3.18 inch at 50 DAP and 3.72 inch at 80 DAP) was recorded at Hero (V_1) and the lowest widths of leaf (2.95 inch at 50 DAP) was observed in Kanok (V_2) and at 80 DAP the lowest leaf breadth (3.6 inch) was observed in both Kanok (V_2) & Super (V_3). In case of Cobs per plant of maize vary significantly in respect of varieties. Significantly, highest number (1.25) of cobs is recorded in Hero (V_1) while lowest number of cobs (1) was recorded in Kanok (V_2) and Super (V_3) and the longest cob (8.73 inch) was recorded from the Hero (V_1) followed by Kanok (V_2) & Super (V_3). The cob with shortest length (6.317 inch) was recorded in Super (V_3). Again the highest diameter of cob (1.971 inch) was recorded from the Hero (V_1) followed by Kanok (V_2) & Super (V_3). The cob with shortest diameter (1.7 inch) was recorded in Super (V_3) & the maximum (14.37 tha^{-1}) yield of maize was recorded in Hero (V_1) followed by Kanok (V_2) & Super (V_3). Significantly lowest (8.744 tha^{-1}) yield was recorded in Super (V_3).

The experimental results revealed that the Main effect of production system on growth, yield contributing characters and yield of maize was found the highest plant height (27.58 inch) at 50 DAP was recorded in open condition and the lowest plant height was observed in Ghora neem based AGFs. At 80 DAP the plant height was found not significant. In case of numbers of leaves maximum number of leaves (9.33 at 50 DAP and 16.33 at 80 DAP) was recorded in sole cropping system and the minimum number of leaves were recorded in Ghora neem + maize based Agroforestry system. Again Longest length of leaves at 50 DAP was observed (23.58 inch) in sole cropping system and the shortest leaf was recorded in Ghora neem + maize based Agroforestry system. At 80 DAP, longest length of leaves was observed (42.25 inch) in sole and shortest length of leaves (41.83 inch) was observed in Ghora neem + maize based Agroforestry system. At 50 DAPs highest leaf breadth (3.16 inch) was found in sole cropping system and the shortest leaf was recorded in Ipil-ipil + maize based Agroforestry system. At 80 DAPs the breadth of leaves found not significant. Moreover, Cobs per plant of maize found not significant in respect of production system. Consequently, only one cob per plant of maize was recorded in each and every production system. Again the longest cob (7.58 inch) was recorded from Ipil-ipil + maize based Agroforestry system followed by in S_0 while the shortest cob was recorded in Ghora neem + maize based Agroforestry system and the highest diameter of cob (1.852 inch) was recorded from open condition while the cob with shortest diameter (1.792 inch) was recorded in both S_1 & S_2. In case of yield of maize in three production system, total yield of maize significantly varies with each other. The maximum (11.55 tha^{-1}) yield of maize was recorded in sole cropping of maize followed by in Ipil-ipil + maize based Agroforestry system while the minimum (10.07 tha^{-1}) yield of maize was recorded in Ghora neem + maize based Agroforestry system.

The experimental results revealed that the interaction effect of variety and production system on the plant height of maize was found significantly different at different Days After Planting (DAP). At 50 DAP the tallest plant of maize (30 inch) was recorded in V_1x S_0 i.e. Hero in sole cropping where as the shortest plant of maize (21.5 inch) was recorded in V_2x S_2 i.e. Kanok under Ghora neem Agroforestry system. However V_1x S_1, (Hero + Ipil-ipil), V_1xS_2, (Hero + Ghora neem), V_3xS_0, (Super + Sole cropping), V_3xS_1, (Super + Ipil-ipil) and V_3xS_2 (Super + Ghora neem) were statistically similar. Again at 80 DAP the tallest plant of maize (103.3 inch) was recorded in V_1xS_2 i.e. Hero under Ipil-ipil based AGFs. On the other hand shortest plant of maize (85.75 inch) was observed in $V_3x\ S_0$ i.e. Super in sole cropping. Again the numbers of leaves per plant of maize were also significantly disposed. The maximum number of leaves (10 at 50 DAP) was recorded in V_1xS_0 Sole cropping with Hero AGFs which was statistically identical to that of V_1xS_1 (Hero + Ipil-ipil), V_1xS_2 (Hero + Ghora neem), V_3xS_0 (Super + sole cropping), V_3xS_1 (Super + Ipil-ipil), and V_3xS_2 (Super + Ghora neem) Agroforestry system. Again at 80 DAP the maximum number of leaves of maize (17) was recorded in V_1xS_0 (Hero + sole cropping) and $V_1x\ S_1$ (Hero + Ipil-ipil), $V_1x\ S_2$ (Hero + Ghora neem) AGFs. In case of Leaf length of maize, the longest leaf (24.5 inch at 50 DAP) was recorded from $V_1x\ S_1$ (Hero + Ipil-ipil) Agroforestry system followed by Ghora neem + Maize AGFs. The leaf with shortest length (21.5 inch at 50 DAP) was recorded in $V_1x\ S_1$ (Hero +Ipil-ipil) AGFs. On the other hand the longest leaf (48.75 inch at 80 DAP) was recorded from $V_1x\ S_0$ (variety + Sole cropping) AGFs and the leaf with shortest length (38.5 inch at 80 DAP) was recorded in V_3xS_2 (Super +Ghora neem) AGFs. On the other hand the widest leaf (3.215 inch at 50 DAP) was recorded from V_1xS_0 (Hero + Sole cropping) Agroforestry system followed by Ghora neem + Maize and Ipil-ipil + Maize AGFs. The leaf with shortest breadth (2.85 inch at 50 DAP) was recorded in V_2xS_2 (Kanok + Ghora neem) AGFs. Again the widest leaf (3.717 inch at 80 DAP) was recorded from $V_1x\ S_0$ (variety + Sole cropping) AGFs and the leaf with shortest breadth (3.6 inch at 80 DAP) was recorded in V_3xS_2 (Super +Ghora neem) AGFs.

Moreover, Cobs per plant of maize found not significant in terms variety and production system. The longest cob (9.425 inch) was recorded from V_1xS_1 (Hero + Ipil-ipil) Agroforestry system followed by Ghora neem + Maize

AGFs. The cob with shortest length (5.8 inch) was recorded in V_3xS_2 (Super + Ghora neem) AGFs. The highest dia. of cob (6.276 inch) was recorded from $V_1x\ S_0$ (Hero + Sole cropping) Agroforestry system followed by Ghora neem + Maize AGFs. The cob with shortest dia. (2.757 inch) was recorded in $V_3x\ S_2$ (Super + Ghora neem) AGFs.

Finally, the experimental results revealed that the Interaction effect of variety and production system on Yield of maize varies significantly with different Agroforestry system and their interaction with each other. The maximum yield (16.73 tha^{-1}) of maize was recorded in V_1xS_0 (Hero + sole cropping) AGFs followed by Ipil-ipil + Maize and Ghora neem + Maize AGFs. The maximum yield was gained in the treatment due to favorable condition prevailed during the growing period. Significantly lowest (7.352 ton) yield per ha. was recorded in $V_3x\ S_2$ (Super + Ghora neem) AGFs.

5.2 Conclusion

The findings of the present investigation specified that the Hero maize variety had showed highest yield among the three maize varieties. Again the present investigation specified that the sole cropping of maize production system had showed highest yield than the other two production system. The presence of tree canopies of Ghora neem which is deciduous in nature had very low influenced on growth of maize. But another tree Ipil-ipil which is leguminous in nature had positive influenced on the yield of maize (table-5). In case of the interaction of maize variety and production system, Hero maize variety had showed highest yield for both sole and Ipil-ipil +Maize based Agroforestry system. So Hero maize variety and Ipil-ipil tree combination can be grown under forest tree based Agroforestry systems.

5.3 Recommendations and suggestions for further studies

1. Maize +Ipil-ipil based Agroforestry systems are credible under Bangladesh condition.
2. The developed model should be applied in the woodlot and forest plantation of Bangladesh.
3. The present study opened the avenues for further investigation into the screening of tree species suitable for agroforestry systems with different maize variety.
4. This study should be repeated in different location of the country to obtained valid recommendation.

Reference

Anon, 2004. Bangladesh:State of the Environment 2001. http://www.rrcap .unep. org/ reports soe/bangladesh_land pdf, Accesed on November 2007.

Afzalur, R. and Islam, S. S. 1997. Financial viability of Agroforestry under participatory approach in Bangladesh: The case of Forest Department's first logged over plots of Dinajpur, Bangladesh J. For. Sci., 26 (1): 47-55.

Akter, M. S., M. Z. Abedin and M. A. Quddus. 1989. Why farmers grow trees in agricultural fields: some thoughts, some results. In: Research Report,1988-89. On Farm Research Division, Joydebpur.

Akter, M.S., Abedin, M.Z. and Quddus, M.A. 1990. Why farmer grow trees in agricultural fields; some results. Proc. Regional Symposium on Tree plantation in the Humid/Sub-humid Tropics in Asia; held on May 5-9 1988 in University Partanian, Malaysia.

Atta-Krah, A.N. 1990. Alley Cropping with *Leucaena* effect follows on soil fertility and crop yields. Agric. Comb. 26(l): 1-10.

Attri, B.S. 1982. Neem as a source of pest control material. In: Cultivation and utilization of Medlcinal Plants, Atal, C.K. and Kapur, B.M., (eds.) Regional Resarch Laboratory, C.S.I.R., Jammu-Tawi, pp.680-684.

Bhuva, D.A., Vagadia, F. J. and Jiladia, M. A. Department of Pharmaceutical chemistry, Veerayatan Institute of Pharmacy, Jakhania, Bhuj-Mandvi Road,Dist. Bhuj, Gujarat-370460. Ic value – 4.01. 2623. Pharma science monitor. An international journal of pharmaceutical sciences.

Chauhan, H.S. 2000. Influence of plant density and nitrogen on growth and yield of *Tageles minutes* under poplar based Agroforestry system. J. Medicinal Aromatic Pl. Sci., 22:84.

Chowdhury, M.K. and Satter, M.A. 1993. Homestead and crop land Agroforestry practices in the high Ganges river Floodplain. pp. 23-56- In: Agroforestry Farming System Linkage in Bangladesh. BARC Winrock International. Dhaka, Bangladesh.

Crookstan, R.K., Trehome, K.J., Ludford, P. and ozbun, J. I. 1975. Response of beans to shading. Crop Sci-, 15:412-416.

Eicher C.K. and Byerlee, D., 1997: Africa's Emerging Maize Revolution. Lynne Rienner Publishers, 301 pp.

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for agricultural research. (2nd eds) John Wiley and Sons. Inc., New York. p 680.

Halliday, J. and Somasegaran, P. 1983. Nodulation, nitrogen fixation and Rhizobium strain affinities in the genus Leucana, In: Leucana research in asia-pacific region, Proc. of a workshop held in Singapore, 23-26 Nov. 1982.

Haque, M.A., Hossain, M.A., Hocking, D. and Islam, M.K. 1992. Production of trees in the crop field. Proc. Bangladesh Agril. Univ. Res. Prog. 6: 212-218.

Haque, M.A., Hossain, M.A., Hocking, D. and Islam, M.K. 1996. Production of trees in the crop field. Proc. Bangladesh Agril. Univ. Res. Prog. 6:212-218.

Harou, 1983. Economic principles of appraise Agroforestry project. Agricultural Administration. 12 : 127 -139.

Hocking, D. and Islam, K. (1998) Trees on farms in Bangladesh. 5. Growth of top and root-pruned trees in wetland rice fields and yield of understorey crops. Agroforestry Systems 39, 101–115.

Howard, S.8., On& C. K. Rao, M. R.. Mathuva, M. and Black, C. R. 1995. The partitioning of light and watet in Leucaena- rnarze Agroforestry systems. 1n: Sinoquet, H. and P. Cruz (ed) Ecophysiology of tropical intercropping IRNA, Edition, Paris, France.

Huang, S., Pan, G. and Gao, R, 1991. Physiological and biochemical characteristics of tea plants integrated with trees. In: Zhaohua, 2., Mantang, C., Shiji, W. and Youxu, J. (eds.). Agroforestry Systems in China. The Chinese Academy of Forestry, Peoples Republic of China and International Development Center, Canada. pp. 162-163.

Jackson, J.E. 1987. Tree and crop selection and movement to optimize overall system productivity especially light utilization in

Agroforestry. Meteorology and Agroforestry. ICRAF, WHO and UNEF.

Janardhan, K.V. and Murthy, K.S. 1980. Effect of low light during vegetative stage on photosynthesis and growth attribute in rice. Ind. J. Pl. Physiol., 23: 156-162.

Kass, D.L, Jose, F.A.S., Jaime S.O. and Fereira, P. 1992. Ten years Experience with alley farming in Central America. Paper present at the international conference on alley farming in IITA, Ibadan, Nigeria, t4-18 September 1992.

Korikanthimath, V.S., Kiresur, V., Hiremath, G.M. Rajendra Hegde, Ravindera Mulge, Hosmani, M.M., Hedge, R. and Mulge, R. 1997. Economics of mixed cropping of cardamom (*Elettario cardamom* Maton) in arecanut (Areca catechu L.) gardens. J Spices Aromatic Crops, 6: 107-113.

Leopold, Luna B., 1964, Water in the World, UNESCO, Courier (July-August), p.11-13.

MacDicken, K.G. and Vergaro, N. 1990. (eds). Agroforestry: Classification and Management. John Willey, New York, USA.

Marz,U. 1992. The economic potential of an Agroforestry system with neem (*Azadirachta indica* A. Juss.) for small farms in the Sudano-Sahelian zone of Burkina Faso. Tropenlandwirt, 93: 23-38.

Meisheri, J. 1979. Agri silviculture: A system holding great pressure for social forestry in Bihar. Ina. For., 105: 638-643.

Miah, M. G., Garrrty, D. P. and Argon, M.L. 1996. Light availability to the understorey annual crops in an Agroforestry system. In : Sinoquet, H. and P. Cruz (ed) Ecophysiology of tropical inter cropping. IRNA Editions. Paris. France.

Nagveni, H.C., Ananthapadmanabha, H.S. and Rai, S.N. 1987. Note on the extension viability of *Melia azedarach*, My Forest, Vol.23(a), p.245.

Okigbo, B.N. 1980. The importance of mixed stands in tropical agriculture. In:R.G. Hurd, P.V. Bisco and C. Dennis (eds), Opportunity for increasing crop yields. Boston, London and Melbourne: Pitman.

Okigbo, B.N. and D.J. Greenland. 1976. Inter cropping systems in tropical Africa. Multiple cropping. American Society of Agriculture. Publication No. 27.

Ong, C. K. Rao, M. R. and Mathuva, M. 1992. Trees and Crops. Composition for resources above and below ground. Agroforest. Today 4(2): 4-5.

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.

Pathak, P.S. and Gupta, S.K. 1987. Soil amelioration role of Leucana in the agroforestry system, Proc. Int. Workshop on agroforestry for rural needs, New Delhi.

PCARRD. 1983. Technology for Agroforestry. Agroforestry in Perspective: Proceeding of Agroforestry Symposium Workshop' December 19-20, 1979. PCARRD. Los Banos.

Raintree, J.B. 1997. Agroforestry concepts. In: Alam, M.K. F.U. Ahmed and A.M. Ruhul Amin (eds.), Agroforestry: Bangladesh Perspectives, BARC, pp.1-17.

Rang, A., Bhat, M.L. Makaya, A.S. Masoodi, N. A. Anani, A-Z- and Sharma, D.P. 1990. Cited in Solanki, K.R. Agroforestry Research in India Indian Journal of Agricultural Science. 68 (8, Special issue): 559-66.

Reifsnyder, W.E. 1987. Control of solar radiation in Agroforestry practices. Meteorology and Agroforestry. ICRAF, WHO and UNEP.

Saxena, M.B.L. 1984. Improved crop variety in Agroforestry. Agroforestry in Arid and semi-Arid Zones. Central Arid Zane Research Institute, Jodhpur India.

Schoch, P.G. 1972. Effects of shading on structural characteristics of the leaf and yield of fruit in *Capsicum annuum* L.J. Amer. Soc. Hort. Sci. 97:461-464.

Singh, A., 1997. "Liberalisation, the Stock Market and the Market for Corporate Control: A Bridge Too Far for the Indian Economy?," Accounting and Finance Discussion Papers 97-af35, Faculty of Economics, University of Cambridge.

Sivaram S., Monnig K., Tolles R., Maury A. and Leggett R., Proc. 3rd Int. Symposium on ULSI Science and Technology, The Electrochemical Society, Inc., Pennignton, NJ, p. 606, (1991)

Solanki, K.R. 1998. Agroforestry research in India. Indian. J. Agric. Sci. 68(8): 559-66.

Soriano, H.M. 1991. Soil fertility and productivity aspects of alley cropping schemes using legumes trees as hedgerows and corns as an alley crop. A. Ph. D. dissertation, UPLB, Laguna.

Srinivasan, V.M., Subramaniam, S. and Rai, R.S.V. 1990. Studies on intercropping with multipurpose tree resource sharing ability of the trees. Advances in Casuarina rcsearch and utilization. Proceed. of the 2nd Intern. Casuarina Workshop, Cairo. Jan. I5-2A, pp. 85-93.

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

Thakur, P.S. and Dutt, V. 2003. Performance of wheat as alley crop grown wrth *Morus alba* hedge row under rainfed conditions. Ind. J. Agrofor. 5: 36-44.

Thakur, P.S. and Singh, 2004. Performance of *vigna mungo* and *Pisum sativum* under managed canopies of *Morus* trees in northwestern India. Agrofor. Syst., (Accepted)

Tiwari, K.M. 1983. Social Forestry for Rural Developmemt, International Book Distributor, Dehra Dun, pp.94-95.

Virdi J., Sivakami S., Shahani S., Suthar A.C., Banavalikar M.M., Biyani MK (2003). Antihyperglycemic effects of three extracts from Momordica charantia. J. Ethnopharmacol., 88(1): 107-111.

Wainwright, P.C. and Richard, B.A. (1995b). Scaling the feeding mechanism of the largemouth bass (Micropterus salmoides): motor patterns. J. Exp. Biol. 198, 1161–1171.

Wallace, David Foster. *Infinite Jest.* 1st. ed. Boston, MA: Little, Brown and Company. 1996

Wannawong, S., Belt, G. H. and McKetta, C. W. 1991. Benefit-cost analysis of selected Agroforestry systems in northeastern Thailand. Agroforestry Syst., 16 (1): 83-94.

Willey, R.W., Natararyan, M., Reddy, M.S. and Rao, M.R. 1986. Cropping systems with groundnut: Resource use and productivity. In: Agrometeorology of groundnut. Proceeding of an International symposium, 21-26 August, 1985. ICRISAT, sahelian centrer, Niamey, Niger 193-205.

York, E.T. 1991. The importance of Agroforestry education and training. Agrofor. Syst., 12: 7-12.

Appendixes

Appendix-I: The physical and chemical properties of soil in Agroforestry farms HSTU, Dinajpur.

Soil characters	Physical and Chemical
Texture	
Sand (%)	64
Silt (%)	30
Clay (%)	6
Textural class	Sandy loam
CEC (meq/100e)	8.07
pH	5.1
Organic matter (%)	1.16
Total nitrogen (%)	0.10
Sodium (meq/100e)	0.06
Calcium (meq/100e)	1.26
Magnesium (meq/100e)	0.40
Potassium (meq/100e)	0.26
Phosphorus (pdg)	23.5
Sulphur (pe/e)	3.3
Boron (pg/g)	0.26
Iron (pg/g)	5.26
Zinc (pg/g)	0.90

Source: Soil Resources Development Institute, Dinajpur (2011).

Appendix-II: Weather data of the experimental site during the period from January to May.

Month	* Air Temperature (°C)			*Minimum Rainfall (mm)	*Relative Humidity (%)
	maximum	minimum	Average		
January	27.25	16.35	21.75	12	83.45
February	28.35	16.78	22.08	20	82.20
March	30.9	19.8	25.01	35	81.15
April	32.8	21.10	27.85	54	83.05
May	33.9	21.5	30.02	213	77.04

(Note: * = Monthly Average)

Source: Meteorological Station, Wheat Research Center Nosipur, Dinajpur.