PERFORMANCE OF CANE AND EGGPLANT IN MULTISTORIED AGROFORESTRY SYSTEM

A Thesis
By

MD. ZIAUR RAHMAN
Student No. 0605007
Session: 2006-07
Thesis Semester: January-June, 2007

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Approved as to style and contents by:

.....	.....
Md. Main Uddin Miah	**Prof. Md. Abdul Hamid**
Supervisor	**Co-supervisor**

Prof. Dr. Md. Sadrul Amin
Chairman
Examination Committee

And

CHAIRMAN DEPARTMENT OF AGROFORESTRY
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY
UNIVERSITY DINAJPUR

June 2007

Dedicated

To

My Parents

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ABSTRACT

Two field experiments were conducted at the Agroforestry Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur during February 2006 to March 2007 to examine the performance of four cane species and one eggplant variety (Kajla) under different multipurpose trees as the middle and the lower storey crops in multistoried agroforestry system. The treatments were three tree species viz. Mehogony, Deshi neem and Eucalyptus, which were used as the upper storey. There was also a control (Open field) treatment. Four cane species namely Bhudum beth, Udum beth, Jali beth and Golla beth were used as the middle storey non-woody perennial and eggplant was used as the lower storey crop. Two separated experiments were conducted for the study. One experiment was laid out in the single factor Randomized Complete Block Design (RCBD) with three replications for eggplant, another one was two factorial Randomized Complete Block Design (RCBD) with three replications for cane species. The aim of the experiments was to study the growth performances and selection of potential cane species and also to assess the morphological behaviors and fruit yield of eggplant in the said multistoried agroforestry systems.

Considering cane species, jali beth was the best performer compared to other cane species. Considering the tree effects, Mehogony was the best one followed by Deshi neem and significantly the poorest performance was found in the open field for the growth of cane species.

In case of interaction effects, both the cane species and tree species, combination of Jali beth and Mehogony was the best performer compared to other combinations. Growth performances of all cane species, Jali beth was found to have vigourous growth irrespective of tree species.

As far as yield (Kg/ha) of eggplant is considered, the Open field ensured the maximum yield compared to other combinations followed by Mehogony with Golla beth but the lowest performance was recorded from the Eucalyptus with Jail beth combination.

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CHAPTER 1

INTRODUCTION

Cane is mostly trailing or climbing spiny-palm with characteristic scaly fruits and classified under the Lepidocaryoid major group (Moore, 1973) of the palm family Aracaceae (Palmae). It is an integral part of the tropical forest ecosystem. There are 14 genera of canes in the world comprising about 600 species (Dransfield, 1981). The species is a very important source of livelihood for the economically and socially weaker sections of the community. The plant is used as raw material for variety of products of handicraft and small cottage industries, having increasing demand in national and international markets. The climber is mainly used for making ropes, furniture frames, walking sticks, polo sticks, umbrella handles, baskets, sports goods, mat making, wicker work, for stuffing and packing etc. Apart from conventional uses, cane has beneficial medicinal uses as well (Bhatt, 1992).

Cane is one of the important natural resources of Bangladesh forests and homesteads. In Bangladesh, only two cane genera and reported to occur namely *Daemonorops* and *Calamus*. The former is represented by a single species i.e. *Daemonorops jenkinsianus*. On the contrary, the later one has 10 species (Alam, 1990). All local species except *Calamus tenuis* are forest dwelling canes. Generally, in the forest of Bangladesh cane occurs in the north-eastern hill forests of Chittagong, Cox's Bazar, Hill Tracts and Sylhet. The climber is comparatively cheaper and has a tremendous growth potential in rural areas (Banik, 1997).

Cane is partially shade-loving non-timber species. In any agroforestry system, partial shade loving species are always preferable and various researches have been done for different cane species but a little in any agroforestry system. Though most of the cane species are suitable for hilly areas, it is a matter of research works to study the suitability of some species in plain land or northern side of Bangladesh in multistoried agroforestry systems. Therefore, this kind of research has been taken.

Eggplant (*Solanum melongena* L.) belonging to the family Solanaceae is a popular vegetable throughout the entire tropical and subtropical regions. It is grown extensively in Bangladesh, China, India, Pakistan and the Philippines. It is also a popular vegetable crop of France, Italy, USA, Mediterranean and Balkan areas (Bose and Som, 1986).

Eggplant is grown year round in Bangladesh. However, due to some environmental limitations only a few varieties are grown during the rainy season. The bulk of its production is obtained during the winter season. It is also a familiar vegetable for its easier cooking quality, better taste and lower market price.

The average consumption of vegetables in Bangladesh is only 70 gram per capita per day including potato and sweet potato. Except tuber crops, it is only 30 grams against the FAO recommendation of 200 gram. To supply the minimum daily requirement of 200 gm, the national production of vegetables should be over 10 million tons. In addition, population of Bangladesh is increasing rapidly; therefore, demand for vegetables is also increasing simultaneously. Eggplant ranks second among the vegetables in terms of both acreage and production. Total production of vegetables in Bangladesh is 6,63,1000 tons where kharif

production of vegetables in Bangladesh is 6,63,1000 tons where kharif eggplant and rabi eggplant are produced 1,10,000 & 2,30,000 tons, respectively (BBS, 2005). Unfortunately, these limited areas are decreasing due to increasing the housing and other facilities for the over increasing population as well as increasing the area of boro rice and wheat in winter season. Under these situations, new techniques must be developed to bridge the wide gap between the supply and the demand for vegetables.

Recently, some techniques have already been advocated to overcome the future food challenges including vegetables, multistoried agroforestry is one of them. Michon *et al.* (1986) stated that multistoried agroforestry system is characterized by an intensive integration of forestry species and commercial crops forming a forest like system. The multistoried agroforestry system is a profitable productions system and provides a buffer between villages and protected forest.

In the view of proper utilization of plain land or shaded places and to increase the production of eggplant and cane, the present study was undertaken with the following objectives.

1. To find out the growth performance of four cane species as the middle storey non-timber agroforestry species.
2. To assess the morphological behavior and fruit yield of eggplant as the lower storey crop in multistorey agroforestry system.
3. To select the potential cane species from multistoried three agroforestry systems.

CHAPTER 2

REVIEW OF LITERATURE

The review of literature of the past studies related to the present experiment collected through reviewing of journals, theses, reports, periodicals other forms of publications are presented below-

2.1 Concepts of multistoried cropping in agroforestry system

According to Rang *et al.* (1990), homestead gardens are common in Bangladesh were farmers take up combinations of 10-15 species of fruits, and multipurpose trees along with vegetables to satisfy their versatile requirements.

Rabarimandimby (1992) observed that hedgerows significantly competed for nutrients and light with upland rice and mungbean in the alley. He found that competition was severe in the 2-3 rows closest to the hedgerows while yields were reduced by 47-95 and 11-37 percent for rice and mungbean, respectively.

Yantashath *et al.* (1992) stated that the first growing multipurpose tree species in agroforestry play an imperative role through providing food, fuel wood, fodder, green manure, soil and environment conservation, and other wood-uses.

Nair (1993) claimed that multispecies tree gardens characterized by a large variety of diversed plants in various vegetation layers provided effective utilization of environmental factors like water, nutrients and sunlight. He also urgued that the shade from such vegetations lower ground surface temperature, which may reduced the rate of loss of soil organic matter by oxidation.

Michon and Mary (1994) proved that multistoried village gardens near Bogor, West Java, Indonesia had long been essential multipurpose production systems for low-income households. Nevertheless, they are being subjected to vital conversion processes linked to socioeconomic changes presently found in overcrowed semiurban zones.

In agroforestry, multistrata canopies offer scope for regulating the light distribution patterns between the plant components and of utilizing the light energy more efficiently overall (Wallace, 1996).

Sathish *et al.* (1998) evaluated the performance of 12 turmeric *(C. longa)* cultivars in a 20-year old coconut plantation. Plant crop cycle duration, yield and quality were assessed. Cuddapah produced the tallest plants (57.27 cm) and BSR-1 resulted the greatest number of tillers (4.47/ clump).

Jayachandran *et al.* (1998) conducted studies in Kerala, India who indicated that combination of coconut *(Cocos nucifera)* and ginger *(Zingiber officinale)* under rainfed conditions gave good returns as ginger performs well under shade where few other crops do. The yield of ginger under 0, 25, 50 and 75% artificial shades was tested. Under artificial 25% shade ginger yields were 11-27% higher than in open fields, and even under 50% artificial shade the yield was better than under open conditions.

Growth of trees and seasonal yields of understudy crops were evaluated by Hocking and Islam (1998) for five years period for four crops grown under 17 tree species at 8 X 8 m spacing in wetland at rice field. All tree species grew well in rice fields, at rates comparable to their growth in forest plantations. Top and root pruning reduced average tree

girths by up to 19% and average tree volume by up to 41% depending on the intensity of pruning. The crops monitored were *Oryza sativa*, *Tritictum aestivum*, *Corchorus oletorius*, and *Lens culinaris*. Crop yields under the trees averaged 93% of the corresponding yield outside the tree canopy.

Mishra and Pandey (1998) investigated the intercroppings of *Curcuma longa* with *Leucaena leucocephala, Eucalytus comaldulensis, Melia azadirachta* or *Manilkara* spp. in Madhya Pradesh, India. The highest mean yield of *C. longa* was observed in the *L. leucocephala* treatment. Mean yield of *C. longa* decreased with the increasing tree ages and with the increasing densities of planted of trees.

Solanki (1998) studied fruit trees and crops grown together in various ways. Depending on the patterns and configurations, these companion crops are known as intercrops, under planting, hedgerow planting or alley cropping. In an agroforestry system where agriculture crops are normally grown between rows of fruit trees, the agricultural crops provide seasonal revenue whereas fruit trees managed for 30-35 years give regular returns of fruits and in some cases fuel wood from pruned wood and fodder. Several kinds of crops are also under planted to take the advantages of shades provided by the canopies of fruit trees.

Ali (1999) claimed red amaranth and lady's finger could be grown successfully under drumstick tree although 10-15 percent yield was reduced compared to the open field.

Singh *et al.* (2001) observed the effects of three tree species namely, eucalyptus *(Eucalyptus teretieornis)*, acacia *(Acacia nilotica)* and Poplar *(Populus deltoides)* on the performance of turmeric (*C. longa)* was in Karnal, Haryana, India. The mean emergence of turmeric was

maximum when grown in association with acacia while the minimum in the control i.e. in the open conditions. The tallest turmeric plants after 90 days of planting were under eucalyptus and the lowest under poplar. The yields of turmeric were in the order: eucalyptus > control > poplar > acacia.

Under a systematic investigation of the multistoried agroforestry system at the Bangladesh Agricultural University, Mymensingh, Rahim and Haider (2002) experienced that natural resources could be used properly in this system as various trees planted at different layers exploited sunlight from several strata.

Hossain *et al.* (2005) carried out an experiment to evaluate the performance of Indian spinach grown under Eucalyptus tree in different orientations from May to August 2003 at the Bangladesh Agricultural University, Mymensingh. The treatments involved different orientations: north, south, east and west for each of the tree. The fresh yield produced in south orientations followed by west, east and north, 56.37%, less than the open field and that of for dry yields were 52.74, 56.41, 58.14 and 59.80% less respectively.

Islam (2005) conducted an experiment to investigate the performance of lemon and guava grown under coconut based multistoried agroforestry system and observed a significant influence on yield, yield attributing and quality parameters of lemon as well as guava. The best yield of lemon was found in the coconut + lemon based agroforestry systems while the highest yield of guava was obtain from the open conditions.

2.2 Benefits of multistoried cropping in agroforestry system

In trials between December and March, the average fruit yields of tomatoes, cucumber, phaseolus beans, capsicums, melons and okras grown under plastic tunnels were 12.4, 8.67, 2.0, 4.32, 1.89 and 0.29 kg/m^2, respectively, and for crops grown in the open the corresponding figures were 1.53, 0.47, 0.8, 1.12, nil (melons were not grown in the open) and 0.5 kg/m^2 (Aidy, 1984).

Rang *et al.* (1990) studied the performance of maize, cassava and cowpea in alley cropping with *Leucaena leucocephala* and *Gliricidia sepium* in Nigeria. They obtained significantly higher yields of maize and cassava in the alley cropping than that in the monoculture. It was reported by Ngambeki (1985) that cowpea yield in the alley cropping with *L. leucocephala* showed no response.

Yamoah *et al.* (1986) reported that maize height as well as stover and cob weights was insignificantly reduced in maize rows close to the shrub hedgerows compared to those in the middle of the alley.

Akber *et al.* (1990) reported that wheat yield under different tree species (*E. camaldulensis*, Mulberry, Siris, Ipil-ipil) showed no significant differences in terms of yield.

Akter *et al.* (1990) reported that 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.

Atta-Krah (1990) reported that application of *Leucaena* prunings 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.

Deep-rooted trees absorb nutrients from great soil depths and deposit them on the surface as organic matter, thus making nutrients more available to shallow rooted crops (York, 1991).

Sharma (1992) examined the influence of Acacia nilotica on the growth and yield of associated wheat crop under irrigated conditions in India. He reported that the tree line affected negatively all crop parameters like plant height, shoot number, ear length, grain number and grain yield near trees and established that as the distance from the tree line increased, the growth and yield of wheat were also progresively improved.

Haque (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 trees in crop 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.

Kass *et al.* (1992) observed significantly 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.

Zheo and Oesterhuis (1995) observed that when light intensity was reduced to 37% of full sunlight during flowing and fruiting, the photosynthetic rate decreased by 47-55% resulting in a significant increase in boll shading with a concomitant decrease in lint yield of 18-25% in cotton.

Hocking and Islam (1998) observed that due to pruning of shoot and root the tree yield was reduced by 41% 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.

2.3 Effect of light on plant growth in multistoried agroforestry system

Okigbo and Greenland (1976) identified ways of more efficient uses of light resources by plants of different heights and canopy structures as one of the advantages to be gained by growing crops in mixed stands.

According to Salisbury and Ross (1986), in darkness or at very low light level, the green plants become etiolated with maximum elongation of internodes. The stem becomes soft and weak with degeneration of xylem and differentiation of too much parenchyma. Different spectra have different effects on plants. Plants attain maximum height under red light. In blue and violet rays, the plants become healthy in structures and functions.

The yield advantage of conventional intercropping has been explained in terms of improved capture of utilization of growth resources. The resource capture by agroforestry systems will probably be greater than in sole crops (Ong *et al.* 1991).

The potential benefits because of combining field crops with trees are so obvious from the consideration of the waste of light resources experienced in orchard and tree crop orientation (Jackson, 1987).

Interaction among trees and solar geometry produce particular solar climate of tree/crop systems. These interactions and effects include interception of radiation by tree stands of various densities, effect of canopy structure, effect of latitude and time of year on solar paths, shade from single crowns and spectral quality of sun light under partial shade (Reifsnyder, 1987).

The higher amount of light transmitted through *Gliricidia sepium* species may be due to its small and thin leaflets as well as low branching habit (Miah, 1993).

Essentially, the underlying processes involved in the partitioning of resources (e.g. light, water and nutrients) are not well understood. A better mechanistic understanding of resource capture and utilization in agroforestry system involves in terms of species combination, planting arrangement and management (Howard *et al.* 1995).

Light demanding under storey species (e.g. *Echinaces sp.*) may be intercropped initially to provide early returns from plantations and after canopy closure, shade tolerant species such as ginseng and goldenseal could be intercropped (Teel and Buck, 2002).

2.4 Effect of shade on plant growth in multistoried agroforestry system

It has been reported that canopy shading reduced leaf number, leaf area, and thickness of dry bean (Crookston *et al.,* 1975). They also reported 38% decrease in short synthesis per unit area of shaded leaves.

Alley cropping agroforesty systems have been emerged as a sound technology where tree leaves are periodically pruned to prevent shading the companion crops (Kang *et al.,* 1984).

Chaturvedi and Ingram (1989) mentioned that pre-flowering shade (50% shade) resulted in reduced leaf area and tiller number spikelets per panicle, whereas post flowering shade reduced filled spikelet fraction and grain weight in rice.

The shading was responsible for suppression of maize yields in the second season, where rains ended abruptly; moisture competition was the main factor causing the drastically low yield (Singh *et al.,* 1989).

Miah *et al.* (1995) reported that the mean light availability on crop rows decreased as they approached the tree rows across the alleys. The rate of decrease was greater in unpruned alleys than in pruned ones. Rice and mungbean yield decreased linearly with the reduced percent light incidence, rice yields decreased by 47 kg/ha but mungbean yields decreased 10 kg/ha. In pruning regimes mungbean yield decreased more in pruned condition (13 kg/ha) than in unpruned condition (9kg/ha).

Studies in New Zealand have indicated that the American ginseng can be successfully grown under *Pinus radiata* with best growth under a tree stand of 130 stems/ha (Follett, 1997).

Rao and Mittra (1988) observed that shading by taller species usually reduced the photosynthetically active radiation. It also regulated photosynthesis, dry matter production and yield of crop.

2.5 Importance of the study

2.5.1 Importance of eggplant

The eggplant (*Solanum melongena* L.) is one of the principal vegetables commonly cultivated in Bangladesh. Eggplants are cultivated in about 28 thousand hectares of land in both Rabi and kharif seasons with yearly production of approximately 182 thousand tons occupying the third position in respect of vegetable production in Bangladesh (Ahmed et al. 1983). As winter, the production of Rabi eggplant was 13.1 thousand tons in the year 1996-97, which was placed the second highest position.

Human nutrition is very essential in order to develop a nation in all respect. Vegetables may play a vital role in this aspect. In the recent years, the value of vegetables as well as eggplant has been recognized as an important item of daily human diet all over the world. They have been playing a very important role in our daily diet by providing taste, palatability, variability and increase appetite. Generally, vegetables are rich sources of minerals, vitamins and essential amino acid. They are essential for balanced diet and neutralizing the acids produced during digestion of rich food (meats cheese and fatty acids). They are also considered as one of the most important groups of food crops having

features of high nutritive value, labour-intensive, relatively higher yield and higher fiscal gain. They are further considered as a cheap natural source of supplementary food and can be grown in a short. Being labour intensive, vegetable production creates opportunities for employment.

Eggplant is a strong garden herb, grown for its large fruits. It is of major importance as a commercial crop and is grown all over the Bangladesh. Contrary to the common belief, it is quite high in nutritive value. Nadkarni (1997) has cited many medicinal uses of eggplant. According to Aukroyd (1941), eggplant fruit contains the following nutrients per 100 grams edible portion:

Table 2.1 Eggplant fruit contains the following nutrients per 100 grams edible portion:

Nutrients composition	Content (per 100 g of edible portion)
Water	91.5 gm
Protein	1.3 gm
Fat	0.3 gm
Carbohydrate	6.4 gm
Minerals	5 gm
Calcium	.02 mg
Phosphorus	.06 mg
Iron	.0013 mg

2.5.2 Importance of cane

Cane is a very important forest species of Bangladesh and the rural people in various household activities have traditionally used it. It provides expensive furniture, which is important in the handicraft and small cottage industry sector. Cane is comparatively cheap and has a tremendous growth potential in rural areas (Banik, 1997).

Employment of many people in cane based enterprises, income opportunity and improvement of socio-economic conditions of the rural people in various chains from producer to the processors to consumers is increasing.

The demand for well-processed, good quality canes are going up in the world market and it is presumed that the demand is three times more than the supply. Indonesia exports 90% of world's requirement of canes. In the total world export of primary forest products, cane occupies second position next to timber. In Bangladesh, however, cane occupies minor position. It is considered as a neglecting forest product and no special attention is given to its propagation, harvesting, extraction, processing and manufacture. Moreover, hardly any research has been undertaken to improve the quality of local canes.

Consumption pattern of canes in Bangladesh:

Table 2.2 the consumption pattern of cane (Tiwari, 1992) is given below-

Uses	Percentage consumption (%)
Rural uses	20
Handicraft and small cottage industry	20
Furniture	50
Tying material, frames etc in house construction	10

In Bangladesh, canes are used mostly for making furniture, basket, woven, cane seats and other products with split canes. Any processing is seldomly carried out except for drying, rubbing and finishing at the manufacturing end. As a result, those products are often affected by stain fungi, which do not allow a good finish. Borers particularly in dry immature canes also attack canes. In the manufacturing process, bending is done by blowtorches, which scorches the bent portion, thus affecting the good finish. Fixing and joining is done with nails and tying with split canes, which spoils the look and many a time these come loose, thus damaging the furniture. Therefore, there is a considerable scope for improving the processing of the cane from the harvesting up to the manufacturing stage.

Cane furniture is very popular among foreigners because of its cheapness and the natural look. If the quality and the design can be improved by proper research and training, the demand for cane furniture, particularly among overseas buyers and the richer section of Bangladeshis will go up. Now, there is several cane furniture making shops in the cities of Dhaka. Sylhet, Comilla, Chittagong, Khulna and some other towns too.

It can be assumed that both the number of cane handicraft industries and people employed those have increased. At present, cane furniture is continuously providing employment opportunities and the main source of livelihood for thousands of workers and families including women and children, partly or wholly engaged in the enterprise.

Development programmers for cane focusing activities in three major areas e.g. Resource management & development, Product development and improvement and Research needs should be identified and undertaken as early as possible. The important research issues such as data base development, determining suitable silvicultural and management systems for cane inter-cropping and understorey planting should be undertaken for further development of this resource in Bangladesh.

CHAPTER 3

MATERIALS AND METHODS

This episode deals with the location of the experiments, materials used and methodologis followed in different operations during the experiment as well as for data collection in the following subheads.

3.1 Location of the study

The experiments were conducted in tree-cane based multistoried model at the western side of the Agroforestry Research Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur. The site was between 25° 13′ latitude and 88° 23′ longitude, and about 37.5m above the sea level.

3.2 Soil characteristics

The experimental plot was situated in a medium high land belonging to the old Himalayan Piedmont Plain area (AEZ 01). Land was well-drained as drainage system was well developed. The soil texture was sandy loam in nature. The soil P^H was 5.1.

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 the rest period of the year. Monthly maximum and minimum temperatures, rainfall and relative humidity recorded during the experimental period (April 2006 to April 2007) are included in the Appendix-1.

3.4 Experimental period

April 2006 to April 2007

3.5 Experimental materials

The three tree species used as the upper storey were -

i) Mehogony (*Swietenia macrophylla*)

ii) Deshi Neem (*Azadirachtha indica*)

iii) Eucalyptus (*Eucalyptus camaldulensis*)

The four cane species used as the middle storey were -

i) Udum beth (*Calamus longisetus*)

ii) Bhudum beth (*Calamus latifolius*)

iii) Jali beth (*Calamus guruba*)

iv) Golla beth (*Daemonorops jenkinsianus*)

The eggplant (*Solanum melongona*) used as the Lower storey is -

i) Kajla (BARI - 4)

3.6 Experimental design

The experiments were laid out following the RCBD under three different tree species i.e. Mehoney, Deshi neem, and Eucalyptus. Four cane species planted randomly in between tree species with a control plot (open field). There were three replications of each treatment. The spacing for the cane species was 3 x 3M while for trees 3 x 3M. There were five plots. Each plot size was 2.5 x 2.5M. Adjacent plots and neighboring blocks were separated by 0.5x 3M respectively.

3.7. Treatment combination of the study

3.7.1 Single factor RCBD was followed for eggplant

Replication number: 03

Treatments of eggplant

T_1 = Eggplant + Open field (control)

T_2 = Eggplant + Mehogony + Bhudum beth

T_3 = Eggplant + Mehogony + Udum beth

T_4 = Eggplant + Mehogony + Jali beth

T_5 = Eggplant + Mehogony + Golla beth

T_6 = Eggplant + Deshi Neem + Bhudum beth

T_7 = Eggplant + Deshi Neem + Udum beth

T_8 = Eggplant + Deshi Neem + Jali beth

T_9 = Eggplant + Deshi Neem + Golla beth

T_{10} = Eggplant + Eucalyptus + Bhudum beth

T_{11} = Eggplant + Eucalyptus + Udum beth

T_{12} = Eggplant + Eucalyptus + Jali beth

T_{13} = Eggplant + Eucalyptus + Golla beth

3.7.2 Two (2) factorial RCBD was followed for cane species

Replication number: 03

Factor A: Cane species

C_1= Bhudum beth (*Calamus latifolius)*

C_2= Udum beth (*C. longisetus*)

C_3= Jali beth (*C. guruba*)

C_4= Golla beth (*Daemonorops jenkinsianus*)

Factor B: Tree species

T_1 = Mehogony (*Swietenia macrophylla*)

T_2 = Deshi neem (*Azadirachta indica)*

T_3 = Eucalyptus (*Eucalyptus camaldulensis*)

T_4 = Open field (Control)

Treatment combinations

$C_1 T_1$ = Mehogony + Bhudum beth

$C_2 T_1$ = Mehogony + Udum beth

$C_3 T_1$ = Mehogony + Jali beth

$C_4 T_1$ = Mehogony + Golla beth

$C_1 T_2$ = Deshi neem + Bhudum beth

$C_2 T_2$ = Deshi neem + Udum beth

$C_3 T_2$ = Deshi neem + Jali beth

$C_4 T_2$ = Deshi neem + Golla beth

$C_1 T_3$ = Eucalyptus + Bhudum beth

$C_2 T_3$ = Eucalyptus + Udum beth

$C_3 T_3$ = Eucalyptus + Jali beth

$C_4 T_3$ = Eucalyptus + Golla beth

$C_1 T_4$ = Open field (Control) + Bhudum beth

$C_2 T_4$ = Open field (Control) + Udum beth

$C_3 T_4$ = Open field (Control) + Jali beth

$C_4 T_4$ = Open field (Control) + Golla beth

3.8 Land preparation

The land was opened in the middle of October 2006 and prepared thoroughly by spading to obtain a good tilth. All weeds and stubbles were removed from the filed and bigger clods were broken into smaller pieces.

3.9 Description of agroforestry species

Three tree species were selected for the experiments. Brief descriptions of the species and the reasons of their selection are given below :

A) Mehogony (***Swietenia macrophylla***) - It is an evergreen shading tree species. Leaves paripinnate, up to 60 cm long; leaflet 6-16, ovate-lanceolate, acuminate, slightly oblique, up to 20.5 cm long; and 1.5-5 cm wide, petiole very short. Flowers are greenish white. Fruits are capsule. Flowering time is March - April. Fruiting time: December - February. Its wood is excellent for high furniture, also used in jetty piles and ply wood manufacture. (Khairul, 1996)

Climate: The maximum temperature varies from 32to 45°C and the minimum temperature varies from 2.1 to 16° C. It grows well on sites that receives rainfall from 400 -1000 mm/year.

Soil: It grows well under laterite soil but not on bare laterite. It does not stand much shade.

Light: Young plants are capable of standings a moderate amount of light. It is moderate light - demander. For its best development, the tree requires much light.

Wood: It is popular for panels, furniture, boat buildings, and toys agricultural implements.

Fooder: Foliage is a valuable supplement to grass. The foliage is nutritious. It is an excellent fodder for goats

B) Deshi neem ***(Azadirachta indica)*** - It is a short duration tree species. It can be harvested within 6-8 years. It is a fast growing and completely evergreen tree species. Leaves tripinnate, 30-75 cm long, pale beneath, elliptic to ovulate. Flowers white, 12.5 cm in diameter, scented. Fruit long slender flexile pods, 20-40 cm long in hanging clusters, having nine distinct ribs and wavy edges. Flowering time: November - January; fruiting time: April - May. (Khairul, 1996)

Climate: The absolute maximum shade temperature varies from 30-to 48°C and the absolute minimum shade temperature varies from 1°C to 16°C. It grows satisfactorily on sites that receive rainfall annually from 450-1200 mm or more.

Soil: It grows under a wide range of soil. It is planted in black cotton soils, alkaline soils, dry stony shallow soils and in well - drained loamy soil too.

Light: *Azadirachta indica* is light demander. Young plants are capable of standing a moderate amount of shade. In alley cropping, 3 x 3m spacing is recommended and *Cajanas cajan* fills space between two trees as fillers. This helps in improving fertility status of soil (Jha, 1990.)

Water: It is not a moisture-loving tree. It can tolerate excessive drought. It does not stand water logging, intolerant of an excess of moisture in the soil, the taproot tending to rot. (Troup, 1921).

Wood: The sapwood is grey and the heartwood dark-red, hard. The weight of the wood at 12 % moisture content is 83 kg/ m^3.It is popular for panels, furniture, boat buildings, toys, agricultural implements etc.

Fuelwood: The branches are used as firewood.

Soil improvement: Its leaves and twigs are used as mulch and green manures.

Fooder: Neem foliage is a valuable supplement to grass. The foliage is nutritious. It is an excellent fodder for goats.

Neem oil: Seeds of this plant contain oil (margosa oil), which is of great demand for pharmaceutical, soap and disinfectant industry. The seed cakes can be processed to produce biofertilizer (Tiwari, 1983).

Repellent: Experiments conducted on the use of neem products as protectants against insect largely do not indicate whether the relief was due to the repellent or the antifeedent action (Attri, 1982).

Attractant: It also acts as an attractant for many insect species. But the nature of the attractant is not known.

Insecticides: Attri (1982) mentioned that it is now amply clear that several neem products do have low to moderate toxicity particularly to soft-bodied insects.

Gum: Its gum has medicinal values.

C) Eucalyptus (*Eucalyptus camaldulensis*) - It is a tall evergreen tree with straight bole and gently ascending branches with graceful and drooping leaves. Leaves are simple, alternate, 8-25 cm in long and 2-4 cm width, lanceolate, Pendulous. Flowers 1.0 cm in diameter, white in globosely heads arranged in lateral or supra-axillary umbels. Fruits are capsule. Flowering time: August - October; Fruiting time: October - December. Generally, wood is used for fuel wood, furniture. It pulled up more water from deep soil layer to upper root level. (Khairul, 1996)

Climate: The absolute maximum temperature varies from 30 to 42°C. The average annual rainfall in the area of distribution varies from 500 to 1500 mm.

Soil: The tree grows on a variety of soils, e.g. laterile soil, red sandy and loamy soil. According to Kaushik (1969) this species cannot grow on sites containing soil with p^H exceeding 10, and soluble salts exceeding 0.7 %.

Light: Young plants are capable of standing in a moderate amount of shade. It is light demander. For its best development the tree requires full overhead light Patel (1985).

Water: Eucalyptus hybrid is an efficient user of water compared to other tree species. However, the amount of consumption of water per hectare is high. Studies conducted by F R.I and college of Dehra Dun showed that water consumed per gram an eucalyptus as against 2.59 mm per gram by rose wood and 3.87 mm by chir. It can consume only sub-surfaceseepage water and cannot tap subterranean ground water (Shukla, 1980).

Wood: Eucalyptus wood is very well suited for furniture making. It has very good working as well as finishing qualities.

Fuelwood: In any agroforestry system, short coppice rotation provides an effective method of producing high yield of fuel wood. Its caloric value is 4,800 cal/gm.

Pulp: 6-7 years coppice rotations are considered best in view of pulp yield. Different varieties of paper can be produced by proper changes of pulping process and admixtures of other pulps.

Oxalic acid from bark: Prabhu and Theagarajan (1997) have reported that bark can yield 40-50% oxalic acid by oxidation process. Its bark can be used profitably as a raw material for oxalic acid production.

Essential oil: The leaves yield oil. It contains cineole.

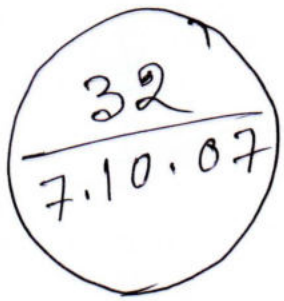

Table 3.1 Growth status of the existing tree species in the research field at different periods

Parameter	Mehogony			Deshi neem			Eucalyptus		
	18 MAP	30 MAP	** MAI	18 MAP	30 MAP	** MAI	18 MAP	30 MAP	** MAI
Height	2.28 m	3.8 m	1.52 m	3.28 m	3.82 m	0.54 m	3.56 m	6.30 m	2.74 m
Base girth	12.45 cm	20.75 cm	8.3 cm	10.35 cm	17.25 cm	6.9 cm	12 cm	20.50 cm	8.2 cm
Girth at the breast height (GBH)	8.7 cm	14.50 cm	5.8 cm	9.3 cm	15.50 cm	6.2 cm	8.25 cm	13.75 cm	5.5 cm
Canopy diameter	96 cm	1.60 m	64 cm	96 cm	1.60 m	64 cm	1.00 m	1.80 m	80 cm

3.10 Descriptions of cane species

***MAP** = Months After Planting

****MAI** = Mean Annual Increment

Bhudum beth (*Calamus latifolius*)

Leaf-sheath with strongly recurved spines, leaflets interrupted, alternately clustered in two (one or two leaflets, solitary towards base), 4.5 cm wide, glabrous on both surfaces, cross veins distinct.

Udum beth (*Calamus longisetus*)

Stem spreading to climbing, diameter with sheath less than 10 cm; ochre not tubular and fibrous; leaflets grouped in two or three up to the upper mid of the rachis.

Jali beth (*Calamus guruba)*

Slender horizontal spines not crowded with smaller spines in between on the leaf-sheath, ochre indistinct, not membranous, nor lacerate; primary bract tubular never split or laminated.

Golla beth (*Daemonarops jenkinsianus*)

Leaf-sheath with slender, conical, spreading spines; leaflets not interrupted, regularly arranged, alternate, equidistant, up to 2 cm wide, lateral veins and midrib setose above, cross veins not distinct. Bracts are open boat like.

Table 3.2: Taxonomy, distribution and uses of cane species:

SL. No.	Cane species	Description	Distribution	Uses
1.	*Calamus latifolius*	A large climber.	North - East India, Sikkim. Bangladesh. Cultivated at the Forest Research Institute, Dehra Dun.	Highly favoured for walking sticks, umbrella handle, and for cane chairs.
2.	*Calamus longisetus*	Moderate sized cane. *Stem* 20 m long, 4.5 cm in diameter.	South Andamans, India.	Suitable for furniture making particularly used as frames
3.	*Calamus guruba*	Tall,slender climbing cane.	North - East India. Bangladesh.	One of the good canes for making ballast baskets.
4.	*Daemonorops jenkinsianus*	High scan dent cane. *Stem* large, up to 2.5 cm in diameter.	North -East India. Sikkim, Bangladesh and Myanmar. Cultivated at the Forest Research Institute, Dehra Dun.	Used for basket work, furniture frames and walking sticks, crooks of umbrella handles.

3.11 Establishment of eggplant and cane species

The four cane species were planted on 28.08.2005 in the 1-year-old MPTs orchard of the Agroforestry Research Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur. Three MPTs (Mehogony, Deshi neem and Eucalyptus) were planted in three blocks. In the block, trees were planted in 3 x 3M spacing. The cane species were randomly arranged in each MPTs. It was planted tree rows just in the middle of two trees i.e. one tree species and one cane species alternatively arranged in the same line 1.5 m apart. 2.5Mx 2.5M sized plots were made between two lines (alley) of trees with cane. Eggplant seedlings were planted in this plot maintaining 50 d 40 cm distances. Therefore, the plant population of eggplant was 20/plot.

Mature fruits of eggplant were plucked by hand time to time when there become marketable size and final plucking was done at 150 DAP.

3.12 Management practices

Recommended doses of fertilizers were used for the respective eggplant variety. The recommended doses of fertilizer kg/ha were-

Urea - 380

TSP -150

MP- 260

All the fertilizers except urea were applied during the final land preparation. The rest of urea was given after 30 and 60 DAPs.

3.13 Intercultural operation

For eggplant, weeding was done periodically when ever necessary. Light irrigation was given at the transplanting. However, heavy irrigation was given twice, at 40 and 80 DAPs, respectively.

3.14 Pest and disease control:

No pesticides were used to control the insect, pest and diseases as it was also an attempt to produce eggplant in organic basis. Fruit borer and bacterial wilt were found a little bit which did not affect severely the total yield. 5-10%, (1-2) plots were removed from each plot due to infestation of bacterial wilt. For minimizing the fruit borer, damaged and infested leaves and twigs of eggplant were immediately picked up and destroyed outside of the field whenever necessary. After all, 10-15%, fruits of eggplant were found infested by the fruit borer.

3.15 Harvesting:

The fruits of eggplant were plucked when as and when they reached the edible mature stage. Final harvesting was done at DAP.

3.16 Data collection:

Among the following data, plant height and number of leaves were recorded thrice in the life cycle of eggplant, at 50, 100 DAP and 150 DAPs. Individual fruit parameters (weight, length, girth) were collected when it is harvested. The other parameters recorded at the time of final harvest were-

I. Plant height
II. Leaf / plant(number)
III. Primary branch / plant (number)

IV. Fruit length / plant
V. Girth of fruit / plant
VI. Weight of fruit / plant
VII. Fruit / plant(number)
VIII. Yield Kg/ha(plot)
IX. Secondary branch/ plant (number)

On the other hand, the data were collected for cane species at three times at 6, 12 and 18 MAPs respectively. The following parameters were recorded for cane species.

I. Plant height
II. Leaf / plant(number)
III. Pinne / leaf(number)
IV. Secondary stem number / plant
V. Leaf length / plant

3.17 Data collection procedure

For data collection, 10 representative sample plants (egplant) were selected. For cane, each species were evaluated.

3.18 Data analyses:

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

CHAPTER 4

RESULT AND DISCUSSION

This episode is the presentation and discussion of the results obtained from the experiments carried out to study the performance of eggplant and cane species under different multistoried agroforestry systems. The data are presented tables, plates and the summary of analysis of variance of all the parameter. The results of each parameter discussed under the following headings.

4.1.1 Plant height and number of leaf of eggplant as the lowerstoried component of multistoried agroforestry system

4.1.1 Plant height

Plant height at different Days After Planting (DAP) was significantly influenced by different over storey species combinations (trees and cane)

Significantly, the tallest plant at 50 and 100 DAPs were recorded 24 and 80 cm, respectively in T_1 (Open field) followed by T_5 (22 cm) and (75 cm), respectively at 100 and 150 DAPs. At 150 DAP the tallest plant (96 cm) was observed in T_1 (Open field), which was 90 cm statistically similar to that of T_5 (Mehgony + Golla beth).

The significant shortest plant at 50, 100 and 150 DAPs were 14, 46, and 70.75 cm respectively in T_{12} (Eucalyptus + Jali beth). [Table 4.1]

4.1.2 Leaf/plant (number)

Leaf/plant (number) was significantly influenced by different over storey (trees and cane) canopies.

At 50 DAP, highest number of leaf/plant (15) was recorded in T_1 (Open field) which was statistically similar to that of T_5 (Mehgony + Golla beth).

Significantly, the highest number of leaf/plant at 100 and 150 DAPs were 45 and 80 respectively in T_1 (Open field) followed by (39.50) and (92) respectively in T_5 (Mehgony +Golla beth).

Significantly, the lowest number of leaf/plant at 50, 100 and 150 DAPs observed were 9.50, 27.80 and 48, respectively in T_{12} (Eucalyptus + Jali beth). [Table 4.1]

Table-4.1 Plant height and number of leaf of eggplant at different DAPs as the lowerstoried component of multistoried agroforestry system

Treatment	Plant height (cm) at			Leaf/plant (number) at		
	50	100	150	50	100	150
T_1 (Open field)	24.00a	80.00a	96.00a	15.00a	45.00a	80.00a
T_2 (Mehogoni + Bhudum beth)	18.00e	65.00e	82.00bc	13.50b	39.00b	70.50bc
T_3 (Mehogoni + Udum beth)	20.00c	70.00c	80.00cd	12.00c	38.00b	65.25cde
T_4 (Mehogoni + Jali beth)	19.00d	67.00d	79.00cd	11.75cd	35.00c	63.5de
T_5 (Mehogoni + Golla beth)	22.00b	75.00b	90.00ab	14.67a	39.50b	72.00b
T_6 (Deshi neem + Bhudum beth)	17.00f	62.00f	78.00cd	11.00de	33.50cd	65.00cde
T_7 (Deshi neem + Udum beth)	18.00e	67.00d	80.50c	10.75ef	33.00cde	62.00def
T_8 (Deshi neem + Jali beth)	17.25f	65.00e	77.50cd	10.50ef	32.00de	60.50ef
T_9 (Deshi neem + Golla beth)	20.25c	71.00c	84.00bc	11.00de	40.50b	67.00bcd
T_{10} (Eucalyptus + Bhudum beth)	16.00g	52.00g	75.50cd	10.00fg	30.25ef	57.25f
T_{11} (Eucalyptus+ Udum beth)	16.25g	49.00h	77.00cd	10.50ef	32.75cde	60.00ef
T_{12} (Eucalyptus + Jali beth)	14.00h	46.00i	70.75d	9.50g	27.80f	48.00g
T_{13} (Eucalyptus + Golla beth)	18.00e	49.00h	82.00bc	11.00de	34.50cd	60.50ef
LSD at 0.05%	2.3209	5.3790	8.401	0.8745	2.610	5.173

4.2 Production of primary and secondary branches and number of fruit of eggplant in the multistoried agroforestry system

4.2.1 Number of Primary branch

Significantly the highest number of primary branches (3) was found in T_1 (Open field), which was statistically similar to other treatments except T_{12} (Eucalyptus + Jali beth). Significantly T_{12} (Eucalyptus + Jali beth) produced the lowest number of primary branches (2). [Table 4.2]

The lower number of branches under shaded condition might be due to higher amount of auxin production, which ultimately suppressed the growth and lateral branches. (Miah *et.al*, 1999).

4.2.2 Number of Secondary branch

The highest number of secondary branches was found in T_1 (Open field) which followed by T_5 (Mehogony + Golla beth). The number of secondary branches obtained in T_1 (18) was statistically similar to T_5 (17.35). Significantly, the lowest number of secondary branches (10.33) was found in T_{12} (Eucalyptus + Jali beth). [Table 4.2]

4.2.3Fruit number

Number of fruits per plant was also influenced by the over storey cane and MPT_S. Significantly, the highest number of fruit per plant (12.50) was recorded in T_1 (Open field) and the lowest number of fruit per plant (8) was observed in T_{12} (Eucalyptus + Jali beth), which was statistically similar to T_{10} (8.5), T_{11} (8.10) and T_{12} (8.60). [Table 4.2]

Lower number of fruits per plant under relatively more and prolonged shaded conditions was probably due to poor photosynthetic capacity of plants. The decreasing photosynthetic capacity of shaded plants was attributed due to both stomata and mesophyll cell properties (Wolff, 1990).

Table-4.2 Production of primary and secondary branches and number of fruit of eggplant in different multistoried agroforestry systems

Treatment	Primary branch /plant(number)	Secondary branch /plant (number)	Fruit/plant (number)
T_1 (Open field)	3.000a	18.00a	12.50a
T_2 (Mehogoni + Bhudum beth)	2.700ab	16.33b	10.50b
T_3 (Mehogoni + Udum beth)	2.667ab	15.00c	10.25bc
T_4 (Mehogoni + Jali beth)	2.567ab	14.60c	9.750bcd
T_5 (Mehogoni + Golla beth)	2.867ab	17.35a	10.50b
T_6 (Deshi neem + Bhudum beth)	2.467ab	14.33cd	9.600bcd
T_7 (Deshi neem + Udum beth)	2.400ab	13.50de	9.500cde
T_8 (Deshi neem + Jali beth)	2.367ab	13.00de	9.000def
T_9 (Deshi neem + Golla beth)	2.533ab	14.50c	9.500cde
T_{10} (Eucalyptus + Bhudum beth)	2.333ab	11.25f	8.500fg
T_{11} (Eucalyptus+ Udum beth)	2.300ab	11.50f	8.100fg
T_{12} (Eucalyptus + Jali beth)	2.000b	10.33g	8.000g
T_{13} (Eucalyptus + Golla beth)	2.500ab	12.66e	8.600efg
LSD at 0.05%	0.8401	0.8401	0.8401

4.3 Fruit yield performance of eggplant in different multistoried agroforestry system

4.3.1 Fruit length

Significantly, the longest fruit (28.25cm) was found in T_1 (Open field) which followed by T_3 (Mehogony + Udum beth) and T_2 (Mehogony + Bhudum beth). Fruit length of T_3 (27cm) while T_2 (26.5cm) was statistically identical to T_1 (Open field). Significantly the shortest fruit length (21 cm) was observed in T_{12} (Eucalyptus + Jali beth), which was statistically similar to T_{10}, T_{11} and T_{13}. The length of different fruits was recorded in T_{10}, T_{11} and T_{13} were 21.50, 21.50 and 22 cm, respectively. [Table-4.3]

4.3.2 Fruit girth

Significantly, the highest fruit girth was found 13.50 cm in T_1 (open field). Significantly, the lowest fruit girth was found 8.5 cm in T_{12} (Eucalyptus + Jali beth) which were statistically similar to T_{10}, T_{11} and T_{13}. [Table-4.3]

4.3.3 Fruit weight

Significantly, the highest fruit weight per fruit (92.25g) was found in T_1 (Open field). The fruit weights of T_2 (85.50), T_3 (85), T_4 (83), T_5 (86.50), T_6 (82.70), T_7 (82.90), T_8 (80.10) and T_9 (83g) were statistically identical to T_1. Significantly the lowest fruit weight 77.17g was observed in T_{12} (Eucalyptus + Jali beth), which was statistically similar to T_{10}, T_{11} and T_{13}. The value of different fruit weights were 78, 77.50 and 78.52g, respectively. [Table-4.3]

4.3.4 Fruit yield (Kg/ha)

Fruit yield of eggplant significantly varied under different (Kg/ha) treatment combinations. Significantly the highest yield (1.153 kg/plant) was found in T_1 (Open field) that was followed by (0.910 kg/plant) in T_5 (Mehogony + Golla beth). The lowest yield (0.616 kg/ plant) was found in T_{12} (Eucalyptus + Jali beth) that were followed by (0.627 kg/ plant) in T_{11} (Eucalyptus + Udum beth). [Table-4.3]

Table–4.3 Fruit yield performance of eggplant in the multistoried agroforestry system

Treatment	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g/fruit)	Yield (kg/ plant)
T_1 (Open field)	28.25a	10.50a	92.25a	1.153a
T_2 (Mehogoni + Bhudum beth)	26.50ab	9.250bc	85.50ab	0.897b
T_3 (Mehogoni + Udum beth)	27.00ab	9.000bc	85.00ab	0.858c
T_4 (Mehogoni + Jali beth)	26.00bc	8.900bc	83.00ab	0.809d
T_5 (Mehogoni + Golla beth)	27.50ab	9.500b	86.50ab	0.910b
T_6 (Deshi neem + Bhudum beth)	25.60bc	9.250bc	2.70ab	0.793d
T_7 (Deshi neem + Udum beth)	28.00bc	9.500b	82.90ab	0.785e
T_8 (Deshi neem + Jali beth)	24.50c	8.800bc	80.10ab	0.7209f
T_9 (Deshi neem + Golla beth)	25.25bc	9.500b	83.00ab	0.788d
T_{10} (Eucalyptus + Bhudum beth)	21.50d	9.000bc	78.00b	0.663g
T_{11} (Eucalyptus+ Udum beth)	21.50d	8.800bc	77.50b	0.627h
T_{12} (Eucalyptus + Jali beth)	21.00d	8.500c	77.17b	0.616i
T_{13} (Eucalyptus + Golla beth)	22.00d	9.200bc	78.52b	0.675g
LSD at 0.05%	1.680	0.8401	8.410	0.03241

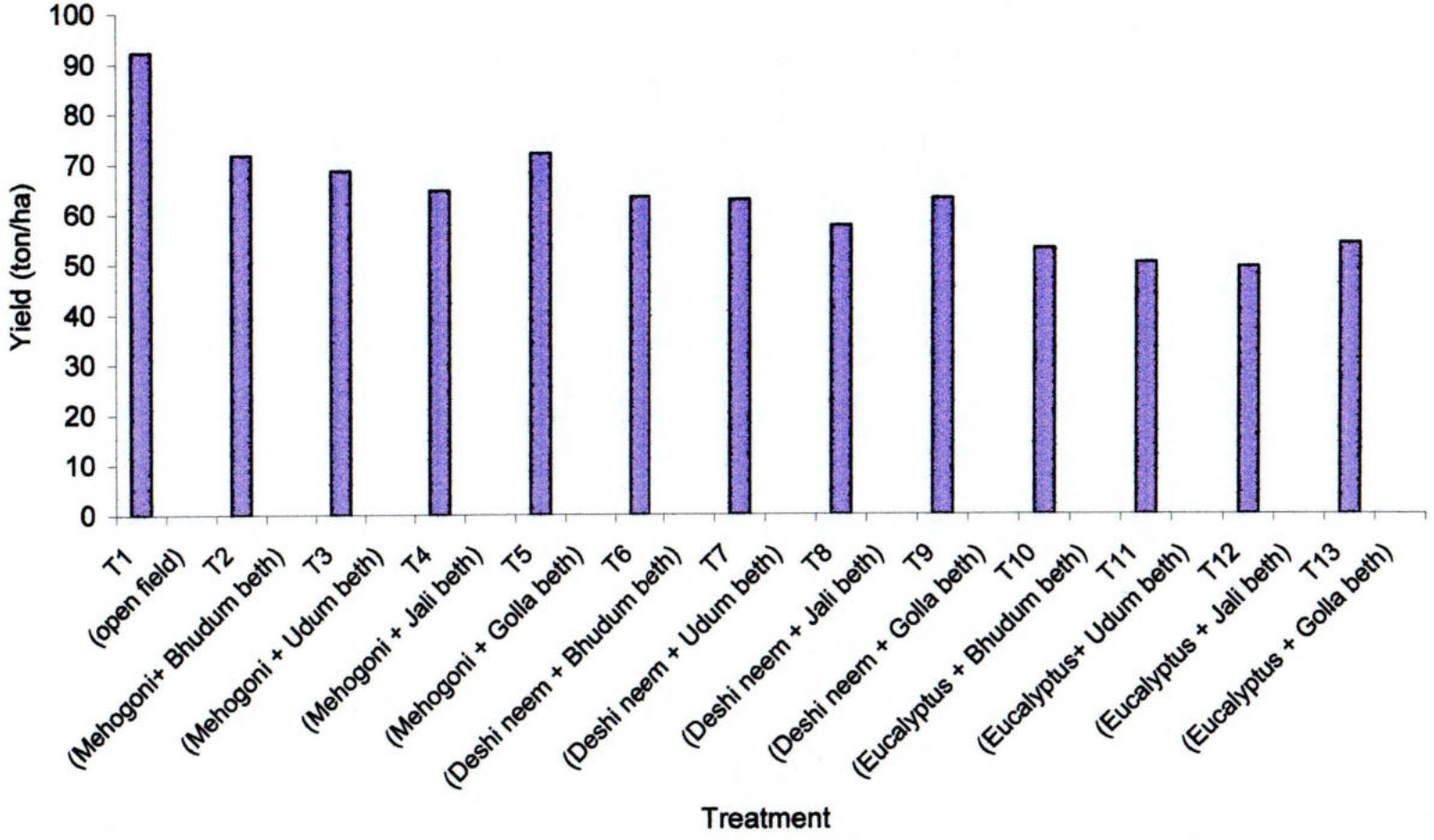

Fig.1 Fruit yield of Egg plant in multistoried agroforestry system

Fig.2 Prepared field for plantation of eggplant in multistoried agroforestry system

Fig.3 Plantation of eggplant in multistoried agroforestry system

Fig. 4 Best performance of eggplant in the open field

Fig. 5 Better performance of eggplant with cane and mehogoni

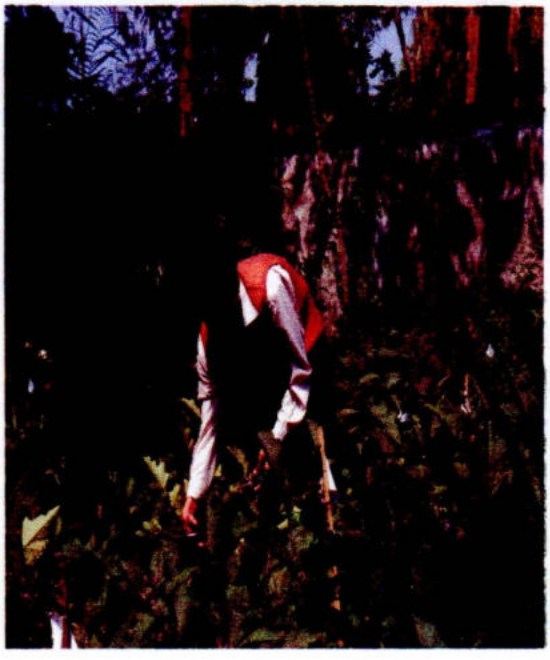

Fig. 6 Good performance of eggplant with cane and deshi neem

Fig. 7 Poorest performance of eggplant with cane and eucalyptus

Table – 4.4 Growth performance of cane species in different MAPs

Cane species	Plant height (cm)			Leaf/plant (number)			Pinne/leaf(number)		
	6	12	18	6	12	18	6	12	18
C_1 (Bhudm beth)	58.33b	129.1b	167.1b	5.333b	11.83b	15.25b	19.50a	89.33a	117.7a
C_2 (Udum beth)	56.50b	125.6b	161.4b	5.583b	11.00b	15.58b	13.17b	80.42b	109.5b
C_3 (Jali beth)	62.17a	153.4a	203.3a	18.08a	36.33a	56.17a	13.67b	58.83c	80.50c
C_4 (Golla beth)	37.25c	83.50c	114.1c	4.000c	7.767c	10.50c	7.167c	32.58b	48.08d
LSD at 0.05%	3.616	7.848	11.94	1.144	1.929	3.060	1.628	5.151	6.111

* MAP =Months After Planting

4.4 Growth Performance of cane species in tree based multistoried agroforestry system

4.4.1Plant height

Significantly, the highest plant height was found in C_3 (Jali beth). The plant heights at 6, 12 and 18 MAPs were recorded as 32.17 cm, 153.4 cm & 203.3 cm, respectively.

Significantly, the lowest plant height were recorded as 37.25, 83.50 and 114.1 cm at 6, 12 and 18 MAPs respectively in C_4 (Golla beth). C_1 and C_2 showed statistically similar performance in case of plant height irrespective of sampling dates. [Table 4.4]

4.4.2 Leaf/plant (number)

Number of leaves/plant was also influenced by the upper storey MPT_S. Significantly the highest numbers of leaves/ plant at 6, 12 and 18 MAPs were observed 18.08, 36.33 and 56.17, respectively in C_3 (Jali beth). Jali beth showed tremendous performances than other species due to their natural growth behaviour.

Significantly, the lowest number of leaves/ plant was observed 4.000, 7.767 and 10.50 respectively at 6 MAP, 12 and 18 MAPs in C_4 (Golla beth). [Table 4.4]

4.4.3 Pinne/leaf (number)

Significantly, the highest pinne/leaf (number) at 6, 12 and 18 MAPs were 19.50, 89.33 & 117.7, respectively in C_1 (Bhudum beth).

Though jail beth showed highest pinne/leaf (number) but Bhudum beth performed highest pinne/leaf (number) than other cane species due to their genetic growth behaviour or some else.

Significantly, the lowest pinne/leaf (number) was observed 167, 32.58 and 48.08 at 6, 12 and 18 MAPs respectively in C_4 (Golla beth). [Table-4.4]

Table–4.4(Continued): Growth performances of four cane species in different period

Cane species	Secondary stem /plant (number)			Pinne length/leaf (cm)		
	6 *MAP	12 MAP	18 MAP	6 MAP	12 MAP	18 MAP
C_1 (Bhudum beth)	00	2.917b	4.833b	56.17a	94.08a	114.5a
C_2 (Udum beth)	00	2.750b	3.833b	55.42a	87.00ab	104.1b
C_3 (Jali beth)	00	6.333a	10.92a	50.42a	83.08b	107.2ab
C_4 (Golla beth)	00	1.417b	3.333b	40.33b	70.67c	94.50c
LSD at 0.05%	**NS	0.7370	1.030	6.087	8.919	7.953

* MAP = Months After Planting

** NS = Null Significant

4.4.4 Secondary stem /plant (number)

The secondary stem /plant (number) at 6 MAP was 00 in all treatments. At 12 and 18 MAP the highest secondary stem /plant (number) was observed as 6.333 and 10.62 respectively in C_3 (Jali beth).

The lowest secondary stem /plant (number) was statistically similar to S_1, S_2 and S_4 both 12 and 18 MAPs. The lowest secondary stem /plant (number) were (2.916, 4.833); (2.750, 3.833) and (1.417, 3.333) respectively in C_1, C_2 and C_4. [Table – 4.4]

4.4.5 Pinne length/leaf

The longest pinne length/leaf at 6 MAP was observed 56.17 cm in C_1 (Bhubum beth) which were statistically similar 55.42 and 50.42 cm respectively to C_2 (Ubum beth) and S_3 (Jali beth). At 12 MAP, the longest pinne length/leaf was observed 94.08 cm in C_1 (Bhubum beth) which was (87 cm) statistically similar to C_2 (Ubum beth). The longest pinne length/leaf at 18 MAP was observed 114.5 cm in S_1 (Bhubum beth)

At 6 MAP, Significantly the shortest pinne length/leaf was found 40.33 cm in C_4 (Golla beth). But both at 12 and 18 MAPs significantly, the shortest pinne length/leaf were found respectively 70.67 and 94.50 cm in C_4 (Golla beth) [Table – 4.4].

Bhudum beth (*Calamus latifolius)*

Udum beth (*Calamus longisetus*)

Jali beth (*Calamus guruba*)

Golla beth (*Daemonorops jenkinsianus*)

Fig 8.Figure showing four different cane species

Table – 4.5 Effect of different trees on the plant height, number of leaf, leaflet number of different cane species

Treatment	Plant height (cm)			Leaf/plant (number)			Pinne /leaf (number)		
	6 *MAP	12 MAP	18 MAP	6 MAP	12 MAP	18 MAP	6 MAP	12 MAP	18 MAP
T_1 Mehogoni	63.50a	151.7a	192.9a	9.500a	19.75a	27.58a	13.58b	73.92a	99.42a
T_2 Deshi neem	58.75b	145.2a	182.9ab	9.417a	20.42a	29.50a	17.33a	73.50a	94.42a
T_3 Eucalytus	55.42b	135.0b	175.7b	8.250b	15.25b	22.33b	13.92b	63.58b	85.00b
T_4 Open field (Control)	36.58c	59.75c	94.33c	5.833c	11.42c	18.08c	8.667c	50.17c	76.92c
LSD at 0.05%	3.616	7.848	11.94	1.144	1.929	3.060	1.628	5.151	6.111

* MAP = Months after planting

4.5 Effect of different trees on the plant height, number of leaves, leaflet number of different cane species

4.5.1 Plant height

Effect of trees on plant heights at 6, 12 and 18 MAPs of different cane species was significant. At 6 MAP, the highest plant height was obtained 63.50 cm in T_1 (Mehogony). At 12 MAP the highest value was observed 151.7 scm in T1 (Mehogony) which was statistically similar 145.2 cm in T_2 (Deshi neem). At 18 MAP, the highest plant height was found 192.9 cm T_1 (Mehogony) that was followed by 182.9 cm T_2 (Deshi neem).

Significantly, the lowest plant height were found in 6, 12 and 18 MAPs respectively 36.58 , 59.57 and 94.33cm in T_4 (Open field). [Table – 4.5]

4.5.2 Leaf/plant (number)

Effect of trees on number of leaves/plant of different cane species varied significantly. At 6 MAP, the highest number of leaves/plant (9.5) was found in T_1 (Mehogony) that was followed (9.417) in T_2 (Deshi neem). At 12 MAP, it was observed 20.42 in T_2 (Deshi neem) which was statistically similar to (19.75) in T_1 (Mehogony). At 18 MAP, the highest number of leaves/plant was found 29.50 in T_2 (Deshi neem) which was statistically similar to (27.58) in T_1 (Mehogony).

Significantly, the lowest number of leaves/plant at 6, 12 and 18 MAPs were found respectively 5.833, 11.42 and 18.08 in T_4 (Open field). [Table –4.5]

4.5.3 Pinne /leaf (number)

Effect of trees on pinne /leaf (number) of different cane species at 6, 12 and 18 MAPs were highly significant. The highest leaflet number/leaf at 6 MAP was observed 17.33 in T_2 (Deshi neem). At 12 MAP, the highest pinne /leaf (number) was observed 73.92 which was statistically similar (73.50) in T_2 (Deshi neem). Again at 18 MAP the highest pinne /leaf (number) was observed 99.42 which was statistically similar 94.42 in T_2 (Deshi neem).

Significantly, the lowest pinne /leaf (number) at 6, 12 and 18 MAPs were respectively 8.667, 50.17 and 76.92 in T_4 (Open field). [Table – 4.5]

Table – 4.6: Effect of different trees on secondary stem number and leaf length of different cane species

Tree species	Secondary stem /plant (number)			Pinne length/leaf (cm)		
	6 *MAP	12 MAP	18 MAP	6 MAP	12 MAP	18 MAP
T_1 Mehogoni	00	4.750b	8.000a	50.75 b	88.50a	109.8a
T_2 Deshi neem	00	5.250a	7.667a	60.83 a	82.83ab	104.2a
T_3 Eucalytus	00	4.083b	7.083a	52.50 b	88.08a	110.5a
T_4 Open field (Control)	00	3.333c	5.167b	34.25 c	75.42b	95.75b
LSD at 0.05%	**NS	0.7370	1.030	6.087	8.919	7.953

* MAP = Months After Planting

** NS = Null Significant

4.6 Effect of different trees on secondary stem number and leaf length of different cane species

4.6.1 Secondary stem /plant (number)

The secondary stem number/plant at 6 MAP was 00 in all treatments. The highest secondary stem number/plant at 12 MAP was 5.250. At 18 MAP, the highest secondary stem number/plant was observed (8) in T_1 (Mehogony) that was statistically similar to 7.667 in T_2 (Deshi neem) & 7.083 in T_3 (Eucalyptus).

Significantly, the lowest secondary stem number/plant at 12 and 18 MAPs was observed respectively 3.333, 5.167 in T_4 (Open field). [Table – 4.6]

4.6.2 Leaf length

Effect of trees on leaf length of different cane species was significant. At 6 MAP, the highest leaf length/leaf was 60.83 cm in T_2 (Deshi neem). At 12 MAP, significantly it was observed 88.50cm in T_1 (Mehogony) that was statistically similar (88.08) and (82.83cm) respectively in T_2 (Deshi neem) and T_3 (Eucalyptus). At 18 MAP significantly the highest value was observed 110.5 cm in T_3 (Eucalyptus) which was statistically similar to 109.8 cm in T_1 (Mehogony) and 104.2 cm in T_2 (Deshi neem).

Significantly, the lowest leaf lengths at 6, 12 and 18 MAPs were respectively 34.25, 75.42 and 95.75cm in T_4 (Open field). [Table 4.6]

Table-4.7 Interaction effect of cane species and trees in multistoried agroforestry system.

Interaction	Plant height (cm)			Leaf/plant (number)			Pinne /leaf (number)		
	6 MAP	12 MAP	18 MAP	6 MAP	12 MAP	18 MAP	6 MAP	12 MAP	18 MAP
$C_1 T_1$ (Mehogoni+ Bhudumbeth)	78.00a	173.3a	234.3a	21.33a	45.00a	68.00a	28.00a	106.0a	137.3a
$C_2 T_1$ (Mehgony + Udum beth)	78.00a	171.3a	233.3a	20.33b	43.67a	64.00b	20.67b	103.3a	125.7b
$C_3 T_1$ (Mehgony + Jali beth)	78.33a	183.7a	238.3a	18.00c	32.00b	50.00c	20.67b	93.33b	122.7bc
$C_4 T_1$ (Mehgony + Golla beth)	51.67d	84.7f	125.0d	12.67d	24.67c	42.67d	19.00c	92.00b	120.7c
$C_1 T_2$ (Deshi Neem + Bhudumbeth)	66.00c	145.3c	186.0b	7.000e	15.33d	21.33e	15.33d	84.00c	106.0d
$C_2 T_2$ (Deshi Neem + Udum beth)	62.67c	143.3c	183.7b	6.333ef	15.00d	19.33ef	15.00de	75.67d	102.7d
$C_3 T_2$ (Deshi Neem + Jali beth)	70.00b	163.3b	200.3b	6.000f	13.33e	18.33fg	14.00ef	65.33e	101.7d
$C_4 T_2$ (Deshi Neem + Golla beth)	41.33e	73.3f	113.3e	6.000f	12.00ef	16.33g	13.67f	64.67e	92.00e
$C_1 T_3$ (Eucalyptus + Bhudum beth)	60.00c	98.3e	130.7d	6.000f	11.00f	14.00h	12.00g	64.00ef	92.00e
$C_2 T_3$ (Eucalyptus + Udum beth)	60.00c	96.67e	128.3d	5.000g	11.00f	14.00h	10.67h	62.67ef	84.00f
$C_3 T_3$ (Eucalyptus + Jali beth)	63.67c	128.37d	167.3c	4.667gh	8.667g	11.67i	8.667i	60.67f	82.00f
$C_4 T_3$ (Eucalyptus + Golla beth)	29.00f	89.33e	128.3d	4.000hi	8.000gh	11.33i	7.667ij	42.67g	64.00g
$C_1 T_4$ Open field + Bhudumbeth	25.67g	60.33h	103.0f	4.000hi	7.667gh	11.33i	7.667ij	34.00h	50.00h
$C_2 T_4$ Open field + Udum beth	25.33g	62.00h	94.3g	4.000hi	7.333gh	9.667ij	7.333j	33.33h	49.33h
$C_3 T_4$ Open field + Jali beth	25.00g	75.33g	108.67f	3.333i	7.000hi	9.333ij	7.000j	32.00h	47.33h
$C_4 T_4$ (Open field + Gollabeth)	21.33h	51.33j	71.33h	3.333i	5.667i	8.667j	6.667j	33.00h	45.67h
LSD at 0.05%	3.571	5.578	8.484	0.8133	1.371	2.175	1.157	3.661	4.344

4.7 Interaction effect of cane species and trees in multistoried agroforesry system.

4.7.1 Plant height

From the interaction effect, significantly the highest plant heights at 6, 12 and 18 MAPs were observed 78.33, 183.3 and 238.3 cm respectively in C_3T_1 (Jali beth + Mehogony). At 6 MAP, the value was statistically similar (78cm) both in C_1T_1 and C_2T_1. At 12 MAP, the value was also statistically similar (173.3 cm) and (171.3cm) respectively in C_1T_1 and C_2T_1. At 18 MAP, the value was also statistically similar (234.3 cm) and (233.3.3cm) respectively in C_1T_1 and C_2T_1.

Significantly, the lowest plant heights at 6, 12 and 18 MAPs respectively 21.33, 51.33 and 71.33cm in CS_4T_4 (Open field + Golla beth). [Table – 4.7]

4.7.2 Leaf/plant (number)

From the interaction effect, significantly the highest leaf/plant (number)at 6, 12 and 18 MAP were found 21.33, 45.00 and 68.00 respectively in C_3T_1 (Jali beth + Mehogony).

Significantly, the lowest leaf/plant (number)at 6,12 and 18 MAPs were found respectively 3.333, 5.667 & 8.667 in C_4T_4 (Open field + Golla beth).[Table – 4.7]

4.7.3 Pinne /leaf (number)

From the interaction effect, significantly the highest pinne/leaf (number) at 6 MAP was found 28 in C_1T_1 (Bhudum beth + Mehogony). At 12 MAP, significantly the highest pinne /leaf (number) was observed 106.0 and 103.3 respectively in C_1T_1 (Bhudum beth + Mehogony) and C_2T_1 (Udum beth + Mehogony). At 18 MAP, the highest pinne /leaf (number)was also observed 137.3 in C_1T_1 (Bhudum beth + Mehogony).

Significantly, the lowest pinne /leaf (number)was observed 6.667, 33.00 and 45.67 respectively in C_4T_4 (Golla beth + Mehogony) at 6, 12 and 18 MAPs.[Table – 4.7].

4.7.4 Secondary stem /plant (number)

The secondary stem number/plant at 6 MAP was 00 in all treatments. The highest secondary stem number/plant at 12 and 18 MAPs was observed (8.333) and (13.67) in C_3T_1 (Jali beth + Mehogony). The lowest secondary stem number/plant was observed (3) respectively in C_4T_4 (Golla beth + Mehogony) which was statistically similar to C_3T_4 and C_2T_4 at 12 MAP. At 18 MAP, the lowest secondary stem number/plant was observed (4.667) in C_2T_4 (Golla beth + Mehogony) [Table – 4.7]

4.7.5 Leaf length

From the interaction effect, significantly the highest leaf lengths at 6, 12 and 18 MAPs were observed (56.67), (104.3) and (122.3) cm, respectively in C_1T_1 (Bhudumbeth + Mehogony). At 6 MAP, the value was statistically similar (55cm) and (50.67cm) respectively in C_2T_1 and

C_3T_1. At 12 MAP, the value was statistically similar (104.4) and (100.0 cm) respectively in C_2T_1 and C_3T_1.

Significantly, the shortest leaf lengths at 6, 12 and 18 MAP were 18.67 , 58.33 and 75.7 cm, respectively in C_4T_4 (Golla beth + Open field). [Table – 4.7]

Table – 4.7(continued): Interaction effect of trees & cane species in multistoried agroforestry system

Interaction	Secondary Stem Number/plant			Leaf length/leaf (cm)		
	6 MAP	12 MAP	18 MAP	6 MAP	12 MAP	18 MAP
$C_1 T_1$ (Mehogoni+ Bhudumbeth)	00	4.000ef	6.333cd	56.67a	104.43a	122.3a
$C_2 T_1$ (Mehgony + Udum beth)	00	3.000h	6.667c	55.00a	104.4a	115.0b
$C_3 T_1$ (Mehgony + Jali beth)	00	8.333a	13.67a	50.67a	100.00a	103.67c
$C_4 T_1$ (Mehgony + Golla beth)	00	3.667fg	5.333efg	26.67d	75.00d	98.3d
$C_1 T_2$ (Deshi Neem +Bhudumbeth)	00	4.333e	5.667def	54.67a	92.67b	114.7b
$C_2 T_2$ (Deshi Neem + Udum beth)	00	5.667d	6.667c	50.00a	89.00b	104.7c
$S_3 T_2$ (Deshi Neem + Jali beth)	00	7.333b	12.67b	44.33b	87.33c	102.0c
$C_4 T_2$ (Deshi Neem + Golla beth)	00	3.667fg	5.667def	24.33d	72.33d	95.33d
$C_1 T_3$ (Eucalyptus + Bhudum beth)	00	3.333gh	5.333efg	50.67a	93.33b	110.0b
$C_2 T_3$ Eucalyptus + Udum beth)	00	3.000h	5.333efg	44.33b	87.00c	106.7b
$C_3 T_3$ (Eucalyptus + Jali beth)	00	6.667c	12.33b	40.33b	85.33c	102.0c
$C_4 T_3$ (Eucalyptus + Golla beth)	00	3.333gh	5.333efg	23.67d	76.67d	83.3e
$C_1 T_4$ (Open field + Bhudumbeth	00	4.000ef	6.000cde	34.67c	90.00c	111.0b
$C_2 T_4$ (Open field + Udum beth)	00	3.333gh	4.667g	30.33c	87.33c	90.00d
$C_3 T_4$ (Open field + Jali beth)	00	3.000h	5.000fg	28.33d	76.00d	95.33d
$C_4 T_4$ (Open field + Gollabeth)	00	3.000h	5.000fg	18.67e	58.33e	75.7f
LSD at 0.05%	NS	0.1637	0.7321	4.483	8.312	11.653

CHAPTER 5

CONCLUSION AND RECOMMENDATION

The result of the present study revealed that the performances of different cane species testedsignificantly different in the multistoried agroforestry systems. Among the four cane specie, the Jali beth performed in the best way and the least growth performance was found with the Golla beth. The degrees of their growth suitabilities were rank in the Jali beth > Bhudum beth > Udum beth > Golla beth.

Oppositely,ranks of the synergistic effect of trees on the growth performance of cane species were Mehogony > Deshi neem > Eucalyptus > Open field

From the interaction point of view, Jali beth + Mehogony was found as the best combination followed by Jali beth + Deshi neem combination and Bhudum bet + Mehogony combination. Significantly the lowest potentiality was found in open field for all the cane species.

Performance of eggplant in association of trees and cane species varied significantly. Morphological behaviour i.e. growth of eggplant was highest in the open field followed by Mehogony + Golla beth, Mehogony + Udum beth and Mehogony + Bhudum beth combination but the poor performance was experienced in the combination of Eucalyptus + Jali beth. On the contrary, yield of eggplant was highest in the open field followed by Mehogony + Golla beth combination and Mehogony + Udum beth. The lowest fruit yield of eggplant was found i the Eucalyptus + Jali beth combination.

Production of eggplant is an innovation in cane based multistoried agroforestry system. Nevertheless, the result of the present study was achieved based on the trial of eggplant and specific cane species, which was of early aged hence, may not be sufficient to asses the sustainability of the results obtained for further (2 year) production of eggplant in such a multistoried agroforestry practice. Similar experiment can be followed by summer tomato, lady's finger etc. as the lower storey crop in the cane based multistoried agroforestry system till there was the heaviest shade and bushy area occupied by cane and trees.

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APPENDICES

Appendix 1. Distribution of monthly temperature, relative humidity and rainfall of the experimental site during April 2006 to April 2007.

Month	** Air Temperature (°C)			**Relative Humidity (%)	*Rainfall (mm)	*Sunshine (hrs.)
	Maximum	Minimum	Average			
April/06	32.8	21.1	26.95	83	54	212.4
May/06	32.9	22.7	27.8	94.0	425.0	220.1
June/06	33.6	24.3	28.95	87.5	276.0	93.0
July/06	33.5	26.6	30.05	86.0	238.0	158.1
August/06	33.4	26.3	29.85	86.1	76.0	189.1
September/06	32.2	24.0	28.1	90.9	317.0	129
October/06	32.4	22.3	27.35	92.4	24.0	257.3
November/06	28.4	16.1	22.25	91.1	8.0	183.0
December/06	25.2	11.73	18.46	88.1	15.0	201.5
January/07	22.8	8.6	15.7	90.5	9.0	142.6
February/07	25.0	13.1	19.05	89.0	53.0	148.4
March/07	29.8	15.0	22.4	87.0	1.0	269.7
April/07	31.06	20.90	25.98	89.76	52.0	215.0

* Monthly Total

** Monthly average

Source: Wheat Research Centre (WRC), Nashipur, Dinajpur.

Appendix 2. Fruit yield performance of egg plant in multistoried agroforestry system

Treatment	Yield (ton/hectare)
T_1 (open field)	92.24 a
T_2 (Mehogoni+ Bhudum beth)	71.76 b
T_3 (Mehogoni + Udum beth)	68.64c
T_4 (Mehogoni + Jali beth)	64.72d
T_5 (Mehogoni + Golla beth)	72.08b
T_6 (Deshi neem + Bhudum beth)	63.44d
T_7 (Deshi neem + Udum beth)	62.80e
T_8 (Deshi neem + Jali beth)	57.60f
T_9 (Deshi neem + Golla beth)	63.04d
T_{10} (Eucalyptus + Bhudum beth)	53.04g
T_{11} (Eucalyptus+ Udum beth)	50.16h
T_{12} (Eucalyptus + Jali beth)	49.28i
T_{13} (Eucalyptus + Golla beth)	54.00g
LSD 0.05%	37.04