PERFORMANCE OF OKRA, CANE AND *MULTIPURPOSE* TREE SPECIES IN MULTISTORIED AGROFORESTRY SYSTEM

A THESIS

BY

MD. SHAHAJAHAN ALI
Student No. 0705012
Session: 2007-08
Thesis Semester: January-June, 2008

MASTER OF SCIENCE (M.S.)
IN
AGROFORESTRY

DEPARTMENT OF AGROFORESTRY
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY
DINAJPUR

June 2008

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

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June 2008

DEDICATED

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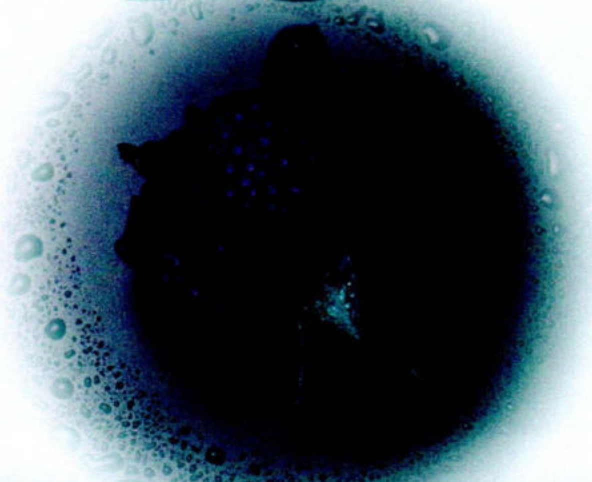

PROPHET HAZRAT MUHAMMAD

(SALLALLAHU-ALAIHE-WASALLAM)

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The Author

ABSTRACT

A field experiment was conducted at the Agroforestry Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during 20 April to 20 July 2007 to evaluate the performance of Okra plant and four cane species under different multipurpose trees as the lower and the middle 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 okra was used as the lower storey crop. This experiment was laid out in the single factor Randomized Complete Block Design (RCBD) with three replications for okra and two factorial Randomized Complete Block Design (RCBD) with three replications for cane species. The aim of the experiments was to study the growth performance and selection of potential tree and cane species and also to assess the morphological behaviors and fruit yield of okra in the said multistoried agroforestry system. Considering cane species, jali beth was the best performer compared to other cane species. Udum beth + Deshi Neem was found as the best combination Significantly the lowest peformance was found in open field irrespective of 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. Considering the lower storied crop (okra), highest vegetative growth was under mehogony with Jali beth combination followed by mehogony with Golla beth combination. In case of yield, 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

CHAPTER 1

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench.) is an important vegetable crop of family Malvaceae, which is originated in Africa or Asia; has been growing in Bangladesh. The bulk of its production is obtained during the winter season predominantly in the summer season. Although as vegetables it is very much popular in Bangladesh, the yield per hectare of the crop is not satisfactory. Okra ranks fourth position among the vegetables in summer season respectively, in terms of both acreage and production.

Okra is grown year round in Bangladesh. However, due to some environmental limitations only a few varieties are grown during the rainy 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 gm per capita per day including potato and sweet potato. Except tuber crops, it is only 30 gm against the FAO recommendation of 200 gm. To supply the minimum daily requirement of 200 gm, the national production of vegetables should be over 10 million tons. In addition, population in Bangladesh is increasing rapidly; therefore, demand for vegetables is also increasing simultaneously. The production of okra in Bangladesh is 39,000 MT from 9311.74 hectares of land in summer with an average yield of 4.19 MT per hectare (BBS, 2007) which is very low compared to other developed countries where the yields are as high as 7 to 12 tons per hectare (Thompson and Kelly, 1959). The yield of Okra is greatly influenced by sowing density. The plant spacing for okra generally ranges between 15 to

75 cm in the row spaced 60 to 150 cm apart (Ahmed, 1976; Rashid, 1976). High yield of Okra have been reported by sowing in closer spacing (Gonzales and Dej, 1976; Wing and Rajkomar, 1982; Gupta and Srinivas, 1981).

Unfortunately, the areas of vegetable production are decreasing due to increasing the housing and other facilities for the over increasing population as well as increasing the area of staple food. Under these situations, new techniques must be developed to bridge the wide gap between the supply and the demand for vegetables.

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 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.

Multipurpose trees can be used for more than one purpose. It provides food, fodder, fuel wood, timber, minor tree products and shelter material to subsistence farmer. But all plants may not be referred as multipurpose species. If the tree is grown in the farm land to get intended products (food, fodder, fuel wood, and shelter material) would be placed in multipurpose category.

The prefix "multipurpose" appears to be used most commonly when a species is deliberately grown at one site which is capable to produce more than one product or benefit. These include, timber, fuel wood, medicines, tooth picks, human food and animal fodder (including flower for bees and leaves for silkworm), and service attributes such as shade, shelter, soil conservation and improved soil fertility.

Traditionally farmers grow different types of vegetables in association with trees in homesteads, where productivity of vegetables is low due to lack of appropriate combination and management as well. Therefore, understorey - associated crops should be selected with upperstorey trees accordingly.

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

1. To assess the morphological behavior and yield of okra as the lower storey crop;
2. To find out the growth performance of four cane species as the middle storey non-timber species;
3. To evaluate the growth performance of Mehogoni, Deshi neem and Eucalyptus as the upper storey and
4. To determine the superior combination of okra-cane-tree species.

CHAPTER 2
REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

The research has been carried out to observe the performance of okra under different multipurpose tree species in the different shading conditions. Literatures directly related to this aspect are meager. Therefore, literatures some way linking to the subject of interest from home and abroad are reviewed and outlined below under the following sections.

2.1 Development and concepts of multistoried cropping in agroforestry system

Development of Agroforestry

Agroforestry had been practiced earlier in temperate and sub-tropical countries, e.g., apple orchards with pastures and sheep or timber trees and nuts among cereals in Europe and North America, crops under fruit trees and olives in the Mediterranean, etc. However, the revival of interest in this subject in high- income countries of this region was delayed until prompted by economic circumstances of over supply of agricultural produce, a situation that has forced governments and farmers to think of alternate ways of imposing limits by setting aside land from agricultural production. Thus, the idea of reintroducing trees and tree crops in such circumstances has only recently re-emerged (Gordon and Newman, 1997) and is still not fully accommodated within agricultural incentive schemes (sub sides).

Agroforestry is the idea of combining forestry and agriculture on the same piece of land. The basic concept of intercropping has been extended to agroforestry system. Many authors have defined agroforestry in different ways. A widely used definition given by the International Council for Research in Agroforestry (ICRAF) in different times is that agroforestry is a collective name for all land use systems and technologies where, woody perennials are deliberately grown on the same land management unit as agriculture crops and/or animals either it some form of spatial arrangement or temporal sequence (Nair, 1983).

Agroforestry is the deliberate inter or sequential cropping of woody and non woody plant components (sometimes with animals) in order to generate multiple products and 'services'. There are both ecological and economic interactions between the plant components. Agroforestry is a dynamic, ecologically based, natural resources management system that through the integration of trees in farmland and rangeland, diversities and sustains production for increased social, economic and environmental benefits for land users at all 1evels (Huxley, 1999)

Agroforestry is an age-old practice but modern 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).

Agroforestry is practiced on cropland (Roy, 1997), forestlands etc. However, the sustainability of these practices, a major concerns in Bangladesh. Agroforestry is considered an efficient and sustainable land use option specially suited for resources poor farmers (Stocking *et al.*, 1990).

Use of crop residues and animal dung as fuel; limiting organic matter recycling in the crop field, resulting decline of soil fertility. Trees are also important for providing fruit, timber, building materials, agricultural implements, fodder and shade. They also act as wind breaks and help soil conservation. Trees have an important role in risk management mechanism of the household economy (Akter *et al.*, 1990). They provide cash during ceremonies, economic, hardships and many other occasions like marriages, school expenses of children, buying land and other assets (Abedin and Quddus, 1990).

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

Solanki (1998) observed that, agroforestry can significantly contribute in increasing demand of fuel wood, fodder and lack of cash and infrastructure in many developing countries. He also stated that agroforestry has high potential to simultaneously satisfy three important objectives: (i) protecting and stabling the ecosystems (ii) producing a high level of out-put of economic goods (fuel, fodder, small timber, organic fertilizer etc); (iii) providing stable employment, improved income and basic material to rural populations.

Homestead gardens are common in Bangladesh where the farmers take up combination of 10-15 species of fruit, ornamental and multipurpose trees, along with vegetables to meet their own or aesthetic value (Rang *et al.*, 1990). Trees are grown in the crop land, homesteads, orchards not only produce food, fruits, fodder, fuel wood or to generate cash for various purposes (Chowdhury and Satter, 1993) but also gives better living environment (Haque, 1996). Macdicken and Vergara, (1990) stated that agroforestry is 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. Agroforestry is a traditional land use system in the tropics including Bangladesh is being practiced for countries (Karim and Savill, 1991). In traditional agroforestry systems in Bangladesh, farmers consider trees as, saving and insurance against risk of crop failure or compensate low yields of crops (Akter *et al.*, 1989).

Alley cropping is one kind of agroforestry technology that is being explored as one of the land use options in the tropics. It is a land management practice in which food crops are grown in the interspaces between rows of planted woody shrubs or tree species, usually legumes, and in which the woody species are periodically pruned during the cropping season to prevent shading and to reduce competition with the companion crops and the pruning provide the addition of organic matter from the hedgerow plants to improve soil physical, biological and chemical conditions; reduction in soil erosion; and harboring of beneficial predators in the hedgerows (Lal, 1991)

Concepts of agroforestry

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 argued 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 socio-economic changes presently found in overcrowd semi urban 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 rain fed 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 ulinaris*. Crop yields under the trees averaged 93% of the corresponding yield outside the tree canopy.

Mishra and Pandey (1998) investigated the intercropping 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.

In another experiment 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 (*longa)* 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 tomato, 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 kgm^{-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 kgm^{-2} (Aidy, 1984).

In another experiment 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.

In another experiment Akter *et al.* (1990) reported that in the recent years public interests in planting trees in croplands have increased greatly at the south-western part in 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* sp. 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 progressively improved.

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 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 flowering 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.

In another experiment 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 spacing on growth and yield of okra

The plant spacing for okra cultivation recommended in different books and bulletins generally ranges between 30 to 75 in the rows spaced 60 to 150 cm apart (Thompson and Kelly, 1959; Mac Gillivray, 1961; Kamaluddin, 1966; Knott, 1966).

Optimum plant density is important and uncontroversial factor for maximizing the yield of a crop. Reports generally agree that up to a certain limit, crop yield increased with the increasing plant density (Taj *et al.*, 1968; Albregts and Howard, 1974).

Kamalanathan *et al.* (1970) working with spacing and maturing on okra cv. Pusa sawani and observed that the closest spacing of 60 cm x 20 cm produced the highest yield per hectare. However, the yield per plant was observed to be the lowest at close spacing.

In another experiment Gonzales and Dej (1976) worked with three different okra varieties namely, Perkins, Emerald and Clemson spineless. The varieties gave the highest yield at the spacing of 90 cm x 10 cm, 110 cm x 10 cm and 90 cm x 10 cm, respectively.

Absar and Siddique (1982) while studying the effect of cultivar and plant spacing on yield of okra under Mymensingh conditions observed that yield per hectare increased with decreasing plant spacing. However, they noted that close row spacing was difficult for intercultural operations and harvesting. They also observed that the decreased yield per plant at higher plant densities was compensated by the increased number of plants per unit area. With an increase in the number of plants per plot from 24 to 48 and 90 yields increased on average from 5.76 kg to 7.45 and 11.16 kg per plot, respectively.

Shrestha (1983) studied the effect of spacing on okra cv. pusa sawani and observed that spacing had no significant effect on the number of days to first harvest or pod length, but the same influenced the number of pods per plant. Although individual plant yield at each harvest was maximum at larger plant spacing (45 cm x45 cm), pod yield per hectare was maximum at closer (45 cm x 15 cm) spacing.

The effect of sowing date (20 June, 5 July, 20 July or 4 August) and spacing (45 cm x 30 cm, 45 cm x 45 cm, 60 cm x 30 cm or 60 cm x 45 cm) on the yield of okra seeds was investigated at Jabbalpur by Bizen *et al.* (1994). The best yields of fruits and seeds per plant were observed from plants sown on 20

June at a spacing of 60 cm x 45 cm. The highest yield of seed/ha was obtained from plants sown on 20 June at a spacing of 45 cm x 30 cm (1882.71 kg/ha).

The effects of spacing (single row at a spacing of 45 cm x 45 cm or 67 cm x 30 cm and paired rows 15 or 30 cm apart at a plant spacing of 67 cm x30 cm) and fruit thinning (0, 1, 2, 3 or 4 fruits picked/plant) on seed yield were investigated by Taya *et al.* (1995). Fruit thinning decreased the yield of seeds. Among thinning treatments the highest yields were obtained for the 15 cm apart paired row treatment. Maximum yield (10.79 q/ha) was observed with no fruit thinning at a paired row spacing of 15 cm.

Singh and Brar (1995) carried out a trial in Punjab, India in 1992 on the effects of different plant spacing on the incidence of *Amrasca biguttula* and *Earias sp.* on okra revealed that the highest yield (19.91 q/ha) was obtained at a spacing of 30 cm *x* 15 cm and the lowest yield (4.77 q/ha) at 60 cm x 30 cm.

The effects of 4 sowing dates (21 February or 1, 11 or 21 March) and 3 plant spacing (15 cm x 30 cm, 30 cm x 30 cm or 45 cm x 30 cm) on growth and yield of okra cv. Pusa Sawani were investigated by Raghav (1996). Results from the 1992 and 1993 seasons were pooled. Plant height was greatest with sowing on 1 March and at the closest spacing. Green pod yield was highest with sowing on 1 March (57.32 q ha^{-1}) and at the widest spacing (47.67 q ha^{-1}).

2.4 Effect of intercropping on growth and yield of okra

Chilli, cocoyam, cucumber, french bean, ginger, groundnut, okra, long bean *(Vigna sp.)*, maize and tomato were investigated as intercrops in pineapple on peat soil (Lee, 1972). All except cocoyam, french bean and maize were potentially profitable.

In another experiment Okra cv. Varsha Uphar and Palak (Spinach) cv. HS-25 were grown as the third crops in two successive years in potato/tomato/okra and potato/okra/spinach rotations, respectively, to study the residual effect of fertilizers applied to the potato crops (Taya *et al.,* 1995). The third crops in the rotation were given 0, 25, 50 or 75% of the recommended rate of nitrogen without phosphorus or potassium or the recommended rate of NPK. Application of an NPK rate 33% higher than the recommended rate to the potato crop increased fruit yield and leaf NPK content in okra. However, in spinach, improvements in yield and NPK content were recorded only during the second year while Zn applied to potato had no effect on any of these parameters. Application of 75% of the recommended N rate without P or K was sufficient to obtain yields not significantly differ to those with the recommended rate of NPK. Leaf N content increased in both species as N rate increased, but leaf P and K content was unaffected.

The effects of intercropping cowpeas, groundnuts, maize, okra and sweet potatoes with taro were studied. All intercrops reduced taro yield and the extent of reduction varied with crops (Sivan, 1984). Okra produced the highest yield reduction of nearly 40%. Maize, long beans *(Vigna unguiculata)* and cowpeas reduced taro yield by about 16%, 20%and 23%, respectively. The taro/long bean intercrop gave the .highest gross return of 50% above the non-intercropped taro treatment. Maize, cowpeas and okra also increased gross returns, but to a lesser extent.

Several field experiments were conducted by Fawusi (1985), during the early cropping seasons of 1982 and 1983 to investigate the response of intercropped maize and okra grown under 5 spatial arrangements. In okra, plants grown in alternate hills with maize had the least number of branches, the tallest stems, the least DM yields and lowest fruit yields. Okra planted in 3 rows alternating with 3 rows of maize had the highest DM and FW of fruit yields. Similarly, in maize plants grown in 3 alternating rows with okra had the highest yields among the intercropped systems but there were no significant differences in the DM and, grain yields of maize sown in alternate hills with or between the rows of okra. Percentage light transmission and yields of both crops followed similar trends under the various intercropping systems. The spatial arrangement that allowed the lowest light transmission also produced the lowest yields.

Prabhakar *et al.* (1985), in 2-year trials, 8 intercropping combinations involving capsicum or okra intercropped with beetroots, peas, onions and knol-khol (kholrabi) were compared for nutritional value with the same crops in monoculture. Higher yields, in nutritional terms were obtained with intercropping, particularly when beetroots, peas or knol-khol were grown with okra or capsicum.

Intercropping okras with radish or *Phaseolus vulgaries* in a sandy loam soil gave greater returns than growing okras alone. The following returns were obtained: 9489, 12438, 8201, 3071 and 11468 Rs./ha for okras + P. *vulgaris,* okras + radishes and okras, P. *vulgaris* and radish alone, respectively fertilized with 100 kg N/ha, 44 kg P/ha and 42 kg K/ha. These values increased to 12886, 19478, 10807, 7305 and 17546 Rs./ha, respectively, with 150 kg N/ha, 66 kg P/ha and 42 kg K/ha (Prabhakar and Shukla , 1991)

The effects of three plant densities (28000, 56000 and 111000 plants/ha) of okra cv. NHA474 intercropped within or between maize cv.

yellow rows were investigated in two seasons trials during 1990 and 1991 wet season at Nsukka, Nigeria (Muoneke and Asiegbu, 1997). The plant height and leaf area index (LAI) increased as the plant density increased in sole or intercropped okra while the number of branches per plant decreased with increasing okra plant density. The height of maize plants also increased as okra plant density increased but the LAI decreased. Intercropping reduced the yield and yield components of okra (number and weight of pods per plant) and maize (number of cobs, cob length and 1000 grain weight). Increasing okra plant density reduced the sole and the intercropped okra yield and also the maize intercrop yield by reducing the number of pods and grains as well as the pod and grain size, respectively. Assessment of the productivity of the mixtures showed that the highest yield advantage (35%) obtained at 28000 okra plants/ha while the highest monetary return was realized at' the highest okra plant density of 111000 plants ha^{-1} intercropped between maize rows. The patterns of row arrangement did not affect the growth, yield and yield components of the mixtures.

2.5 Effect of picking interval on growth and yield of okra

Chauhan and Bhandari (1971) recommended that pods of cv. usa sawani should be harvested in 6 to 9 days after flowering. Long picking interval may allow the pods grow beyond edible maturity making them unsuitable for marketing.

Generally, okra pods are harvested before they are over mature i.e. before they become fibrous, rendering the pod inedible. Absar and Siddique (1982) found that quality of pods deteriorate after 8 days of fruit setting. Okra pods generally remain edible up to 7 to 8 days (Singh and Singh, 1974).

Picking interval also influenced fruit setting in okra. As reported by Rashid (1976), and Tomar and Chauhan (1982), higher frequency of picking increased fruit number per plant, which eventually increased the yield of okra.

In a field trial at Vellayani in 1994-95, okras were grown with 6 t FYM + chemical fertilizers or 12 t FYM + chemical fertilizers or vermicompost or poultry manures (Isaac and Pushpakumari, 1998). The effect of picking No. 2, 4 or 6 green fruit/plant was also examined. Fruits and seed yield were highest with FYM + chemical fertilizer but there was only a marginal benefit in applying the higher FYM rate. Seed yield declined as more fruits were picked.

A field experiment was conducted on okra cv. Pusa Sawani in 1992-93 at HPKV, Palampur, India (Bhat and Singh, 1997). Phosphorus rate (50, 70, 90 kg/ha) and GA3 seed treatment (200 or 300 ppm for 12 hour) had no significant effect on seed yield. However, taking 2 fruit harvest had no detrimental effects on seed yield.

2.6 Effect of light on growth and yield of Okra

Maize, Sorghum, Green gram (*Vigna radiate)*, Groundnut and okra were unshaded, shaded to 65% normal light at ambient temperature (33°C or 38°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).

The production of 5 okra cultivars during the regular cycle and after pruning was evaluated (Franco and Ortegon, 1997). Four hybrids and cv. Clemson Spineless 80 were tested with 2 planting dates during 1994 (15 February or 22 March) and 1995 (21 February or 15 March). At the end of the regular season, the stalks of the plants were cut 25 cm above the soil surface to measure the fruits after pruning. During the regular season, March planting dates resulted in greater precocity than the February dates. Most of the hybrid showed harvest precocity and larger fruit yields than Clemson Spineless 80. Cajun delight registered the highest yield in both years. After pruning in 1994, the hybrids were 4 days more precocious than cv. Clemson Spineless 80, and Green Best and North South had the greatest yields for the two planting dates. Increased yields ranging from 10 to 76% were obtained by pruning. The planting date of 15 February was superior in terms of total yield. Yields after pruning in 1995, were adversely affected by high *Benisia argentifolii* population.

2.7 Benefits of okra intercropping in agroforestry system

Chaudhary *et al.* (2006) observed that the okra (*Abelmoschus esculentus* L. Monech) is an important vegetable crop grown in Konkan region of Maharashtra state during rabi-hot weather season wherever irrigation is available. The vegetative characters viz., plant height and inter nodal length showed positive effect on yield of okra. The number of pods plant^{-1} and weight of pods plant^{-1} significantly increased the yield of okra hybrids. All hybrids except Tulsi recorded significantly higher pod yield as compared to check Antara. Growing of all okra hybrids as well as Antara found profitable. The highest net returns (Rs. 85769 ha^{-1}) were obtained due to the cultivation of Rashmi hybrid. All hybrids except Tulsi were more profitable than Antara.

Odeleye *et al*. (2001) were conducted that pot and field trials to evaluate the effects of sowing depth on the performance of two varieties of okra grown as a sole crop. The pot experiment involved a factorial combination of 5 sowing depths (1, 2, 3, 4 and 5 cm), with 2 varieties of okra. The pots were arranged in randomized complete block design with four replications. The 5 cm depth appears to be the most damaging in this regard. Good seedling emergence were obtained at 1, 2 and 3 cm sowing depth but the 3 cm depth appears to be the optimum sowing depth for okra as the highest yield and the overall best performance of okra were attained at this depth.

Alabi and Esobhawan (2006) were conducted that three planting combinations were used: sole maize, sole okra and maize-okra intercropping. Maize and okra were sown at one seed per stand, at a spacing of 75 cm x 25 cm for maize, while okra was planted at a spacing of 60 cm x 30 cm. In the intercrops, the crops were planted to maintain their original populations in sole stands. The results recorded a land equivalent ratio (LER) of 0.82, a relative value total (RVT) of 0.99 and a relative value of intercropping (RVI) of 1.10. Although LER and RVT showed that monocrops of maize and okra have an advantage over intercrops, RVI showed that the profit from intercropping was 10% higher than monocropping. This was because of the reduction in variable costs of labour and fertilizer that are associated with intercrops. The economic implication of the results is that any strategy that reduces the cost of production in maize-okra intercropping will increase its profitability and attractiveness to farmers.

Lourduraj *et al.* (1997) investigations were carried out on okra cv. Parbhani Kranti to study the effect of different mulches (plastic mulch and organic mulch) and irrigation regimes (IW/CPE ratios of 0.4, 0.6 and 0.8) on yield. Mulching significantly increased yield, particularly the plastic mulch. Irrigation at a IW/CPE ratio of 0.6 was the best irrigation regime to promote yield. The black plastic mulch was very effective at controlling weeds. Black plastic mulch increased net seasonal income by Rs 14 300/ha compared with the unmatched control.

Sharma (1999) conducted an experiment that chilli [*Capsicum*], bringel [aubergines], okras and cauliflowers were each grown in an open field or as intercrops under a 5-year-old mango canopy in field experiments in 1991-92. Brinjal produced the highest marketable fruit yield under both open and shaded conditions (319.10 and 62.69 q/ha, respectively). Reductions in yield of capsicum, brinjal, cauliflower and okra due to intercropping were 87.0, 80.3, 70.4 and 62.3%, respectively.

Pertierra and Melin (1998) conducted that okra seeds were direct-sown with 70 cm between rows and 30 cm between plants within the row. Cultivar NN Claudia had the tallest plants (63.1 cm), the most leaves in the central axis (15.7), the highest number of fruits per plant (142) and the highest fruit yield per plant (691.1 g). . Harvesting began 69 and 71 days after sowing for NN Claudia and Dwarf Green Long Pod, respectively.

Pandit *et al.* (2001) were stated that the effect of ambient air temperature on the development of 7 okra cultivars (Pusa Sawani, HOE-202, VRO-4, P-7, Lorm-1, Arka Abhoy and Arka Anamika) was investigated during 1996 and 1997 in West Bengal, India, by measuring the index growing degree days (GDD) at different phenological stages. The average accumulated GDD (degrees Cd) of the cultivars, measured over years and replications, was 812.3 degrees Cd, with little intervarietal differences except for Pusa Sawana. Differences in index value were most prominent between first flowering and maturity. The cultivars Lorm-1 and Arka Abhoy recorded the highest heat use efficiency of 11.21 and 10.49 kg/ha per degrees Cd. Different degrees of correlation were observed while studying the contribution of phenophasic accumulation of GDD to that of the final yield.

The three agro-economic indicators, increased yield, increased net returns and benefit-cost ratio, employed in determining the suitability of intercropping with tomato and okra in a series of experiments conducted in Nigeria during the 1997 and 1998 cropping seasons showed that the most profitable practice is the sole cropping of tomato at a population density of 37000 plants per hectare. The practice produced a favorable 8:1 benefit-cost ratio and increased net returns of between 8.9 and 85.1% per hectare above other treatments hence its recommendation as a modest cultural practice. Subsidizing the high cost of pest-control chemicals on okra fields and/or the introduction of price support programmes could provide incentives for okra production as a short-term measure, while in the long run; large-scale production could be feasible if improved varieties with high yields and disease resistant qualities were developed for vegetable crop farmers in Nigeria (Adeniyi, 2001).

According to Li-XueZhi *et al.* (2004) pod lengths, soluble protein contents, several nutrient contents, and mucilage viscosity of okra cv. Green finger were determined at different stages after anthesis under protected cultivation. The eating quality of okra was best when the pods at 8- to 9-cm length were picked approximately five days after anthesis.

Barani and Anburani (2004) conducted an experiment with okra cv. Arka Anamika in Annamalainagar, Tamil Nadu, India. There were 18 treatments, involving application of farmyard manure (FYM; at 12.5, 25 and 37.5 t/ha), inorganic fertilizer (at 50, 75 and 100% of the recommended dose of NPK of 40:50:30 ka/ha), vermicompost (at 3, 4 and

5 t/ha), and a control (application of the recommended dose of NPK). Application of FYM at 25 t/ha, along with 75% of the recommended dose of inorganic fertilizer and vermicompost at 5 t/ha, recorded the highest nutrient (N, P and K) uptake and postharvest available soil nutrients.

John *et al.* (2004) stated that intercropping improved the number and yield of pods of cowpea. The incidence of cowpea aphid was the lowest when intercropped in okra at lower spacing. The performance of amaranth and cucumber as intercrops in okra was not promising. However, the occurrence of fruit fly seemed reduced in cucumber when it was intercropped. Cowpea can be recommended as a suitable intercrop in okra..

Ribas *et. al.* (2003) carried out an experiment, the effects of 2 population densities of *C. juncea* (400000 or 600000 plants/ha, with 2 or 3 rows between rows of okra) as a green manure, and 2 rates of cattle manure (pre-plant applications of 10 or 20 t/ha, equivalent to 225 or 550 k N/ha) on okra (cv. Santa Cruz 47) were studied. Intercropping with *C. juncea* increased okra yield by approx. 13%, with no significant difference between treatments. In addition, there was a marked reduction in the incidence of okra root galls due to *Meloidogyne spp*. in the presence of *C. juncea*. Cattle manure application had no effect on okra performance.

John and Mini (2005) stated that okra planted at 60 cm x45 cm spacing intercropped with cowpea produced the highest okra equivalent yield, low weed weight, and the highest net and gross returns during both the seasons.

Singh *et al.* (2004)conducted field experiments to determine the effects of integrated nutrient management on crop nutrient uptake and yield under okra-pea-tomato cropping sequence. The integrated use of organic and inorganic sources of nutrients and biofertilizers increased the N, P and K concentrations in the plants (including fruits) of okra, pea and tomato. The integrated nutrient management also significantly increased shoot dry matter yield of tomato and fruit yields of okra and tomato.

2.8 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).

2.9 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 agroforestry 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.

2.10 Importance of the study

Importance of the okra plant

Okra (*Abelmoschus esculentus*) is an annual vegetable crop grown from seed in tropical and sub tropical parts of the world. It is a very common vegetable in Bangladesh and popular among all classes of people. Though it is grown round the year and plays an important role in human diet in the lean period of vegetable production in Bangladesh. Vender green fruits are used as vegetables either boiled of fried form. Its tender green fruits are used as a vegetable and are generally marketed in the fresh state, but sometimes canned or dehydrated form (Thakur and Arora, 1996). Okra is rich in vitamins, calcium, potassium and other mineral matters. However, the nutritive values of okra reported by Aykoryed (1963) as follows:

Table 2.1 Okra plant contains the following nutrients per 100 grams of edible portion:

Nutrients composition	Content (edible portion per 100g)	Nutrients composition	Content (edible portion per 100g)
Moisture	89.6 g	Iron	1.5 mg
Carbohydrates	6.4 g	Sodium	6.9 mg
Protein	1.9 g	Potassium	103 mg
Fat	0.2 g	Copper	0.19 mg
Fibre	1.2 g	Sulphur	30 mg
Minerals	0.7 g	Vitamin A	88 I U
Calcium	66 mg	Nicotinic acid	0.6 mg
Magnesium	43 mg	Vitamin C	13 mg
Oxalic acid	8 mg	Riboflavin	0.1 mg
Phosphorus	56 mg	Thiamin	0.07 mg

Okra fruit can be cooked in a variety of ways . It can be fried in butter or butter oil and with necessary ingredients . They can be boiled and served as salad or cut into pieces and served with soup (Thakur and Arora, 1986) Young fruirs of okra are agreeable mucilaginous vegetable , much relished by some when boiled and served in salad or soups. Its ripe seeds are roasted, ground and used as a substitute for coffee in Turkkey (Mehta, 1959). The roots and stems of okra are used for clearing the cane juice from which gur or brown sugar beet is prepared (Chauhan, 1972).

Importance of the 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 (Rahman, 2006).

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 (Rahman, 2006).

2.11 Consumption pattern of canes in Bangladesh:

Table 2.2 The consumption pattern of cane (Tiwari, 1992) in Bangladesh 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 seldom 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 (Rahman, 2006).

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 (Rahman, 2006).

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 (Rahman, 2006).

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 (Rahman, 2006).

CHAPTER 3
MATERIALS AND METHODS

CHAPTER 3

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 experiments were conducted in 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 37.5 m 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 and drainage system was well developed. The soil texture was sandy loam in nature. The soil pH was 5.1. The details soil properties were 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 (20 April, 2007 to 20 July, 2007) are included in the Appendix-II.

3.4 Experimental period

20 April to 20 July, 2007.

3.5 Experimental materials

The three tree species used as the upper storey were -

i) Mehogony (*Swietenia macrophylla*)

ii) Deshi Neem (*Azadirachta 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 okra (*Abelmoschus esculentus*)used as the Lower storey was –

1) Okra (Variety arka anamika)

3.6 Experimental design

The experiments were laid out following the RCBD under three different tree species i.e. Mehogoney, Deshi neem and Eucalyptus with 3 m x 3 m spacing. 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 m x 3 m. There were five plots in total for tree and cane. Each plot size was 2.5 m x 2.5 m. Adjacent plots and neighboring blocks were separated by 0.5 m x 3 m respectively.

3.7 Treatment combination of the study

3.7.1 Single factor RCBD was followed for okra

Replication number: 03

Treatments of Okra

T_0= Okra (control)

T_1= Okra + Mahogony + Bhudum beth

T_2= Okra + Mahogony + Udum beth

T_3= Okra + Mahogony + Jali beth

T_4= Okra + Mahogony + Golla beth

T_5= Okra + Deshi Neem + Bhudum beth

T_6=Okra + Deshi Neem + Udum beth

T_7=Okra + Deshi Neem + Jali beth

T_8= Okra + Deshi Neem + Golla beth

T_9= Okra + Eucalyptus + Bhudum beth

T_{10} Okra + Eucalyptus + Udum beth

T_{11}= Okra + Eucalyptus + Jali beth

T_{12}= Okra + Eucalyptus + Golla beth

3.7.2 Two 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 = Mahogony (*Swietenia macrophylla*) in multistorey

T_2 = Deshi neem (*Azadirachta indica)* in multistorey

T_3 = Eucalyptus (*Eucalyptus camaldulensis*) in multistory

T_4 = Mahogony (*Swietenia macrophylla*) in open field

T_5 = Deshi neem (*Azadirachta indica)* in open field

T_6 = Eucalyptus (*Eucalyptus camaldulensis*) in open field

Treatment combinations

C_1T_0= Bhudum beth (Control)

C_2 T_0= Udum beth (Control)

C_3 T_0= Jali beth (Control)

C_4 T_0= Golla beth(Control)

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

3.8 Land preparation

The land was opened in the middle of March 2007 and prepared thoroughly by spading to obtain a good tilth. All weeds and stubbles were removed from the field 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) Mahogony (*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 plywood manufacture. (Khairul, 1996)

Climate: The maximum temperature varies from 32 to 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)* – A large to middle-sized tree. Leaves imparipinnate, 22-40 cm long, crowded towards the ends of branches; leaflets9-15, terminal often aborted, subopposite, obliquely lanceolate to ovate-lanceolate or falcate. Flowers white in axillary, glabrous panicle. Fruit a drupe, ovoid to oblong, 1-seeded, greenish yellow when ripe. Flowering time: March-April; Fruiting time: July-August;

Adaptability: Grows well on most soils but does not tolerate seasonally waterlogged soils or deep sands with deep water table. Does not grow on saline soils. Can withstand 7-8 dry months with average growth.

Geographical distribution: The tree is a native of Myanmar but now common all over India, and many other hot countries.

Occurrence in Bangladesh: Cultivated in homesteads, village groves and institution yards throughout the country. More common in Rajshahi and the neighbouring semi-arid areas (All strata).

Propagation and management: Generally propagated through seeds. Coppicing ability is good and coppice growth is much faster than that of seedlings;

Uses: Wood is used in building as boarding and panels, for toys, carts, ploughs, for backing of cupboards and for sides and bottoms of drawers. It is more often grown for shade and ornamental purposes. Leaves are used in medicines. Seeds produce insecticide and industrial, non0edible margosa oil. Bark has high tannin content (12-14%).

Pests and diseases: Neem scale is reported to be a pest.

Recommendations: Selection and centralization of better clones; biochemical aspects on insecticidal properties.

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.

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-surface seepage water and cannot tap subterranean ground water (Shukla, 1980).

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).

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 pH exceeding 10, and soluble salts exceeding 0.7 %.

Wood: Eucalyptus wood is used for furniture making. It has very good

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.

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

Parameter	Mehogony			Deshi neem			Eucalyptus		
	33 MAP	36 MAP	MAI	33 MAP	36 MAP	MAI	33 MAP	36 MAP	MAI
Plant height (m)	4.93	5.32	1.95	4.55	4.94	1.90	6.30	6.69	2.85
Base girth (cm)	25.17	25.60	2.58	18.00	18.15	0.90	21.05	21.69	3.84
Bole girth (cm)	14.75	17.16	14.46	11.98	13.05	6.42	18.00	20.71	16.26
Girth at breast height (m)	2.56	3.04	2.88	2.27	2.56	1.75	3.08	3.82	4.44

Table 3.2 Growth status of the existing cane species in the research field at different period

Parameter	Budhum beth			Udum beth			Jali beth			Golla beth		
	21 MAP	24 MAP	MAI	21 MAP	24 MAP	MAI	21 MAP	24 MAP	MAI	21 MAP	24 MAP	MAI
Plant height (cm)	198.5	253.4	219.6	170.2	223.9	214.8	236.5	296.7	240.8	128.3	155.4	108.4
Base girth (cm)	14.03	16.04	8.4	11.14	12.41	5.08	4.96	5.60	2.56	8.99	10.63	6.56
Stem plant^{-1}	3.97	4.65	2.72	2.81	3.04	0.92	9.19	13.26	16.28	1.79	1.85	0.24

MAP= Month After Planting, MAI = Mean Annual Increment

3.10 Descriptions of cane species

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.

3.11 Establishment of cane species

The four cane species were planted on 28 August 2005 in the one year old MPTS orchard of the Agroforestry Research Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur. Three MPTS (Mahogony, Deshi neem and Eucalyptus) were planted in three blocks. In the block, trees were planted in 3 m x 3 m 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 by 1.5 m apart.

3.12 Establishment of okra

Okra (variety arka anamika) seeds were sown on 20 Aprill, 2007 in the prepared plot for lowered storied. All seeds were soaked for 12 hours, then sown in the experimental plot at 50 cm × 50 cm spacing. Three seeds were sown in each hole and finally one healthy seedling was allowed to grow in each hole. Necessary gap filling was done by healthy seedlings with in a week. The plant population number of okra was 40/plot. One day after sowing okra seeds, natural light, rain fall was occurred that helped the good germination of okra seeds. Mature fruits of okra were plucked by hand time to time when there becomes marketable size and final plucking was done at 90 DAS.

3.13 Management practices

Fertilizer application

Recommended doses of fertilizers were used for the respective okra variety (Islam and Haque, 1992). For okra, 10 ton cowdung, 115 kg Urea, 175 kg TSP and 130 kg M P per hectare were applied. All cowdung, T S P and one third of Urea and M P were applied during the final land preparation and rest of the Urea and M P were applied into two equal installments at 15 and 30 days after sowing.

.3.14 Intercultural operation

Weeding and mulching were done as and when necessary to keep the crop weed free and to pulverize the soil. Heavy irrigation was given three times at 15, 30 and 50 DAS, respectively.

3.15 Pest and disease control:

After sowing okra seed, some seedlings were affected by sclerotia, therefore, vitavax 300 ml/20 litre was applied to prevent the sclerotia. Yellow vein mosaic virus affected plants were rogued out and burned up to three fruit stage. Spraying with Thiodan 35 E C. at .07 per cent conc.(1 to 1.5 litre per hectare) for YVM control . This crop infested by Shoot and fruit borer .To control the insect, Sevin-50 W. P. (1 to 1.5 kg per hectare) and Thiodan 35 E. C. (1to 1.5 litres per hectare) were sprayed at 15 days intervals after emergence.

3.16 Harvesting:

The fruits of okra were harvested in several pickings when okra pods age up to 6 to 7 days after anthesis period. The harvesting was started at 30 DAS and ended at 90 DAS. The stage was determined visually and by pressing the fruit with fingers. The fruits were harvested at one-day interval. Final harvesting was done at 90 DAS.

3.17 Data collection:

Among the following data, plant height, number of leaves plant^{-1} was recorded three times in the life cycle of okra at 30, 60 and 90 DAS. 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 (cm)
II. Number of Leaf plant^{-1}
III. Leaf size (cm^{2})
IV. Fruits plant^{-1}
V. Fruit length (cm)
VI. Fruit girth (cm)
VII. Weight of fruit (g) plant^{-1}
VIII. Single fruit weight (g)
IX. Yield (ton/ha)

On the other hand, the data were collected for cane species at two times at 21 and 24 MAP respectively. The following parameters were recorded for cane species:

I. Plant height (cm)
II. Number stem plant^{-1}
III. Number leaves plant^{-1}
IV. Leaf length (cm)
V. Leaf breadth (cm)
VI. Base girth (cm)

The data were collected for MPTS at two times at 33 and 36 MAP, respectively. The following parameters were recorded for MPTS species:

i. Plant height (m)
ii. Base girth (cm)
iii. Bole girth (cm)
iv. Girth at base height (m)

3.18 Sampling procedure and data collection

Five (minimum 1 from each row) plants of okra from each plot were selected for data collection. Plant height was measured at 40, 60 and 90 DAS, while number of branches per plant and number of leaves per plant were determined from the sample plants at the final harvest. Number of fruits per plant, fruit length (cm), fruit girth (cm) and fruit weight (g) were measured when fruits were attained to edible size. Days to first edible fruit harvest were noted. Fresh yield of okra was determined from the summation of each fruit weight and then converted into ton/ha.

3.19 Data analyses

Data were statistically analyzed using the (ANOVA) "Analysis 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).

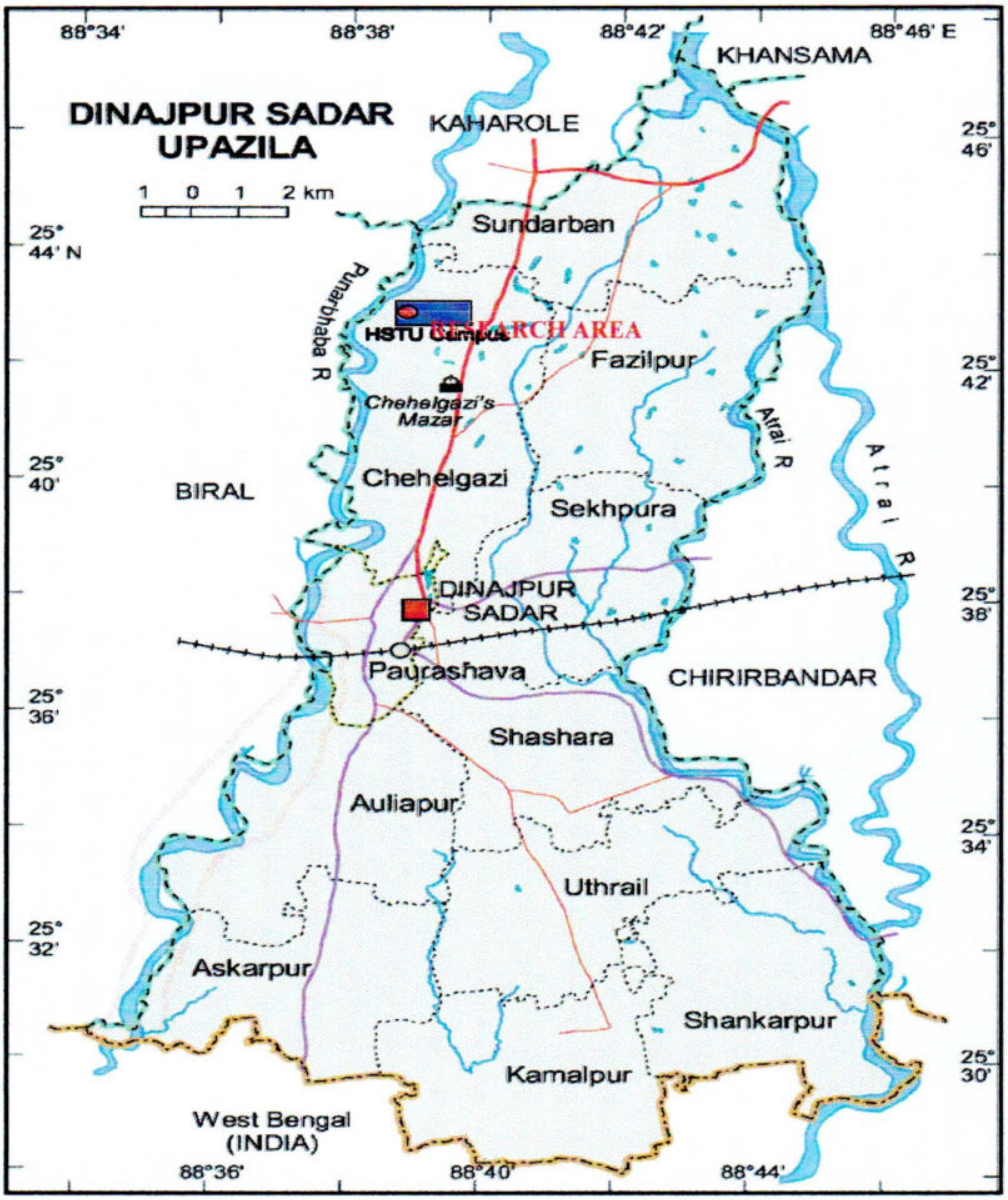

Fig. 1 Map of Dinajpur Sadar Upazila showing the research working area.

CHAPTER 4
RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSIONS

This episode is the presentation and discussion of the results obtained from the experiments carried out to study the performance of okra 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 summaries of analysis of variance for all yield contributing characters and growth parameters studied have been presented in Appendix V. The results of each parameter discussed under the following headings.

4.1 Performance of okra as the lower storied component of cane based multistoried agroforestry system

Plant height

Plant height at different days after sowing (DAS) was significantly influenced by different over storey species combinations (trees and cane). Significantly, the tallest plant at 30 and 60 DAS were recorded 28.90cm and 84.30 cm, respectively in T_3 (Mahogony + Jali beth) followed by T_4 (28.30cm and 79.10 cm), at 30 and 60 DAS respectively. At 90 DAS the tallest plant (127.8 cm) was observed in T_3 (Mahogony + Jali beth), and the following was 112.8 cm from T_4 (Mehogony + Golla beth). Significantly, the shortest plants at 30, 60 and 90 DAS were 15.68, 26.78, and 43.56 cm respectively in T_8 (Deshi Neem + Golla beth) Appendix-X . The increase in plant height with corresponding increase of plant population was due to the less light penetration through the canopy which was also reported by Fawusi (1985). The sole crop has received more light than the intercropped treatment and eventually the plant remained shorter than that of intercropped treatment.

The present study revealed that the plant height increased with the decrease of light levels. 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 (aerial and edaphic), and genetic set-up of the plants. 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 (Hillman 1984). Ali (1999) observed taller plant height of okra under reduced PAR levels created by guava and drumstick trees. Similarly higher plant height under reduced light levels was also observed in eggplant (Miah, 2001) , (Ali, 1998; Islam, 1996) and in chickpea (Murshed, 1996). This may be attributed due to the simulation of cellular expansion and cell division under shaded condition (Sehoch, 1972).

Number of leaf

Leaf plant^{-1} was significantly influenced by different over storey (trees and cane) canopies. At 40 and 60 DAS, highest number of leaf plant^{-1} (8.80 and 13.40 respectively) were recorded in T_0 (Open field) which were statistically similar to that of T_4 (Mehgony + Golla beth) at that two sampling dates. Significantly, the highest number of leaf plant^{-1} at 90 DAS was 18.20 in T_0 (Open field) followed by 13.0 in T_4 (Mehgony +Golla beth). Significantly, the lowest numbers of leaf plant^{-1} at 40, 60 and 90 DAS observed were 4.20, 4.80 and 7.40, respectively in T_{10} (Eucalyptus + Udum beth) [Table 4.1]. Number of leaves was greater in sole crops because of vigorous growth and plenty of food materials production & uptake. Increased plant density (multistoried) was found to reduce leaf number & thereby leaf area per plant. (Muoneke and Udeogalanya, 1991). The lower number of leaves under shaded conditions might be due to higher auxin production in plant grown shaded condition which ultimately suppressed the growth of lateral branches (Miah *et al.*, 1999). Similar result was also found by Wadud (1999) in case of okra.

Leaf size

Leaf area (cm^2) was significantly influenced by different over storey (trees and cane) canopies. Significantly, the highest number of leaf area at 30 DAS was 977.7 cm^2 in T_0 (Open field) followed by 599.5 in T_4 (Mahgony +Golla beth). At 60 and 90 DAS, highest leaf size (1033.3 and 1313 cm^2, respectively) were recorded in T_0 (Open field) which were statistically similar to that of T_4 (Mahgony + Golla beth) at that two sampling dates. Significantly, the lowest leaf size at 30, 60 and 90 DAS observed were 187.6, 222.4 and 430.8 cm^2, respectively in T_{11} (Eucalyptus + Jali beth). [Table 4.2].

Number of fruit

Number of fruits $plant^{-1}$ was also influenced by the over storey cane and MPT_S. Significantly, the highest number of fruit $plant^{-1}$ (8.50) was recorded in T_0 (Open field) and the lowest number of fruit per $plant^{-1}$ (2.25) was observed in T_{11} (Eucalyptus + Jali beth) [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). The present results are in support of Rahman (2006) who found the highest number of fruits per plant in open field when eggplant grown as multistoried system.

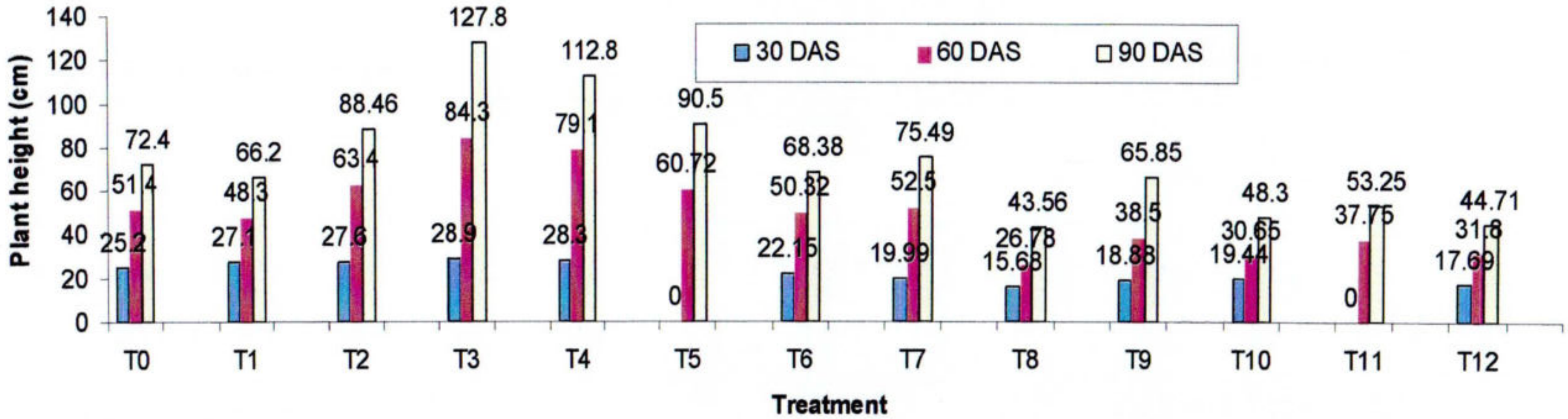

Fig. 2 Plant height of okra at different days after sowing as the lower storied component under multistoried agroforestry system

Table 4.1 Number of leaf of okra at different DAS as the lower storied component of multistoried agroforestry system

Treatment	Number leaf plant^{-1} at		
	30 DAS	60 DAS	90 DAS
T_0 (Control)	8.80a	8.80a	8.80a
T_1 (Mehogony + Bhudum beth)	6.60c	6.60c	6.60c
T_2 (Mehogony + Udum beth)	8.0b	8.0b	8.0b
T_3 (Mehogony + Jali beth)	6.75c	6.75c	6.75c
T_4 (Mehogony + Golla beth)	8.65a	8.65a	8.65a
T_5 (Deshi Neem+ Bhudum beth)	6.45c	6.45c	6.45c
T_6 (Deshi Neem + Udum beth)	6.75c	6.75c	6.75c
T_7 (Deshi Neem + Jali beth)	6.70c	6.70c	6.70c
T_8 (Deshi Neem + Golla beth)	5.40d	5.40d	5.40d
T_9 (Eucalyptus+ Bhudum beth)	4.75ef	4.75ef	4.75ef
T_{10} (Eucalyptus + Udum beth)	4.20f	4.20f	4.20f
T_{11} (Eucalyptus + Jali beth)	4.65ef	4.65ef	4.65ef
T_{12} (Eucalyptus + Golla beth)	5.15de	5.15de	5.15de
Level of Sig.	**	**	**
LSD (0.05)	0.5967	0.5967	0.5967

** 1% level of significance

* 5% level of significance

Plate 1. Showing the land preparation for experiment set up

Plate 2. Showing the okra in association with Cane-Mehogony in mutistoried

Plate 3. Showing the okra in association with Cane-Deshi neem in mutistoried agroforestry system

Plate 4. Showing the okra in association with Cane-Eucalyptus

Plate 5. Showing the data collection of okra by researcher.

Plate 6. Showing the morphological feature of okra at 30 DAS (left) and 60 DAS (right).

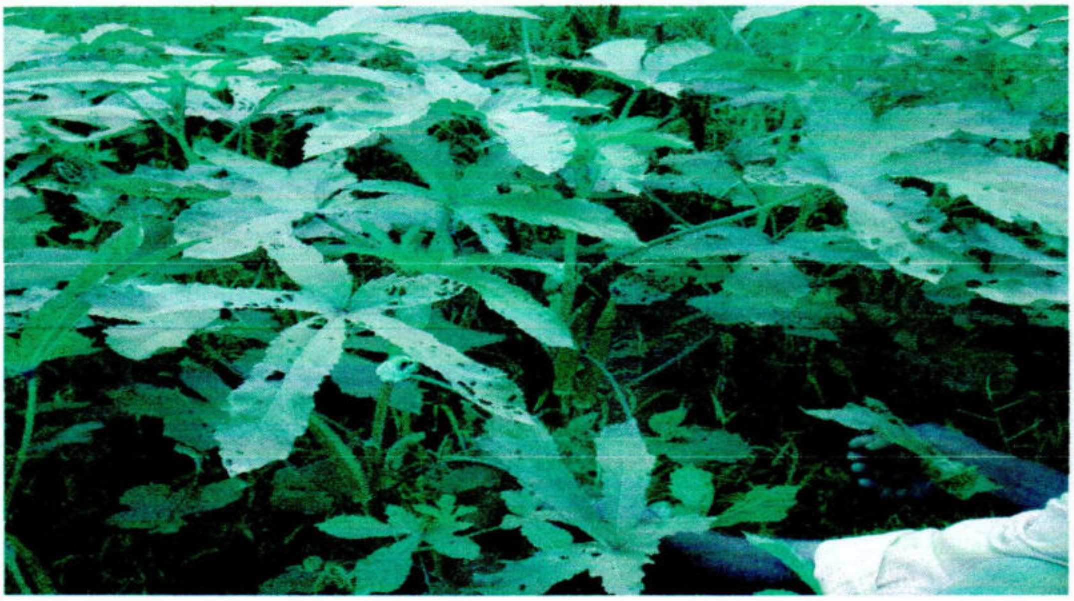

Plate7. Plate showing the morphological feature of okra at 90 DAS

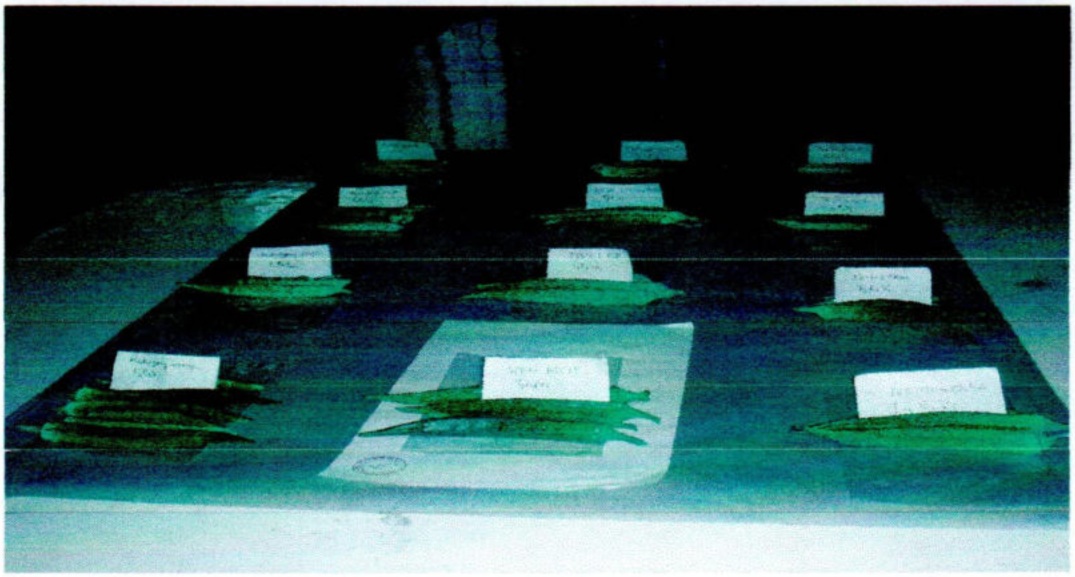

Plate 8. Showing the demonstration of different parts of okra for calculating dry matter.

The greater number of fruits in monoculture and in less severe intercropped plot was found because of their higher amount of food reserve due to less competition which was relevant with Birbal *et al.* (1995) who stated that number of fruits per plant, individual fruit weight and yield per plant were the highest with greater spacing. Muoneke and Asiegbu (1997) also found less plant height and LAI (leaf area index) is intercropping and number of weight of pods per plant of okra. Saha (1989) reported less number of fruits per plant of okra.

Fruit length

Fruit length (cm) was also influenced by the over storey cane and $MPT_{S.}$ Significantly, the highest fruit length (14.25 cm) was recorded in T_0 (Open field) which was statistically similar with T_4 (13.75 cm). The lowest fruit length (8.65 cm) was observed in T_{11} (Eucalyptus + Jali beth) [Table 4.2]. Similar result was also reported by Rahman (2006) on performance of cane and eggplant in multistoried agroforestry system. Shorter fruit length in less populated plots was due to more exposure to light and other inputs which was hampered in densely populated plots.

Fruit girth

Fruit girth (cm) was also influenced by the over storey cane and $MPT_{S.}$ Significantly, the highest fruit girth (7.43 cm) was recorded in T_0 (Open field) which was statistically similar with T_4 (7.365 cm) and T_2 (7.335 cm). The lowest fruit length (5.55 cm) was observed in T_{11} (Eucalyptus + Jali beth) which was statistically similar with T_9 and T_{12} [Table 4.2]. The lower fruit girth under heavy shade may be associated with the lower mobilization of reserve assimilation to reproductive organ.

Fruit weight per plant

Significantly, the highest fruit weight per plant (159.72 g) was found in T_0 (Open field). The second highest fruit weight (119.9 g) was observed from T_4 (Mehogony + Golla beth). Significantly the lowest fruit weight (24.395 g) was observed in T_{11} (Eucalyptus + Jali beth). [Table-4.3]. This result supported the experiment of Rahman (2006). Weight of okra per plant in monoculture was maximum because of their greater pell thickness due to the maximum deposition of photosynthesis.

Single Fruit weight

Significantly, the highest single fruit weight per fruit (18.79 g) was found in T_0 (Open field) which was followed by T_4 (16.33 g) that was statistically similar with T_2 (16.13 g) and T_8 (15.61 g). Significantly the lowest single fruit weight (8.445 g) was observed in T_7 (Deshi Neem + Jali beth) which was statistically similar with T_5 (8.78g) [Table-4.3]. Here the single fruit weight was greater in case of control and less shady plots because of the maximum use of natural resources.

Dry Weight of fruit

Significantly, the highest dry weight per fruit (10.25 g) was found in T_0 (10.25g) and the second highest single fruit weight was observed from T_4 (9.65 g). The fruit dry weight (7.75 g) was observed in T_{11} (5.53g) (Deshi Neem + Jali beth) which was statistically similar with T_7 and T_9 [Table-4.3]. The highest dry mater was accumulated in sole crop because they received plenty of lights and complete less for food and other inputs. The opposite scenario was experienced in case of multistoried system which received less input due to different degrees of competition. Reduced dry matter of plants and fruits was also reported by Fawusi (1985).

Table 4.2 Leaf size and number of fruits plant^{-1}, fruit length and fruit girth of okra at different DAS as the lower storied component of multistoried agroforestry system

Treatment	Leaf size (cm^2) at			Fruits plant^{-1}	Fruit Length (cm)	Fruit Girth (cm)
	30 DAS	60 DAS	90 DAS			
T_0 (Control)	977.7a	1033.0a	1313.0a	8.50a	14.25a	7.430a
T_1 (Mehogony + Bhudum beth)	427.2bcd	613.9d	743.6b	7.25b	12.25bc	6.450bc
T_2 (Mehogony + Udum beth)	411.5bcd	604.8e	692.9f	6.45c	12.75b	7.335a
T_3 (Mehogony + Jali beth)	514.4bc	510.6g	670.5g	5.535d	11.75c	6.370bc
T_4 (Mehogony + Golla beth)	599.5b	877.3b	1042.0b	7.345b	13.75a	7.365a
T_5 (Deshi Neem+ Bhudum beth)	403.0bcd	594.9f	739.3e	4.375e	9.545f	6.225bc
T_6 (Deshi Neem + Udum beth)	345.6bcd	492.8h	661.2h	4.320e	10.67b	6.515bc
T_7 (Deshi Neem + Jali beth)	312.7bcd	428.3i	621.4j	4.400e	9.700ef	6.200bc
T_8 (Deshi Neem + Golla beth)	521.5bc	730.9c	961.8c	4.250e	11.90c	6.700b
T_9 (Eucalyptus+ Bhudum beth)	252.0cd	323.2j	535.1k	3.500f	9.525f	5.650d
T_{10} (Eucalyptus + Udum beth)	190.5d	225.4k	440.7l	3.400f	10.30de	6.250bc
T_{11} (Eucalyptus + Jali beth)	187.6d	222.4l	430.8m	2.250g	8.650g	5.550d
T_{12} (Eucalyptus + Golla beth)	339.6bcd	492.1h	638.1i	4.125e	10.84d	6.000cd
Level of Sig.	**	**	**	**	**	**
LSD (0.05)	266.2	1.991	2.409	0.5927	0.6716	0.4724

**** 1% level of significance**

*** 5% level of significance**

Fruit yield

Fruit yield (t ha^{-1}) of okra significantly varied under different treatment combinations. Significantly the highest yield (10.24 t ha^{-1}) was found in T_0 (Open field) that was followed by (7.685 t ha^{-1}) in T_4 (Mehogony + Golla beth). The lowest yield (1.56 t ha^{-1}) was found in T_{11} (Eucalyptus + Jali beth) [Figure 3 and appendix X]. The present results are in support of the findings of Sivan (1984) where 40% yield reduction was noticed when okra was intercropped with taro. However, 65% shading was not so deleterious in case of okra as was experimented by Singh (1997). Similar result was also reported by Rahman (2006).

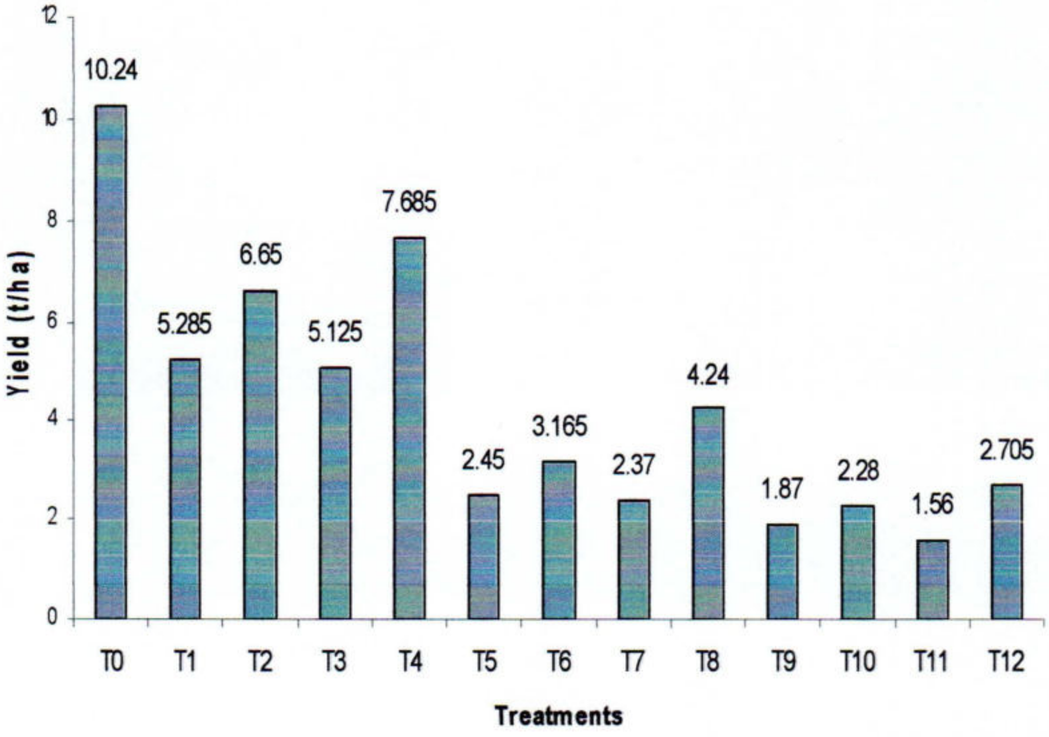

Fig. 3 Fruit yield of okra as the lower storied component of multistoried agroforestry system

Table 4.3 Fruit weight plant^{-1}, single fruit weight and dry weight of fruits of okra as the lower storied component of multistoried agroforestry system

Treatment	Fruit weight (g) plant^{-1}	Single fruit weight (g)	Dry weight of fruits (g)
T_0 (Control)	159.72a	18.79a	10.25a
T_1 (Mehogony + Bhudum beth)	82.600d	11.49d	8.85e
T_2 (Mehogony + Udum beth)	104.015c	16.13b	9.15c
T_3 (Mehogony + Jali beth)	80.100e	14.55c	8.45g
T_4 (Mehogony + Golla beth)	119.900b	16.33b	9.65d
T_5 (Deshi Neem+ Bhudum beth)	38.290i	8.78f	7.95i
T_6 (Deshi Neem + Udum beth)	49.465g	11.47d	8.75f
T_7 (Deshi Neem + Jali beth)	37.000j	8.445f	7.75j
T_8 (Deshi Neem + Golla beth)	66.290f	15.61b	8.95d
T_9 (Eucalyptus+ Bhudum beth)	29.220l	8.48f	7.75j
T_{10} (Eucalyptus + Udum beth)	35.660k	10.49de	8.25h
T_{11} (Eucalyptus + Jali beth)	24.395m	10.85de	7.75j
T_{12} (Eucalyptus + Golla beth)	42.220h	10.24e	8.75f
Level of Sig.	**	**	**
LSD (0.05)	1.128	1.010	0.09744

** 1% level of significance

* 5% level of significance

4.2 Growth performance of cane species under different MPTS

4.2.1 Effect of MAP of various species on the plant height, number of stem, number of leaf, leaf length, leaf breadth and base girth of cane

Plant height

Significantly, the highest plant height (cm) was found in C_3 (Jali beth). The plant heights at 21 and 24 MAP were recorded as 236.5cm, & 296.7cm, respectively. Significantly, the lowest plant heights were recorded as 128.3 &155.4 cm at 21 & 24 MAP respectively in C_4 (Golla beth). C_1 and C_2 showed statistically dissimilar performance in case of plant height irrespective of sampling dates [Fig. 4 and Appendix XII]. This result was similar to the previous experiment carried out by Rahman (2006) on cane based multistoried agroforestry system.

Number of stem

Significantly, the highest numbers of stem /plant at 21 & 24 MAP were 9.199 & 13.26, respectively in C_3 (Jali beth). Significantly, the lowest number of stem/plant was observed 1.788 at 21 MAP respectively in C_4 (Golla beth) which was statistically similar to C_1& C_2. Significantly, the lowest number of stem/plant was observed 1.85 at 24 MAP respectively in C_4 (Golla beth) which was statistically similar to C_2 [Table-4.4]. This result was more or less same to the research work of Rahman (2006).

Plate 9. Showing the different cane species are Bhudum beth (left) and Udum beth (right).

Plate 10. Showing the different cane species are Jali beth (left) and Golla beth (right).

Number of leaf

Number of leaves/plant was also influenced by the upper storey MPTS. Significantly the highest numbers of leaves/plant at 21 & 24 MAP were observed 89.18 & 155.6 respectively in C_3 (Jali beth). Jali beth showed tremendous performances than other species due to their natural growth behaviour.

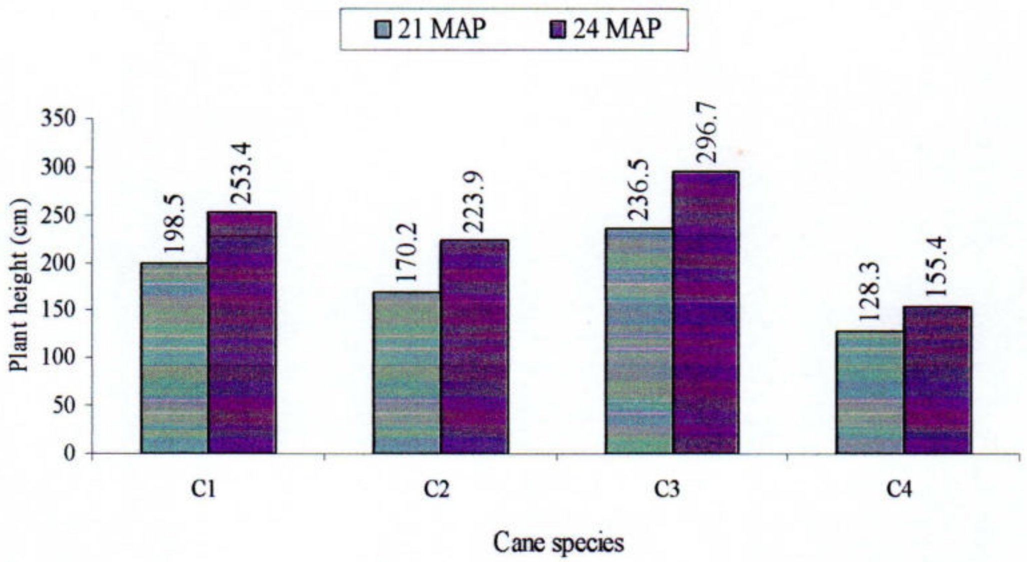

Fig. 4: Plant height of different cane species in open field at the time of the study period.

Significantly, the lowest number of leaves/ plant was observed 8.275 respectively at 21 MAP in C_4 (Golla beth). C_1 & C_2 were statistically dissimilar. Significantly, the lowest number of leaves/ plant was observed 18.20 at 24 MAP in C_2 (Udum beth) which was statistically similar to C_1 & C_4 [Table 4.4].

Leaf length

The longest leaf length (cm) at 21 MAP was observed 109.6 cm in C_2 (Udum beth) and the lowest leaf length was observed 82.13 cm in C_3 (Jali beth). At 24 MAP, the longest leaf length was observed 143.6 cm in C_2 (Udum beth) which was statistically similar with C_1 (Bhudum beth) (130.1 cm). At 24 MAP, the shortest leaf length was observed 91.03 cm in C_3 (Jali beth) which was (98.80 cm) statistically similar to C_4 (Golla beth) [Table – 4.4].

Leaf breadth

Leaf breadth (cm) of cane was significantly influenced by the upper storey MPTs. The widest leaf breadth at 21 MAP was observed 76.03 cm in C_4 (Golla beth) and the lowest leaf breadth was observed 38.70 cm in C_2 (Udum beth). At 24 MAP, the widest leaf breadth was observed 81.61 cm in C_4 (Golla beth) and the shortest leaf breadth was observed 54.74 cm in C_2 (Udum beth) which was (56.96 cm) statistically similar to C_3 (Jali beth) [Table – 4.4].

Base girth

The upper storey MPTs had significant effect on base girth (cm) of cane at different sampling dates. The highest base girth at 21 and 24 MAP were observed 14.03 and 16.04 cm, respectively in C_1 (Bhudum beth) and the lowest base girth were observed 4.963 and 5.601cm, respectively in C_3 (Jali beth) [Table – 4.4].

Table 4.4 Stem plant^{-1} and leaves plant^{-1} of different cane species in different month after planting (MAP)

Cane species	Stem plant^{-1}at		Leaves plant^{-1}at	
	21 MAP	24MAP	21 MAP	24 MAP
C_1 (Bhudum beth)	3.975b	4.655b	16.25b	23.81b
C_2 (Udum beth)	2.818b	3.046bc	12.53c	18.20b
C_3 (Jali beth)	9.199a	13.26a	89.18a	155.6a
C_4 (Golla beth)	1.788b	1.850c	8.275d	20.49b
Level of significance	**	**	**	**
LSD (0.05)	4.655	2.078	2.407	23.77

Table 4.4 (continued) Leaf length, leaf breadth and base girth of different cane species in different month after planting (MAP)

Cane species	Leaf length (cm) at		Leaf breadth (cm) at		Base girth (cm) at	
	21 MAP	24 MAP	21MAP	24 MAP	21 MAP	24MAP
C_1 (Bhudum beth)	102.5b	130.1a	62.22b	75.14b	14.03a	16.04a
C_2 (Udum beth)	109.6a	143.6a	38.70d	54.74c	11.14b	12.41b
C_3 (Jali beth)	82.13d	91.03b	51.16c	56.96c	4.963d	5.601d
C_4 (Golla beth)	87.82c	98.80b	76.03a	81.61a	8.995c	10.63c
Level of sig.	**	**	**	**	**	**
LSD (0.05)	1.885	26.59	5.135	4.890	0.9780	0.9418

** 1% level of significance

* 5% level of significance

MAP= Month After Planting

4.2.2 Effect of different trees on the growth performance (plant height, stem plant^{-1}, number of leaves plant^{-1}, leaf length, leaf breadth and base girth) of different cane species.

Plant height

Plant height (cm) of different cane species (used in middle storey) was significantly influenced by the upper storey trees and lower storey crop production. At 21 MAP, the plant height of Cane species recorded under open field, Mehogony, Deshi neem and Eucalyptus were 153.6, 224.9, 178.2 and 176.8 cm in respectively. At 24 MAP, the plant height of cane species recorded under open field, Mehogony , Deshi neem and Eucalyptus were 176.6, 279.7, 246.3 and 226.9 cm in respectively. Finally, cane height under Mahogony was significantly the highest and the lowest under in open field [Fig. 5 and Appendix XIII]. This result was similar to the previous experiment carried out by Rahman (2006) on cane based multistoried agroforestry system.

Number of stem

Effect of trees and lower storey crop on number of stem plant^{-1} of different cane species varied significantly. At 21 MAP, the highest number of stem plant^{-1} (5.890) was found in under Deshi neem which was statistically similar to that under Mehogony and Eucalyptus (5.764 and 3.902). The lowest number of stem plant^{-1} (2.285) was found in open field that was statistically similar to that of found under Eucalyptus (3.902). Similar trend of variation of result was found in 24 MAP. It was observed 9.023 in T_1 (Mehogony) which was statistically similar to (7.118) in T_2 (Deshi neem). The lowest number of stem plant^{-1} at 24 MAP was found as 2.2405 in T_0 (open field) which was statistically similar to (4.199) in T_3 (Eucalyptus) [Table – 4.5].

Table 4.5 Effect of tree species on stem plant^{-1} and leaves plant^{-1} of different cane species in different month after planting (MAP)

Treatment	Stem plant^{-1}at		Leaves plant^{-1}at	
	21 MAP	24 MAP	21 MAP	24 MAP
T_0(Open field)	2.285b	2.405b	14.59d	19.24c
T_1 (Mehogony)	5.764a	9.023a	33.29b	67.05ab
T_2 (Deshi neem)	5.890a	7.118a	58.49a	84.56a
T_3 (Eucalyptus)	3.902ab	4.199b	19.87c	47.21b
Level of sig.	**	**	**	**
LSD (0.05)	2.410	2.078	2.407	23.77

Table 4.5(continued) Leaf length, leaf breadth and base girth of different cane species in different month after planting (MAP)

Treatment	Leaf length (cm) at		Leaf breadth at		Base girth at	
	21MAP	24 MAP	21 MAP	24 MAP	21 MAP	24 MAP
T_0(Open field)	67.55d	74.26b	50.60c	52.42d	8.170c	8.900d
T_1 (Mehogony)	112.8a	124.4a	60.14b	75.11b	9.875b	12.24b
T_2(Deshi neem)	104.1b	137.3a	66.16a	80.45a	12.14a	13.52a
T_3 (Eucalyptus)	97.63c	127.6a	51.20c	60.45c	8.943bc	10.02c
Level of sig.	**	**	**	**	**	**
LSD (0.05)	1.885	26.59	5.135	4.890	0.9780	0.9418

** 1% level of significance

* 5% level of significance

MAP= Month after Planting

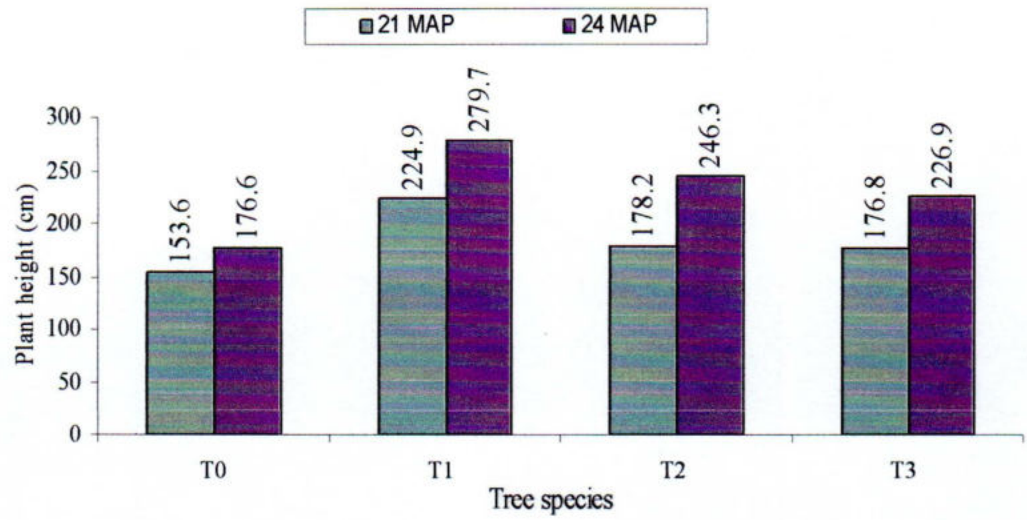

Fig. 5 Effect of tree and okra on plant height of cane species in different MAP

Number of leaf

Effect of trees on number of leaves plant $^{-1}$ of different cane species varied significantly. At 21 MAP, the highest no. of leaves/plant as 58.49 was found in T_2 (Deshi Neem) that was followed 33.29 in T_1 (Mehogony). Significantly, the highest no. of leaves/plant was 84.56 at 24 MAP in T_2 (Deshi Neem) that was statistically similar with 67.05 in T_1 (Mehogony). Significantly, the lowest no. of leaves/plant was 14.59 and 19.24 at 21 and 24 MAP in T_0 (open field). [Table – 4.5]

Leaf length

Effect of trees on leaf length (cm) of different cane species was significant. At 21 MAP, the highest leaf length was 112.8 cm in T_1 (Mehogony). At 24 MAP, significantly it was observed 137.3 cm in T_2 (Deshi Neem) that was statistically similar to 124.4 and 127.6 cm respectively in T_1 (Mehogony) and T_3 (Eucalyptus). Significantly, the shortest leaf length was 67.55 and 74.26 cm at 21 and 24 MAP respectively in T_0 (open field). [Table – 4.5]

Leaf breadth

Effect of trees on leaf breadth (cm) at 21 and 24 MAP of different cane species was significant. At 21 and 24 MAP, the highest leaf breadths were 66.16 and 80.45 cm respectively in T_2 (Deshi Neem) which was followed by 60.14 and 75.11 cm respectively in T_1 (Mehogony). Significantly, the lowest leaf breadth was 50.60 cm in T_0 (Open field) at 21 MAP which was statistically similar T_3 (Eucalyptus). At 24 MAP, the lowest leaf breath was 52.420 cm in T_0 (Open field) [Table – 4.5].

Base girth

Significantly, the highest base girth (cm) was found 12.14 and 13.52 cm in T_2 (Deshi Neem) respectively at 21 and 24 MAP which was followed by 9.875 and 12.24 cm in T_1 (Mehogony). At 21 MAP, the shortest base girth was 8.17 cm respectively in T_0 (open field) which was similar to 8.943 cm in T_3 (Eucalyptus). Significantly, the shortest base girth was 8.90 cm respectively in T_0 (open field) at 24 MAP. [Table – 4.5]

4.2.3 Interaction effect of Cane species and trees on the growth performance of cane species in multistoried agroforestry system.

Plant height

In the interaction effect, significantly the highest plant heights at 21 and 24 MAP were observed 285.6 and 345.6 cm respectively in C_2T_2 (Deshi Neem + Udum beth) which were followed by 238.2 and 315.3 cm respectively in C_2T_0 and C_3T_2 . Significantly, the lowest plant heights at 21 and 24 MAP were 105.5 and 127.6 cm respectively in C_1T_3 (Eucalyptus +Bhudum beth). [Fig. 6 and Appendix XIV]

Number of stem

In the interaction effect, significantly the highest stem number plant^{-1} at 21 and 24 MAP were found 14.03 and 22.50 (Number) respectively in C_3T_2(Deshi Neem + Jali beth) and C_2T_2(Deshi Neem + Udum beth). Significantly, the lowest number of stem plant $^{-1}$ at 21 MAP was observed 1.010 in C_1T_3 (Eucalyptus + Bhudum beth) and the value was statistically similar to 2.050, 3.330, 2.7602, 2.750, 2.050 and 1.590 respectively in C_1T_0 C_3T_1, C_4T_1, C_2T_3 ,C_3T_3 ,C_4T_3 treatments

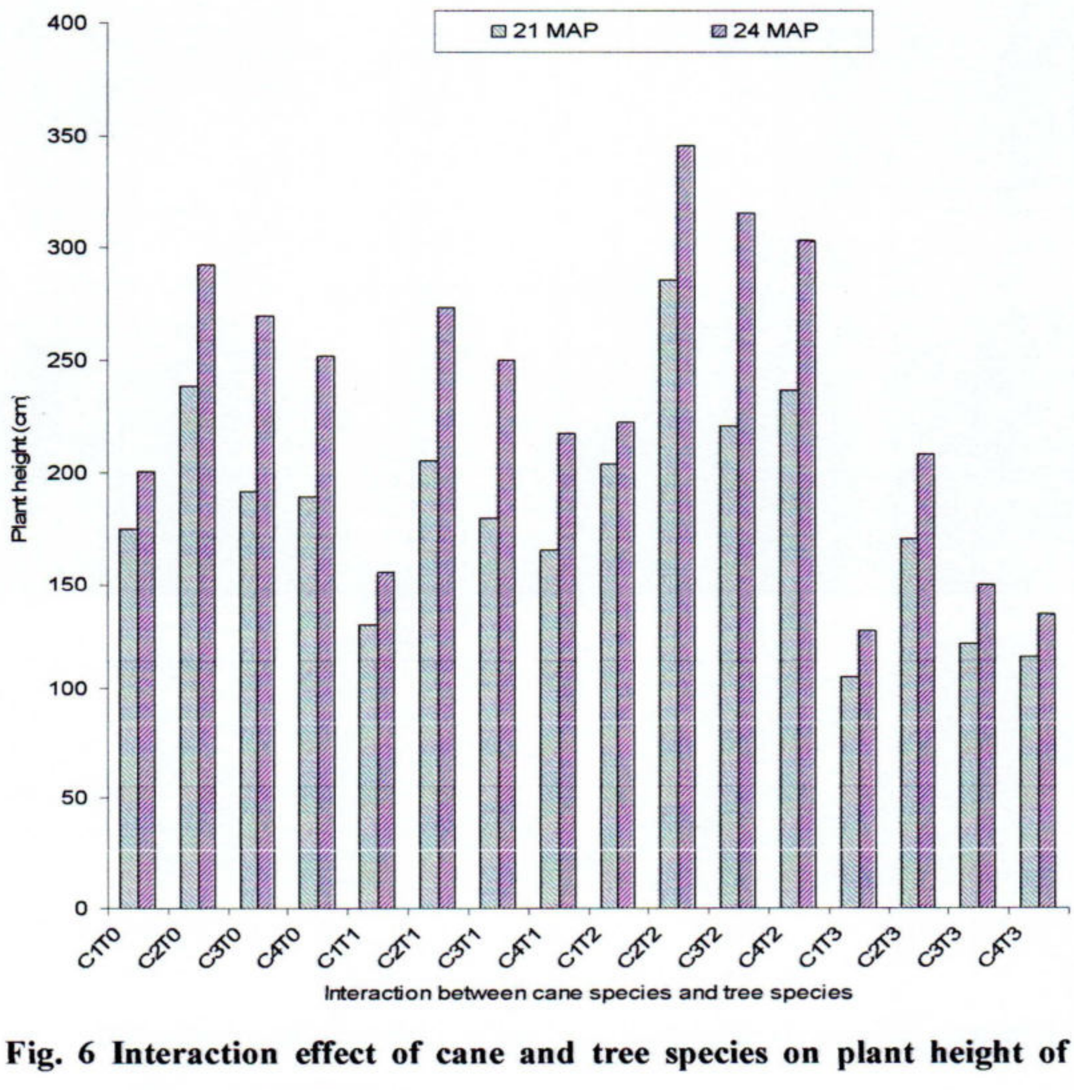

Fig. 6 Interaction effect of cane and tree species on plant height of different cane species

Significantly, the lowest stem number plant $^{-1}$ at 24 MAP was found 1.050 in C_4T_3 (Eucalyptus + Udum beth), the value was statistically similar to 2.150, 1.650, 2.960, 1.120, 2.900, 2.80 respectively found in C_1T_0, C_1T_1, C_4T_1, C_1T_3, C_2T_3 and C_3T_3 [Table – 4.6].

Number of leaf

In the interaction effect, significantly the highest number leaves plant $^{-1}$ at 21 and 24 MAP were observed 184.5 and 275.0 (Number) respectively in (Number) C_3T_2 (Deshi Neem + Jali beth) which were followed by 92.33 and 196.0 (Number) respectively in C_2T_2 (Deshi Neem + Udum beth). Significantly, the lowest number of leaves plant $^{-1}$ was observed at 21 MAP as 6.150 in C_1T_3 (Eucalyptus + Bhudum beth) which was statistically identical with 8.50 and 7.330(no.) respectively in C_2T_3 and C_4T_3. Significantly, the lowest number of leaves plant $^{-1}$ at 24 MAP were found 9.650 in C_1T_3 (Eucalyptus + Bhudum beth), the value was statistically identical to 14.75, 32.00, 25.33, 23.16, 11.50, 27.0, 22.66, 11.66, 13.21 and 15.25 respectively found in C_1T_0, C_2T_0 C_3T_0, C_4T_0 , C_1T_1 , C_2T_1, C_3T_1, C_4T_1, C_2T_3 and C_3T_3 [Table – 4.6].

Table 4.6 Interaction effect of cane species and trees on stem plant $^{-1}$ and leaves plant^{-1} in multistoried agroforestry system

Interaction	Stem plant^{-1} at		Leaves plant^{-1} at	
	21 MAP	24 MAP	21 MAP	24 MAP
C_1T_0 (control x Bhudum beth)	2.050efg	2.150fg	11.00g	14.75ef
C_2T_0 (control x Udum beth)	6.330cd	6.700cd	18.33e	32.00def
C_3T_0 (control x Jali beth)	4.150def	5.150de	20.33e	25.33def
C_4T_0 (control x Golla beth)	3.370efg	4.620de	15.33f	23.16def
C_1T_1 (Mehogony x Bhudum beth)	1.520fg	1.650fg	8.800gh	11.50f
C_2T_1 (Mehogony x Udum beth)	3.660efg	3.990ef	14.00f	27.00def
C_3T_1 (Mehogony x Jali beth)	3.330efg	3.583ef	18.00e	22.66def
C_4T_1 (Mehogony x Golla beth)	2.760efg	2.960efg	9.33gh	11.66f
C_1T_2 (Deshi neem x Bhudum beth)	4.560de	4.700de	32.40d	41.06de
C_2T_2 (Deshi neem x Udum beth)	10.32b	22.50a	92.33b	196.0b
C_3T_2 (Deshi neem x Jali beth)	14.03a	17.66b	184.5a	275.0a
C_4T_2 (Deshi neem x Golla beth)	7.890c	8.167c	47.50c	110.2c
C_1T_3 (Eucalyptus x Bhudum beth)	1.010g	1.120g	6.150i	9.650f
C_2T_3 (Eucalyptus x Udum beth)	2.750efg	2.900efg	8.500ghi	13.21f
C_3T_3 (Eucalyptus x Jali beth)	2.050efg	2.080fg	11.12g	15.25ef
C_4T_3 (Eucalyptus x Golla beth)	1.590fg	1.050g	7.330hi	43.83d
Level of significance	**	**	**	**
LSD (0.05)	2.410	2.078	2.407	23.77

** 1% level of significance

* 5% level of significance

MAP= Month After Planting

Leaf length

From the interaction effect, significantly the largest leaf length(cm) at 21 MAP was observed 125.0 cm in C_2T_1 (Mehogony+ Udum beth). At 21 MAP, significantly the shortest leaf length was 59.40 cm respectively in C_1T_2 (Deshi Neem + Bhudum beth). At 24 MAP, significantly the longest leaf length was 156.0 cm in C_2T_1(Mehogony + Udum beth), this value was statistically identical with 168.7, 54.20, 174.1 and 161.0 cm respectively in C_3T_0, C_4T_0, C_3T_1 and C_4T_1. Significantly, the shortest leaf length(cm) at 24 MAP was observed 63.50 cm in C_1T_2 (Deshi Neem + Bhudum beth) which was statistically similar with 76.60, 83.25, 94.03and 71.90 respectively in C_1T_0, C_1T_1, C_4T_2 and C_1T_3 [Table – 4.6].

Leaf breadth

In the interaction effect, significantly the highest leaf breadth at 21 MAP was observed 81.33 cm in C_3T_3 (Eucalyptus + Jali beth). Significantly, the shortest leaf breadth at 21 MAP was observed 32.13 cm respectively in C_1T_1 (Mahogony + Bhudum beth) which was statistically identical with 33.33 cm in C_4T_1 (Mahogony + Golla beth). At 24 MAP, significantly the highest leaf breadth was 92.06 cm in C_3T_3 (Eucalyptus + Jali beth) and this value was statistically identical with 89.20 and 89.01 cm, respectively in C_3T_0 and C_2T_3. Significantly, the shortest leaf breadth at 24 MAP was observed 34.50 cm respectively in C_1T_1 (Mahogony + Bhudum beth) [Table – 4.6].

Base girth

In the interaction effect, significantly the highest base girth (cm) at 21 and 24 MAP were found 15.80 and 18.66 cm respectively in C_3T_0 (Control + Jali beth).At 21 MAP, significantly the lowest base girth was 4.120 cm in

C_1T_2 (Deshi Neem + Bhudum beth) which was statistically identical to 4.180 cm in C_4T_2 (Deshi Neem + Golla beth). At 24 MAP, significantly the lowest base girth was found 4.603 cm in C_1T_2 (Deshi neem + Bhudum beth), this value was statistically similar to 4.80 cm, in C_4T_2 [Fig. 7 and Appendix XIV].

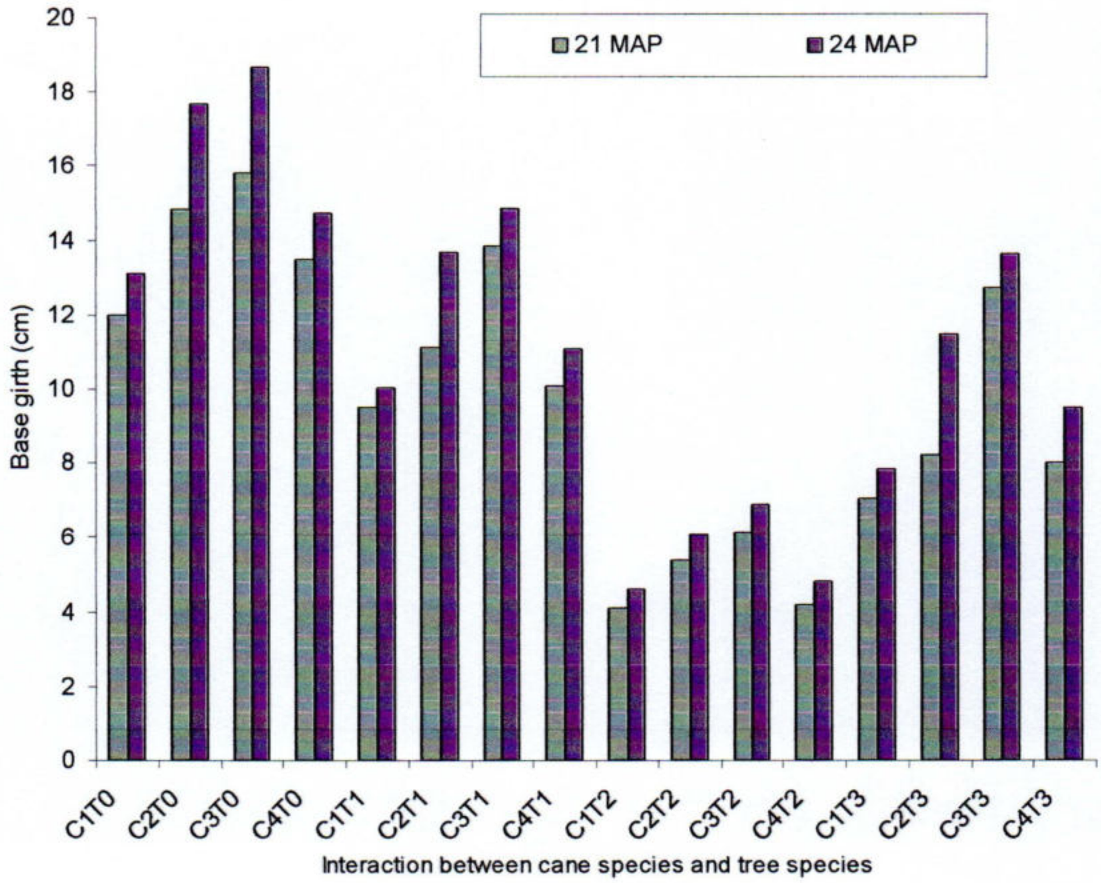

Fig. 7 Interaction effect of cane and tree species on base girth of different cane species

Table 4.6 (Continued) Interaction effect on leaf length and leaf breadth of cane species and trees in multistoried agroforestry system

Interaction	Leaf length (cm) at		Leaf breadth (cm) at	
	21 MAP	24 MAP	21 MAP	24 MAP
C_1T_0(control x Bhudum beth)	69.50l	76.60def	56.08e	60.03d
C_2T_0 (control x Udum beth)	120.0b	120.70b	68.90c	86.05b
C_3T_0 (control x Jali beth)	115.3c	168.70a	72.66bc	89.20ab
C_4T_0 (control x Golla beth)	105.0e	154.20a	51.25ef	65.27d
C_1T_1 (Mehogony x Bhudum beth)	79.10k	83.25cdef	32.13h	34.50f
C_2T_1 (Mehogony x Udum beth)	125.0a	156.00a	41.99g	64.33d
C_3T_1 (Mehogony x Jali beth)	120.9b	174.10a	47.33f	77.05c
C_4T_1 (Mehogony x Golla beth)	113.4d	161.00a	33.33h	43.06e
C_1T_2 (Deshi neem x Bhudum beth)	59.40n	63.50f	39.08g	43.17e
C_2T_2 (Deshi neem x Udum beth)	101.0f	105.7bcd	54.33e	61.07d
C_3T_2 (Deshi neem x Jali beth)	85.03i	99.05bcd	63.33d	63.50d
C_4T_2 (Deshi neem x Golla beth)	83.09j	94.03bcde	47.90f	60.10d
C_1T_3 (Eucalyptus x Bhudum beth)	62.20m	71.90ef	75.11b	72.00c
C_2T_3 (Eucalyptus x Udum beth)	105.0e	115.10b	75.33b	89.01ab
C_3T_3 (Eucalyptus x Jali beth)	95.01g	107.20bc	81.33a	92.06a
C_4T_3 (Eucalyptus x Golla beth)	89.05h	101.10bcde	72.33bc	73.37c
Level of significance	**	**	**	**
LSD (0.05)	1.885	26.59	5.135	4.890

** 1% level of significance

* 5% level of significance

MAP= Month After Planting

4.7 Effect of management practices for lower storey crop production (cane and okra) on the growth performance of MPTS

Plant height

Plant height (m) at different month after planting (MAP) was significantly influenced by different storey combinations (okra and cane). Significantly, the tallest plant at 33 and 36 MAP were recorded 6.30 m and 6.69 m respectively in T_3 (Eucalyptus in multistorey) , respectively which were statistically identical with T_0 (Eucalyptus in open field). At 33 and 36 MAP, the significant shortest plants were 3.54 and 3.88 m in T_5 (Deshi neem in open field) which were statistically similar with T_1 ,T_2 and T_4 (Mehogony and Deshi neem in multistory) and (Mehogony in open field), respectively [Fig. 8 and Appendix XV].

Base girth

Significantly, the biggest base girth (cm) at 33 MAP was recorded 25.17 cm in T_1 (Mehogony in multistorey). The significant smallest base girth at 33 MAP was found 16.39 cm in T_5 (Deshi neem in open field), which was statistically similar to that of T_2 and T_3 (Deshi neem and Eucalyptus in multistorey) [Fig. 9 and Appendix XV]. Significantly, the biggest base girth at 36 MAP was recorded 25.60 cm in T_1 (Mehogony in multistorey), which was statistically identical toT_4 T_3 (Eucalyptus in multistorey). At 36 MAP, the smallest base girth was 17.15 cm in T_5 (Deshi neem in open field) which was statistically similar with T_2 (Deshi neem in multistorey) and T_6 (Eucalyptus in open field).

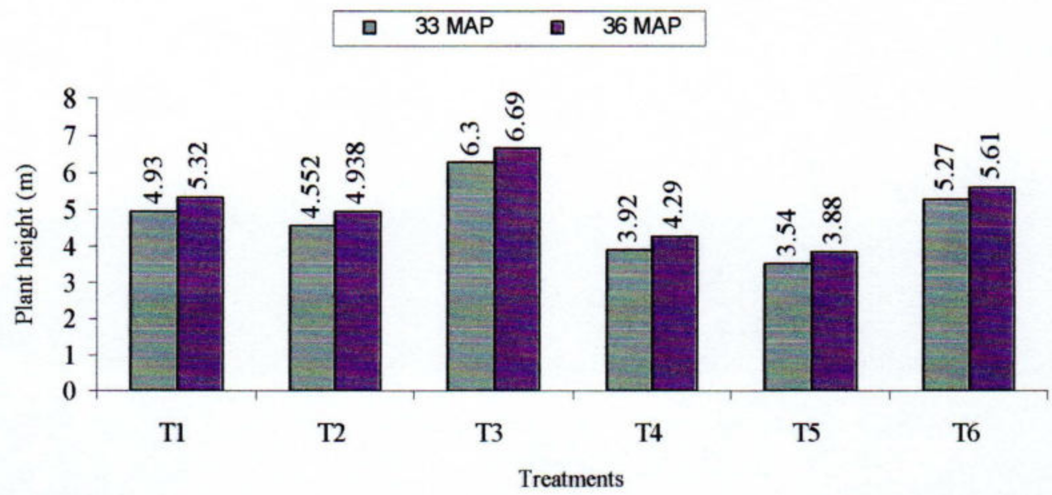

Fig. 8 Effect of management practices for lower storey crop (cane and okra) on the plant height of different tree species

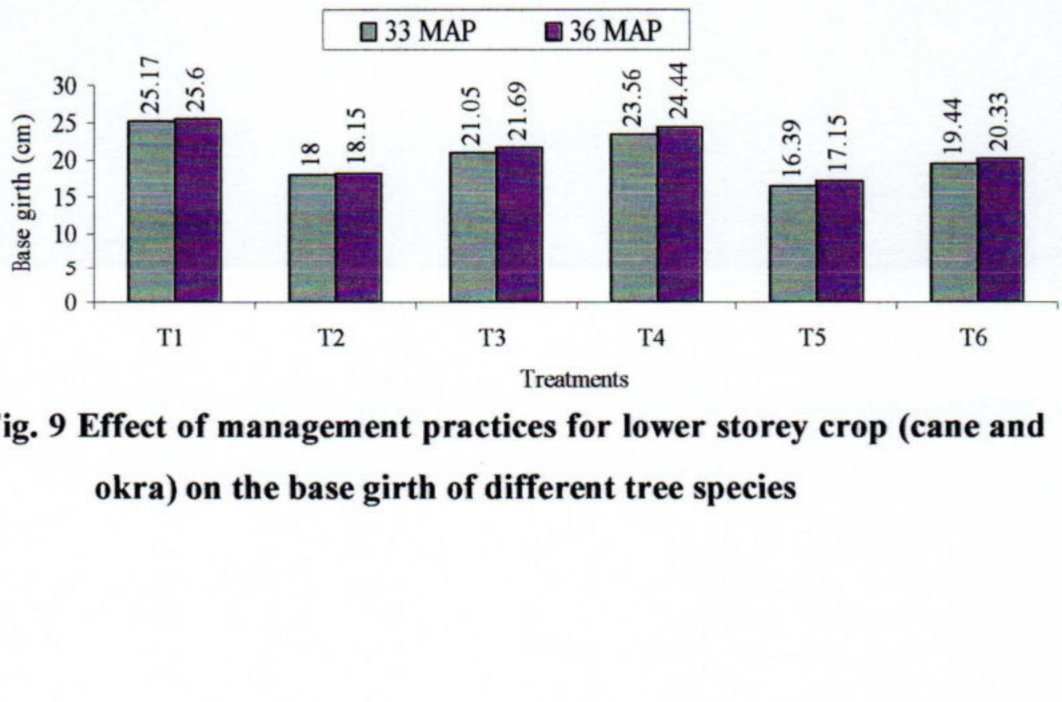

Fig. 9 Effect of management practices for lower storey crop (cane and okra) on the base girth of different tree species

Bole girth

Significantly, the biggest bole girth (cm) at 33and 36 MAPS were recorded at 18.00 and 20.71 cm respectively in T_3 (Eucalyptus). The significant smallest bole girth at 33 and 36 MAP were recorded 8.9 and 11.5 cm, respectively in T_5 (Deshi neem in open field) [Table – 4.7].

Girth at breast height

Significantly, the highest girth at breast height (m) at 33 and 36 MAP were recorded at 3.075 and 3.82 m, respectively in T_3 (Eucalyptus in multistorey). The significant lowest girth at breast height at 33 and 36 MAP were found 1.91 and 2.1 m, respectively in T_5 (Deshi neem in open field) [Table – 4.7].

Table 4.7 Effect of management practices for lower storey crop production on the bole girth and gbh (girth at breast height) of different cane species

Treatment	Bole girth (cm)		Girth at breast height (m)	
	33 MAP	36 MAP	33 MAP	36 MAP
T_1 (Mehogony in multistorey)	14.75b	17.16b	2.563b	3.043b
T_2 (Deshi neem in multistorey)	11.98c	13.05c	2.273b	2.555c
T_3 (Eucalyptus in multistorey)	18.00a	20.71a	3.075a	3.820a
T_4 (Mehogony in open field)	11.75c	15.1c	2.1d	2.68c
T_5 (Deshi neem in open field)	8.9d	11.5d	1.91e	2.1e
T_4 (Eucalyptus in open field)	15.0b	18.17b	2.5b	3.4b
Level of significance	**	**	**	**
LSD (0.05)	2.187	1.883	0.3328	0.3588

** 1% level of significance

* 5% level of significance

MAP= Month After Planting

CHAPTER 5
SUMMARY AND CONCLUSION

CHAPTER 5

SUMMARY AND CONCLUSION

The result of the present study revealed that the performance of okra in association with trees and cane species varied significantly. Morphological behaviour of okra i.e. plant height was the highest under Mehogony + Jali beth (127.8 cm) followed by Mehogony + Golla beth (112.8 cm), Deshi neem+ Bhudum beth (90.5 cm) , Mehogony + Udum beth (88.46 cm), Deshi neem + Jali beth (75.49cm) and open field (72.40 cm) but the poor performance was experienced in the combination of Deshi Neem + Golla beth (43.56 cm) at 90 DAS. On the contrary, yield of okra was highest in the open field (10.24 t ha-1) followed by Mehogony + Golla beth (T4) (7.685 t ha-1) and Mehogony + Udum beth (6.65 t ha-1) T2 combination. The lowest fruit yield of okra was found in the Eucalyptus + Jali beth (1.56 t ha-1) T11 combination.

Performance of different cane species tested significantly different in the multistoried agroforestry systems. Among the four cane species, the Jali beth performed in the best 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.

Production of okra is an innovation in cane based multistoried agroforestry system. Nevertheless, the result of the present study was achieved based on the trial of okra plant and specific cane species, which was of early aged

(3rd year) and hence, it may not be sufficient to asses the sustainability of the results obtained for further (4th year) production of okra in such a multistoried agroforestry practice. Similar experiment can be followed by summer tomato, egg plant etc. as the lower storey crop in the cane based multistoried agroforestry system.

From the interaction point of view, the Udum beth perform in terms of height (345.6cm), stem plant-1 (22.50) number of leaves plant-1 (275.0) etc. under Deshi neem followed by Jali beth (315.3 cm) + Deshi neem and Golla beth (303.3) + Deshi neem combination respectively at 24 MAP. Significantly the lowest potentiality of all cane species we found in open field .

The study also revealed that the cane species showed most synergestic effect over tree species and the severe antagonistic effect in okra with the multistoried system.

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APPENDICES

Appendix I: The physical and chemical properties of soil in Agroforestry farm HSTU, Dinajpur

Soil characters	Physical and chemical properties
Texture	
Sand (%)	65
Silt (%	30
Clay(%	5
Textural class	Sandy loam
CEC (meq/ 100g)	8.07
pH	5.35
Organic matter (%)	1.06
Total nitrogen (%)	0.10
Sodium (meq/ 100g)	0.06
Calcium (meq/ 100g)	1.30
Magnesium (meq/ 100g)	0.40
Potassium (meq/ 100g)	0.26
Phosphorus (μg/g)	24.0
Sulphur (μg/g)	3.2
Boron (μg/g)	0.27
Iron (μg/g)	5.30
Zinc (μg/g)	0.90

Source: Soil Resources Development Institute, Dinajpur (2007)

Appendix II. Monthly weather data of the experimental site during the period of April to July 2007

Month	** Air Temperature (^0C)			**Relative Humidity(%)	*Rainfall(mm)	*Sunshine(hrs)
	Maximum	Minimum	Average			
April/07	31.06	20.90	25.98	89.76	52.0	215.0
May/07	31.5	23.0	27.25	90.0	422.0	215.2
June/07	33.8	23.7	28.75	88.3	312.0	105.0
July/07	33.9	26.5	30.2	88.0	407.0	110.0

* Monthly Total

** Monthly Average

Source: Wheat Research Center (WRC), Nashipur, Dinajpur

Appendix III. Monthly average light intensity during April to July 2007

Month	Date	Light intensity in different time (LUX)			Total light intensity (LUX)	Average light intensity (LUX)	Monthly average light intensity (LUX)
		10 AM	12 AM	4 PM			
April, 2007	8.4.07	32200	38300	33100	103600	34533	34499
	15.4.07	30600	33500	30000	94100	31366	
	22.4.07	38200	42300	37600	118100	39366	
	29.4.07	31200	33700	33300	98200	32733	
May, 2007	6.5.07	36200	37600	35700	109500	36500	28891
	13.5..07	29700	37200	32400	99300	33100	
	20.5.07	22000	23200	22600	67800	22600	
	27.5.07	23800	24700	21600	70100	23366	
June, 2007	4.6.07	30200	33300	22800	86300	28766	40191
	11.6..07	42200	47300	41600	131100	43700	
	18.6..07	38800	47700	40100	126600	42200	
	25.6.07	40700	56200	41400	138300	46100	
July, 2007	01.7..07	41100	50800	42200	134100	44700	44624
	8.7.07	40700	48100	43300	132100	44033	
	15.7.07	41000	50200	40900	132100	44033	
	29.7.07	42200	52000	43000	137200	45733	

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

Appendix IV. Summary of analysis of variance (mean square) of plant height, leaf plant^{-1} and leaf size at different days after sowing (DAS) of okra plant

Source of variation	Degrees of freedom	Mean Square Values								
		Plant height (cm) at			Leaf plant^{-1} (No) at			Leaf size (cm^2) at		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Replication	1	0.012	4.95	0.351	5.63	0.50	41.28	584175.27	45.81	93.71
Treatment	12	39.35**	642.4**	1320.7**	4.49**	9.35*	18.95**	86864.33**	111479.51**	122081.72**
Error	12	1.72	4.88	8.77	0.08	2.50	1.50	14924.36	0.835	1.222

** 1% level of significance

* 5% level of significance

Appendix V. Summary of analysis of variance (mean square) of fruits plant^{-1}, fruit length, fruit girth, fruit weight plant^{-1}, single fruit weight, dry weight of fruits and yield of okra

Source of variation	Degrees of freedom	Mean Square Values						
		Fruits plant^{-1}	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g) plant^{-1}	Single fruit weight (g)	Dry weight of fruits (g)	Yield (t ha^{-1})
Replication	1	2.586	3.457	3.129	58.470	4.104	1.727	0.238
Treatment	12	16.269**	5.936**	0.743**	7590.052**	23.599**	1.179**	31.099**
Error	12	0.074	0.095	0.047	0.268	0.215	0.002	0.001

** 1% level of significance

* 5% level of significance

Appendix VI. Summary of analysis of variance (mean square) of plant height, stem plant^{-1} and leaves plant^{-1} at different month after planting (MAP) of cane species

Source of variation	Degrees of freedom	Mean Square Values					
		Plant height (cm) at		Stem plant^{-1} at		Leaves plant^{-1}	
		21 MAP	24 MAP	21 MAP	24 MAP	21 MAP	24 MAP
Replication	2	215.730	206.389	2.976	0.839	108.004	745.144
Cane Species (A)	3	25042.247**	42292.307**	128.819**	322.187**	17834.249**	54521.873**
Tree Species (B)	3	10703.635**	22306.997**	35.149**	104.638**	4610.986**	9429.888**
Interaction (A×B)	9	244.645**	763.300**	8.868**	38.489**	3188.400**	7572.731**
Error	30	1.068	1.390	2.089	1.553	2.083	203.159

** 1% level of significance

* 5% level of significance

Appendix VII. Summary of analysis of variance (mean square) of leaf length, leaf breadth and base girth at different month after planting (MAP) of cane species

Source of variation	Degrees of freedom	Mean Square Values					
		Leaf length (cm) at		Leaf breadth (cm) at		Base girth (cm)	
		21 MAP	24 MAP	21 MAP	24 MAP	21 MAP	24 MAP
Replication	2	360.716	1142.313	372.053	210.579	6.150	6.832
Cane Species (A)	3	1940.083**	7515.969**	3033.448**	2123.512**	174.834**	226.169**
Tree Species (B)	3	4627.087**	9592.944**	673.455**	2008.384**	35.394**	52.533**
Interaction (A×B)	9	45.169**	825.153**	51.103**	117.895**	2.055**	1.621**
Error	30	1.278	254.363	9.484	8.601	0.344	0.319

** 1% level of significance

* 5% level of significance

Appendix VIII. Summary of analysis of variance (mean square) of plant height and base girth at different month after planting (MAP) of tree species

Source of variation	Degrees of freedom	Mean Square Values			
		Plant height (m) at		Base girth (cm)	
		33 MAP	36 MAP	33 MAP	36 MAP
Replication	3	0.424	0.193	4.339	0.046
Tree Species	2	3.382*	3.396*	51.866**	1.628**.
Error	6	0.352	0.394	4.360	0.043

** 1% level of significant

* 5% level of significant

Appendix IX. Summary of analysis of variance (mean square) of bole girth and clear bole height at different month after planting (MAP) of tree species

Source of variation	Degrees of freedom	Mean Square Values			
		Bole girth (cm) at		Clear bole height (m)	
		33 MAP	36 MAP	33 MAP	36 MAP
Replication	3	3.252	4.827	0.032	0.046
Tree Species	2	36.317**	58.778**	0.661**	1.628**
Error	6	1.598	1.185	0.037	0.043

** 1% level of significance
* 5% level of significance

Appendix X. Plant height of okra at different DAS as the lower storied component of multistoried agroforestry system

Treatment	Plant height (cm) at		
	30 DAS	30 DAS	30 DAS
T_0 (Control)	25.20b	25.20b	25.20b
T_1 (Mehogony + Bhudum beth)	27.10ab	27.10ab	27.10ab
T_2 (Mehogony + Udum beth)	27.60ab	27.60ab	27.60ab
T_3 (Mehogony + Jali beth)	28.90a	28.90a	28.90a
T_4 (Mehogony + Golla beth)	28.30a	28.30a	28.30a
T_5 (Deshi Neem+ Bhudum beth)	24.95bc	24.95bc	24.95bc
T_6 (Deshi Neem + Udum beth)	22.15cd	22.15cd	22.15cd
T_7 (Deshi Neem + Jali beth)	19.99de	19.99de	19.99de
T_8 (Deshi Neem + Golla beth)	15.68f	15.68f	15.68f
T_9 (Eucalyptus+ Bhudum beth)	18.88e	18.88e	18.88e
T_{10} (Eucalyptus + Udum beth)	19.44de	19.44de	19.44de
T_{11} (Eucalyptus + Jali beth)	20.58de	20.58de	20.58de
T_{12} (Eucalyptus + Golla beth)	17.69ef	17.69ef	17.69ef
Level of Significance	**	**	**
LSD (0.05)	2.857	2.857	2.857

** 1% level of significance

Appendix XI. Fruit yield of okra as the lower storied component of multistoried agroforestry system

Treatment	Yield (t ha^{-1})
T_0 (Control)	10.24a
T_1 (Mehogony + Bhudum beth)	5.285d
T_2 (Mehogony + Udum beth)	6.650c
T_3 (Mehogony + Jali beth)	5.125e
T_4 (Mehogony + Golla beth)	7.685b
T_5 (Deshi Neem+ Bhudum beth)	2.450i
T_6 (Deshi Neem + Udum beth)	3.165g
T_7 (Deshi Neem + Jali beth)	2.370j
T_8 (Deshi Neem + Golla beth)	4.240f
T_9 (Eucalyptus+ Bhudum beth)	1.870l
T_{10} (Eucalyptus + Udum beth)	2.280k
T_{11} (Eucalyptus + Jali beth)	1.560m
T_{12} (Eucalyptus + Golla beth)	2.705h
Level of Significance	**
LSD (0.05)	0.06890

* *1% level of significance

* 5% level of significance

Appendix XII. Plant heights of different cane species in different month after planting (MAP) in open field

Cane species	Plant height (cm) at	
	21 MAP	24 MAP
C_1 (Bhudum beth)	198.5b	253.4b
C_2 (Udum beth)	170.2c	223.9c
C_3 (Jali beth)	236.5a	296.7a
C_4 (Golla beth)	128.3d	155.4d
Level of sig.	**	**
LSD (0.05)	1.723	1.966

Appendix XIII. Plant heights, stem plant^{-1} and leaves plant^{-1} of different cane species in different month after planting (MAP)

Treatment	Plant height (cm) at	
	21 MAP	24 MAP
T_0(Open field)	153.60c	176.6d
T_1 (Mehogony)	224.9a	279.7a
T_2 (Deshi neem)	178.2b	246.3b
T_3 (Eucalyptus)	176.8b	226.9c
Level of sig.	**	**
LSD (0.05)	1.723	1.966

** 1% level of significance

* 5% level of significance

MAP= Month After Planting

Appendix XIV. Interaction effect of cane species and trees on plant height and base girth cane in multistoried agroforestry system

Interaction	Plant height (cm) at		Base girth (cm) at	
	21 MAP	24 MAP	21 MAP	24 MAP
C_1T_0 (control x Bhudum beth)	175.2i	200.5k	12.01ef	13.12d
C_2T_0 (control x Udum beth)	238.2b	291.9d	14.80b	17.66b
C_3T_0 (control x Jali beth)	191.3f	269.8f	15.80a	18.66a
C_4T_0 (control x Golla beth)	189.4g	251.3g	13.50cd	14.71c
C_1T_1 (Mehogony x Bhudum beth)	130.5l	155.7l	9.50g	10.03f
C_2T_1 (Mehogony x Udum beth)	205.1e	273.4e	11.10f	13.69d
C_3T_1 (Mehogony x Jali beth)	179.7h	249.6g	13.86bc	14.86c
C_4T_1 (Mehogony x Golla beth)	165.6k	217.2i	10.09g	11.08e
C_1T_2 (Deshi neem x Bhudum beth)	203.7e	222.4h	4.120l	4.603i
C_2T_2(Deshi neem x Udum beth)	285.6a	345.6a	5.400k	6.100h
C_3T_2 (Deshi neem x Jali beth)	220.4d	315.3b	6.150jk	6.901h
C_4T_2 (Deshi neem x Golla beth)	236.4c	303.3c	4.180l	4.800i
C_1T_3 (Eucalyptus x Bhudum beth)	105.5o	127.6o	7.050ij	7.851g
C_2T_3 (Eucalyptus x Udum beth)	170.8j	207.9j	8.200h	11.50e
C_3T_3 (Eucalyptus x Jali beth)	121.4m	150.4m	12.73de	13.66d
C_4T_3 (Eucalyptus x Golla beth)	115.6n	135.6n	8.000hi	9.500f
Level of significance	**	**	**	**
LSD (0.05)	1.723	1.966	0.9780	0.9418

** 1% level of significance

* 5% level of significance

MAP= Month After Planting

Appendix XIV. Effect of management practices on different cane and okra on the plant height and base girth of different tree species

Tree species	Plant height (cm) at		Base girth (cm) at	
	33 MAP	36 MAP	33 MAP	36 MAP
T_1 (Mehogony in multistorey)	4.930b	5.320b	25.17a	25.60a
T_2 (Deshi neem in multistorey)	4.552b	4.938b	18.00b	18.15b
T_3 (Eucalyptus in multistorey)	6.300a	6.690a	21.05b	21.69ab
T_4 (Mehogony in open field)	3.92b	4.29b	23.56a	24.44a
T_5 (Deshi neem in open field)	3.54b	3.88b	16.39b	17.15b
T_6 (Eucalyptus in open field)	5.27a	5.61a	19.44b	20.33b
Level of sig.	*	*	**	*
LSD (0.05)	1.027	1.086	3.613	4.364

** 1% level of significance

* 5% level of significance

MAP= Month After Planting