PERFORMANCE OF CABBAGE AND CAULIFLOWER UNDER TWO MULTIPURPOSE TREE SPECIES

A Thesis

By

PONKOJ LAKRA

Student no. 0705010

Session: 2007-08
Thesis Semester: January-June, 2008

MASTER OF SCIENCE (M.S.)
IN
AGROFORESTRY

DEPARTMENT OF AGROFORESTRY
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY
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Submitted to the Department of Agro forestry, Hajee Mohammad Danesh Science and Technology University, Dinajpur in partial fulfillment of the requirements for the degree of

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The Author

Performance of Cabbage and Cauliflower under Two Multipurpose Tree Species

ABSTRACT

A field experiment was conducted at the Agroforestry Farm, Department of Agroforestry, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during 24th November 2007 to 24th February 2008 to evaluate the performance of cabbage and cauliflower under two multipurpose trees .i.e.black siris *(Albezia lebbeck)* and mango *(Mangifera indic*a) .There was also a control plot (open field). Local variety of cabbage and cauliflower were used as test crops. The experiment was laid out in RCBD with three replications. The data were collected at 20, 40, and 60 DAT (day after transplanting) for growth parameter. The significant effect of different tree association was found in the following growth characteristics i.e number of outer leaf, leaf breath, leaf weight, plant height, root length curd size of cauliflower and head size of cabbage At 80 DAP (at harvesting time) growth and yield contributing characteristics were measured. It was recorded that in partial shade condition the higher yield of cabbage would produced (28.33t/ha) and cauliflower (38.33t/ha) were recorded in mango field than black siris. Both the crops showed significantly the lowest yield potential under black series and the values were 18.50t/ha and 28.50 t/ha for cabbage and cauliflower respectively. The study revealed that both cabbage and cauliflower can be produced under 4 years old mango tree without significant yield loss as compared to open field but the yield of cauliflower (38.33 t/ha) were greater than that of cabbage. The black siris created approximately 55-60 % shade was not found suitable for cabbage and cauliflower production. Hence it can be advocated that production of cauliflower with early aged (up to 4 years) mango tree created around 45-50% shade could be profitable agroforestry practice.

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CHAPTER 1

INTRODUCTION

Agroforestry has been a collective term for land-use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land-management unit, either in a spatial mixture or a temporal sequence. The trees in agroforestry practices generally fulfill multiple purposes, involving the protection of the soil or improvement of its fertility, as well as the production of one or more products (Cooper *et al.,* 1996). The domestication of these agroforestry trees should enhance their capacity to fulfill either or both of these service or production functions. Domestication should also aim at increasing the social and economic benefits of agroforestry; through improved profitability, reduced risks and diversified sources of income to buffer against crop failure (Sanchez, 1995). This will act as an incentive for adoption by farmers.

It is very important and essential in order to develop a nation in all respect. Human nutrition is one of the best ways for this. Remarkably vegetables may play a vital role in this aspect. Now a day the important of vegetables has been recognized as an item of daily human diet all over the world and is playing a significant role in providing taste, palatability, variability and increase appetite. On the other hand vegetables are containing of minerals, vitamins and essential amino acids. That is why vegetables are known as one of the most important groups of food crops having features of high nutrition value and higher fiscal gain. Vegetables are considered as a cheap natural source of supplementary food and also can be grown in a small area in short duration. Vegetable production creates opportunities for employment.

Nearly 150 different crops are grown in Bangladesh of which about 100 are vegetables (Rashid, 1999). But these excluding cauliflower occupy only 2.6% of the arable lands with an annual production of 1.38 million tons (BBS, 2006). On the other hand annual production of cabbage production was 1.76 million tons (BBS, 2006). Here, cereals and vegetables are produced at the ratio of 5: 1 including roots and tubers. But in many developing countries it is nearly 1: 2 (Siddique and Aditya, 1992).

The average consumption of vegetables in Bangladesh aspect is only 70 g per capita per day including potato and sweet potato. Except tuber crops, it is only 30 g as against the FAO recommendation of 200 g. To supply the minimum daily requirement of 200 gm vegetables/ capita/day, national production of vegetables should be over 10 million tons. In addition, population of Bangladesh is increasing rapidly; therefore, demand of vegetables is increasing simultaneously.

In order to meet the food deficit of Bangladesh (especially vegetable) and to cope with the demand of food for the increasing population vegetable production need to increase. On the other hand fruit, fodder, fuel, timber, constriction and raw materials requirement is a crying need. There is no scope to increase monoculture crop command area horizontally. So production of vegetables and forest along with fruit species would be an alternative to meet the entire requirement. Before adopting this sustainable agroforewstry production system by the farmer tree-crop interaction effect and production potential must be studied from scientific point of view.

Keeping this view in mind the research has been under taken to assess the following objectives-

i) To characterize the growth and yield behavior of cabbage and Cauliflower under Black siris, and Mango tree and

ii) To select the better tree vegetable combination for advocacy of large scale Agroforestry practice.

CHAPTER 2

REVIEW OF LITERATURE

The research was carried out to observe the performance of cabbage and cauliflower under various shade and multipurpose tree species. In recent times, the modern practices of Agroforestry are extended in the vegetable field in Bangladesh. The farmers are growing tree in the crop field to get maximum benefit. But tree directly influence vegetable's yield. Literatures 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 Concepts of Agroforestry

Agroforestry is an age-old and ancient practice. It is an integral part of the traditional farming systems in Bangladesh. The concept of agroforestry probably originate from the realization that trees play an important role in protecting the long range interests of agriculture and in making agriculture economically viable. The emergence of agroforestry was mainly influenced by the need to maximize the utilization of soil resources through the "marriage of forestry and agriculture" (PCARRD, 1983). Agriculture and forestry were considered before as two distinct areas but these practices are now considered as complementary. This was brought about by the increasing realization that agroforestry can become an important component of ecological, social and economic development efforts.

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 agro forestry in different ways. A widely used definition given by the International Council for Research in Agro forestry (Nair, 1983) 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 agricultural crops or animals either in some forms of spatial arrangement or temporal sequence.

Saxena (1984) pointed out that agroforestry utilizes the inter spaces between tree rows for intercropping with agricultural crops and this does not impair the growth and development of the trees but enable farmers to derive extra income in addition to benefits accrued from the use of fuel and timber from trees.

From a bio-economic point of view, Harou (1983) stated that

agroforestry is a combined agriculture-tree crop farming system which enables a farmers or land user to make more effective use of his land which may yield a higher net economic return on a sustainable basis.

From a business point of view agroforestry is an economic enterprise which aims to produce a combination of agricultural and forest crops simultaneously on the same land area.

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

MacDicken and Vergara (1990) state that agroforestry in a means of managing or using land (i.e., a land use system) that combines trees or shrubs with agricultural/horticultural crops and/or livestock.

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). 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 aesthetic value (Rang *et al.,* 1990).

Trees are grown in the crop land, homestead, orchard not only produce food, fruits, fodder, fuel wood or to generate cash for various purpose (Chowdhury and Satter, 1993) but also gives better living environment (Haque, 1996).

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

2.2 Tree-crop interaction

Khan and Aslam (1974) studied the effect of single sissoo (*Dalbergia sissoo*) tree on the yield of wheat crop. Yield was from plots within a quadrate of $1m^2$. The quadrates were taken at a distance of 3m, 4.5m and

6m from the base of tree. One quadrate was taken from the center of the field, that is, well away from the influence of trees involved. The grain yield showed a decrease of 30.88%, 23.6% and 12.7% at the distance of 3, 4.3 and 6m, respectively as compared to the open field. Both the tree and the crops were raised under irrigated condition.

Scott (1987) investigated the *Inga edulis* rows reduced rice yield 50% compared with those in rows farthest away. A follow up research was designed to observe the effect of *Inga edulis* on upland rice yield. It was known that *Inga edulis* has a pronounced effect reducing rice yields by 50% up to 2.5m away; beyond that, yield were similar to those in rows 6m away (Palm *et al.,* 1992).

Dhukia *et al.* (1988) observed that in the rabi season of 1984-87, four fodder crops (*Trifolium alexandrium*, oats, *Vicia faba* and *Trifolium foenum-graecum)* and 2 field crops (*Triticum aestivum* and *Cicer arietinum*) were grown under *Dalbergia sissoo* and *Albizia lebbeck.* Among the fodder crops the highest fresh fodder and dry matter yields under both plantations were given by *Trifolium alexandrium* followed by oats. The yields decreased less than 4 years old trees compared with those less than 3 years old trees. Wheat gave higher yields than *Cicear* *arietinum* under both plantations. Yields of all crops under the *Dalbergia sissoo* plantation were higher than under the *Albizia lebbeck* plantation.

Hazra and Tripathi (1989) reported that four oat cultivars were grown under the canopy of different trees and in open plots of a suitable cultivar for cultivation under an agroforestry system. Cv. OL- 189 and OL- 125 gave the highest fodder yields under different trees. The average yields were 95% under *Albizia lebbeck*, 90% under *Hardwickia* binarta, 88% under *Acacia nilotica*, and 74% under *Melia azadirachta* (*Azadirachta indica*), compared with the open plot yields. The PAR received under the 4 trees canopies was 90, 87, 80 and 63%, respectively of suitable for cultivation in agroforestry system especially under *A. lebbeck.*

Basri *et al.* (1990) observed that hedgerow trees competed for nutrients and light with upland rice crops to a significant extent. Competition was most severe in the 2-3 rice rows closed in the hedgerows where yields were reduced by 50-70% compared with those in the center of the alley.

Garrity *et al*. (1992) observed that in an alley cropping system yield depression of upland rice was obtained in the zone near the hedgerows although plant height did not affected much. Results of three-year trial indicated that *Geliricida sepium* exhibited the lowest yield depression on upland rice in rows near the hedges.

Studies at ICRAF's research filed with *Leucaena lucocephala* and maize showed that total maize yields under improved trees were only 50% of the sole maize yield which increased to 80% due to pruning (Ong *et al.*, 1992) indicating the benefits of pruning in reducing tree-crop competition.

Puri and Bangarwa (1993) studied wheat yield in agroforestry system. He collected data on crop yield from each tree species at different distances 1, 3, 5 and 7m) and in 4 directions (east, west, north and south) from the tree bases and control. The results indicated that *Azadirachta indica* and *Prosopis cineraria* did not make any significant difference to wheat yield. While *Acacia nilotica* reduced yield by 4-30%, but reduction was only up to a distance of 3m. In general, the effect of trees on wheat yield was observed up to 3m distances and there was little effect from 3 to 5m distances, and almost no effect at 7m distances. In all the tree species, the wheat yield was reduced to a maximum on the north side of trees and had almost no effect in the southern direction.

Khan and Ehrenreich (1994) determined the influence of boundary planting of *Acacia nilotica* on the growth and yield of associated rice (*oryza sativa*) crops under irrigated condition. The results indicated that close proximity to trees adversely affected tillers m^{-2}, grains $panicle^{-1}$ or 1000-grain weight, but grain yield were slightly lowest near largest trees.

Shading effect can be minimized by proper orientation of rows, side or top pruning of trees in the outer of plots, having larger plots for crops and isolating sole-crop plots from tree plot (Rao and Govindarajan, 1996).

Reports of trees that are deliberately maintained in upland rice (*Oryza sativa*) fields are rare. Hocking and Islam (1995) reported the growing of trees like *Acacia nilotica, Acacia catechu,* and *Borassus flabellifer* in rice paddy fields in Bangladesh. Jambulingam and Fernandes (1988) have documented the cultivation of *Acacia nilotica* trees on rice bunds (raised risers) in Tanjavur reports on the practice of maintaining *Acacia nilotica* trees in upland rice fields in the Chhattisgarh region are also available (Jena, 1991; Puri *et al.,* 1994; Viswanath *et al.,* 1998).

2.3 Importance of Light in Agroforestry

Okigbo and Greenland (1976) and Okigbo (1980) identified more efficient use of light resource by plants of different heights and canopy structures as one of the advantage to be gained by growing crops in mixed stands.

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

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

The yield advantage of conventional intercropping has been explained in terms of improved capture of utilization of growth resources (Willy *et al.*, 1986). The resource capture by agro forestry systems will probably be greater than in sole crops (Ong *et al.,* 1991).

Limiting light (shade) is obviously the most important factor that cause poor performance of under storey crops. The key to the development of compatible tree crop combination in agroforestry is greater light interception by under storey crops. In India, it is widely believed that shading by trees is responsible for poor yields of associated crops (Ong *et al.*, 1992).

The severity of competition in agroforestry system, ultimately crop yield is dependent upon the partitioning of resources, primarily of light and water between trees and crops (Howord *et al.,* 1995).

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 is required to facilitate the development of improved systems in terms of species combinations, planting arrangement and management (Howord *et al.,* 1995).

2.4 Characteristics of Tree Species in Agro forestry Systems

Selection of Suitable tree species is vital factor in an agroforestry system. Nair (1980) considered the most choice of suitable plants species that can grown together as important factor in ensuring the sources of agro forestry. The most appropriate species for this system remains an open question for research. King (1979) listed the characteristics at tree species that should be grown with agricultural crops:

a) They should tolerate relatively high incidence of pruning.

b) They should have a low crown diameter to bole diameter ratio.

c) They should be light branching in their habit.

d) They should be tolerant of side shade.

e) Their phylotaxiy should permit penetration of the light on the ground.

f) Their phenology, particularly with reference to leaf flushing and leaf fall, should be advantageous to growth of the annual crop in conjunction with which their being raised.

g) The rate litter fall and litter decomposition should have positive effect on the soil.

h) The above ground changes over time in structure and morphology should be such that retain or improve those characteristics which reduce competition for solar energy, nutrient and water.

i) Their root systems and root growth characteristics should ideally result in exploration of soil layers that are different to those being tapped by agricultural crops.

Rachie (1983) pointed out the following factors to be considered during the selection of woody legumes for intercropping with annuals in the low land tropics:

i) Ease of establishment from seeds or seedlings.
ii) Rapid growth and high productivity of foliage and wood.
iii) Limited maximum size (may be optimum in small trees).
iv) Good coppicing ability (regrowth following topping).
v) Effective nutrient recycling abilities especially di-nitrogenfixation.
vi) Multiple uses: food, feed, fire wood, construction materials and other products and service (shade, shelter etc.).
vii) Minimum competition with shallow rooted annual crops.
viii) Small leaflets readily detached when dried and quickly decomposed when used as fertilizer.
ix) A high proportion of leaves to secondary branches.
x) Free from pests and diseases and
xi) Ease of control of eventual elimination.

Purohit (1984) suggested to selecting those species which would (i) not compete for moisture, space and air (ii) supply nitrogen in the soil (iii) provide food, fodder, fuel and timber (iv) maintain proper ecosystems (v) have no toxic effects to the crops; and (vi) have thin and erect leaves. Singh (1984) opined that suitable species should be multipurpose, well-adapted to different sites, easy to establish: have nitrogen-fixing ability, rapid growth and ability to coppice.

Hegde and MacDicken (1990) pointed out some criteria for planting trees under the agroforestry system: (i) Non-Interference with arable crops. (ii) Easy establishment (iii) Fast growth and short gestation period (iv) Non-Allelopathic effects on arable crops, (v) Ability to Atmospheric nitrogen (vi) Easy decomposition of litter (Ability to litter, (vii) Ability to withstand frequent lopping (viii) Multiple uses and high returns, and (ix) Ability to generate employment.

However, it is not possible to select having all the above mentioned criteria. Therefore, researchers should select which have most of the points and which are adapted to local soil and environmental conditions.

2.5 Performance of Crop in Agroforestry Systems

The response of different crops to the agroforestry systems was different. The performance of field crops in agroforestry systems is influenced by the tree and crop species and their compatibility, spacing between tree lines, management practices, soil and climatic factors.

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

Fifty per cent shading during ear formation and milking stage of rice decreased yield by 48% and 18%, respectively (Park and Kwon, 1975).

Nayak and Murty (1980) reported that yield reduction of rice by 47, 57 and 74 percent in 75, 50 and 25 percent of normal light, respectively. This was mosltly due to impaired dry matter production, panicle number and grains per panicle.

Yamoah *et al.* (1986) reported that maize heigh, stover and cob weights were reduced (though insignificantly) in maize rows close to the shrub hedgerows compared with those in the middle of the alley.

Jadhav (1987) reported that partial shading (45-50% of normal light) at 15 days after transplanting reduced grain yield of rice by 73 percent because of reduction in number of penicles per plant (51.5%), number of grain per penicle (16.7%) and increase in number of unfilled spiklets (42.1%) in 25 rice cultivars.

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

Akber *et al.* (1990) reported that wheat yield under different tree species (*E. camaldulensis*, Mulberry, Siris, Ipil-ipil) did not show any significant difference as compared to control yield.

The influence of *Acacia nilotica* on the growth and yield of associated wheat crop under irrigated condition in India was examined by Sharma and Tiware (1992). He reported that the tree line did negatively affect all crop parameters like yield in the vicinity of trees and established that as the distance from the tree line increased the growth and yield of wheat also increased.

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 percent and 11-37 percent for rice and mungbean, respectively.

Nazir *et al.* (1993) conducted a trial in Pakistan, rice was sown parallel to *Dalbergia sissoo* trees at distance which gave 0.2, 3, 4, 5, 6, 7, and 8 hour to shade/ day. Increasing duration at shading decreased plant height, number of fertile tillers $unit^{-1}$ area, number of grains/ spike, 1000-grain weight, grain protein concentration and percentage DM and grain yield. Yield was 2.99, 2.96, 2.11, 2.57, 2.4, 2.12, 164 and 1.32 t /ha with 0.2, 3, 4, 5, 6, 7 and 8 hr. shade /day respectively.

Jiang *et al.* (1994) reported that tree crown had no significant effect on the number of effective spikelets and grains of rice but it affected total grain yield and 1000-grain weight, with the size of the effect on crop, depending on the distance from the trees.

Miah *et al.* (1995) reported that the mean light availability on crop rows decreased as they approached the trees rows across the alleys. The rate of decrease was greater in unpruned that in pruned alleys. Rice and mungbean yield decreased linearly with the reduced percent light incidence, rice yields decreased 47 kg/ha and mungbean yields decreased

10 kg/ha. In pruning regimes, mungbean yields decreased more in pruned conditions (13 kg/h) than in unpruned condition (9 kg/ha).

Growth of trees and seasonal yields of understorey crops were measured by Hocking *et al.* (1998) over a five year period for 4 crops grown under 17 tree species at 8 x 8 m spacing in wetland rice field. All tree species grew well in rice fields, at rates comparable to their growth in forest plantations. Top and rood pruning reduced average tree girths by up to 19% and average tree volume b up to 41% depending on intensity of pruning. The crops monitored were *Oryza sativa*, *Triticum aestivum*, *Corchorus oletorius*, and *lens culinaris*. Crop yields under the trees average 93% of the corresponding yield outside the tree canopy.

Solanki (1998) stated that fruit trees and crops are grown together in various ways. Depending on the pattern and configuration, these companion crops are known as intercrops, under planting, hedgerow planting or alley cropping. In an agroforestry system where agricultural crops are normally grown between rows of fruit trees, the agricultural crops provide seasonal revenue, whereas fruit trees managed for 30-35 years giving regular returns of fruit and in some cases fuel wood from pruned wood and fodder. Several kinds of crops are also under planted to take the advantage of shade provide by the canopy of fruit trees.

Nandal *et al.* (1999) had grown 5 rice cultivars under the *Sissoo* tree. In their experiment grain yield, dry matter yield, leaf area index, spiklets m^{-1}, grain spike^{-1} and test weight were reduced under the tree canopy compared with crops growing in the open place.

Pandey *et al.* (1999) reported that rice yield was positively related to distance from the tree. Impact of the trees was maximum at 2m distance from the tree crop yield reduced by 44% and declined with increasing the distance (to 14% reduction at 8 m). There was an increase relationship between the percentage decrease in the parameters and the distance indicating that the greater the distance the smaller the effect of the tree.

Time tested, indigenous land use systems can provide valuable information for the design of ecologically sustainable and socially acceptable agro forestry systems. One such traditional system is the growing of *Acacia nilotica* (L.) Willd. Ex Delile trees, locally known as babul, in rice fields of smallholder farmers in Madhya Pradesh State of central India, an area with subhumid monsoon climate and hot summer.

The functional characteristics of the system were collected through participatory rural appraisal involving intensive interactions with farmers in the region during six years, and through a structured-questionnaire survey in 25 villages, involving a total of 200 farm families. The farms had an average of 20 babul trees, ranging in age from <1 to 12 years, per hectare in upland rice fields, the tree-stand density being greater on smaller than of larger farms (>8 ha). Over a ten year rotation period, the trees provide a variety of products such as fuel wood (30 kg/tree), brushwood for fencing (4 kg/tree), small timber for farm implements and furniture (0.2 cu.m), and non-timber products such as gum and seeds.

The babul + rice system was extimated to have a benefit/cost (B/C) ratio of 1.47 and an internal rate of return (IRR) of 33% at 12% annual discount rate during a ten-year period, though at a low level of income. Babul trees account for nearly 10% of the annual farm income of smallholder farmers (<2 ha). By practicing the agroforestry (rice+babul) system, farmers get higher cash returns on a short-term (10 year) harvest cycle of trees, and the labour input (both family-and hired) on farms was distributed more uniformly throughout the year than in rice monoculture. Purchased inputs are seldom used in the system. The ease of management of the system, the self-generating and robust nature of the tree and the multiple products and services it provides, and easy marketability of the products are the major factors that encourage farmers to adopt the system. Furthermore, the farmers have secure ownership rights to their farms. In spite of its long history and tradition as a sustainable approach to land

use, the system has not attracted the attention of development agencies. More detailed investigations on its social, economic, and cultural attributes are warranted to not only improve this system, but provide insights into farmer adoption of agroforestry innovations
(Viswanath *et al.,* 2000).

Samsuzzaman *et al.* (2002) carried out three studies in Bangladesh to find out the effect of tree species on crops and alternative management practices for better system productivity. The first experiment revealed that the highest yield of mustard (0.788 t/ha) and rice (2.89 t /ha) was obtained under *Albizia lebbock* trees and *Acacia nilotica*, respectively. The result of the second experiment indicated that the lower reduction in yield of adjacent crop with wider the tree spacing the result of the third experiment showed that root and shoot pruning increased the grain yieldof wheat by 22%. The highest increase in the yield of rice (27%) and radish (72%) were obtained due to pruning of *Acacia nilotica* two and three times a year respectively. Pruning of *Albizia lebbeck* three times a year contributed to the highest increase in rice (50%) and radish (35%) yields.

2.6 Importance of studied of Cabbage

Cabbage: The cabbage *(Brassica oleracea* var. *capitata Linn.*) is an important winter vegetable crop in Bangladesh. The climatic adaptability of the crop is so wide that its commercial cultivation is possible over a wide range of temperature, varying from 5 to 21° C. A long period of cold treatment induces the plants to bolt sooner and flower more abundantly (Rashid, 1976). In Bangladesh, winter is very short but is long enough for cabbage heads to mature. In 96-97, total production of cabbage was 106655 m ton from 26425 acre land which was the third highest production of winter vegetable in Bangladesh of that year (Anon, 1998).

It is mostly employed as culinary and dietic. It is used alone or mixed with potatoes for vegetable purposes. It is also used in curries, pickles etc. It may be used for feeding stock and chicken. "Sauerkraut' a favourite food in Russia, Germany and U.S.A., is made by fermenting chopped, ground, or sliced cabbage in its own juice, with a little salt added to it (Chauhan, 1989). From the nutrition point of view, it ranks very high.

According to Chatfield (1954) Watt and Merrill (1964) it contains the following nutrients per 100 grams fresh edible portion.

Nutrient composition	Content (per 100 g of edible portion)	Nutrient composition	Content (per 100 g of edible portion)
Water	92.1 gm	Vit. A	0.7 mgm
Protein	1.4 gm	FA	0.8 mgm
Total Fat	0.2 gm	Na	13 mgm
Total Carbohydrate	5.7 gm	K	227 mgm
Fibre	1.5 gm	Ca	26 mgm
Vitamin A	70 IU	Mg	23 mgm
Vitamin B1	0.05mgm	Fe	0.5mgm
Vitamin B2	0.04 mgm	P	28mgm
Vitamin B6	0.11 mgm	Cl	87 mgm
Vitamin C	46.00 mgm		

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 Experimental Plot

The site of the experiment is situated between 25°13' latitude and 88°23' longitude at the elevation of 37.5m above the sea level. The experimental plots were laid out at the Agroforestry Farm, Department of agro forestry, Hajee Mohammad Danesh Science and Technology University, Dinajpur.

3.2 Experimental Period

Duration of the experiential period was from 24 November, 2007 to 24 February, 2008.

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3.3 Soil Characteristics

The experiment was laid out in a medium high land belonging to the AEZ Old Himalayan Piedmont Flood Plain area. The soil texture was sandy loam with p^H 5.35 the structural class of the soil was fine and the organic matter content was around 1.06%. The characteristics of the soil were previously tested in the Soil Resource Development Institute (SRDI), Dinajpur (Appendix-I).

3.4 Climate and Weather

The climate of the study area is characterized by scanty rainfall during rabi season (November to February) and minimum rainfall (8.8 mm). The mean of maximum temperature in winter (November to February) was 27.69 °C and the mean of minimum temperature 17°C. The mean humidity during this period was 86.69 mm was found during this period from November to February. (Appendix-II).

3.5 Experimental Design and Treatment

Two vegetables such as cabbage and cauliflower were planted as an individual experiment following Randomized Complete Block Design (RCBD) with three replications. In each vegetable total number of experimental plots were 45. The size of each unit plot was (2.5 x 2.5 m) 6.25 m^2. Thirty plots were laid under the trees and 15 plots were laid in control (open field).

Tree species were as follows:

T_1 = Open field

T_2 = Mango (*Mangifera indica*)

T_3 = Black siris (*Albizia lebbeck*)

Test crops:

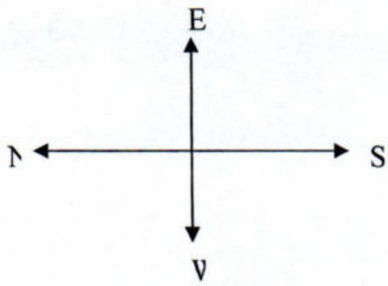
i) **Cabbage (local variety)**

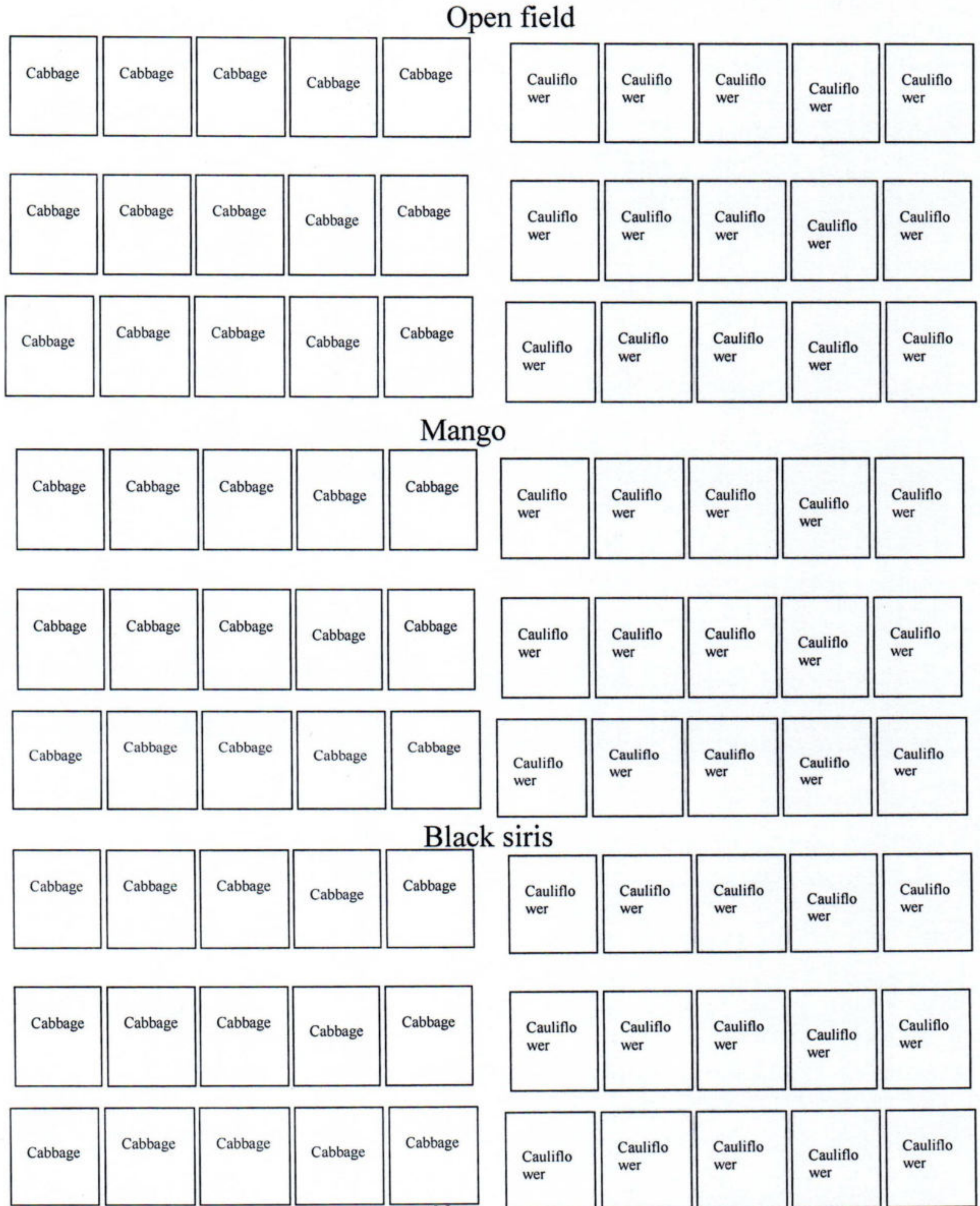
ii) **Cauliflower (local variety)**

3.6 Land Preparation

The experimental field was opened with a spade on 14 November 2007. The land was spaded several times followed by hammering to obtain good tilth. All the weeds and other major rubbishes were removed from the field and then left exposed to natural weathering for several days before the land was finally prepared for seedling transplanting.

Layout of the Experimental plot:
Plot size: 2.25 × 2.25 m^2
No. of replication: 3
Total number of plot: 45





3.7 Fertilizer Application

The following fertilizer and manure doses were applied in the field according to recommended doses as Razzaque *et al.* (2000).

Types of Fertilizer	Recommended dose kg/ha
Urea	180kg
TSP	100 kg
MP	70kg
Gypsum	60kg
Cow dung	7-10 ton/ha

One-third of urea and entire amount of other fertilizers were applied as basal dose at the time of final land preparation. The individual plot was spaded and fertilizers were incorporated before seedling transplanting. The remaining two-third of urea was top dressed in to equal splits at early tillering and late tillering stages after weeding followed by irrigation.

3.8 Weeding and irrigation

The experimental plots were kept weed free by weeding frequently. The plots were irrigated whenever needed spinkler by using hose pipe for top supply as sufficient soil moisture is essential for the vegetables.

3.9 Description and importance of the Trees used in the Study

3.9.1 Black siris (*Albizia lebbeck*):

Description: It is belongs to the family Leguminosae (Mimosoideae) a moderate to large deciduous tree with a straight bole and broad crown. In the open area, the tree forms a short bole, branching low down with a broad crown, but in the forests when drawn up by other trees, it produces a long straight bole. In Andamans,it is found at its best attaining a height of 20-30 m and a girth of 2-3 m in the dry zone, it grows to smaller dimensions generally 1.2 m to 1.5 m in girth,13-15 m height with a 4.0 m clean bole. It produces white flowers in heads. The long dry straw colored pods are characteristics and rustle in a breeze. It is nearly leafless in part of the year (R.K. Luna.1993).

Importance

Young plants are capable of standing a moderate amount of shade. However, for its best development, the tree requires full over-head light from the very beginning. The root system is largely superficial and may produce root suckers if the roots are exposed. It coppices very well. The seedlings are not very frost tender, the leading shoots may be killed black during severe frost. Young plants are sensitive to drought. Due to its shallow root system, the trees are liable to be blown down by wind.

Through deciduous, it has a heavy crown during the letter part of hot season and suppresses the grass quite well.

Uses: The timber is used for high class furniture. Cabinet work**,** interior decoration, penelling etc. It is suitable for building purpose, agricultural implements, tool handles, flooring, paneling and railway carriages. It is fairly suitable for tennis racquets and opium chests. It is also suitable for carving and turnery articles, house posts, picture frames etc.

The existing tree growth status is given below-

i. **Average plant height 5.10 miter**

ii. **Average basal diameter 10.01 cm**

iii. **Average canopy diameter 130 cm**

3.9.2 Mango trees (*Mangifera indica*):

Description: Mango is one of the important members of the family Anacardiaceae, a large evergreen tree with a dense dome-shaped crown, up to 45 m high and 3.6 m in girth with a short, stout straight bole when grown in the open. In the high forest, it tends to form a clear bole of 12 m and over. Bark is smooth and brown when young, becomes rough, thick, dark grey and rugose with age. Leaves crowded at the ends of the branches, 10-30 cm by 2-10 cm oblong, bluntly acuminate, dark glossy green, pinkish when young, emit aromatic and resinous smell when crushed, base acute, petiole seollen at the base. Panicles conical, flowers small, greenish-yellow, scented, male and bisexual on the same panicle. Fruit a fleshy drupe, 5-20 cm long, or more, generally yellow when ripe containing one seed. Stone compressed, longitudinally furrowed, covered with hard fibrous endocarp. There is a great variation in the fruit size, colour, flavour and other characters among the number of varieties of mango found in the different parts of India. (Bose, *et. al.* 2004).

Importance:

Mango is a shade-bearer tree. It withstands normal frosts but suffers both from severe droughts to frosts. Temperatures above 45 degree celcious accompanied by strong winds damage the fruit, requiring wind breaks around orchards. Large trees withstand fire well. It is easily killed by girdling. In southern India, the bark on the western side often gets cracked by hot winds and dries up making possible the entry of white ants. It does not thrive in very dry localities and for this reason it becomes partially deciduous in such areas.

Uses: The wood is extensively used for low-cost furniture. floor, cejling boards, window frames, heavy packing cases, match splints, brush backs, oar blades, agricultural implements etc. Also suitable for tea chest plywood after preservative treatment. It can be used as a substitute for teak as beams, rafters, trusses and door and window frames. A hard charcoal of high calorific value is obtained from mango wood.

The existing tree growth status is given below-

i. **Average plant height 2.56 miter**

ii. **Average basal diameter 6.06 cm**

iii. **Average canopy diameter 112.6 cm**

3.10 Sampling Procedure and Data collection

For both cabbage and cauliflower same procedure of data collection was followed. Ten representative plant samples of the test crops were selected randomly from each plot. These sample plants were used for data collection. The collected data were outer leaf length, outer leaf breadth, and number of outer leaves per plant, fresh weight, dry weight of outer leaves, head / curd length, head / curd breadth, head/curd fresh and dry yield. The yield per plant was converted in to ton/ha. For dry yield, 100 g sub samples were oven dried at 70 ° C for 72 hours. Total dry yield was calculated using the following formula:

$$\textbf{Total dry weight (yield)} = \frac{\textbf{Sub sample oven dried weight}}{\textbf{Sub sample fresh weight}} \times \textbf{total fresh weight}$$

Total dry matter (TDM) was calculated from the sum of dry yield of each plant part. i.e.Total dry matter= dry wt.of root +dry wt. of stem + dry wt. of outer leaf+ dry wt.of head/ curd.

3.11 statistical analyses

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

CHAPTER 4

RESULTS AND DISCUSSION

The results obtained from the present study along with statistical analyses of data have been presented and discussed in this chapter. The present study regarding shading effect of mango and black siris. On the performance of cabbage and cauliflower was presented . The summery of analysis of variance for all yield contributing characters and growth parameters studied have been presented here.

4.1 Performance of cabbage

Growth and yield performance of cabbage were significantly affected by the partial shade of mango and heavy shade of black siris. The results were described below.

4.1.1 Outer leaf length

There was no significant different on outer leaf length among the treatments (Table 1). The longest (29.00 cm) outer leaf length was found under heaviest shade of black siris which was followed by that of produced under mango (26.33 cm). The shortest leaf length was recorded in open field (25.33 cm). Outer leaf of cabbage cultivated under various shade of different tree canopies grew vigorously than those in the open field. This may be attributed due to the stimulation of cellular expansion and cell division of outer leaf under shaded conditions (Schoch, 1972). Miah (2001) found significantly higher outer leaf length in heaviest shade (25% PAR) in compared with other (50%, 75%, 100%, PAR level) artificial shade levels.

4.1.2 Outer leaf breadth

Outer leaf breadth of cabbage varied significantly under both tree canopies in respects to open field (Table 1). Significantly the highest leaf breadth of cabbage was recorded under black siris (25.00 cm) followed by mango (19.67 cm). The lowest outer leaf breadth of cabbage was found in open field (17.67 cm) which statistically similar to that of found under mango.

4.1.3 Number of outer leaf

The number of outer leaf of cabbage per plant varied significantly with the variation of shade of different trees (Table 1). Significantly the highest number of outer leaf per plant was observed under black siris (19.33) which was followed by mango (18.00). The lowest number of outer leaf was recorded in open field (16.00). The outer leaf number recorded under mango was identical to both open field and black siris.

This may be occurred due to modification of maximum inner leaf in head formation.

4.1.4 Outer leaf weight

Fresh weight: Fresh weight of outer leaf of cabbage per plant was also affected by different tree associations (Table 1). The highest leaf fresh weight per plant was recorded in open field (720.20 g) which was statistically identical that of mango (675.50 g). This may be attributed due to maximum rates of net photosynthesis under partial shaded conditions. Significantly the lowest leaf fresh weight per plant was recorded under black siris (480.60 g).

Dry weight: Dry weight of outer leaf of cabbage per plant showed the similar trend to that of outer leaf of cabbage fresh weight per plant. The highest outer leaf dry weight of cabbage per plant was recorded in open field (50.50 g) which was followed by mango (46.00 g). Significantly the lowest weight of outer leaf of cabbage was found under black siris (36.30 g).

Table 1. Growth characters of cabbage under different tree species

Treatment	Outer leaf length (cm)	Outer leaf breadth (cm)	Number of Outer leaf/plant	Outer leaf fresh weight (g)	Outer leaf dry weight (g)
Open	25.33 a	17.67 b	16.00 b	720.20 a	50.50 a
Mango	26.33 a	19.67b	18.00 ab	675.50 a	46.00 a
Kala Koroi	29.00 a	25.00 a	19.33 a	480.60 b	36.30 b
Lsd (0.05%)	3.890	4.308	2.724	1.55	8.20
CV%	6.38	9.45	6.76	5.5	6.25

Mean followed by a common letter are not significantly different at the 5% level by DMRT

4.1.5 Head length

The important yield contributing character of cabbage is head length. Head length was affected significantly by the different shade levels (Table 2). The largest cabbage head was recorded in open field (16.00 cm) followed by that of mango (15.50 cm). Significantly the lowest head length was observed under black siris (13.52 cm).

4.1.6 Head breadth

Head breadth of cabbage was significantly affected by the different shade levels (Table 2). Minimum head breadth (11.32 cm) of cabbage was found under maximum shade condition (black seris). Significantly the maximum head breadth was found in open field (15.92 cm) that was similar to that of mango (15.10 cm).

4.1.7 Head weight

Fresh weight: Influencing pattern of different shade levels on the fresh weight of cabbage head per plant was similar to the head length (Table 2). The highest fresh weight of head per plant was observed in open field (610.20 g), followed by mango (550.60 g). Significantly the lowest yield (head fresh weight) per plant was recorded under black siris (488.52 g). The lowest head fresh weight per plant may be due to lower production of photosynthesis under low light condition for a longer period (Miah *et at*, 1999).

Dry weight: The head dry weight of cabbage per plant had shown similar trend to the head fresh weight (Table 2). The highest head dry weight per plant was recorded in open field (36.13 g) which was statistically similar to that of mango (32.08 g). The lowest head dry weight per plant was found under black siris (21.00 g).

4.1.8 Total yield

Fresh yield: Marketable yield of cabbage (ton / ha) was significantly Influenced by different shade levels (Table 2). Fresh yield (t/ha) showed the similar trend to that of individual head fresh weight. Partial shade condition had positive effect on the yield of cabbage. Marketable total yield gradually increased up to 50 percent reduction of light, levels. Further reduction of PAR level, decreased yield drastically. The highest yield was recorded in open field (30.50 t/ha) which was statistically similar to that of mango (28.33 t/ha). Similarly, the highest yield of head cabbage under 30-47% shaded condition was found by Wolff and Coltman (1990). Significantly the lowest yield was recorded under black siris (18.15 t/ha).

4.1.9 Dry yields: The total dry yield (t/ha) of cabbage had showed similar pattern to fresh yield of cabbage (Table 2). The highest dry yield of head was found in open field (2.00 t/ha) which was followed by mango (1.85 t/ha). The lowest yield was recorded under black siris (1.2 t/ha).

Table 2. Yield and yield contributing characters of cabbage under different tree species

Treatment	Head length (cm)	Head breadth (cm)	Head fresh weight (g)	Head dry weight (g)	Fresh yield (t/ha)	Dry yield (t/ha)
Open	16.00 a	15.92 a	610.20 a	36.13 a	30.50 a	2.00a
Mango	15.50 a	15.10 a	550.60 a	32.08 a	28.33 a	1.85a
Kala Koroi	13.52 b	11.32 b	488.52 b	21.00 b	18.50 b	1.20a
Lsd (0.05%)	2.11	3.70	60.50	8.00	9.30	1.4
CV%	6.5	8.79	11.25	7.29	5.63	6.45

Mean followed by a common letter are not significantly different at the 5% level by DMRT

4.1.10 Stem weight

Fresh weight: Influencing pattern of different shade levels due to different MPTS on the stem fresh weight of cabbage was observed statistically significant (Fig l).The highest stem fresh weight was found under mango (59.67 g) which was statistically similar to that of black sirish (59.33 g). Significantly the lowest stem fresh weight was recorded in open field (40.67 g).

Dry weight: The stem dry weight of cabbage shown similar trend to the stem fresh weight (Fig 1). The highest stem dry weight of cabbage was found under mango (8.63 g) which was statistically similar to that of open field (5.367 g). Significantly the lowest stem fresh weight was recorded under black sirish (4.90 g).

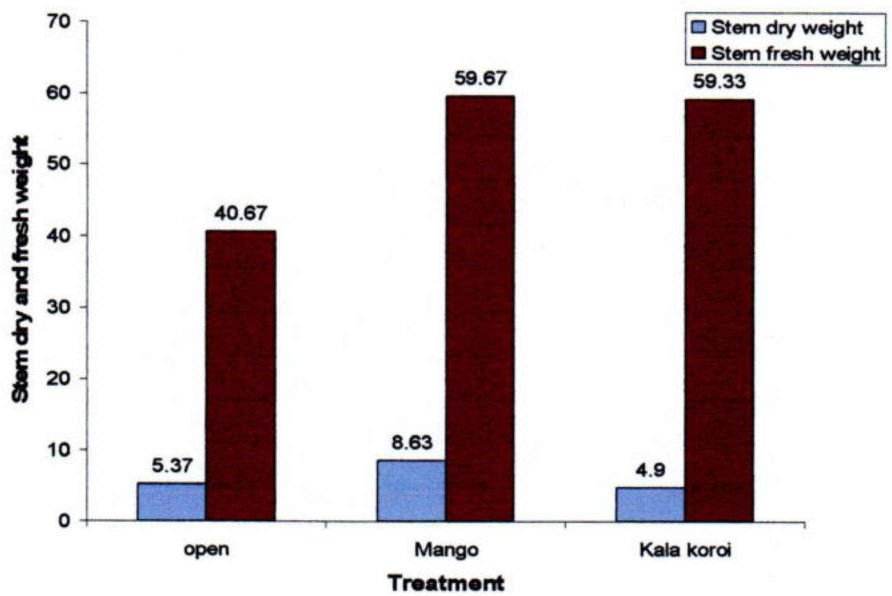


Figure 1: Stem fresh & dry weight (g/plant) of cabbage under different tree species

4.1.11 Root weight

Fresh weight: Influencing pattern of different shade levels on cabbage, root fresh weight, was observed which statistically significant (Fig 2) was. The highest root fresh weight was found under mango (12.40 g) which was statistically similar to that of black siris (11.00 g). Significantly the lowest root fresh weight was recorded in open field (9.667 g)).

Dry weight: The root dry weight of cabbage shown similar trend to the stem fresh weight (Fig 2). The highest stem dry weight was found under mango (2.60 g) which was statistically similar to that of black siris (2.40 g). Significantly the lowest root fresh weight was recorded in open field (2.20 g).

4.1.12 Root length

Root length of cabbage was affected significantly by the different shade levels (Fig 3). The largest cabbage root was recorded under mango (2.40 cm) followed by that of black siris (2.10 cm). Significantly the lowest root length was observed in open field (2.00cm).

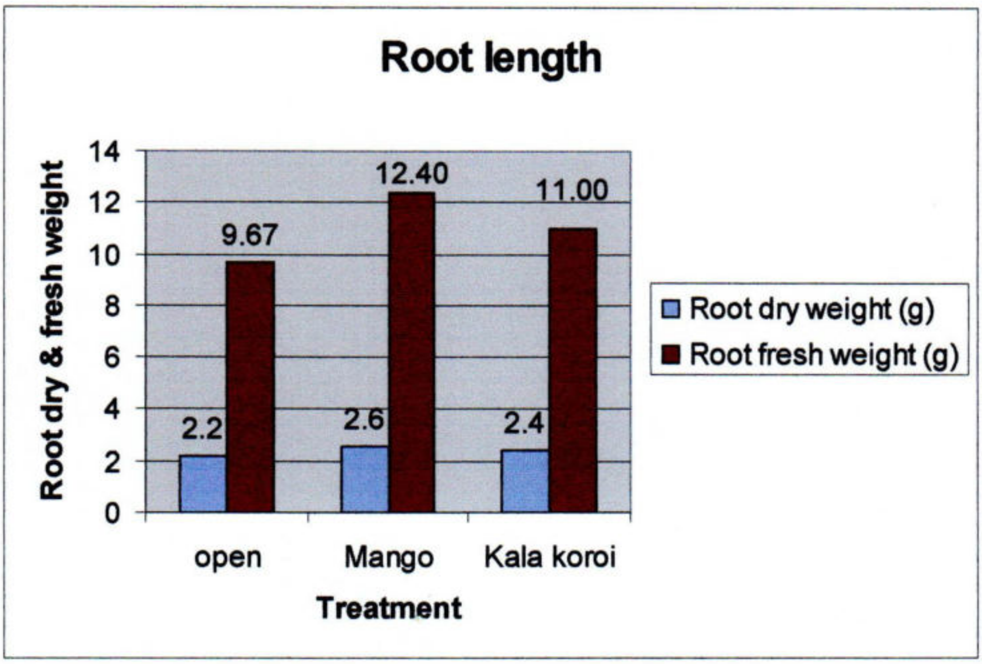


Figure 2: Root fresh & dry weight (g) of cabbage under different tree species

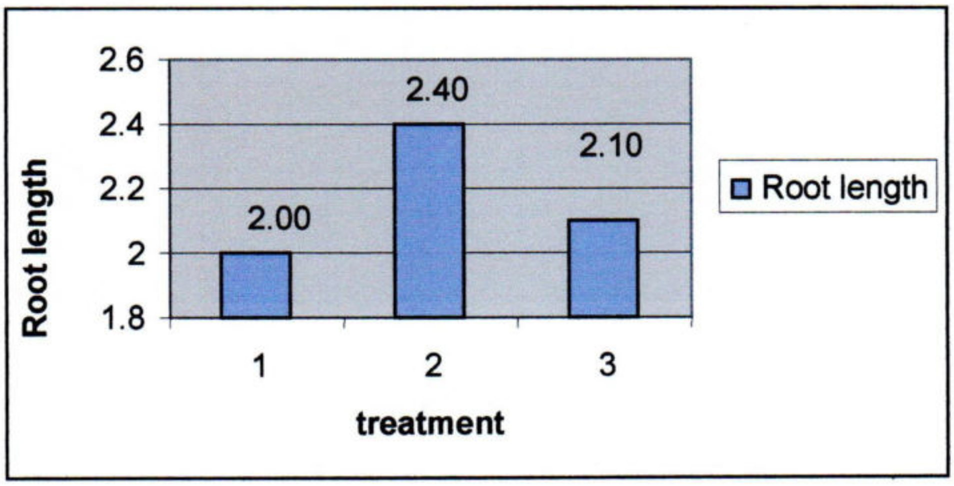
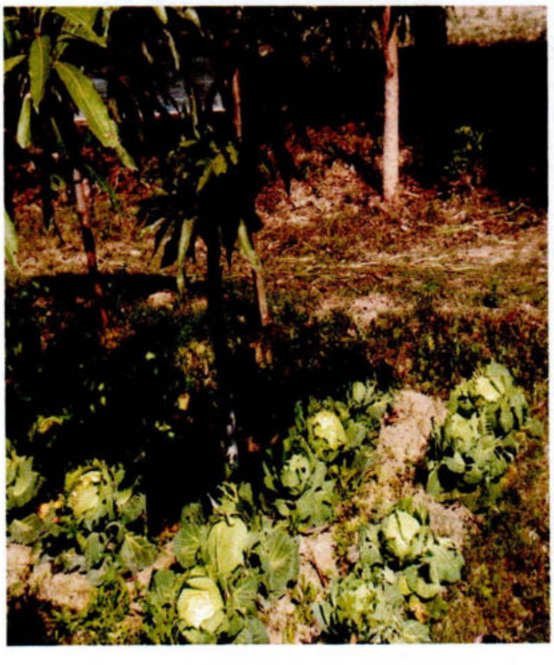


Figure 3: Root length (cm) of cabbage under different tree species.

Cabbage under mango at 20 DAP

Cabbage under mango at 40 DAP

Cabbage under mango at 60 DAP



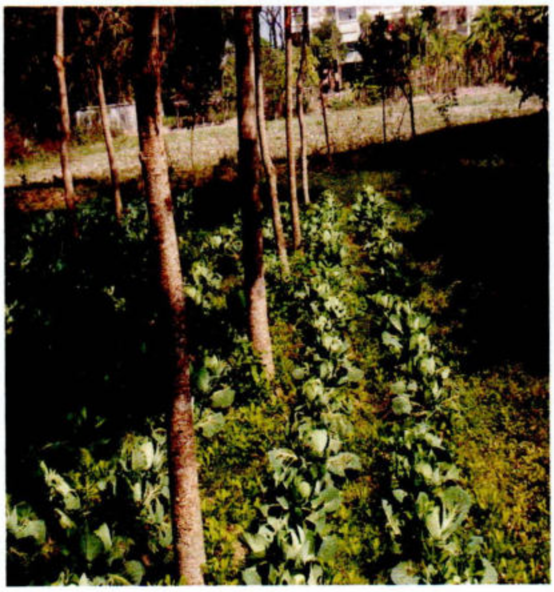
Cabbage under mango at 80 DAP

Plate 1. Different stage of cabbage under mango tree

Cabbage under black siris at 20 DAP

Cabbage under black siris at 40DAP

Cabbage under black siris at 60 DAP



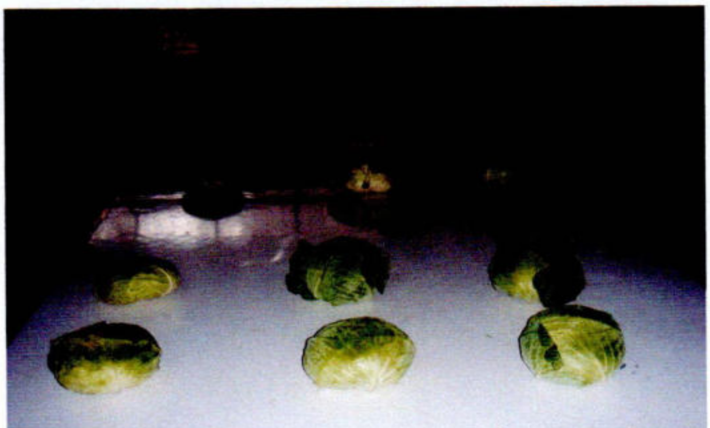
Cabbage under black siris at 80 DAP

Plate 2. Different stage of cabbage under black siris tree

Cabbage in open field at 40 DAP

Cabbage in open field at 80 DAP

Plate 3. Different stage of cabbage in open field



Photograph showing yield of cabbage under different shade level

4.2 Performance of Cauliflower

Growth and yield performance of cauliflower were significantly affected by the light shade of mango and heavy shade of black siris. The results were described below.

4.2.1 Outer leaf length

Length of outer leaf of cauliflower was increased gradually with the increased of shade levels (Table 3). Statistically an insignificant result has observed numerical here the longest leaf was found under black siris (43.33 cm). Numerical the shortest leaf was recorded in open field (42.33 cm). Outer leaf of the cauliflower cultivated under shade grew more vigorously than those in the open field. This may be attributed due to the stimulation of cellular expansion and cell division of outer leaf under shaded conditions.(Schoch,1972).

4.2.2 Outer leaf breadth

Outer leaf breadth of cauliflower increased gradually as the light level decreased up to a certain level (Table 3). But there is no significant different among outer leaf breath. The highest leaf breadth was recorded under black siris (16.00 cm). The lowest leaf breadth was observed under mango (15.37 cm) which was statistically similar to that of open field.

4.2.3 Number of outer leaf

The number of outer leaf of cauliflower per plant varied significantly with the variation of light levels (Table 3). Significantly the highest number of outer leaf per plant was observed under black siris (16.10). Significantly the lowest number of outer leaf was recorded in open field (11.00 cm) which was followed by mango (11.40). This may be occurred due to the modification of maximum inner leaf in head formation. The lower number of leaf per plant at the reduced light conditions may be due to lower production of photosynthates under low light conditions for a longer period (Miah *et. al,* 1999).

4.2.4 Outer leaf weight

Fresh weight: Fresh weight of outer leaf of cauliflower per plant was also affected by different light levels (Table 3). The highest leaf fresh weight per plant was recorded in open field (820.20 g) which was statistically identical to that of mango (775.50 g). This may be attributed due to maximum rates of net photosynthesis under partial shaded conditions. Significantly the lowest leaf fresh weight per plant was recorded under black siris (580.60 g).

Dry weight: Dry weight of outer leaf of cauliflower per plant showed the similar trend to the outer leaf fresh weight per plant. The highest leaf dry weight per plant was recorded in open field (60.50 g) which was followed by mango (56.00 g) the lowest dry weight of outer leaf was recorded under black siris (46.30 g).

Table 3. Growth characteristics of cauliflower under different tree species

Treatment	Outer leaf length (cm)	Outer leaf breadth (cm)	Number of Outer leaf/plant	Outer leaf fresh weight (g)	Outer leaf dry weight (g)
Open	42.33 a	15.37 a	11.00 b	820.20 a	60.50 a
Mango	42.67 a	15.67 a	11.40 b	775.50 a	56.00 a
black siris	43.33 a	16.00 a	16.10a	580.60 b	46.30 b
Lsd (0.05%)	4.406	0.7553	2.10	55.0	8.20
CV%	4.54	2.11	7.22	5.5	6.25

Mean followed by a common letter are not significantly different at the 5% level by DMRT

4.2.5 Curd length

The important yield contributing character of cauliflower is curd length. Curd length was affected significantly by the different shade levels (Table 4). The largest cauliflower curd was recorded in open field

(18.00 cm) followed by that of mango (17.50 cm). Significantly the lowest head length was observed under black siris (15.52 cm).

4.2.6 Curd breadth

Curd breadth of cauliflower was significantly affected by the different shade levels (Table 4). Minimum curd breadth (14.32 cm) of cauliflower was found under maximum shade condition (black siris). Significantly the maximum curd breadth was found in open field (18.92 cm) that was similar to that of mango (18.10 cm).

4.2.7 Curd weight

Fresh weight: Influencing pattern of different shade levels on the fresh weight of cauliflower curd per plant was similar to the curd length (Table 4). The highest fresh weight of curd per plant was observed in open field (810.20 g), followed by mango (750.60 g). Significant the lowest yield (curd fresh weight) per plant was recorded under black siris (688.52 g). The lowest curd fresh weight per plant may be due to lower production of photosynthates under low light condition for a longer period (Miah *eta l.,* 1999).

Dry weight: The curd dry weight of cauliflower per plant had shown similar trend to the curd fresh weight (Table 4). The highest curd dry weight per plant was recorded in open field (46.13 g) which was statistically similar to that of mango (42.08 g). The lowest head dry weight per plant was found under black siris (31.00 g).

4.2.8 Total yield

Fresh yield: Marketable yield of cauliflower (ton/ha) was significantly influenced by different shade levels (Table 4). Fresh yield (t/ha) showed the similar trend to that of individual curd fresh weight. Partial shade condition had positive effect on the yield of cauliflower. Marketable total yield gradually increased up to 50 % reduction of light, levels. Further reduction of PAR level, yield decreased drastically. The highest yield was recorded in open field (40.50 t/ha) which was statistically similar to that of mango (38.33 t/ha). Similarly, the highest yield of curd cauliflower under 30-47% shaded condition was found by Wolff and Coltman (1990). Significantly the lowest yield was recorded under black siris (28.50 t/ha).

4.2.9 Dry yields: The total dry yield (t/ha) of cauliflower had showed similar pattern to fresh yield of cauliflower (Table 4). The highest dry yield of curd was found in open field (3.00 t/ha) which was followed by mango (2.85 t/ha). The lowest yield was recorded under black siris (2.2 t/ha).

Table 4. Yield and yield contributing characters of cauliflower under different tree species

Treatment	Curd length (cm)	Curd breadth (cm)	Curd fresh weight (g)	Curd dry weight (g)	Fresh yield (t/ha)	Dry yield (t/ha)
Open	18,00 a	18.92 a	810.20 a	46.13 a	40.50 a	3.00a
Mango	17.50 a	18.10a	750.60 a	42.08 a	38.33 a	2.85a
black siris	15.52 b	14.32 b	688.52 b	31.00 b	28.50 b	2.20a
Lsd (0.05%)	2.12	3.72	72.50	9.20	10.30	1.5
CV%	8.5	5.79	12.25	5.29	8.63	6.50

4.2.10 Stem weight

Fresh weight: Influencing pattern of different shade levels on the stem fresh weight of cauliflower was observed statistically significant (Fig 3).The height stem fresh weight was found under black siris (130.0 g). Significantly the lowest stem fresh weight was recorded in open field (65.0 g)) which was statistically similar to that of mango (76.67 g).

Dry weight: The stem dry weight of cauliflower shown similar trend to the stem fresh weight (Fig 3). The height stem dry weight was found under mango (8.633 g) which was statistically similar to that of open field (7.33 g). Significantly the lowest stem fresh weight was recorded under black siris (4.90 g)).

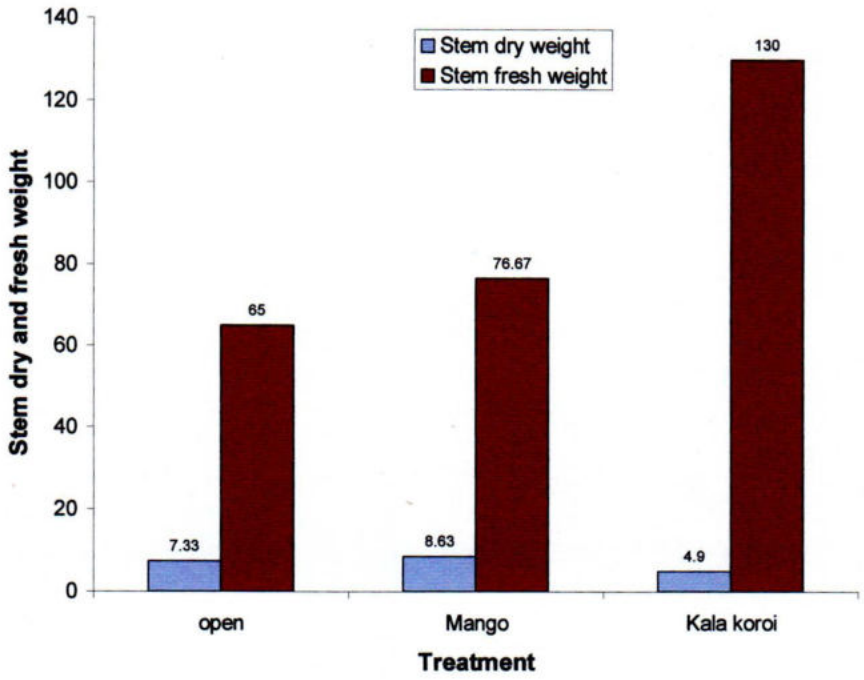


Figure 3: Stem fresh and dry weight (g) of cauliflower under different tree species

4.2.11 Root weight

Fresh weight: Influencing pattern of different shade levels on the root fresh weight of cauliflower was observed statistically significant (Fig 4).The height root fresh weight was found under black siris (17.30 g) which was statistically similar to that of mango (17.07 g). Significantly the lowest root fresh weight was recorded in open field (16.37 g)).

Dry weight: The root dry weight of cauliflower shown similar trend to the stem fresh weight (Fig 4). The height stem dry weight was found under black siris (4.2 g) which was statistically similar to that of mango

(3.96 g). Significantly the lowest root fresh weight was recorded in open field (3.43 g).

4.2.12 Root length

Root length was affected significantly by the different shade levels (Fig 4). The largest cauliflower root was recorded under black siris (27.67 cm) followed by that of mango (25.4 cm). Significantly the lowest root length was observed in open field (14.43 cm).

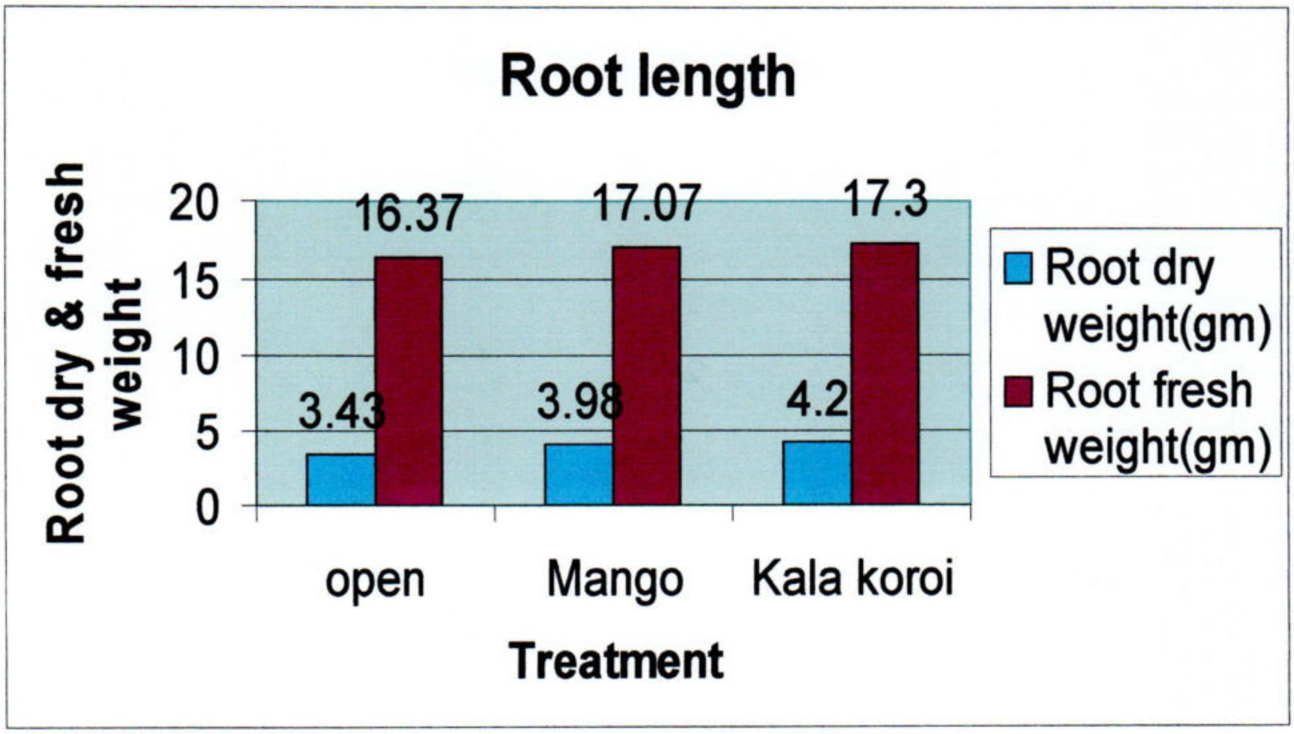


Figure 4: Root fresh & dry weight (g) of cauliflower under different tree species

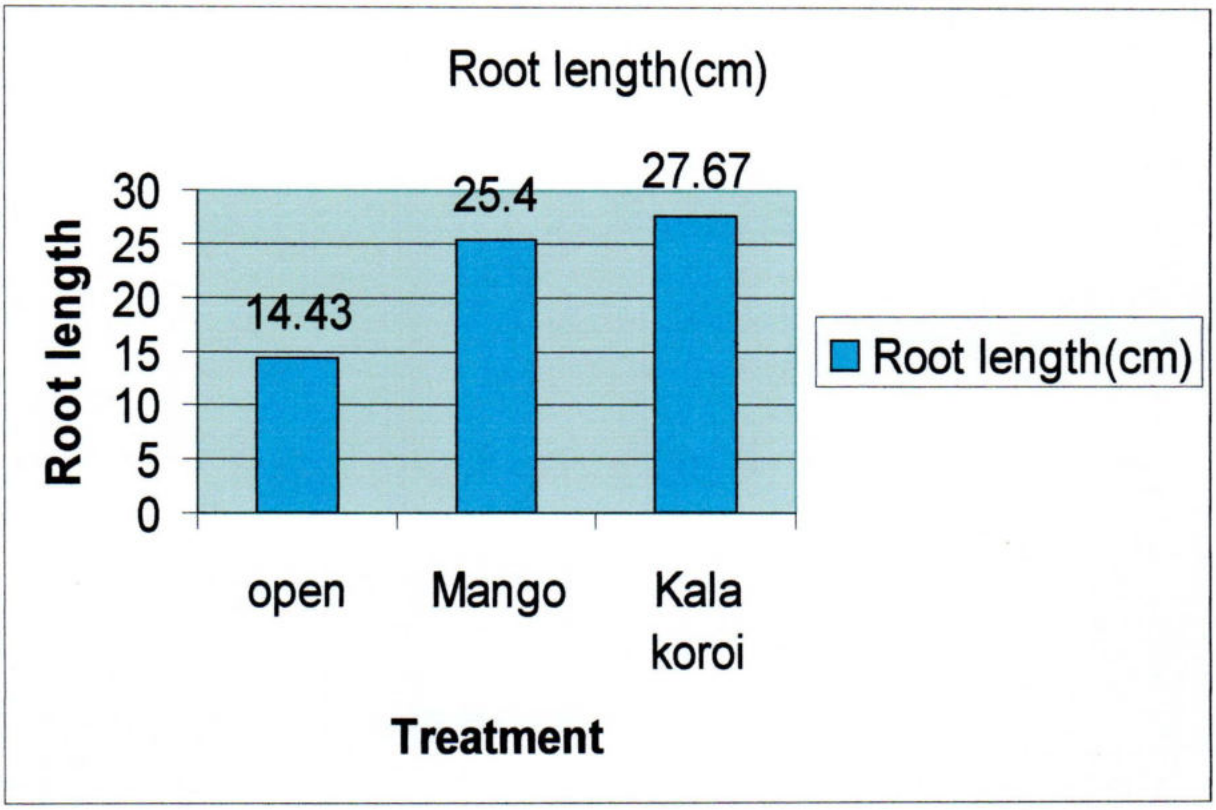


Figure 4: Root length (cm) of cauliflower under different tree species

Cauliflower under mango at 20 DAP

Cauliflower under mango at 40 DAP

Cauliflower under mango at 80 DAP

Cauliflower under mango at 60 DAP

Plate 4. Different stage of cauliflower under mango tree

Cauliflower under black siris at 20 DAP

Cauliflower under black siris at 40 DAP

Cauliflower under black siris at 80 DAP

Cauliflower under black siris at 60 DAP

Plate 5. Different stage of cauliflower under black siris tree

Cauliflower in open field at 40 DAP

Cauliflower in open field at 80 DAP

Plate 6. Different stage of cauliflower in open field

Plate 7: showing yield of Cauliflower under different shade level

CHAPTER 5

CONCLUSION AND RECOMMENDATION

A field experiment was conducted at the Agroforestry Farm, Department of Agroforestry, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during 24th November 2007 to24th February 2008 to evaluate the performance of cabbage and cauliflower under two multipurpose trees .i.e. black siris (*Albezia lebbeck)* and mango (*Mangifera indica)* .Which were established in 2004 with 3x3m spacing. The shade created by mango canopy was arranged 45-50 percent and the shade formed by black siris canopy was approximately 55- 60 percent. There was also a control plot (open field i.e. no shade). Local variety of cabbage and cauliflower were used as the test crops.

The result of the present studies showed that the performance of cabbage and cauliflower under different shade of multipurpose tree species varied significantly. In case of cabbage the highest yield was found in open field (30.50 t/ha), followed by mango (28.33 t/ha). Significantly the lowest yield of cabbage was recorded under black siris (18.50t/ha). Similar trend of variation was observed in cauliflower also, but the curd yield was higher irrespective of treatments. The curd yield of cauliflower (40.50 t/ha) was found highest in open field. The yield obtained under mango (38.33 t/ha) was statistically similar to that of open field. Significantly the lowest curd yield was produced by allbizia lebbeck (28.50t/ha). The study revealed that 4 years mango orchard having less than 3m x3m spacing can be used for cabbage and cauliflower production without sacrificing significant yield loss as compared to open field. Between two vegetables cauliflower showed the higher yield potential than cabbage. So, mango based cauliflower production can be the better combination for large scale production.

However, the result of the present study was achieved based on one season trial and specific tree species which were early aged may not be sufficient to asses the sustainability of the results for all agroforestry practices entertaining older tree with larger canopy i.e. heavy shade condition.So Similar experiments should be repeated at least in another season with the same orchard for strong recommendation.

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Appendices

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

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

Appendix II. Weather data of the experimental site during the period From November 2007 to February 2008

Month	* Air Temperature (C)			*Rainfall (mm) (Minimum)	*Relative Humidity (%)
	Maximum	Minimum	Average		
November	29.70	19.09	24.39	25	88.35
December	28.54	18.01	23.27	00	89.93
January	26.95	15.06	20.98	10	86.10
February	25.55	16.00	20.78	00	82.37

* = Monthly average

Source: Meteorological Station, Wheat Research Center, Nosipur, Dinajpur (2007-08).

Appendix III. Monthly average light intensity during the period from November to February 2007-08

November, 2007	5.9.05	41400	49900	43200	134500	44833	41291
	12.9.05	40500	47600	39700	127800	42600	
	19.9.05	39200	45100	38500	122800	40933	
	26.9.05	36400	42200	36600	115200	38400	
December, 2007	03.10.05	35900	41100	36000	113000	37666	36383
	17.10.05	35200	40000	33600	108800	36266	
	24.10.05	34900	39600	33800	108300	36100	
	31.10.05	34700	38600	33200	106500	35500	
January 2008	7.11.05	34100	37500	35900	107500	35833	34116
	14.11.05	33600	36300	34000	103900	34633	
	21.11.05	33100	35500	31400	100000	33333	
	28.11.05	32500	34700	30800	98000	32666	
February 2008	5.12.05	39300	31700	28200	99200	33066	30266
	12.12.05	37200	30500	28000	95700	31900	
	20.12.05	28600	30300	27600	86500	28833	
	29.12.05	27500	28200	26100	81800	27266	

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

Appendix IV. Stem fresh & dry weight (g) of cabbage under different tree species

Treatment	Stem fresh weight(g)	Stem dry weight(g)
open	40.67 b	5.37 b
Mango	59.67 a	8.63 a
Black siris	59.33 a	4.9 b
Lsd (0.5%)	1.511	2.918
CV%	5.4	9.45

Appendix V. Root fresh & dry weight (g) and root length (cm) of cabbage under different tree species.

Treatment	Root fresh weight (g)	Root dry weight (g)	Root length (cm)
open	9.667 a	2.2	2
Mango	12.4 a	2.6	2.4
Black siris	11 a	2.4	2.1
Lsd (0.5%)	2.977	0.6913	2.23
CV%	11.91	12.73	13.15

Appendix VI. Stem fresh & dry weight (g) of cauliflower under different tree species

Treatment	Stem fresh weight(g)	Stem dry weight(g)
open	65 b	7.33a
Mango	76.6 b	8.63a
Black siris	130 a	4.9b
Lsd (0.5%)	55.0	2.56
CV%	12.32	8.5

Appendix VII. Root fresh & dry weight (g) and root length (cm) of cauliflower under different tree species

Treatment	Root fresh weight(gm)	Root dry weight(gm)	Root length(cm)
Open	16.37 a	3.43 a	14.43b
Mango	17.07 a	3.98 a	25.4 a
Black siris	17.3 a	4.2 a	27.67a
Lsd (0.5%)	2.23	2.36	5.95
CV%	5.64	12.60	8.6