BIO-ECONOMIC PERFORMANCE OF CUCUMBER UNDER DIFFERENT TREE BASED AGROFORESTRY SYSTEMS AS INFLUENCED BY ORGANIC MULCHING

A THESIS
BY

Registration No. 1605446
Session: 2016

Thesis Semester: July-December, 2017

MASTER OF SCIENCE (M.S.)
IN
AGROFORESTRY AND ENVIRONMENT

DEPARTMENT OF AGROFORESTRY AND ENVIRONMENT
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

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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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December, 2017

DEDICATED
TO MY
BELOVED PARENTS

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The Author

Bio-economic performance of cucumber under different tree based agroforestry system as influenced by organic mulching

ABSTRACT

A field experiment was carried out at the Agroforestry and Environment Research Farm, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, during April to July 2017 to evaluate the performance of cucumber cv. Hybrid geeen bird, Hybrid shezade and Local sufola variety under different tree based agroforestry systems along with sole cropping i.e. open field condition. The experiment was conducted in existing 12 years established tree woodlot. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. The treatments were factor A: four production system viz. T_1 (Cucumber sole cropping), T_2 (kalo koroi + cucumber), T_3 (ghora neem + cucumber) and T_4 (mango + cucumber), on the other hand factor B: three cucumber varieties viz. V_1 (Hybrid green bird), V_2 (Hybrid shehzade) and V_3 (local sufola variety). So the treatment combinations were T_1 v_1, T_1 v_2, T_1 v_3, T_2 v_1, T_2 v_2, T_2 v_3, T_3 v_1, T_3 v_2, T_3 v_3, T_4 v_1, T_4 v_2 and T_4 V_3. The unit plot size was 2.5m × 2.5m (6.25 m^2). Seeds of cucumber were sown in 4 May, 2017. Necessary intercultural operations were done effectively. *Albiza lebbeck*, *Melia azedarach* and *Mangifera indica* tree leaf biomass 2.5kg was used in each experimental plot as organic mulching in agroforestry system except the control treatment. All the organic mulching materials were applied in 15 days after seed germination in the experimental plots. The experimental result revealed that in case of production system significantly the highest fruit weight plant^{-1} (489.0g) and fruit yield (11.37 tha^{-1}) was found in cucumber in sole cropping production system and lowest fruit weight plant^{-1} (1.667 g) and fruit yield (2.667 tha^{-1}) was recorded in cucumber + ghora neem based agroforestry production system. Again in case of varietal performance the highest cucumber fruit yield (7.02 t ha^{-1}) was found in (hybrid green bird) followed by (5.64 t ha^{-1}) hybrid shehzade and the lowest fruit yield (4.24 t ha^{-1}) was observed in local sufola. The highest benefit-cost ratio of 2.68 was recorded from cucumber + kalo koroi (T_2) based agroforestry production system followed by cucumber sole cropping production system 2.48 and cucumber + mango (T_4) 2.36 based agroforestry production system and the lowest benefit-cost ratio of 2.02 was observed in cucumber + ghora neem (T_3) based agroforestry production system. So, cucumber can profitably be cultivated in kalo koroi based agroforestry production systems.

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CHAPTER 1

INTRODUCTION

The concept of agroforestry embraces many intermediate-intensity land use forms, where trees still cover a significant proportion of the landscape and influence microclimate, matter and energy cycles, and biotic processes. In the last three decades, agroforestry has been widely promoted in the tropical and sub-tropical countries as a natural resource management strategy that attempts to balance the goals of agricultural development with the conservation of soils, water, local and regional climate, and, more recently, biodiversity (Izac and Sanchez, 2001). Agroforestry systems like such as alley cropping, homegardens, crop-fallow rotations, and the use of timber trees in tree crop plantations increase soil fertility by application of biomass to the soil through the input of nutrient and organic matter (Lehman *et al.,* 1995). Plantations of multipurpose trees alone or combined with agricultural crops could be an effective land rehabilitation strategy (Maikhuri *et al.,* 2000). One of the main tenets of agroforestry is that trees maintain soil fertility.

A country needs 25% of forest land of its total area for ecological stability and sustainability. Sadly, Bangladesh is endowed with only 17.08% of unevenly distributed forests (BBS, 2007). Conversely, actual tree coverage is less than 10% (Akter *et al.,* 1989). Due to rapid growth of population, there is a tremendous pressure on the forest lands. The northern part of the republic has got least forest resources. Substantial depletion of these possessions have occurred in the last few decades, and now it is reduced to less than 0.02 ha person^{-1}, which is one of the lowly ratios in the glob (BBS, 2008). The existing land use systems will become more vulnerable owing to augment in the atmospheric temperature, levels of CO_2 and other green house gases. The result would be drastic reduction in productivity potential of the system. Nevertheless, the limits of agricultural productions even using the most intensive high input agriculture have already been reached. The situation on fuel, fodder and timber production front is also not reasonable. There is a great need to increase the production of high valued cash crops e.g. vegetables, spices, medical plants, floricultural plants etc. The agroforestry technology play role in the light of combating hunger, poverty, diseases, environmental degradation is highly appreciable and ecological efficiency lead to increase in total production per unit of land (Garrity *et al.,* 1992). The loss and degradation of forests exacerbate the problem of food insecurity both directly and indirectly: directly, by affecting the availability of fruits and other forest- and tree-based food products, and indirectly by modifying ecological factors relevant for crop and livestock and thereby affecting the availability of food (Van Noordwijk *et al*., 2014). According to the World Food Summit (1996), "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food which meet their dietary needs and food preferences for an active and healthy life". Food security encompasses many issues ranging from food production and distribution to food preferences and health status of individuals.

Again, mulching helps in better utilization of all the nutrients in the soil, meeting up the need of irrigation and thus increases yield. In the production of crops, soil always serves as the basic ingredient to be exploited fully to produce more. Mulching stimulates microbial activity in soil (Sayren, 1971). Organic production is an integrated production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity (FAO/WHO Codex Alimentarius Commission, 2007).

Tree planting has become so widespread that farm forestry has been proposed as a viable alternative to expensive government-driven reforestation projects (Pasicolan *et al.,* 1997). The low price of farm-grown timber is not the only reason for diminishing returns from tree farming systems. When fast-growing timber species are planted on farms, tree competition for above- and below-ground resources reduces yields of intercrops below economic levels as early as one year after tree planting. Furthermore, severe pruning to control tree competition effects and the lack of thinning in woodlots due to farmers' reluctance to remove immature trees, reduce timber yield and quality (Bertomeu, 2004).

Cucumber (*Cucumis sativus* L.) is an important member of the family cucurbitaceae. The fruits are eaten as salad and pickle and are often consumed as cooked vegetables in various ways. These green fruits contain 0.6 g protein, 2.6 g carbohydrate, energy 12 cal, 18 mg Ca, 0.2 mg Fe, 0.02 mg thiamin, 0.02 mg riboflavin, 0.01 mg niacin, and 10 mg vitamin C per 100 g of edible portion (Rashid, 1999). In Bangladesh, vegetable production is not uniform round the year: plenty in winter but less in summer. Around 30% of total vegetables are produced during summer and 70% in winter. The present consumption of vegetables in Bangladesh is 112 g/day/capita (23 g leafy vegetables, 89 g non-leafy vegetables), which is far below the minimum average requirement of 400 g/day/capita (FAO, 2003). Therefore, there is a big gap between the requirement and the supply of vegetables in Bangladesh. Successful cucumber production may contribute partially in solving vegetable scarcity in summer. The total production of cucumber in

Bangladesh was about 32000 metric tons in 4858 hectares in the year 2014-2015 (BBS, 2015). But the demand of cucumber is more now a days. Food security encompasses many issues ranging from food production and distribution to food preferences and health status of individuals. Despite impressive productivity increases, there is growing evidence that conventional agricultural strategies fall short of eliminating global hunger, result in unbalanced diets that lack nutritional diversity, enhance exposure of the most vulnerable groups to volatile food prices, and fail to recognize the long-term ecological consequences of intensified agricultural systems (FAO, 2013). So an alternative sustainable production system like cucumber production under different tree based agroforesty system may be a good option. The present experiment will be exploited to study the bio-economics performance of cucumber under different timber tree based agroforestry system.

Objectives-

- To find out the growth and yield potential of different cucumber varieties under different tree based agroforestry systems.
- To measure the economic performance of cucumber under different tree based agroforestry systems.
- To find out the interaction effect of production system and variety on the growth and yield performance of cucumber under different tree based agroforestry systems.

CHAPTER 2
REVIEW OF LITERATURE

This research has been undertaken to observe the performance of okra under litchi based agroforestry system. Review is a required part of grant of research proposals and often a chapter in thesis. The reviews of literature of the past studies related to the present experiment collected through reviewing of journals, thesis, internet browsing, reports, newspapers, periodicals and other form of publications are presented and discussed in this chapter.

2.1 Development and Concept 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 promoted by economic circumstance of ever supply of agriculture produce, 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 circumstance has only recently re-emerged (Gordon and Newman,1997) and is still not fully accommodated within agricultural incentive schemes (sub sides).

‘Agroforestry is a collective name for all land-use systems and technologies, where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land management unit as agricultural crops and/or animals, either in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components' (ICRAF, 1993).

‘Agroforestry should be reconsidered as a dynamic, ecologically based, natural resource management system that, through the integration of trees in farm and rangeland, diversifies and sustains production for increased social, economic and environmental benefits (Leakey, 1996).

‘The ecological integrity of an agroforestry is a state of system development in which the habitat structure, natural functions and species composition of the system are interacting in ways that ensure its sustainability in the face of changing environmental conditions as well as both internal and external stresses (Wyant, 1996).

Agroforesty 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).

Homegardens represent intimate, multistory combinations of various trees and crops, sometimes in association with domestic animals, around the homestead. This concept has been developed around the rural settings and subsistence economy under which most homegardens exist (ed). The practice of homegardening is now being extended to urban settings (Drescher *et al.,* 2006) as well as with a commercial orientation (Abdoellah *et al.,* 2006; Yamada and Osaqui, 2006).

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).

Though agroforestry is an age old practice in Bangladesh, further development may be brought for harvesting maximum benefit by identification of appropriate tree-crop combination. Recently International Centre for Research in Agroforestry (ICRAF) defined, "Agroforestry as a dynamic, ecologically based natural resources management system that through the integration of trees on farmland and in the agricultural landscape, diversifies and sustains production or increased social, economic and environmental benefits for land users at all levels."

"Agroforestry is a collective name for all land use systems and technologies where woody perennials (trees, shrubs, palms, bamboo etc.) are deliberately grown on the same land management unit as agricultural crops and/or animals either in spatial mixture or in temporal sequence. There must be significant ecological non-woody components," (Lundgren and Raintree, 1982).

Vergara (1982) defined that agroforestry as a system of combining agricultural and tree crops of various longevity (ranging from annual through biennial and perennial plants), arranged either temporally (crop rotation) or spatially intercropping to maximize and sustain agricultural production.

Harou (1983) stated that agroforestry is a combined agriculture-tree crop farming system which enables a farmer or land user to make more effective use of his land which may yield a higher net economic return on a sustainable basis.

Penafiedl (1985) stated that 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 a mixed canopy intercepts more solar energy.

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

2.2 Effect of tree-crop interaction in agroforestry system

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

Akter *et al*. (1989) mentioned that farmers also considered tree as savings and insurance against risk of crop failure and low yield, as well as assets for their children. Some farmers stated that tree would contribute towards expenses for marriage of their daughters. In tree crop agroforestry system tree species are grown and managed in the farmland along with agricultural crops. The aim is to increase the overall yield of the land. This system is also based on the principle of sustained yield (Nair, 1990).

Agroforestry is the integration of tree and crop or vegetable on the same area of land is a promising production system for maximizing yield and maintaining friendly environment (Nair, 1990).

Agroforestry significantly contributes in increasing fuels wood, fodder, cash income and infrastructure in many developing countries. It was 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 output of economic goods (fuel, fodder, small timber, organic fertilizer, etc.) and (iii) providing stable employment, improved income and material to rural populations (Solanki, 1998).

2.3 Characteristics of tree species used in agroforestry systems

Selection of suitable tree species is vital in an agroforestry system. Nair (1990) considered that most choice of suitable plant species that can grow together as important factor in ensuring the 7 success of agroforestry. The most appropriate species for this system remains an open question for research.

King (1979) listed that the characteristics of tree species that should be grown with agricultural crops:

(a) They should tolerate relatively high incidence of planning

(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 phylotaxie should permit penetration of the light to the ground

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

(g) The rate of 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 they 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) point out that the following factors to be considered during the selection of woody legumes for intercropping with annuals in the low land tropics:

(1) Ease of establishment from seeds or seedlings

(2) Rapid growth and high productivity of foliage and wood,

(3)) Limited maximum size (may be optimum in small trees)

(4) Good coppicing ability (re-growth following topping),

(5) Effective nutrient recycling abilities especially di-nitrogen fixation,

(6) Multiple uses: food, feed, firewood, construction materials and other products and services (shade, shelter etc.)

(7) Minimal competition with shallowly rotted annual crops

(8) Small leaflets readily detached when dried and quickly decomposed when used as fertilizer

(9) A high proportion of leaves to secondary branches, Good tolerance for drought, low fertility and others, Freedom from pests and diseases

(10) Ease of control of eventual elimination.

Purohit (1984) suggested that some criteria for selecting species which

(1) do not compete for moisture, space and air,

(2) supply nitrogen in the soil,

(3) provide food, fodder, fuel and timber,

(4) maintain proper ecosystems,

(5) have no toxic effects to the crops, and

(6) Have thin and erect leaves.

He also 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:

(1) non-interference with arable crops.

(2) easy establishment.

(3) fast growth and short gestation period .

(4) non allelopathic effects on arable crops .

(5) ability to fix atmospheric nitrogen, easy decomposition of litter.

(6) ability to withstand frequent lopping multiple uses

(7) abilit y 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.

2.4 Response of crops in agroforestry systems

Baevre (1990) reported that reducing incoming light by 30 and 60% resulted in significant reductions in the number of flowers, percent fruit set and yield. The reduction of yield was primarily caused by decreased of the number of fruit production.

Hanada (1990) conducted an experiment under 8 levels of shading (0, 20, 37, 48, 50, 72, 87 and 98 percent) cultivating radish, kangkong, cucumber and tomato and reported that shading decreased soil temperature, preserved soil moisture and prevented insect attack. Shading increased yields in kangkong and cucumber with 20 % and 37 % shading but decreased yields in radish and tomato with increasing amount of shade levels.

Leonardi (1996) suggested that shading (60% light reduction) reduce vegetative and fruits growth. Shading increased plant height. Shading also reduced chlorophyll content, stomata density, transpiration rate and photosynthetic rate. Yield of peppers decreased with increasing amount of shade levels.

Ali (1998) conducted an experiment during April to August in 1998, at BBSMRAU, Salna, Gazipur to study the performance of red amaranth and lady's finger grown at different orientations and distances under guava (*Psidium Guajava*) and drumstick (*Nloringa oleofera*) trees. The orientation was North, South, East, and West.21 and 28 days after emergence. The 30% level of shading did not reduce the size or weight of the roots.

Healey *et al.* (1998) reported that level of incident radiation reduced by 25% under shade-cloth decreased final yield and final leaf index, but increased canopy leaf, nitrogen concentration and radiation uses efficiency. A similar level of reduced incident radiation under solar weave shade cloth increased final yield and radiation use efficiency (46-50%).

Ong and Leakey (1999) reported that recent research findings on resource sharing between trees and crops in the semiarid tropics. In general, productivity of natural vegetation under savannah trees increases as rainfall decreases, while the opposite occurs in agroforestry. In agroforestry practices such as alley cropping where tree density is high, any beneficial effects of the trees on microclimate are negated by reductions in soil moisture due to increasing interception losses and tree transpiration. While investment in woody structure can improve the water economy beneath agroforestry trees, it inevitably reduces the growth rate of the trees and thus increases the time required for improved under storey productivity.

Souza *et al.* (1999) studied that the effect of 3 levels of shading (0, 30, and 50%) on the development and tuberous root yield of radish *(Raphanus sativus)* under field conditions and reported that 50% level of shading increased the plant height, life cycle, foliar area and reduce leaf chlorophyll content and the tuberous root yield where the plant were evaluated at 7, 14, 21 and 28 days after emergence. The 30% level of shading did no reduce the size or weight of the 10 root.

Reddy *et al.* (2002) observed that under the tree shade plant height was higher and root length, girth, dry weight and yield were lower.

Azad (2004) studied that the performance of three winter vegetable i.e. carrot, turnip and spinach were evaluated under three different orientations of guava tree and observed that plant height and leaf length increased gradually in treatments where light availability was meager in case of carrot and turnip. It concluded that the three winter vegetable grown in south side from the tree base showed better performance followed by north side in agroforestry system.

Nazrul *et al*. (2004) suggested that pineapples are being cultivated in the Hilly area in association with different kinds of trees and vegetables. Among all the vegetables, pumpkin has made the best association (i.e. 53%) with the pineapple and benefit cost ratio (BCR) was found the highest (5.11 and 3.38) in the associated crop production.

Hasan (2006) studied that the performance of stem amaranth as under storied vegetable with akashmoni and eucalyptus in four orientations. The tree species were Among the different morphological characters of stem amaranth, plant height, stem girth, no. of leaves/plant, fresh leaf weight, dry leaf weight, fresh stem weight and dry stem weight were decreased consistently as the canopy density increased but the trend of orientation in respect of yield was south> East>West> North, where best result obtained in south and lowest was North orientation.

Chipungahelo *et al.* (2007) reported that light intensity strongly influenced on growth and development of sweet potato especially leaf morphological characteristics. Specific leaf area values in full light were smaller than those in under heavy shade.

Ding *et al.* (2007) observed the performance (growth, development, yield and disease resistance) of alpine cucumber (cv. Jing-You 5) plants grafted on rootstocks of *Cucurbita ficifolia*, Zaoqing pumpkin, Jingli pumpkin and Hangzhou long bottle gourd to evaluate and compare with that of non-grafted plants. The survival rate was higher and the incidence of Fusarium wilt was lower in grafted seedlings than in non-grafted seedlings

Rahman (2008) reported that except plant height all others morphological characters viz. no. of branches plant-1, no. of fruit plant-1, fruit length, fruit diameter and fruit weight of three vegetables (Tomato, Brinjal, Chilli) were highest in open field condition. Among the different agroforestry system, highest yield was obtained in Horitoki - Lemon - Vegetable based 11 Agroforestry system.

Pulok (2008) identified that a total of five agroforestry practices viz. Palmyra palm - rice based agroforestry practices, pond size agroforestry practices, MPTs plantation the border of rice field, ailed based agroforestry practices and homestead agroforestry practices in the study area. He recommended that the selection and introduction of fast growing trees and multipurpose tree species are suitable for agroforestry practices for socioeconomic improvement of the farmers.

Nahidur (2009) stated that Agroforestry practice had significant role in improving the economic status of the people. It is implied that if people are encouraged to plant trees in their homestead, thereby, the people can live in a healthy environment at the same time if can ensure the supply of timber, fuel,

fodder, nutrient and other products. Therefore, there is a great scope to improve the prevailing homestead agroforestry practices with modern agroforestry technologies for maximization of income of the farmers.
Partha (2009) has reported that CARE assisted Road side agroforestry program bring a change in the socioeconomic status of the participants through increasing income generating capacity and using the waste land of the road side. The program also improved the overall environmental condition and prevented the soil erosion.

Nahar (2009) observed that the average size of the homestead in the study area was 0.12 ha which increased with the increase of farm size. The homestead production system was found to be poor due to management practices. It was also observed that the major problem of planning new trees in the homestead was damaged by grazing animals (80.0%) followed by unavailability of space (61.0%), damaged by flood (55.0%), lack of good quality seeds (64.0%) and insect and pest infestation (56.0%). There is enough scope if improve productivity in the homestead by replacing the existing tree species with the improved and /or exotic ones, planting trees in planned ways and improving management practices.

Basak *et al.* (2009) found that the growth characteristics of *Xylia dolabiformis* tree are quite better in association with radish than tomato but found higher in association with soybean. The result of the experiment revealed that the yield contributing characters of vegetables gradually increased with the increase of planting distance of the tree.

Bari and Rahim (2009) found that multistrata agroforestry systems with different tree spacing were found to significant influence on the root yield of carrot. The highest carrot root yield (29.87t ha-1in 2005 and 29.24t ha^{-1} in

2006) was recorded under sole cropping which were 12 followed by the wider and intermediate spacing of sissoo + lemon based MAF. The reduction in yield of carrot compared to sole cropping was more at closer spacing of MAF.

Islam *et al*. (2009) reported that morphological characteristic of winter vegetables, leaf length, leaf diameter, stem girth, fresh and dry weight decreased consistently with the decrease of distance from the tree. The growth characteristics of *Hopea oaiorata* was significantly influenced by all the three winter vegetables (red amaranth, stem amaranth and coriander).

Mamun (2009) studied that the performance of carrot, turnip and pea at different distances from the Boilam tree and found that the result of the experiment revealed that the yield contributing characters of the vegetables increased gradually with the increase of planting distance from the tree. The growth character of Boilam was not satisfactory in association with carrot and turnip but satisfactory in association with pea.

Moontasir (2009) studied that different Agroforestry practices for socioeconomic improvement of the farmers. The findings revealed that majority (40.75%) of the farmers belong to medium category possessed medium (21-30 trees) number of diversified tree species. The majority 33.33% of the farmers had low attitude regarding contribution of diversified tree species for their socioeconomic condition, where 25.92% was found to large category respectively. Within 40 different tree species, the high relative density of the study area was Mango (21.34%), Betelnut (12.89%) and Jackfruit (8.73%) respectively

Tanni (2010) observed that the yield of crops increased gradually with increase of planting distance from the Lohakat tree and crops under pruned condition provide better yield performance compared to unpruned condition. The growth characters of Lohakat tree are not satisfactory in association with tomato and radish but quite better in association with lettuce but found higher in association with soybean.

Ding *et al.* (2007) reported that tree shading reduced the crop yield by 27 and 22% in western and eastern regions, respectively, and also, mean crop yield for western side was 23% lower the eastern side.

Ahmed (2012) found that the kankong and jute yield was gradually increased with increasing distance from akashmoni tree base. However, the vegetables yield had reduced remarkably at 5 feet distant from tree base. Both kankong and jute successfully cultivate along with 2 years old Akashmoni tree without significant yield loss.

Babu (2012) conducted an experiment to study the growth and yield of two vegetables i.e. chilli and sweet gourd under different spacing from Eucalyptus tree, and he found that all the parameters i.e. plant height, diameter, leaf length, leaf diameter, no. of fruits plant^{-1}, yield were increased gradually with increasing distance from Eucalyptus tree It concluded that boundary plantation of Eucalyptus has negative effect on the growth & yield of chilli & sweetgourd.

Ummah (2012) reported that among the morphological parameters of bottle gourd such as vine length, no. of leaves, no. of fruits, weight of fruits, no. of branch and yield were decreased gradually when distance reduced in association of Mahogoni tree.

Habib *et al.* (2012) studied that the performance of summer vegetable in association with *Xylia dolabriformis* tree on summer vegetables. The results showed that the yield of the summer vegetables increased gradually with the increase of planting distance of the tree.

Bali (2012) conducted an experiment to study the growth and yield of okra under different spacing from lemon and guava tree, and he found that all the parameters i.e. plant height, , leaf length, leaf diameter, no. of fruits plant-^{1}, yield were increased gradually with increasing distance from lemon and guava tree. The result of the experiment revealed that the yield of Okra was increased gradually with the increase of planting distance from the tree.

2.5 Effect of light on growth and yield of cucumber

Haque *et al.* (2009) was conducted an experiment at the research farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh with the cucumber cv. Modumoti to evaluate the porpho-physiological characters and yield performance under four different levels of light (100, 75, 50 and 25% PAR). Significant differences were observed among the treatments in response to different evaluated characters. Main stem length, internode length and individual leaf area increased, whereas main stem diameter and numbers of leaves per plant decreased due to the reduced light levels. At 50% PAR number of leaves per plant decreased markedly. Leaf weight ratio (LWR) remained more or less similar up to 50% reduction of PAR. SPAD value increased with the reduction of PAR level i.e. partial shading stimulated chlorophyll synthesis in leaves. Compared to 100% PAR the total dry matter (TDM) was not reduced by reduction of light up to 50% PAR level. Cucumber produced the highest yield (15.32 t ha 1) at full sunlight. Significant fruit yield reduction was observed at 25% PAR in cucumber.

However, considering TDM and fruit yield cucumber were found suitable for reduced light condition (up to 50% PAR).

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

Bertomeu, (2006) reported that timber production on small farms has become profitable as a result of reduced supplies due to extensive deforestation and increasing demand. In the early 1990s, when the price of timber was high, farmers were promised huge returns from tree farming. However, widespread planting of few species has led to oversupply and a sharp decline in the price of farm grown timber. Moreover, low intercrop yields as a result of competition from fast-growing trees and low timber yields due to poor tree management, further reduce net economic returns. In spite of this, interest in tree farming remains high. This paper examines the private profitability of two tree-maize systems, namely trees in blocks and trees in hedgerows, compared with the alternative of maize monocropping. The analysis reveals that maize monocropping provides higher returns to land at the current timber price, but considerably lower returns to labour, than the maize-tree systems tested. This suggests that tree farming is a more attractive option for labour and capital constrained households or those with off-farm opportunities that compete for their labour. These farmers may raise productivity and income by planting trees on the excess land that cannot be devoted to annual crops. The analysis also indicates that wide-spaced tree hedgerows are superior to tree blocks, due to lower establishment and management costs, longer periods of viable intercropping and more rapid tree growth.

Caluza (2002) observed that the tree farming has been promoted on the promise of huge economic returns, based on overoptimistic yields of fast-growing trees in favorable tropical humid conditions and unrepresentatively high timber prices at specific times and locations. In the past few years, lower than expected returns from tree farming, particularly with *Gmelina arborea* R.Br (gmelina) and *Paraserianthes falcataria* (L.) Nielsen (falcata), has caused disenchantment among upland farmers.As planted trees reached harvestable age, prices fell drastically due to market saturation. In 1997, the price of gmelina on stumpage averaged PhP. 4 per board foot (bd.ft.), (i.e., 33 US $), a sixty percent (60%) decline with respect to prices in the early 90's. Moreover in the smallholder context, timber yields may be lower than predicted as a result of adverse soil conditions and farmers' poor management practices (e.g., excessive pruning and lack of thinning).

A second substantial thrust of agroforestry research has been on the inclusion of timber species into agricultural systems. De Foresta and Michon (1997) have suggested that in an acceptable (sustainable) agroforestry system, the majority of yields would be available for harvest or use on a "daily or monthly basis" and that some products of the system should be for household consumption. Systems that emphasize the production of even short-rotation timber as a principal focus will be hard pressed to meet these criteria, particularly as the timber matures (Sumitro, 1983; Barbier, 1990).

While substantial value may be accumulated through annual increments, this value is inaccessible to farmers for a considerable time period, and again the importance of crop losses due to resource competition will be increased.

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.

The other potential benefit of agroforestry is that of the diversification of species grown on farm. Through this, and the domestication of an increasing number of tree species, it should be possible to make small-holder farming both more biologically diverse and more rewarding economically. Through the incorporation of a range of domesticated trees into different agroforestry practices within the same landscape, agroforestry can become, as recently defined (Leakey, 1996).

Systems based on annual crops with timber producing, fruit producing, and biomass-biological nitrogen producing trees were studied. Sorghum (*Sorghum bicolor*) and black gram (*Vigna mungo*) with *Acacia auriculiformis* (auri), with *Psidium guajava*, and with *Leucaena leucocephala* as alley-crops were evaluated on infertile, rainfed, alfisols. For all forms of mixed cropping, relative yields of sorghum and black gram were reduced compared to yields where trees were absent. Within the 19 mixed systems, sorghum performed best with guava where its yield relative to solecropped sorghum ranged from 55 to 100%. Black gram in mixed systems produced best with guava or *Leucaena* with yields from 22 to 32% of solecropped black gram. Both crops performed poorly when associated with *Acacia auriculiformis*. Runoff measurements during the four years of the study showed that runoff losses were lowest in the fruit-tree-based system (4.9% of total precipitation). It should be noted that the guava system produced substantial quantities of fuelwood (300 t ha-1) after 15 years as compared to (500 t ha-1) for *Acacia auriculiformis* (Das *et al.,* 1993).

2.6 Effect of light on plant growth in understoried 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.

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 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 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).

2.7 Effect of shade on plant growth of 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.

Chaturvedi and Ingram (1989) mention 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 (9 kg/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.

2.8 Benefits of cucumber intercropping in agroforestry system

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 raio 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 14300/ha compared with the unmatched control.

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.

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.

John and Mini (2005) stated that okra planted at 60 cm × 45 cm spacing intercropped with cowpea produced the highest okra equivalent yield, low weed weight and the highest net and grows returns during both the seasons. 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.

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.

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

3.2 Soil Characteristics

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

3.3 Climate and Weather

The experimental site was situated under the tropical climate characterized by heavy rainfall from July to August and scanty rainfall in the rest period of the year. Monthly maximum and minimum temperatures, rainfall and relative humidity recorded during the experimental period (April to July, 2017) are included in the Appendix-II.

3.4 Experimental period

Duration of the experiential period was from April to July 2017

3.5 Experimental materials

Cucumber varieties were used as experimental crop; these were Hybrid Green bird , Hybrid Shehzedi and Local variety Sufola.

3.6 Experimental design

The experiment was laid out following two factors Randomized Complete Block Design (RCBD) with three replications. Total number of experimental plot was 36. The unit plot size is 2.5m x 2.5m = 6.25 m^2. The treatments of the experiment were as follows-

Factor A:	**Factor B:**
Four Production systems	Three cucumber varieties
T_1 = sole cropping of cucumber (control)	V_1 = Hybrid Greenbird)
T_2 = Kalo koroi + cucumber)	V_2 = Hybrid Shehzade
T_3 = Ghora neem + cucumber	V_3 = Local Sufola
T_4 = Mango + cucumber	

The treatment combinations were T_1 V_1, T_1 V_2, T_1 V_3, T_2 V_1, T_2 V_2 ,T_2 V_3, T_3 V_1, T_3 V_2, T_3 V_3, T_4 V_1, T_4 V_2 and T_4 V_3.

The spacing for all the tree species is 3 m x 3 m. and the age 12 years. The present status of the tree species in the research field are-

Trees	Plant height (m)	Clean bole height (m)	Base Girth (cm)	Bole Girth (cm)	Diameter at Breast Height cm.
Albiza lebbeck	17.5	7.5	125	95	75.0
Melia azedarach	15.0	10.5	118	97	80.0
Mangifera indica	6.0	2.0	24	18	15

The above mentioned individual tree leaf biomass 2.5kg was used in each experimental plot as organic mulching in agroforestry system except the control treatment. All the organic mulching materials were applied in 15 days after seed germination in the experimental plots.

3.7 Land preparation The land which was selected to conduct for the experiments was opened on 28 April 2017 by ploughing. Opening the land the plots were cross-ploughed followed by laddering to break up the soil clods to obtain good tilth and level the land. After final land preparation the experimental plots were laid out, and the edge around each unit plot was raised to check run out of the nutrients.

3.8 Manuring and fertilizer application

The entire quantity of cow dung (10 ton/ha) was applied just after opening the land (Rashid, 1999). Urea, TSP and MP were applied as the source of nitrogen, phosphorus and potassium respectively as recommended dose in each experimental plot. TSP was applied at the rate of 100 kg/ha (Rashid, 1999). The entire amount of Urea, TSP and MP in the experiment was applied at the time of final land preparation.

3.9 Sowing of seeds

The Cucumber seeds of cv. Greenbird, Shehzade and Local variety were sown on 4^{th} May 2017 in pits of each plot. There seeds were sown in each location. Then the seeds were covered with fine soil by hand.

3.10 Intercultural operations

Necessary intercultural operations were done through the cropping season for proper growth and development of the plant. Five to Six days after germination only one healthy seedling was kept to grow in each location and other seedling were removed. Three weeding were done to keep the plots free from weeds. Stagnant water was effectively drained out at the time of heavy rain.

Gap filing

Dead, injured and weak seedlings were replaced by new vigour seedling from the stock kept on the border line of the experiment.

Weeding

Significant numbers of weed were found in the control treatment. Weeding was done three times in these plots where it was necessary.

Irrigation

Light irrigation was given just after sowing the seed. A week after sowing the requirement of irrigation was envisaged through visual estimation. Wherever the plants of a plot had shown the symptoms of wilting the plots were irrigated on the same day with a hosepipe until the entire plot was properly wet.

Cucumber in open field

Cucumber under Kalo koroi tree

Cucumber under Ghora neem tree

Cucumber under Mango tree

Plate 3.1. Initial Land preparation, planting of cucumber seed and different age cucumber plants in different treatments

3.11 Harvesting

Green fruits were harvested at 2-3 days interval when they attained edible stage (i.e. the tender young fruits of cm long). Green fruits harvesting was started from 18, June and was continued up to 16 July.

3.12 Collection of data

Data were recorded on the following parameters from the sample plants during experimentation.

- Plant height (cm)
- Number of leaves plant^{-1}
- Leaf length (cm)
- Leaf breadth (cm)
- Petiole length(cm)
- Stem girth(cm)
- Main stem internode length (cm)
- Number of lateral shoots plant^{-1}
- Number of fruits plant^{-1}
- Fruit length (cm)
- Fruit girth (cm)
- Individual fruit weight (g)
- Fruit yield

Plant height (cm)

Plant height is measured in centimeter (cm) by a meter scale at 15, 30 and 45 days after sowing (DAS) from the point of attachment of the leaf to the ground level up to the tip of the longest leaf.

Number of leaves plant^{-1}

Number of leaves plant^{-1} of ten randomly selected plans was counted at 15, 30 and 45 days after sowing (DAS). All the leaves of selected plants were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting. .

Leaves length

Leaves of randomly selected plants were made detached and measured in centimeter (cm) by a meter scale at 15, 30 and 45 days after sowing (DAS).

Leaves breadth

Leaves of randomly selected plants were made detached and leaf breadth was measured in centimeter (cm) by a meter scale at 15, 30 and 45 days after sowing (DAS).

Petiole length

Petiole length was measured in centimeter (cm) by a meter scale at 15, 30 and 45 days after sowing (DAS).

Stem girth

Stem girth was measured in centimeter (cm) by a meter scale at 15, 30 and 45 days after sowing (DAS).

Main stem internode length

Main stem internode length was measured in centimeter (cm) by a meter scale at 15, 30 and 45 days after sowing (DAS).

Number of lateral shoots plant^{-1}

Number of lateral shoots plant^{-1} of randomly selected plans was counted at 30 and 45 days after sowing (DAS). Calculating the average number of shoots, the average number was recorded.

Number of fruits plant^{-1}

Mean number of fruits of selected plants from each plot was recorded.

Fruit length

The randomly selected fruits from each plot were taken and length was recorded by a meter scale in cm and finally mean was calculated.

Fruit girth

The randomly selected fruits from each plot were taken and girth were measured in cm with the help of slide calipers and finally mean was calculated.

Individual fruit weight

The fruits from selected plants of each plot were harvested and their weight was recorded and finally mean was calculated.

Fruit yield (kg plot^{-1})

After harvesting, the total yield for each treatment was counted and fruit yield per plot was calculated in kilogram by converting the mean green fruit yield per plot.

Fruit yield (t ha^{-1})

After harvesting, the total yield for each treatment was counted and fruit yield per hectare was calculated in metric ton by converting the mean green fruit yield per plot.

3.13 Bio-economics of the cucumber under different tree based agroforestry production systems

In order to work out the economic profitability of the agroforestry systems, the economic yield of cucumber and trees was subjected to economic analysis by calculating the cost of cultivation, gross and net returns per hectare and benefit-cost ratio. All these parameters were calculated on the basis of market prices prevailing at the time of the termination of experiments.

Total cost of production

The cost of cultivation of the cucumber was worked out on the basis of per hectare. The initial plantation cost of the kalo koroi, ghora neem mango saplings were integrated in this study. The management cost of kalo koroi, ghora neem and mango was also included. The total cost included the cost items like human labour and mechanical power costs, material cost (including cost of seed, fertilizers and manures, pesticide, bamboos, ropes etc.), land use cost and interest on operating capital (Appendix III).

Gross return

Gross return is the monetary value of total product and by-product. Per hectare gross returns from cucumber fruit was calculated by multiplying the total amount of production by their respective market prices.

Net return

Net return usually means the profit of the enterprises. Net return was calculated by deducting the total cost of production from the gross return (Kundu, 2002).

Net return = Gross return (Tk. ha^{-1}) – Total cost of production (Tk. ha^{-1})

Benefit-cost ratio (BCR)

Benefit-cost ratio is the ratio of gross return with total cost of production. It was calculated by using the following formula (Islam *et al.,* 2004).

$$\text{Benefit-cost ratio} = \frac{\text{Gross return (Tk. ha}^{-1}\text{)}}{\text{Total cost of production (Tk. ha}^{-1}\text{)}}$$

3.14 Statistical analysis

The collected 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).

CHAPTER 4
RESULTS AND DISCUSSION

The present experiment was carried out to investigate the varietal performance of cucumber as influenced by different timber tree based agroforestry production system involving organic mulching on growth, yield contributing characters and yield of cucumber. The results of the experiment was described in the 3 sub heads viz. main effect of timber tree based production system, cucumber variety, and finally their different combinations under the following sub-headings.

4.1 Main effect of the production system on growth, yield contributing characters and yield of cucumber

4.1.1 Plant height

Cucumber grown under different timber tree based agroforestry system was more vigorous than those grown in sole cropping i.e. in full sun light conditions (Table 4.1). At 15 DAS the highest plant height (38.11 cm) was observed in mango + cucumber based agroforestry system (T_4) which was statistically similar to that of ghora neem + cucumber based agroforestry system (T_3) and kalo koroi + cucumber based agroforestry system, where as the lowest plant height (23.44 cm) was observed in sole cropping (T_1) of cucumber production system, respectively. Again at 45 DAS, the highest plant height (171.6cm) was found in mango + cucumber based agroforestry system (T_4) similar to that of ghora neem + cucumber based agroforestry system, where as the lowest plant height (138.7 cm) was observed in (T_1) sole cropping of cucumber production system. Significantly at 60 DAS the highest plant height (310.4cm) was recorded mango + cucumber based agroforestry system (T_4) followed by that of ghora neem + cucumber based agroforestry system (T_3) and kalo koroi + cucumber based agroforestry system, where as the lowest plant height (260.0 cm) was observed in (T_1) sole cropping of cucumber production system,. Hillman (1984) reported that, plant grown in low light levels was found to be more apical dominant than those grown in high light environment resulting in taller plants under shade.

Table 4.1 Effect of production system on plant height (cm) of cucumber at different days after sowing

Treatments	Plant height (cm)		
	15 DAS	30 DAS	45 DAS
T_1	23.44 b	138.7 c	260.0 d
T_2	35.67 a	153.8 b	289.3 b
T_3	34.22 a	169.7 a	270.7 c
T_4	38.11 a	171.6 a	310.4 a
CV%	14.65	9.72	2.5

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.1.2 Number of leaves plant^{-1}

Number of leaves plant^{-1} of cucumber was observed significantly varied in different production system (Table 4.2). At 15 DAS the maximum number of leaves plant^{-1} (7.33) was recorded in sole cropping of cucumber (T_1) where as the minimum number of leaves plant^{-1} (5.89) was recorded in both ghora neem + cucumber based agroforestry system (T_3) and mango + cucumber based agroforestry system (T_4). Again at middle stage (30 DAS) the maximum number of leaves plant^{-1} (44.00) was observed in sole cropping of cucumber (T_1). On the other hand the minimum number of leaves plant^{-1} (23.67) was recorded in ghora neem + cucumber based agroforestry system (T_3) similar to that of T_2 and T_4. Significantly at 90 DAS, the maximum number of leaves plant^{-1} (93.22) was found in sole cropping of cucumber (T_1) and the minimum number of leaves plant^{-1} (61.44) was recorded in mango+ cucumber based agroforestry system (T_4), respectively.

Table 4.2 Effect of production system on number of leaf plant^{-1} of cucumber at different days after sowing

Treatments	Number of leaf plant^{-1}		
	15 DAS	**30 DAS**	**45 DAS**
T_1	7.33 a	44.00 a	93.22 a
T_2	6.22 ab	28.89 b	71.44 b
T_3	5.89 b	23.67 c	65.11 c
T_4	5.89 b	25.00 bc	61.44 d
CV%	19.63	15.08	2.63

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.1.3 Leaf length

Leaf length of cucumber was experimented significantly as influenced by different production system (Table 4.3). At 15 DAS, the highest leaf length (8.12 cm) was recorded in gora neem + cucumber based agroforestry system (T_3) similar to that of T_4, where as the lowest leaf length (6.53 cm) was found in sole cropping of cucumber (T_1). Again at 45 DAS the highest leaf length (12.96 cm) was observed in mango+ cucumber based agroforestry system (T_4) and the lowest leaf length (12.10 cm) was recorded in sole cropping of cucumber (T_1) followed by (T_2). Finally at 45 DAS, significantly the highest leaf length (17.87 cm) was observed in mango + cucumber based agroforestry system (T_4) and the lowest leaf length (15.97 cm) was recorded in sole cropping of cucumber (T_1) followed by (T_2), respectively.

Table 4.3 Effect of production system on leaf length (cm) of cucumber at different days after sowing

Treatments	Leaf length (cm)		
	15 DAS	**30 DAS**	**45 DAS**
T_1	6.53 b	12.10 b	15.97 c
T_2	6.80 b	12.21 b	16.00 c
T_3	8.12 a	12.62 ab	17.06 b
T_4	7.86 a	12.96 a	17.87 a
CV%	14.27	4.59	3.12

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.1.4 Leaf breadth

Leaf breadth of cucumber was also found significantly as influenced by different production system (Table 4.4). At 15 DAS, the highest leaf breadth (8.83cm) was recorded in mango+ cucumber based agroforestry system (T_4) which was identical to T_3 and the lowest leaf breadth (6.63cm) was found in kalo koroi +cucumber based agroforestry system (T_2) similar to T_1 . Again at 30 DAS the highest leaf breadth (15.79 cm) was observed in ghora neem + cucumber based agroforestry system (T_3), on the other hand the lowest leaf breadth (13.14cm) in sole cropping of cucumber (T_1). Finally at 45 DAS, significantly the highest leaf breadth (22.58 cm) was observed in kalo koroi + cucumber based agroforestry system (T_2) and the lowest leaf breadth (18.87 cm) was recorded in ghora neem + cucumber based agroforestry system (T_3), respectively.

Table 4.4 Effect of production system on leaf breadth (cm) of cucumber at different days after sowing

Treatments	Leaf breadth (cm)		
	15 DAS	**30 DAS**	**45 DAS**
T_1	6.83 b	13.14 c	20.07 b
T_2	6.63 b	14.12 b	22.58 a
T_3	8.07 a	15.79 a	18.87 c
T_4	8.83 a	14.40 b	19.96 b
CV%	10.91	6.64	2.53

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.1.5 Petiole length

Petiole length of cucumber was also found significantly as influenced by different production system (Table 4.5). At 15 DAS, the highest petiole length (7.63cm) was recorded in mango+ cucumber based agroforestry system (T_4) which was identical to T_3 where as the lowest petiole length (4.92 cm) was found in sole cropping of cucumber (T_1) followed by T_2. Again at 30 DAS the highest petiole length (12.18 cm) was observed in mango + cucumber based agroforestry system (T_4), on the other hand the lowest petiole length (8.38 cm) in sole cropping of cucumber (T_1). Finally at 45 DAS, significantly the highest petiole length (19.23 cm) was observed in mango + cucumber based agroforestry system (T_4) and the lowest petiole length (14.74 cm) was recorded in sole cropping of cucumber (T_1), respectively.

Table 4.5 Effect of production system on petiole length (cm) of cucumber at different days after sowing

Treatments	Petiole length (cm)		
	15 DAS	**30 DAS**	**45 DAS**
T_1	4.92 c	8.38 c	14.74 d
T_2	6.50 b	9.59 b	18.83 b
T_3	6.98 ab	9.51 b	16.58 c
T_4	7.63 a	12.18 a	19.23 a
CV%	15.64	9.73	2.01

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.1.6 Stem girth

Cucumber stem girth was found statistically significant by the effect of different production systems (Table 4.6). Significantly the highest stem girth (2.66 cm) was recorded in mango+ cucumber based agroforestry system (T_4) which was identical to (T_1) cucumber in sole cropping. On the other hand, the lowest stem girth (2.23 cm) was recorded in kalo koroi + cucumber based agroforestry system (T_2) which was similar to (T_3) ghora neem + cucumber based agroforestry system.

4.1.7 Main stem internode length

Cucumber main stem internode length was found statistically significant by the effect of different production systems (Table 4.6). Significantly the highest main stem internode length (5.67 cm) was recorded in ghora neem + cucumber based agroforestry system (T_3) that was statistically similar to T_1 and T_2, respectively. The lowest main stem internode length (4.31 cm) was recorded in mango+ cucumber based agroforestry system (T_4).

4.1.8 Number of lateral shoots plant^{-1}

Number of lateral shoots plant^{-1} was found statistically significant by the effect of different production systems (Table 4.6). At 30 DAS, the highest number of lateral shoots plant^{-1} (5.44) was recorded in open field i.e, sole cropping of cucumber(T_1) and the lowest number of lateral shoots plant^{-1} (3.22) was found in mango+ cucumber based agroforestry system (T_4) as well as T_2 and T_3, respectively. Again, at 45 DAS, , the highest number of lateral shoots plant^{-1} (8.78) was recorded in open field i.e, sole cropping of cucumber(T_1) control treatment and the lowest number of lateral shoots plant^{-1} (4.67) was found in ghora neem + cucumber based agroforestry system (T_3) similar to that of T_4, respectively.

Table 4.6 Effect of production system on stem girth, main stem inter node length and number of lateral shoot plant^{-1} (cm) of cucumber

Treatments	Stem girth (cm)	Main stem internode length (cm)	Number of lateral shoots plant^{-1}	
			30 DAS	45 DAS
T_1	2.522 a	5.433 a	5.444 a	8.78 a
T_2	2.233 b	4.844 ab	3.333 b	6.67 b
T_3	2.267 b	5.667 a	3.556 b	4.67 c
T_4	2.656 a	4.311 b	3.222 b	4.78 c
CV%	8.97	13.67	15.19	14.38

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.1.9 Number of fruits plant^{-1}

Number of fruits plant^{-1} was found statistically significant by the effect of different production systems (Table 4.7). Significantly the highest number of fruits plant^{-1} (15.33) was recorded in open field ie. sole cropping of cucumber (T_1) and the lowest number of fruits plant^{-1} (5.56) was found in ghora neem + cucumber based agroforestry system (T_3).

4.1.10 Fruit length

Cucumber fruit length was found statistically significant by the effect of different production systems (Table 4.7). Significantly the longest fruit length (20.02 cm) was recorded in sole cropping of cucumber (T_1), where as the shortest fruit length (17.89 cm) was recorded in ghora neem + cucumber based agroforestry system (T_3).

4.1.11 Fruit girth

Cucumber fruit girth was found statistically significant by the effect of different production systems (Table 4.7). Significantly the widest fruit girth (19.57 cm) was recorded in sole cropping of cucumber (T_1), where as the shortest fruit girth (17.03 cm) was recorded in ghora neem + cucumber based agroforestry system (T_3).

4.1.12 Individual fruit weight

Individual fruit weight of cucumber was found statistically significant by the effect of different production systems (Table 4.7). Significantly the highest fruit weight (489.0 g) was recorded in sole cropping of cucumber (T_1), where as the lowest fruit weight (335.8 g) was recorded in ghora neem + cucumber based agroforestry system (T_3).

4.1.13 Fruit yield (kg plot^{-1})

Cucumber yield was differed significantly by the production systems (Table 4.7). The highest yield (7.11 kg plot^{-1}) was found in sole cropping of cucumber (T_1). On the other hand the lowest yield (1.67 kg plot^{-1}) was observed in ghora neem + cucumber based agroforestry system (T_3).

4.1.14 Fruit yield (t ha^{-1})

Cucumber yield was differed significantly by the production systems (Table 4.7). The highest yield (11.37 t ha^{-1}) was found in sole cropping of cucumber (T_1). On the other hand the lowest yield (2.67 t ha^{-1}) was observed in ghora neem + cucumber based agroforestry system (T_3).

Table 4.7 Effect of production system on number of fruits plant^{-1}, fruit length, individual fruit weight and fruit yield of cucumber

Treatments	Number of fruits plant^{-1}	Fruit length (cm)	Fruit girth (cm)	Individual fruit weight (g)	Fruit yield (kg plot^{-1})	Fruit yield (t ha^{-1})
T_1	15.33 a	20.02 a	19.57 a	489.0 a	7.107 a	11.37 a
T_2	9.11 b	19.11 ab	17.32 ab	417.8 ab	3.264 b	5.224 b
T_3	5.56 c	17.89 b	17.03 b	335.8 b	1.667 c	2.667 c
T_4	6.11 c	18.07 ab	17.50 ab	361.9 ab	2.046 bc	3.271 bc
CV%	14.99	10.44	12.88	11.32	13.77	13.84

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.2 Main effect of variety on the growth, yield contributing characters and yield of cucumber

4.2.1 Plant height

The varietal effect on plant height (cm) of cucumber was found statistically significant at 30 and 45 DAS (Table 4.8). At 15 DAS the plant height was found insignificant. Numerically highest plant height (35.33 cm) was found in V_2 (hybrid shehzade) and the lowest plant height (31.58 cm) was observed in V_1 (hybrid green bird). At 30 DAS, significantly the highest plant height (178.8 cm) was observed in V_3 (local sufola) followed by V_1 (hybrid green bird), while the lowest plant height (140.3 cm) was found in V_2 (hybrid shehzade). Finally, at 45 DAS, significantly the highest plant height (343.6 cm) was recorded in V_3 (local sufola) followed by V_1 (hybrid green bird), while the lowest plant height (275.8 cm) was found in V_2 (hybrid shehzade). This might be occurred due to the varietal genetic characters of the cucumber.

Table 4.8 Effect of variety on plant height (cm) of cucumber at different days after sowing

Treatments	Plant height (cm)		
	15 DAS	**30 DAS**	**45 DAS**
V_1	31.58	156.2 b	275.8 b
V_2	35.33	140.3 c	228.5 c
V_3	31.67	178.8 a	343.6 a
CV%	14.65	9.72	2.5

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.2.2 Number of leaves plant^{-1}

Number of leaves plant^{-1} was significantly influenced by the different cucumber variety only at 45 DAS (Table 4.9). At 15 DAS, the number of leaves plant^{-1} was found insignificant. Numerically, the maximum number of leaves plant^{-1} (6.75) was recorded in V_1 (hybrid green bird) and the minimum number of leaves plant^{-1} (5.75) in V_3 (local sufola) variety. Similar trend was observed in 30 DAS. Finally, at 45 DAS the maximum number of leaves plant^{-1} (79.83) was found in V_1 (hybrid green bird) variety and the minimum number of leaves plant^{-1} (65.00) was found in V_2 (hybrid shehzade), respectively. This might be occurred due to genetic differences and inherent capacity of the cucumber varieties along with environmental conditions of the experimental sites. At 45 DAS the maximum number of leaves plant^{-1} (79.83) was found in hybrid green bird variety and the minimum number of leaves plant^{-1} (65.00) was found in hybrid shehzade.

Table 4.9 Effect of variety on number of leaf plant^{-1} of cucumber at different days after sowing

Treatments	Number of leaf plant^{-1}		
	15 DAS	30 DAS	45 DAS
V_1	6.75	30.92	79.83 a
V_2	6.50	32.00	65.00 c
V_3	5.75	28.25	73.58 b
CV%	19.63	15.08	2.63

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.2.3 Leaf length

The varietals effect on leaf length of cucumber was found statistically significant at 15, 30 and 45 DAS (Table 4.10). Significantly at 15 DAS the highest leaf length (7.79 cm) was found in V_3 (local sufola) which was statistically identical (7.75 cm) in V_2 (hybrid shehzade) and the lowest leaf length (6.44 cm) was observed in V_1 (hybrid green bird). At 30 DAS, the highest leaf length (12.85 cm) was found in V_2 (hybrid shehzade) statistically identical (12.68 cm) in V_3 (local sufola) and the lowest leaf length (11.89 cm) was observed in V_1 (hybrid green bird). Finally, at 45 DAS, the highest leaf length (19.03 cm) was found in V_3 (local sufola) followed by (15.83 cm) in V_1 (hybrid green bird) and the lowest leaf length (15.30 cm) was observed in V_2 (hybrid shehzade), respectively. This might be occurred due to genetic differences and inherent capacity of the cucumber varieties along with environmental conditions of the experimental sites.

Table 4.10 Effect of variety on leaf length (cm) of cucumber at different days after sowing

Treatments	Leaf length (cm)		
	15 DAS	**30 DAS**	**45 DAS**
V_1	6.44 b	11.89 b	15.83 b
V_2	7.75 a	12.85 a	15.30 c
V_3	7.79 a	12.68 a	19.03 a
CV%	14.27	4.59	3.12

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.2.4 Leaf breadth

The varietals effect on leaf breadth of cucumber was found statistically significant at 15, 30 and 45 DAS (Table 4.11). At 15 DAS significantly, the highest leaf breadth (8.61 cm) was found in V_3 (local sufola) which was statistically identical (8.00 cm) in V_2 (hybrid shehzade) and the lowest leaf breadth (6.13 cm) was observed in V_1 (hybrid green bird). At 30 DAS, the highest leaf breadth (14.98 cm) was found in V_2 (hybrid shehzade) which was statistically identical (14.88 cm) in V_3 (local sufola) and the lowest leaf breadth (13.13 cm) was observed in V_1 (hybrid green bird). Finally, at 45 DAS, the highest leaf breadth (23.94 cm) was found in V_3 (local sufola) followed by (19.01 cm) in V_1 (hybrid green bird) and the lowest leaf breadth (18.15 cm) was observed in V_2(hybrid shehzade). This might be occurred due to genetic differences and inherent capacity of the cucumber varieties along with environmental conditions of the experimental sites.

Table 4.11 Effect of variety on leaf breadth (cm) of cucumber at different days after sowing

Treatments	Leaf breadth (cm)		
	15 DAS	30 DAS	45 DAS
V_1	6.13 b	13.13 b	19.01 b
V_2	8.03 a	14.98 a	18.15 c
V_3	8.61 a	14.88 a	23.94 a
CV%	10.91	6.64	2.53

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.2.5 Petiole length

The varietals effect on petiole length of cucumber was found statistically significant at 15, 30 and 45 DAS (Table 4.12). Significantly at 15 DAS the highest petiole length (7.04 cm) was found in V_3 (local sufola) followed by (6.55 cm) in V_2 (hybrid shehzade) and the lowest petiole length (5.93 cm) was observed in V_1 (hybrid green bird). At 30 DAS, the highest petiole length (11.07 cm) was found in V_3 (local sufola) followed by (9.48 cm) in V_2 (hybrid shehzade) and the lowest petiole length (9.19 cm) was observed in V_1 (hybrid green bird). At 45 DAS, the highest petiole length (19.38 cm) was found in V_3 (local sufola) followed by (16.48 cm) in V_1 (hybrid green bird) and the lowest petiole length (16.18 cm) was observed in V_1 (hybrid green bird). This might be occurred due to genetic differences and inherent capacity of the cucumber varieties along with environmental conditions of the experimental sites.

Table 4.12 Effect of variety on petiole length (cm) of cucumber at different days after sowing

Treatments	Petiole length (cm)		
	15 DAS	30 DAS	45 DAS
V_1	5.93 b	9.19 b	16.48 b
V_2	6.55 ab	9.48 b	16.18 c
V_3	7.04 a	11.07 a	19.38 a
CV%	15.64	9.73	2.01

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.2.6 Stem girth

Stem girth of cucumber was varied insignificantly as directly influenced by the different cucumber variety (Table 4.13). Numerically, the longest stem girth (21.78 cm) was found in V_3 (local sufola). On the other hand the shortest stem girth (2.37 cm) was observed in V_2 (hybrid shehzade).

4.2.7 Main stem internode length

Main stem internode length of cucumber was also varied insignificantly as directly influenced by the different cucumber variety (Table 4.13). Numerically, the longest main stem internode length (5.54 cm) was found in V_2 (hybrid shehzade). On the other hand the shortest main stem internode length (4.78 cm) was observed in V_3 (local sufola).

4.2.8 Number of lateral shoots plant^{-1}

Number of lateral shoots plant^{-1} was significantly influenced by the different cucumber variety (Table 4.13). Significantly at 30 DAS the maximum number of lateral shoots plant^{-1} (4.83) was recorded in V_1 (hybrid green bird) which was statistically identical to (4.08) in V_2 (hybrid shehzade) treatment and the minimum number of lateral shoots plant^{-1} (5.75) in V_3 (local sufola). The number of lateral shoots plant^{-1} was increased in the course of time up to

45 DAS, respectively. At 45 DAS, the maximum number of lateral shoots plant^{-1} (7.17) was recorded in V_2 (hybrid shehzade) treatment which was statistically identical to (6.75) in V_1 (hybrid green bird) and the minimum number of lateral shoots plant^{-1} (4.75) in V_3 (local sufola). This might be occurred due to genetic differences and inherent capacity of the varieties along with environmental conditions of the experimental sites.

Table 4.13 Effect of variety on stem girth, main stem inter node length and number of lateral shoot plant^{-1} (cm) of cucumber

Treatments	Stem girth (cm)	Main stem internode length (cm)	Number of lateral shoots plant^{-1}	
			30 DAS	45 DAS
V_1	2.43 a	4.867 a	4.83 a	6.75 a
V_2	2.37 a	5.542 a	4.08 a	7.17 a
V_3	2.47 a	4.78 a	2.75 b	4.75 b
CV%	8.97	13.67	15.19	14.38

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at P ≤ 5% level.

4.2.9 Number of fruits plant^{-1}

Number of fruits plant^{-1} was varied significantly as influenced by the different varieties of cucumber (Table 4.14). Significantly the highest number of fruits plant^{-1} (11.75) was found in V_1 (hybrid variety) which was statistically identical to (11.17) V_2 (hybrid shehzade) . On the other hand the lowest number of fruits plant^{-1} (4.17) was observed in V_3 (local sufola).

4.2.10 Fruit length

Fruit length of cucumber was also varied significantly as directly influenced by the different cucumber variety (Table 4.14). Significantly the longest fruits length (21.78 cm) was found in V_3 (local sufola) which was followed by V_1 (hybrid green bird). On the other hand the shortest fruit length (17.09 cm) was observed in V_2 (hybrid shehzade).

4.2.11 Fruit girth

Fruit girth of cucumber was also varied significantly as directly influenced by the different cucumber variety (Table 4.14). Significantly the longest fruits girth (20.22 cm) was found in V_3 (local sufola) which was followed by V_2 (hybrid shehzade). On the other hand the shortest fruit girth (16.14 cm) was observed in V_1 (hybrid green bird).

4.2.12 Individual fruit weight

Individual fruit weight of cucumber was found statistically significant by the effect of different cucumber variety (Table 4.14). The highest individual fruit weight (577.1 g) was recorded in V_3 (local sufola) which was followed by V_1 (hybrid green bird).On the other hand the lowest individual fruit weight (303.6 g) was recorded in V_2 (hybrid shehzade).

4.2.13 Fruit yield (kg plot^{-1})

Cucumber fruit yield was differed significantly due to the influenced of the variety. The highest cucumber fruit yield (4.38 kg plot^{-1}) was found in V_1 (hybrid green bird) followed by (3.53 kg plot^{-1}) V_2 (hybrid shehzade). On the other hand the lowest fruit yield (2.65 kg plot^{-1}) was observed in V_3 (local sufola).

4.2.14 Fruit yield (t ha^{-1})

Cucumber fruit yield was differed significantly due to the influenced of the variety. The highest cucumber fruit yield (7.02 t ha^{-1}) was found in V_1 (hybrid green bird) followed by (5.64 t ha^{-1}) V_2 (hybrid shehzade). On the other hand the lowest fruit yield (4.24 t ha^{-1}) was observed in V_3 (local sufola).

Table 4.14 Effect of variety on number of fruits plant^{-1}, fruit length, individual fruit weight and fruit yield of cucumber

Treatments	Number of fruits plant^{-1}	Fruit length (cm)	Fruit girth (cm)	Individual fruit weight (g)	Fruit yield (kg plot^{-1})	Fruit yield (t ha^{-1})
V_1	11.75 a	17.44 b	16.14 b	322.7 b	4.38 a	7.02 a
V_2	11.17 a	17.09 b	17.21 b	303.6 b	3.53 ab	5.64 ab
V_3	4.17 b	21.78 a	20.22 a	577.1 a	2.65 b	4.24 b
CV%	14.99	10.44	12.88	11.32	13.77	13.84

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.3 Interaction effect of production system and variety on the growth, yield contributing characters and yield of cucumber

4.3.1 Plant height

The interaction effect of production system and variety on the plant height of cucumber was found significantly different at 15, 30 and 45 DAS (Table 4.15). At 15 DAS, significantly the highest plant height (42.33 cm) was found in T_3V_2 (ghora neem+ hybrid shehzade) followed by 41.00 cm in T_4V_1 (mango + hybrid green bird) treatment combination and the lowest plant height (20.67 cm) was recorded in T_2V_3 (kalo koroi + local sufola variety). At 30 DAS, significantly the highest plant height (195.0 cm) was found in T_1V_3 (open + local sufola variety) followed by 192.7 cm in T_4V_3 (mango + local sufola variety) treatment combination and the lowest plant height (117.3 cm) was recorded in T_2V_2 (kalokoroi + hybrid shehzade) followed by 124.0 cm in T_4V_2 (mango + hybrid shehzade), respectively. The trend of cucumber plant height was found gradually increase until 60 DAS. Finally at 60 DAS the highest plant height (441.7 cm) was recorded in T_1V_3 (0pen + local sufola variety) followed by 354.3 cm in T_2V_3 (kalokoroi + local sufola variety) treatment combination where as the lowest plant height (204.3 cm) was observed in T_4V_2 (mango + hybrid shehzade) which was statistically identical 222.3 cm in T_1V_2 (open + hybrid shehzade) treatment combination.

Table 4.15 Interaction effect of production system and variety on plant height (cm) of cucumber at different days after sowing

Treatments combinations	Plant height (cm)		
	15 DAS	30 DAS	45 DAS
T_1 V_1	32.00 abcd	154.0 cd	267.3 de
T_1 V_2	40.67 ab	165.7 bc	222.3 h
T_1 V_3	34.33 abcd	195.0 a	441.7 a
T_2 V_1	25.33 bcd	151.7 cde	279.o d
T_2 V_2	24.33 cd	117.3 f	235.0 g
T_2 V_3	20.67 d	192.3 ab	354.0 b
T_3 V_1	28.00 abcd	126.7 def	295.0 c
T_3 V_2	42.33 a	154.0 cd	252.3 f
T_3 V_3	32.33 abcd	135.3 def	232.7 gh
T_4 V_1	41.00 ab	192.3 ab	261.7 ef
T_4 V_2	34.00 abcd	124.0 ef	204.3 i
T_4 V_3	39.33 abc	192.7 ab	346.0 b
CV%	14.65	9.72	2.5

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.3.2 Number of leaves plant^{-1}

Number of leaves plant^{-1} was significantly influenced by the interaction effect of four production system and different cucumber variety (Table 4.16). At 15 DAS significantly the maximum number of leaves plant^{-1} (7.67) was recorded in T_1V_1 (open + hybrid green bird) followed by (7.67) in T_1V_2 (open+ hybrid shehzade) treatment combination and the minimum number of leaves plant^{-1} (5.00) in T_3V_3 (ghora neem + local sufola variety). The number of leaves plant^{-1} was increased in the course of time up to 45 DAS, respectively. At 30 DAS, the maximum number of leaves plant^{-1} (47.33) was recorded in T_1V_3 (open + local sufola variety) followed by (44.00) in T_1V_1 (open + hybrid green bird) treatment combination and the minimum number of leaves plant^{-1} (16.00) in T_3V_3 (ghora neem + local sufola variety) which was identical to 20.33 was found in T_4V_3 (mango+ local sufola variety) treatment combination. Finally, at 45 DAS the maximum number of leaves plant^{-1} (133.7) was found in T_1V_3 (open + local sufola variety) followed by 88.67 in T_1V_1 (open + hybrid green bird) treatment combination and the minimum number of leaves plant^{-1} (39.00) in T_3V_3 (ghora neem + local sufola variety) which was identical to (55.33) was found in T_4V_3 (mango + local sufola variety) treatment combination, respectively.

Table 4.16 Interaction effect of production system and variety on number of leaf plant^{-1} of cucumber at different days after sowing

Treatments combinations	Number of leaf plant^{-1}		
	15 DAS	**30 DAS**	**45 DAS**
T_1 V_1	7.67 a	40.67 ab	88.67 b
T_1 V_2	7.67 a	44.00 a	57.33 f
T_1 V_3	6.67 ab	47.33 a	133.7 a
T_2 V_1	6.67 ab	35.00 bc	85.67 b
T_2 V_2	5.67 ab	22.33 efg	62.33 e
T_2 V_3	6.33 ab	29.33 cde	66.33 d
T_3 V_1	6.33 ab	23.33 defg	78.33 c
T_3 V_2	6.33 ab	31.67 cd	78.00 c
T_3 V_3	5.00 b	16.00 g	39.00 g
T_4 V_1	6.33 ab	24.67 def	66.67 d
T_4 V_2	6.33 ab	30.00 cde	62.33 e
T_4 V_3	5.00 b	20.33 fg	55.33 f
CV%	19.63	15.08	2.63

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.3.3 Leaf length

Leaf length was significantly influenced by the interaction effect of four production system and three cucumber varieties (Table 4.17). In the initial stage at 15 DAS significantly the highest leaf length (8.80 cm) was recorded in T_3V_3 (ghora neem + local sufola variety) followed by (8.50 cm) in T_4V_2 (mango + hybrid shehzade) treatment combination and the lowest leaf length (6.00 cm) in T_3V_1 (ghora neem + hybrid green bird). In the middle stage at 30 DAS significantly the highest leaf length (13.53 cm) was found in T_4V_2 (mango + hybrid shehzade) followed by (13.50 cm) in T_4V_3 (mango + local sufola variety) treatment combination and the lowest leaf length (11.73 cm) in T_1V_2 (open + hybrid shehzade) which was identical to (13.43 cm) was found in T_2V_3 (open + local sufola variety) treatment combination, respectively. Finally at 45 DAS the highest leaf length (22.40 cm) was found in T_1V_3 (open + local sufola variety) followed by (22.20 cm) in T_2V_3 (kalokoroi + local sufola variety) treatment combination and the lowest leaf length (13.70 cm) in T_1V_1 (open + hybrid green bird) treatment combination.

Table 4.17 Interaction effect of production system and variety on leaf length (cm) of cucumber at different days after sowing

Treatments combinations	Leaf length (cm)		
	15 DAS	30 DAS	45 DAS
$T_1 V_1$	7.00 bcd	11.97 b	13.70 h
$T_1 V_2$	6.27 d	11.73 b	14.87 g
$T_1 V_3$	7.13 bcd	12.60 ab	22.60 a
$T_2 V_1$	6.07 d	11.93 b	17.23 cd
$T_2 V_2$	6.67 cd	12.83 ab	16.17 ef
$T_2 V_3$	6.87 bcd	11.87 b	20.20 b
$T_3 V_1$	6.00 d	11.83 b	17.00 de
$T_3 V_2$	9.57 a	13.30 a	15.50 fg
$T_3 V_3$	8.80 ab	12.73 ab	15.40 fg
$T_4 V_1$	6.70 cd	11.83 b	15.40 fg
$T_4 V_2$	8.50 abc	13.53 a	14.67 g
$T_4 V_3$	8.37 abc	13.50 a	17.93 c
CV%	14.27	4.59	3.12

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.3.4 Leaf breadth

Leaf breadth was significantly influenced by the interaction effect of four production system and three cucumber varieties (Table 4.18). In the initial stage at 15 DAS significantly the highest leaf breadth (10.00 cm) was recorded in T_4V_3 (mango + local sufola variety) followed by (9.63 cm) in T_4V_2 (mango + hybrid shehzade) treatment combination and the lowest leaf breadth (5.367 cm) in T_3V_1 (ghora neem + hybrid green bird). In the middle stage at 30 DAS significantly the highest leaf breadth (16.60 cm) was found in T_3V_2 (ghora neem + hybrid shehzade) followed by (16.57 cm) in T_3V_3 (ghora neem + local sufola variety) treatment combination and the lowest leaf breadth (11.97 cm) in T_1V_1 (open + hybrid green bird) which was identical to (12.70 cm) was found in T_1V_2 (open + hybrid shehzade) treatment combination, respectively. Finally at 45 DAS the highest leaf breadth (26.47 cm) was found in T_1V_3 (open + local sufola variety) followed by (26.47 cm) in T_1V_3 (open + local sufola variety) treatment combination and the lowest leaf breadth (16.77 cm) in T_1V_1 (open + hybrid green bird) treatment combination.

Table 4.18 Interaction effect of production system and variety on leaf breadth (cm) of cucumber at different days after sowing

Treatments combinations	Leaf breadth (cm)		
	15 DAS	30 DAS	45 DAS
T_1 V_1	6.53 bc	11.97 f	16.77 f
T_1 V_2	6.37 bc	12.70 ef	16.97 f
T_1 V_3	7.60 b	14.77 bcd	26.47 a
T_2 V_1	5.77 c	13.53 cdef	21.43 c
T_2 V_2	6.57 bc	15.6o ab	20.13 d
T_2 V_3	7.57 b	13.23 def	26.17 a
T_3 V_1	5.37 c	14.20 bcde	18.10 e
T_3 V_2	9.57 a	16.60 a	17.97 e
T_3 V_3	9.27 a	16.57 a	20.53 d
T_4 V_1	6.87 bc	12.83 ef	19.73 d
T_4 V_2	9.63 a	15.03 abc	17.53 ef
T_4 V_3	10.00 a	15.33 ab	22.60 b
CV%	10.91	6.64	2.53

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.3.5 Petiole length

Petiole length was significantly influenced by the interaction effect of four production system and three cucumber variety (Table 4.19). In the initial stage at 15 DAS significantly the highest petiole length (8.83 cm) was recorded in T_4V_3 (mango + local sufola variety) followed by (7.93 cm) in T_3V_2 (ghora neem + hybrid shehzade) treatment combination and the lowest petiole length (4.43cm) in T_2V_3 (kalo koroi + local sufola variety). In the middle stage at 30 DAS significantly the highest petiole length (15.73 cm) was found in T_2V_3 (kalo koroi + local sufola variety) followed by (10.47 cm) in T_2V_1 (ghora neem + hybrid green bird) treatment combination and the lowest petiole length (7.47 cm) in T_1V_1 (open + hybrid green bird) which was identical to (8.33 cm) was found in T_1V_2 (open + hybrid shehzade) treatment combination, respectively. Finally at 45 DAS the highest petiole length (23.70 cm) was found in T_2V_3 (kalo koroi + local sufola variety) followed by (22.93 cm) in T_1V_3 (open + local sufola variety) treatment combination and the lowest petiole length (12.93 cm) in T_3V_3 (ghora neem + local sufola variety) treatment combination.

Table 4.19 Interaction effect of production system and variety on petiole length (cm) of cucumber at different days after sowing

Treatments combinations	Petiole length (cm)		
	15 DAS	30 DAS	45 DAS
T_1 V_1	6.467 bcde	7.467 d	15.87 e
T_1 V_2	5.967 cdef	8.333 cd	17.70 c
T_1 V_3	7.067 abcd	9.333 bc	22.93 b
T_2 V_1	5.267 def	10.47 b	17.93 c
T_2 V_2	5.067 ef	10.33 b	16.07 e
T_2 V_3	4.433 f	15.73 a	23.70 a
T_3 V_1	5.167 def	9.833 bc	14.33 f
T_3 V_2	7.933 ab	9.400 bc	16.97 d
T_3 V_3	7.833 abc	9.300 bc	12.93 g
T_4 V_1	6.833 bcde	9.000 bcd	17.80 c
T_4 V_2	7.233abc	9.833 bc	14.00 f
T_4 V_3	8.833 a	9.933 bc	17.93 c
CV%	15.64	9.73	2.01

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.3.6 Stem girth

The interaction effect of production system and variety on the stem girth of cucumber was found significantly different (Table 4.20). Significantly the longest stem girth (2.80 cm) was found in T_4V_3 (mango + local sufola variety) treatment combination followed by (2.63 cm) was observed in T_4V_1 (mango + hybrid green bird variety) treatment combination and the shortest stem girth (1.97 cm) was recorded in T_2V_2 (kalo koroi + hybrid shehzade) that was statistically identical to (2.17 cm) found in T_3V_1 (ghora neem + hybrid green bird) treatment combination, respectively.

4.3.7 Main stem internode length

The interaction effect of production system and variety on the main stem internode length of cucumber was found significantly different (Table 4.20). Significantly the longest main stem internode length (7.00 cm) was found in T_3V_2 (ghora neem + hybrid shehzade) treatment combination followed by (6.03 cm) was observed in T_1V_3 (open + local sufola variety) treatment combination and the shortest main stem internode length (3.87 cm) was recorded in T_4V_3 (mango + local sufola variety) that was statistically identical to (4.27 cm) found in T_4V_1 (mango + hybrid green bird) treatment combination, respectively.

4.3.8 Number of lateral shoots plant^{-1}

Number of lateral shoots plant^{-1} was significantly influenced by the interaction effect of four production system and three different cucumber varieties (Table 4.20). At 30 DAS significantly the maximum number of lateral shoots plant^{-1} (7.33) was recorded in T_1V_1 (open + hybrid green bird) followed by 5.33 in T_1V_3 (open + local sufola variety) treatment combination. On the other hand the lowest number of lateral shoots plant^{-1} (1.00) was recorded in T_3V_3 (ghora neem + local sufola variety) which was identical

(1.33) in T_4V_3 (mango + local sufola variety) treatment combination, respectively. The number of lateral shoots plant^{-1} was increased in the course of time up to 45 DAS, respectively. At 45 DAS, the maximum number of lateral shoots plant^{-1} (10.33) was recorded in T_1V_1 (open + hybrid green bird) followed by (8.00) in T_1V_2 (open + hybrid shehzade) treatment combination and the minimum number of lateral shoots plant^{-1} (2.67) in T_3V_3 (ghora neem + local sufola variety) which was similar to (2.67) was found in T_4V_3 (mango+ local sufola variety) treatment combination.

Table 4.20 Interaction effect of production system and variety on stem girth, main stem inter node length and number of lateral shoot plant^{-1} (cm) of cucumber

Treatments combinations	Stem girth (cm)	Main stem internode length (cm)	Number of lateral shoots plant^{-1}	
			30 DAS	45 DAS
$T_1 V_1$	2.50 abc	4.97 ab	7.33 a	10.33 a
$T_1 V_2$	2.57 abc	5.30 ab	3.67 bcd	8.00 b
$T_1 V_3$	2.50 abc	6.03 ab	5.33 b	8.00 b
$T_2 V_1$	2.40 abc	4.83 ab	4.00 bcd	7.67 b
$T_2 V_2$	1.97 d	5.07 ab	2.67 de	6.67 c
$T_2 V_3$	2.33 bcd	4.63 b	3.33 cd	5.67 c
$T_3 V_1$	2.17 cd	5.40 ab	4.67 bc	5.33 c
$T_3 V_2$	2.40 abc	7.00 a	5.00 bc	6.00 c
$T_3 V_3$	2.23 bcd	4.60 b	1.00 e	2.67 d
$T_4 V_1$	2.63 ab	4.27 b	3.33 cd	3.67 d
$T_4 V_2$	2.53 abc	4.80 ab	5.00 bc	8.00 b
$T_4 V_3$	2.80 a	3.87 b	1.33 e	2.67 d
CV%	8.97	13.67	15.19	14.38

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.3.9 Number of fruits plant^{-1}

Number of fruits plant^{-1} was significantly influenced by the interaction effect of four production system and three different cucumber varieties (Table 4.21). Significantly the highest number of fruits plant^{-1} (20.33) was recorded in T_1V_1 (open + hybrid green bird) followed by (17.33) in T_1V_2 (open + hybrid shehzade) treatment combination. On the other hand the lowest number of fruits plant^{-1} (1.667) was recorded in T_4V_3 (mango + local sufola variety) which was identical (2.33) in T_3V_3 (ghora neem + local sufola variety) treatment combination, respectively. 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 .

4.3.10 Fruit length

The interaction effect of production system and variety on the fruit length of cucumber was found significantly different (Table 4.21). Significantly the longest fruit length (23.33 cm) was found in T_1V_3 (open + local sufola variety) treatment combination followed by (23.17 cm) was observed in T_2V_3 (kalokoroi + local sufola variety) treatment combination and the shortest fruit length (15.80 cm) was recorded in T_3V_1 (ghora neem + hybrid green bird) that was statistically identical to (16.97 cm) found in T_3V_2 (ghora neem + hybrid shehzade) treatment combination, respectively.

4.3.11 Fruit girth

The interaction effect of production system and variety on the fruit girth of cucumber was found significantly different (Table 4.21). Significantly the longest fruit girth (22.83 cm) was found in T_1V_3 (open + local sufola variety) treatment combination followed by (20.30 cm) was observed in T_2V_3 (open + local sufola variety) treatment combination and the shortest fruit girth (15.30 cm) was recorded in T_3V_1 (ghora neem + hybrid green bird) that was statistically similar to (15.83 cm) found in T_2V_1 (open + hybrid green bird) treatment combination, respectively.

4.3.12 Individual fruit weight

Individual fruit weight was significantly varied by the interaction effect of four production system and three different cucumber varieties (Table 4.21). Significantly the highest individual fruit weight (728.7 g) was recorded in T_1V_2 (open + hybrid shehzade) followed by (665.3 g) was recorded in T_2V_2 (kalokoroi+ hybrid shehzade) treatment combination. On the other hand the lowest individual fruit weight (72.52 g) was recorded in T_4V_3 (mango + local sufola variety) treatment combination, respectively. The individual fruit weight was higher in control than shady plots because of the maximum use of natural resources.

4.3.13 Fruit yield (kg plot^{-1})

Fruit yield of cucumber was significantly varied as influence by the interaction effect of production system and different variety (Table 4.21). Significantly the highest yield (6.25 kg plot^{-1}) was found in T_1V_1 (open + hybrid green bird) followed by (5.72 kg plot^{-1}) was recorded in T_1V_2 (open + hybrid shehzade) treatment combination. On the other hand the lowest yield (0.77 kg plot^{-1}) was recorded in T_4V_2 (mango + hybrid shehzade) treatment combination, respectively.

4.3.14 Fruit yield (t ha^{-1})

Fruit yield of cucumber was significantly varied as influence by the interaction effect of production system and different variety (Table 4.21). Significantly the highest yield (9.99 t ha^{-1}) was found in T_1V_1 (open + hybrid green bird) followed by (9.16 t ha^{-1}) was recorded in T_1V_2 (open + hybrid shehzade) treatment combination. On the other hand the lowest yield (1.23 t ha^{-1}) was recorded in T_4V_2 (mango + hybrid shehzade) treatment combination, respectively.

Table 4.21 Interaction effect of production system and variety on number of fruits plant^{-1}, fruit length, individual fruit weight and fruit yield of cucumber

Treatments combinations	Number of fruits plant^{-1}	Fruit length (cm)	Fruit girth (cm)	Individual fruit weight (g)	Fruit yield (kg plot^{-1})	Fruit yield (t ha^{-1})
$T_1 V_1$	20.33 a	19.30 cde	17.60 bc	349.0 c	6.25 a	9.99 a
$T_1 V_2$	17.33 a	17.43 cde	18.27 bc	728.7 a	5.72 ab	9.16 ab
$T_1 V_3$	8.33 bcde	23.33 a	22.83 a	314.7 c	3.75 abc	6.01 abc
$T_2 V_1$	11.67 b	17.17 de	15.83 c	273.3 cd	3.11 bc	4.97 bc
$T_2 V_2$	11.33 bc	17.00 de	15.83 c	665.3 ab	2.93 bc	4.69 bc
$T_2 V_3$	4.33 ef	23.17 ab	20.30 ab	256.7 cd	1.96 c	3.14 c
$T_3 V_1$	7.67 bcde	15.80 e	15.30 c	279.7 cd	1.86 c	2.97 c
$T_3 V_2$	6.67 de	16.97 de	17.37 bc	471.0 bc	1.18 c	1.89 c
$T_3 V_3$	2.33 f	20.90 abc	18.43 bc	330.0 c	2.47 c	3.96 c
$T_4 V_1$	7.33 cde	17.50 cde	15.83 c	312.3 c	2.89 bc	4.63 bc
$T_4 V_2$	9.33 bcd	16.97 de	17.37 bc	443.3 bc	0.77 c	1.23 c
$T_4 V_3$	1.667 f	19.73 bcd	19.30 ab	72.52 d	0.88 c	1.43 c
CV%	14.99	10.44	12.88	11.32	13.77	13.84

In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

4.4 Economic analysis

Profitability of growing cucumber as inter-crop under different multipurpose trees (*Albizia lebbeck, Melia azedarach and Mangifera indica*) based agroforestry production system along with sole cropping was calculated based on local market rate prevailed during experimentation. The cost of production of cucumber and cost of production of tree plantation and management of trees have been summarized in appendix III. The return of produce and the profit per taka i.e. Benefit Cost Ratio (BCR) also have been presented in Table 4.22.

4.4.1Total cost of production

The values in Appendix III indicate that the total cost of production was highest (198974.85 Tk./ha) under cucumber + kalo koroi based agroforestry production system (T_2) followed by cucumber sole cropping production system (160780.85 Tk./ha) (T_1) and cucumber + mango based agroforestry production system (197025.6 Tk./ha) in (T_4). The lowest cost of production (194567.85 Tk./ha) was recorded cucumber + ghora neem based agroforestry production system system (T_3) . Higher cost of production was found in the cucumber + kalo koroi based agroforestry production system due to higher plantation cost of the system.

4.4.2 Gross return

Gross return is an important indicator whether crop cultivation is profitable or not. The highest value of gross return (532840 Tk. /ha) was obtained from cucumber + kalo koroi (T_2) based agroforestry production system. On the other hand, the lowest value of gross return (393450 tk. /ha) was obtained from cucumber + ghora neem based agroforestry production system (T_3) .The highest gross return was obtained due to higher wood vale of kalo koroi trees along with the cucumber value (Table 4. 22).

4.4.3 Net return

The results presented in the Table 4.22 showed that net return (333865.15) was comparatively higher in producing cucumber + kalo koroi (T_2) based agroforestry production system than other agroforestry production system. It was observed that cucumber + kalo koroi based agroforestry production system (T_2) gave the highest net return (333865.15 tk./ha) followed by 267424.4tk/ha) in cucumber + mango (T_4) based agroforestry production system. At the same time, the lowest net return (198882.15Tk. /ha) was received from cucumber + ghora neem based agroforestry production system system (T_3).Higher net return was the result of higher gross return from the cucumber cultivation together with kalo koroi trees.

4.3.4 Benefit-cost ratio

The highest benefit-cost ratio of 2.68 was recorded from cucumber + kalo koroi (T_2) based agroforestry production system followed by 2.48 cucumber sole cropping production system and 2.36 cucumber + mango (T_4) based agroforestry production system and the lowest benefit-cost ratio of 2.02 was observed in cucumber + ghora neem (T_3) based agroforestry production system. So, cucumber can profitably be cultivated in kalo koroi based agroforestry production systems. Thus, it may be advocated that such type of speculation will be beneficial to the farmer as because such production system not only provides cash money to the farmer but also gradually can enrich the soil nutritionally.

Table 4.22 Economics of cucumber production under kalo koroi, ghora neem and mango based agroforestry system along with sole cropping (average of one year)

Tret.	Return (Tk./ha)				Gross Return (Tk./ha)	Total cost of Production (Tk./ha)	Net Return (Tk./ha)	BCR
	Cucumber	Kala koroi	Ghora neem	Mango				
T_1	397950				397950	160780.85	237169.15	2.48
T_2	182840	375000			532840	198974.85	333865.15	2.68
T_3	93450		300000		393450	194567.85	198882.15	2.02
T_4	114450			380000	464450	197025.60	267424.4	2.36

Note: cucumber 35 Tk./kg, Kala koroi 400 Tk./Tree/Year Ghora neem 300Tk./Tree/Year, Mango 350 Tk./Tree/Year

CHAPTER 5
SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

A field experiment was carried out at the Agroforestry and Environment Research Farm, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, during April to July 2017 to evaluate the performance of cucumber cv. Hybrid geeen bird, Hybrid shezade and Local sufola variety under different tree based agroforestry systems along with sole cropping i.e. open field condition. The experiment was conducted in newly established tree woodlot. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. The treatments were factor A: Four production system viz. T_1 (Cucumber sole cropping), T_2 (kalo koroi + cucumber), T_3 (ghora neem + cucumber) and T_4 (mango + cucumber), on the other hand factor B: 3 cucumber varieties viz. V_1 (Hybrid green bird), V_2 (Hybrid shehzade) and V_3 (local sufola variety). So the treatment combinations were T_1 V_1, T_1 V_2, T_1 V_3, T_2 V_1, T_2 V_2, T_2 V_3, T_3 V_1, T_3 V_2, T_3 V_3, T_4 V_1, T_4 V_2 and T_4 V_3. The unit plot size was 2.5m × 2.5m (6.25 m^2). Seeds of cucumber were sown in 4 May, 2017. Necessary intercultural operations were done effectively. *Albiza lebbeck*, *Melia azedarach* and *Mangifera indica* tree leaf biomass 2.5kg was used in each experimental plot as organic mulching in agroforestry system except the control treatment. All the organic mulching materials were applied in 15 days after seed germination in the experimental plots.

The data were taken at 15, 30 and 45 days after sowing (DAS) for plant height, number of leaves plant^{-1}, leaf length ,leaf breadth , petiole length, stem girth ,main stem internode length , number of lateral shoots plant^{-1} ,number of fruits plant^{-1} .The data of the other parameters such as fruit length, fruit girth , individual fruit weight , fruit yield were taken in the harvesting stage. The data were analyzed statistically and means were adjusted by DMRT (Duncan's Multiple Range Test). The results of the research were showed that the production system, variety and the combine effect were significant in respect of plant height (cm), number of leaves plant^{-1}, leaf length (cm), leaf breadth (cm), petiole length(cm), stem girth(cm) ,main stem internode length(cm) , number of lateral shoots plant^{-1} , number of fruit plant^{-1}, fruit length (cm), fruit girth (cm), individual fruit weight and fruit yield, respectively.

The main effect of production system, the results of the research were showed significant in respect of plant height at (15 DAS, 30 DAS, & 45 DAS), number of leaves plant^{-1} at (15 DAS, 30 DAS, & 45 DAS), leaf length (cm) at (15 DAS, 30 DAS, & 45 DAS), leaf breadth (cm) at (15 DAS, 30 DAS, & 45 DAS), petiole length(cm) at (15 DAS, 30 DAS, & 45 DAS), stem girth (cm), main stem internode length (cm) ,number of lateral shoots plant^{-1} at (30 DAS, & 45 DAS), number of fruit plant^{-1}, fruit length (cm), fruit girth (cm), individual fruit weight and fruit yield, respectively. Significantly the plant height increased gradually with the advancement of time up to the harvesting stage and at 45 DAS the highest plant height (38.11 cm) was found in cucumber + mango based agroforestry production system and the lowest plant height (23.44 cm) was recorded in cucumber in sole cropping production system. But in case of number of leaves plant^{-1} and also leaf length & leaf breadth was found highest in cucumber production in sole cropping production system. On the other hand the lowest number of leaves plant^{-1} and also leaf length & leaf breadth was observed in cucumber + mango based agroforestry production system. Significantly the highest number of fruit plant^{-1}(15.33), longest fruit length (20.02 cm) and fruit girth (19.57cm) was found in cucumber sole cropping production system and the lowest number of fruit plant^{-1}(5.56), shortest fruit length (17.89cm) and fruit girth (17.03cm) was found in cucumber + ghora neem based agroforestry system. Finally the highest fruit weight plant^{-1} (489.0g) and fruit yield (11.37 tha^{-1})was found in cucumber in sole cropping production system and lowest fruit weight plant^{-1} (1.667 g) and fruit yield (2.667 tha^{-1})was recorded in cucumber + ghora neem based agroforestry production system.

Main effect of variety on the growth, yield contributing characters and yield of cucumber was found significantly different. At 30 DAS, significantly the highest plant height (178.8 cm) was observed in local sufola, while the lowest plant height (140.3 cm) was found in hybrid shehzade. Finally, at 45 DAS, significantly the highest plant height (343.6 cm) was recorded in local sufola and the lowest plant height (275.8 cm) was found in hybrid shehzade. At 30 DAS, the highest petiole length (11.07 cm) was found in V_3 (local sufola) followed by (9.48 cm) in V_2 (hybrid shehzade) and the lowest petiole length (9.19 cm) was observed in V_1 (hybrid green bird). At 45 DAS, the highest petiole length (19.38 cm) was found in local sufola and the lowest petiole length (16.18 cm) was observed in hybrid green bird. Significantly the highest number of fruits plant^{-1} (11.75) was found in hybrid variety and the lowest number of fruits plant^{-1} (4.17) was observed in (local sufola). Significantly the longest fruits length (21.78 cm) was found in local sufola and the shortest fruit length (17.09 cm) was observed in hybrid shehzade. The highest individual fruit weight (577.1 g) was recorded in local sufola and lowest individual fruit weight (303.6 g) was recorded in hybrid shehzade. The highest cucumber fruit yield (7.02 t ha^{-1}) was found in hybrid green bird) followed by (5.64 t ha^{-1}) hybrid shehzade and the lowest fruit yield (4.24 t ha^{-1}) was observed in local sufola.

Interaction effect of production system and variety on the growth, yield contributing characters and yield of cucumber was found significantly different. At 15 DAS, significantly the highest plant height (42.33 cm) was found in (ghora neem+ hybrid shehzade) treatment combination and the lowest plant height (20.67 cm) was recorded in kalo koroi + local sufola variety). At 30 DAS, significantly the highest plant height (195.0 cm) was found in open + local sufola and the lowest plant height (117.3 cm) was recorded in kalokoroi + hybrid shehzade The trend of cucumber plant height was found gradually increase until 60 DAS. At 45 DAS the highest petiole length (23.70 cm) was found in kalo koroi + local sufola variety treatment combination and the lowest petiole length (12.93 cm) in ghora neem + local sufola variety treatment combination. Significantly the highest number of fruits plant^{-1} (20.33) was recorded in open + hybrid green bird) and treatment combination and the lowest number of fruits plant^{-1} (1.667) was recorded in mango + local sufola variety treatment combination, respectively. Significantly the longest fruit length (23.33 cm) was found in open + local sufola variety treatment combination treatment combination and the shortest fruit length (15.80 cm) was recorded in ghora neem + hybrid green bird treatment combination. The individual fruit weight was higher in control than shady plots because of the maximum use of natural resources. Fruit yield of cucumber was significantly varied as influence by the interaction effect of production system and different variety. Significantly the highest yield (9.99 t ha^{-1}) was found in open + hybrid green bird treatment combination and the lowest yield (1.23 t ha^{-1}) was recorded in T_4V_2 (mango + hybrid shehzade) treatment combination, respectively. The highest benefit-cost ratio of 2.68 was recorded from cucumber + kalo koroi (T_2) based agroforestry production system followed by 2.48 cucumber sole cropping production system and 2.36 cucumber + mango (T_4) based agroforestry production system and the lowest benefit-cost ratio of 2.02 was observed in cucumber + ghora neem (T_3) based agroforestry production system. So, cucumber can profitably be cultivated in kalo koroi based agroforestry production systems.

5.2 Conclusion

Based on the findings of the experiment it will be concluded that cucumber production was based under the Kalo koroi tree as compare to the other trees. The results of this experiment clearly included that the choice of species of tree and cucumber variety for an Agroforestry system is very significant. Therefore, before making choice about the shade plants the crop which is usually supposed to be grown in partial shade condition green bird was performed the best in point of yield contributing character in association with Kalo koroi, respectively.

5.3 Recommendation

1. To get good result the developed model should be applied in different multipurpose tree species of the northern side of Bangladesh.
2. It may be also advocated that to get a vital results it will be recommendation this study should be repeated in different location of the country with different aged multipurpose tree species woodlots as well orchard.
3. Fruit tree is another option for cucumber production.
4. This research should be accomplise in different like condition.

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APPENDIX

Appendix-I: The soil properties of Agroforestry and Environment farm HSTU, Dinajpur.

Soil characters	Physical and chemical properties
Texture	
Sand (%)	67
Silt (%	33
Clay(%	5
Textural class	Sandy loam
CEC (meq/ 100g)	8.00
pH	5.1
Organic matter (%)	1.25
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)	25.0
Sulphur (µg/g)	3.1
Boron (µg/g)	0.28
Iron (µg/g)	5.30
Zinc (µg/g)	0.90

Source: Soil Resources Development Institute, Dinajpur (2017).

Appendix II. Monthly records of different weather data at the period from April to July 2017.

Month	** Air Temperature (ºC)					
	Maximum	Minimum	Average	**Relative Humidity (%)	*Rainfall (mm)	*Sunshine (hrs.)
April	21.8	18.0	19.9	83.0	1.0	269.7
May	32.8	21.1	26.9	85.0	54.0	280.4
June	32.9	22.7	27.8	90.0	425.0	250.1
July	35.5	27.6	31.5	92.0	538.0	220.1

* Monthly Total

** Monthly average

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

Appendix III. Cost of production for cucumber under different tree based agroforestry system (average of one years)

Treatment	Input cost									Total input cost (Tk/ha)	Over head cost			Total cost of production (Tk/ha)
	Non material cost (Tk/ha)			Material cost (Tk/ha)							Interest of input cost @ 8% for the crop season (Tk/ha)	Interest of the value of land (Tk. 300000/ha /ha) @ 8% for the crop season (Tk/ha)	Miscellaneous cost @ 5% of the input cost (Tk/ha)	
	Trees	cucumber production	Total non material cost	Seed	Fertilizer	Pesticide	Maintenance cost of trees	Initial plantation cost of trees	Total material cost (Tk/ha)					
T_1	………	81050	81050	24445	6660	8890	………	………	39995	121045	9683.6	24000	6052.25	160780.85
T_2	14300	81050	95350	24445	6660	8890	5000	14500	59495	154845	12387.6	24000	7742.25	198974.85
T_3	14400	81050	95450	24445	6660	8890	5000	10500	55495	150945	12075.6	24000	7547.25	194567.85
T_4	14575	81050	95625	24445	6660	8890	5000	12500	57495	153120	12249.6	24000	7656	197025.6

Note: Urea 12 Tk./kg, TSP 22 Tk./kg; MP 24 Tk./kg, Labour 400 Tk./day, Plantation cost for mango, ghora neem and Kala koroi were 50, 15, and 18 Tk./tree, respectively (rotation year for mango, ghora neem and Kala koroi were 12, 15 and 20 years, respectively).

Appendix IV. Initial stage of Cucumber plants in different treatments

Palte No. a: Cucumber in open field

Plate No. b: Cucumber under Kalo koroi tree

Pate No. c: Cucumber under Ghora neem

Plate No. d: Cucumber under Mango tree

Appendix V. Harvesting stage of Cucumber plants in different treatments

Plate No. e: Cucumber in open field

Plate No. f: Cucumber under Kalo koroi tree

Plate No. g: Cucumber under Ghora neem tree

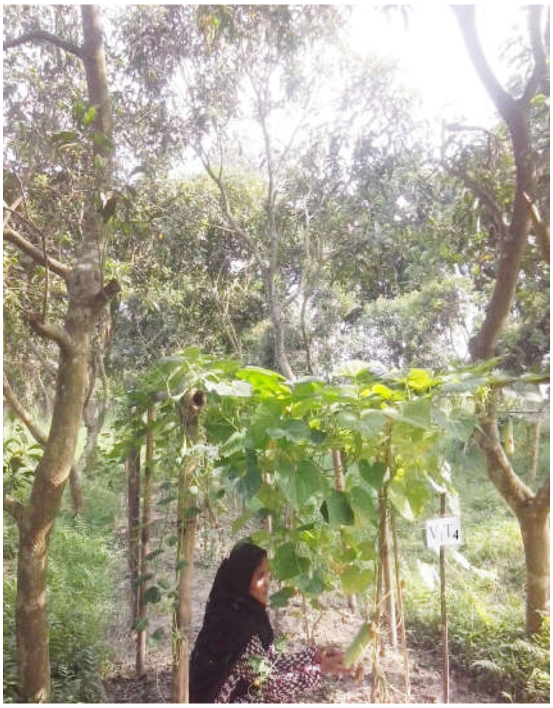

Plate No. h: Cucumber under Mango tree