AGRO-ECONOMIC PERFORMANCE OF ONION UNDER KALO KOROI, GHORA NEEM AND IPIL-IPIL BASED AGROFORESTRY SYSTEMS

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A THESIS

BY

JOY PROKASH ROY

Registration No. 1305061
Session: 2013

Thesis Semester: July-December, 2014

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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DEDICATED TO MY BELOVED PARENTS

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The Author

ABSTRACT

A field experiment was carried out at the Agroforestry and Environment Research Farm, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, during November 2013 to April 2014 to evaluate the agro-economic performance of onion under kalo koroi, gora neem and ipil-ipil based agroforestry systems. The experiment was conducted in newly established orchard of multipurpose tree species namely *Albizia lebbeck* (Kalo koroi), *Melia azedarach* (Ghora neem) and *Leucaena leucocephala*) (Ipil-ipil). The tree saplings were planted at the spacing (3 m×3 m) and the orchard was 8 years old. A popular local onion variety Taherpuri was used for the study. The experiment was laid out following the Randomized Complete Block Design (RCBD) with three (3) replications. The results of the research revealed that effect of trees was significant in respect of plant height at 30,45,60 and 75 days after transplanting (DAT), number of leaf/plant at 30,45 and 75 DAT except 60 DAT, leaf fresh and dry weight, root fresh, bulb diameter, bulb fresh and dry weight and bulb yield (t/ha). In initial stage 30 DAT the tallest plant (24.27 cm) was recorded in Ipil-Ipil + onion based agroforestry system (AFS). Consequently, the shortest plant was observed (20.07 cm) in sole cropping of onion (T_0). In final stage at 75 DAT the tallest plant height 51.01 cm was found under Ipil-Ipil + onion based AFS followed by Ghora neem + onion based AFS (49.83 cm). On the other hand the shortest plant height 44.83 cm was recorded in sole cropping of onion. At 30 DAT, the maximum number of leaves palnt^{-1} 4.80 was recorded under ipil-ipil + onion based agroforestry production system. Apparently, the minimum number of leaves plant^{-1} (3.77 at 30 DAT) was observed in open field i.e. onion sole cropping production. The highest bulb diameter (4.40 cm) was

measured in sole cropping of onion production and the lowest bulb diameter (3.85 cm) was measured under ipil-ipil based agroforestry production system which was similar to that of T_2 (3.87 cm) and T_1 (3.92 cm), respectively. The highest fresh weight of bulb plant^{-1} (27.04 g) was found in open field i.e. sole cropping of onion followed by (25.33 g) kalo koroi + onion based agroforestry production system, respectively. The highest benefit-cost ratio of 3.58 was recorded from kalo koroi + onion based agroforestry production system followed by ipil-ipil + onion based agroforestry production system and ghora neem + onion based agroforestry production system. The lowest benefit-cost ratio of 2.56 was observed in i.e. in sole cropping of onion. Finally, onion can be cultivated profitably in kalo koroi based agroforestry production systems.

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CHAPTER 1

INTRODUCTION

Agricultural production, particularly crop cultivation, has remained a significant and important component of human population, due to its strategic role of providing food supply to the generality of the entire human race. This system has however, had severe repercussions on land resources; as continuous tillage of the land easily loosens the soil and results in soil erosion and large-scale environmental degradation. (Beets, 1990; Kang *et al.,* 1999). FAO (1986) noted that the pressures of growing populations in developing counties, have forced landless farmers unto soils which cannot sustain crop production and unto slopes which cannot be safely cultivated, at least with technologies and resources available to the farmers. Furthermore, the pressure on trees and other plant matter due to demand for fuel wood, housing and others, have forced some rural poor families to reduce their cooking, and eventually, their cooked meals. This has also consumed a lot of human labour, as well as significant proportions of family budgets (FAO, 1986).

The overall consequence of continuous cultivation and monocropping is thus large-scale environmental degradation which will eventually result in reduction in food supply and increase in level of poverty, landlessness, deprivation, and communal conflicts, to mention a few. Crop cultivation however cannot be halted, as this would cut down food supply and would be associated with consequences that are terribly severe on man and the environment. Attention has therefore shifted to ways through which available land resources could be effectively utilized so that the resources would continue to be available and also be used in such a way as to ensure its conservation (Allan, 1965; Beets, 1990; Kang *et al.,* 1999; Kelly and Adger, 2000).

A country needs 25% of forest land of its total area for ecological stability and sustainability. Sadly, Bangladesh is endowed with only 13.6% of unevenly distributed forests (BBS, 2007). Conversely, actual tree coverage is less than 10%. 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 globe (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.

Among the spice crops grown in Bangladesh, onion ranks top (7.54 lakh MT) in respect of production and second (1.41lakh ha) in respect of area (Anon., 2006). Its demand exceeds domestic supply and the average yield is low (5.35 t/ha) as compared to the world average yield (17.46 t/ha) (FAO, 2006). In Bangladesh, the annual requirement of onion is about 14.60 lakh MT, but its local production is insufficient which can meet only 0.52% of the total requirement (Ali and Haq, 1994). A large volume of onion enters into the country through smuggling from the neighboring country. Moreover, to meet the shortage, Bangladesh has to import onion from India and other countries every year at the cost of its valuable foreign currency (Hussain and Islam, 1994).

So, to combat these alarming situations, efficient management of natural resources is the call for of the hour. The existing land use systems with separate allocation to agriculture and forest are insufficient to meet the demands for food, fuel, fodder, timber and other minor products in the 21st century. One should follow effective and compatible cultivation approaches where fruits, vegetables, spices, medicinal plants and timber can be grown combined in the limited land. In this link, the multistoried agroforestry system may be the best substitute cultivation approach. By practicing this cultivation arrangement, one can efficiently amplify the production of fruits, vegetables, spices, medicinal plants and timber vertically. Consequently, multistoried agroforestry is considered a panacea for overcoming most of the problems related to the alleviation of poverty, socio-economic instability and lessening ill effects of the global warming.

In order to meet the food deficit of Bangladesh and to cope with the demand of food for the increasing population spices production need to increase. On the other hand fuel wood, fodder, foil, timber, timber constriction materials and raw materials requirement is a crying need. There is no scope to increase monoculture crop command area horizontally. So combined production of spices and forest species (agroforestry) is the best alternative to meet the entire requirement. Before large scale production of onion under multipurpose tree species by farmer, tree- crop interaction effect must be studied from scientific point of view.

Objectives-

1. to find out the growth and yield of onion under Kalo Koroi, Ghora neem and Ipil-Ipil based agroforestry system.
2. to measure the economic performance of onion under Kalo Koroi, Ghora neem and Ipil-Ipil, based agroforestry system.

CHAPTER 2

REVIEW OF LITERATURE

The research was carried out to observe the agro-economic performance of onion under kalo koroi, ghora neem and ipil-ipil based agroforestry systems. In recent times, the modern practices of Agroforestry are extended in the fallow and woodlots in Bangladesh. The farmers are growing vegetable and spices in the woodlots to get maximum benefits. But tree directly influence crop's yield. Literatures directly related to this aspect are meager. Therefore, literatures some way linking to the subject of interest from home and abroad are reviewed and outlined below under the following sections.

2.1 Concepts of Agroforestry

2.2 Tree-crop interaction

2.3 Importance of Light in Agroforestry

2.4 Characteristics of Tree Species in Agroforestry Systems

2.5 Performance of Crop in Agroforestry Systems

2.6 Yield and associated components of onion

2.1 Concepts of Agroforestry

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

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

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

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

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

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

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

In traditional agroforestry systems of Bangladesh, Farmers consider trees as saving and insurance against risk of crop failure or compensate low yields of crops (Akter *et al.,* 1989). Homestead gardens are common in Bangladesh where the farmers take up combination of 10-15 species of fruit, ornamental and multipurpose trees along with vegetables to meet their own or aesthetic own or aesthetic value (Rang *et al.,* 1990).

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

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).

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

2.2 Tree-crop interaction

Khan and Aslam (1974) studied the effect of single sissoo (*Dalbergia sissoo*) tree on the yield of wheat crop. Yield was from plots within a quadrate of $1m^2$. The quadrates were taken at a distance of 3m, 4.5m and 6m from the base of tree. One quadrate was taken from the center of the field, that is, well away from the influence of trees involved. The grain yield showed a decrease of 30.88%, 23.6% and 12.7% at the distance of 3, 4.3 and 6m, respectively as compared to the open field. Both the tree and the crops were raised under irrigated condition.

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

Dhukia *et al.* (1988) observed that in the rabi season of 1984-87, four fodder crops (*Trifolium alexandrium*, oats, *Vicia faba* and *Trifolium foenum-graecum)* and 2 field crops (*Triticum aestivum* and *Cicer arietinum*) were grown under *Dalbergia sissoo* and *Albizia lebbeck.*

Among the fodder crops the highest fresh fodder and dry matter yields under both plantations were given by *Trifolium alexandrium* follower by oats. The yields decreased less than 4 years old trees compared with those under 3 years old trees. Wheat gave higher yields than *Cicear arietinum* under both plantations. Yields of all crops under the *Dalbergia sissoo* plantation were higher than under the *Albizia lebbeck* plantation.

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

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

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

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

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

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

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

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

2.3 Importance of Light in Agroforestry

Okigbo and Geenland (1976) and Okigbo (1980) identified more efficient use of light resource by plants of different heights and canopy structures as one of the advantage to be gained by growing crops in mixed stands. The potential benefits as a results of combining field crops with trees are so obvious from consideration to the waste of light resources experienced ind orchard and tree crop orientations (Jackson, 1987).

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

The yield advantage of conventional intercropping has been explained in terms of improved capture of utilization of growth resources (Willy *et al.*, 1986). The resource capture by agroforestry systems will probably be greater than in sole crops (Ong *et al.,* 1992).

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

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

Essentially the underlying processes involved in the partitioning of resources (e.g. light water and nutrients) are not well understood. A better mechanistic understanding of resource capture and utilization in agroforestry system is required to facilitate the development of improved systems in terms of species combinations, planting arrangement and management (Howord *et al.,* 1995). Agroforestry system that incorporate a range of tree and crop species offer much more scope for useful management of light interception and distribution than do monoculture forests and agricultural crops (Miah, 1996).

2.4 Characteristics of Tree Species in Agroforestry Systems

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

a) They should tolerate relatively high incidence of pruning.

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

c) They should be light branching in their habit.

d) They should be tolerant of side shade.

e) Their phylotaxie should permit penetration of the light of the ground.

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

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

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

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

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

i) Ease of establishment from seeds or seedlings.

ii) Rapid growth and high productivity of foliage and wood.

iii) Limited maximum size (may be optimum in small trees).

iv) Good coppicing ability (regrowth following topping).

v) Effective nutrient recycling abilities especially di-nitrogenfixation.

vi) Multiple uses: food, feed, fire wood, construction materials and other products and service (shade, shelter etc.).

vii) Minimum competition with shallow rooted annual crops.

viii) Small leaflets readily detached when dried and quickly decomposed when used as fertilizer.

ix) A high proportion of leaves to secondary branches.

x) Free from pests and diseases and

xi) Ease of control of eventual elimination.

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

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

2.5 Performance of Crop in Agroforestry Systems

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

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

Fifty percent shading during ear formation and milking stage of rice decreased yield by 48% and 18%, respectively (Park and Kwon, 1975). Nayak and Murty (1980) reported that yield reduction of rice occur by 47, 57 and 74 per cent in 75, 50 and 25 percent of normal light.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

2.6 Yield and associated components of onion

Muktadir *et al.* (2003) studied the effect of planting time and bulb size on the yield and quality of onion seed cv. Taherpuri at Horticulture farm of Bangladesh Agricultural University, Mymensingh. The experiment consists of three date of planting time viz. November 1, November 16 and December 1 and four bulb sizes viz.5±.5, 10±5,15±.5 and 20±.5g. They opined that different planting time and bulb size had significant effect on plant emergence, % flowering, Number of flower bud per umbel, Numbers of seeded fruit per umbel, Weight of 1000 seeds and seed yield per plot. But time of planting significantly affected on % of harvested umbel. Combined effect of planting time and different bulb size showed that November 1 planting gave the better result when 20g size bulb was used as planting materials.

Islam (2002) conducted an experiment at Horticulture Farm of the Bangladesh Agricultural University Mymensingh to find the effect of planting time and shading on the quality of onion seed. There were two planting time eg. 16^{th} October and 16^{th} November and three shading 25%, 50% and No shading (open condition). He concluded that the seed yield was the highest under 50% shade condition compared to 25% shade and no shade (control), but in respect of seed quality (1000 seed weight and germination) open condition was the best.

Islam *et al.* (2008) conducted an experiment at Horticulture Farm, BAU, Mymensinh to examine the effects of planting time, bulb size and shading on the quality seed production of onion cv. Taherpuri. The experiment was carried out with two planting dates viz. 16 October and 1 November, three bulb sizes, small (5±2g), medium (10 ±2g) and large (15±2g) and two growing condition viz. shading with mosquito net and non shading. Shading showed insignificant effects on number of leaves $hill^{-1,}$ number of flowers $umbel^{-1}$, number of seeded fruits $umbel^{-1}$, seed yield $hill^{-1}$,1000 seeds weight (g), seed germination (%). The higher seed yield (336.33kg/ha) was recorded from plants growing under shading with mosquito net. Although the interaction effects of planting time and shading was not significant for all the traits studied, but their combined effects varied significantly.

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 25° 13′ latitude and 88° 23′ longitude, and about 37.5 m above the sea level.

3.2 Soil characteristics

The experimental plot was in a medium high land belonging to the old Himalayan Piedmont Plain Area (AEZ No. 01). Land was well-drained and drainage system was well developed. The soil texture was sandy loam in nature. The soil pH was 5.1 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 (November, 2013 to April, 2014) are presented in the Appendix-II.

3.4 Experimental period

November, 2013 to April, 2014

3.5 Experimental materials

1^{st} layer: Three Multipurpose Trees

The tree species were -

- Kalo koroi (*Albizia lebbeck*)
- Ghora Neem (*Melia azedarach*)
- Ipil- Ipil (*Leucaena leucocephala*)

The spacing for all the tree species were 3 m x 3 m. and the age were 8 years. The present status of the tree species in the research field are-

Table 3.1. Status of the existing tree species in the research field

Trees	Plant height (m)	Clean bole height (m)	Base Girth (cm)	Bole Girth (cm)	Diameter at Breast Height (cm)
Kalo koroi	15.5	5.5	100.0	80.0	75.0
Ghora neem	13.0	5.0	110.0	85.0	80.0
Ipil-Ipil	16.5	6.5	95.0	70.00	70.0

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

A) Kalo Koroi (*Albiza lebbeck*) - *Albizia lebbeck* is a tropical hardwood species. It is a large deciduous tree with spreading crown. It has blackish or dark grey, irregularly cracked bark. Leaf rachis 17-35 cm long (sometimes up to 20 cm) usually with an oval gland at the base, pinnae usually 2-5 pairs 5-20 cm long often with glands between the leaflets. leaflets 3-10 pairs/pinna 2.5-3.0x1.5-2.0 cm oblong Flowers greenish white in pedunculate heads calyx funnel shapped corolla te twice the length of the calyx Fruit a pod 15-30x3-4 cm pale shiny yellowish-brown alterrately depressed on either side over the seed (Singh and Srivastra, 1989) The rootsystem is largely superficial leaflets during cold season Flowering time May jun freiting time: December-February

Functional uses:

Young leaves are used as cattle fodder. Albizia forage has about 20% protein. The wood of this tree burns well Its calarfic value is 5200k cal/kg of dry fuel. *Albizia* is a strong wood being about the same weight and hardness as teaj the wood is excellent for high cous furriture interior decoration and panelling. It is also used for making agricultural implements transport bodies etc (Trotter, 1982).

Services:

The foliage may be used as green manure or mulches in Agroforestry system the mulch reduces airdrop impact and prevent deterioration of the land the chopped leaves when used as green manure improves soil fertility status of soil. *Albizia lebbeck* is good soil binder. Its flower is a good source for honey production.

B) Ghora neem (*Melia azedarach*)- A handsome deciduous tree up to 45 m tall with wide spreading branches. The bark is smooth greenish brown. Leaves are bipinnate, sometimes tripinnate, 20-50 cm long. Pinnae usually opposite, 3-7 leaflets are found in each pinnae. Flowers are small liliac blue, Inflorescences long, auxillary panicle upto 20 cm long. Fruit a small, yellow drupe round about 1.5 cm in diameter, seed oblonged, 3.5 mm x 1.6 mm (Nagveni *et al.* 1987). Flowering time: March to May. Fruiting time: December to January.

Functional uses

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

Services:

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

C) Ipil- ipil (*Leucaena leucocephala*)- *Leucaena leucocephala* is a fast growing deciduous tree with a short clear bole to 5 m upright, angular branching and open crown, maximum height 20 m. Bole diameter 10-15 cm, bark on young branches smooth, grey-brown, rustly orange- brown vertical tissues and deep red inner bark on older branches and bole. The deep- rooted plant often has a combination of flowers, immature and mature pods, all presents on the tree at the same time. Flowering time: March-April and August-October; Fruiting time: December-February.

Functional uses:

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

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

Ground layer : Onion

A popular local onion variety Taherpuri was used for the study. This is a high yielding indeterminate type. The seeds of the variety were collected from the Dinajpur seed market. The variety was marketed by ACI seed Company Limited.

3.6 Experimental design

The experiment was laid out following the RCBD with three (3) replications. Total no of experimental plots will be 12. The unit plot size is 2.5m x 2.5m = 6.25 m^2. The treatments of the experiment are as follows-

T_0= Open field + Onion

T_1= Kalo Koroi + Onion

T_2= Ghora Neem + Onion

T_3= Ipil-ipil + Onion

3.7 Raising of seedlings

Onion seedlings were raised in a seed bed situated on a relatively high land adjacent to the Agroforestry and Environment Research field. Five gram of seeds was sown in a seedbed on November 10^{th}, 2013. Sown seeds were covered with light soil. Complete germination of the seeds took place within 7 days after sowing. Weeding, mulching and irrigation were done from time to time as and when needed.

3.8 Land preparation

The land of experimental plot was opened in the 2nd week of December 2013 with spade and it was made ready for transplanting on 30^{th} December 2013. The corners of the land were spaded and visible larger clods were hammered to break into small pieces. All weeds and stubbles were removed from the field. The layout was done as per experimental design. All basal dosages of fertilizer as per scheduled of the experiment was incorporated in the soil and finally the plots were made ready for planting.

3.9 Application of fertilizers and Manures

Cowdung and TSP were added to the soil at final land preparation. Half of Urea and MP, were applied at the time of land preparation and remaining urea and MP were top dressed in two equal installation at 25 and 50 days after transplanting. The doses were according to BARC rate i.e. 217 kg N/ha, 227 kg P_2O_5/ha and 187 kg K_2O/ha and cowdung 14000 kg/ha.

3.10 Transplanting of seedlings

Fifty days old healthy and disease free seedlings were uprooted from the seedbed and transplanted in to the main field on 30th December 2013 maintain spacing 15 cm plant to plant and line to line 10cm.

3.11 Intercultural Operations

Weeding and Mulching

Manual weeding was done as and when necessary to keep the plots completely free from all weeds. The soil was mulched by breaking the crust for aeration and to conserve soil moisture after irrigation.

Irrigation

Irrigations were provided throughout the growing period. The first one was done at 10 days after transplanting. Subsequently irrigations were given at 15 days interval.

Plant protection

Rovral 50 WP was sprayed (0.2%) at 10 days interval after 15 days of transplanting up to 75 DAP to control purple blotch caused by *Alternaria porri.*

3.12 Harvesting

The crop was harvested on 4 April, 2013. Before 10 days of harvest, when the plants attained maturity by showing drying up of leaves and weakening of necks, the crop was bended at the soil level by hands and kept as such up to harvest to hasten maturity (Faruq, 2001). The onion was lifted with the help of khurpi. Care was taken so that no bulb was injured during lifting. Then they were kept in a cool and dry place for curing.

3.13 Data collection

Five plants were selected randomly from each plot and tagged properly for data collection. For this purpose, the outer two rows of plants and the plants in the extreme ends of the middle rows were not considered for selecting the sample plants.

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

- Plant height (cm)
- Number of leaves per plant
- Fresh weight of leaves per plant (g)
- Dry weight of leaves per plant (g)
- Fresh weight of roots per plant (g)
- Dry weight of roots per plant (g)
- Bulb diameter (cm)
- Fresh weight of bulb per plant (g)
- Dry weight of bulb per plant (g)
- Yield of bulb per hectare (ton)

Plant height (cm)

The height of the selected plants was recorded at 30, 45, 60 and 75 days after transplanting (DAT). Plant height was measured in centimeter from the neck of the bulb to the tip of the longest leaf. Mean height of the individual plants were calculated from representative of 5 plants.

Number of leaves per plant

The number of active leaves per plant at 30, 45, 60 and 75 days after transplanting was counted and the average of selected 5 plants were taken as the number of leaves per plant. Mean of total number of active leaves per plant was then recorded from the representative of 5 plants.

Fresh weight of leaves per plant (g)

Fresh leaves were collected from marked plants during harvesting time of bulb and were weighted by a balance and their mean value was calculated as per plant leaf weight in gram.

Dry weight of leaves per plant (g)

The dry weight of leaves per plant was recorded from the average of marked 5 plants selected from each plot at the final harvest. After initial drying in sun, the leaves were dried in an oven at 65^0 C temperatures for 72 hours.

Fresh weight of roots per plant (g)

The fresh weight of roots was determined from the average of marked 5 plants selected from each plot at the final harvest.

Dry weight of roots per plant (g)

The dry weight of roots was determined from the average of represented 5 plants selected from each plot at final harvest.

Bulb diameter (cm)

The diameter of bulb was measured at harvest with a slide calipers at the middle portion of bulb obtained from 5 randomly selected plants and the average diameter of bulb was calculated in centimeter.

Fresh weight of bulb per plant (g)

The tops of the selected 5 plants harvested at maturity were removed by cutting the pseudo-stem keeping 2.5 cm from the bulb. Fresh weight of the 5 bulbs was recorded using a balance and the average was calculated in gram.

Dry weight of bulb per plant (g)

Dry weight of bulb per plant was recorded from the average of randomly selected 5 plants from each plot at final harvest.

Yield of bulb per hectare (ton)

The weight of the bulbs harvested from each unit plot was taken separately by a simple balance and the yield of bulb per hectare was calculated from the data on yield per plot and was recorded in ton.

3.14 Bio-economics of the onion under different tree based agroforestry production systems

In order to work out the economic profitability of the agroforestry systems, the economic yield of onion 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 onion was worked out on the basis of per hectare. The initial plantation cost of the kalo koroi, ghora neem and ipil-ipil saplings were integrated in this study. The management cost of kalo koroi, ghora neem and ipil-ipil 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.

Gross return

Gross return is the monetary value of total product and by-product. Per hectare gross returns from onion bulb 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).

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

3.15 Data analysis

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 investigation was carried out to agro-economic performance of onion under kalo koroi, ghora neem and ipil-ipil based agroforestry systems on the growth, yield and yield contributing characters. The results of the experiment as influenced by shade have been presented and discussed in this chapter under the following sub-headings.

4.1 Effect of different production system on growth, yield and yield contributing characters of onion

4.1.1 Plant height

The plant height was measured at 30, 45, 60 and 75 days after transplanting (DAT) and it was observed that there was a significant variation in plant height at different tree based agroforestry system along with sole cropping. Plant height increased gradually with the advancement of time up to the maximum vegetative growth stage (60 DAT) and then the plant height slowly decreased in all the treatments due to senescence. In initial stage 30 DAT the tallest plant (24.27 cm) was recorded in Ipil-Ipil + onion (T_3) based AFS followed by in Ghora neem + onion (T_2) based AFS and. Consequently, the shortest plant was observed (20.07 cm) in sole cropping of onion (T_0) (Table 4.1). Again, in middle stage at 45 DAT the tallest plant (40.47 cm) was recorded under Ipil-Ipil + onion based AFS (T_3) followed by under Ghora neem + onion (T_2) based AFS while the shortest plant (34.87 cm at 45 DAT) was recorded in sole cropping of onion (T_0). In later stage at 60 DAT the tallest plant (53.73 cm) was observed under Ipil-Ipil + onion based AFS (T_3) whereas the shortest plant (48.00 cm at 60 DAT) was recorded in sole cropping of onion (T_0). In final stage at 75 DAT the tallest plant height 51.01 cm was found under Ipil-Ipil + onion based AFS (T_3) followed by Ghora neem + onion (T_2) based AFS (49.83 cm). On the other hand the shortest plant height 44.83 cm was recorded in sole cropping of onion (T_0). The present study revealed that the plant height increased with the decrease of light levels. Plant height depends on a number of factors such as availability of required quality of water, mineral nutrients, quantity, quality and duration of light, temperature, area of growing space and genetic set-up of the plants. Hillman (1984) reported that, plant grown in low light levels was found to be more apical dominant than those grown in high light environment resulting in taller plants under shade.

Table 4.1. Effect of different tree based production systems on plant height (cm) of onion

Treatments	Plant height (cm)			
	30 DAT	45 DAT	60 DAT	75 DAT
T_0	20.07 d	34.87 d	48.00 d	44.83 d
T_1	22.27 b	37.27 c	50.07 c	47.77 c
T_2	21.37 c	38.23 b	51.77 b	49.83 b
T_3	24.27 a	40.47 a	53.73 a	51.10 a
$LSD_{(0.05)}$	0.4094	0.6834	0.4728	0.3791

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

T_0 = Open field + Onion
T_1 = Kalo Koroi + Onion
T_2 = Ghora Neem + Onion
T_3 = Ipil-ipil + Onion

4.1.2 Number of leaves plant^{-1}

Number of leaves per plant of onion was also significantly disposed by the diverse agroforestry production systems (Table 4.2). At 30 DAT, the maximum number of leaves palnt^{-1} 4.80 was recorded under ipil-ipil + onion based agroforestry production system (T_3) followed by ghora neem

Table 4.2. Effect of different tree based production systems on leaves plant^{-1} of onion

Treatments	Number of leaves plant^{-1}			
	30 DAT	45 DAT	60 DAT	75 DAT
T_0	3.77 d	4.76 d	6.20 a	6.03 d
T_1	4.07 c	5.26 c	6.47 a	6.60 c
T_2	4.53 b	5.60 b	6.77 a	6.83 b
T_3	4.80 a	5.96 a	6.90 a	7.03 a
$LSD_{(0.05)}$	0.1548	0.1787	1.076	0.063

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

T_0 = Open field + Onion
T_1 = Kalo Koroi + Onion
T_2 = Ghora Neem + Onion
T_3 = Ipil-ipil + Onion

4.1.3 Leaf fresh weight plant^{-1}

Different tree based production systems had significant effect on the fresh weight of leaves plant^{-1} (Graph 4.1). The highest fresh weight of leaves plant^{-1} (11.88 g) was found under ghora neem + onion based agroforestry production system (T_2) followed by ipil-ipil + onion based agroforestry production system 11.37g. Apparently, the lowest fresh weight of leaves plant^{-1} was observed in open field i.e. sole cropping of onion 9.28 g followed by kalo koroi + onion based agroforestry production system (T_1) 10.65 g, respectively.

+ onion based agroforestry production system 4.53. Apparently, the minimum number of leaves plant^{-1} (3.77 at 30 DAT) was observed in open field (T_0) i.e. onion sole cropping production. At 45 DAT, the maximum number of leaves palnt^{-1} 5.96 was recorded under ipil-ipil + onion based agroforestry production system (T_3) followed by ghora neem + onion based agroforestry production system 5.60. On the other hand, the minimum number of leaves plant^{-1} (4.76 at 45 DAT) was observed in open field (T_0) i.e. sole cropping of onion. Number of leaves plant^{-1} at 60 DAT was found not significant that is there was no statistically difference among the treatments, respectively. In the 75 DAT, the maximum number of leaves palnt^{-1} 7.03 was found under ipil-ipil + onion based agroforestry production system (T_3) followed by ghora neem + onion based agroforestry production system 6.83. Consequently, the minimum number of leaves plant^{-1} (6.03 at 75 DAT) was observed in open field (T_0) i.e. onion sole cropping production. The highest number of leaves is due to the effect of temperature pressure. Many researchers (Kirk and Marshall, 1992; Van Delden *et al.*, 2001; Vos, 1995 and Steward *et al.*, 1981) reported that temperature profoundly influences the growth and development of the onion, leaf appearance, expansion, and senescence, leaf orientation and physiological. The leaf-level photosynthetic rate also varies with temperature; air temperatures at 23°C and above increase the number of leaves and the leaf appearance and senescence rates (Manrique *et al.*, 1989; Marinus and Bodlaender, 1975). This finding was in agreement with the findings of Benoit *et al.*, 1986 who stated that, cooler temperatures promote lower number of total leaves.

Table 4.2. Effect of different tree based production systems on leaves plant^{-1} of onion

Treatments	Number of leaves plant^{-1}			
	30 DAT	45 DAT	60 DAT	75 DAT
T_0	3.77 d	4.76 d	6.20 a	6.03 d
T_1	4.07 c	5.26 c	6.47 a	6.60 c
T_2	4.53 b	5.60 b	6.77 a	6.83 b
T_3	4.80 a	5.96 a	6.90 a	7.03 a
$LSD_{(0.05)}$	0.1548	0.1787	1.076	0.063

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

T_0 = Open field + Onion
T_1 = Kalo Koroi + Onion
T_2 = Ghora Neem + Onion
T_3 = Ipil-ipil + Onion

4.1.3 Leaf fresh weight plant^{-1}

Different tree based production systems had significant effect on the fresh weight of leaves plant^{-1} (Graph 4.1). The highest fresh weight of leaves plant^{-1} (11.88 g) was found under ghora neem + onion based agroforestry production system (T_2) followed by ipil-ipil + onion based agroforestry production system 11.37g. Apparently, the lowest fresh weight of leaves plant^{-1} was observed in open field i.e. sole cropping of onion 9.28 g followed by kalo koroi + onion based agroforestry production system (T_1) 10.65 g, respectively.

4.1.4 Leaf dry weight plant^{-1}

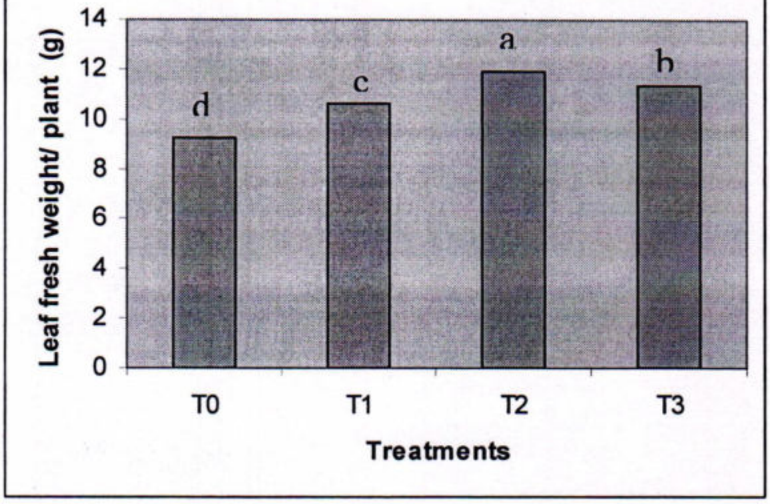
Leaf dry weight plant^{-1} was statistically influenced by different tree based production systems (Graph 4.2). The highest leaf dry weight plant^{-1} (1.63 g) was found under in both ghora neem + onion based agroforestry production system (T_2) and ipil-ipil + onion based agroforestry production system, respectively. On the other hand, the lowest leaf dry weight plant^{-1} was recorded in open field i.e. sole cropping of onion 1.36 g followed by kalo koroi + onion based agroforestry production system (T_1) 1.54 g, respectively.

4.1.5 Root fresh weight plant^{-1}

Different tree based production systems had significant effect on the fresh weight of root plant^{-1} (Graph 4.3). The highest fresh weight of root plant^{-1} (0.40 g) was found under ghora neem + onion based agroforestry production system (T_2) followed by ipil-ipil + onion based agroforestry production system 0.36g and also under kalo koroi + onion based agroforestry production system (T_1) 0.36g, respectively. Consequently, the lowest fresh weight of root plant^{-1} was observed in open field i.e. sole cropping of onion 0.34 g.

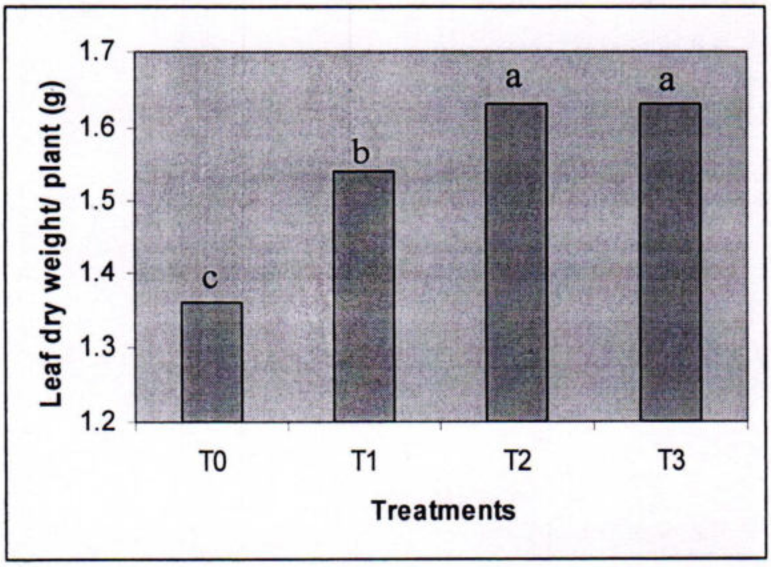
4.1.6 Root dry weight plant^{-1}

Root dry weight plant^{-1} was found statistically not significant by different tree based production systems (Graph 4.4). Numerically the highest root dry weight plant^{-1} (0.09 g) was found under in both ghora neem + onion based agroforestry production system (T_2) and ipil-ipil + onion based agroforestry production system, respectively. On the other hand, the lowest root dry weight plant^{-1} was recorded in open field i.e. sole cropping of onion 0.08 g followed by kalo koroi + onion based agroforestry production system (T_1) 0.08 g, respectively.



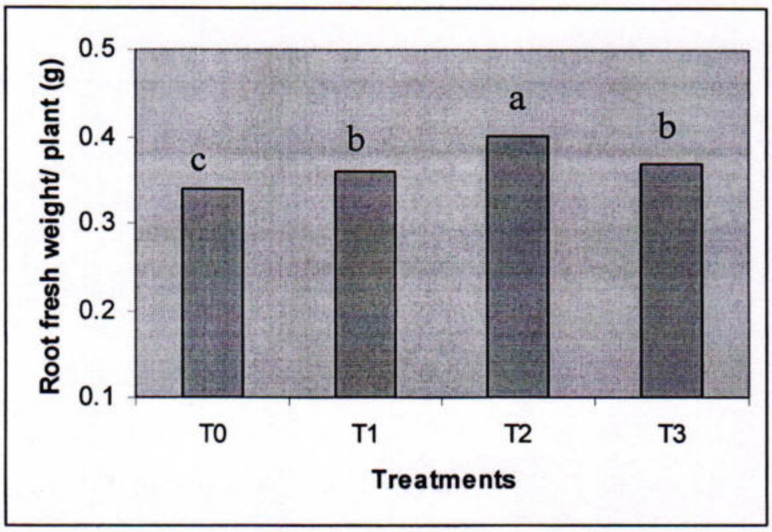
In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

Graph 4.1. Graphical presentation of leaf fresh weight/plant (g)



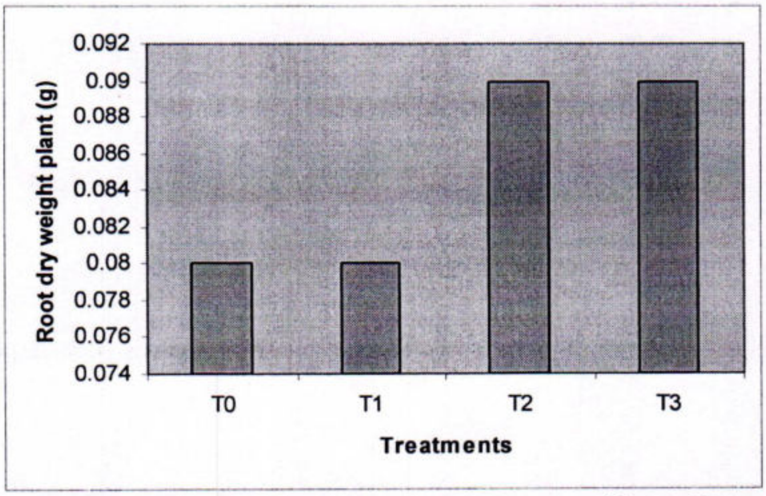
In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at $P \leq 5\%$ level.

Graph 4.2. Graphical presentation of leaf dry weight/plant (g)



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

Graph 4.3. Graphical presentation of root fresh weight/plant (g)



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

Graph 4.4. Graphical presentation of root dry weight/plant (g)

4.1.7 Bulb diameter

Bulb diameter is one of the important yield contributing characteristic of onion which was significantly affected by the different tree based agroforestry production system (Graph 4.5). The highest bulb diameter (4.40 cm) was measured in T_1 sole cropping of onion production and the lowest bulb diameter (3.85 cm) was measured under ipil-ipil based agroforestry production system (T_3) which was similar to that of T_2 (3.87 cm) and T_1 (3.92 cm), respectively. This was happened due to more photosynthesis an activity was performed in the sun light of open field. The finding of M M U Miah (2010) was in agreement with the present result.

4.1.8 Bulb fresh weight plant^{-1}

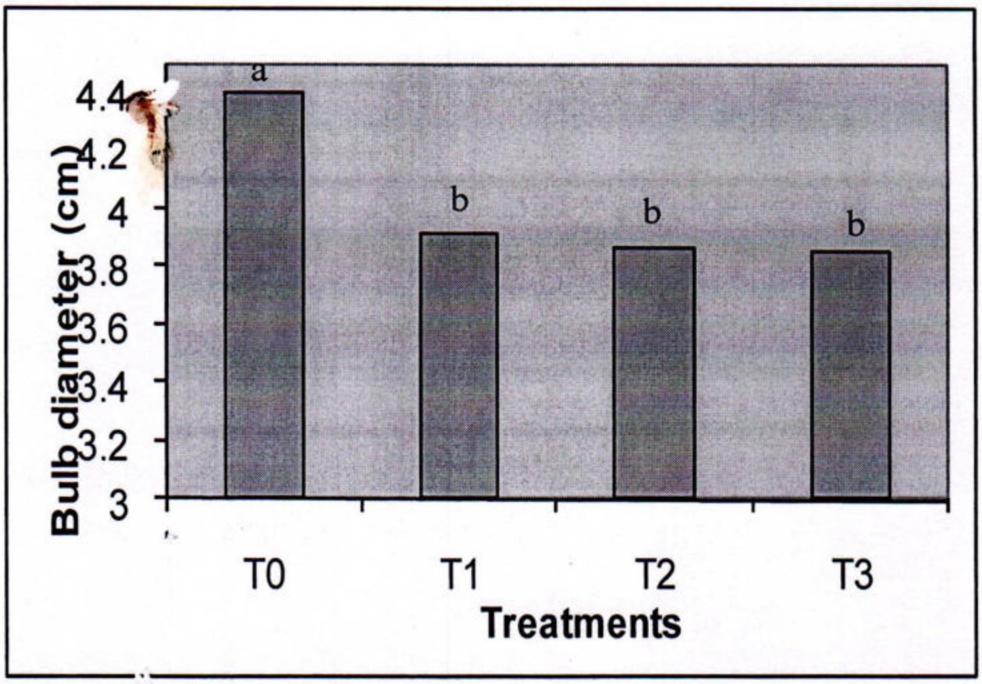
Different tree based production systems had significant effect on the fresh weight of bulb plant^{-1} (Graph 4.6). The highest fresh weight of bulb plant^{-1} (27.04 g) was found in open field i.e. sole cropping of onion followed by (25.33 g) kalo koroi + onion based agroforestry production system (T_1), respectively. Consequently, the lowest fresh weight of bulb plant^{-1} was observed under ipil-ipil + onion based agroforestry production system 23.60 g which was similar to that of ghora neem + onion based agroforestry production system (T_2) 24.17g, respectively. The finding of M M U Miah (2010) was in agreement with the present result.

4.1.9 Bulb dry weight plant^{-1}

Bulb dry weight plant^{-1} was found statistically highly significant by different tree based production systems (Graph 4.7). Significantly the highest bulb dry weight plant^{-1} (3.08 g) was found under in open field i.e. sole cropping of onion followed by (2.97 g) under kalo koroi + onion based agroforestry production system (T_1). On the other hand, the lowest bulb dry weight plant^{-1} 2.79 g was recorded under ipil-ipil + onion based agroforestry production system which was ststistically similar to that of (2.87 g) ghora neem + onion based agroforestry production system (T_2), respectively. The finding of M M U Miah (2010) was in agreement with the present result.

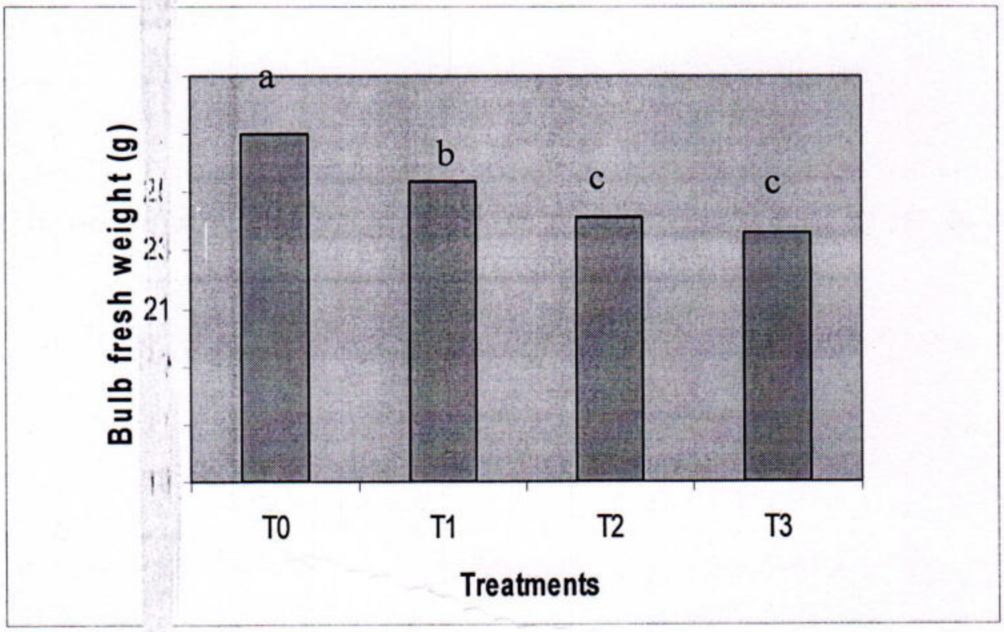
4.1.10 Bulb fresh yield

Bulb fresh yield as affected by different tree based agroforestry production system was found statistically highly significantly (Graph 4.8). The highest fresh bulb yield (10.14 tha^{-1}) was found in open field i.e. sole cropping of onion followed by (9.94 tha^{-1}) kalo koroi + onion based agroforestry production system (T_1), respectively. Consequently, the lowest fresh bulb yield (9.11 tha^{-1}) was measured under ipil-ipil + onion based agroforestry production system which was similar to that of ghora neem + onion based agroforestry production system (T_2) (9.57 tha^{-1}), respectively. The finding of M M U Miah (2010) was in agreement with the present result.



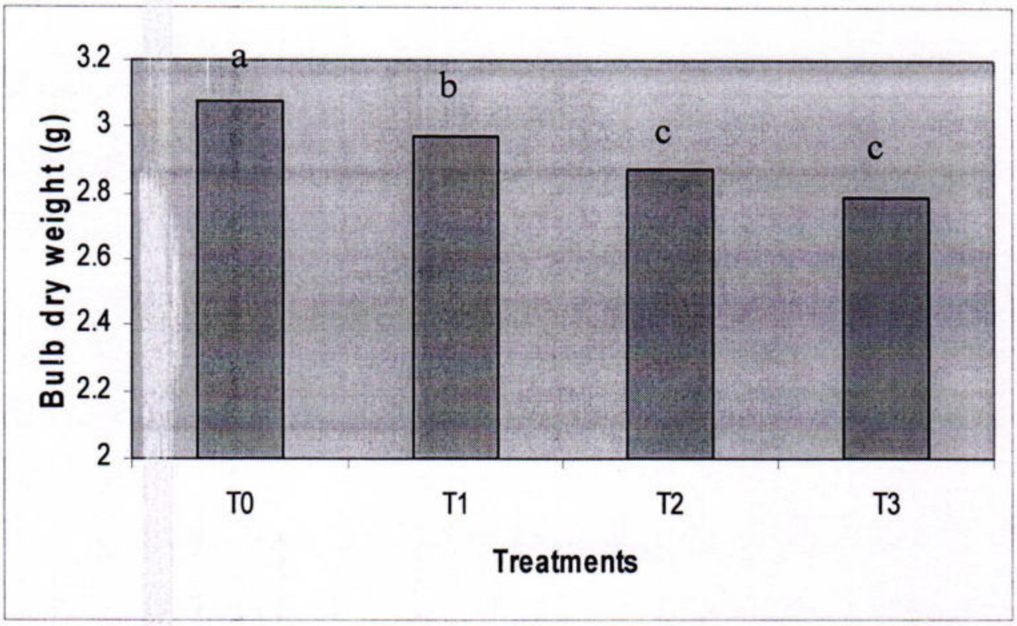
In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at P ≤ 5% level.

Graph 4.5. Graphical presentation of bulb diameter (cm)



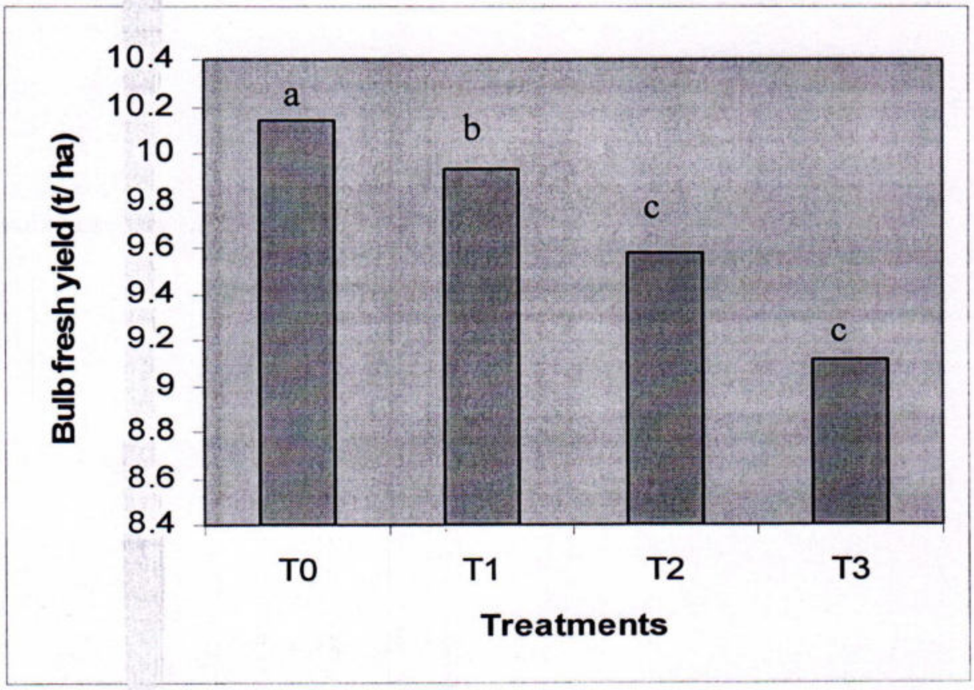
In column, figures having the similar letter (s) or without letter (s) do not differ significantly by DMRT at P ≤ 5% level.

Graph 4.6. Graphical presentation of bulb fresh weight (g)



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

Graph 4.7. Graphical presentation of bulb dry weight (g)



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

Graph 4.8. Graphical presentation of bulb diameter (cm)

4.2 Economic analysis

Profitability of growing onion as inter-crop in different tree (kalo koroi, ghora neem and ipil-ipil) based agroforestry production system was calculated based on local market rate prevailed during experimentation. The cost of production of onion and cost of production of tree plantation and management of trees have been summarized in appendix V. The return of produce and the profit per taka i.e. Benefit Cost Ratio (BCR) also have been presented in Table 4.3.

4.2.1Total cost of production

The values in Appendix V indicate that the total cost of production was highest (196720.5 Tk./ha) under kalo koroi + onion based agroforestry production system system (T_1) followed by ipil-ipil + onion based agroforestry production system (194771.25 Tk./ha) (T_3) and ghora neem + onion based agroforestry production system (192313.5 Tk./ha) in (T_2). The lowest cost of production (158526.5 Tk./ha) was recorded from the sole cropping of onion (T_0). Higher cost of production was found in the kalo koroi + onion based agroforestry production system due to higher plantation cost of the system.

4.2.2 Gross return

Gross return is an important indicator whether crop cultivation is profitable or not. The highest value of gross return (704800 Tk. /ha) was obtained from kalo koroi + onion (T_1) based agroforestry production system (Table 4.3). On the other hand, the lowest value of gross return (405600Tk. /ha) was obtained from sole cropping of onion production system (T_0). The highest gross return was obtained due to higher yield of onion along with the value of kalo koroi trees.

4.2.3 Net return

Results presented in the Table 4.3 show that net return was comparatively higher in producing onion under kalo koroi + onion based agroforestry production system than other agroforestry production system. It was observed that kalo koroi + onion based agroforestry production system (T_1) gave the highest net return (508079.5 Tk. /ha) followed by (442695.75 tk/ha) in Ipil-Ipil + onion (T_3) based agroforestry production system. At the same time, the lowest net return (158526.5 Tk. /ha) was received from the sole cropping onion based production system (T_0). Higher net return was the result of higher gross return from the onion cultivation together with kalo koroi trees.

Table 4.3 Economics of onion production under different tree (kalo koroi, ghora neem and ipil-ipil) based agroforestry system (average of one year)

Treatments	Return (Tk./ha)				Gross Return (Tk./ha)	Total cost of Production (Tk./ha)	Net Return (Tk./ha)	BCR
	Onion	Kalo koroi	Ghora neem	Ipil-Ipil				
T_0	405600	------	------	------	405600	158526.5	247073.5	2.56
T_1	397600	307200	------	------	704800	196720.5	508079.5	3.58
T_2	382800	------	230400	------	613200	192313.5	420886.5	3.19
T_3	364400	------	-------	273067	637467	194771.25	442695.75	3.27

Note: Onion 40 Tk./kg, Kalo koroi 300 Tk./Tree/Year Ghora neem 225 Tk./Tree/Year, Ipil-Ipil 267 Tk./Tree/Year

4.2.4 Benefit-cost ratio

The highest benefit-cost ratio of 3.58 was recorded from kalo koroi + onion (T_1) based agroforestry production system followed by ipil-ipil + onion (T_3) based agroforestry production system and ghora neem + onion (T_2) based agroforestry production system. The lowest benefit-cost ratio of 2.56 was observed in T_0 i.e. in sole cropping of onion. In the final harvesting product market price is important. So, onion can profitably be cultivated in kalo koroi based agroforestry production systems. Thus, it may be advocated that such type of agroforestry practices 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.

CHAPTER 5
SUMMARY AND CONCLUSION

A field experiment was carried out at the Agroforestry and Environment Research Farm, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, during November 2013 to April 2014 to evaluate the agro-economic performance of onion under kalo koroi, ghora neem and ipil-ipil based agroforestry systems. The experiment was conducted in newly established orchard of multipurpose tree species namely *Albizia lebbeck* (Kalo koroi), *Melia azedarach* (Ghora neem) and *Leucaena leucocephala*) (Ipil-ipil) the tree saplings were planted at the spacing (3 m×3 m) and the orchard was 8 years old.

The experiment included a popular local onion variety Taherpuri was used for the study. This is a high yielding indeterminate type. The experiment was laid out following the Randomized Complete Block Design (RCBD) with three (3) replications. Total no of experimental plots will be 12. The unit plot size is 2.5m x 2.5m = 6.25 m^2. Before planting, the Onion seedlings were raised in a seed bed situated on a relatively high land adjacent to the Agroforestry and Environment Research field. Five gram of seeds was sown in a seedbed on November 10^{th}, 2013. Sown seeds were covered with light soil. The land of experimental plot was opened in the 2nd week of December 2013 with spade and it was made ready for transplanting on 30^{th} December 2013. The corners of the land were spaded and visible larger clods were hammered to break into small pieces. All weeds and stubbles were removed from the field. The layout was done as per experimental design. All basal dosages of fertilizer as per scheduled of the experiment was incorporated in the soil and finally the plots were made ready for planting. Fifty days old healthy and disease free seedlings were uprooted from the seedbed and transplanted in to the main field on 30th December 2013 maintain spacing 15 cm plant to plant and line to line 10cm. After planting necessary intercultural operations were done accordingly. Five plants were selected randomly from each plot and tagged properly for data collection. For this purpose, the outer two rows of plants and the plants in the extreme ends of the middle rows were not considered for selecting the sample plants.

The data were recorded two broad heads, i) growth stage ii) 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 effect of trees were significant in respect of plant height at 30,45,60 and 75 DAT, number of leaf/plant at 30,45 and 75 DAT except 60 DAT, leaf fresh and dry weight, root fresh, bulb diameter, bulb fresh and dry weight and bulb yield (t/ha). In initial stage 30 DAT the tallest plant (24.27 cm) was recorded in Ipil-Ipil + onion (T_3) based AFS followed by in Ghora neem + onion (T_2) based AFS and. Consequently, the shortest plant was observed (20.07 cm) in sole cropping of onion (T_0). In final stage at 75 DAT the tallest plant height 51.01 cm was found under Ipil-Ipil + onion based AFS (T_3) followed by Ghora neem + onion (T_2) based AFS (49.83 cm). On the other hand the shortest plant height 44.83 cm was recorded in sole cropping of onion (T_0). At 30 DAT, the maximum number of leaves palnt^{-1} 4.80 was recorded under ipil-ipil + onion based agroforestry production system (T_3) followed by ghora neem + onion based agroforestry production system 4.53. Apparently, the minimum number of leaves plant^{-1} (3.77 at 30 DAT) was observed in open field (T_0) i.e. onion sole cropping production. In the 75 DAT, the maximum number of leaves palnt^{-1} 7.03 was found under ipil-ipil + onion based agroforestry production system (T_3) followed by ghora neem + onion based agroforestry production system

6.83. Consequently, the minimum number of leaves plant^{-1} (6.03 at 75 DAT) was observed in open field (T_0) i.e. onion sole cropping production.

Bulb diameter is one of the important yield contributing characteristic of onion which was significantly affected by the different tree based agroforestry production system. The highest bulb diameter (4.40 cm) was measured in T_1 sole cropping of onion production and the lowest bulb diameter (3.85 cm) was measured under ipil-ipil based agroforestry production system (T_3) which was similar to that of T_2 (3.87 cm) and T_1 (3.92 cm), respectively. The highest fresh weight of bulb plant^{-1} (27.04 g) was found in open field i.e. sole cropping of onion followed by (25.33 g) kalo koroi + onion based agroforestry production system (T_1), respectively. Consequently, the lowest fresh weight of bulb plant^{-1} was observed under ipil-ipil + onion based agroforestry production system 23.60 g which was similar to that of ghora neem + onion based agroforestry production system (T_2) 24.17g, respectively. The highest fresh bulb yield (10.14 tha^{-1}) was found in open field i.e. sole cropping of onion followed by (9.94 tha^{-1}) kalo koroi + onion based agroforestry production system (T_1), respectively. Consequently, the lowest fresh bulb yield (9.11 tha^{-1}) was measured under ipil-ipil + onion based agroforestry production system which was similar to that of ghora neem + onion based agroforestry production system (T_2) (9.57 tha^{-1}), respectively.

Profitability of growing onion as inter-crop in different tree (kalo koroi, ghora neem and ipil-ipil) based agroforestry production system was calculated based on local market rate prevailed during experimentation. The values in Appendix VII indicate that the total cost of production was highest (196720.5 Tk./ha) under kalo koroi + onion based agroforestry production system system (T_1) followed by ipil-ipil + onion based agroforestry production system (194771.25 Tk./ha) (T_3) and ghora neem + onion based agroforestry production system (192313.5 Tk./ha) in (T_2). The lowest cost of production (158526.5 Tk./ha) was recorded from the sole cropping of onion (T_0). The highest value of gross return (704800 Tk. /ha) was obtained from kalo koroi + onion (T_1) based agroforestry production system (Table 4.3). On the other hand, the lowest value of gross return (405600Tk. /ha) was obtained from sole cropping of onion production system (T_0). It was observed that kalo koroi + onion based agroforestry production system (T_1) gave the highest net return (508079.5 Tk. /ha) followed by (442695.75 tk/ha) in Ipil-Ipil + onion (T_3) based agroforestry production system. At the same time, the lowest net return (158526.5 Tk. /ha) was received from the sole cropping onion based production system (T_0). The highest benefit-cost ratio of 3.58 was recorded from kalo koroi + onion (T_1) based agroforestry production system followed by ipil-ipil + onion (T_3) based agroforestry production system and ghora neem + onion (T_2) based agroforestry production system. The lowest benefit-cost ratio of 2.56 was observed in T_0 i.e. in sole cropping of onion. So, onion can profitably be cultivated in kalo koroi based agroforestry production systems.

Conclusion:

The present research finding may be concluded that onion is profitable spices crops that can be grown well in agroforestry practices specially in multipurpose tree like kako koroi based agroforestry system.

Moreover, the developed model should be applied in the same aged different woodlots of the northern site of Bangladesh. It may also be advocated that to get a vital recommendation, this study should be repeated in different locations of the country with some moderate shaded multipurpose tree species.

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APPENDICES

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

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

Source: Soil Resources Development Institute, Dinajpur (20014).

Appendix II. Weather data of the experimental site during the period from November 2013 to April 2014

Months	* Air Temperature (C)			* Minimum Rainfall	* Relative Humidity
	Maximum	Minimum	Average		
November	29.85	19.68	24.77	05	88.50
December	28.70	18.45	23.56	18	85.92
January	27.20	16.10	21.65	12	83.45
February	26.95	15.78	21.37	00	82.20
March	29.61	20.57	25.09	18.50	80.61
April	30.25	21.46	25.85	20.21	81.85

Note * Monthly average

Source: Meterological Station, Wheat Research Center, Noshipur, Dinajpur.

Appendix III. Effect of production system on number of bulb weight and diameter of onion

Treatments	Leaf fresh weight (g) plant^{-1}	Leaf dry weight (g) plant^{-1}	Root fresh weight (g) plant^{-1}	Root dry weight (g) plant^{-1}
T_0	9.28 d	1.36 c	0.34 c	0.08 a
T_1	10.65 c	1.54 b	0.36 b	0.08 a
T_2	11.88 a	1.63 a	0.40 a	0.09 a
T_3	11.37 b	1.63 a	0.37 b	0.09 a
$LSD_{(0.05)}$	0.420	0.063	0.015	0.01

Appendix IV. Effect of production system on number of bulb weight and diameter of onion

Treatments	Bulb diameter (cm)	Bulb fresh weight (g)	Bulb dry weight (g)	Bulb fresh yield (t ha^{-1})
T_0	4.40 a	27.04 a	3.08 a	10.14 a
T_1	3.92 b	25.33 b	2.97 b	9.94 b
T_2	3.87 b	24.17 c	2.87 c	9.57 c
T_3	3.85 b	23.60 c	2.79 c	9.11 d
$LSD_{(0.05)}$	0.1548	0.8213	0.089	0.063

Appendix V. Cost of production for onion based agroforestry system (average of one years)

Treatment	Input cost										Over head cost			
	Non material cost (Tk/ha)			Material cost (Tk/ha)						Total input 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)	Total cost of production (Tk/ha)
	Trees	Onion production	Total non material cost	Seedlings	Fertilizer	Pesticide	Maintenance cost of trees	Initial plantation cost of trees	Total material cost (Tk/ha)					
T_0	………	70550	70550	30500	14500	3500	………	………	48500	119050	9524	24000	5952.5	158526.5
T_1	14300	70550	84850	30500	14500	3500	5000	14500	68000	152850	12228	24000	7642.5	196720.5
T_2	14400	70550	84950	30500	14500	3500	5000	10500	64000	148950	11916	24000	7447.5	192313.5
T_3	14575	70550	85125	30500	14500	3500	5000	12500	66000	151125	8967	24000	7556.25	194771.25

Note: Urea 12 Tk./kg, TSP 22 Tk./kg; MP 24 Tk./kg, Labour 120 Tk./day, Plantation cost for Ipil-Ipil, Ghora neem and Kala koroi were 20, 15, and 18 Tk./tree, respectively (rotation year for Ipil-Ipil, Ghora neem and Kala koroi were 12, 8 and 20 years, respectively).