Reprint **ISSN 1997-2571 (Web Version)**

Journal of Innovation & Development Strategy (JIDS)

(J. Innov. Dev. Strategy)

Volume: 11 **Issue: 1** **April 2017**

J. Innov. Dev. Strategy 11(1): 1-8 (April 2017)

ECONOMIC PERFORMANCE OF ONION UNDER *Albizia lebbeck, Melia azedarach* and *Leucaena leucocephala* BASED AGROFORESTRY SYSTEMS

M.H.A. AMIN, J.P. ROY, M.S. RAHMAN AND M. KAJAL

An International Scientific Research Publisher

Green Global Foundation©

Web address: http://ggfjournals.com/e-journals archive
E-mails: editor@ggfjournals.com and editor.int.correspondence@ggfjournals.com

ISSN-1997-2571 (Online)
J. Innov. Dev. Strategy 11(1):1-8(April 2017)

ECONOMIC PERFORMANCE OF ONION UNDER *Albizia lebbeck, Melia azedarach* and *Leucaena leucocephala* BASED AGROFORESTRY SYSTEMS

M.H.A. AMIN*, J.P. ROY, M.S. RAHMAN AND M. KAJAL

Department of Agroforestry and Environment, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh.

*Corresponding author & address: Md. Hafiz All Amin, E-mail: hafizallamin@gmail.com
Accepted for publication on 10 March 2017

ABSTRACT

Amin MHA, Roy JP, Rahman MS, Kajal M (2017) Economic performance of onion under *Albizia lebbeck, Melia azedarach* and *Leucaena leucocephala* based agroforestry systems. *J. Innov. Dev. Strategy.* 11(1), 1-8.

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 kalokoroi, goraneem and ipil-ipil based agroforestry systems. The experiment was conducted in newly established orchard of multipurpose tree species namely *Albizia lebbeck* (Kalokoroi), *Melia azedarach* (Ghoraneem) and *Leucaena leucocephala* (Ipil-ipil) the tree saplings were planted at the spacing (3m×3m) and the orchard was 8 years old. The experiment included a popular onion variety Taherpuri was used for the study. The experiment was laid out following the Randomized Complete Block Design (RCBD) with three (3) replications. Total number of experimental plots was 12. The unit plot size was 2.5m × 2.5m = 6.25m^2. The treatments of the experiment were T_0= Open field + onion, T_1= *Albizia lebbeck* + onion, T_2= *Melia azedarach* + onion and T_3= *Leucaena leucocephala* + onion. The results of the research revealed 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, 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 *Leucaena leucocephala* + onion based 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 *Leucaena leucocephala* + onion based AFS followed by *Melia azedarach* + 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 *Leucaena leucocephala* + onion based agroforestry production system. Apparently, the minimum number of leaves plant^{-1} (3.77 at 30 DAT) was observed in 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 *Leucaena leucocephala* 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 sole cropping of onion followed by (25.33 g) *Albizia lebbeck* + onion based agroforestry production system, respectively. The highest benefit-cost ratio of 3.58 was recorded from *Albizia lebbeck* + onion based agroforestry production system followed by *Leucaena leucocephala* + onion based agroforestry production system and *Melia azedarach* + onion based agroforestry production system. The lowest benefit-cost ratio of 2.56 was observed in sole cropping of onion. Finally, it may be concluded that onion can be cultivated profitably in *Albizia lebbeck* based agroforestry production systems.

Key words: *economy, onion, multipurpose tree, agroforestry system*

INTRODUCTION

The consequence of mono-cropping cultivation is large-scale environmental degradation that creates food scarcity, poverty, deprivation, and communal conflicts. 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 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). Forest degradation is a serious environmental, social and economic problem, particularly in developing countries. On the other hand, afforestation and natural expansion of forests in some countries have significantly reduced the net loss of forest area at the global level. More than 12 million ha per year are afforested or reforested each year (FAO 2010). Bangladesh is endowed with only 13.6% of unevenly distributed forests (BBS 2014). Conversely, actual tree coverage is less than 10%. Due to rapid growth of population, there is a tremendous pressure on the forest lands in Bangladesh. The northern part of the country 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 per person, which is one of the lowest ratios in the globe (BBS 2015). The existing land use systems will become more vulnerable owing to augment in the atmospheric temperature, levels of CO_2 and other greenhouse 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 have already been reached. The present situation on fuel wood, fodder and timber production is not rational to meet the local demand. 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 (1.41 lakh ha) in respect of area (Anonymous 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).To combat with these

Copyright© 2017 Green Global Foundation
www.ggfjournals.com

alarming situations, proper management of natural resources is highly needed. 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 as combined in the limited land. In this regard, 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 stability and lessening ill effects of the global warming. Keeping all these facts in mind this research was undertaken with the following objectives: to find out the growth and yield of onion under *Albizia lebbeck, Melia azedarach and Leucaena leucocephala* based agroforestry system along with sole cropping control condition and to measure the economic performance of onion under *Albizia lebbeck*, *Melia azedarach* and *Leucaena leucocephala* based agroforestry system.

MATERIALS AND METHODS

The experiment was conducted in Agroforestry and Environment Research Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur during November, 2013 to April, 2014. It was laid out following the RCBD with three (3) replications. Total number of experimental plots was 12. The unit plot size was 2.5m × 2.5m = 6.25 m^2. The treatments of the experiment were T_0= Open field + Onion, T_1= *Albizia lebbeck* + Onion, T_2= *Melia azedarach* + Onion and T_3= *Leucaena leucocephala* + Onion. The spacing for all the tree species were 3m × 3m and the age were 8 years. The status of the woodlots at the time of the experiment was *Albizia lebbeck*: plant height 12.0m, clean bole height 5.5m, base girth 1m, bole girth 0.8m, *Melia azedarach*: plant height 13.5m, clean bole height 5.0m, base girth 1.1m, bole girth 0.9m, *Leucaena leucocephala*: plant height 16.5m, clean bole height 6.5m, base girth 0.9m, bole girth 0.7m. A popular onion variety Taherpuri was used for the study. This is a high yielding indeterminate type variety. The seeds of the variety were collected from the Dinajpur seed market. The variety was marketed by ACI seed Company Limited. 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. The land of experimental plot was opened in the 2nd week of December 2013 with spade and it was made ready for transplanting. The layout was done as per experimental design. The fertilizer and manure doses were 217 kg N/ha, 227 kg P_2O_5/ha and 187 kg K_2O/ha and cow dung 14000 kg/ha. Full cow dung 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 installations at 25 and 50 days after transplanting. 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. Manual weeding was done as and when necessary to keep the plots completely free from all weeds. 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. The crop was harvested on 4 April, 2014. 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. Five plants were selected randomly from each plot and tagged properly for data collection. Data were recorded from the sample plants during experimentation as plant height (cm), number of leaves per plant, bulb diameter (cm), fresh weight of bulb per plant (g), dry weight of bulb per plant (g) and yield of bulb (ton per hectare). 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. Data were statistically analyzed using the "Analysis of Variance" (ANOVA) 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).

RESULTS AND DISCUSSION

The present research was carried out to evaluate the economic performance of onion under *Albizia lebbeck*, *Melia azedarach* and *Leucaena leucocephala* based agroforestry systems on the growth, yield and yield contributing characters as well as the cost of cultivation, gross and net returns per hectare and benefit-cost ratio.

Plant height

It was observed that there was a significant variation in plant height at different tree based agroforestry system along with sole cropping (Table 1). 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 *Leucaena leucocephala* + Onion (T_3) based AFS followed by in *Melia azedarach* + onion (T_2) based AFS. Consequently, the shortest plant was observed (20.07 cm) in sole cropping of onion (T_0) (Table 1). Again, in middle stage at 45 DAT, the tallest plant (40.47 cm) was recorded under *Leucaena leucocephala* + onion based AFS (T_3) followed by under *Melia azedarach* + 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 *Leucaena leucocephala* + onion based AFS (T_3) whereas the shortest plant (48.00 cm at 60 DAT) was recorded in sole cropping of onion (T_0). Finally at 75 DAT, the tallest plant height (51.01 cm) was found under *Leucaena leucocephala* + onion based AFS (T_3) followed by (49.83 cm) *Melia azedarach* + onion (T_2) based AFS. 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 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 ≤ 5% level

Number of leaves plant^{-1}

Number of leaves per plant of onion was also significantly disposed by the diverse agroforestry production systems (Table 2). At 30 DAT, the maximum number of leaves palnt^{-1} (4.80) was recorded under *Leucaena leucocephala* + onion based agroforestry production system (T_3) followed by (4.53) *Melia azedarach* + onion based agroforestry production system. Apparently, the minimum number of leaves plant^{-1} (3.77 at 30 DAT) was observed in (T_0) onion sole cropping production. At 45 DAT, the maximum number of leaves palnt^{-1} (5.96) was recorded under *Leucaena leucocephala* + onion based agroforestry production system (T_3) followed by (5.60) *Melia azedarach* + onion based agroforestry production system. On the other hand, the minimum number of leaves plant^{-1} (4.76 at 45 DAT) was observed in (T_0) 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 *Leucaena leucocephala* + onion based agroforestry production system (T_3) followed by (6.83) *Melia azedarach* + onion based agroforestry production system. Consequently, the minimum number of leaves plant^{-1} (6.03 at 75 DAT) was observed in (T_0) onion sole cropping production. 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, like leaf appearance, expansion, senescence, leaf orientation and physiological growth. 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 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 ≤ 5% level

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 (Table 3). The highest bulb diameter (4.40 cm) was

measured in (T_0) sole cropping of onion production and the lowest bulb diameter (3.85 cm) was measured under *Leucaena leucocephala* + onion 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 may be happened due to more photosynthesis an activity was performed in the sun light of open field. The finding of Miah (2010) was in agreement with the present result.

Bulb fresh weight plant^{-1}

Different tree based production systems had significant effect on the fresh weight of bulb plant^{-1} (Table 3). The highest fresh weight of bulb plant^{-1} (27.04 g) was found in (T_0) sole cropping of onion followed by (25.33 g) *Albizia lebbeck* + onion based agroforestry production system (T_1), respectively. Consequently, the lowest fresh weight of bulb plant^{-1} (23.60g) was observed under *Leucaena leucocephala* + onion based agroforestry production system which was similar to that of (24.17g) *Melia azedarach* + onion based agroforestry production system, respectively.

Bulb dry weight plant^{-1}

Bulb dry weight plant^{-1} was found statistically highly significant by different tree based production systems (Table 3). Significantly the highest bulb dry weight plant^{-1} (3.08 g) was found under in (T_0) sole cropping of onion followed by (2.97 g) *Albizia lebbeck* + onion based agroforestry production system (T_1). On the other hand, the lowest bulb dry weight plant^{-1} (2.79 g) was recorded under *Leucaena leucocephala* + onion based agroforestry production system which was statistically similar to that of (2.87 g) *Melia azedarach* + onion based agroforestry production system (T_2), respectively.

Bulb fresh yield

Bulb fresh yield as affected by different tree based agroforestry production system was found statistically highly significant (Table 3). The highest fresh bulb yield (10.14 t ha^{-1}) was found in (T_0) sole cropping of onion followed by (9.94 t ha^{-1}) *Albizia lebbeck* + onion based agroforestry production system (T_1), respectively. Consequently, the lowest fresh bulb yield (9.11 t ha^{-1}) was measured under *Leucaena leucocephala* + onion based agroforestry production. The finding of Miah (2010) was in agreement with the present result.

Table 3. Effect of different tree based production systems on bulb diameter, bulb fresh weight, bulb dry weight and bulb fresh yield 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

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

Economic return of onion

Profitability of growing onion as inter-crop in different tree (*Albizia lebbeck*, *Melia azedarach* and *Leucaena leucocephala*) 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 presented in Table 4. The return of produce and the profit per taka i.e. Benefit Cost Ratio (BCR) also have been presented in Table 5.

Total cost of production

The values in Table 5 indicated that the total cost of production was highest (196720.5 Tk/ha) under *Albizia lebbeck* + onion based agroforestry production system (T_1) followed by *Leucaena leucocephala* + onion based agroforestry production system (194771.25 Tk/ha) (T_3) and *Melia azedarach* + 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 *Albizia lebbeck* + onion based agroforestry production system due to higher plantation cost of the system.

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 *Albizia lebbeck* + onion (T_1) based agroforestry production system (Table 5). On the other hand, the lowest value of gross return (405600 Tk/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 *Albizia lebbeck* trees.

Net return

Results presented in the Table 5 indicated that net return was comparatively higher in producing onion under *Albizia lebbeck* + onion based agroforestry production system than other agroforestry production system. It was

observed that *Albizia lebbeck* + onion based agroforestry production system (T_1) gave the highest net return (508079.5 Tk/ha) followed by (442695.75 Tk/ha) in *Leucaena leucocephala* + 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 *Albizia lebbeck* trees.

Benefit-cost ratio

The highest benefit-cost ratio of 3.58 was recorded from *Albizia lebbeck* + onion (T_1) based agroforestry production system followed by *Leucaena leucocephala* + onion (T_3) based agroforestry production system and *Melia azedarach* + 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 under *Albizia lebbeck* 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. Cost of production of onion under different tree based agroforestry system along with control (average of one year)

Treatments	Input cost									Total input cost (Tk/ha)	Overhead 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	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 *Albizia lebbeck*, *Melia azedarach* and *Leucaena leucocephala* were 18, 15, and 20 Tk/tree, respectively (rotation year for *Albizia lebbeck*, *Melia azedarach* and *Leucaena leucocephala* were 20, 8 and 12 years, respectively)

Table 5. Economic return of onion production under different tree (*Albizia lebbeck*, *Melia azedarach* and *Leucaena leucocephala*) 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	*Albizia lebbeck*	*Melia azedarach*	*Leucaena leucocephala*				
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, *Albizia lebbeck* 300 Tk/Tree/Year *Melia azedarach* 225 Tk/Tree/Year, *Leucaena leucocephala* 267 Tk/Tree/Year

CONCLUSION

The most useful spices onion may be adapted to inter-crop in different tree (*Albizia lebbeck*, *Melia azedarach* and *Leucaena leucocephala*) based agroforestry production system. The production of onion is highest in sole cropping as sun light, temperature and wind movement available, but *Albizia lebbeck* + onion based agroforestry production system is suitable among other tree based agroforestry production system. Finally, on the basis of economic return the highest benefit-cost ratio of 3.58 was recorded from *Albizia lebbeck* + onion based agroforestry production system followed by *Leucaena leucocephala* + onion based agroforestry production system and *Melia azedarach* + onion based agroforestry production system. The lowest benefit-cost ratio of 2.56 was observed in sole cropping of onion. It can be concluded that onion can be cultivated beneficially in *Albizia lebbeck* based agroforestry production systems.

REFERENCES

Ali MY, Haq MF (1994) Production of Onion through Application of Optimum Fertilizer and irrigation is a profitable Technology (Booklet in Bengali). OFRD, BARI, Joydebpur, Gazipur. p. 4.

Allan W (1965) The african husbandman. Greenwood press publishers. West point Conecticut.

Anonymous (2006) Annual Report, Spices Research Centre. BARI, Joydebpur, Gazipur. pp. 61-65.

BBS (2014) Statistical Pocket Book of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Govt. of Peoples' Republic of Bangladesh.

BBS (2015) Statistical Pocket Book of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Govt. of Peoples' Republic of Bangladesh.

Beets WC (1990) Raising and sustaining Productivity of Small Holder Farming Systems in the Tropics. Agbe Publishing. Holland.

Benoit GR, Grant WJ, Devine OJ (1986) Potato top growth as influenced by day–night temperature differences. *J. Agron*. 78:264–269.

FAO (Food and Agriculture Organization) (2006) Tree growing by Rural people, Forestry paper no. 64, FAO Rome, Italy.pp.10-13.

FAO (Food and Agriculture Organization) (2010) Global forest resources assessment. The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture. Rome. p. 370.

Faruq MO (2001) Effect of time of planting and pre-harvest malaichydrazide application on the growth, yield and storage performance of onion. M.S. thesis, Dept. of Hort., BAU, Mymensingh. p. 31.

Gomez KA, Gomez AA (1984) Statistical procedures for Agricultural Res. 2nd edn. John Wiley and Sons, New York. p. 680.

Hillman JR (1984) Apical dominance, In: Wilking, M. b. (ed). Advanced plant physiology. Pitman, London, pp. 127-184.

Hussain AKMA, Islam MJ (1994) Status of *Allium* production in Bangladesh. Acta Hort., 358: 33-63.

Kang BT, Atta-Krah AN, Reynolds L (1999) Alley Farming Macmillan Education Ltd.

Kelly PM, Adger WN (2000) Theory and Practice in assessing vulnerability to climate change and facilitating adaptation. Climate change47, pp. 325-252.

Kirk WW, Marshall B (1992) The influence of temperature on leaf development and growth in potatoes in controlled environments. Ann. Appl. Biol., 120:511–525.

Manrique LA, Bartholomew DP, Ewing EE (1989) Growth and yield performance of several potato clones grown at three elevations in Hawaii: I. Plant morphology. Crop Sci. 29:363–370.

Marinus J, Bodlaender KBA (1975) Response of some potato varieties to temperature. Potato Res., 18:189–204.

Miah MMU (2010) Maximization of land use through agroforestry practices in floodplain ecosystem of Bangladesh. Phd thesis. HSTU, Dinajpur.

Steward FC, Moreno U, Roca WM (1981) Growth, form and composition of potato plants as affected by environment. Ann. Bot. 48:1–45.

Van Delden A, Kropff MJ, Haverkort AJ (2001) Modeling temperature- and radiation-driven leaf area expansion in the contrasting crops potato and wheat. Field Crops Res., 72:119–142.

Vos J (1995) Foliar development of the potato plant and modulations by environmental factors. p. 21–38. *In* P. Kabat et al. (ed.) Modeling and parameterization of the soil–plant–atmosphere system: WageningenPers, Wageningen, the Netherlands.