Performance of summer vegetables in charland based agroforestry system

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Abstract: The experiment was carried out in Char Kalibari of Old Brahmaputra River under Sadar Upazila, Mymensingh during the period from March, 2012 to September, 2012. This study was examined the performance of different summer vegetables in association with different trees for 'Char' based farming system. Summer vegetables were planted in association with different trees following two factorial Randomized Complete Block Design (RCBD) with 4 (four) replications. Factor A comprised of eleven different tree species and these were Akashmoni (*Acacia auriculiformis*), Mahagony (*Swietenia macrophylla*), Lambu (*Swietenia hybrida*), Eucalyptus (*Eucalyptus camaldulensis*), Mango (*Mangifera indica*), Lemon (*Citrus spp.*), Jujube (*Zizypus spp*.), Papaya (*Carica papaya*), Guava (*Psidium guajava*), Hijal (*Barringtonia acutangula*) and Karanja (*Pongamia pinnata*); while Factor B included four summer vegetables viz. Kangkong (*Ipomoea reptans*), Indian spinach (*Basella alba*), Amaranth (*Amaranthus spp*.) and Okra (*Abelmoschus esculenta*). Yield and yield attributes of all tested summer vegetables was better in open field condition. Fresh yield of Kangkong, Indian spinach, Amaranth and Okra in open field condition was 50.2, 62.5, 18.0 and 32.5 tha^{-1}, respectively. Among the tree association, highest yield was along with Mahogoni, Lambu, Mango and Guava where 6-12% yield reduced compare to without tree combination. Second highest yield obtained from Akashmoni, Lemon and Jujube mixed combination with summer vegetables where 15-28% fresh yield decreased compare to control condition. Third highest yield recorded in combination with Eucalyptus and Papaya where 30-38% yield reduced compare to without tree combination. In case of Kangkong and Indian spinach least fresh yield was obtained in association with Hijal and Karanja where 40-45% yield reduced compare to control condition. Growth of studied trees was measured before and after the summer season for height and girth measurement. It was found that growth of all trees almost similar in association different vegetables. In control condition i.e. without vegetables tree growth was bit higher compare to mixed combination with vegetables. Among the different tree species yield produced from only papaya. Papaya yield was highest (33.5 tha^{-1}) in control condition i.e. without vegetable mixed combination. Statistically similar yield obtained from Papaya in mixed vegetables combination with all vegetables and average yield was 30.25 tha^{-1}, which is near 10% less compare to control condition.
Key words: Summer vegetables, agroforestry, trees, sapling, charland.

Introduction

Bangladesh is one of the most densely populated countries of the world struggling hard to feed her 160 million people (BBS 2010). The country has a land area of only 14.39 million hectares, but due to the ever increasing population, per capita land area is decreasing at an average rate of 0.005 ha/cap./year since 1989 (Hossain and Bari, 1996). The capacity of our land is decreasing day by day due to intensive cropping and use of high input technologies. Our forest resource which has important role in maintaining environmental equilibrium and socio-economic upliftment of the people is also declining with increasing population. To maintain the environmental equilibrium and rate of socio-economic development at least 25% area of a country should be covered with forest. In Bangladesh the total forest area covers about 17% of the land area (BBS, 2010) but the actual tree covered area is estimated at around 9.4% which is decreasing at an alarming rate (Hossain and Bari, 1996). Due to continuous transformation of forest land to agricultural land, aquaculture, homestead and other purposes about 8000 ha of forest land is decreasing per year (FAO, 1981). Another 99,000 ha of reserved forest lands were encroached or subjected to shifting cultivation. Village forest, mainly covered by homesteads accounts only 0.27 million ha. Out of 64 districts, as estimated, 28 districts have no public forest land (Islam, 1991). So, the effective area of forest (9.4%) in Bangladesh is neither in a position to fulfill the requirements of the people's demand for fuel, fodder and timber nor to stabilize the climatic condition. Under these alarming situations, agricultural production as well as forest resources must be increased by using modern or new techniques. Recently, some techniques have already been advocated to overcome the future challenges, Agroforestry is one of them. Agroforestry, the integration of tree and crops/vegetables on the same area of land is a promising production system for maximizing yield (Nair, 1990) and maintaining friendly environment. Agroforestry is the combination of forestry and agriculture with attributes of productivity, sustainability, and adoptability.

In Bangladesh scope of Agroforestry is vast. The major venues of agroforestry are homestead, roadside, railway side, embankment side, charland, coastal area, deforested area, institutional premises, riverside etc. Among them charland is the most important venue for practicing agroforestry systems. 'Char' a tract of land surrounded by the waters of an ocean, sea, lake, or stream; it usually means any accretion in a river course or estuary (Chowdhury, 1988). Chars in Bangladesh have been distributed into five sub-areas: the Jamuna, the Ganges, the Padma, the Upper Meghna and the Lower Meghna rivers. There are other areas of riverine chars in Bangladesh, along the Old Brahmaputra and the Tista rivers. But compared to the chars in the major rivers, these constitute much less land area. It is estimated that in 1993 the total area covered by chars in Bangladesh was 1,722 sq km (Banglapedia). A large number of populations are living in these char areas and maintaining their livelihood through char based farming systems. Therefore, for increasing production, maintaining ecological balance and improving socio-economic condition of the charland people, integrated approach with crops/vegetables and trees is necessary.

In Bangladesh, a large number of vegetables are grown of which most of them are grown in winter season. In summer season few vegetables are grown of which amaranth, okra, Indian spinach, Kangkong etc. very common. Amaranth is a popular summer vegetable, its leaves and stems are rich in protein, minerals, vitamin A and C. It fit well in crop rotation because of its short life

cycle. Okra is also very popular among all classes of people. It is rich in vitamins, Ca, K and other minerals. Indian spinach is an another popular summer vegetable that has high nutritional value and grow easily under excessive rainfall condition. Kankong has some desirable characteristics, such as high nutritive value, tasty, relatively free from pest and disease infection and ability to grow under excessively humid condition. It may help considerably in solving vegetable scarcity during summer season. Present study was undertaken to observe the performance of summer vegetables in association with different tree species in the Char Kalibari in the bank of Old Brahmaputra River.

Materials and Methods

Experimental site: The experiment was carried out in Char Kalibari of Old Brahmaputra River under the Department of Agroforestry, Bangladesh Agricultural University, Mymensingh during the period from March, 2012 to September, 2012. The geographical position of Char Kalibari located between 24˚45' - 24˚45'40" North and 90˚24'4" - 90˚24'44" East Latitude (Fig.1). The physiographic unit of the soil of this char is old Brahmaputra flood plain. Every year after the monsoon huge area along the bank of the river old Brahmaputra developed as char which is rich due to silt deposition. The climatic condition of this char is sub-tropical and characterized by high temperature and heavy rainfall during kharif season (April to September) and scanty rainfall associated with moderately low temperature during the Rabi season (October to March). The overall relative humidity remains high almost all over the year except the winter. Char Kalibari is an attached charland which have three distinct elevations. The upper elevation is relatively stable char, while the middle and lower elevation remained inundated during the rainy season from June to September each year. During summer season only stable portion of this char is suitable for vegetables cultivation.

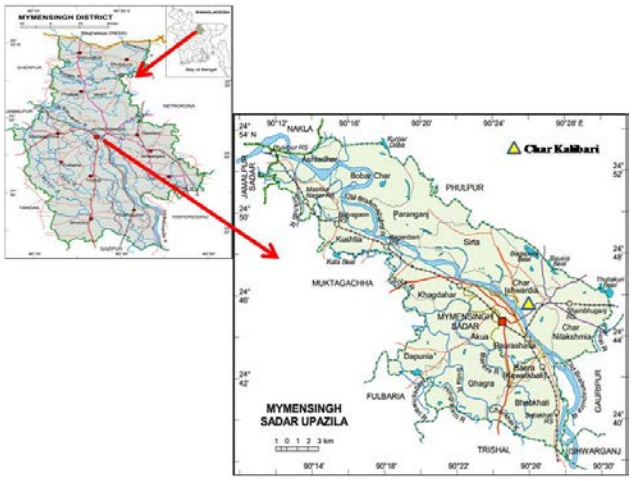

Fig. 1. Location of the study area

Planting material: Total eleven different tree species (5 timber, 4 fruit and 2 soil conserving species) and four different summer vegetable species were used as planting materials in this study (Fig.2). Eleven tree species were Akashmoni (*Acacia auriculiformis*), Mahagony (*Swietenia macrophylla*), Lambu (*Swietenia hybrida*), Eucalyptus (*Eucalyptus camaldulensis*), Mango (*Mangifera indica*), Lemon (*Citrus spp.*), Jujube (*Zizypus spp*.), Papaya (*Carica papaya*), Guava (*Psidium guajava*), Hijal (*Barringtonia acutangula*) and Karanja (*Pongamia pinnata*). Four summer vegetables were Kangkong (*Ipomoea reptans*), Indian spinach (*Basella alba*), Amaranth (*Amaranthus spp*.) and Okra (*Abelmoschus esculenta*).

Fig. 2. Summer vegetables along with trees

Experimental design, layout and tree sapling transplantation: Summer vegetables were planted in association with different trees following two factorial Randomized Complete Block Design (RCBD) with 4 (four) replications. Factor A: eleven different tree species and Factor B: four different summer vegetable species. Tree species were planted maintaining a strip method with 12′ × 12′ spacing during April, 2011 in the study site. Total 528 saplings of 11 different species were transplanted of which 48 saplings for each species. Necessary silvicultural management activities like watering, cleaning, weeding, fertilizing, branch cutting, bamboo stick setting were done in time for proper growth and development of all tree saplings.

Summer vegetable cultivation: Summer vegetables i.e. Kangkong, Indian spinach, Amaranth and Okra were sown after land preparation in a broadcast method. Seeds of Kangkong, Indian spinach, Amaranth and Okra were sown during 10th April, 2012. After germination all necessary cultural operations like thinning, gap filling, weeding, fertilizing, irrigation, pest control etc. were done properly. Individual plot size for all vegetable was same and it was 12′ × 24′.

Growth measurement of tree species: Growth of all planted tree sapling were recorded as height and girth during before and after summer season i.e. first time in the month of March, 2012 and second time in the month of September, 2012. Girth was measured using the formula: $G = 2\Pi r$, where, r = radius. Difference between the recorded data during before and after the summer season treated as increment during summer season for both height and girth. Girth of all trees was measured 8 inch above

from the ground level.

Sampling and Data collection: Data were collected from randomly selected individual plants of all four summer vegetables. Plant height or length (cm), number of branches per plant, stem girth (cm), leaves per plant, fruit size (for Okra) were recorded. For yield measurement, data were recorded from individual plots and it was converted as tha^{-1}. Dry yield was measured after complete drying the samples in the oven at 70° C from representative samples and it was converted as tha^{-1}.

Statistical analysis: The recorded data were compiled and analysed by RCBD design to find out the statistical significance of the experimental results. The means for all recorded data were calculated and the analyses of variance for all the characters were performed. The mean differences were evaluated by Duncan's New Multiple Range Test (DMRT) (Gomez and Gomez, 1984) and also by Least Significant Difference (LSD) test.

Results

Morphological characteristics of summer vegetables:

Kangkong: Morphological parameters of Kangkong like length of twig, twig per plant, leaves per plant and stem girth were significantly variable in association with different trees (Table 1). Longest twig (38.5cm) was observed in association with Hijal trees which is statistically similar with the twig length (37.3cm) of Kangkong recorded along with Karanja trees. Statistically similar size twig observed along with Akashmoni, Mahogoni, Lambu, Mango, Lemon and Jujube which was second highest. Third highest size twig was found in association with Guava and control condition i.e. without trees. Shortest size twig recorded along with Eucalyptus (27.9 cm) and Papaya (28.8cm). Highest number of twig per plant was found in control condition (12.8) which was statistically similar with the number of twig per plant in association with Mahogoni (12.1), Lambu (12.2), Mango (12.2) and Guava (11.8). Second highest number of twig per plant was recorded along with Akashmoni (10.7) followed by lemon (8.5) and Jujube (8.3). Least number of twigs was harvested in association with Papaya (6.1) which was statistically similar in association with Eucalyptus (6.5), Hijal (6.8) and Karanja (7.1). Like twig $plant^{-1}$, similar trend of variation was recorded in case of leaves $plant^{-1}$, where highest (335.5) leaves $plant^{-1}$ found in without tree condition and lowest along with Hijal (223.5, Table 1). Highest stem girth (2.91cm) of Kangkong was found in without tree condition and among the tree association this value was highest along with Lambu (2.83cm) which was gradually decreased as in association with Mahogoni (2.77cm), Mango (2.73cm), Guava (2.71cm), Jujube (2.62cm), Lemon (2.61cm), Akashmoni (2.43cm), Eucalyptus (2.41cm), Papaya (2.35cm), Karanja (2.15cm) and Hijal (2.13cm).

Table 1. Morphological Characteristics of summer vegetables in association with different tree species

	Tree species	Morphological Characteristics of summer vegetables														
		Kangkong				Indian spinach				Amaranth			Okra			
		Length twig^{-1} (cm)	Branches plant^{-1}	Leaves plant^{-1}	Stem girth (cm)	Length twig^{-1} (cm)	Branches plant^{-1}	Leaves plant^{-1}	Stem girth (cm)	Plant height (cm)	Leaves plant^{-1}	Stem girth (cm)	Weight plant^{-1} (g)	Plant height (cm)	Leaves plant^{-1}	Fruit length (cm)	Fruit girth (cm)
Timber trees	1. Akashmoni	33.5b	10.7b	298.5b	2.43c	41.6c	5.5bc	210.5bc	3.3bc	87.4b	24.4c	7.3b	152.5b	103.4b	56.8b	14.5b	5.3b
	2. Mahogoni	31.8bc	12.1a	317.5ab	2.77b	43.1b	6.9b	227.5a	3.6a	91.7a	28.7b	8.5a	179.0a	114.8a	65.3a	17.5a	6.5a
	3. Lambu	31.5bc	12.3a	318.5ab	2.83b	43.3b	7.4b	231.4a	3.5a	90.6a	28.6b	8.8a	179.9a	114.2a	65.9a	17.9a	6.4a
	4. Eucalyptus	27.9d	6.5d	255.5c	2.41c	37.6c	4.6c	201.2c	2.8c	81.8c	20.4d	6.7c	143.6c	92.5c	45.7c	11.5c	4.1c
Fruit trees	5. Mango	31.7bc	12.2a	305.5b	2.73b	43.7b	7.2b	228.5a	3.5a	92.1a	29.2b	8.2ab	178.8a	113.8a	66.5a	17.3a	6.6a
	6. Lemon	32.9b	8.5c	307.5b	2.61b	44.1b	5.1bc	201.7b	3.2b	84.4b	23.4c	7.5b	152.0b	105.2b	53.3b	14.6b	5.1b
	7. Jujube	33.5b	8.3c	311.5b	2.62b	44.3b	5.3bc	203.4b	3.2b	85.4b	23.7c	7.7b	155.0b	104.5b	52.8b	14.9b	5.0b
	8. Papaya	28.8d	6.1d	257.5c	2.35c	37.8d	4.7c	197.1c	2.8c	82.3c	20.1d	6.3c	141.0c	93.6c	43.3c	11.1c	4.3c
	9. Guava	31.2c	11.8a	304.5b	2.71b	43.7b	7.7ab	219.3b	3.5a	92.2a	29.3a	8.2ab	178.5a	114.8a	65.7ab	17.1a	6.6a
soil conserving tress	10. Hijal	38.5a	6.8d	223.5d	2.13d	50.7a	4.1c	178.5d	2.1d	_	_	_	_	_	_	_	_
	11. Karanja	37.3a	7.1d	233.d	2.15d	49.3a	4.5c	183.2d	2.1d	72.3d	19.8d	5.6d	125.1d	83.6d	36.3d	10.2d	3.9c
Without trees		30.5c	12.8a	335.5a	2.91a	40.5c	8.5a	235.5a	3.7a	90.5a	31.1a	9.2a	185.5a	112.5a	68.4a	18.1a	7.1a

Means in column followed by the different letter are significantly different by DMRT at $P \leq 0.05$

Indian spinach: Like Kangkong, all morphological parameters of Indian spinach viz. length of twig, twig per plant, leaves per plant and stem girth were significantly different in combination with different trees (Table 1). Longest twig (50.7cm) was observed in association with Hijal trees which is statistically similar with the twig length (49.3cm) of Kangkong recorded along with Karanja trees. Statistically similar size twig observed along with Mahogoni, Lambu, Mango, Lemon, Jujube and Guava which was second highest. Third highest size twig was found in association with Akashmoni and control condition i.e. without trees. Shortest size twig recorded

along with Eucalyptus (37.6cm) and Papaya (37.8cm). Highest number of twig per plant was found control condition (8.5) which was statistically similar with Guava (7.7). Twigs plant^{-1} of Indian spinach in combination with Akashmoni, Mahogoni, Lambu, Mango, Lemon and Jujube were 5.5, 6.9, 7.4, 7.2, 5.1 and 5.3, respectively. Least number of twigs was harvested in association with Hijal (4.1) which was statistically similar with Eucalyptus (4.6), Papaya (4.7) and Karanja (4.5). Like twig plant^{-1}, similar trend of variation was recorded in case of leaves plant^{-1}, where highest (235.5) leaves plant^{-1} found in without tree condition and lowest along with Hijal (178.5, Table 1). Highest stem girth (3.7cm) of Kangkong was found in without tree condition and among the tree association this value was highest along with Mahogoni (3.6cm) which was gradually decreased as in association with Lambu (3.5cm), Mango (3.5cm), Guava (3.5cm), Akashmoni (3.3cm), Lemon (3.2cm), Jujube (3.2cm), Eucalyptus (2.8cm), Papaya (2.8cm), Karanja (2.1cm) and Hijal (2.1cm).

Amaranth: Morphological features like plant height, leaves plant^{-1}, stem girth and weight plant^{-1}, significantly influenced by different combination along with different trees (Table 1). Tallest plant (90.5 cm) was found in without tree association which was statistically similar with plant height produced along with Mahogoni (91.7cm), Lambu (90.6cm), Mango (92.1cm) and Guava (92.2cm). Statistically similar size plant produced in association with Akashmoni (87.4cm), Lemon (84.4cm), and Jujube (85.4cm). Plant height in association with Eucalyptus (81.8cm) and Papaya (82.3cm) was almost similar as third highest size. Shortest size plant was found in association with Karanja tree (72.3cm). Leaves plant^{-1}, varied as like the same pattern of plant height where highest leaves plant^{-1} obtained control condition (31.1) and lowest (19.8) in association with Karanja tree. Stem girth also varied in a same pattern of plant height where highest stem girth (9.2cm) recorded under control condition and lowest (5.6cm) in association with Karanja tree. Weight plant^{-1} was highest in control condition (185.5g) which was statistically similar with weight plant^{-1} produced along with Mahogoni (179.0g), Lambu (179.9g), Mango (178.8g) and Guava (178.5g). Statistically similar weight plant^{-1} of Amaranth was found combined with Akashmoni (152.5g), Lemon (152.0g), and Jujube (155.0.g) which was second highest value. Third highest weight plant^{-1}was found in association with eucalyptus (143.6g) and Papaya (141.0g). Relatively weakest plant (125.1g) was produced in combination with Eucalyptus trees (Table 1).

Okra: Morphological characters of Okra like plant height, leaves plant^{-1}, fruit length and fruit girth were significantly influenced by different trees. Tallest plant (90.5 cm) was found in association with Guava tree (114.8cm) which was statistically similar with plant height produced along with Mahogoni (114.4cm), Lambu (114.2cm), Mango (113.8cm) and in control condition (112.5cm). Statistically similar size plant produced in association with Akashmoni (103.4cm), Lemon (105.2cm), and Jujube (104.5cm). Plant height in association with Eucalyptus (92.5cm) and Papaya (93.6cm) was almost similar as third highest size. Shortest size plant was found in association with Karanja tree (83.6cm). Leaves plant^{-1}, fruit length and fruit girth also varied in association with different trees in a similar pattern like Plant height where highest value observed in control condition (68.4, 18.1cm and 7.1cm) and lowest in association with Karanja tree (36.3, 10.2cm and 3.9cm).

Table 2. Growth of different tree species in association with summer vegetables

	Tree species	Growth of trees with summer vegetables																			
		With Kangkong				With Indian spinach				With Amaranth				With Okra				Without vegetables			
		Height		Girth		Height		Girth		Height		Girth		Height		Girth		Height		Girth	
		Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Timber trees	1. Akashmoni	321.5	398.1	10.4	14.6	322.7	399.2	9.9	14.9	320.7	397.1	10.5	14.5	321.8	397.0	10.8	14.7	330.5	413.2	10.6	15.4
	2. Mahogoni	164.4	235.8	9.1	16.9	165.8	235.3	8.9	16.7	166.1	234.8	8.7	16.6	164.3	234.8	8.7	16.5	170.9	244.3	9.3	17.6
	3. Lambu	134.7	230.6	11.3	16.9	134.3	229.5	11.1	16.6	133.5	228.5	10.9	16.3	133.7	226.9	10.7	16.3	137.5	241.1	11.5	17.8
	4. Eucalyptus	319.8	412.6	13.3	17.5	316.9	409.3	12.8	17.2	318.2	411.3	13.2	17.4	316.9	407.9	12.7	16.9	331.5	430.8	13.7	18.5
Fruit trees	5. Mango	157.7	198.8	12.8	15.2	155.8	197.3	12.6	14.9	154.9	196.4	12.4	15.1	156.4	198.3	12.6	15.1	163.8	212.3	13.2	16.1
	6. Lemon	146.6	212.7	9.8	16.6	145.3	211.2	9.6	16.4	144.9	210.8	9.5	16.4	144.7	210.2	9.4	16.3	154.8	230.1	10.4	17.7
	7. Jujube	119.4	188.1	8.7	14.9	118.8	187.6	8.6	14.7	118.5	186.9	8.7	15.1	119.2	188.1	8.6	14.8	129.1	204.5	9.1	16.5
	8. Papaya	134.9	267.6	15.4	41.5	133.4	266.2	15.3	40.5	132.5	265.3	15.1	39.7	133.2	265.8	15.6	41.4	138.8	277.6	18.2	46.1
	9. Guava	140.4	177.9	11.2	15.1	139.5	177.2	11.1	14.9	138.3	176.5	10.9	15.0	137.9	176.2	11.0	14.8	147.7	193.3	11.4	16.0
soil conserving tress	10. Hijal	55.8	79.9	3.9	7.2	55.2	79.1	3.9	7.1	54.7	78.5	3.8	7.0	55.0	77.0	4.0	6.9	56.0	86.8	4.0	7.6
	11. Karanja	107.9	244.8	5.3	11.8	107.0	244.0	5.2	11.6	107.4	243.0	5.0	12.0	106.0	242.0	4.9	11.9	114.7	259.9	5.7	12.5

Growth of trees along with summer vegetables:

Growth of studied trees was measured before and after the summer season for height and girth measurement. It was found that growth of all trees almost similar in association different vegetables (Table 2). In control condition i.e. without vegetables tree growth was bit higher compare mixed combination with vegetables. Height increment in association with all summer vegetable was ranges from

23.5 to 136.4 cm with an average of 76.26 cm where as without vegetables combination it was ranges from 30.8 to 145.2 cm with an average of 83.52cm (Fig. 3). Height increment was highest in Karanja (145.cm) and lowest Hijal (30.8cm). It was estimated that on an average 8.7% higher 'height increment' was in without vegetable combination condition. In case of girth increment, in association with vegetables girth increment ranges from 3.2 to 25.4cm with an average of 6.95cm where as without vegetable combination it was ranges from 3.6 to 27.9 cm with an average of 7.7cm (Fig. 3). It was estimated that on an average 9.7% higher 'girth increment' was in without vegetable combination condition.

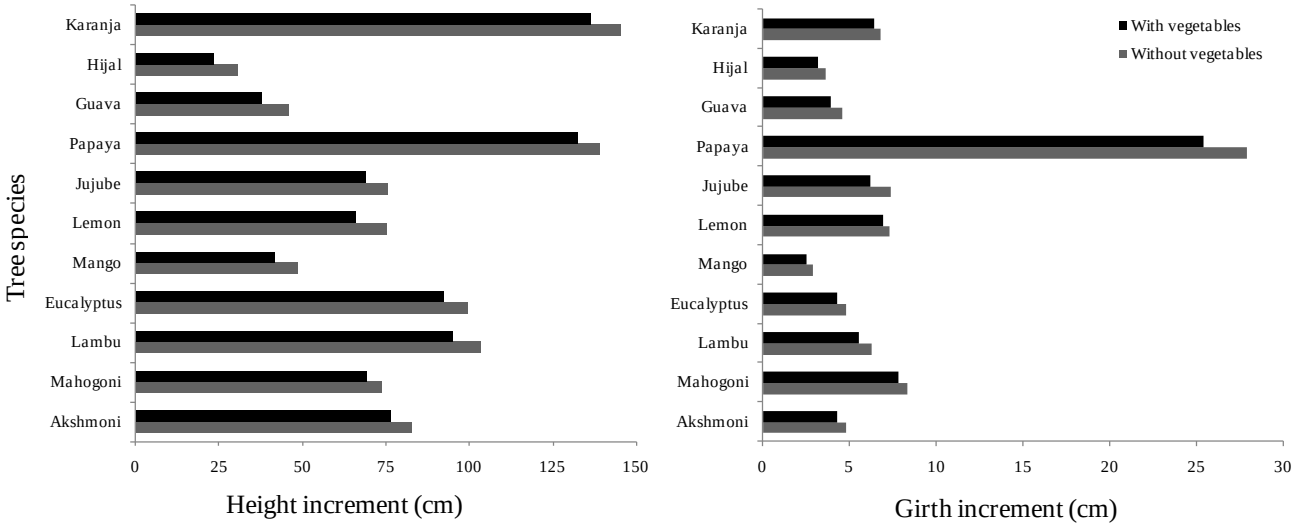

Fig. 3. Hieght and Girth increment during summer season

Yield of summer vegetables:

Fresh yield: Fresh yield of all four summer vegetables i.e. Kangkong, Indian spinach, Amaranth and Okra were significantly influenced by different tree combination (Table 3). Highest yield produced under without tree condition and fresh yield in without tree condition of Kangkong, Indian spinach, Amaranth and Okra was 50.2, 62.5, 18.0 and 32.5 tha^{-1}, respectively. This yield reduced along with different tree combination in different rate. Second highest yield produced in combination with Mahogoni, Lambu, Mango and Guava where 6-12% yield reduced compare to without tree combination. Third highest yield obtained from Akashmoni, Lemon and Jujube mixed combination with summer vegetables where 15-28% fresh yield decreased compare to control condition. Fourth highest yield recorded in combination with Eucalyptus and Papaya where 30-38% yield reduced compare to without tree combination. Incase of Kangkong and Indian spinach least fresh was obtained in association with Hijal and Karanja where 40-45% yield reduced compare to control combination.

Table 3. Yield of summer vegetables in association with different tree species

	Tree species	Yield (t ha^{-1})							
		Kangkong		Indian spinach		Amaranth		Okra	
		Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry
Timber trees	1. Akashmoni	42.1c	3.78cd	52.5c	3.15c	12.9c	1.39c	26.4c	1.80c
	2. Mahogoni	47.0b	4.14b	57.6b	3.46b	15.8b	1.57b	29.3b	2.02b
	3. Lambu	48.8b	4.29ab	58.7b	3.52b	16.0b	1.58b	29.4b	2.02b
	4. Eucalyptus	36.3d	3.57d	43.8d	2.87d	10.5d	1.30d	24.5d	1.66d
Fruit trees	5. Mango	46.5b	4.09b	56.7b	3.40b	16.0b	1.61b	28.5b	1.95b
	6. Lemon	41.5c	3.96c	53.5c	3.21c	13.3c	1.44c	26.2c	1.79c
	7. Jujube	42.0c	3.91c	53.6c	3.22c	12.8c	1.40c	25.7c	1.75c
	8. Papaya	36.2d	3.61d	44.6d	2.68d	10.5d	1.27d	23.5d	1.59d
	9. Guava	46.3b	4.07b	56.4b	3.38b	15.7b	1.62b	28.3b	2.03b
soil conserving tress	10. Hijal	35.1d	1.78e	32.5ef	1.95f	_	_	_	_
	11. Karanja	36.5d	1.92e	35.7e	2.14e	9.2e	0.75e	15.5e	1.01e
Without tree		50.2a	4.45a	62.5a	3.85a	18.0a	1.77a	32.5a	2.38a

Means in column followed by the different letter are significantly different by DMRT at $P \leq 0.05$

Dry yield: Like fresh yield, dry yield also influenced by different tree combination in a similar trend (Table 3). Highest dry yield obtained in control condition for Kangkong, Indian spinach, Amaranth and Okra were 4.45, 3.85, 1.77 and 2.38 tha^{-1}, respectively and in tree-vegetables association dry yield reduced as a same pattern like fresh yield (Table 3). Dry yield produced in control condition moisture reduced 88-90% where as in tree-vegetables mixed combination moisture reduced 92-94%.

Table 4. Yield of Papaya in association with summer vegetables

Vegetables	Yield (t/ha)
Kangkong	29.8b
Indian spinach	30.5b
Amaranth	30.2b
Okra	30.6b
Without vegetables	33.5a

Means in column followed by the different letter are significantly different by DMRT at $P \leq 0.05$

Yield of Papaya: Among the different tree species yield produced from only papaya (Table 4 and Fig. 4). Papaya yield was highest (33.5 tha^{-1}) in control condition i.e. without vegetable mixed combination. Statistically similar yield obtained from Papaya in mixed vegetables combination with all vegetables and average yield was 30.25 tha^{-1}, which is near 10% less compare to control condition (Table 4).

Fig. 4. Papaya along with summer vegetables

Discussion

Different morphological parameters of summer vegetables were influenced by different trees in different pattern. Plant height of Kangkong and Indian spinach was relatively taller where as leaves $plant^{-1}$, twig $plant^{-1}$, stem girth etc. was less in association with Hijal and Karanja tree. In this study, Hijal and Karanja trees were transplanted in the middle elevation of the char area where excess moisture as well as wet condition persists. As a result the plant of this area was relatively taller may be due to apical dominance of Kangkong and Indian spinach. Excess moisture and shade condition enhance apical dominance which results taller plants and less leaves $plant^{-1}$, twig $plant^{-1}$, stem girth (Hillman, 1994). Similar Phenomenon also found by Najafi *et al.* (1997) in soybean, Wadud *et al.* (2002) in Red amaranth and Tanni *et al.* (2010) in Tomato. Different morphological parameters of all tested summer vegetables was almost similar in association with Mahogoni, Lambu, Mango, Guava and open field condition. Crown and root expansion of two years old sapling of these trees was not so prominent (Dwivedi 1992) and at the same time horizontal expansion of lateral root of these species move downward (Krisnawati *et al.* 2011). For this reason, may be interaction effect was minimum in between tree-summer vegetables. Basak *et al.* (2009) also observed similar interaction effect in Radish, Tomato and Soybean along with two year old Lohakat tree sapling. Plant height, leaves $plant^{-1}$, twig $plant^{-1}$, stem girth, weight plant-1, fruit size of tested summer vegetables was lower in association with Akashmoni, Lemon and Jujube tree saplings compare to control condition. Akashmoni is a fast very growing (Lieurance, 2007) and high biomass producing (Gosh *et al.* 2011) tree species, Lemon and Jujube are also fast growing and bushy i.e. expanded crown (Shi *et al.* 2006) even in 2-3 years old plants. Morphological attributes of all studied summer vegetables was more deteriorate condition along with Eucalyptus and Papaya compare to Akashmoni, Lemon and Jujube mixed combination. Eucalyptus reduce growth of associated crops/vegetables as different way like superficial root network in surface area (Laclau *et al.* 1999), adverse effect on soil (Kinadu *et al.* 2005), creating water stress (Gindaba *et al.* 2004), nutrient depletion and exudates allelochemicals to the soil (EI-Amin *et al.* 2001; EI-Khawas and Shehata, 2005). Aiyelaagbe and Jolaoso (1992) reported that Papaya reduce growth of Okra, Sweetgourd and watermelon when cultivated as intercrops by its very fast growing habit and dense root network in soil surface area .

Growth means increase in size and the formation of new tissues. Growth governed by various factors e.g., site conditions, photosynthesis, light, water and nutrients. During each growing season, a tree grows by elongation of the top shoot, side branches, and roots and also by adding a new layer of wood and bark, all over. This increase is termed as increment. Increment may be the increase in girth, diameter, basal area, height, volume of trees over a given period of time. In this study, increment of trees as height and girth was measured for summer season. It was found that increment of each tree species was similar in association with all tested summer vegetables and it was 8-10% lower compare to control condition i.e. without vegetables combination. This growth may be reduced due to competition for moisture and nutrients between tree-vegetable root system in the soil surface horizon. Similar observation also reported by Islam *et al.* (2009) in *Hopea*

odorata and Kahtun *et al.* (2009) in *Swintonia floribunda* along with winter vegetables. Competition for moisture and nutrients in agroforestry systems is common occurring phenomenon, which can affect the system adversely for both trees and crops (Ong *et al.*, 1991; Rao *et al*, 1991).

Yield of all studied summer vegetables was higher in open field condition and in the tree-vegetable association, vegetables yield reduce in different rate along with different trees. Along with Mahogoni, Lambu, Mango and Guava summer vegetables produced highest yield which is 6-12% lower compare to open field condition, along with Akashmoni, Lemon and Jujube produced 15-28% lower, along with Eucalyptus and Papaya produced 30-38% lower and along with Hijal and Karanja produced 40-45% lower yield compare to open field condition. Papaya yield also reduced (≤10%) along with summer vegetables. Generally, in agroforestry system components yield reduce due to resource competition (Rao, *et al.* 1998; Puri and Bangarwa, 1992; Dhillon *et al.* 1998). In association with Hijal and Karanja highest (40-45%) vegetables yield reduced may be due to excess humid condition. As earlier discussed the growth of summer vegetables was lower in combination with different trees at different rate, this reason also responsible for lowering yield of these vegetables. There is another reason responsible for yield reduction is space occupied by tree sapling by its own volume (3-4% area). Average dry yield of all summer vegetables was 9.13% of fresh yield in open field condition and 8.79% when vegetables grown in association with trees i.e. 0.34% greater in open field condition. These results indicate fresh yield under tree i.e. partial shade condition content more water than open field condition. Wadud and Miah (2000, 2001) observed fresh yield under shade condition content more water compare to open field condition in Kangkong and Okra. They opined the possible cause of this higher water content was less transpiration under shade condition.

Considering the results and discussion of this study it is clear that summer vegetables cultivation in the charland areas of Bangladesh will be a profitable agroforestry practices in association with different fruit, timber as well as soil conserving tree species.

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