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PERFORMANCE OF BITTER GOURD IN ASSOCIATION WITH KARANJA (*Pongamia pinnata* L.) TREE

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ABSTRACT

The study was conducted at the Char Kalibari which is situated along the bank of Old Brahmaputra River under Sadar Upazila of Mymensingh district during November 2013 to March 2014 to observe the performance of bitter gourd (*Momordica charantia*) as arable crop with karanja *(Pongamia pinnata* L.) trees in an agroforestry system. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications having four treatments viz., T_0 (open field condition referred as control), T_1 (< 50 cm distance from the tree base), T_2 (50-100 cm distance from the tree base) and T_3 (>100 cm distance from the tree base). The result showed that all the growth parameters and yield of bitter gourd were significantly influenced by the associated tree component at different distances from the karanja tree base. The highest (1.92 tha^{-1}) fresh yield of bitter gourd was obtained in open field condition compare to any other treatments but no significant different was found from the treatment T_3 (distance >100 cm from the tree) while the lowest (0.8 tha^{-1}) in < 50 cm distance from the tree base. It was found that on an average 58.33%, 29.17% and 14.58% yield of bitter gourd were decreased in <50 cm, 50-100 cm and >100 cm distances from karanja tree base compare to open field condition. On the other hand, the growth performance of karanja trees i.e. both height and girth increment was better in sole tree condition compare to tree with bitter gourd condition. Therefore, it can be concluded that tree-crop combination i.e. >100 cm distance from the tree base would be possible although there was some yield loss (14.58%) which was less significant compare to alone bitter gourd. Through this combination we can get diversified product. So, we can follow this agroforestry system to improve char based farming system of Bangladesh during the early establishment period of trees.

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INTRODUCTION

Bangladesh is a densely populated and small country with an area of 147,570 km^2. According to the latest census, the population of the country is over 160 million with an average growing rate of 1.6% and the density of human population is 1033.5/km^2 (Wikipedia, 2015). If the current population growth rate (1.6%) continues, population will increase to 180 million by the year 2025, and the country will face enormous problem for nursing her population. The current forest land of Bangladesh is 2.52 million hectares which is 17.08% of total land area (BFD, 2013).The economy of the country draws its strength and stability mostly from agriculture. The fertility of our land is decreasing day by day due to intensive cropping and use of high input technologies. As a result, the country has been facing acute shortage of food, timber, fruit, vegetable, etc.

Agroforestry plays a vital role in supplying not only the daily necessities of people but also in maintaining ecological balance. In Bangladesh the scope of agroforestry is vast. The major venues of agroforestry are homestead, roadside, railway side, embankment side, char land, coastal area, deforested area, institutional premises, riverside, etc. Among them char land 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 in 1993 that the total area covered by chars in Bangladesh was 1.7 thousand sq km. 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 char land people, integrated approach with crops per vegetables and trees is necessary.

Bitter gourd (*Momordica charantia*) is important for its quick growing nature and high yielding potential. It is easily cultivated as a companion crop or inter crop. Bitter gourd is a well-known and a very popular vegetable grown successfully throughout Bangladesh. Even this vegetable can successfully grow in association with agroforestry system to get more diversified output from the same land. This vegetable is very low in calories, providing just 17 calories per 100g. Nevertheless, its fruits are rich in phytonutrients like dietary fiber, minerals and vitamins. Bitter gourd notably contains phyto-nutrient, polypeptide-P; a plant insulin known to lower blood sugar levels. In addition, it composes hypoglycemic agent called charantin. *Charantin* increases glucose uptake and glycogen synthesis in the cells of liver, muscle and adipose tissue. Recently reported that bitter gourd is more effective for treating HIV infection (USDA, 2013). Karanja (*Pongamia pinnata*), a tree species which can survive in the water logged condition and also can stabilize soil. However, the fertility of our land is decreasing rapidly due to intensive cropping and use of high input technologies. During winter season char land is a unique area for vegetables production where land is fertile due to siltation and irrigation requirement is less or easy. For this reason present study was undertaken to observe the performance of bitter gourd in association with karanja tree in the Char Kalibari in the bank of Old Brahmaputra River, Mymensingh.

MATERIALS AND METHODS

Experimental site and geographical position

The experiment was carried out at the experimental farm in the SPGR project field Char Kalibari, Mymensingh Sadar, under the control of Department of Agroforestry, Bangladesh Agricultural University, Mymensingh, during the period from November 2013 to March 2014. The district Mymensingh is located between 24°38′3″ north and 90°16′4″ east latitude. Total area of this district is 4394.57 km^2 and situated on the west bank of Brahmaputra River. The district has total 12 upazila and the study area i.e. Char Kalibari belong to the Mymensingh sadar upazila. The geographical position of Char Kalibari located between 24°45′ to 45′40″ north and north and 90°24′4″ to 90°24′44″ east latitude (Wikipedia, 2014 and Figure 1). Total area of this char land is about 2.57 km^2 where cultivated land is about 175 ha, 10 ha wetland, 40 ha fallow land, 23 ha household and rest forest area. Total population is 2350 of which 1238 male and 1112 female (Source: Six no. Char Ishwardia union parishad office records, 2014).

Characteristics of soil and climate

Char Kalibari is one of the char land area of Mymensingh district located at the Old Brahmaputra river side. The topography of the field is medium high land above flood level belonging to the Old Brahmaputra flood plain agro-ecological zone-9. It is characterized by non-calcareous dark grey flood plain soil having pH values from 6.5 to 6.8 (FAO, 1988). Most of the soil has silty to clay texture. The climate at the locality is sub-tropical in nature. It is characterized by high temperature and heavy rainfall during kharif season (April to September) and a scanty rainfall during rabi season (October to March). The overall relative humidity remains high almost all over the year except the winter.

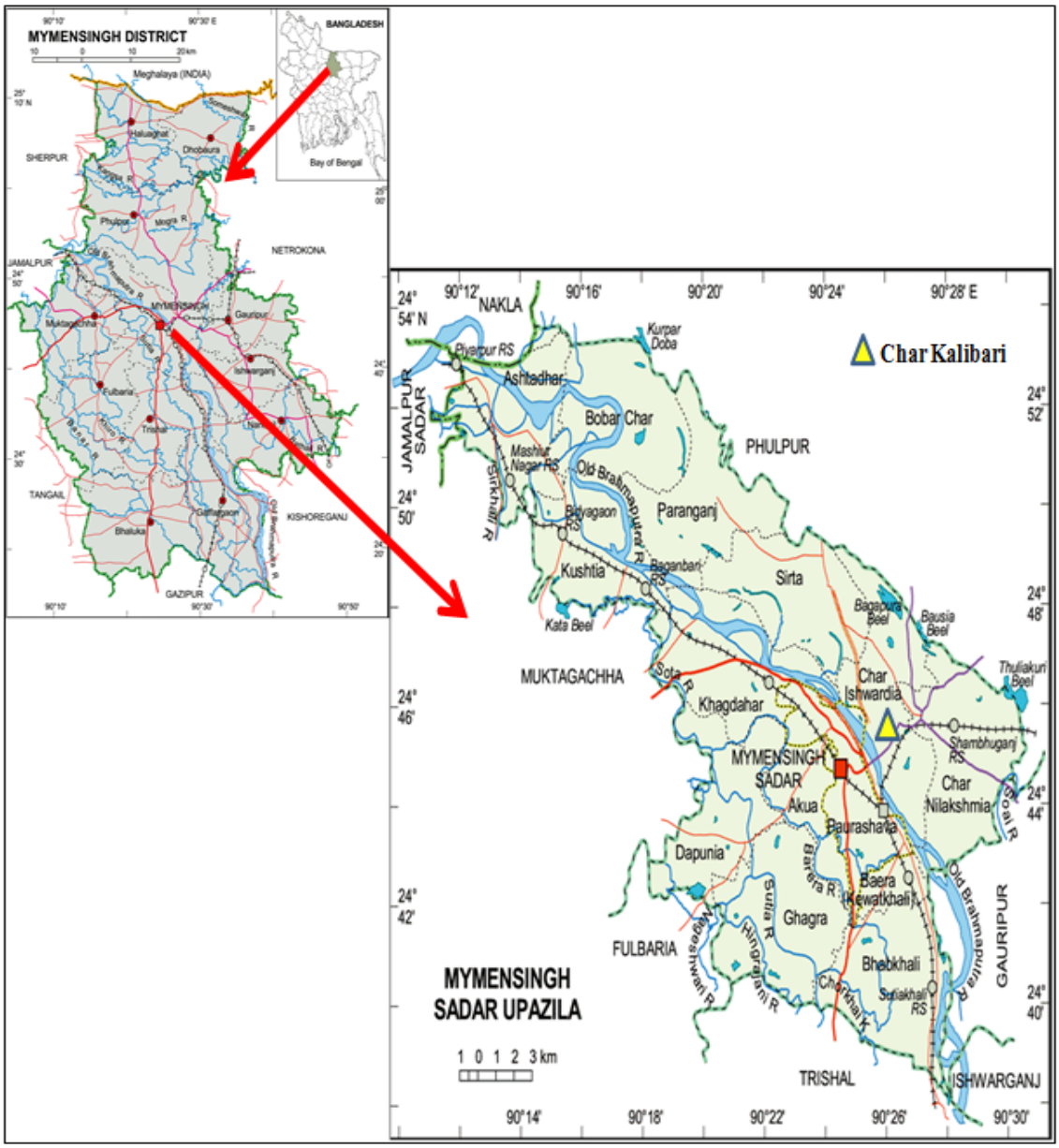

Figure 1. A map of Mymensingh district including Sadar upazila showing the location of the study area (Char Kalibari)

Tree and plant materials

In this study we considered three year's old previously established karanja (*Pongamia pinnata*) tree as test tree component and bitter gourd (*Momordica charantia*) as plant material.

Land preparation

The experimental land was first opened on Ist November 2013 and the operation was done by spade. At first the soils at the base of trees were loosening very well and made friable. Then the land was kept fallow for few days. All the crop residues and weeds were removed from the field and finally the land was properly leveled. Only recommended dose (5 tha^{-1}) of well decomposed cowdung was applied for the crop during final land preparation. No chemical fertilizer was applied.

Experimental design and treatment combination

The experimental design was laid out in a Randomized Complete Block Design (RCBD) with three replications. Four treatments considering the distance from tree to bitter gourd were viz. T_0= Open field referred as control, T_1= <50 cm distance from the tree, T_2= 50-100 cm distance from the tree and T_3= >100 cm distance from the tree.

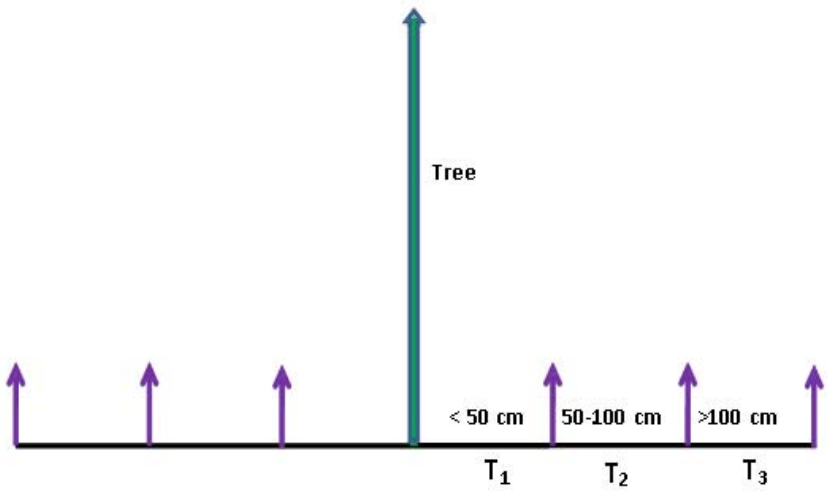

Figure 2. Layout of the experiment

Test crop establishment and management

Bitter gourd seeds were directly sown in the experimental plot on 5th November 2013. After seed sowing, necessary intercultural operations were done properly. To keep the plots free from weeds, weeding was done three times for experimental plots. The plots were irrigated by using water cane to supply sufficient soil moisture for the vegetable. Mulching was used to conserve water. Emergence of bitter gourd seedling was started after two weeks from the date of seed sowing. Bitter gourd seedlings were thinned out at three times. First thinning was done at 15 days after sowing while second and third thinning was done at 5 days interval from every thinning. No pesticide and fungicide were used in the experimental field for tree-vegetable association.

Sampling and data collection

Bitter gourd was harvested at 90 days after seed sowing. It was harvested at several picking. Five bitter gourd plants were randomly selected from each unit plot to record the morphological and yield contributing characters viz. vine length (cm), total leaves per plant, number of primary branches per plant, number of female and male flower per plant, number of fruits per plant, individual fruit weight (g), fresh and dry yield of fruits (tha^{-1}). All the above parameters were taken in three stages of bitter gourd growth like vegetative, flowering and harvesting stage except the fruit yield.

Data analysis

Data were statistically analyzed by using MSTAT-C and wasp2 (Web Agri Stat Package) software package to find out the statistical significance of the experimental results. The analysis of variance for each of the studied parameter was done by F (variance ratio) test. 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 AND DISCUSSION

Morphological characteristics and yield performance of bitter gourd (*Momordica charantia*)

Vine length (cm)

From the Table 1, it was found that the highest vine length of bitter gourd was 45.33 cm, 70.00 cm and 96.00 cm produced by T_0 (open field without treatment) and the lowest was 36.33 cm, 56.66 cm and 69.33 cm in treatment T_1 at 40, 90 and 120 days after sowing, respectively. Among the distance treatments T_3 (>100 cm distance from the tree base) produced the highest (43.00 cm, 64.00 cm and 88.66 cm) vine length at all growth stages of bitter gourd plant. Masfikha (2013) and Rahman (2013) studies on bitter gourd cultivation in association with fruit trees and three selected tree species during winter season and found the similar findings in case of vine length which were supportive to the present study. Alam et al. (2012), Mallick et al. (2013), Rahman et al. (2013), Bali et al. (2013) and Ahmed et al. (2013) also performed the various experiment on different trees and crops under agroforestry system to evaluate their growth performance and observed that the more or less similar findings which were supported by the present study.

Number of primary branches per plant

The maximum average number of primary branches per plant was 3.33, 5.33 and 6.66 in vegetative, flowering and harvesting stage, respectively which was produced by open field referred as control or without associated tree while treatment T_3 (>100 cm distance from the tree base) produces highest number of primary branches (2.33, 3.66 and 5.33 per plant in all three stages, respectively) among the distance treatment. The minimum average number of branches per plant was obtained from the treatment T_1 (<50 cm distance from the tree base) in all growth stage which was 1.33, 2.33 and 2.33, respectively (Table 1). This result indicated that the open field or control condition noticed the maximum branch number per plant than other distance treatment with associated tree. Similar observation also obtained by Islam et al. (2008) who evaluated that the performance of winter vegetables under guava-coconut based multistrata agroforestry system. Rahman et al. (2013) conducted an experiment to see the performance of sweet gourd grown in association with akashmoni saplings and found that the similar type of results which was supported to the present findings.

Number of leaves per primary branch

Different treatments showed significant effect on number of leaves per primary branch of bitter gourd in all examined stage. Table 1 revealed that the maximum number of leaves per primary branch of bitter gourd in vegetative, flowering and harvesting stage (25.66, 58 and 34.33, respectively) was produced by T_0 treatment (open field or without treatment) while second maximum number of leaves per plant (20, 51 and 32.66) was produced under T_3 treatment (>100 cm distance from the tree base) in all three stage which was also highest among the distance treatments. In contrast, the minimum number of leaves per primary branch was 15.33, 34 and 22.66 in vegetative, flowering and harvesting stage, respectively at T_1 treatment (<50 cm distance from the tree base). Rakib (2013) and Uddin (2013) were conducted studies on radish and carrot in association with akashmoni and fruit trees during winter season and observed the similar findings which were strongly supported by the above findings. Masfikha (2013) and Rahman (2013) found the similar findings in their studies which were supportive to the present study.

Table 1. Morphological characteristics of bitter gourd during vegetative, flowering and harvesting stages in association with karanja tree

Treatments	Vine length (cm)			No. of primary branches/plant			Leaves/primary branch			Female flower/plant	Male flower/plant	No. of fruits/plant	Fresh weight of single fruit
	Vegetative stage	Flowering stage	Harvesting stage	Vegetative stage	Flowering stage	Harvesting stage	Vegetative stage	Flowering stage	Harvesting stage				
T_0	45.33 a	70.00 a	96.00 a	3.33 a	5.33 a	5.66 a	25.66 a	58.00 a	34.33 a	20.66 a	96.00 a	23.00 a	33.50 a
T_1	36.33 b	56.66 d	69.33 d	1.33 c	2.33 c	2.33 b	15.33 c	34.00 d	22.66 c	13.00 c	78.66 d	14.00 d	22.82 c
T_2	41.33 ab	60.66 bc	76.66 c	1.67 bc	2.66 c	4.66 a	18.33 b	44.66 c	30.00 b	17.00 b	83.66 c	18.33 c	29.68 b
T_3	43.00 a	64.00 b	88.66 b	2.33 b	3.66 b	5.33 a	20.00 b	51.00 b	32.66 a	18.66 ab	90.66 b	20.33 b	32.43 a
Level of sig.	*	**	**	**	**	**	*	**	**	**	**	**	**

Note: T_0= Control condition, T_1= <50 cm distance from tree base, T_2= 50-100 cm distance from tree base, T_3= >100 cm distance from tree base; sig.=significance; in a column figures having the same letter (s) do not differ significantly; * & ** Significant at 5% and 1% level of probability.

Number of female flowers per plant

Number of female flowers per plant is the most important yield contributing character which was significantly influenced by different distance of growing bitter gourd under karanja tree. The highest number of female flowers per plant (20.66) was found in T_0 (open field referred as control) while treatment T_3 (>100 cm distance from the tree base) produces the second maximum (18.66) which was statistically similar with control treatment. The treatment T_2 (50-100 cm distance from the tree base) recorded the third maximum number of female flowers per plant (17) which was also statistically similar to the treatment T_3. The lowest number of female flowers per plant (13) was found under close contact of the tree i.e. T_1 treatment and it was probably due to poor photosynthetic capacity and resource pool competition between trees and bitter gourd (Table 1). Masfikha (2013) and Rahman (2013) were conducted studies on bitter gourd cultivation in association with fruit trees and three selected tree species during winter season and obtained the similar findings which were highly supportive to the present study results. Similar observation was obtained by Rahman (2013) who reported that except plant height all others morphological characters of three vegetables (tomato, brinjal and chilli) were performed better in open field condition rather than distance treatments from the akashmoni tree base.

Number of male flowers per plant

Number of male flowers per plant is another important yield contributing character which was significantly influenced by different distance of growing bitter gourd from the test sample karanja tree. The highest number of male flowers per plant (96) was produced in open field referred as control treatment and the lowest number of female flowers per plant (78.66) was in T_1 treatment. On the other hand, among the distance treatments, T_3 (>100 cm distance from the tree base) produces the highest number of male flowers per plant (90.66) (Table 1). Rahman (2013) obtained the similar findings in case of tomato, brinjal and chilli grown in association with akashmoni tree under agroforestry system which was supported to the present study result. Masfikha (2013) and Rahman (2013) were mentioned the similar findings in their studies on bitter gourd cultivation in association with fruit trees and three selected tree species during winter season which were helpful to the present study.

Number of fruits per plant

Number of fruits per plant was significantly influenced by different distance of growing bitter gourd under karanja tree. The highest number of fruits per plant (23.00) was produced in T_0 treatment while treatment T_3 (>100 cm distance from the tree base) produces the second highest number of fruits per plant (20.33). The lowest number of fruits per plant (14.00) was produced under close contact of the tree base i.e. treatment T_1. It was probably due to poor photosynthetic capacity and resource pool competition between tree and bitter gourd (Table 1). Similar results also obtained by Basak et al. (2009) who reported that the yield contributing characters of three vegetables increased gradually with the increase of planting distance from the Lohakat (Xylia *dolabriformis*) tree base. Alam et al. (2012), Mallick et al. (2013), Rahman et al. (2013), Bali et al. (2013) and Ahmed et al. (2013) also conducted the various experiment on different tree and crop grown under agroforestry systems and reported those findings which were supported by the present study.

Fresh weight of single fruit (g)

Fresh weight of single fruit of bitter gourd was also significantly influenced by different distance from the karanja tree base. The highest fresh weight of single fruit (33.50 g) was recorded in T_0 (open field referred as control) while statistically similar fresh weight of single fruit (32.43 g) was produced at >100 cm distance from the sample tree base. The lowest fresh weight of single fruit (22.82 g) was found in <50 cm distance from the tree base (Table 1). Similar findings obtained by Masfikha (2013) and Rahman (2013) in their studies which were highly supportive to the present study. Alam et al. (2012), Mallick et al. (2013) and Rahman (2013) also obtained the helpful findings on different tree and crop association under agroforestry systems which were supported by the present study.

Yield of bitter gourd (*Momordica charantia*)

Fresh yield of bitter gourd (tha^{-1})

The fresh yield of bitter gourd (tha^{-1}) was affected significantly due to effect of different treatments (Figure 3). As evident from the observation of figure 3, the highest fresh (1.92 t/ha) yield of bitter gourd was obtained from the treatment T_0 referred as control or without tree association. While the lowest fresh (0.80 tha^{-1}) yield was obtained from the closest distance treatment T_1 (<50 cm distance from the tree base). Among the distance treatments, >100 cm distance from the tree base produced the highest fresh yield (1.64 tha^{-1}) which was statistically similar to that of the control treatment. It is stated that literally there is some yield loss but statistically there was no significant yield loss in compare to control treatment. Masfikha (2013) and Rahman (2013) found the similar findings in case of fresh yield of bitter gourd in their studies which were supportive to the present study. Basak et al. (2009) mentioned that the yield contributing characters of radish, tomato and soybean were increased gradually with the increase of planting distance from the Lohakat (*Xylia dolabriformis*) tree base which was strongly supported to the present result. Sayed et al. (2009) also found the similar results in their study on interaction effects of vegetables in association with two years old Telsur (*Hopea odorata*) sapling. Alam et al. (2012), Mallick et al. (2013), Rahman et al. (2013), Bali et al. (2013), Rakib (2013), Uddin (2013) and Ahmed et al. (2013) also observed that the more or less similar findings in their studies which were highly supported by the present study results.

Dry yield of bitter gourd (tha^{-1})

From figure 4, the highest dry (0.15 tha^{-1}) yield of bitter gourd were obtained from the treatment T_0 referred as control or without tree association while the lowest dry (0.06 tha^{-1}) yield was obtained from the closest distance treatment T_1 (<50 cm distance from the tree base). Among the distance treatments, >100 cm distance from the tree base produced the highest dry yield (0.13 tha^{-1}) which was statistically similar to that of the control treatment. Masfikha (2013) and Rahman (2013) found the similar findings in case of dry yield of bitter gourd in their studies on bitter gourd cultivation in association with fruit trees and three selected tree species during winter season which were supportive to the present study. Sayed et al. (2009) also obtained the similar results in their study on interaction effects of vegetables in association with two years old Telsur (*Hopea odorata*) sapling. Alam et al. (2012), Mallick et al. (2013), Rahman et al. (2013), Bali et al. (2013), Rakib (2013), Uddin (2013) and Ahmed et al. (2013) also observed the interesting results in their studies which were highly supported by the present study result.

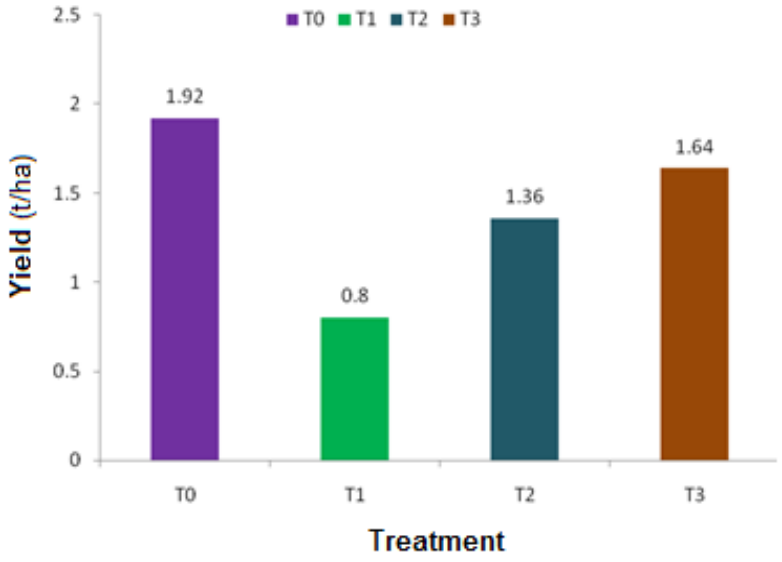

Figure 3. Bar graph showing fresh yield of bitter gourd along with karanja (*Pongamia pinnata*) tree in agroforestry production system.

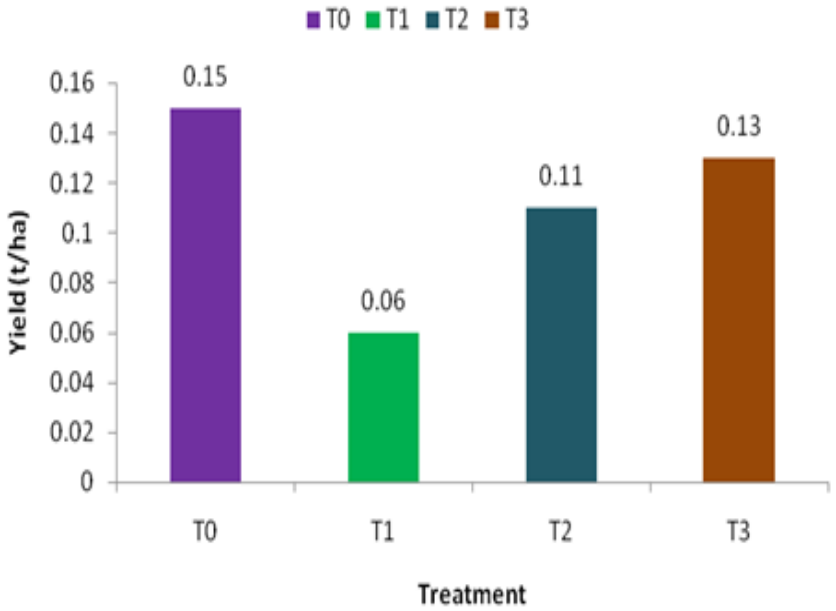

Figure 4. Bar graph showing dry yield (oven dry) of bitter gourd along with karanja (*Pongamia pinnata*) tree in agroforestry production system.

Performance of karanja *(Pongamia pinnata)* tree with and without bitter gourd condition

Tree height (cm)

The height of karanja tree was significantly influenced by the interaction of bitter gourd as arable crops. The highest (45.00 cm) average height increment of sixteen (16) trees was recorded in tree without bitter gourd condition while the lowest (31.00 cm) average tree height increment was found under the tree with bitter gourd condition (Table 2). It might be due to the competition of tree and crop for nutrient, water and light in agroforestry system. The highest tree height was recorded under tree without crop situation in compare to tree with crop association that reported by Sayed et al. (2009), Basak et al. (2009), Islam et al. (2009), Alam et al. (2012), Masfikha (2013), Mallick et al. (2013), Rahman et al. (2013), Bali et al. (2013), Rakib (2013), Uddin (2013) and Ahmed et al. in their studies.

Table 2. Growth performance of karanja tree in association with and without bitter gourd

Condition	Average Height (cm)			Average Girth (cm)		
	Before	After	Increment	Before	After	Increment
Tree with bitter gourd	321.00	352.00	31.00	20.78	23.29	2.51
Tree without bitter gourd	325.20	370.20	45.00	22.10	27.25	5.15

Girth (cm)

The girth of karanja tree was also significantly influenced by the growth of bitter gourd as arable crops. The highest (5.15 cm) average girth increment of sixteen (16) trees was recorded from tree without bitter gourd condition or control condition. On the other hand, the lowest (2.51 cm) average girth increment of sixteen (16) trees was found in tree with bitter gourd condition (Table 2). Similar results also found by Sayed et al. (2009), Islam et al. (2009), Alam et al. (2012), Masfikha (2013), Mallick et al. (2013), Rahman et al. (2013), Bali et al. (2013), Rakib (2013), Uddin (2013) and Ahmed et al. in their studies where they reported that the highest tree girth was recorded under tree without crop condition in compare to tree-crop combination.

CONCLUSION

From the experiment it is observed that growth and yield of bitter gourd gradually decreased with decreasing distance towards the tree base. Growths of any vegetables are directly related with moisture availability in soil but in agroforestry system where a competition occurred between tree and crop for moisture beneath the tree canopy. For this reason, may be growth and yield of bitter gourd remarkably reduced beneath the tree canopy or near the tree base. However, the agroforestry practice is profitable for farmer because from the same land they can produce crop/vegetable and tree/fruit at the same time while other practices like monocropping produces only one product from the same land. Therefore, it can be concluded that agroforestry practices like bitter gourd with karanja tree is better than other practices like agriculture or monocropping system in char based farming system of Bangladesh.

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