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Fruit tree based agroforestry practices in char land farming 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 September, 2013 to February 2014 to examine the performance of sweet gourd as winter vegetable in association with different fruit trees for 'Char' based farming system. Three years old Mango (*Mangifera indica*), Guava (*Psidium guajava*), Jujube (*Zizyphus* spp.) and Lemon (*Citrus spp.*) were used in this experiment. All of these fruit trees were in fruit bearing stage. Sweet gourd was cultivated along with these tree species following Randomized Complete Block Design (RCBD) with 4 (four) replications. Performance of both sweet gourd and fruit trees were observed comparing with a control condition i.e. without fruit trees or without sweet gourd association. Overall performance of this agroforestry system was evaluated considering Land Equivalent Ratio (LER). Yield and yield attributes of both sweet gourd and different fruit tree species were observed in this study. It was found that different morphological parameters of sweet gourd in association with these fruit trees were 15-20% lower compare to open field condition. Highest yield of sweet gourd (25.5 tha^{-1}) was recorded when cultivated as sole crop but in association with different fruit trees yield of sweet gourd was reduced upto 50%. Yield reduction of sweet gourd was much higher in association with lemon and jujube trees where 47.8 and 49.8% yield was reduced compare to its sole condition whereas yield reduction with mango (35.35) and guava (37.6%) was a bit lower compare to sole cultivation of sweet gourd. Like sweet gourd, yield and yield attributes of fruit tree species was little bit better in sole condition. Around 10% yield of these fruit species was reduced along with sweet gourd. Yield of mango, guava, jujube and lemon in association with sweet gourd were 8.5, 2.75, 10.5 and 7.5 tha^{-1}; while these were 9.5, 3.0, 11.5 and 8.3 tha^{-1} in control condition. In this study it was found that LER for sweet gourd and different fruit trees (mango, guava jujube and lemon) was more than one in all cases which indicate combined production of sweet gourd with mango, guava, jujube and lemon is profitable.
Key words: Sweet gourd, agroforestry practices, fruit tree species, char land, farming system.

Introduction

In Bangladesh, it is not surprising that, for above 15 crores people, the total land area is about 14.845 million hacters and the forest land is about 2.999 million hectare (BBS, 2011) and the main point is that, this forest land cannot fulfill the demand of people for food, fuel, fodder, timber etc. Moreover, about 10% of the homestead trees are being removed annually without any replacement (Abedin and Quddus, 1991). Due to continuous transformation of forest land to agriculture, 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. Thus, it is necessary to find out an alternative which will be suitable to overcome this situation. For this context, intercropping can be the best source of getting maximum benefits. Agroforestry is such type of intercropping system which allows for the diversification of farm activities and makes better use of environmental resources. It involves elements of agriculture and forestry wherein woody perennials are deliberately mixed or retained with crop or animal production units (Nair, 1990). Since long term agroforestry practices have been practiced traditionally in Bangladesh, but its systematic management practices are not always done properly. As a farming system, agroforestry need to mantain proper systematic and scientific management scheme considering the available natural resource base, including water, land, grazing areas and forest.

In Bangladesh, prospect of Agroforestry is vast. The major venues for agroforestry practicing 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 and unique area for practicing agroforestry as farming 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). 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 char land people, integrated approach with crops/vegetables and trees is necessary.

Different types of fruit tree species are commonly found in Bangladesh of which mango, guava, jujube and lemon are very common. Mango is rich as a source of Vitamins (Specially vitamins A and C) minerals and total soluble solids. It is also a medium source of carbohydrates (16.9%) (Salunkhe and Desai, 1984). Guava is excellent for processed materials viz. jam, jelly, cheese, ketchup, puree, juice, powder, nectar etc. Jujube can be eaten fresh and various kinds of recipe. The jujube fruits contain 20-28 per cent sugar, 0.3 to 2.5 percent acid, 2.9 percent protein, 500-600 mg vitamin C per 100g pulp and a very high quantity of vitamin B Complex (Kuliev and Guseinnova, 1974). Lemon, rich in vitamin C and other minerals like calcium and phosphorus. The rind of lemon fruits is rich in pectin and certain essential oils. The rind also contains certain glucosides (hesperidin). Sweet gourd is also very nutritive and its 100g contain energy (188 KJ), carbohydrates (11.69 g), sugars (2.20 g), dietary fibre (2.0 g), fat (0.10 g), protein (1.0 g), vitamin A equiv. (532 µg), beta-carotene (4226 µg), thiamine (0.10 mg), riboflavin (0.02 mg), niacin (1.20 mg), vitamin B6 (0.154 mg), vitamin C (12%) and calcium (48 mg) (Gopalan *et al.*, 1996).

Bangladesh has a long heritage of growing fruit trees along with different herbaceous crops/vegetables in the homestead area (Rahman *et al.*, 2009). It will be very beneficial if this type of production system can execute in the char areas of this country. For identifying a sustainable

farming system for the char land areas of Bangladesh present study investigate the performance of sweet gourd in association with different fruit tree species viz. mango, guava, jujube and lemon 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 during the period from September, 2013 to March, 2014. 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).

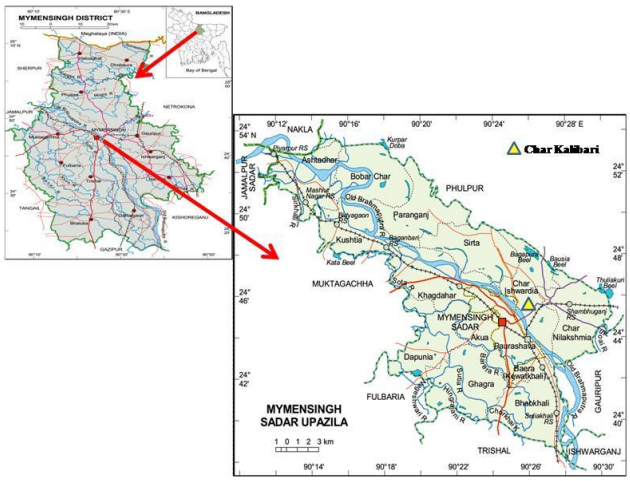

Fig. 1. Location of the study area.

Soil and climate of study area: 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 char 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.

Planting materials: Four different fruit tree species viz. Mango (*Mangifera indica*), Guava (*Psidium guajava*), Jujube (*Zizyphus* spp.) and Lemon (*Citrus spp.*) were planted in the experimental site during March 2011. During this study period all of these fruit trees were three years old and in fruit bearing stage. Sweet gourd was cultivated along with these tree species (Fig. 2) during September, 2013 to March, 2014.

Experimental design and layout: Sweet gourd was cultivated in association with mango, guava, jujube and lemon trees following the Randomized Complete Block Design (RCBD) with 4 (four) replications. Each tree species treated as separate treatment. Yield and yield attributes of both trees species and sweet gourd was compared with separate control condition i.e. without trees and sweet gourd condition. Each fruit species was transplanted in 4 (four) blocks and each block treated as a replication which contain 10 trees and planting spacing was 10 ft. × 10 ft. Number of each tree species in all blocks were 4 × 10 = 40.

Fig. 2. Sweet gourd cultivation along with (A) Mango, (B) Guava, (C) Jujube and (D) Lemon tree.

Land preparation and seed owing (sweet gourd): Land was prepared by ploughing during September 2013 and sweet gourd seeds were sown in the month of October 2014.

Tree and crop management: 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. After germination of sweet gourd seeds necessary intercultural operation like thinning, irrigation, pollination and pest management were also done when required.

Harvesting, Sampling and Data collection: Sweet gourd was harvested when fruit was attained edible size. Morphological characteristics of sweet gourd, viz., vine length, number of primary branches per plant, number of leaves per primary branch, number of fruit per plant and individual fruit weight were recorded from each plant. In case of fruit tree species morphological parameters viz. no. of primary branches per plant, average no. of fruit per primary branch, no. of fruit per plant, fruit size (length × breadth) and individual fruit weight were measured randomly from 5 trees of each replication. Fruit of all species were harvested at mature stage. Finally, yield of sweet gourd and all fruit species was converted as ton per hectare. Land Equivalent Ratio (LER) was also recorded from sole and intercrops yield of fruit trees and sweet gourd as LER = C*i*/C*s* + T*i*/T*s;* Where, C*i* = crop yield under intercropping, C*s* = crop yield under sole cropping, T*i* = tree yield under intercropping, and T*s* = tree yield under sole cropping.

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 sweet gourd: Morphological characteristics of sweet gourd, viz., vine length, number of primary branches per plant, number of leaves per primary branch, number of fruit per plant and individual fruit weight were significantly influenced by different fruit tree species, viz., mango, guava, jujube, lemon, etc. (Table 1). Relatively taller plants (295.5 cm) of sweet gourd were found in the mono/sole cropping system. Statistically similar size sweet gourd plant was found in association with mango (275.5 cm) and guava (270.1 cm) which was 10-15% lower compare to sole cropping system. Similar size plants of sweet gourd were found in association with jujube (245.5 cm) and lemon (230.0 cm) trees which were 15-20% shorter compare to its sole cropping system (Table 1). Number of primary branches per plant (9.5), number of leaves per primary branch 16.5), number of fruit per plant (11.5) and individual fruit weight (1750.0g) of sweet gourd was highest in its sole cropping system (Table 1). In agroforestry system performance of these parameters was relatively lower compare to its sole stands where almost similar effect was found along with mango (8.1, 14.5, 9.5 and 1410.5g) and guava (7.9, 13.8, 9.1 and 1405.0g) trees where only 10-15% lower performance was recorded whereas in association with jujube (6.5, 11.0, 6.2 and 1180.8g) and lemon (5.8, 14.5, 9.5 and 1410.5g) trees growth of the above parameters of sweet gourd was further lower (15-25%) compare to its sole stands (Table 1).

Table 1. Morphological characteristics of sweet gourd in association with different fruit trees during winter season

Tree species	Morphological Characteristics of sweet gourd				
	Vine length (cm)	No. of primary branches/plant	No. of leaves /branch	No. of fruit /plant	Weight /fruit (g)
1. Mango	275.5b	8.1b	14.5b	9.5b	1410.5b
2. Guava	270.1b	7.9b	13.8b	9.1b	1405.0b
3. Jujube	245.5c	6.5bc	11.4c	6.5c	1230.0bc
4. Lemon	230.0c	5.8cd	11.0c	6.2c	1180.8c
5. Without tree	295.5a	9.5a	16.5a	11.5a	1750.0a

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

Yield of sweet gourd: Like morphological parameters, yield of sweet gourd also significantly influenced by different fruit tree species (Fig. 3). Highest yield of sweet gourd (25.5 tha^{-1}) was recorded when cultivated as sole cropping system but in association with different fruit trees yield of sweet gourd was reduced up to 50% . Yield of sweet gourd in association with mango. guava, jujube and lemon were 16.5, 15.9, 13.3 and 12.8 tha^{-1}, respectively (Fig. 3).

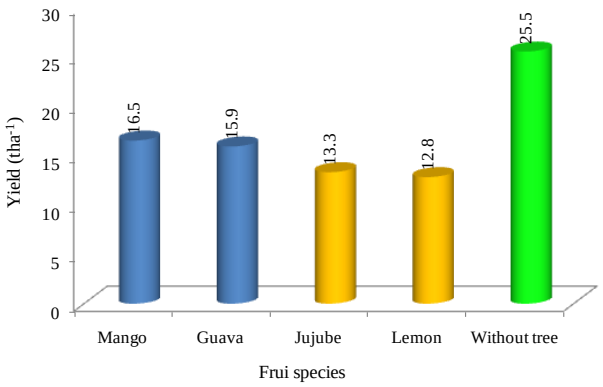

Fig. 3. Yield of sweet gourd in association with mango, guava, jujube and lemon trees.

Yield reduction of sweet gourd was much higher in association with lemon and jujube trees where 47.8 and 49.8% yield was reduced compare to its sole condition where as yield reduction with mango (35.35) and guava (37.6%) was bit higher compare to sole cultivation of sweet gourd.

Morphological characteristics of fruit tree species: Morphological characters of fruit tree species i.e. mango, guava, jujube and lemon were also influenced by sweet gourd (Table 2). Different morphological parameters viz. no. of primary branches per plant, average no. of fruit per primary branch, no. of fruit per plant, average fruit length, average fruit diameter and individual fruit weight of all fruit tree species was similarly influenced by sweet gourd plants with compare to their sole stands (Table 2). It was found that no. of primary branches per plant of all fruit tree species almost similar in combined and sole condition (Table 2). Others parameters i.e. yield attributes of all fruit tree species (average no. of fruit per primary branch, no. of fruit per plant, average fruit length, average fruit diameter and individual fruit weight) significantly reduced in combination with sweet gourd plants where reduction value of these parameters were 15-25, 13-24, 5-11, 8-10 and 4-11%, respectively. Average number of fruit per plant of mango, guava and lemon with sweet gourd were 57.8, 62.5 and 295.8, respectively. Average number of fruit per plant of mango, guava and lemon without sweet gourd were 7.0, 77.5 and 341.1, respectively (Table 2).

Average individual fruit weight of mango, guava, jujube and lemon with sweet gourd were 127.5, 235.5, 18.5 and 140.5 g, respectively. Average individual fruit weight of mango, guava, jujube and lemon without sweet goured were 141.7, 250.5, 19.2 and 148.5 g, respectively (Table 2).

Table 2. Morphological parameters of Fruit species with and without sweetgourd combination

Tree species		No. of primary branches plant $^{-1}$	Av. no. of fruit primary banch $^{-1}$	No. of fruit plant $^{-1}$	Av. fruit length (cm)	Av. fruit diameter (cm)	Av. fruit weight (g)
Mango	With sweet gourd	3.5	16.5	57.8	9.3	15.5	127.5
	Without sweet gourd	3.5	22.0	77.0	10.3	17.4	141.7
Guava	With sweet gourd	5.0	12.5	62.5	11.5	18.3	235.5
	Without sweet gourd	5.1	15.2	77.5	12.2	19.2	250.5
Jujube	With sweet gourd	..	..	..	3.5	4.2	18.5
	Without sweet gourd	..	..	..	3.8	4.4	19.2
Lemon	With sweet gourd	6.5	45.5	295.8	10.5	15.5	140.5
	Without sweet gourd	6.5	52.5	341.3	11.1	16.4	148.5

Yield of fruit tree species: In this study, yield of mango, guava, jujube and lemon were recorded, from all trees (Fig. 4). Unlike sweet gourd yield, yield of mango, guava, jujube and lemon was also partially influenced in association with sweet gourd (Fig. 5) where only around 10% yield of these fruit species was reduced along with sweet gourd. Yield of mango, guava, jujube and lemon in association with sweet gourd and without sweet gourd condition were 8.5, 2.75, 10.5 and 7.5 tha^{-1} and 9.5, 3.0, 11.5 and 8.3 tha^{-1}(Fig. 5).

Fig. 4. Fruits of (A) Mango, (B) Guava, (C) Jujube and (D) Lemon along with sweet gourd in the research field.

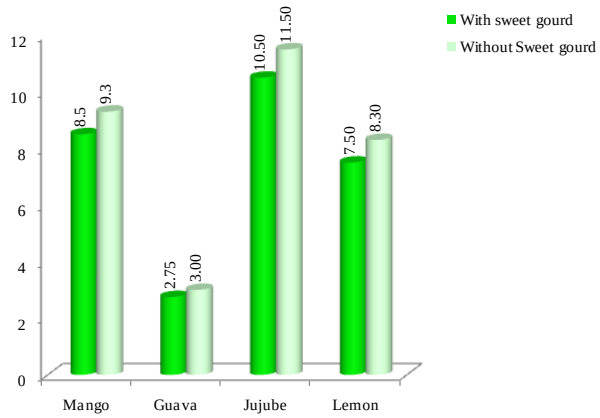

Fig. 5. Yield of different fruits with and without sweet gourd condition.

Land Equivalent Ratio (LER): LER is the sum of relative yields of the components species. Relative yield is the ratio of a component yield as intercrops and its sole stands in any agroforestry system. In this study yield of sweet gourd, mango, guava, jujube and lemon was separately measured for sole and combined stands. Yield of sweet gourd, mango, guava, jujube and lemon as sole stands were 25.5, 9.5, 3.0, 11.5 and 8.3 tha^{-1}, respectively (Fig. 3 and Fig. 5). Yield of sweet gourd along with mango, guava, jujube and lemon were 16.5, 15.9, 13.3 and 12.8 tha^{-1}, respectively (Fig. 3). Yield of mango, guava, jujube and lemon in association with sweet gourd were 8.5, 2.75, 10.5 and 7.5 tha^{-1}, respectively (Fig. 5). Using the above yield values LER were determined for mango - sweet gourd, guava - sweet gourd, jujube - sweet gourd and lemon - sweet gourd and the LER values for these combination were 1.57, 1.55, 1.45 and 1.42, respectively (Table 3).

Table 3. LER value of fruit tree species in association with sweet gourd

Tree-Vegetable combination	Land Equivalent Ratio (LER)
Mango-sweet gourd	1.57
Lemon-sweet gourd	1.42
Guava-sweet gourd	1.55
Jujube-sweet gourd	1.45

Discussion

In combination with mango, guava, jujube and lemon trees performance of different morphological parameters of sweet gourd viz., vine length, number of primary branches per plant, number of leaves per primary branch, number of fruit per plant and individual fruit weight was relatively l lower compare its sole stands. The reasons of lower performance of sweet gourd in association with the above fruit trees may be due to competition for light, water and nutrients between shoot and root system of sweet gourd and fruit trees. Similar Phenomenon was also found by Najafi *et al.* (1997) in soybean, Wadud *et al.* (2002) in Red amaranth, Alam *et al.* (2012) in different summer vegetables, Mallick *et al.* (2013) in strawberry during combined production with different tree species. The lower performance of morphological parameters of sweet gourd was exactly same with mango, guava, jujube and lemon trees. It was found that along with mango and guava trees only 10-15% lower performance was recorded

where as in association with jujube and lemon trees it was more lower (15-25%) compare to its sole stands. This indicate competition for different growth resources was more prominent in association with jujube and lemon and it might be due more crown and root expansion of jujube and lemon tree compare to mango and guava. Alam *et al.* (2012) also noted similar lower growth of different summer vegetables along with lemon trees. Like morphological characteristics, yield of sweet gourd also lower in combined condition with fruit trees and yield reduction was also more in association with jujube and lemon tree. Yield reduction in association with different fruit tree species may also be due to negative interaction between the root and shoot system of fruit trees and sweet gourd. Sayed *et al.* (2009) and Uddin *et al.* (2013) found lower yield of spinach and carrot in association with telsur and akashmoni trees. Yield reduction of sweet gourd with jujube and lemon was more severe compare to its morphological parameters which may be due to severe competition for natural resources (on which plant production depends) by their more expanding root and shoot system and fast growing habit (Shi *et al.,* 2006; Lieurance, 2007).

Minimum reduction of yield (up to 10%) and yield attributes (4-25%) of mango, guava, jujube and lemon were recorded in association with sweet gourd. It is well known that trees are deep rooting compare to herbaceous plants as results during tree-crop combined production trees are less affected (Ong *et al.*, 1991; Rao *et al.*, 1991; Gindaba *et al.*, 2004). Similar observation was also reported by Rakib *et al.* (2013) in combined production of radish and different fruit tree species. Rahman *et al.* (2013) also reported similar result during combined production of akashmoni and different winter vegetables.

The term Land Equivalent Ratio (LER) was derived from its indication of relative land requirements for intercrops versus monocultures. LER help to judge the relative performance of a component of a crop combination compared to sole stands of that species. If *LER = 1*, there was no advantage (i.e., neutral) to intercropping or agroforestry in comparison to sole cropping. If *LER > 1*, indicate better use of resources or positive interaction between the components. If *LER < 1*, indicate the competition, i.e., negative interactions between the components. In this study it was found that LER for sweet gourd and different fruit trees (mango, guava jujube and lemon) was more than one which indicate combind production of sweet gourd with mango, guava jujube and lemon is profitable.

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