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Performance of guava fruit tree-based agroforestry practice during summer season in charland and plainland ecosystems

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Abstract: This experimental study was carried out in two locations separately for charland and plainland ecosystems during March to June 2019. For charland ecosystem, study site was in 'Char Kalibari' one of the char land area of Mymensingh district located at the Old Brahmaputra river side and plainland ecosystem, experimental site was in 'Agroforestry Farm Lab. Bangladesh Agricultural University, Mymensingh. The main objective of this study was to observe the yield performance of four different summer vegetables viz. stem amaranth, jute as leafy vegetables, kangkong and Indian spinach in association with guava fruit trees and also to observe the effect of each component (guava tree and summer vegetables) to others. For observing the effect of guava trees on each summer vegetable different distances were maintained as 0-60cm, 60-120cm and 120-180cm both for charland and plainland which were the treatments of this study. Each of the vegetable also cultivates without guava fruit tree combination which were treated as the control. Total seven treatments (1+3+3) were laid out following a Randomized Complete Block Design (RCBD) with 3 (three) replications. For observing the effect of summer vegetables on guava fruit trees, each vegetable treated as a treatment and without crop combination treated as control condition. Growth and yield parameters of summer vegetables and guava trees were recorded during harvesting time of each components separately. As evidence the results of this study, it was found that growth and yield of all tested summer vegetables were significantly decreased towards the base of guava fruit trees. The trend of yield reduction of all tested summer vegetables was almost identical and the average yield reduction compare to control condition in 0-60cm, 60-120cm, 120-180cm distance areas from guava fruit tree base in charland and plain land were 32.16, 18.86, 4.69 and 29.45, 15.02, 1.03%, respectively. Irrespective of distance areas, overall yield reduction of all tested summer vegetables compares to without tree combination in charland and plainland was 18.57 and 15.17%, respectively. Effect of all tested summer vegetables on guava yield and yield contributing parameters was non-significant but numerically a few yield reductions of guava fruit compare to without vegetable condition in charland (5.31%) and plainland (5.72%) ecosystems were recorded. Average Land Equivalent Ratio (LER) of all tested agroforestry models in charland and plainland ecosystems were 1.75 and 1.81, respectively. Considering LER analysis of this study it may conclude that guava fruit tree-based agroforestry practices are profitable both charland and plainland ecosystems.

Key words: Guava fruit tree, agroforestry, summer vegetables, charland ecosystem, plainland ecosystem.

Introduction

Bangladesh is mainly an agriculture-based country and two-third of the population depends directly or indirectly upon agriculture. 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. The demand for food, shelter, fuel and fodder is rising at a geometric rate as jointly influenced by rapid population growth and overuse of land (World Bank, 2015). As a result, the gap between actual demand and supply of the products is widening day by day. Tree plantation was conceived as a potential strategy to meet the food and economic needs of rural people and protect the environment (Tamale *et al.*, 1995; Nair, 1993; Foley and Barnard, 1984). To maintain the environmental equilibrium and socio-economic development at least 25 percent area of a country should be covered with forest (FAO, 2010). With the growing population, and their increasing needs in various sectors, land use patterns are undergoing a qualitative change in which the areas under the net cropped land, and forest land is gradually shrinking (Hossain and Bari, 1996). Under this circumstance it is necessary to find out a suitable alternative to overcome this situation. Since there is neither scope for expanding forest area nor sole grain crop area, the country has to develop combined production system integrating trees and crops which is now being called agroforestry (King, 1968). Agroforestry is the combination of forestry and agriculture with attributes of productivity, sustainability, and adoptability (Vergara, 1982).

Agroforestry is a promising alternative, which is considered as one of the very few options to lift people out of the poverty trap and to protect the existing forest as well as improving environmental sustainability. In Bangladesh homestead, roadside, railway side, embankment side, char land, coastal area, deforested area, institutional premises, riverside etc. are the major venues for practicing agroforestry. Among them char land is an important venue where large number of populations are living for maintaining their livelihood through char-based farming systems (Chowdhury, 1988). Therefore, for increasing production, maintaining ecological balance and improving socio-economic condition of the charland people, integrated approach with crop and trees is necessary.

Different types of fruit tree species are commonly found in Bangladesh of which guava is excellent for processed materials viz., jam, jelly, cheese, ketchup, puree, juice, powder, nectar etc. (Salunkhe and Desai, 1984). Large number of vegetables are grown in this country of which most of them are grown in winter season. In summer season few vegetables are grown of which amaranth, jute as leafy vegetable, Indian spinach, Kangkong are very common which provide protein, minerals, vitamin A and C. So, cultivation of summer vegetables in combination with guava fruit trees will be appropriate agroforestry model for charland ecosystem

Though the agroforestry practices in plainland is running well but, it was till now very scattered and limited practices is done in charland. Plainland agroforestry have been extensively studied by many scientists but very little report about Charland based agroforestry practices was found. However, the comparison between Plainland agroforestry and Charland based agroforestry is still missing. So, to identify the actual potentialities in comparing the plainland and charland agroforestry practices, present study was conducted a research as 'Guava fruit tree-based agroforestry practice during summer season'.

Materials and Methods

Experimental site and period: The experimental study was carried out in two locations separately for charland and plainland ecosystem. For charland ecosystem, experimental site was in 'Char Kalibari' one of the char land area of Mymensingh district located at the Old Brahmaputra river side (Fig. 1a). 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 2 ha forest area. Total family number of this Char area is about 590. Total population is 2350 of which 1238 male and 1112 female (Source: Six no. Char Ishwardia union parishad office records, 2014). For plainland ecosystem, experimental site was in 'Agroforestry Farm Lab.' Bangladesh Agricultural University, Mymensingh Sadar, Mymensingh, located in scenic rural surroundings on the western bank of the old Brahmaputra River, 5 km south from Mymensingh Railway Station and 120 km north from Dhaka, the capital city of Bangladesh (Fig. 1b). The geographical position of Agroforestry Farm Lab, BAU located at 24°75' N latitude and 90°50' E longitude at an elevation of 18m above the mean sea level. Experimental study period was March 2019 to June 2019.

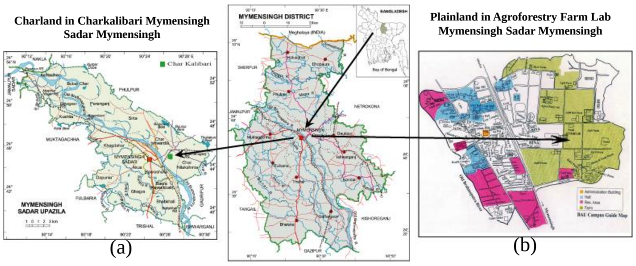

Fig. 1. Location of study site (a) Charland (b) Plainland ecosystem

Tree and crop plant materials: In this study, Guava fruit tree (*Psidium guajava*) was used as tree component and four different summer vegetables viz. stem amaranth (*Amaranthus retroflexus*), Jute as leafy vegetable (*Corchorus capsularis*), Kangkong (*Ipomoea aquatica*) and Indian spinach (*Basella alba*) were used as crop component.

Tree establishment and management: Guava fruit trees were transplanted in the both experimental site during April, 2018 maintaining the spacing 12 ft. × 12 ft. and initial average height of guava seedlings was 0.75m. During the starting of this experiment the age of guava trees were 1 year old and average height and basal girth were 1.92m and 11.15cm, respectively. Before summer vegetables cultivation light pruning was done for removing unnecessary, infected, infested and deformed branches. After pruning, other necessary management activities like cleaning, weeding, fertilizing, bamboo sticks setting were done in time for proper growth and development of all guava saplings.

Experimental design, treatment combinations and layout: In this experiment, four different summer vegetables (stem amaranth, jute as leafy vegetable, kangkong and Indian spinach) were cultivated in association with guava fruit trees. For observing the effect of guava trees on each summer vegetable different distances were identified as 0-60cm, 60-120cm and 120-180cm. Considering these distances as the treatments of the study each summer vegetable was laid out following a Randomized Complete Block Design (RCBD) with 3 (three) replications. Above treatments were applicable for both charland and plainland separately. Each vegetable also cultivates without guava fruit tree combination which was treated as the control condition of the study. So, total treatments of this study were 7 (1+3+3) as T_0 = Control, T_1 = 0-60cm distance from guava tree base in charland, T_2 = 60-120cm distance from guava tree base in charland, T_3 = 120-180cm distance from guava tree base in charland, T_4 = 0-60cm distance from guava tree base in plainland, T_5 = 60-120cm distance from guava tree base in plainland and T_6 = 120-180cm distance from guava tree base in plainland. For observing the effect summer vegetables on guava fruit trees, each vegetable treated as a treatment and without crop combination treated as control condition. Overall layout of the study is shown in Fig. 2.

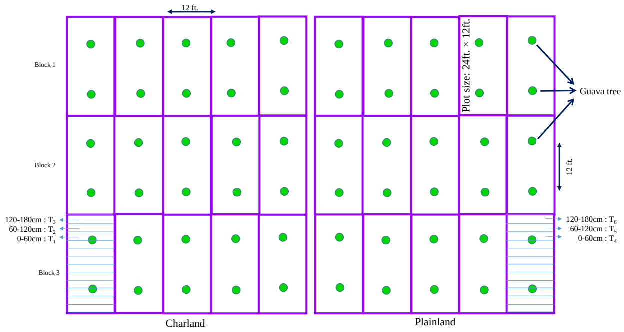

Fig. 2. Layout of the experiment

Land preparation and summer vegetables cultivation: The land used for the experiments was first opened one week before laying out the experimental plots i.e. 18 March 2019. The land was well prepared with the tractor followed by harrowing and laddering up to a good tilth. All crop residues, stubbles and weeds were removed from the field and finally the land was properly leveled (Fig. 3). Seeds of stem amaranth, jute, kangkong and Indian spinach were sown during 25 March 2019 surrounding the guava trees. Each research plot size was 24ft. × 12ft. After emerging the seedling all summer vegetables necessary cultural management operations viz. thinning, gap filling, weeding, pest control etc. were done when it was required.

Fig. 3. Land preparation for summer vegetables cultivation

Sampling and Data collection: Data regarding growth and yield parameters of all studied summer vegetables viz. plant height, number of leaves per plant, number of branches per plant, leaf length, leaf breadth, stem girth, weight per plant etc. were collected during harvesting time. For data collection representative plant samples were selected randomly from all the treatments of the plots.

Stem amaranth and jute as leafy vegetables were harvested at a time at 45 and 30 days after sowing (DAS). Indian spinach and kangkong were harvested several times at 10 days interval where first harvest were done 40 DAS. Guava fruit were harvested when it was reached edible size and different yield contributing parameters of each fruit viz. number of fruit per plant, fruit length, fruit girth, individual fruit weight etc. were recorded.

Land Equivalent Ratio (LER) Measurement: LER was determined by using the equation 'LER = C*i*/C*s* + T*i*/T*s*' Where, C*i* = summer vegetables yield under intercropping, C*s* = summer vegetables under sole cropping, T*i* = guava fruit tree yield under intercropping, and T*s* = guava fruit tree yield under sole cropping. C*i*/C*s* or T*i*/T*s* is the relative yield of summer vegetables and guava fruit tree which were measured separately from their respective yields.

Statistical analysis: The recorded data were compiled and analyzed 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 by using 'WASP 2' software. 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

Effect of guava fruit trees on summer vegetables: Morphological parameters and yield of studied different summer vegetables i.e. stem amaranth, jute as leafy vegetable, kangkong and Indian spinach are significantly influenced by guava fruit tees both in charland and plainland ecosystems (Fig. 4). Effect of guava fruit trees on the performance of studied summer vegetables for their morphological parameters and yield separately presented here as:

a b c d

Fig. 4. Summer vegetables in association with guava fruit tree (a) Stem amaranth (b) Jute as leafy vegetable (c) Kangkong (d) Indian spinach

Morphological parameters summer vegetables: Morphological parameters of stem amaranth, jute as leafy vegetable, kangkong and Indian spinach in association with guava fruit trees were as:

Table 1. Morphological characteristics of stem amaranth in association with *Psidium guajava*

Treatment	Morphological parameters of stem amaranth					
	Height (cm)	No. of leaves	Leaf Length (cm)	Leaf breath (cm)	Stem girth (cm)	Weight/ Plant (g)
T_0	98.50a	18.98a	15.44a	12.60a	11.96a	302.24a
T_1	63.83c	13.86c	11.16d	8.47c	9.05c	195.49c
T_2	79.11b	16.25b	13.11c	10.84b	10.58b	223.13bc
T3	97.42a	18.75a	15.26ab	12.12ab	11.51ab	287.56a
T_4	64.05c	13.99c	11.36d	8.67c	9.29c	202.37cd
T_5	79.97b	16.97b	13.64bc	11.19ab	10.99ab	229.28b
T_6	98.19a	18.66a	15.38a	12.43 a	11.96a	293.36a
CV (%)	9.16	4.4	8.44	8.73	6.74	7.31
CD (0.01)	15.48	1.49	2.34	1.94	1.47	36.81

Mean in column followed by the different letter are significantly diifferent by DMRT at P< 0.01, CD = Critical Difference; T_0 = Control, T_1 = 0-60cm distance from guava tree base in charland, T_2 = 60-120cm distance from guava tree base in charland, T_3 = 120-180cm distance from guava tree base in charland, T_4 = 0-60cm distance from guava tree base in plainland, T_5 = 60-120cm distance from guava tree base in plainland, T_6 = 120-180cm distance from guava tree base in plainland.

Stem amaranth: Different growth parameters of stem amaranth viz. plant height, number of leaves per plant, leaf length, leaf breadth, stem girth, weight per plant etc. were significantly varied by guava fruit tees both in charland and plainland ecosystems (Fig. 4a). It was found that growth regarding all morphological parameters of stem amaranth gradually decreased towards the base of guava fruit trees (Table 1). Highest values of plant height, number of leaves per plant, leaf length, leaf breadth, stem girth and weight per plant of stem amaranth were found in control condition and values were 98.50cm, 18.98, 15.44cm, 12.60cm, 11.96cm and 302.24g, respectively which were statistically similar with the values of all parameters found in treatment T_3 (120-180cm distance from guava tree base in charland) and T_6 (120-180cm distance from guava tree base in plainland) (Table 1). Lowest values of plant height (63.83cm), number of leaves per plant (13.86), leaf length 911.16cm), leaf breadth 98.47cm), stem girth (9.05cm) and weight per plant (195.49g) of stem amaranth were found in treatment T_1 (0-60cm distance from guava tree base in charland) which were statistically identical with the values of all of these parameters of stem amaranth recorded in the treatment T_4 (0-60cm distance from guava tree base in plainland) and values were 64.05cm, 14.0, 11.36cm, 8.67cm, 9.29cm and 202.37g, respectively (Table 1). Growth suppression of stem amaranth both in charland and plainland towards the base of guava fruit trees may be due to the competition for different growth resources between the root system of summer vegetables and guava fruit trees. Growth of guava fruit trees was comparatively better in charland ecosystem (Table 6) which may the reason for relatively better growth of stem amaranth in charland ecosystem. Alam *et al.* (2012) opined that growth of different summer vegetables gradually decreased towards the base of different timber trees during combined production of in the charland ecosystem.

Table 2. Morphological characteristics of jute as leafy vegetables in association with *Psidium guajava*

Treatment	Morphological parameters of jute as leafy vegetable				
	Height (cm)	No. of leaves	Leaf Length (cm)	Leaf breath (cm)	Weight/ Plant (g)
T_0	39.78a	10.15a	9.16a	3.83ab	10.24a
T_1	29.99d	7.50c	6.02c	2.84d	7.87e
T_2	33.55bc	8.57b	7.67b	3.35c	8.84cd
T3	39.00a	9.85a	8.80a	3.92a	9.85ab
T_4	30.92cd	7.76c	6.25c	2.92d	7.91de
T_5	35.23b	8.94b	7.97b	3.49bc	8.97bc
T_6	39.39a	10.12a	9.02a	4.04a	9.82ab
CV (%)	6.33	5.96	6.39	7.29	7.16
CD (0.01)	4.57	1.1	1.02	0.52	1.33

Mean in column followed by the different letter are significantly diifferent by DMRT at P< 0.01, CD = Critical Difference; T_0 = Control, T_1 = 0-60cm distance from guava tree base in charland, T_2 = 60-120cm distance from guava tree base in charland, T_3 = 120-180cm distance from guava tree base in charland, T_4 = 0-60cm distance from guava tree base in plainland, T_5 = 60-120cm distance from guava tree base in plainland, T_6 = 120-180cm distance from guava tree base in plainland

Jute as leafy vegetables: Morphological behavior of Jute as leafy vegetable was observed by observing its plant height, number of leaves per plant, leaf length, leaf breadth and weight per plant (Fig. 4b). It was found that, like stem amaranth all morphological parameters of jute as leafy vegetable were also significantly influenced by guava fruit trees both in charland and plainland ecosystems (Table 2). As evidence from results of this study it is clear that growth of jute as leafy vegetable were gradually decreased with decreasing distance towards the base of guava fruit trees. Growth of jute as leafy vegetable was better in without tree combination (T_0) considering the values of plant height, number of leaves per plant, leaf length, leaf breadth and weight per plant as 39.78cm, 10.15, 9.16cm, 3.83cm and 10.24g, respectively. Growth performance of jute as leafy vegetable was almost statistically similar in the treatment T_0, T_3 (120-180cm distance from guava tree base in charland) and T_6 (120-180cm distance from guava tree base in plainland). Minimum values of plant height (29.99cm), number of leaves per plant (7.50), leaf length (6.02cm), leaf breadth (2.84cm) and weight per plant (7.87g) of jute as leafy vegetable were recorded in 0-60cm distance areas from guava fruit trees base in charland ecosystem which were statistically identical with the values of all above parameters of in 0-60cm distance areas from guava fruit trees base in plainland ecosystem (Table 2). Though the growth of all studied parameters of jute as leafy vegetable were statistically identical in 0-60cm areas from guava fruit tree base in charland and plainland ecosystem but numerically it was bit lower in charland ecosystem may be due to better growth of guava fruit tree in charland ecosystem which suppressed the growth of jute. Generally, growth of jute as leafy vegetable was lower in the near areas from guava tree base might be due to the negative interactions between jute and guava trees. Tanni *et al.* (2010) and Hasan *et al.* (2013) opined that root crops growth was remarkably reduced very near the base of lohakat (*Xylia dolabriformis*) and eucalyptus tree.

Table 3. Morphological characteristics of kangkong in association with *Psidium guajava*

Treatment	Morphological parameters of kangkong						
	Height (cm)	No. of leaves/cutting/plant	No. of Branches/cutting/plant	Leaf Length (cm)	Leaf breath (cm)	Stem girth (cm)	Weight/ twig (g)
T_0	37.15a	40.65a	9.01a	12.54a	4.16a	3.88a	35.16a
T_1	27.50c	29.88c	4.45c	7.17c	2.59c	2.18c	24.87d
T_2	32.75b	34.84b	6.70b	10.10b	3.33b	2.95b	28.97bc
T3	36.10a	39.56a	8.58a	12.27a	3.96a	3.74a	34.04a
T_4	27.49c	30.80c	4.63c	7.51c	2.71c	2.28c	26.16cd
T_5	32.87b	35.54b	6.96b	10.60b	3.50b	3.08b	30.29b
T_6	36.98a	39.20a	8.90a	12.51a	4.12a	3.69a	35.47a
CV (%)	6.3	5.49	7.27	6.18	5.49	8.34	6.66
CD (0.01)	4.22	4.01	1.03	1.31	0.39	0.52	4.17

Mean in column followed by the different letter are significantly diifferent by DMRT at P< 0.01, CD = Critical Difference; T_0 = Control, T_1 = 0-60cm distance from guava tree base in charland, T_2 = 60-120cm distance from guava tree base in charland, T_3 = 120-180cm distance from guava tree base in charland, T_4 = 0-60cm distance from guava tree base in plainland, T_5 = 60-120cm distance from guava tree base in plainland, T_6 = 120-180cm distance from guava tree base in plainland

Kangkong: Morphological characteristics of kangkong was examined by recording its plant height, number of leaves per cutting per plant, number of branches per cutting per plant, leaf length, leaf breadth, stem girth and weight per twig (Fig. 4c). Like stem amaranth and jute as leafy vegetables, all morphological parameters of kangkong were also influenced remarkably by guava fruit trees both in charland and plainland ecosystems (Table 3). Results of this study confirm that growth parameters of kangkong were gradually increased with increasing distance from guava fruit tree base. Better performance of all growth parameters of kangkong was found in control condition which were statistically similar with the values of all parameters in treatment T_3 and T_6. The values of plant height, number of leaves per cutting per plant, number of branches per cutting per plant, leaf length, leaf breadth, stem girth and weight per twig of kangkong in control treatment (T_0) were 37.15cm, 40.65, 9.01, 12.52cm, 4.16cm, 3.88cm and 35.16g, respectively. Lowest values of all parameters were recorded in 0-60cm distance areas from guava tree base in charland ecosystem which was statistically similar with values of same parameters in the same areas in plainland ecosystem (Table 3). Though the values of all parameters of kangkong in the same distances from guava trees in charland and plainland are statistically similar but numerically a few reductions were noticed in charland ecosystem may be due to more canopy coverage by guava trees (Table 6). Average guava tree height was more than 2m, its canopy was bushy and create overstorey as a result it created more shade to the surrounded ground areas which may reduce the growth of different growth parameters of kangkong near the base guava tree. Rakib *et al.* (2013) reported remarkable growth reduction of radish with two years old mango fruit trees due to creation of shade.

Table 4. Morphological characteristics of Indian spinach in association with *Psidium guajava*

Treatment	Morphological parameters of Indian spinach					
	Height (cm)	No. of leaves/cutting/plant	Leaf Length (cm)	Leaf breath (cm)	Stem girth (cm)	Weight/ twig (g)
T_0	59.32a	3.83a	11.32a	8.83a	5.97a	63.30a
T_1	45.27c	2.48c	7.49c	6.11c	4.48b	45.12d
T_2	51.17b	3.06b	9.62b	7.65b	4.92b	53.98c
T3	56.92a	3.71a	11.27a	8.46ab	5.73a	60.90ab
T_4	46.78c	2.55c	7.93c	6.12c	4.48b	46.31d
T_5	52.65b	3.10b	10.15ab	7.65b	4.92b	56.27bc
T_6	58.59a	3.76a	11.03a	8.46ab	5.73a	59.23abc
CV (%)	5.09	7.9	8.69	7.49	8.56	7.02
CD (0.01)	5.49	0.51	1.73	1.16	0.9	7.86

Mean in column followed by the different letter are significantly diifferent by DMRT at P< 0.01, CD = Critical Difference; T_0 = Control, T_1 = 0-60cm distance from guava tree base in charland, T_2 = 60-120cm distance from guava tree base in charland, T_3 = 120-180cm distance from guava tree base in charland, T_4 = 0-60cm distance from guava tree base in plainland, T_5 = 60-120cm distance from guava tree base in plainland, T_6 = 120-180cm distance from guava tree base in plainland

Indian spinach: Like above all others summer vegetables, **g**rowth parameters of Indian spinach viz. plant height, number of leaves per cutting per plant, leaf length, leaf breadth, stem girth, weight per twig etc. were significantly varied by guava fruit tees both in charland and plainland ecosystems (Fig. 4d). From the results of the study, it was found that growth regarding all parameters of Indian spinach gradually decreased towards the base of guava trees both charland and plainland ecosystems (Table 4). Highest values of plant height, number of leaves per twig, leaf length, leaf breadth, stem girth and weight per plant of Indian spinach were found in control condition and values were 59.32cm, 3.83, 11.32cm, 8.83cm, 5.97cm and 63.3g, respectively which were statistically similar with the values of all parameters found in treatment T_3 (120-180cm distance from guava tree base in charland) and T_6 (120-180cm distance from guava tree base in plainland) (Table 4). Lowest values of plant height (45.27cm), number of leaves per cutting per plant (2.48), leaf length (7.49cm), leaf breadth (6.11cm), stem girth (4.48cm), weight per twig (45.12g) of Indian spinach were found in treatment T_1 (0-60cm distance from guava tree base in charland) which were statistically identical with the values of all of these parameters of Indian spinach recorded in the treatment T_4 (0-60cm distance from guava tree base in plainland) and values were 46.78cm, 2.55, 7.93cm, 6.12cm, 4.48cm and 46.31g, respectively (Table 4). Growth suppression of Indian spinach both in charland and plainland towards the base of guava fruit trees may be due to the competition for light, water and nutrients between the roots and shoot system of summer vegetables and guava fruit trees. Growth of guava fruit trees was comparatively better in charland ecosystem (Table 6) which may be the reason for growth suppression Indian spinach in charland ecosystem. Similar type of results also opined by Anwar *et al.* (2013) and Uddin *et al.* (2013) in bottle gourd and carrot in association with young *Acacia auriculiformis* where significant growth suppression was occurred.

Yield of summer vegetables: Like morphological parameters yield of stem amaranth, jute as leafy vegetable, kangkong and Indian spinach were also significantly influenced by guava fruit trees at different distances both in charland and plainland ecosystems (Table 5). Highest yield of stem amaranth, jute as leafy vegetable, kangkong and Indian spinach were recorded in control condition (T_0) and the values were 28.42, 4.18, 5.97 and 59.28 t/ha, respectively. Yield of all vegetables in without guava tree combinations were statistically identical with yield of these vegetables produced in the treatments T_3 and T_6. Among the different distance areas from guava tree base in charland (Treatments T_1, T_2 and T_3) and plainland (Treatments T_4, T_5 and T_6) yield of all above summer vegetables gradually decreased towards base of guava trees (Table 5). Trend of variation in different distance areas both in charland and plainland ecosystem were almost similar in all tested summer vegetables. Average yield reduction of these vegetables in charland at treatments T_1, T_2, T_3 were 4.69, 18.86 and 32.16% and in plainland at treatments T_4, T_5 and T_6 were 1.03, 15.02, 29.45%, respectively. Average yield of these vegetables in charland, plainland with guava tree and without guava tree combination is shown in Fig. 5. Average yield reduction of all studied summer vegetables was 18.57 and 15.17%, respectively. During study period average height of guava tree was more than 2m, its canopy was bushy which create overstorey and root system was more prominent. As a result, competition for different growth resources (light, water, nutrients etc.) was occurred between the shoot and root system which may the reasons lowering growth and yield all summer vegetables towards the base of guava fruit trees both in charland and plainland. Mallick *et al.* (2013) and Rajput *et al.* (1989) found lower yield of strawberry and bitter gourd near the base of young *Xylia dolabriformis* and *Mangifera indica* tree.

Table 5. Yield of different summer vegetables in association with guava under charland and plainland ecosystem

Treatments	Yield of different summer vegetables (t/ha)			
	Stem Amaranth	Jute as leafy vegetables	Kangkong	Indian Spinach
T_0	28.42a	4.18a	5.97a	59.28a
T_1	19.29c	2.83c	4.06c	40.17c
T_2	23.01b	3.40b	4.84b	48.14b
T_3	27.06a	3.98a	5.69a	56.57a
T_4	20.04c	2.95c	4.21c	41.84c
T_5	24.15b	3.54b	5.08b	50.42b
T_6	28.12a	4.13a	5.91a	58.74a
CV (%)	5.42	5.396	5.424	5.515
CD (0.01)	2.682	0.393	0.568	5.698

Mean in column followed by the different letter are significantly diifferent by DMRT at P< 0.01, CD = Critical Difference; T_0 = Control, T_1 = 0-60cm distance from guava tree base in charland, T_2 = 60-120cm distance from guava tree base in charland, T_3 = 120-180cm distance from guava tree base in charland, T_4 = 0-60cm distance from guava tree base in plainland, T_5 = 60-120cm distance from guava tree base in plainland, T_6 = 120-180cm distance from guava tree base in plainland

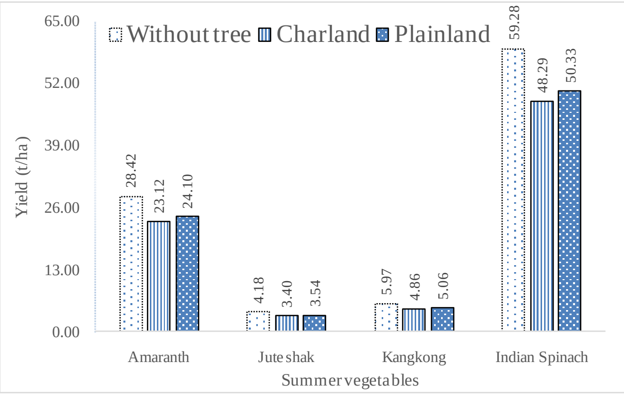

Fig. 5. Average yield of summer vegetables with guava tree in charland and plainland ecosystem.

Effect of summer vegetables on guava fruit trees

Growth and yield contributing parameters: Effect of different studied summer vegetables were observed on growth and yield contributing parameters of guava fruit trees (Fig. 6). Growth of guava fruit trees was observed by observing the total height and basal girth. Different yield contributing parameters of guava fruits were number of fruits per plant, fruit length, fruit girth and individual fruit weight. As evidence from results it was found that effect of all tested summer vegetables on growth (Table 6) and yield contributing characters (Table 7) of guava fruit trees both in charland and plainland was insignificant. Root system of guava tree was more prominent and developed compare to tested summer vegetables. As a results guava tree can absorbed more nutrients from intensively cultivated summer vegetables which may the reason for similar growth of guava trees with and and without vegetables in both ecosystems. But numerically slight better growth of guava fruit trees was recoded in charland ecosystem (Tables 6 and 7) may be due to better soil health in charland ecosystem. Rahman *et al.* (2014) observed the similar growth of different fruit trees in association with winter vegetables in a fruit tree-based agroforestry practices in char land farming system.

Table 6. Growth of guava trees during study period in charland and pliannland

Ecosystem	Crop comibinations	Average total height (m)	average basal girth (cm)
Charland	With vegetables	2.15	11.92
	Without vegetables	2.17	12.01
Plainland	With vegetables	2.04	11.85
	Without vegetables	2.06	11.88
CV (%)		9.53	10.24
Level of significance		NS	NS

Fig. 6. Guava fruits in association with summer vegetables

Table 7. Yield contributing parameters of guava with summer vagatables in char and planland ecosystem

Conditions/associated summer vegetables	Yield contributing parameters of guava							
	Fruits per plant		Fruit length (cm)		Fruit girth (cm)		Individual fruit weight (g)	
	Charland	Plainland	Charland	Plainland	Charland	Plainland	Charland	Plainland
Sole guava	25.83	25.75	15.75	15.35	25.65	25.59	332.52	331.25
With stem Amaranth	24.45	24.25	15.21	15.00	25.46	25.18	326.10	325.50
With jute as leafy vegetable	24.50	24.25	14.74	14.58	26.10	25.99	328.75	328.50
With kangkong	25.75	25.50	15.80	15.63	23.65	23.47	330.86	330.25
With Indian Spinach	25.25	25.00	16.55	16.40	23.01	22.48	316.15	315.50
CV (%)	10.50	10.49	15.63	15.55	18.75	18.51	18.45	18.30
No. of Significance	NS	NS	NS	NS	NS	NS	NS	NS

NS = son-significant

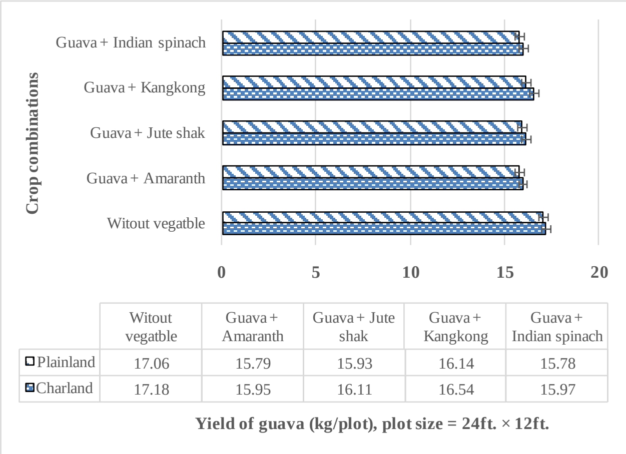

Fig. 7. Yield of guava with different crop combinations

Yield of Guava: Yield of guava in association different summer vegetables and without vegetables were recorded in charland and plainland ecosystem (Fig. 7). It was found that yield of guava with all tested summer vegetables in both ecosystems were not affected significantly but numerically few variations in different crop combination or agroforestry practices (Fig.7). But numerically some variations were found in agroforestry combinations compare to without vegetables condition in both ecosystems. Highest yield (per plot, plot size 24ft. × 12 ft.) of guava was found in without vegetables in charland and plainland were 17.18 and 17.06kg, respectively. Yield reduction of guava with stem amaranth, jute as leafy vegetable, kangkong and Indian spinach in charland and plainland ecosystem were 7.17, 6.22, 0.81 and 7.06% and 7.44, 6.62, 1.29 and 5.72%, respectively. Due to competition for nutrients, fruit setting of guava with associated summer vegetables slightly affected (up to 7.44%) in both ecosystems. Momtaz *et al.* (2014) and Bari *et al.* (2014) observed similar type of variation in mango and lemon when cultivated with bitter gourd and sweet gourd, respectively.

Table 8. Land Equivalent Ratio (LER) of different agroforestry parctices in charland and plainland ecosystem

Agroroforestry practices	Relative yield of guava (1)		Relative yield of summer vegtables (2)		LER (1+2)	
	Charland (a)	Plainland (b)	Charland (a)	Plainland (b)	Charland (1a+2a)	Plainland (1b+2b)
Guava+ Stem amaranth	0.93	0.93	0.81	0.85	1.74	1.78
Guava+ Jute shak	0.94	0.93	0.82	0.85	1.76	1.78
Guava+ Kangkong	0.96	0.95	0.81	0.85	1.77	1.90
Guava+ Indian spinach	0.93	0.92	0.81	0.85	1.74	1.77

Land Equivalent Ratio (LER): LER of this study was measured separately in charland and plainland for four different tree-crop combinations viz. guava + stem amaranth, guava + jute as leafy vegetable, guava + kangkong and guava + Indian spinach (Table 8). LER of these above crop combinations were 1.74, 1.76, 1.77 and 1.74 in charland ecosystem and 1.78, 1.78, 1.90 and 1.77 in plainland ecosystem, respectively (Table 8). The term LER is 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. LER is the sum of relative yields of the component's species under agroforestry practice where relative yield of a component is the ratio of 'yield as intercrop' and 'yield as sole crop' on the same unit of land. If LER = 1, there is 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. As evidence from the results of this study it was found that LER of all crop combinations i.e. guava + summer vegetables were more than one which indicate all of these agroforestry practices in combinations with guava and summer vegetables will be profitable both in charland and plainland ecosystem.

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