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Yield and growth performance of bitter gourd with Karanja trees under alley cropping system in river island of Mymensingh

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ABSTRACT

The field experiment was conducted to evaluate the yield and growth performance of bitter gourd in combination with karanja tree species under alley cropping system. The experiment was laid out in randomized complete block design with three replications having four treatments viz., T_0 (open field condition referred to 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 growth and yield of bitter gourd were significantly influenced by the associated trees at different distances from the karanja tree base. It was found that all the growth parameter of bitter gourd viz. vine length, total leaves per plant, number of primary branches per plant, number of leaves per primary branches, number of female flower per plant, number of male flower per plant, number of fruits per plant, individual fruit weight, fresh and dry weight of fruits (t ha^{-1}) etc. were better in the open filed condition compare to in association with karanja tree species. Among the distances from the tree base growth of bitter gourd gradually decreased with decreasing distances towards the tree base. Similar trend of variation was also found in case of yield of bitter gourd in combination with this tree species. The highest fresh yield of bitter gourd was obtained in open field condition which was 1.85 t ha^{-1}. Among the different distances viz. <50 cm, 50-100 cm and >100 cm distance from the tree base, yield of bitter gourd was decreased towards the tree base. Fresh yield of bitter gourd in these distances (<50 cm, 50-100 cm and >100 cm) from tree base in combination with karanja species were 0.79, 1.38 and 1.64 t ha^{-1}, respectively. It was found that on an average 1.06 t ha^{-1}, 0.47 t ha^{-1} and 0.21 t ha^{-1} yield of bitter gourd were gradually decreased in <50 cm, 50-100 cm and >100 cm distances from tree base compare to open field condition, respectively. Both height and girth increment of the tree was a bit better in combination with bitter gourd. Finally, it may be concluded that bitter gourd can successfully be grown in combination with karanja tree in island based farming system of Bangladesh during the establishment period of timber trees.

Introduction

Bangladesh is one of the most densely populated small country with an area of 147,570 km^2 where 158.9 million people live with 1077 people per square kilometer (BBS, 2017). It is not wondering to hear that, for above 15 crores people, the per capita forest land is about 0.018 acre and the forest land is about 2.78 million (BBS, 2016) and the main point is that, this forest land cannot fulfill the demand of people for food, fuel, fodder, timber etc. If we will increase the tree coverage area through intercropping, that open a path to get multi-crops as well as multi benefits from the same piece of land insuring sustainable environment (Jeruto Pascaline and Ouma George). So, vegetables like bitter gourd, sweet gourd, pointed gourd etc. are grown along with homestead trees in Bangladesh throughout the year help to fulfil farmers' needs. Because the demand for those vegetables are increasing but the areas under vegetables production are decreasing. Unfortunately, these limited areas are decreasing due to increasing the area of solo crop cultivation. On the other hand, a country needs 25% of forest land of its total area for ecological stability but the effective area of forest (13.6%) in Bangladesh is neither in a position to fulfill the requirements of the people's fuel and timber nor to stabilize the climatic condition (Climate Asia Bangladesh Report, 2017). Under these circumstances it is necessary to find out a suitable alternative to overcome this situation. Since there is no scope for expanding forest area and sole grain crops area. The country has to develop a sustainable combined production system by the integration of trees and crops in the same unit of land which is now being called agroforestry. Agroforestry, the integration of tree and crop or vegetables on the same area of land is a promising production system for maximizing yield and maintaining friendly environment (Nair, 1990). In Bangladesh scope of agroforestry is vast. Among them island is the most important venue for practicing

agroforestry systems. 'Island' 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).

Alley cropping is an agroforestry system for food production involving growing of arable crops in spaces (alleys) between hedgerows of plated fallows of woody shrubs or trees, preferably leguminous species. The fallow species are periodically pruned during the companion crops. Alley cropping system is a good option for partially degraded medium high island because farmers easily practice agrisilviculture in present of sufficient water. Again there is a common problem in the island areas of Bangladesh is lack of soil conserving per binding tree species. Karanja (*Pongamia pinnata),* a tree species which can help to bind soil particles and hold more siol moistues. Consequence of that this fast growing and multipurpose tree, Karanja (*Pongamia pinnata)* is very helpful for cultivating along with several vegetables in alley cropping system (Steven Franzel).

Considering the above mentioned facts and potentiality, this study was undertaken to identify a sustainable farming system for the island areas of Bangladesh for investigating the growth and yield performance of bitter gourd in association with karanja tree in the island Kalibari in the bank of Old Brahmaputra River.

Materials and methods

Experimental site and season

The experiment was carried out at Island Kalibari belongs to the Mymensingh sadar upazila during the period from November 2016 to March 2017. The geographical position of Island Kalibari located between 24°45'-24°45'40" North and 90°24'4"- 90°24'44" East Latitude.

Planting material

Three year's old previously established karanja *(Pongamia pinnata*) trees were used as test tree components and bitter gourd *(Momordica islandantia)* were used as vegetables plant.

Tree establishment and management

Necessary management activities like watering, cleaning, weeding, fertilizing, branch cutting, bamboo stick setting were done in time for proper growth and development of all plants saplings. Before starting this study the tree was partially pruned disease infected and insect infested leaves and twigs were also removed. Need more information regarding tree planting, height, average canopy size, plot size and tree planting orientation etc.

Experimental design, layout and treatment combination

The experimental design was layout in a randomized complete block design with three replications. Four treatments were used as T_0 = Open field referred to as control, T_1 = <50 cm, T_2 = 50-100 cm, T_3 = >100 cm distance from the tree . Tree was planted on fallows and crops are cultivated in alley following above mentioned distances. The four treatments (distances) in each block were randomly assigned to the three plots.

Crop establishment

Bitter gourd seeds were directly sown in the experimental plot on 5th November 2016. After emergence, bitter gourd was thinned out at three times while first thinning was done at 15 days after sowing; second and third thinning out was done at 5 days interval from first thinning. Bitter gourd are ploughed in the field to fine tilth and dig pits of 30 cm × 30 cm × 30 cm size at 2 × 1.5 m spacing. Common fertilizers were applied at the rate of 10 kg of FYM per pit (20 t ha^{-1}), 100 g of NPK 6:12:12 per pit as basal and 10 g of N per pit after 30 days of sowing and irrigation was done at two days interval.

Crop harvesting

The fruits were harvested at tender stage and before 100% maturity when they are still green. However, bitter gourd was harvest after 120 days after sowing. Harvesting is done by hand picking. After harvest size and weight of each fruit was measured.

Sampling and Data collection

Data of different morphological islandacteristics were collected at three different stages like vegetative, flowering and harvesting. For data collection three plants were randomly selected from each pit. The parameters studied were- vine length (cm), total leaves/plant, number of primary branches/plant, leaves/primary branches, female flower/plant, male flower/plant, fruits/plant, weight/fruit (g), fresh and dry weight of fruits (t ha^{-1}). For karanja tree, sixteen tree samples were selected randomly from all treatments of the plots for data collection. Sample trees were selected at before and after of vegetables cultivation. Tree height (cm) and tree girth (cm) were recorded.

Statistical analysis

The recorded data were compiled and analyzed by RCBD design to find out the statistical significance of experimental results. The means for all recorded data were calculated and analyzed statistically by using 'SAS University

Edition' software package to find out the statistical significance of the experimental results for all the islandacters were performed. The mean differences were evaluated by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) at 5% level of significance and also by Least Significance Difference (LSD) test.

Results and Discussion

Different morphological parameters of bitter gourd in different study period significantly influenced by Karanja tree at different distance from the tree base.

Morphological features of Bitter gourd

Vine length

Vine lengths of bitter gourd in association with Karanja tree at vegetative, flowering and harvesting stages at 50 DAP (Days After Planting) were significantly different in different treatments (Table 1, 2 and 3). In all stages (vegetative, flowering and harvesting) the longest (44.95, 71.24, 96.45 cm, respectively) vine lengths were found in open field condition (T_0), i.e. without tree condition which was statistically similar with treatment T_3 (43.00 cm) at vegetative stages and for other stages (flowering and harvesting), these lengths were statistically close with treatment T_0 (64.21 and 89.07 cm respectively). Vine lengths of bitter gourd in all stages with treatment T_1 (i.e. <50 cm distance from the tree base) were 19.24, 57.66 and 69.29 cm; lower compare to control condition (T_0) respectively (Table 1, 2 and 3). Therefore, enhancement of vine lengths of bitter gourd was proportional to increase of the distance from the tree base.

From this study it was found that, among the different distant area from Karanja tree base vine length of Bitter gourd gradually decreased toward the tree base which may be due to competition for nutrient and water between the root system of bitter gourd and Karanja tree. Parveg et al. (2014), Akter et al. (2013), Hasan et al. (2012) recorded chili, carrot and okra plant very near the base of Akashmoni, Lohakat and Lombu (*Khya* spp.) tree..

Plate 1. Bitter gourd in association with Karanja tree at vegetative growth stages.

Number of leaf

The numbers of leaves per plant are also important islandacter due to its direct relation with yield via photosynthesis. For this reason, due to variation of number of leaf, yield of bitter gourd also varied in this stage. It was noted that number of leaves of bitter gourd was meaningfully enlarged with the rise of distance from tree base (Table 1, 2). In vegetative and flowering stages highest no. of leaves (25.71 and 58.21 cm, respectively) were found in open field condition (T_0) i.e. without tree condition which were statistically close with treatment T_3 (20.00 and 51.00 cm, respectively). These results revealed that leaves number significantly increase in gradually increasing distance with Karanja tree. Islam et al. (2014), Hasan et al. (2013) also found similar kind of variation in number of leaf of bitter gourd in association with Lohakat and Eucalyptus tree, respectively.

Number of primary branches/plant

No. of primary branches/plant of bitter gourd was affected significantly due to the effect of different treatments at all stages (vegetative, flowering and harvesting) in association with Karanja tree and the highest no. of primary branches/plant (3.33, 5.43 and 5.71) were recorded in T0 (Table 1, 2 and 3). The result noted that the highest no. of branches/plant at harvesting stage was recorded 5.71 in treatment T0 which was statistically similar with the treatment T2 and T3 where the value was 4.59 and 5.43, respectively (Table 3). But, rest of harvesting stage, no. of branches/plant of bitter gourd in the treatment T3 were 29.72 and 31.67% lower compare to control condition (T0) and the values were 2.34 and 3.71, respectively (Table 1 and 2). Near the tree base no. of branches/plant were lower may be due to competition for different nutrient elements and moisture between the root system of bitter gourd and Karanja tree. Rakib et al. (2013) and Bithi et al. (2014) observed lower no. of no. of branches/plant in radish and bitter gourd very near the base of mango and ipil-ipil tree.

Total female flowers per plant

Number of female flowers per plant is the most important yield contributing islandacter, which was significantly influenced by different distance of growing bitter gourd under Karanja tree (Table 2). The maximum number of female flowers per plant (20.45) was found in T_0 (open field referred as control) while treatment T_3 (> 100 cm distance from the tree base) produced the second maximum which was statistically similar with control treatment (Table 2). Treatment T_2 (50-100 cm distance from the tree base) recorded the third maximum number of female flowers per plant (17.00) which was also statistically similar to T_3. The lowest number of female flowers per plant (13.00) was found under close contact of the tree condition (T_1= <50 cm from tree base) and it was probably due to poor photosynthetic capacity and nutrients competition between trees and studied bitter gourd. Similar observation was also obtained by Rahman et al. (2004), who reported that except plant height all others morphological islandacters were highest in open field condition.

Number of male flowers per plant

It was clearly observed that no. of male flowers per plant of bitter gourd was meaningfully affected and influenced at flowering stage (Table 2) in association with Karanja tree. The greatest number of male flowers per plant (96.45) was found in T_0 (open field) while treatment T_3 (>100 cm distance from the tree base) had the second maximum number of male flowers per plant (90.66). The minimum number of female flowers per plant (78.69) was found under close contact of the tree condition and it was probably due to poor photosynthetic capacity and nutrients competition between trees and bitter gourd (Table 2).

Number of leaves per primary branch

Different treatments showed the significant effect on number of leaves per primary branch of bitter gourd in association with Karanja tree (Table 3) which revealed that the maximum number of leaves per primary branch of bitter gourd (34.36) was produced by T_0 treatment (open field) while second highest number of leaves /plant (33.47) was found under T_3 (>100 cm distance) where they were statistically similar. In contrast, the lowest no. of leaves per primary branch (22.41) was observed at T_1 treatment (<50 cm distance) which was statistically differed from other treatments and was similar to the observed by Rakib (2013) and Uddin (2013).

Number of fruits/plant

The result noted that the highest no. of fruits/plant at harvesting stage was recorded 24.00 in treatment T_0 which was statistically close with the treatment T_3 where the value was 14.87% lower compare to control condition (T_0) and that was 20.43 (Table 3). The least number of fruits per plant (14.00) was obtained under close contact of the tree condition (T_1= <50 cm from tree base) and it was probably due to food, moisture and nutrients competition between trees and studied bitter gourd (Table 3). Similar finding was also observed by Basak et al. (2011) who found that the yield contributing islandacters of the vegetables increased gradually with the increase of planting distance from the tree.

Weight of fruit

Results of this study showed that weight of single fruits of bitter gourd was also significantly influenced by different planting distance from the Karanja tree where the heaviest single fruit (32.71 g) was recorded in T_0 (open field referred as control) which was statistically similar weight of single fruit (32.43 g) produced at >100 cm distance from the sample tree base (Table 3). Due to high competition between tree and crop the lowest weight of single fruit (22.82 g) was found in T_1 (<50 cm distance from the tree base) while treatment T_2 (50-100 cm distance from the tree base) observed the third highest weight of single fruit (29.68 g) (Table 3). Similar observation was also obtained by Rahman et al. (2004), Farhana et al. (2013), and Kundu et al. (2014) reported smaller sized spinach and bitter gourd fruit in association with *Xylia* and Lohakt tree as agroforestry system.

Table 1. Morphological islandacteristics of bitter gourd during vegetative stage at 25 and 50 DAP in association with Karanja.

Treatment	25 DAP			50 DAP		
	Vine length (cm)	Total leaves per plant	No. of primary branches per plant	Vine length (cm)	Total leaves per plant	No. of primary branches per plant
T_0	31.49 a	16.58 a	1.62 a	44.95 a	25.71 a	3.33 a
T_1	19.24 d	8.40 c	0.33 c	36.27 b	15.37 c	1.33 c
T_2	22.41 c	9.29 bc	1.00 bc	41.85 ab	18.40 b	1.67 bc
T_3	28.36 b	12.29 b	1.33 b	43.00 a	20.00 b	2.34 b
CV	5.253	13.674	34.34	6.48	6.770	23.07
Level of significance	**	**	*	*	**	*

Note: T_0 = Control condition; T_1 = <50 cm from tree base; T_2 = 50-100 cm from tree base; T_3 = >100cm from tree base. The mean differences were evaluated by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) at **1% and *5% level of significance and also by Least Significance Difference (LSD) test.

Table 2. Morphological islandacteristics of bitter gourd during flowering stage in association with Karanja.

Treatment	Vine length (cm)	Total leaves per plant	No. of primary branches per plant	Total female flowers per plant	Total male flowers per plant
T_0	71.24 a	58.21 a	5.43 a	20.45 a	96.45 a
T_1	57.66 d	34.00 d	2.34 c	13.00 c	78.69 d
T_2	60.66 bc	44.59 c	2.66 c	17.00 b	83.71 c
T_3	64.21 b	51.00 b	3.71 b	18.81 ab	90.66 b
CV	3.367	4.448	12.601	6.78	1.093
Level of significance	**	**	**	**	**

Note: T_0 = Control condition; T_1 = <50 cm from tree base; T_2 = 50-100 cm from tree base; T_3 = >100cm from tree base. The mean differences were evaluated by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) at **1% and *5% level of significance and also by Least Significance Difference (LSD) test.

Table 3. Morphological islandacteristics of bitter gourd during harvesting stage in association with Karanja tree.

Treatments	Vine length (cm)	No. of primary branches per plant	No. of leaves per primary branch	No. of fruit per plant	Weight per fruit (g)
T_0	96.45 a	5.71 a	34.36 a	24.00 a	32.71 a
T_1	69.29 d	2.34 b	22.41 c	14.00 d	22.82 c
T_2	76.66 c	4.59 a	30.00 b	18.40 c	29.68 b
T_3	89.07 b	5.43 a	33.47 a	20.43 b	32.43 a
CV	1.545	14.945	3.398	1.741	3.692
Level of significance	**	**	**	**	**

Note: T_0 = Control condition; T_1 = <50 cm from tree base; T_2 = 50-100 cm from tree base; T_3 = >100cm from tree base ** Significant at 1% level of probability.

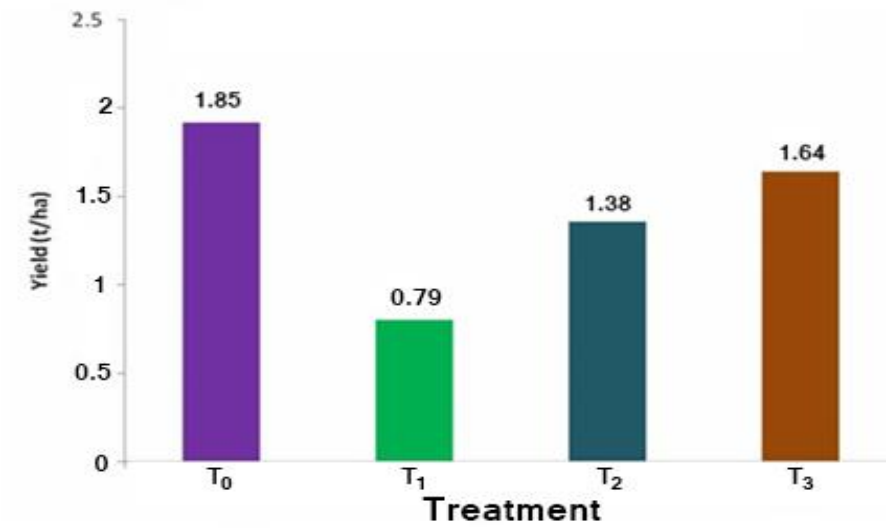

Fig. 1. Yield of bitter gourd in association with Karanja tree in agroforestry production system. T_0 = Open field referred to as control, T_1 = <50 cm, T_2 = 50-100 cm, T_3 = >100 cm distance from the tree

Table 4. Growth of Karanja in association with bitter gourd and without bitter gourd control condition) in agroforestry production system

Production system	No. of trees	Height (cm)			Girth (cm)		
		Before	After	Increment	Before	After	Increment
Without bitter gourd	1	357	410	53	24.92	30.36	5.44
	2	302	352	50	24.32	29.16	4.84
	3	335	380	45	24.92	29.86	4.94
	4	356	416	60	24.12	28.36	4.54
	5	349	397	48	19.52	25.26	5.74
	6	324	313	11	20.32	27.76	7.44
	7	223	404	181	22.32	24.86	2.54
	8	356	358	2	19.82	27.66	7.84
	9	285	328	43	21.82	27.16	5.34
	10	435	471	36	21.42	26.56	5.14
	11	400	440	40	26.72	30.46	3.74
	12	341	381	40	20.82	26.66	5.84
	13	214	290	76	14.92	19.86	4.94
	14	276	330	54	25.02	29.76	4.74
	15	245	299	54	19.52	25.46	5.94
	16	304	363	59	21.12	26.56	5.44
Average		325.20	370.20	45.00	22.10	27.25	5.15
with bitter gourd	1	353	392	39	23.6	26.4	2.8
	2	298	334	36	23.0	25.2	2.2
	3	331	362	31	23.6	25.9	2.3
	4	352	398	46	22.8	24.7	1.9
	5	344	378	34	18.2	21.3	3.1
	6	320	295	25	21.0	23.8	2.8
	7	219	386	167	21.0	20.9	0.1
	8	352	340	12	18.5	23.7	5.2
	9	281	310	29	20.5	23.2	2.7
	10	430	452	22	20.1	22.6	2.5
	11	396	422	26	25.4	26.5	1.1
	12	337	363	26	19.5	22.7	3.2
	13	210	272	62	13.6	15.9	2.3
	14	272	312	40	23.7	25.8	2.1
	15	240	280	40	18.2	21.5	3.3
	16	300	345	45	19.8	22.6	2.8
Average		321.00	352.00	31.00	20.78	23.29	2.51

Yield of bitter gourd with Karanja tree

The yield of bitter gourd (t ha^{-1}) was affected significantly due to effect of different treatments. As evident from the observation of Fig. 1 and 2, the highest fresh (1.85 t ha^{-1}) and dry (0.16 t h^{-1}) yield of bitter gourd were obtained from the treatment T_0 (Open field referred as control) where both yield viz. fresh (1.64 t ha^{-1}) and dry (0.14 t ha^{-1}) were statistically similar to that of the treatment T_3 (>100 cm distance from the tree base). The second lowest yield of bitter gourd (1.38 and 0.12 t ha^{-1}) was obtained from T_2 (50-100 cm distance from the tree base) as fresh and dry yield of bitter gourd, respectively. On the other hand, the lowest fresh (0.790 t ha^{-1}) and dry (0.065 t ha^{-1}) yield were found from closest distance as in treatment T_1 (<50 cm distance from the tree base). Sayed et al. (2009) reported that the highest production of vegetables was recorded in control condition (without tree) and tomato, radish and; soybean

vegetables yield gradually increased with the increases distance of the tree bases.

Tree height of Karanja tree with bitter gourd

The growth performances of Karanja (*Pongamia pinnata*) was significantly influenced by vegetables of bitter gourd. The height of tree is one of the most important growth factor. It depends on the minimum competition of tree and crop as well as the less allelopathic effect on tree and crop each other. While the lowest tree height increment (31.00 cm) was recorded under the combination of tree-bitter gourd production system. The highest tree height increment (45.00 cm) was found in without vegetables condition (Table 4). The highest tree height was recorded under without vegetables that reported by Sayed et al. (2009) and Islam et al. (2009).

Girth of Karanja tree with bitter gourd

The girth of tree is an important growth factor. While the average lowest girth increment (2.51 cm) was found in combination of tree-bitter gourd vegetables. The highest average girth increment (5.15 cm) was recorded from without vegetables condition or control condition (Table 4). The highest tree girth was recorded under without vegetables that was reported by Sayed et al. (2009) and Islam et al. (2009).

Conclusion

The result of this study indicates that the growth and yield of bitter gourd gradually decreased with decreasing distances towards the tree base. Growth of any vegetables are directly related with moisture and nutrients availability in soil. In agroforestry system, a competition occurred for uptaking moisture and nutrients between tree and crop at the beneath of tree canopy. For this reason, may be growth and yield of bitter gourd remarkably reduced near the tree base. Among the different distances from the tree base, yield of bitter gourd is decreased towards the tree base (<50 cm) but the production of bitter gourd is statistically similar with far distance from tree base (>100 cm) . Finally, it may be concluded that the cultivation of bitter gourd is profitable if maintaining proper distances (>100 cm) from the tree base in combination with different trees in island based farming system of Bangladesh.

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