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Indian spinach and Okra cultivation along with *Swietenia hybrida* tree as agroforestry practices

M. R. Hasan, A. Akter, Z. Alam and M. A. Wadud
Department of Agroforestry, Bangladesh Agricultural University, Mymensingh
E-mail: educationmrh@gmail.com and awadudaf@yahoo.com

Abstract: A field experiment was conducted in SPGR (Sponsored Public Goods Research) sub-project research field to evaluate the performance of Indian spinach (*Basella alba*) and Okra (*Abelmoschus esculentus*) in association with Lombu (*Swietenia hybrida*) tree at different distances from tree base during January to June 2012, under the Department of Agroforestry, Bangladesh Agricultural University, Mymensingh. This study was laid out in a Randomized Complete Block Design (RCBD) with three replications and four treatments. Different distances from the tree base were treated as different treatment. There was control treatment i.e. Indian spinach and Okra vegetables were cultivated in the open field condition (without tree). Four treatment of this study were viz. T_0 (open field condition referred as control), T_1 (0.0-2.5 feet distance from the tree base), T_2 (2.5-5.0 feet distance from the tree base) and T_3 (5.0-7.5 feet distance from the tree base). The results showed that in association with Lombu tree fresh yield of both Okra and Indian spinach were gradually increased with increasing distance from tree base. The fresh yield of Indian spinach and Okra were highest in open field condition and these were 43.70 t/ha, 22.53 t/ha respectively. On the other hand the yield of Indian spinach in association with Lombu tree reduced 46.45%, 26.77% and 3.2% in 0.0-2.5 feet, 2.5-5.0 feet and 5.0-7.5 feet distant area, respectively. Similarly the yield of Okra along with Lombu tree reduced 14.20%, 7.15% and 1.73% in 0.0-2.5 feet, 2.5-5.0 feet and 5.0-7.5 feet distant area, respectively. Thus it appears that the yield performance of both Indian spinach and Okra vegetables were better in open field condition comparing to Lombu tree-vegetable association.

Key words: Indian spinach, okra, *Swietenia hybrid*, Agroforestry.

Introduction

Bangladesh, with its unique landscape of forests, uplands, plain and wet lands and a diversified flora and fauna lies across the Tropic of Cancer and the 90º Meridian East. It is a densely populated country with a population of more than 161 million with an annual growth rate of 1.7 percent in some 85,000 villages in a total area of about 14,757,000 ha. The rural population makes up 74 percent of the total production (ESCAP, 2007). Bangladesh has a favorable climatic and hydro-edaphic conditions supporting intensive agriculture. Villages of Bangladesh have a long tradition of growing trees along with other perennial shrubs and herbs. In Bangladesh homestead agroforestry is an operational unit in which a number of crops, trees and shrubs are grown with livestock, poultry and/or fish production, mainly for the purpose of satisfying the farmer's basic needs (Akhter *et al.*, 1997). Therefore it is also a part of the long heritage of traditional agroforestry practices in Bangladesh as well as in other regions of Asia (Abedin and Quddus, 1991; Abedin *et al.*, 1990; Siddiqui and Khan, 1999). Non timber forest products (NTFPs) and vegetables gardens are also found in the agroforestry of poorer households (Siddiqui and Khan, 1999). Agroforestry systems are most extensive in developing countries where approximately 1.2 billion poor people depend directly on a variety of agroforestry products and services (IPCC, 2000). Franzel and Scherr (2002) described that agroforestry is shown to have potential to increase farm incomes and solve environmental problems in the five sub-Sahara African case studies. It is financially more profitable to local farmers in comparison with traditional agriculture, beside its other economic and social benefits. Thus, it can be a potential alternative cultivation practice that helps to enhance poverty reduction and transition to permanent cultivation. With an increased rate of deforestation and limitations to the state forestry activities, agroforestry has now assumed a special significance. The practice may be viewed as technology with considerable potential for the reduction of rural poverty. It is an integrated approach of using the interactive benefits from combining trees and shrubs with crops and/or livestock. It combines agricultural and forestry technologies to create more diverse, productive, profitable, healthy, and sustainable land-use systems. Growing annual crops in association with trees is becoming popular day by day for their higher productivity. Bangladesh is one of the most densely populated countries of the world struggling hard to feed her more than 161 million peoples. If the current population growth rate continues, population will increase to 180 million by the year 2025. The economy of the country draws its strength and stability mostly from agriculture. The country has only a land area of 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) and therefore, steadily declining the land man ratio. The productivity of our land is decreasing day by day due to intensive cropping and use of high input technologies. The average consumption of vegetable in Bangladesh is only 70 g per head per day including potato and sweet potato. Except tuber crops, it is only 30 g as against the FAO recommendation of 200 g. To supply the minimum daily requirement of 200 g vegetable/head/day, national production of vegetable should be increased over 10 million tons in addition. Population of Bangladesh is increasing rapidly, therefore, demand for vegetable is increasing simultaneously whereas the areas under vegetable production including tuber crops are 7,14,000 ha that produce 10.30 million metric tons of vegetable yearly (BBS, 2009). Unfortunately these limited areas are decreasing due to increasing the area of other crops. In Bangladesh, different crops are cultivated in different season. Among the different vegetables, Indian spinach and Okra is the important vegetables in Bangladesh. These are well known and very popular vegetables grown successfully during summer season in Bangladesh. Present study was undertaken to examine the morphological performance of Indian spinach and Okra in association with Lombu tree at different distance from tree base and to find out the optimum distance from tree base where the production of Indian spinach and Okra were satisfactory.

Materials and Methods

Experimental site: The experiment was carried out at char Kalibari belongs to the Mymensingh Sadar Upazilla during the period from January to June 2012. The district Mymensingh is located between 24˚38'3" North and 90˚16'4" East Latitude (Fig.1). Total area of this district is 4363.48 km^2 and situated on the west bank of Brahmaputra River. The geographical position of char Kalibari located between 24˚45' to 24˚45'40" North and 90˚24'4" to 90˚24'44" East Latitude (Fig.1). It is an attached Char land which has three distinct elevations i.e. upper elevation is relatively stable char, while the middle and lover elevation remained inundated during the rainy season in each year. Only upper portion is suitable for cultivation of vegetables during summer and winter season.

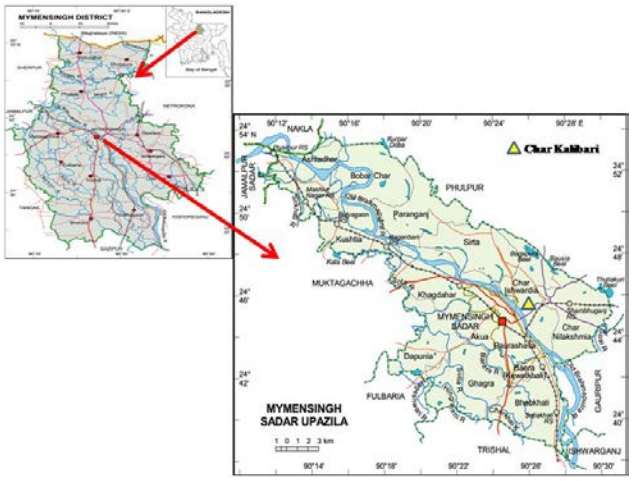

Fig. 1. Location of the study area

Tree and planting materials: In this study the two years old previously established Lombu trees (*Swietenia hybrida*) were used as tree components. The seeds of Indian spinach (*Basella alba*) variety viz., BARI Puishak-1 (Chitra) were purchased from BRAC seed center. The seeds of Okra (*Abelmoschus esculenta*) variety BARI Dherosh-1 were also collected from International Seed Fair in Bangladesh Agricultural University campus, Mymensingh. These two vegetables were used as plant materials in this study.

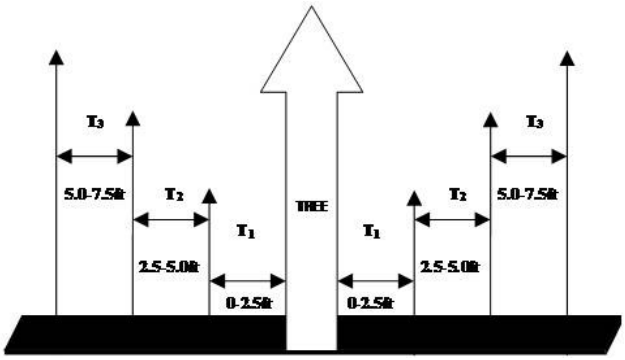

Fig. 2. Layout of the study area

Experimental design and treatment combination: Two crops such as Indian spinach and Okra were laid out (Fig. 2) separately following the Randomized Complete Block Design (RCBD) with three replications. Four treatments were used in this study such as, T_0 (Open field referred to as control), T_1 (0.0 feet to 2.5 feet distance from the tree base), T_2 (2.5 feet to 5.0feet distance from the tree base), T_3 (5.0 feet to 7.5 feet distance from the tree base).

Sampling procedure and data collection: Indian spinach plant samples were collected randomly from all rows of the respective plots. Ten representative sample plants were selected from each plot for data collection. Sample plants were collected at 50, 60, 70, 80 & 90 days after sowing. The leaf stem ratio was determined by dividing the leaf weight by stem weight. For determining dry yield/ dry weight of plants, 100 *g* subsamples were oven dried at 70^0C for 72 hours. Dry yield was calculated using the following formula:

$$\text{Total dry weight} = \frac{\text{Subsample oven dried weight}}{\text{Subsample fresh weigh}} \times \text{Total fresh weight}$$

Plant samples of Okra were collected randomly from all rows of the respective plots. Ten plants of Okra were selected from each plot for data collection. The parameter such as plant height, number of leaves per plant, number of branches per plant, number of fruit per plant, single fruit weight, fruit length, fruit girth and days to first edible fruit harvest was considered for data collection. Dry yield was calculated by previous method as well as dry yield of Indian spinach

Statistical analysis: Data were analyzed statistically by ANOVA to examine whether treatment effects were significant (Gomez and Gomez, 1984). Mean value were compared by DMRT (Duncan's Multiple Range Test). The software package, MSTATC was followed for statistical analysis.

Results and Discussion

Indian spinach

Indian spinach was cultivated under different distance from the Lombu tree base. Different growing parameters such as plant height, leaf numbers per plant, leaf size, twigs number per plant, weight of leaves per plant, weight of stems per plant and leaf stem ratio were significantly influenced by different distances from tree base (Fig. 3). Except plant height and leaf stem ratio all others growing parameters were highest in open field condition and lowest in 0.0-2.5 feet distances from the tree base at every five harvesting time (Table 1).

Fig. 3. Indian spinach cultivation along with Lombu tree

Plant height: The result shows that plant height of Indian spinach gradually decreases with increasing the distance from tree base at each harvesting time i.e. first, second, third, fourth and fifth time harvest. These were probably

due to higher apical dominance under shade condition (Hillman, 1984). Among the four distance levels, the tallest plants (43.6 cm, 42.7 cm, 45.5 cm, 43.2 cm and 40.2 cm) were produced within T_1 (0.0-2.5 feet distance from the tree) and shortest plant near the tree base (Table 1). Plant height of Indian spinach grown within T_0 and T_3 level was statistically similar and intermediate as compared to T_1 and T_2 level at every harvesting time. This may be attributed due to the stimulation of cellular expansion and cell division under shaded condition (Schoch, 1972).

Leaf number: The number of leaves increased gradually with increasing the distance from tree base at every harvesting time. The highest number of leaves per plant (50, 125.2, 119.5, 112.3 and 82.6) at first, second, third, fourth and fifth time harvest, respectively, under full sunlight was statistically similar to (46, 121.2, 115.2, 109.6 and 78.5) that of 5.0-7.5 feet distance from the Lombu tree bases (Table 1). The lower number of leaves per plant at every harvesting time under T_1 (0.0-2.5 feet distance from tree base) level for reduced light conditions may be due to lower production of photosynthates under low light conditions for a longer period and tree crop competition for food, space, light and water etc.

Table 1. Morphological characteristics of Indian spinach in association with Lombu tree at different harvesting time

Harvesting period	Treatment	Morphological characteristics of Indian spinach								
		Plant length (cm)	Number of leaves/plant	Numberof twigs/plant	Leaf length (cm)	Leaf breadth (cm)	Stem girth (cm)	Weight of leaves/plant (g)	Weignt of stem/plant (g)	Leaf stem ratio
First at 50 DAS	T_0	38.5c	50a	2a	14.6a	8.5a	3.5a	200a	130a	1.54a
	T_1	43.6a	40d	1.3c	11.5c	6.1c	2.3c	133d	90c	1.48a
	T_2	41.4b	42c	1.6b	13.1b	6.9b	2.8b	150c	102b	1.47b
	T_3	39.3c	46b	2a	14.3a	8a	3.4a	180b	126a	1.43b
Second at 60 DAS	T_0	37.5c	125.2a	4.8a	13.8a	8.1a	3.4a	432a	280a	1.54c
	T_1	42.7a	82.5c	3.2d	9.5c	4.2d	2.2c	256c	130d	1.96a
	T_2	40.3b	92.5c	3.8c	11.5b	5.9c	2.8b	340b	182c	1.86a
	T_3	38.1c	121.2c	4.5b	13.5c	7.0b	3.3a	428a	262b	1.63b
Third at 70 DAS	T_0	38.5b	119.5a	4.5a	14.5a	7.8a	3.7a	430a	290a	1.48c
	T_1	45.5a	54.3c	2.1c	11.5b	5.8b	2.1c	262c	133d	1.96a
	T_2	44.2a	75.3b	3.2b	12.3b	6.2b	2.8b	290b	172c	1.68b
	T_3	38.0b	115.2a	4.4a	14.2a	7.7a	3.6a	417a	233b	1.78b
Fourth at 80 DAS	T_0	37.0c	112.3a	4.1a	13.6a	6.9c	3.4a	380a	320a	1.18d
	T_1	43.2a	72.6b	1.8b	9.7c	3.2c	1.7c	170c	95d	1.78b
	T_2	40.2b	81.2b	2.2b	11.6b	4.7b	2.2b	210b	131c	1.60c
	T_3	36.8c	109.6a	3.6a	13.2a	6.5a	3.1a	375a	182b	2.06a
Fifth at 90 DAS	T_0	36.0c	82.6a	3.3a	12.8a	6.4a	3.1a	290a	172a	1.68c
	T_1	40.2a	55.2c	1.3c	7.5c	3.2c	1.4c	120c	70c	1.71c
	T_2	38.3b	68.2b	1.6c	9.7b	4.9b	2.2b	170b	90b	1.89a
	T_3	34.3d	78.5a	2.8b	12.4a	6.2a	3.0a	282a	160a	1.76b

Means in different column followed by the different letter are significantly different by DMRT at $P \leq 0.05$; Where, T0 = Open field referred as control, T1= 0.0 feet to 2.5 feet distance from the tree, T2 = 2.5 feet to 5.0 feet distance from the tree, T3 = 5.0 feet to 7.5 feet distance from the tree.

Number of twigs: The effect of different distance levels at different harvesting period from tree base on the number of twigs per plant were almost similar to the number of leaf per plant (Table 1), where the highest number of twigs per plant (2, 4.8, 4.5, 4.1 and 3.3 at first, second, third, fourth and fifth time harvest, respectively) were recorded under open place and 5.0-7.5 feet (2, 4.5, 4.4, 3.6 and 2.8 at first, second, third, fourth and fifth harvesting time, respectively) distance from tree base. Significant reduction of the number of twigs per plant was observed, when the distance was further reduced. The lower number of twigs under shaded conditions might be due to higher auxin production in plant grown under shaded condition which ultimately suppressed the growth of lateral branches.

Leaf size (Length x Breadth): Both length and breadth of Indian spinach leaves were significantly influenced by different levels of distance from tree base at every harvesting time and the pattern of variation in both cases was almost identical (Table 1). Leaf size decreased progressively with decreasing distance from tree base. Similar observation was reported earlier by Yoshida and Parao (1976) who observed that vegetables grown under shade resulted ill smaller leaves. Among the four distance levels, the biggest leaf size (14.6 × 8.5 cm) was obtained in open place and the smallest leaf (37.7 cm× 17.7 cm) was obtained in 0.0-2.5 feet distance from tree base. This may be due to the stimulation of cellular expansion and cell division under shaded conditions (Schoch, 1972).

Stem girth: Stem girth of Indian spinach grown under full sunlight (3.5 cm, 3.4 cm, 3.7 cm, 3.4 cm and 3.1 cm at first, second, third, fourth and fifth time harvest, respectively) and 5.0-7.5 feet distance (3.4 cm, 3.3 cm, 3.6 cm, 3.1 cm and 3.0 cm at first, second, third, fourth and fifth time harvest, respectively) were statistically identical but reduced drastically when grown under 2.5-5.0 feet distance (2.8 cm, 2.8 cm, 2.8 cm, 2.2 cm and 2.2 cm at first, second, third, fourth and fifth harvest time, respectively) and 0.0-2.5 feet distance (2.3 cm, 2.2 cm, 2.1 cm, 1.7 cm and 1.4 cm at first, second, third, fourth and fifth time harvest, respectively).

Leaf weight: Leaf weight of Indian spinach per plant decreased substantially as the distance decreased (Table 1). Among the four distance levels, the highest weight of leaves per plant were obtained under full sunlight (200 g, 432 g, 430 g, 380 g and 290 g at first, second, third, fourth and fifth time harvest, respectively); whereas the lowest (133 g, 256 g, 262 g, 170 g and 120 g at first, second, third, fourth and fifth time harvest, respectively) were obtained within 0.0-2.5 feet distance form the trees.

Stem weight: The highest weight of stem per plant (130 g, 280 g, 290 g, 320 g and 172 g at first, second, third, fourth and fifth time harvest, respectively) were produced under full sunlight condition which was statistically similar to that of 5.0-7.5 feet distance form the tree base (126 g, 262 g, 233 g, 182 g and 160 g at first, second, third, fourth and fifth time harvest, respectively). But significant reduction

of stem weight per plant (120 g, 182 g, 172 g, 131 g and 90 g at first, second, third, fourth and fifth time harvest, respectively) were observed within 2.5-5.0 feet distance and the lowest stem weight per plant (90 g, 130 g, 133 g, 95 g and 70 g at first, second, third, fourth and fifth time harvest, respectively) were produced within 0.0-2.5 feet distance from tree base.

Leaf stem ratio: The leaf stern ratio of Indian spinach progressively decreased with decreasing distance from Lombu tree base at different harvesting time (Table 1). This might be due to reduced production of number of leaves per plant, smaller leaves and increased length of stem under reduced light conditions. At first harvest time highest leaf stem ratio was 1.54 under open field condition and lowest was 1.43 under 5.0-7.5 feet distance from tree base. At second and third harvesting time the highest leaf stem ratio were 1.96 and 1.96, respectively, under 0.0-2.5 feet distance from the tree base and lowest were 1.45 and 1.48, respectively under open field condition.

Table 2. Fresh yield (t/ha) and dry (t/ha) yield of Indian spinach along with Lombu tree

Yield	Treatment	First harvest	Second havrest	Third harvest	Fourth harvest	Fifth harvest	Total
Fresh	T_0	4.6a	11.3a	10.8a	9.2a	7.8a	43.7a
	T_1	2.5c	6.8c	6.3c	4.6c	3.2c	23.4c
	T_2	3.8b	8.9b	8.2b	6.5b	4.6b	32.0b
	T_3	4.5a	11.1a	10.2a	8.9a	7.6a	42.3a
Dry	T_0	0.32a	0.73a	0.72a	0.65a	0.55a	2.97a
	T_1	0.15c	0.38c	0.4c	0.31c	0.25c	1.49c
	T_2	0.22b	0.53b	0.5b	0.41b	0.35b	2.01b
	T_3	0.31a	0.71a	0.7a	0.63a	0.54a	2.89a

Means in different column followed by the different letter are significantly different by DMRT at $P \leq 0.05$; Where, T_0 = Open field referred as control, T_1= 0.0 feet to 2.5 feet distance from the tree, T_2 = 2.5 feet to 5.0 feet distance from the tree, T_3 = 5.0 feet to 7.5

Yield: Different distance from tree base had significant influence on the both fresh yield and dry yield of Indian spinach and yield gradually increased with increasing the distance from tree base (Table 2). At every harvesting period the highest both fresh yield and dry yield were found in open field condition which were statistically alike to second highest were found in 5.0-7.5 feet distance from Lombu tree base (Table 2). The lowest both fresh yield and dry yield were found in 0.0-2.5 feet distance from tree base at every harvesting time (Table 2). Total fresh yield of Indian spinach in different distance category i.e. 0.0-2.5 feet, 2.5-5.0 feet and 5.0-7.5 feet from tree base were 46.45%, 26.77% and 3.2% reduced compare to it open field condition. Considering this result it is clear that two years old Lombu tree negatively affect the yield of associated crops / vegetables up to 5 feet distance from the tree base. Similar result also observed by Tanni *et al*., (2010) and Habib *et al.,* (2012) in different winter and summer vegetable in association with Lohakat (*Zylia dolabiformis*) tree in agroforestry system. Total dry yield of Indian spinach was 6.79% of total fresh yield in open field condition and 6.54% when it grown in association with trees i.e. 0.25% greater in open field condition. These results indicate fresh yield under tree i.e. partial shade condition content more water than open field condition. Wadud and Miah (2000, 2001) was observed fresh yield of Kangkong and Okra under shade condition content more water compare to open field condition and they opined the possible cause of this higher water content was due to less transpiration under shade condition.

Okra

Morphological behavior/characteristics and yield of Okra along with Lombu tree significantly influenced in different distances from tree base (Fig. 4).

Fig. 4. Okra cultivation along with Lombu tree

Plant height: Different distance from tree base significantly influenced the height of Okra where it's grown in open field were much shorter than those grown under short distance (Table 3). The growth of Okra was more vigorous in the open field than those grew close distance to the tree. The highest average plant height of Okra was 131.2 cm, found in T_1 (0.0-2.5 feet distance) and lowest average plant height of Okra was 120.6 cm, found in T_0 (open field referred as control). Plant grown in low light levels was found to be more apically dominant than those grown in high light environment resulting in taller plants under shade (Hillman, 1984).

Leaf number: Different distance from tree base significantly influences the number of leaves per plant of okra (Table 3). It has been shown that okra grown at open field produced the highest number of leaves per plant (54.25). Okra grown at 0.0-2.5 feet distance produced the number of leaves per plant (51.5) which was statistically similar to those grown at 5.0-7.5 feet distance (51.32). At open field highest number of leaves produce because shade effect is less in open place than closed distanced from the tree. The lower number of leaves per plant at the reduced light conditions may be due to lower production of photosynthates under low light conditions for a longer period (Miah *et al.,* 1999).

Number of branches per plant: Okra grown in open field level produced more number of branches per plant (3.75) which was similar to within 5 feet to 7.5 feet distance from tree base (Table 3). But number of branches per plant of okra was depressed remarkably when grown at 5 feet distance from tree base (3.25) and even more depressed when grown at 2.5 feet distance (2.85). The lower number of branches under shaded conditions due to higher auxin production in plant grew shaded condition which ultimately suppressed the growth of lateral branches (Miah *et al.*, 1999).

Number of fruit per plant: Number of fruits plant is the most important yield contributing character, which was also significantly influenced by different distance of growing Okra plant from the tree. The maximum number of fruits per plant was found in the open field (51.17). The lower number of fruits per plant (45.25) was found under close contact of the tree condition (0.0-2.5 feet distance

from tree base) and it was probably due to poor photosynthetic capacity and nutrients competition between tree and crops. Basak *et al*., (2009) also showed that the yield contributing characters of the vegetables increased gradually with the increase of planting distance from the tree. Khatun *et al., (*2009) showed the similar results.

Fruit weight: Single individual fruit weight of okra grown at different distance was affected significantly (Table 3). The heaviest single fruit (19.75 g) was produced under open field and was followed identically by 5.0-7.5 feet distance from tree base (19.12 g). However, it reduced significantly when the distance was further reduced to 2.5-5.0 feet (18.33 g) and 0.0-2.5 feet (17.55 g), although, the fruit weight tended to be reduced progressively with reduced distance. Due to high competition between tree and crop the lowest yield per plant (17.55 g) was found in T_1 (0.0-2.5 feet distance from the tree).

Fruit length: Fruit length of plant is one of the important yields contributing character, which was also significantly influenced by different distance of growing Okra plant from the tree. The maximum average length of fruits per plant was found in the open field (16.12 cm). The lower number of fruits per plant (13.28 cm) was found under close contact of the tree condition (0.0-2.5 feet distance form tree base) and it was probably due to poor photosynthetic capacity and nutrients competition between tree and crops.

Fruit girth: The fruit girth of okra was also affected by different distance (Table 3). In general, fruit girth increased gradually with increasing crop distance form tree base because photo synthetically active radiation levels become higher and tree crop competition become low in open place. The highest fruit girth observed under open field was 5.44 cm which was statistically similar to that of 5.0-7.5 feet distance from tree base (5.28 cm). Again, the lowest fruit girth recorded under 2.5-5.0 feet distance from tree was 4.78 cm which was statistically similar to that of 0.0-2.5 feet distance from tree base (4.25 cm).

Table 3. Morphological characteristics of Okra in association with Lombu tree at different distance from tree base

Treatment	Morphological characteristics of okra							
	Plant height (cm)	Number of leaves/plant	Number of branches/plant	Number of fruit/plant	Single fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Days to first edible fruit harvest
T_0	120.6d	54.25a	3.75a	51.17a	19.75a	16.12a	5.44a	49c
T_1	131.2a	51.5c	2.85d	45.25c	17.55d	13.28c	4.25c	52a
T_2	128.4b	52.4b	3.25c	48.32b	18.33c	14.33b	4.78b	50b
T_3	122.7c	51.32c	3.66b	50.55a	19.12b	15.98a	5.28a	49c

Means in different column followed by the different letter are significantly different by DMRT at $P \leq 0.05$; Where, T_0 = Open field referred as control, T_1= 0.0 feet to 2.5 feet distance from the tree, T_2 = 2.5 feet to 5.0 feet distance from the tree, T_3 = 5.0 feet to 7.5 feet distance from the tree.

Days to first edible fruit harvest: Remarkable variation in number of days to first edible fruit harvest of okra due to different reduced distance was observed (Table 3) where the days to first edible fruit harvest became significantly shorter (49) and longer (52) under open field and 0.0-2.5 feet distance form tree base respectively. The days to first edible fruit harvest under open field (49) and 5.0-7.5 feet distance (49) was statistically similar.

Table 4. Fresh yield t/ha) and dry yield (t/ha) of Okra along with Lombu tree

Yield	Treatment	Period I (0-14 days)	Period II (15-29 days)	Period III (30-44 days)	Period IV (45-69 days)	Total (0-69 days)
Fresh	T_0	2.88a	5.65a	7.22a	6.87a	22.53a
	T_1	2.35c	5.15c	6.23c	5.60c	19.33c
	T_2	2.55b	5.35b	6.90b	6.12b	20.92b
	T_3	2.75a	5.67a	7.05a	6.67a	22.14a
Dry	T_0	0.18a	0.38a	0.45a	0.43a	1.44a
	T_1	0.13c	0.29c	0.35c	0.32d	1.09c
	T_2	0.15b	0.34b	0.39b	0.37c	1.25b
	T_3	0.17a	0.37a	0.43a	0.40b	1.37a

Means in different column followed by the different letter are significantly different by DMRT at $P \leq 0.05$; Where, T_0 = Open field referred as control, T_1= 0.0 feet to 2.5 feet distance from the tree, T_2 = 2.5 feet to 5.0 feet distance from the tree, T_3 = 5.0 feet to 7.5 feet distance from the tree.

Yield: As like as yield of Indian spinach, the both fresh yield and dry yield of Okra were gradually increased with increasing the distance at every harvesting period and highest both fresh yield and dry yield were found in open field condition and lowest were found in 0.0-2.5 feet distance from tree base (Table 4)**.** Total fresh yield of Okra in different distance group i.e. 0.0-2.5 feet, 2.5-5.0 feet and 5.0-7.5 feet from tree base were 14.20%, 7.15% and 1.73% reduced compare to it open field condition. This result indicates that yield in the 7.5 feet far from tree base was almost similar with open field condition which also indicate there is no negative interaction or competition between tree crop root zone of this area (> 5 feet from the tree base). Another information found this result also formed that interaction up to 5 feet far from tree base was negatively affected the yield of Okra similarly Indian spinach. Considering this result it is clear that two years old Lombu tree negatively affect the yield of associated crops/vegetables up to 5 feet distance from the tree base. Similar result also observed by Tanni *et al*., 2010) and Habib *et al.,* (2012) in different winter and summer vegetable in association with Lohakat (*Zylia dolabiformis*) tree. Total dry yield of Okra was 6.39% of total fresh yield in open field condition and 5.94% when Okra grown in association with trees i.e. 0.45% greater in open field condition (Table 4). These results indicate fresh yield under tree i.e. partial shade condition content more water than open field condition. Wadud and Miah (2000, 2001) observed that fresh yield under shade condition content more water compare to open field condition in Kangkong and Okra and also investigated the possible cause of this higher water content was less transpiration under shade condition.

From these studies, it is concluded that the performance of Indian spinach and Okra i.e. yield and yield contributing characters under different distances from the Lombu tree base were different. Under open field condition the performance of Indian spinach and Okra were better than those of the other treatments. But also it was observed that these two vegetables can be grown in association with Lombu tree as agroforestry system in 5.0-7.5 feet distance

from tree base by scarifying 3.20% and 1.73% yield loss, respectively. Near the tree base completion for light, air, water, space, nutrients etc. were severe but after 5 feet distances from the tree base such type of competition were minimum. So, it may clear that both the vegetables Indian spinach and Okra are suitable in agroforestry systems at early stage of plantation.

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