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Interaction effect of four years old *Xylia dolabriformis* tree on the growth and yield of summer vegetables

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Abstract: A field experiment was conducted at the Agroforestry Farm of Bangladesh Agricultural University, Mymensingh, during the period from 05 February 2012 to 25 May 2010 to observe the performance (growth and yield) of Indian spinach, Amaranth, Okra, Bottle gourd, Sweet gourd and Kangkong grown at different distances from the *Xylia dolabriformis*. Different treatments of the experiment were T_0 (open field referred as control), T_1 (3 feet distance from tree), T_2 (6 feet distance from tree) and T_3 (9 feet distance from tree). The experiment was laid out in RCBD for all six crops with 3 replications. The objectives of the study were to observe the performance of summer vegetable in association with *Xylia dolabriformis* tree and to observe interaction effect of *Xylia dolabriformis* tree on summer vegetables. The result of the experiment revealed that the growth and yield of the vegetables increased gradually with the increase of planting distance from the tree base. Except kangkong and Okra, highest yield of other four vegetables i.e. Indian spinach, Amaranth, Bottle gourd (as leafy vegetable) and Sweet gourd (as leafy vegetable) were in open field condition. Yield of Indian spinach, Amaranth, Bottle gourd (as leafy vegetable) and Sweet gourd (as leafy vegetable) in open field condition were 55.2, 12.7, 43.7 and 40.3 t/ha, respectively. Yield Kangkong and Okra were highest in 9 feet distant plot from tree base and the values were 39.2 and 15.5 t/ha. But yield of all vegetables in open field condition and 9 feet distant plot from tree base was statistically similar. Yield of tested all summer vegetables was lower near the upto three feet from base of Lohakat tree. 20-30% yield reduced within the 3-6 feet distance from the base of tree and in case of Kankong yield was similar with control. Very near the tree base yield reduce may be due to competition by tree roots for water and nutrients.

Key words: Summer vegetables, *Xylia dolabriformis*, growth, yield, tree-crop interaction, agroforestry.

Introduction

Agroforestry 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. Agroforestry, the integration of tree and crop or vegetable on the same area of land is a promising production system for maximizing yield and maintaining friendly environment (Nair, 1990). In agroforestry systems, trees or shrubs are intentionally used within agricultural systems, or non-timber forest products are cultured in forest settings. Knowledge, careful selection of species and good management of trees and crops are needed to optimize the production and positive effects within the system and to minimize negative competitive effects. 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 capacity of our land is decreasing day by day due to intensive cropping and use of high input technologies. The climate and soil of Bangladesh are favorable for vegetable production. In Bangladesh, a large number of vegetable are grown throughout the year including summer season. About 30 per cent of vegetable are produced in summer and rainy seasons.

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 200g. To supply the minimum daily requirement of 200g vegetable/head/day, national production of vegetable should be over 10 million ton 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. 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. On the other hand, in Bangladesh the demand of food crops is increasing rapidly due to ever increasing population. The population has doubled in the last 30 years and 910 persons are living per square kilometer at present. This put heavy pressure on land for human habitation and crop production.

In Bangladesh, different crops are cultivated in summer season. Among the different summer vegetables, Indian spinach, Amaranth, Okra, Bottle gourd, Sweet gourd and Kangkong are the important summer vegetables in Bangladesh. These are well known and very popular vegetables grown successfully during summer season in Bangladesh. Though the aforementioned vegetables are very common to all and have good potential in our climate, none of them was systematically tested in agroforestry system or in natural shade condition to see their production ability under partial shade conditions. For identifying the compatible tree-crop combination, particularly under storey species i.e. different crops should be screened out in terms of their adaptability and yield in association with the early stage of tree. For this purpose, the best way of experimentation is to grow different crops at different spacing from the tree. So, if we know the suitability of different crops in terms of growth and yield, it would be very useful information for selecting the best tree-crop combination. In this regard present study investigates the interaction effect four years old Lohakat (*Xylia dolabriformis*) tree on the growth and yield of different summers vegetables.

Materials and Methods

Experimental site: The experiment was carried out at the Field Laboratory of the Department of Agroforestry, Bangladesh Agricultural University, Mymensingh during the period from 05 February 2012 to 25 May 2012.. The experimental site was located at 24.75˚N latitude and 90.5E longitude at the mean elevation of 18m above the sea level (FAO, 1988). The climatic condition of the experimental site 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.

Planting material: In this study the four years old previously established *Xylia dolabriformis* tree were used as tree components. Six different summer vegetables like Indian spinach, Amaranth, Okra, Bottle gourd (as leafy vegetables), Sweet gourd (as leafy vegetables), and Kangkong were grown along this tree for observing interaction effect. The seeds of Indian spinach variety viz., BARI Puishak-1 (Chitra) were purchased from BRAC seed center, seeds of Amaranth variety viz., BARI Danta - 2 were collected from International Seed Fair in BAU campus Mymensingh, the seeds of Bottle gourd variety BARI lau-4 and Sweet gourd variety BARI Misti Kumra-1 were collected from International Seed Fair in Bangladesh Agricultural University campu, Mymensingh. The seeds of Okra variety BARI Dherosh-1 and Kangkong variety BARI Gimakalmi were also collected from International Seed Fair in Bangladesh Agricultural University campus, Mymensingh. These six summer vegetables were used as plant materials in this study.

Experimental design and layout: Six summer crops such as Indian spinach, Amaranth, Okra, Bottle gourd, Sweet gourd and Kangkong were laid out following the Randomized Complete Block Design (RCBD) with single factorial arrangement having three replications (Fig. 1). Individual plot size was 9ft x 2ft. Each treatment was replicated 3 times. Four treatments were used in this study which were, T_0 = Open field referred to as control, T_1 = 3 feet distance from the tree base, T_2 = 6feet distance from the tree base, and T_3 =9 feet distance from the tree base.

Crop Establishment: Seeds of six vegetables (Indian spinach, Amaranth, Okra, Bottle gourd, Sweet gourd and Kangkong) were directly sown in the experimental plot on 15 February 2012 (Fig. 1). The seeds of Indian spinach were sown continuously; spacing was 20 cm x 30 cm. Seeds of Amaranth were sown following broadcasting method of seed sowing. After the emergence Amaranth seedlings were thinned out. Seeds of Okra were sown following the spacing 30 cm x 35 cm. Seeds of Bottle gourd and Sweet gourd were sown following the spacing 40 cm x 45 cm. Seeds of Kankong were sown following the line sowing method and the spacing was 10 cm x 20 cm. All necessary cultural operations were done when it was required.

Harvesting: Indian spinach was harvested 3 times; first harvesting was done after 60 days of seed sowing. Amaranth was harvested 3 times and first harvesting was done 25 days after the emergence of the seedlings. Okra was harvested in several pickings; first harvesting was done 70 days after the seed sowing. Bottle gourd and Sweet gourd were harvested by cutting the twigs as vegetables as they were not grown for fruit cultivation. Kangkong was harvested 3 times and first harvesting was done after 55 days after seed sowing.

Data collection and analysis: Related data were recorded from the different treatment of this study. The growth and yield parameters of all tested vegetables viz., Plant height (m), Number of leaves per plant, Number of branches per plant, stem girth (cm), weight per plant (g), total yield was estimated from plant/fruit weight as t/ha. 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.

Fig.1. Experimental view (A) After 20 days (B) After 30 days (c) After 35 days (D) After 40 days

Results and Discussion

Interaction effect of four years old *Xylia dolabriformis* tree on the growth and yield of Indian spinach, Amaranth, Okra, Bottle gourd, Sweet gourd and Kangkong are presented here separately for Growth and yield:

Effect on growth parameters:

Indian spinach: Morphological characteristics Indian spinach significantly affected by *Xylia dolabriformis* tree at different distances from tree base (Table 1). Branch length (cm), branch plant^{-1}, leaves plant^{-1}, stem weight per plant^{-1}, leaf weight plant^{-1} and weight plant^{-1}of Indian spinach were influenced by Lohakat tree in a similar pattern where highest values of all above parameters was in open field condition which was statistically similar with 9 feet distance from tree base (Table 1). Among the different distance group highest value was in 9 feet distant plnats followed by 6 feet and 3 feet distant plants. Highest

values of Branch length (cm), branch plant^{-1}, leaves plant^{-1}, stem weight per plant^{-1}, leaf weight plant^{-1} and weight plant^{-1} were 51cm, 5, 30, 90g, 142g and 232g, respectively. Near the tree base growth of all morphological parameters was less vigorous compare to distant plant from tree base. This might be due to negative interaction between tree-vegetable root systems for growth resources like water and nutrients. Khatun *et al.* (2009) observed similar type interaction in winter vegetables in association Civit tree.

Amaranth: Like Indian spinach Morphological characteristics Amaranth also significantly affected by Lohakat tree at different distances from tree base (Table 2). Plant height (cm), leaves plant^{-1}, stem weight per plant^{-1}, leaf weight plant^{-1} and weight plant^{-1}of Amaranth were influenced by Lohakat tree in a similar pattern where highest values of all above parameters was in open field condition which was statistically similar with 9 feet distance from tree base (Table 2). Among the different distance group highest value was in 9 feet distant plnats followed by 6 feet and 3 feet distant plants. Highest values of Plant height (cm), leaves plant^{-1}, stem weight per plant^{-1}, leaf weight plant^{-1} and weight plant^{-1}of Amaranth were 91cm, 19, 160g, 80g and 240g, respectively. Near the tree base growth of all morphological parameters was less vigorous compare to distant plant from tree base. This might be due to negative interaction between tree-vegetable root systems for growth resources like water and nutrients. Islam *et al.* (2009) observed similar type interaction in winter vegetables in association *Hopea odoratat* tree.

Table 1. Morphological characteristics of Indian spinach in association with *Xylia dolabriformis* tree

Treatment	Branch plant^{-1}	Av. Length of branch (cm)	Leaves plant^{-1}	Stem weight plant^{-1} (g)	Leaf weight plant^{-1} (g)	Weight plant^{-1} (g)
T_1	2c	38c	12c	30c	52c	82c
T_2	3b	41b	21b	58b	101b	159b
T_3	4a	45a	25a	68a	116a	184a
T_0	5a	51a	30a	90a	142a	232a

Means in column followed by the different letter are significantly different by DMRT at P ≤0.05; T_1=3 feet distance fro the tree, T_2= 6 feet distance form the tree, T_3= 9 feet distance from the tree, T_0= Open field referred as control.

Table 2. Morphological characteristics of Amaranth in association with *Xylia dolabriformis* tree

Treatment	Plant height (cm)	Leaves plant^{-1}	Stem wt. plant^{-1} (g)	Leaf wt. plant^{-1} (g)	Wt. plant^{-1} (g)
T_1	56c	12c	60c	44c	104c
T_2	78b	16b	122b	68b	190b
T_3	88a	17a	148a	75a	223a
T_0	91a	19a	160a	80a	240a

Means in column followed by the different letter are significantly different by DMRT at P ≤0.05; T_1=3 feet distance fro the tree, T_2= 6 feet distance form the tree, T_3= 9 feet distance from the tree, T_0= Open field referred as control.

Okra: Morphological behaviors of Okra significantly influenced by *Xylia dolabriformis* tree at different distances from tree base (Table 3). Plant height (cm), flower plant^{-1}, fruit plant^{-1}, fruit length (cm) and weight plant^{-1}of Okra were influenced by Lohakat tree in a similar pattern where highest values of all above parameters was in open field condition which was statistically similar with 9 feet distance from tree base (Table 3). Among the different distance group highest value was in 9 feet distant plants followed by 6 feet and 3 feet distant plants. Highest values of Plant height (cm), flower plant^{-1}, fruit plant^{-1}, fruit length (cm) and weight plant^{-1} of Okra were 145cm, 6, 6, 16cm, and 75g, respectively. Near the tree base growth of all morphological parameters was less vigorous compare to distant plant from tree base. This might be due to negative interaction between tree-vegetable root systems for growth resources like water and nutrients. Basak *et al.* (2009) observed similar type influence in Radish, Tomato and Soybean along with two years old Lohakat tree.

Table 3. Morphological characteristics of Okra in association with *Xylia dolabriformis* tree

Treatment	Av.plant height (cm)	Flowers plant^{-1}	Fruit plant^{-1}	Av. Length of fruit (cm)	Total fruit weight (g)
T_1	94b	2b	1b	9b	16b
T_2	103b	3b	3b	13b	65b
T_3	127a	5a	5a	14a	69a
T_0	145a	6a	6a	16a	75a

Means in column followed by the different letter are significantly different by DMRT at P ≤0.05; T_1=3 feet distance fro the tree, T_2= 6 feet distance form the tree, T_3= 9 feet distance from the tree, T_0= Open field referred as control.

Bottle gourd (as leafy vegetable): Growth of bottle gourd (as leafy vegetable) significantly influenced by *Xylia dolabriformis* tree at different distances from the tree base (Table 4). Branch length (cm), branches plant^{-1}, Leaves plant^{-1}, Stem weight plant $^{-1}$ (g), leaf weight plant $^{-1}$ (g) and weight plant^{-1}of bottle gourd were influenced by Lohakat tree in a similar pattern where highest values of all above parameters was in open field condition which was statistically similar with 9 feet distance from tree base (Table 4). Among the different distance group highest value was in 9 feet distant plnats followed by 6 feet and 3 feet distant plants. Highest values of Branch length (cm), branches plant^{-1}, Leaves plant^{-1}, Stem weight plant $^{-1}$ (g), leaf weight plant $^{-1}$ (g) and weight plant^{-1}of were 125cm, 5, 29, 112g, 218g and 330g, respectively. Close the tree base growth of morphological parameters of bottle gourd were less vigorous compare to distant plant from tree base. This may be due to competitive interaction between bottle gourd and lohakat tree root systems for water and nutrients. Khatun *et al.* (2010) reported competitive interaction between medicinal plants and winter vegetables near the base area of medicinal plants.

Table 4. Morphological characteristics of Bottle gourd in association with *Xylia dolabriformis* tree

Treatment	Branches plant^{-1}	Av. branch length (cm)	Leaves plant^{-1}	Stem weight plant^{-1} (g)	Leaf weight plant^{-1} (g)	Total weight plant^{-1} (g)
T_1	2c	61c	11c	41c	79c	120c
T_2	3b	109b	18b	238b	238b	238b
T_3	4a	117a	23a	104a	209a	313a
T_0	5a	125a	29a	112a	218a	330a

Means in column followed by the different letter are significantly different by DMRT at P ≤0.05; T_1=3 feet distance fro the tree, T_2= 6 feet distance form the tree, T_3= 9 feet distance from the tree, T_0= Open field referred as control.

Sweet gourd (as leafy vegetable): Like bottle gourd growth of sweet gourd (as leafy vegetable) significantly influenced by *Xylia dolabriformis* tree at different distances from the tree base (Table 5). Branch length (cm), branches plant^{-1}, Leaves plant^{-1}, Stem weight plant $^{-1}$ (g), leaf weight plant $^{-1}$ (g) and weight plant^{-1}of sweet gourd were influenced by Lohakat tree in a similar pattern where highest values of all above parameters was in open field condition which was statistically similar with 9 feet distance from tree base (Table 5). Among the different distance group highest value was in 9 feet distant plnats followed by 6 feet and 3 feet distant plants. Highest values of Branch length (cm), branches plant^{-1}, Leaves plant^{-1}, Stem weight plant $^{-1}$ (g), leaf weight plant $^{-1}$ (g) and weight plant^{-1}of sweet gourd were 124cm, 6, 30, 107g, 213g and 320g, respectively. Close to the tree base growth of morphological parameters of sweet gourd were less vigorous compare to distant plant from tree base. This may be due to competitive interaction between bottle gourd and lohakat tree root systems for water and nutrients. Khatun *et al.* (2010) reported competitive interaction between medicinal plants and winter vegetables near the base area of medicinal plants.

Table 5. Morphological characteristics of Sweet gourd in association with *Xylia dolabriformis* tree

Treatment	Branches plant^{-1}	Leaves plant^{-1}	Av. branch length (cm)	Stem weight plant^{-1} (g)	Leaf weight plant^{-1} (g)	Total weight plant^{-1} (g)
T_1	2c	10c	64c	36c	74c	110c
T_2	4b	20b	109b	96b	192b	288b
T_3	5a	25a	115a	99a	204a	303a
T_0	6a	30a	124a	107a	213a	320a

Means in column followed by the different letter are significantly different by DMRT at P ≤0.05; T_1=3 feet distance fro the tree, T_2= 6 feet distance form the tree, T_3= 9 feet distance from the tree, T_0= Open field referred as control.

Kangkong: Morphological characteristics Kangkong significantly affected by Lohakat (*Xylia dolabriformis*) tree at different distances from tree base (Table 6). Branch length (cm), branch plant^{-1}, leaves plant^{-1}, stem weight per plant^{-1}, leaf weight plant^{-1} and weight plant^{-1}of Kangkong were influenced by Lohakat tree in a similar pattern where highest values of all above parameters were in open field condition which was statistically similar with 9 feet distance from tree base (Table 6). Among the different distance group highest value was in 9 feet distant plnats followed by 6 feet and 3 feet distant plants. Highest values of Branch length (cm), branch plant^{-1}, leaves plant^{-1}, stem weight per plant^{-1}, leaf weight plant^{-1} and weight plant^{-1} were 27cm, 19, 121, 206g, 95g and 301g, respectively. Near the tree base growth of all morphological parameters was less vigorous compare to distant plant from tree base. This might be due to negative interaction between tree-vegetable root systems for growth resources like water and nutrients. Khatun *et al.* (2009) observed similar type interaction in winter vegetables in association Civit tree.

Yield: Total yield of all tested summer vegetables were significantly influenced by *Xylia dolabriformis* tree at different distances from the tree base (Table 7). Among the different distance group highest yield was obtained from 9feet far from tree base which was also statistically similar with the yield obtained from open field condition. Yield of Indian spinach, Amaranth, Okra, Bottle gourd (as leafy vegetable), Sweet gourd (as leafy vegetable) and Kangkong under open field and 9 feet far from tree base

were 55.2, 12.7, 12.4, 42.5 40.3 & 38.5 t/ha and 53.3, 12.5, 12.5, 43.7, 38.2 & 39.2, respectively. Yield of all six summer vegetables was significantly lower at very near (0-3 feet) to the tree base and yield within 3-6 feet distant area 20-30% reduced compare open field condition except Kangknog where yield was similar with open field condition.

Table 6. Morphological characteristics of Kangkong in association with *Xylia dolabriformis* tree

Treatment	Branches plant^{-1}	Av. height of branch (cm)	Leaves plant^{-1}	Stem weight plant^{-1} (g)	Leaf weight plant^{-1} (g)	Total weight plant^{-1} (g)
T_1	5b	19b	20b	55b	25b	80b
T_2	14a	21a	60a	163a	89a	252a
T_3	15a	25a	90a	195a	90a	285a
T_0	19a	27a	121a	206a	95a	301a

Means in column followed by the different letter are significantly different by DMRT at P ≤0.05; T_1=3 feet distance fro the tree, T_2= 6 feet distance form the tree, T_3= 9 feet distance from the tree, T_0= Open field referred as control.

Table 7. Yield performance of summer vegetables in association with *Xylia dolabriformis* tree

Treatment/ Crop	Yield (t/ha)			
	T_1	T_2	T_3	T_0
Indian spinach	25.2c	47.6b	53.3a	55.2a
Amaranth	5.2c	8.1b	12.5a	12.7a
Okra	9.4b	9.7b	12.5a	12.4a
Bottle gourd (as leafy vegetable)	20.5c	37.4b	43.7c	42.5b
Sweet gourd (as leafy vegetable)	15.5c	32.3b	38.2b	40.3a
Kangkong	17.2b	38.5a	39.2a	38.5a

Means in column followed by the different letter are significantly different by DMRT at P ≤0.05; T_1=3 feet distance fro the tree, T_2= 6 feet distance form the tree, T_3= 9 feet distance from the tree, T_0= Open field referred as control.

Very near the tree base yield reduce remarkably may be due to completion for growth resources like water and nutrients. It was found from this study competition for growth resources was minimum after 9 feet far from tree base which indicates root of four years old *Xylia dolabriformis* spread after 9 feet far from tree base beyond the crop root system as a result after 9 feet distance from tree base competition between the tree-crop was absent or minimum in this area. Similar observation was reported by Islam *et al.* (2009) and Tanni *et al.* (2010) in different winter vegetables along with Telsur (Hopea odorata) and Lohakat (two years old) tree.

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