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Winter leafy vegetables cultivation along with five years old Lombu (*Khaya anthotheca*) tree in charland based agroforestry system

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Abstract: A research experiment was conducted in Char Kalibari at the bank of Old Brahmaputra River under Sadar Upazila, Mymensingh during September 2015 to February 2016 to study the growth and yield performance of different winter leafy vegetables viz. radish, mustard, red amaranth, coriander and spinach under the strip of lombu (*Khaya anthotheca*) trees in both east and west direction. Different distances from tree base were considered as different treatments of this study i.e. T_1= 0-3.0 ft., T_2 = 3.0-6.0ft., T_3 = 6.0-9.0ft. and T_0 = control (open field without lombu tree situation). In each direction, different winter leafy vegetables were grown under different treatments following a Randomized Complete Block Design with three replications. Morphological behavior, yield attributes and yield of all above mentioned winter leafy vegetables were significantly affected by lombu tree where control condition showed the most vigorous growth and yield performance. Highest values of different growth parameters and yield of all above winter leafy vegetables were recorded in treatment T_3 of east direction which was significantly lower (10-12%) than control condition followed by treatment T_3 of west direction, T_2 of east direction, T_2 of west direction and significantly minimum values were found in treatment T_1 of west and east direction of lombu tree. Growth and yield of all studied winter leafy vegetables were drastically (70-74%) reduced very near the base (0 – 3.0ft. distance) of lombu tree. These values were dominantly (50-55%) reduced in 3.0 – 6.0ft. distances from tree base and moderately (8-12%) reduced in the distance of 6.0 – 9.0ft. from lombu tree base. Growth and yield reduction of all of these winter leafy vegetables was relatively higher (near 8%) in west direction compare to east direction.
Key words: Leafy vegetables, *Khaya anthotheca*, charland, agroforestry.

Introduction

Bangladesh is a densely populated deltaic country of 147,570 km^2 area having 145 million people (BBS, 2007). It has the lowest per capita arable land due to its high population density. Most of the people of Bangladesh earn their living from agriculture directly or indirectly, which contributes about 16.33% to the gross domestic product (GDP) (BER, 2014). Agricultural land is very important input of agriculture which is converting to non-agricultural land at 1% annually mentioned by UNDP in 2003 (cited by Hasan *et. al.* 2013). Therefore, it is becoming a challenge to produce more food for its increasing population with the decreasing agricultural land resources.

Agroforestry, the integration of the tree, crop and vegetable on the same area of land is a promising production system for maximizing yield and maintaining friendly environment (Nair, 1990). In other word, 'Agroforestry is the intentional integration of woody perennials with crops or livestock, is a polyculture cropping strategy that can have economic and environmental benefits over that of traditional monoculture production systems' (Jose, 2009). In Bangladesh, scope of agroforestry is vast and charland is the most important place for practicing agroforestry systems. Mymensingh is a char inhabited district in Bangladesh where Mymensingh sadar, Ishwargonj, Trishal, Gaffargaon and Gouripur upazila contain about 584 sq. km charland areas with at least 361000 homesteads of which 25 percent i.e. 90000 homesteads remained in char areas (BBS, 2007). A large number of populations are living in these char areas and maintaining their livelihood through char-based farming systems. For increasing production, maintaining ecological balance and improving socio-economic condition of the charland people, integrated approach with crop and trees is necessary. There are about 150 tree species grown in the homestead and village groves of Bangladesh (Das, 1990). Fast growing and multipurpose trees like *Khaya anthotheca* (Lombu) will be very helpful to meet up the need for fuel wood and timber. Lombu wood is highly valued for furniture, cabinet work, decorative boxes and veneer, and is also commonly used for window frames, paneling, doors and stair cases. It is suitable for light flooring, ship building, vehicle bodies, sporting goods, toys, novelties, carving, plywood and pulpwood (Maroyi, 2008).

In in the charland areas of Bangladesh, a large number of vegetables are grown during the rabi season viz. radish, mustard, spinach, red amaranth, coriander etc. as sole crops but seldom found in association with trees as agroforestry system. But these vegetables can be grown during the early establishment period (3-4 years) of lombu tree where competition for growth resources (Light, water and nutrients) between trees and associated crops are minimum or absent. Therefore, the present study was undertaken to observe the morphological growth and yield performance of selected winter leafy vegetables in different spacing under five years old lombu tree for both east and west direction.

Materials and Methods

Location and time of the study: The experiment was carried out in char Kalibari at the bank of old Brahmaputra river belongs to the sadar upazila of Mymensingh district during the period from September 2015 to February 2016. The place is geographically located between 24°45'-24°45'40" North and 90°24'4"- 90°24'44" East Latitude.

Climate and soil: The climate is sub-tropical in nature characterized by high temperature and heavy rainfall during kharif season (April to September) and a scanty rainfall during rabi season (October to March) with high relative humidity almost all over the year except the winter. The topography of the field was medium high land above flood level belonging to the old Brahamaputra flood plain agro-ecological zone-9 (FAO, 1988). It is characterized by non- calcareous dark grey flood plain soil having pH value from 6.5 to 6.8 and the soil texture is silty loam.

Land preparation: The experimental land i.e. land under lombu tree was first opened on 10th September 2015 and operation was done by spade (Plate 1). All crop residues and weeds were removed from the field and finally the land was properly leveled on 15 October 2015.

Plate 1. Land preparation under lombu tree

Tree and plant materials: In this study, five years old lombu (*Khaya anthotheca*) tree which were transplanted during the year of 2011 following strip plantation method and these lombu trees were used as tree components. Crop species were radish, mustard, red amaranth, coriander and spinach which were collected from BRAC seed center and International Seed Fair in Bangladesh Agricultural University campus, Mymensingh.

Experimental design and treatment combination: The experiment was laid out following a Randomized Complete Block Design (RCBD) with three replications. Different winter leafy vegetables viz. radish, mustard, red amaranth, coriander and spinach were grown in the east and west direction of lombu tree. Treatments of the study were (i) T_1 = 0.0 - 3.0ft distance from the tree base, (ii) T_2 = 3.0 - 6.0ft distance from the tree base, (iii) T_3 = 6.0 - 9.0ft distance from the tree base, and (iv) T_0 = control condition i.e. without lombu tree. Details layout of this study is shown in Fig. 1.

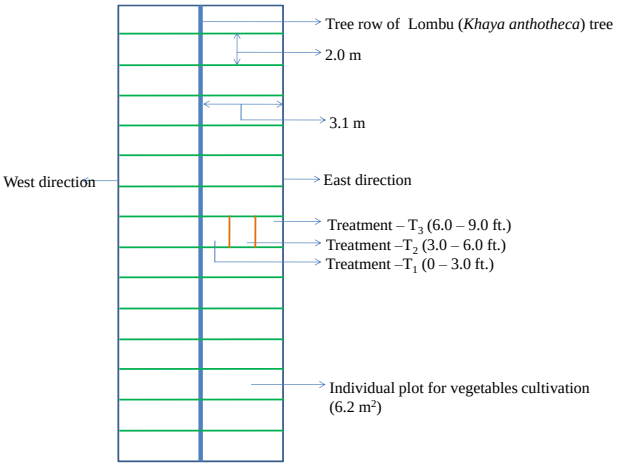


Figure 1. Layout of the experimental plot

Method of data collection: Plant samples of radish, mustard, red amaranth, coriander and spinach were collected randomly from the respective plots. The parameters under study were as plant height (cm), leaf number, leaf length (cm), leaf breath (cm), weight / plant (g), yield plot/kg and yield t/ha.

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

Results and Discussion

The research results obtained from radish, mustard, red amaranth, coriander, spinach (Plate 2) was observed as morphological characteristics and yield separately and these are as:

Plate 2. Different winter vegetables with lombu tree

Morphological characteristics:

Radish: Different morphological parameters of radish viz. plant height (cm), no. of leaves per plant, leaf length (cm), leaf breadth (cm), weight/plant (g) were significantly affected by lombu tree at different distance from tree base (Table 1). Tallest plant of radish (27.88 cm) was found in control condition (Table 1). Among the different distances both in east and west direction tallest plant of radish was found in treatment T_3 of west direction (25.09 cm) which was statistically similar with control condition and T_3 of east direction (24.26 cm). Other treatments were significantly lower than control condition at both east and west direction i.e. T_2 of west direction (18.10 cm), T_2 of east direction (15.97 cm) and significantly minimum plant height of radish was found in treatment T_1 of east direction (10.64 cm) and treatment T_1 of west direction (11.16 cm) of this study (Table 1). Highest no. of leaves per plant of radish (4.73) was also found in control condition (Table 1). Among the different distances both in east and west direction highest no. of leaves per plant of radish was recorded in treatment T_3 of east direction (4.41) which was significantly lower (6.77%) than control condition followed by T_3 of west direction (4.21), T_2 of east direction (2.92), T_2 of west direction (2.82) and significantly minimum no. of leaves per plant of radish

was found in treatment T_1 of west direction (1.74) and treatment T_1 of east direction (1.80) of this study (Table 1). Highest leaf length of radish (8.49 cm) was also found in control condition (Table 1). Among the different distances both in east and west direction highest leaf length of radish was recorded in treatment T_3 of east direction (7.98 cm) which was significantly lower (5.93%) than control condition followed by T_3 of west direction (7.48 cm), T_2 of west direction (5.30 cm), T_2 of east direction (5.12 cm) and significantly minimum leaf length of radish was found in treatment T_1 of east direction (2.26 cm) and treatment T_1 of west direction (2.33 cm) of this study (Table 1). Highest leaf breadth of radish (3.43 cm) was found in control condition i.e. without lombu tree condition (Table 1). Among the different distances both in east and west direction highest leaf breadth of radish was recorded in treatment T_3 of east direction (3.19 cm) which was significantly lower (7%) than control condition followed by T_3 of west direction (3.09 cm), T_2 of east direction (2.00 cm), T_2 of west direction (2.07 cm) and significantly minimum leaf breadth of radish was found in treatment T_1 of east direction (1.23 cm) and treatment T_1 of west direction (1.27 cm) of this study (Table 1). Highest weight per plant of radish (7.41 g) was also found in control condition i.e. without lombu tree (Table 1). Among the different distances both in east and west direction highest weight per plant of radish was recorded in treatment T_3 of east direction (6.96 g) which was significantly lower (6.07%) than control condition followed by T_3 of west direction (6.59 g), T_2 of west direction (2.88 g), T_2 of east direction (2.83 g) and significantly minimum weight per plant of radish was found in treatment T_1 of east direction (1.75 g) and treatment T_1 of west direction (1.77 g) of this study (Table 1). Very near the lombu tree base plant height, no. of leaves per plant, leaf length, leaf breadth and weight per plant was minimum may be due to competition for moisture and nutrients between radish and lombu tree roots. Similar type of assumption was also opined by Islam *et al.* (2009) that morphological characteristics of winter vegetables number of leaves, leaf length and diameter, stem girth, fresh and dry weight etc. decreased consistently with the decrease of distance from the tree base.

Table 1. Morphological characteristics of radish in association with *Khaya anthotheca* tree

Treatment combinations		Morphological characteristics				
Direction	Treatment	Plant height (cm)	No. of leaves/plant	Leaf length (cm)	Leaf breadth (cm)	Weight /plant (g)
East	T_1	10.64d	1.80e	3.15e	1.23d	1.75e
	T_2	15.97c	2.92d	5.12d	2.00c	2.83d
	T_3	24.26b	4.41b	7.98b	3.19b	6.96b
West	T_1	11.16d	1.74e	3.27e	1.27d	1.77e
	T_2	18.10c	2.82d	5.30d	2.07c	2.88d
	T_3	25.09ab	4.21c	7.48c	3.09b	6.59c
Control	T_0	27.88a	4.73a	8.49a	3.43a	7.41a
CV (%)		9.809	2.23	2.466	5.42	3.084
LSD (0.01)		4.646	0.186	0.351	0.314	0.335
Level of significance		**	**	**	**	**

Mean in column followed by the different letter are significantly different by DMRT at P< 0.01; T_1 = 0-3.0 ft., T_2 = 3.0-6.0 ft., T_3 = 6.0-9.0 ft., T_0 = Control i.e., without tree.

Table 2. Morphological characteristics of mustard in association with *Khaya anthotheca* tree

Treatment combinations		Morphological characteristics				
Direction	Treatment	Plant height (cm)	No. of leaves/plant	Leaf length (cm)	Leaf breadth (cm)	Weight /plant (g)
East	T_1	8.86e	2.53e	1.98d	0.82d	0.71e
	T_2	14.38d	4.10d	3.22c	1.33c	1.15d
	T_3	22.49b	6.84b	5.84ab	2.93b	2.82b
West	T_1	8.63e	2.61e	1.79d	0.84d	0.72e
	T_2	14.00d	4.23d	3.33c	1.36c	1.17d
	T_3	21.53c	6.55c	5.47b	2.83b	2.67c
Control	T_0	23.92a	7.36a	6.21a	3.15a	3.00a
CV (%)		2.222	3.422	7.153	5.852	3.113
LSD (0.01)		0.907	0.41	0.701	0.276	0.139
Level of significance		**	**	**	**	**

Mean in column followed by the different letter are significantly different by DMRT at P< 0.01; T_1 = 0-3.0 ft., T_2 = 3.0-6.0 ft., T_3 = 6.0-9.0 ft., T_0 = Control i.e., without tree.

Mustard: Different morphological parameters of mustard viz. plant height (cm), no. of leaves per plant, leaf length (cm), leaf breadth (cm), weight/plant (g) were significantly affected by lombu tree at different distance from tree base (Table 2). Like radish effect of lombu tree was almost similar which are shown in Table 2. Similar observation also reported by Rahman (2013), Babu (2012) and Rahman (2012) in sweet gourd and Mallick *et al.* (2013) in other plants.

Red amaranth: Different morphological parameters of red amaranth viz. plant height (cm), no. of leaves per plant, leaf length (cm), leaf breadth (cm), weight/plant (g) were significantly affected by lombu tree at different distance from tree base (Table 3). Like radish and mustard, effect of lombu tree was almost similar which are shown in Table 3. Similar observation also reported by Rahman (2013), Babu (2012) and Rahman (2012) in sweet gourd and Mallick *et al.* (2013) in other plants. It has been reported that shading reduced leaf number, leaf area and thickness of dry bean (Crookston *et al.*, 1975). They also reported 38% decrease in photosynthesis per unit area of shaded leaves.

Coriander: Different morphological parameters of red amaranth viz. plant height (cm), no. of leaves per plant, leaf length (cm), leaf breadth (cm), weight/plant (g) were significantly affected by lombu tree at different distance from tree base (Table 4). Like radish, mustard and red amaranth, effect of lombu tree was almost similar which are shown in Table 4. Dhukia *et al.* (1988) who found that closer plant from tree base has severely affected by root competition.

Table 3. Morphological characteristics of red amaranth in association with *Khaya anthotheca* tree

Treatment combinations		Morphological characteristics				
Direction	Treatment	Plant height (cm)	No. of leaves/plant	Leaf length (cm)	Leaf breadth (cm)	Weight /plant (g)
East	T_1	10.89e	3.52d	2.16e	0.95d	0.89e
	T_2	17.67d	5.70c	3.51d	1.54c	1.46d
	T_3	27.64b	9.51b	6.38b	3.38b	3.59b
West	T_1	10.61e	3.62d	2.24e	0.96d	0.92e
	T_2	17.21d	5.87c	3.63d	1.56c	1.48d
	T_3	26.47c	9.10b	5.98c	3.34b	3.40c
Control	T_0	29.41a	10.22a	6.79a	3.64a	3.82a
CV (%)		2.236	3.414	4.88	6	2.708
LSD (0.01)		1.115	0.576	0.531	0.32	0.152
Level of significance		**	**	**	**	**

Mean in column followed by the different letter are significantly different by DMRT at P< 0.01; T_1 = 0-3.0 ft., T_2 = 3.0-6.0 ft., T_3 = 6.0-9.0 ft., T_0 = Control i.e., without tree.

Table 4. Morphological characteristics of coriander in association with *Khaya anthotheca* tree

Treatment combinations		Morphological characteristics				
Direction	Treatment	Plant height (cm)	No. of leaves/plant	Leaf length (cm)	Leaf breadth (cm)	Weight /plant (g)
East	T_1	5.00e	1.70d	1.87e	0.66d	0.32e
	T_2	8.10d	2.76c	3.03d	1.07c	0.52d
	T_3	12.68b	4.60b	5.50b	2.36b	1.28b
West	T_1	4.87e	1.75d	1.93e	0.67d	0.32e
	T_2	7.90d	2.84c	3.13d	1.09c	0.53d
	T_3	12.14c	4.40b	5.15c	2.28b	1.21c
Control	T_0	13.49a	4.95a	5.85a	2.53a	1.36a
CV (%)		2.255	3.417	4.933	5.98	3.039
LSD (0.01)		0.519	0.281	0.465	0.226	0.058
Level of significance		**	**	**	**	**

Mean in column followed by the different letter are significantly different by DMRT at P< 0.01; T_1 = 0-3.0 ft., T_2 = 3.0-6.0 ft., T_3 = 6.0-9.0 ft., T_0 = Control i.e., without tree.

Spinach: Different morphological parameters of red amaranth viz. plant height (cm), no. of leaves per plant, leaf length (cm), leaf breadth (cm), weight/plant (g) were significantly affected by lombu tree at different distance from tree base (Table 5). Like radish, mustard, red amaranth and coriander, effect of lombu tree was almost

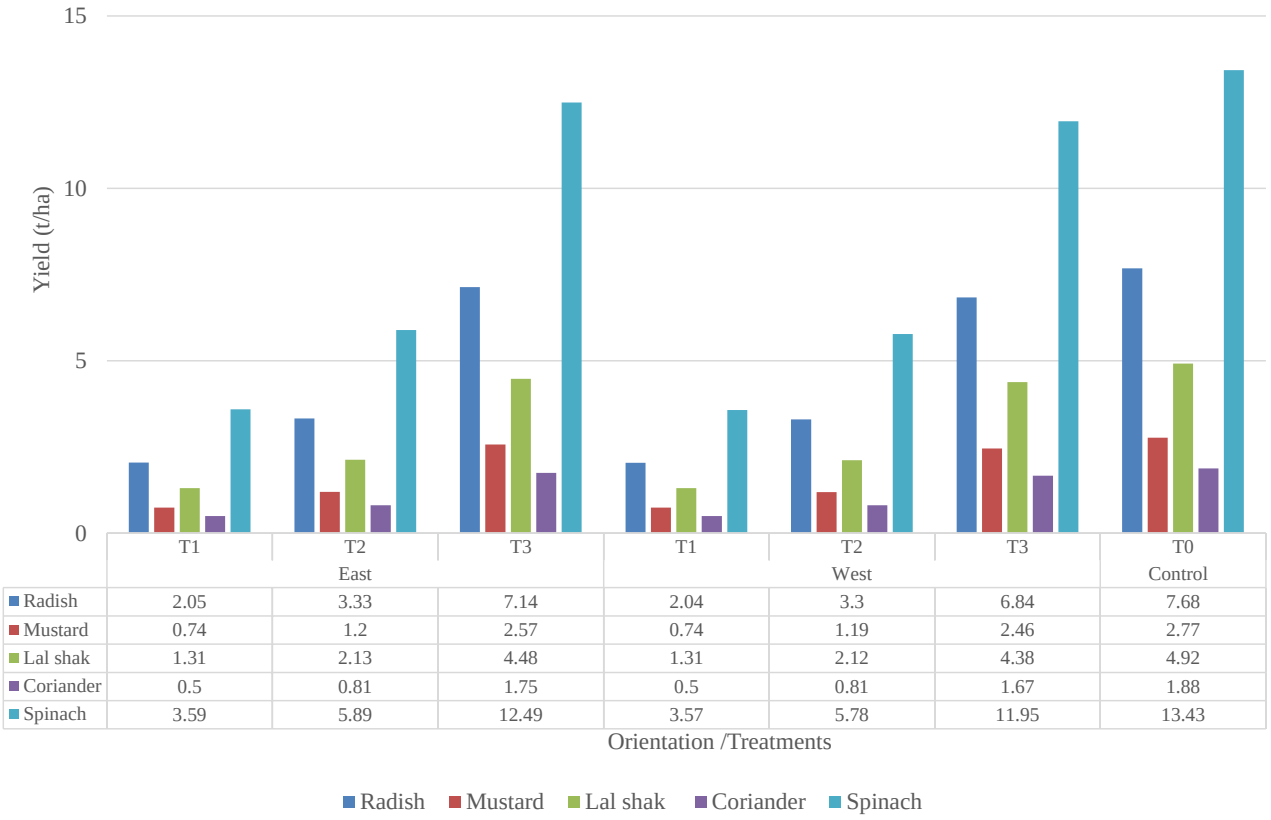
similar which are shown in Table 5. Dhukia *et al.* (1988) who found that closer plant from tree base has severely affected by root competition. Competition for growth resources (Light, water and nutrients) may be the reason for reducing leaf area of coriander decreased near the base of Civit (*Swintonia floribunda*) tree which was reported by Khatun *et al*., (2009).

Table 5. Morphological characteristics of spinach in association with *Khaya anthotheca* tree

Treatment combinations		Morphological characteristics				
Direction	Treatment	Plant height (cm)	No. of leaves/plant	Leaf length (cm)	Leaf breadth (cm)	Weight /plant (g)
East	T_1	8.69f	2.43d	8.17d	2.22d	2.50e
	T_2	14.09e	3.53c	11.01c	3.59c	4.05d
	T_3	21.39b	4.95ab	17.18ab	5.74b	9.94b
West	T_1	9.11f	1.96d	7.03d	2.29d	2.53e
	T_2	14.78d	3.18c	11.41c	3.71c	4.11d
	T_3	20.48c	4.73b	16.09b	5.55b	9.41c
Control	T_0	22.76a	5.32a	18.28a	6.17a	10.58a
CV (%)		2.301	8.717	8.091	5.436	3.015
LSD (0.01)		0.916	0.811	2.577	0.561	0.462
Level of significance		**	**	**	**	**

Mean in column followed by the different letter are significantly different by DMRTat P< 0.01; T_1 = 0-3.0 ft., T_2 = 3.0-6.0 ft., T_3 = 6.0-9.0 ft., T_0 = Control i.e., without tree.

Yield: Yield of all different winter leafy vegetables were significantly varied with lombu tree. Yield data was recorded as kg per plot as well as ton per hectare (Figure 2). Yield of vegetables was significantly influenced by different treatments i.e. different distances from lombu tree base in both east and west direction (Fig. 2). Maximum yield of radish, mustard, red amaranth, coriander and spinach were found in control condition and the values were 7.68, 2.77, 4.92, 1.88 and 13.43 t/ha, respectively followed by east direction of T_3 treatment for radish, mustard, red amaranth, coriander and spinach where the values were 7.14, 2.57, 4.48, 1.75 and 12.49 t/ha, respectively. Lowest yield was found from T_1 of west direction with the value of 2.04, o.74, 1.31, 0.5 and 3. t/ha for radish, mustard, red amaranth, coriander and spinach respectively. Very near the lombu tree base yield was minimum may be due to competition for growth resources (water and nutrients) as well as shade effect of lombu tree on spinach. Sayed *et al.* (2009).



	T1	T2	T3	T1	T2	T3	T0
	East			West			Control
Radish	2.05	3.33	7.14	2.04	3.3	6.84	7.68
Mustard	0.74	1.2	2.57	0.74	1.19	2.46	2.77
Lal shak	1.31	2.13	4.48	1.31	2.12	4.38	4.92
Coriander	0.5	0.81	1.75	0.5	0.81	1.67	1.88
Spinach	3.59	5.89	12.49	3.57	5.78	11.95	13.43

Figure 2. Yield of different winter leafy vegetables in association with *Khaya anthotheca* tree

In this study, it was found that growth and yield of all studied winter leafy vegetables were drastically (70-74%) reduced very near the base (0 – 3.0ft. distance) of lombu tree. These values were dominantly (50-55%) reduced in 3.0 – 6.0ft. distances from tree base and moderately (8-12%) reduced in the distance 6.0 – 9.0ft. from lombu tree base. Growth and yield reduction of all of these winter leafy vegetables was relatively higher (near 8%) in west direction compare to east direction. Very near the base of lombu tree performance of all winter vegetables was drastically reduced may be due to competition for different growth resources both in above and below the ground. From the results of this study, it is clear that winter vegetables production very near (up to 6.0 feet distance) the base of lombu tree was not profitable but beyond six feet distance it will profitable. So, considering the results of this study it may be concluded that beyond six feet distances from five years old lombu tree winter vegetables can be grown without significant yield loss.

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