J. Agrofor. Environ. 9 (1 & 2): 1-6, 2015 ISSN 1995-6983

Growth and yield performance of mustard under kalokoroi (*Albizia lebbeck*) based cropland agroforestry system

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Abstract: The experiment was conducted at the Field Laboratory of the Department of Agroforestry of Bangladesh Agricultural University, Mymensingh during the period from November 2013 to March 2014 to observe the performance of mustard grown in association with Kalo koroi (*Albizia lebbeck*), a timber yielding tree species in crop based Agroforestry system. The study was laid out in Randomized Complete Block Design (RCBD) with three replications. Different treatments in association with Kalo koroi tree were T_1 = 0-1.5m distance from the tree base, T_2 = 1.5-3.0m distance from the tree base, T_3 = 3.0-4.5m distance from the tree base and T_4 =open field condition referred as control. Growth and yield of mustard grown in association with Kalo koroi tree was recorded in different growth stage viz. vegetative, flowering and harvesting stage. It was found that growth parameters viz. plant height (cm), number of leaves per plant, leaf size including length (cm) and breadth (cm), length of floral rachis, no. of branches/rachis, no. of flower/branch, no. of siliqua/plant, length of siliqua (cm), no. of seed/siliqua, weight of 1000 seeds (g) of mustard varied almost similar pattern in all treatments when grown combindly with Kalo koroi tree. The highest values of all growth parameters were found in treatment T_4 i.e. without tree condition (control treatment) while the lowest data regarding above parameters were drastically reduced very near the tree base (0-1.5m from the tree base). As evident from the result it was found that yield of mustard gradually increased with increasing distance from Kalo koroi tree base.Yield of mustard remarkably reduced compare to control condition towards the base of Kalo koroi tree.Yield of mustard was highest (0.945 t/ha) in control condition which was statistically similar with the yield obtained from the treatment T_3 (0.94 t/ha) followed by treatment T_2 (0.635 t/ha) and lowest (0.425 t/ha) yield was obtained from treatment T_1 in association with kalo koroi tree.Yield reduction of mustard with kalo koroi tree in treatments T_1, T_2 and $T_3$was 55.03, 32.80 and 0.53%, respectively compared to treatment T_4 i.e. open field condition.
Key words: Mustard, kalokoroi , cropland agroforestry.

Introduction

A proverb says, "Farming without tree culture is incomplete". There has been a practice of growing one or the other tree species with agricultural crop for multipurpose uses. Farmers from time immemorial are in the habit of planting various economic tree species on the field bunds, corners of field or sporadically or zonally or sequentially for fuel, fodder, fruits, fertilizers (manure), finance and timber. This is kind of growing economic trees zonally or sequentially is termed as "Agro-forestry".

Cropland based Agroforestry (CAF) is a traditional land use system in Bangladesh where different tree species grow naturally or planted on agricultural lands and are purposely retained and maintained by the farmers for different household utilities, products and also for cash income, which also reflects biophysical and social variations. Trees are planted on the borders or within the field, systemically or at irregular intervals, usually with crops such as rice, wheat, pulse, jute, oilseed, sugarcane, vegetables and others, and farmers also grow shade-tolerant crops such as turmeric, ginger and aroid when trees have high canopy coverage (e.g. jackfruit, mahagony).

Bangladesh has only 7.63 million hectares (ha) of arable land and per person arable land is 0.05 hectares (Nourbakhsh, 2009). Due to over growing population, per capita land area is decreasing at an alarming rate of 0.005 ha/capita/year since 1989. This put heavy pressure on land for human habitation and crop production (Nelson and Sommers, 1996). In such circumstances, traditional land use pattern should be converted into sustainable land use, which will permit maintenance of productivity combined with conservation of the resources. CAF might be the best land-use system for sustainable livelihood in Bangladesh to cope with the present situation.

Albizia lebbeck is a tree well known in the Indian subcontinent for its range of uses. A medium to large tree, of multi-stemmed widely spreading habit (30 m diameter) when grown in the open, but capable of good log form in plantation. Average height 20m. It can grow well under a wide range of rainfall regimes (600-2,500 mm) yet can be seen in areas with only 400 mm. It may be established in areas of highly variable rainfall but in its natural habitat probably requires a reliable wet season. It is found on a wide range of soil types including those that are alkaline and saline (Prinsen, 1986). *Albizia lebbeck* has potential for use in silvopastoral systems with a number of benefits to graziers. Its foliage is of high quality for animals and the shade of its canopy is likely to benefit livestock directly, by reducing temperatures in hot environments, and indirectly by stimulating improved grass growth. Finally, the wood of Kalo koroi has value as a timber.

Mustard (also known as Mustard greens, leaf Mustard) is a quick to mature, easy to grow, cool season vegetable. Spicy, crunchy Mustard greens (leaf Mustard) are indeed one of the most nutritious green-leafy vegetables. Have actually more carotenes, Vitamin K and flavonoid anti-oxidants than some commonly consumed vegetables. Mustard is very important and well known edible oils. The oil has a low content of saturated fat as compared to other oils. Its oil is healthier and good for the heart and has cholesterol - reducing properties.

Considering the above mentioned facts and potentiality this study was undertaken to observe the morphological behavior and yield performance of mustard with kalokoroi based agroforestry system.

Materials and Methods

Experimental site and season: The experiment was carried out at the experimental farm in the field under Department of Agroforestry in Bangladesh Agricultural University, Mymensingh during the period from November 2013 to March 2014.

Planting material: A local variety of Mustard (*Brassica napus*) was selected as experimental material for the investigation of the study along with established mature tree, Kalo koroi (*Albizia lebbeck*).

Tree establishment and management: During the period of field present study, the trees of all species were enough mature and well established. Average height and girth of Kalo koroi, was 35.85 & 3.5ft. Before starting this study the tree was partially pruned disease infected and insect infested leaves and twigs were also removed.

Experimental design, layout and treatment combination: Mustard seeds were sown surrounding the selected tree following Randomized Complete Block Design (RCBD) with four treatments. Different distances surrounding trees were 0-1.5m (T_1), 1.5-3.0m (T_2) and 3.0-4.5m (T_3). Mustard was also grown in without tree condition (T_4) which was treated as control treatment of this study.

Crop establishment: Mustard seeds were directly sown in the experimental plot on the 1st week of November 2014. The seeds were sown by broadcasting method. After emergence, mustard was thinned out to maintaining approx. 4-5 cm distance from plant to plant.

Sampling and Data collection: Different morphological data were collected at vegetative, flowering and harvesting period of the study. Total 40 plants (10 from each direction) were collected in each data collecting period. Growth and yield parameters of mustard viz. plant height, no. of leaves/plant, leaf area, rachis length, branch/rachis, flower/branch, siliqua/plant, siliqua length, seed/siliqua, 1000 seed wt. (gm.) etc. were recorded from selected mustard plant samples.

Crop harvesting: Mustard was harvested after 90 days from the date of sowing. Mustard were harvested as whole plants from the fields when more than 80% of the pods become straw color and 2/3rds of the pods on the terminal raceme turn into chocolate brown color.

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 wasp2 software package to find out the statistical significance of the experimental results for all the characters 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.

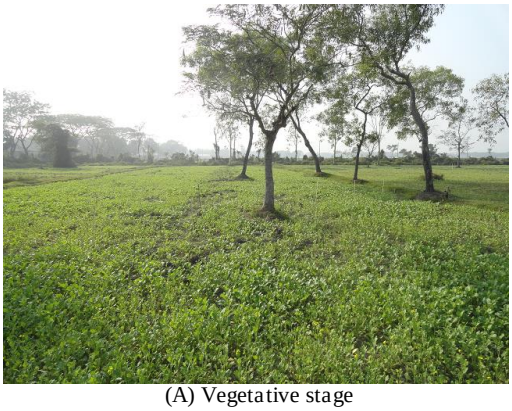
Results and Discussion

Different morphological parameters of mustard in different study period significantly influenced by Kalo koroi tree at different distance from the tree base.

Morphological features of Mustard

Morphological parameters of mustard was observed in different growth period viz. vegetative stage (Plate 1A), flowering stage (Plate 1B) and mature stage (Plate 1C). In these growth stages different parameters of mustard was recorded and these are as- Plant height, No. of leaves/plant, Leaf area, Rachis length, Branch/rachis, Flower/branch, Siliqua/plant, Siliqua length, Seed/siliqua, 1000 seed wt. (gm.).

Plant height: Plant height of mustard in association with Kalo koroi tree at vegetative, flowering and mature stages were significantly different in different treatments (Table 1, 2 and 3). In all stages (vegetative, flowering and harvesting) tallest (20.05, 60.07 and 72.39cm, respectively) plant was found in open field condition i.e. without tree condition which were statistically similar with treatment T_3 (19.88, 57.80 and 68.36cm respectively). Plant height of mustard in the treatment T_2 i.e. 1.5-3.0m distance from the tree base was 19.6, 19.8 and 22.14% lower compare to control condition and the values were 16.12, 48.18 and 56.36 cm, respectively (Table 1, 2 and 3).



(A) Vegetative stage

(B) Flowering stage

(C) Harvesting stage

Plate 1. Mustard in association with kalo koroi tree at different growth stages

In all stages, shortest (15.72, 28.07 and 35.33cm, respectively) plant was found very near the tree base i.e. 0-1.5m distance area from the tree base which are 21.6, 53.3 and 51.2% lower compare to open field condition (Table 1, 2 and 3). From this study it was found that, among the

different distant area from Kalo koroi tree base plant height of Mustard gradually decreased toward the tree base which may be due to competition for nutrient and water between the root system of mustard and Kalo koroi tree. Parveg *et al.* (2014), Akter *et al.* (2013), Hasan *et al.* (2012) recorded shorted chili, carrot and okra plant very near the base of Akashmoni, Lohakat and Lombu (*Khya* spp.) tree.

Number of leaf: The numbers of leaves per plant are also important character due to its direct relation with yield via photosynthesis. For this reason, due to variation of number of leaf, yield of mustard also varied in this stage. It was noted that number of leaves of mustard was meaningfully enlarged with the rise of distance from tree base (Table 1). Number of leaves per plant was recorded at vegetative stage where it was found that highest number of leaves (7.225) was noted in control condition (T_4) which was statistically similar with the number of leaves produced under the treatment T_3 (3-4.5m distance from the tree base) and the value under T_3 was 6.91 (Table 1). Leaf number of mustard in the treatment T_2 (1.5-3.0m distance from the tree base) was 24.91% lower compare to control condition and the values was 5.42.The minimum number leaves per plant (4.8cm) was observed in T_1 (0-0.5m from the tree base) which was 33.56% lower compare to control condition (T_4). These result revealed that leaves number significantly increase in gradually increasing distance with Kalo koroi 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.

Table 1. Morphological characteristics of mustard in association with Kalo koroi tree at vegetative stage

Treatments	Morphological characteristics of mustard			
	Plant height (cm)	No. of leaves/plant	Leaf size	
			Leaf length (cm)	Leaf bredth (cm)
T_1	15.73c	4.8c	4.29c	2.79c
T_2	16.12b	5.43b	5.49b	3.57b
T_3	19.88a	6.92a	6.73a	4.38a
T_4	20.05a	7.23a	7.15a	4.65a
CV(%)	3.921	3.958	7.443	7.472
LSD(0.01)	1.619	0.551	1.013	0.665
Level of significance	**	**	**	**

Mean in column followed by the different letter are significantly different by DMRT at P≤ 0.05. T_1= 0-1.5m distance , T_2= 1.5 - 3.0 m distance , T_3= 3.0-4.5 m distance and T_4 = Control (without tree)

Leaf size

Length: Length of leaf of mustard was affected significantly due to the effect of different treatment in association with Kalo koroi (Table 1). Longest leaf (7.15cm) was recorded in T_4 (control i.e. without tree) which was statistically similar (6.37cm) with the treatment T_3 (3-4.5m distance from the tree base) followed by treatment T_2 (5.49cm) i.e. 1.5-3m distance from the tree base where 23.21% lower leaf length was observed compared to control condition and smallest length of leaf was in the treatment T_1 which was 40% lower compared to treatment T_4 (Table 1) and the value (4.29cm) was found under T_1 (0-1.5m distance from the tree base). Hossian *et al*. (2014) and Farhana *et al*. (2013) observed similar variation in Lettuce and Spinach leaf in association with Lohakat tree.

Breadth: Like leaf length, leaf breadth of mustard was also significantly enlarged with the rise of distance from the tree base (Table 1). The maximum breadth of leaf (4.65cm) was recorded at T_4 (open field condition) while the second higher (4.37cm) was observed under T_3 (3-4.5m distance from the tree base) where they were statistically same. The lowest breadth (2.79cm) was recorded in T_1 (0-1.5m distance from the tree base) i.e. very close to tree base and it was 40% lower compared to control condition. Tanni *et al*. (2010) recorded similar variation in leaf breadth of lettuce and radish when grown in association with lohakat tree as agroforestry system.

Length of floral rachis (cm): It was observed that the length of floral rachis of mustard was meaningfully enlarged and influenced at the floral stage (Table 2). The result showed that the longest floral rachis (35.05cm) was noted in T_4 (open field) treatment. The next maximum length of floral rachis (32.02cm) was found under T_3 (3-1.5m distance from the tree base) treatment which was statistically similar to T_4 (control) treatment (Table 2). Relatively shorter (24.1cm) floral rachis was found in under the treatment T_2 i.e. 1.5-3cm distance from the tree base which was 27.08% lower compared to T_4 i.e. control condition. The lowest length of floral rachis (16.75cm) was recorded under T_1 (0-1.5m distance from the tree base) treatment which was 49.31% lower compared to control treatment (T_4). This may be also due to higher competition for moisture and nutrients very near the Kalo koroi tree base. Akter *et al.* (2014) also observed relatively shortest floral rachis of mustard very near the tree base when grown along with lohakat tree.

Number of branches/rachis: The result noted that the highest no. of branches per rachis at flowering and harvesting stage was recorded 3.56 and 3.56 respectively in treatment T_4 (without tree) which was statistically similar with the treatment T_3 (3-4.5m away from the tree base) where the value was 3.07 and 3.27 respectively. Number of branches per rachis of mustard in the treatment T_2 i.e. 1.5-3.0m distance from the tree base was 31.64 and 29.77% lower compare to control condition and the values were 2.3 and 2.5, respectively (Table 2 and 3).The lower most no. of branch per rachis (1.2 and 1.4, respectively) was found under T_1 treatment (0-1.5m distance area from the tree base) in both stages (Table 2 and 3) i.e. very near to the tree base which were 64.33 and 60.67% lower compare to openfield condition. Near the tree base no. of

rachis/branch was lower may be due to competition for different nutrient elements and moisture between the root system of mustard and kalo koroi tree. Rakib *et al.* (2013) and Bithi *et al.* (2014) observed lower no. of branches/rachis in radish and mustard very near the base of mango and ipil-ipil tree.

Flower per branch: The highest flower per branch (13.45) was recorded at treatment T_4 (control condition) which was statistically similar to treatment T_3 i.e. 3-4.5m distance from the tree base and the value recorded was 13.21 (Table 2) followed by treatment T_2 (1.5-3m from the tree base) where no. of flower/branch was 11.6 which was 13.75 % lower compare to treatment T_4 (control). The lowest no. of flower per branch (7.3) was observed under treatment T_1 (0-0.5m distance from tree base) and the value was 45.72% lower compare to control condition. Habib *et al.* (2012) reported that no. of flower of okra gradually decreased towards tree base during combined production with *Xylia dolabriformis* tree.

Table 2. Morphological characteristics of mustard in association with Kalo koroi tree at flowering stage

Treatments	Morphological characteristics of mustard			
	Plant height (cm)	Rachis length (cm)	Branch/rachis	Flower/branch
T_1	28.07c	16.75c	1.2c	7.3c
T_2	48.18b	24.1b	2.3b	11.6b
T_3	57.8a	32.03a	3.07a	13.21a
T_4	60.07a	33.05a	3.36a	13.45a
CV(%)	3.897	5.131	13.141	8.1
LSD(0.01)	4.341	3.12	0.756	2.123
Level of significance	**	**	**	**

Mean in column followed by the different letter are significantly different by DMRT at P≤ 0.05. T_1= 0-1.5m distance , T_2= 1.5 - 3.0 m distance , T_3= 3.0-4.5 m distance and T_4 = Control (without tree)

Number of siliqua per plant: Highest (35.62) number of siliqua per plant was found in without tree condition i.e. treatment T_4 which was statistically similar with the siliqua produced in treatment T_3 i.e. 3-4m distance from the tree base and the value was recorded as 35.06 (Table 3). Number of siliqua per plant produced under T_2 and T_1 treatments where 22.48 and 13.70, respectively and these values were 36.88 and 61.53% lower compare to control condition. The lowest value was observed under 0-1.5m distance from the tree base i.e. very near to the tree base which was 13.70. Fruit formation greatly influenced by the total assimilates which is produced by photosynthesis, near the tree base due to less interception of solar radiation (resulted by tree shade very near tree base) total assimilate production also reduced. Due to this reason no. of siliqua of mustard was lower may be near the kalo koroi tree base. Shah (2013) also found less number of siliqua in mustard very near eucalyptus and *Xylia dolabriformis*tree.

Table 3. Morphological characteristics of mustard in association with Kalo koroi tree at harvesting stage

Treatments	Morphological characteristics of mustard					
	Plant height	Branch/rachis	Siliqua/plant	Siliqua length	Seed/siliqua	1000 seed wt.(gm.)
T_1	45.33c	1.4c	13.70c	2.59c	6.15c	1.32c
T_2	56.36b	2.5b	22.48b	3.54b	8.9b	1.72b
T_3	68.36a	3.28a	35.07a	6.05a	13.25a	2.05a
T_4	72.39a	3.56a	35.63a	6.12a	13.63a	2.12a
CV(%)	7.623	12.166	7.303	3.977	5.686	5.25
LSD(0.01)	10.624	0.756	4.484	0.419	1.374	0.218
Level of significance	**	**	**	**	**	**

Mean in column followed by the different letter are significantly diifferent by DMRT at P≤ 0.05. T_1= 0-1.5m distance , T_2= 1.5 - 3.0 m distance , T_3= 3.0-4.5 m distance and T_4 = Control (without tree)

Length of siliqua: The result revealed that the longest siliqua (6.11cm) was obtained at open filed condition (T_4) which was statistically similar with treatment T_3 where siliqua length was 6.05cm and the highest siliqua length was recorded under the treatment T_2 which was 42.22% lower compared to control condition and the value recorded 3.53cm. Shortest (2.58cm) size siliqua of mustard was found in the treatment i.e. 0-1.5m distance from the tree base, i.e. 57.77% compared to open field condition (Table 3). Shortest size siliqua of mustard was found very near the kalo koroi tree base may be due to partial shade effect, competition for moisture and nutrients between the Mustard and Kalo koroi tree roots. The fruit size (length x diameter) of sweet gourd was decreased by increasing shade level that reported by Healey *et al.* (1998), Souza *et al.* (1999) and Reddy *et al.* (2002).

No. of seed per siliqua: The maximum no. of seed per siliqua (13.62) was recorded in without tree condition i.e. treatment T_4 (Table 3). Seed per siliqua produced in treatment T_3 is the second highest amount (13.25) and this was statistically similar with without tree condition. No. of seed per siliqua was relatively lower in the treatment T_2 and T_1 compare to that of treatments T_3 and T_4. No. of siliqua were 36.65 and 54.84% lower in the treatment T_2 and T_1 compare to control condition. Basak *et al*. (2011) reported lower number of seed per siliqua in mustard near base of *leucaena* tree during combined production system as agroforestry practices.

Weight of thousand seed: Results of this study showed that 1000 seed weight was maximum (2.11 g) in the control condition i.e. without tree condition which was statistically almost similar with the 1000 seeds weight (2.05 g) obtained from the treatment T_3 i.e. 3.0-4.5m distances from kalo koroi tree base (Table 3). Thousand seeds weight in the treatments T_2 and T_1 were 1.71g and 1.31 g, respectively, which were 18.95 and 37.91% lower compare to control condition. Thousand seeds weight i.e. seed size lower in closer distances of kalo koroi tree base may be due to cumulative effect of partial shade effect and competition for moisture and different nutrients between the root system of mustard and kalo koroi tree. Farhana *et al*. (2013), and Kundu *et al*. (2014) reported smaller sized spinach and mustard seed in association with *Xylia* and Lohakt tree as agroforestry system.

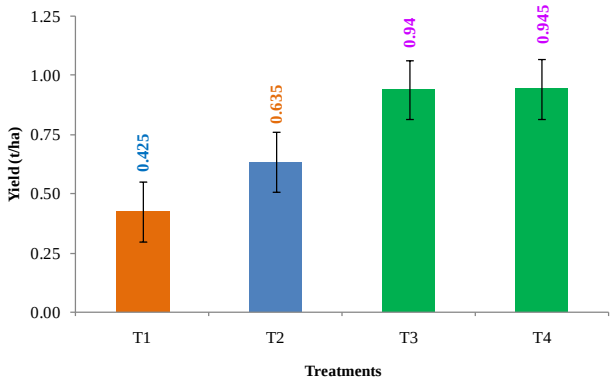


Fig. 1. Yield of mustard in association with kalo koroi tree

Yield of mustard with Kalo koroi tree: It was found that yield of mustard gradually increased with increasing distance from kalo koroi tree base. Yield of mustard was highest (0.945 t/ha) in control condition i.e. without kalo koroi tree condition which was statistically similar with treatment T_3 i.e. 3.0-4.5m distance from tree base (0.940 t/ha) followed by treatment T_2 i.e. 1.5-3.0m distance from tree base (0.635 t/ha) and lowest (0.425 t/ha) yield was obtained from treatment T_1 i.e. 0-1.5m distance from tree base (Fig. 1). Yield reduction of mustard in the different distant area (0-1.5m, 1.5-3.0m and 3.0-4.5m from tree base i.e. treatments T_1, T_2 and T_3) from kalo koroi tree base compare to control condition i.e. without kalo koroi tree condition were 55.03, 32.80 and 0.53%, respectively.
Mustard, yield is the cumulative products of different yield attributes viz. number of flower, length of floral rachis, number of siliqua, siliqua size and seed size. From this study, it was found that all of these yield attributes of mustard were less in the closest area of kalo koroi tree. As a result yield of mustard also lower very near the tree base of kalo koroi tree. Grain yield reduction of mustard in the different distant area (0-1.5m, 1.5-3.0m and 3.0-4.5m) from kalokoroi tree base compare to control condition i.e. without tree condition were 55.03, 32.8 and 0.50 %, respectively. These yield reduction of mustard in closer distance from kalo koroi tree was might be due to severe competition for different nutrients elements and moisture between the root system of kalokoroi tree and mustard. Kundu *et al.* (2014), Farhana *et al.* (2013), Habib *et al.* (2012) and Tanni *et al.* (2010) found lower yield of soybean, spinach, okra and lettuce when cultivate very near the base of different years old *Xylia dolabriformis* trees. Rakib *et al*. (2013) and Khatun *et al*. (2009) found lower yield of radish and coriander when cultivate very near the base of different fruit trees and *Swintonia floribunda* trees. So, it may be concluded that mustard can be successfully grown in association with kalo koroi tree beyond 3.0m distance from the base of each of these tree species.

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