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RESEARCH PAPER

Cultivation of Kohlrabi (*Brassica oleracea* var. *gongylodes*) with Raj Koroi Tree as Agroforestry

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ABSTRACT

An agroforestry experiment was conducted at Ramlakkhan village which is situated at Bauphal upazilla, Patuakhali district, during the period from November 2017 to March 2018. The main objective of the experiment was to evaluate the performance of kohlrabi (*Brassica oleracea* var. *gongylodes*) in association with raj koroi (*Albizia richerdiana*) tree (2.5 year's) at different distances from tree base. The experiment consisted of four different treatments viz. T_0 (open field referred as control), T_1 (25 cm distance from the tree base), T_2 (50 cm distance from the tree base) and T_3 (75 cm distance from the tree base). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were collected on morphological and yield contributing characteristics of kohlrabi and analyzed for evaluation of the treatment effects. In this study, different growth parameters viz. length of leaf, breadth of leaves, total number of leaves per plant, plant height, length of root, weight of root, individual weight of fruit and fresh and dry weight of yield of kohlrabi was observed in association with raj koroi tree. Results showed that growth and yield of kohlrabi was better in the open field condition compared to other treatments of the study. The highest (540.8g) and lowest (380.6g) fresh weight of modified stem of kohlrabi were recorded in T_0 (open field referred as control) and T_1 (25 cm from tree base), respectively. In combination with tree species, though maximum parameters of growth and yield of kohlrabi gradually decreased with decreasing distances towards the tree base, kohlrabi can be cultivated in association with raj koroi tree as agroforestry.

Key words: Agroforestry, growth, Kohlrabi, raj koroi, yield

Introduction

Agroforestry is a land use management system in which trees or shrubs are grown around or among crops or pastureland. It combines shrubs and trees in agricultural and forestry technologies to create more diverse, productive, profitable, healthy, ecologically sound, and sustainable land-use systems. Agroforestry systems can be advantageous over conventional agricultural, and forest production methods. They can offer increased productivity, economic benefits, and more diversity in the ecological goods and services provided which is more effective in densely populated country like Bangladesh. The current population is 15.89 crores (BBS, 2016), growth rate is 1.37% and the population density in Bangladesh is 1077 people per Km^2. The country is facing enormous problem for nursing her population. Moreover sound environment is needed to maintain the environmental equilibrium and rate of socio-economic development at least 25% area of a country should be covered with forest. In Bangladesh, the total forest area covers about 11% of the total land area (World Bank, 2015). Bangladesh became a food deficient country in the late 1950s, when population pressures took their toll. Land that could be used for farming crops or raising livestock is being used for living space. In 2003, the population density was 1060 people per square kilometer. The population in Bangladesh was 127.6 million in 1998, while a recent 2006 estimate is 141.3 million. At current rates of population growth, it is estimated that the total population

could reach 175 million by about 2025. The large population in its relatively small area makes for a country facing poverty. Bangladesh ranks as third in the extent of poverty after China and India. At least 50 percent-over 55 million-of the people in Bangladesh are living below the country's poverty level. The poorest third of people in Bangladesh eat 1,500 calories or fewer per day. The country has some of the highest malnutrition levels in the world; 84 percent of children under the age of five in Bangladesh are considered malnourished.

The average consumption of vegetables in Bangladesh is only 70g per person per day including potato and sweet potato. Except tuber crops, it is only 30g in comparison with FAO recommendation of 200g. Population of Bangladesh is increasing rapidly; therefore, demand for vegetables is increasing. The areas under vegetables production including tuber crops are 7,14,000 ha that produce 10.30 million metric tons of vegetables yearly. As a result, there is a tremendous pressure on the natural resources as well as lands of the country. So instead of horizontal expansion, vertical expansion of agriculture and forestry can be helpful and agroforestry can be a possible solution for this problem. Kohlrabi (German turnip or turnip cabbage; *Brassica oleracea* Gongylodes Group) is a biennial vegetable, and is a low, stout cultivar of cabbage. It can be eaten raw as well as cooked. Edible preparations are made with both the stem and the leaves. It is a member of the cabbage family grown for its swollen, turnip-shaped portion of the stem which rests on the ground. The edible portion can be white, purple or green with a creamy white interior. They are eaten raw in salads or can be cooked like a turnip. Kohlrabi can be grown anywhere that turnips can be produced. They do best in cool weather with abundant moisture to prevent the edible portion from becoming tough and woody. It requires 50 to 65 days from seed to maturity and should be harvested when slightly larger than a golf ball. Raj koroi popularly planted by farmers in homesteads specially southern part of Bangladesh which attained an average height of 14m and dph of 28cm within 15 years (Anonymus, 2009). Wood is whitish, often without colored sap wood, hard and sustainable (Islam *et al*., 2012). Wood is used to make boats in Barisal districts of Bangladesh along with cheap furniture and fuel wood in local markets (Das & Alam, 2001). The pulp yield of Raj koroi was comparable to other hardwood species widely used in pulp and paper mills of Bangladesh (Biswas *et al*., 2012).

For identifying the compatible tree-crop combination, i.e. different crops should be screened out in terms of their adaptability and yield in association with trees. For this purpose, the best way of experimentation is to grow different crops at different spacing from the tree base. 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. Therefore, it would be wise to conduct experiments under different tree crop or vegetable combination at different spacing for screening of different crops in terms of their growth and yield performance. Considering the aforementioned facts and potentiality, a study was undertaken with the broad objectives to examine the competitive effect of one vegetable (kohlrabi) grown in association with raj koroi tree in tree-crop agroforestry system. However the specific objectives were (i) to evaluate the morphological characteristics and yield of kohlrabi along with raj koroi trees and (ii) to identify the optimum distance from the tree base so as to know the optimum growth and yield of kohlrabi.

Materials and Methods

Location of the study area: The area of Bauphal is 486.91 km2 and it is located in between 22°19´ and 22°36´ north latitudes and in between 90°25´ and 90°40´ east longitudes. It is bordered by Bakerganj and Bhola Sadar Upazila on the north, Dashmina and Galachipa Upazila on the south, Bhola Sadar, Burhanuddin and Lalmohan Upazila on the east and Patuakhali Sadar and Bakergonj upazilla.

Soil: The soil of the experimental field belongs to the Barisal soil series of the Ganges Tidal Floodplain (AEZ-13). The general soil type of the experimental field is silty clay loam. Topsoil is silty clay in texture. Organic matter content is very low and soil pH value 6.8.

Climate and weather: The climate of study area is tropical. Rainfall is significant most months of the year, and the short dry season has little effect. The average annual temperature is 25.9 ^{o}C and annual precipitation is 2642 mm. The driest month is January with 8mm rainfall. Most of the precipitation falls in July which is averaging 576mm. The warmest month of the year is May with average temperature 29.8 ^{o}C. January is the coolest month with temperature averaging 19.5 ^{o}C.

Tree and plant material: Previously established raj koroi trees (2.5 year's) were used as tree component and vegetable crop kohlrabi was used as plant materials. Kohlrabi is a winter vegetable from genus *Brassica* belongings to the family Brassicaceae or cabbage family. Raj koroi (*Albizia richardiana*) belongs to the family Fabaceae is one of the most important and popular trees in Bangladesh.

Tree management: The study was done under 2.5 year's old raj koroi. At first soils at the base of tree were loosen very well and made friable. Weeds were removed from the surrounding area of the tree base; insect infected leaves were also removed.

Experimental design and treatment combination: Randomized Complete Block Design (RCBD) was done with three replications. Different treatments in this study were; T_0=open field referred to as control, T_1= 25cm distance from tree base, T_2=50cm distance from tree base and T_3=75cm distance from tree base.

Land preparation: The experimental land was opened in 18 November 2016 and the operations were done by spade. Then the land was fallow for few days. Second operation was done in 1 December 2017. All crops

residues and weeds were removed from the field and finally the land was properly leveled.

Crop establishment: Seedlings of kohlrabi were planted in previously developed land on 5th December 2017.

Management practices: Different management practices such as fertilizer application, weeding, irrigation, thinning, pest and disease management etc. were done for better growth of the kohlrabi plants. The management practices were done is described as follows:

***Application of fertilizer and manures*:** Only recommended doses of well decomposed cowdung were applied for the crop. No chemical fertilizer was applied and full amount of well decomposed cowdung was incorporated during the final land preparation.

***Irrigation*:** Irrigation was done at 8 to 10 days interval depending on the weather conditions and requirements.

***Thinning or filling*:** Thinning was done to maintain the proper plant density.

***Pest and disease control*:** The crops were not infected with any insect diseases and no pesticide and fungicide were used.

Harvesting: The kohlrabi fruits were harvested at tender stage and before 85% maturity. Harvesting was done at 5th February 2017.

Data collection: Five plants from a plot were randomly selected for data collection. The studied parameters were no. of leaves/plant, length of leaf (cm), breadth of leaves (cm), plant height, length of root (cm), fresh weight of leaf (g/plant), fresh weight of root (g/plant), fresh weight of modified stem (g/plant), dry weight of leaf (g/plant), dry weight of root (g/plant), dry weight of modified stem (g/plant). Data of different morphological characteristics were collected at two different stages like vegetative and harvesting. The recorded parameters were as follows:

No. of leaves per plant: No of leaves were counted at 20days, 40 days and final harvest time at 60 days, respectively.

Length of leaf: The length from the base of main leaf to the tip was recorded at 20 days, 40 days and 60 days (harvest time). Leaf length was measured using measuring tape and expressed in centimeter (cm).

Breadth of leaf: The breadth of leaves was recorded at three intervals like 20 days, 40 days and 60 days (harvest time). Breadth of leaves was measured by measuring tape and expressed in cm.

Plant height: Randomly 3 plant of kohlrabi from each distance (25cm, 50cm, 75cm) were recorded in three intervals (20 days, 40 days, 60 days) with measuring tape in cm.

Length of root: The length of root was recorded at three intervals like 20 days, 40 days and 60 days (harvest time). Breadth of leaves was measured by measuring tape and expressed in cm.

Fresh weight of leaf: Total fresh weight of leaf per plant was measured in weigh machine at laboratory after harvesting and expressed in gram.

Fresh weight of root: Randomly 3 fresh weight of root of kohlrabi plant from each distance (25cm, 50cm, 75cm) was recorded in weigh machine in laboratory after harvesting and expressed in gram.

Fresh weight of modified stem: Randomly 3 fresh weight of modified stem from each distance was recorded by weigh machine in laboratory and expressed in gram.

Dry weight of leaf: After taking fresh weight, the leaves were kept on sundry for 5 days then oven dried @ 75 ^{o}C for 10 days. Then its weight measured in laboratory and expressed in gram.

Dry weight of root: Total roots per plant from each distance was dried following same way using oven for 10 days then its weight measured in laboratory and expressed in gram.

Dry weight of modified stem: Randomly 3 oven dry weight of modified stem from each distance was recorded in weight machine after harvesting and expressed in gram.

Data analysis: The analysis of variance (ANOVA) for each of the recorded characteristics were done by F (variance ratio) test following Randomized Complete Block Design (RCBD). The data were collected from the experiment at different stages of various growth and then analyzed statistically by using SPSS package to find out the statistical significance of the experimental results. The mean differences were evaluated by Duncan Multiple Range Test (DMRT) (Gomez & Gomez, 1984).

Results and Discussion

The data have been presented in tables, figures and a summary of the analysis and variance in respect of all the parameters. The results of each parameter have been discussed.

Morphological characteristics of kohlrabi under raj koroi tree:

Number of leaves per plant: The highest (13.33) number of leaves were noted under T_0 (open field referred as control) followed by 12 found in case of T_3, respectively (Table 1). The lowest (11.33) number of leaves were recorded in T_1 (25cm distances from tree base). Total number of leaves per plant of kohlrabi was increased with the increase of distance from tree base; the similar types of findings were mentioned by Rahman (2013) in their experiment with the effect of two years old akashmoni tree on three winter vegetables grown in agroforestry system. It might be due to the competition for natural resources like air, water, nutrient, sunlight etc.

Length of leaf: Among different distances the highest (46.66cm) and lowest (34cm) length of leaf of kohlrabi was recorded at 60 DAS (harvest time) in T_0 (open field referred as control) and T_1 (50 cm distance from the tree base), respectively. Control produces the highest length, it might be due to sufficient sunlight which is comparable with the findings of Ray (2014) in his study with Interaction effects of vegetables in association with tree (*Mangifera indicia L.*) sapling.

Breadth of leaf: Significant difference found in breadth of leaves of kohlrabi under raj koroi tree (Table 1). The highest (29.40cm) and lowest (15.07cm) breadth of leaves were found in T_0 (open field referred as control) and found T_1 (50cm from tree base).

Table 1: Morphological characteristics of kohlrabi in association with raj koroi tree

Treatment	No. of leaves per plant			Length of leaf (cm)			Breadth of leaf (cm)		
	20days	40days	60days	20days	40days	60days	20days	40days	60days
T_0	8.00	8.33	13.33	20.77a	41.50	46.66	13.77a	23.53a	29.40a
T_1	7.33	8.66	11.33	15.83c	30.33	34.00	7.500c	12.33b	15.07b
T_2	7.33	8.66	11.66	17.83b	32.00	37.00	8.833c	14.33b	18.07b
T_3	7	9.66	12.00	18.10b	35.80	42.00	11.40b	17.07ab	26.03a
Level of significance	NS	NS	NS	**	NS	NS	**	*	**
Co-efficient of variation	14.74	11.78	13.86	5.33	19.58	15.43	9.48	21.25	16.70

Note: * = Significant at 5% level of probability, ** = Significant at 1% level of probability and NS = Not significant. T_0= Control (open field), T_1= 25cm distance from tree base, T_2= 50cm distance from tree base, T_3= 75cm distance from tree base.

Table 2: Morphological characteristics of Kohlrabi in association with raj koroi tree at harvest time

Treatment	Plant height (cm)			Length of root per plant (cm)	Weight of leaves per plant (g/plant)	Weight of root per plant (g/plant)	Weight of modified stem (g/plant)
	20 days	40 days	60 days				
T_0	7.10a	15.43a	18.23a	12.33a	218.8a	20.23a	540.8a
T_1	3.66c	9.500b	12.83c	6.50oc	195.7b	16.83c	380.6c
T_2	4.40bc	10.33b	13.73bc	10.33ab	207.0ab	17.83b	421.0bc
T_3	4.80b	10.83b	14.57b	8.833bc	206.4ab	19.47a	455.5b
Level of significance	**	**	**	**	*	**	*
Co-efficient of variation	8.18	12.58	5.28	12.35	3.06	2.57	5.14

Note: * = Significant at 5% level of probability, ** = Significant at 1% level of probability and NS = Not significant. T_0= Control (open field), T_1= 25cm distance from tree base, T_2= 50cm distance from tree base, T_3= 75cm distance from tree base.

Plant height: There was significant variation found in plant height of kohlrabi plant in association with raj koroi tree (Table 2). The highest (18.23cm) and lowest (12.83cm) plant height of kohlrabi was observed at T_0 (open field referred as control) and T_1 (50cm from tree base), respectively. It might be due to competition for natural resources like sunlight, air, water nutrient etc.

Length of root: There was significant variation found in length of root of kohlrabi under raj koroi tree (Table 2). The highest (12.33 cm) length of roots were recorded in T_0 (open field referred as control) followed by 10.33 cm in T_2 (50 cm distances from the tree base), respectively. The lowest (6.50cm) length of root was produced in T_1 (25cm distance from the tree base).

Fresh weight of leaf per plant: Fresh weight of leaf of kohlrabi in different treatments was found significant (Table 2). Results showed that the highest (218.8g) and lowest (195g) fresh weight of leaf of kohlrabi were recorded from T_0 (open field referred as control) and T_1 (25 cm from tree base), respectively.

Fresh weight of root per plant: Fresh root weight of kohlrabi in different treatments was found to be significant (Table 2). The highest (20.23g) and lowest (16.83g) fresh weight of root of kohlrabi were recorded from T_0 (open field referred as control) and T_1 (25 cm from tree base), respectively. Fresh weight of root of kohlrabi was increased consistently with the increasing distance from tree base which is comparable by the findings of Taher (2014) in sweet gourd and Basak *et al.* (2009) in other plant.

Fresh weight of modified stem: Significant variation was observed in fresh weight of modified stem in kohlrabi (Table 2). The highest (540.8g) and lowest (380.6g) fresh weight of modified stem of kohlrabi were recorded in T_0 (open field referred as control) and T_1 (25 cm from tree base), respectively. Similar results were recorded by Saha *et al.* (2015) in ipil-ipil based alley cropping system.

Dry weight of leaf: Difference found in dry weight of leaf of kohlrabi from the different distance of tree base (Fig. 1). As evident from the results, the highest (20.77g) and lowest (17.43gm) dry weight of leaf were obtained from treatment T_0 (Open field referred as control) and T_1 (25 cm distances from the tree base), respectively (Figure 1). The dry weight of leaf was increased consistently with the increase of distance from tree base, the similar types of findings were mentioned by Ray (2014) in their experiment with performance of mango-radish based agroforestry system.

Dry weight of root: The variation in dry weight of root of kohlrabi in different treatments was found to be different (Fig 1). Results showed that the highest (4.847g) and lowest (4.033g) dry weight of root were created from T_0 (open field referred as control) and T_1

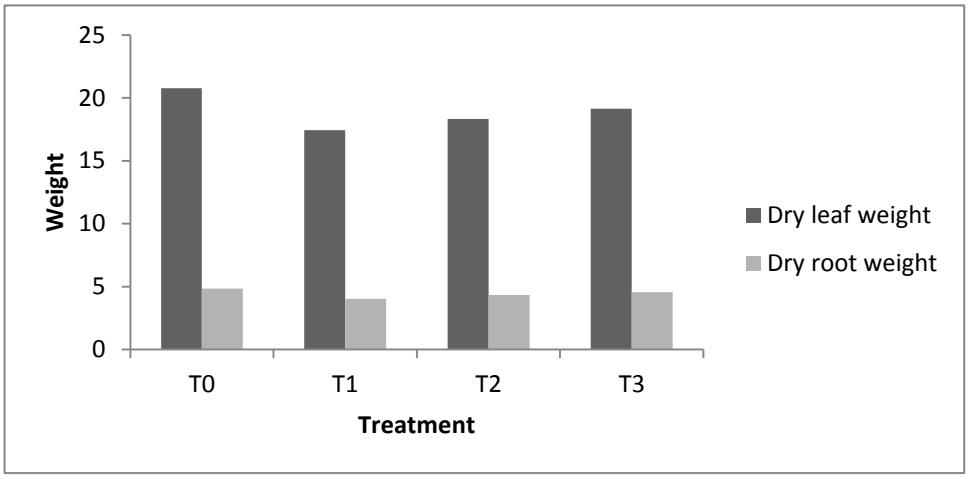

Figure 1: Dry weight of leaf and root of kholrabi per plant
Note: T_0= Control (open field), T_1= 25cm distance from tree base, T_2= 50cm distance from tree base, T_3= 75cm distance from tree base. Weight expressed in gm.

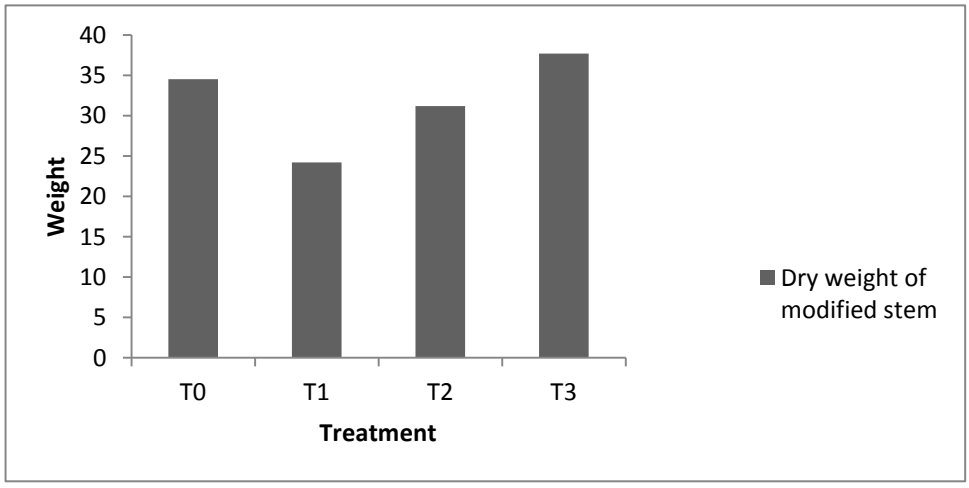

Figure 2: Dry weight of modified stem of kholrabi per plant
T_0= Control (open field), T_1= 25cm distance from tree base, T_2= 50cm distance from tree base, T_3= 75cm distance from tree base.

(25cm from tree base), respectively. The second highest dry root weight of kohlrabi (4.567g) was obtained from T_3 (75 cm from tree base).

Dry weight of modified stem: Results showed that the highest (37.67g) dry weight modified stem of kohlrabi were created from T_3 (75cm from tree base) followed by 34.49g from T_0 (open field referred as control). On the other hand, the lowest (24.2g) dry weight modified stem of kohlrabi were recorded in T_1 (25cm from tree base) (figure 2). It might be due to the competition for natural resources like air, water nutrient sunlight etc. Because short distance crops faces more competition and it will be minimum with the increasing distances.

Conclusion

Though the yield component and growth characteristics of kohlrabi are affected in association with raj koroi tree, it may be concluded that kohlrabi can be successfully grown in association with raj koroi tree where the tree-crop based agroforestry practice is profitable for farmer as it gives both vegetable and timber at the same time. It was a primary and small scale experiment, so further experiment should be done at larger scale and in different regions. Because results can vary for different factors like soil, sunlight, weather, topography and several other factors. So, before recommend for farmer's level, more experiments should be done to more authentications the result.

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