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Interaction effect of mahogany tree on the yield performance of rice under agri-silvicultural system

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Abstract: The experiment was conducted at the Kalibari char which is situated by the side of Brahmaputra river adjacent to the Bangladesh Agricultural University, Mymensingh, during the period from August 2018 to December 2018 with the aim of evaluating the growth performance of rice cultivated in association with seven years old boundary planted mahogany tree during aman season under irrigated condition. Mahogany trees were planted in the south, north and west side of the plot. Interaction effects of mahogany tree viz. shade effect and root competition were observed in south side, north side and west side separately. In each side i.e. south, north and west, three distances viz. 0-12 ft., 12-24 ft., 24-36 ft. etc. were selected for data collection which were considered as the different treatments of this study. Rice also cultivated without mahogany tree combination which was the control treatment of this study. Total ten treatments {1 + (3x3) =10} in control, south, north and west side were defined as T_0, T_1, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 respectively. Different growth and yield characteristics of rice were observed under the above-mentioned treatments where it was found that growth and yield of rice significantly influenced by mahogany trees. Yield of rice gradually decreased towards the base of mahogany tree in each side. Among the different side highest yield reduction was found in west side where 77.6, 64.3 and 48.9% reduction were recorded in 0-12, 12-24 and 24-36 ft. distance from tree base i.e. in the treatments T_7, T_8 and T_9. Similar type of yield reduction was recorded in south (T_1 -71.3%, T_2-53.5% and T_3-12.8%) and north (T_4-73%. T_5-55.4% and T_6-14.9%) side but numerically slight increase reduction was found in north side due to the shading effect, competition for nutrient, water and light in the view of tree-crops combination.
Key words: Rice, Agri-silvicultural system, Mahogany, Char land agroforestry.

Introduction

Rice is the major cereal crop being grown widely and it is the main staple food for the people of Bangladesh. The current level of food grain production, averaged over the last eight years during the decade had been around 19.31million tons of which rice alone accounted for almost 18.04 million tons (Pillai, 1998). Bangladesh is a food deficit country, mainly due to an increasing population pressure. Bangladesh is a country, where rice uniquely dominates the farming systems of the country. Nearly 70% land area of Bangladesh is now under rice Cultivation. Rice is grown in the open field (i.e. field having no tree) because sunlight is the important resource for photosynthesis and transpiration production). The yield of rice is depend on solar radiation. The edges (boundary) of crop fields remain fallow. To utilize this fallow land, trees are planted on the rice field boundary. When trees are established in the boundary of rice field, proper management practices is necessary, to reduce the harmful effect of tree on crop.

Mahogany *(Swetania macrophylla)* is the most important timber tree species that is grown all over the country for their wider range of adaptability. This timber species is deep rooted, large sized having spread canopy at mature stages and contributed the major share of the timber supply of the country. Besides, the excessive part of this tree is used as fuel wood and other purposes. Mahogany is a suitable tree species for boundary plantation surrounding the rice field. Growing of this economic tree zonally or sequentially along with crops on the same area of land that promising production system for maximizing yield and maintaining friendly environment known as "Agri-silvicultural system" (Craig R. Elevitch, 2000).

It is believed that tree shade is responsible for poor yields of associated crops except those loving shade or tolerant shade condition. This problem is more acute to the tree remains unpruned. It influences to increase plant height, decreases tiller and panicle number per hill and grains per panicle and decreases grain yield. Shade stimulates cellular expansion and rapid cell division resulting increase leaf length and plant height (Schoch, 1972). Shading treatment showed the tallest plants and on the other hand, smallest plants are observed under shade free area (Miah *et al*., 1999). Nowadays Bangladeshi farmers plant tree in their crop field. But they were not aware about tree pruning. So unpruned trees provide shade on the understory crop, which ultimately influence the crop yield.

To minimize the competition and maximize the beneficial effects will be the main goal of mixed production system (Young 1997). For obtaining the full benefits of agroforestry it is necessary to maximize the positive effects and to minimize the negative effects of trees on associated crops. For maximizing this beneficial effects and minimizing negative effects, it is essential to observe the tree-crops interactions from agroforestry systems. Considering the above facts this study was investigate the interaction effect of mahogany tree on the yield performance of rice under agri-silvicultural system.

Materials and Methods

Experimental site and season: The experiment was carried out at Char Kalibari belongs to the Mymensingh sadar upazila during the period from August 2018 to December 2018. The geographical position of Char Kalibari located between 24°45'-24°45'40" North and 90°24'4"- 90°24'44" East Latitude.

Tree and plant materials: In this study, seven years old boundary planted mahogany tree was used as test tree components and rice was used as plant materials during aman season under irrigated condition.

Tree, crop establishment and management: Necessary management activities like watering, cleaning, weeding, fertilizing, branch cutting and other intercultural operations were done in time for proper growth and development of all plants.

Experimental design, layout and treatment combination: Rice was cultivated in association with seven years old boundary planted mahogany tree following the Randomized Complete Block Design

(RCBD) with single factorial arrangement with 3 (three) replications. Mahogany trees were planted in the south, north and west side of the plot. Interaction effects of mahogany tree viz. shade effect and root competition were observed in south side, north side and west side separately. In each side i.e. south, north and west, three distances viz. 0-12 ft., 12-24 ft., 24-36 ft. etc. were selected for data collection which were considered as the different treatments of this study. Rice also cultivated without mahogany tree combination which was the control treatment. The treatments were- T_0 = Control area (without tree); T_1, T_2 and T_3 were 0 -12 ft., 12-24 ft. and 24 - 36 ft. respectively distance from tree base at south orientation considering morning period; T_4, T_5 and T_6 were 0-12 ft., 12-24 ft. and 24-36 ft. respectively distance from tree base at north orientation considering afternoon period; T_7, T_8 and T_9 were 0-12 ft., 12-24 ft. and 24-36 ft. respectively distance from tree base at north/south orientation both morning and afternoon period. Total ten treatments {1 + (3×3) =10} in control, south, north and west side were defined as T_0, T_1, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 respectively.

Sampling and Data collection: Data of different growth and yield characteristics of rice were collected at vegetative and harvesting stage. For data collection plant samples were selected randomly from all the treatments of the plots. The studied parameters were plant height, no. of tiller hill^{-1}, no. of leaves hill^{-1}, average leaf length, no. of effective tiller hill^{-1}, no. of non-effective tiller hill^{-1}, no. of panicle hill^{-1}, no. of filled grain hill^{-1}, no. of unfilled grain hill^{-1}, 1000 seed weight (g) and grain yield (t ha^{-1}). Rice was harvested after 90 days from the date of transplanting.

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 'WASP 2' 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

Growth and yield parameters of rice were significantly affected by different treatments of this study at vegetative and harvesting stage (Fig.1). Different morphological parameters of rice in combination with rice at vegetative (Table 1) and harvesting (Table 2) are presented here chronologically:

Plant height: Plant height of rice in association with mahogany tree was affected significantly due to the effect of different treatments at vegetative (Table 1) and harvesting (Table 2). The result noted that the highest plant height 60.80 cm and 68.68 cm were recorded in vegetative (Table 1) and harvesting (Table 2), respectively in control condition (T_0). The second highest plant heights were recorded as 59.56 cm and 67.25 cm at vegetative and harvesting stages, respectively in treatment T_3 which were statistically similar with the treatment T_6 and T_9 where the values were found 59.50 cm and 67.21 cm respectively for T_6 and 58.87 cm and 66.76 cm respectively for T_9. But, plant height in the treatment T_7 produced 50.25 cm and 52.28 cm tall plant at vegetative and harvesting stages, respectively, which indicated as the worst compare to control condition (T_0) (Tables 1 and 2). Near the tree base plant heights were lower may be due to competition for sunlight, different nutrient elements and moisture between the root system of rice and mahogany tree. Rakib *et al.* (2013) and Bithi *et al.* (2014) observed lower plant height in radish and bitter gourd very near the base of mango and ipil-ipil tree.

No. of tiller per hill: No. of tiller per hill of rice in association with mahogany tree was also affected significantly due to the effect of different treatments at vegetative (Table 1) and harvesting (Table 2). The result indicted that the highest number of tiller per hill were 12.21 and 10.11 recorded in vegetative (Table 1) and harvesting (Table 2), respectively in control condition (T_0). The second highest number of tiller per hill were recorded as 11.30 and 9.12 at vegetative and harvesting stages, respectively in treatment T_3 which were statistically similar with the treatment T_6 and T_9 where the values were found 11.25 and 9.09 respectively for T_6 and 10.25 and 8.08 respectively for T_9. The lowest number of tillers hill^{-1} were 6.88 and 4.04 produced by T_7 at vegetative harvesting stage, respectively due to the effect of shade, nutrient and moisture content etc. Control produces the best result due to the absence of shading effect. Singh (1988), Sutater (1987) and Struik (1985) also stated that the rice plants in shade free area increases number of tillers and encouraged more photosynthesis resulting in higher production.

No. of leaves per hill: The number of leaf hill^{-1} of rice were meaningfully enlarged with the rise of distance from the mahogany tree base at vegetative stage (Table 1) by different treatments where the greatest number of leaf hill^{-1} were 52.28 viewed in the treatment T_0 (control area). The second highest number of leaf hill^{-1} was 50.74 produced by treatment T_3 which were statistically similar with treatment T_6 (50.66). The lowest number of leaf hill^{-1} were 35.75 produced by treatment T_7 due to the effect of shade, nutrient and moisture content etc. Islam *et al.* (1995) reported that number of leaves usually decreased under shading condition in most of the crops such as carrot, red amaranth and Indian spinach.

Average leaf length: Average length of leaf of rice was significantly affected by different treatments during combined production with mahogany tree (Table 1) where leaf length gradually decreased towards the mahogany tree base (Fig. 1). Largest leaf was produced in control condition (18.25cm) which was statistically similar with the treatment T_3 (17.96cm) and T_6 (17.88cm) followed by treatment T_9 (17.19cm), T_2 (16.75cm), T_5 (16.69cm), T_1 (15.58cm) and T_4 (15.50cm). Smallest sized leaf of rice was recorded in the treatment T_7 (13.23cm) may be due to competition for light, nutrient and moisture between mahogany tree roots with rice roots in the surface layer of soil. Islam and Wadud (2009) reported that leaf length usually decreased under shading condition in most of the crops such as carrot, red amaranth and Indian spinach.

Figure 1. Rice cultivation in association with mahogany tree

Table 1. Morphological parameters of rice in association with mahogany tree at vegetative stage

Treatments	Plant height (cm)	No. of tillers/ hill	No. of leaves/hill	Av. Leaf length (cm)	No. of effective tillers/hill	No. of Non effective tillers hill^{-1}
T_0	60.80 a	12.21 a	52.28 a	18.25 a	12.33 a	3.98 a
T_1	55.15 e	7.951 e	46.23 e	15.58 c	7.88 e	2.23 f
T_2	57.28 c	9.725 c	48.75 cd	16.75 b	8.85 d	2.52 d
T_3	59.56 b	11.30 b	50.74 b	17.96 a	10.71 b	3.44 b
T_4	55.28 de	7.881 e	46.12 e	15.50 c	7.80 e	2.20 f
T_5	57.21 c	9.665 c	48.69 cd	16.69 b	8.79 d	2.46 de
T_6	59.50 b	11.25 b	50.66 b	17.88 a	10.66 b	3.39 b
T_7	50.25 f	6.886 f	35.75 e	13.23 d	6.88 f	2.04 g
T_8	56.34 cd	8.864 d	47.72 d	16.05 c	8.63 d	2.42 e
T_9	58.87 b	10.25 c	49.25 c	17.12 b	9.52 c	2.86 c
$LSD_{0.01}$	1.09	0.610	1.29	0.549	0.516	0.074
Level of sign.	**	**	**	**	**	**
CV (%)	8.13	7.14	12.98	13.71	9.30	8.14

Mean in column followed by the different letter are significantly different by DMRT at P< 0.01; T_0 = Control area (without tree); T_1, T_2 & T_3 were 0–12 ft., 12-24 ft. & 24 - 36 ft. respectively distance from tree base at south orientation, T_4, T_5 & T_6 were 0-12 ft., 12-24 ft. & 24-36 ft respectively distance from tree base at north orientation, T_7, T_8 & T_9 were 0-12 ft., 12-24 ft. and 24-36 ft. respectively distance from tree base at west orientation.

Number of effective tillers hill^{-1}: Number of effective tillers hill^{-1} of rice under mahogany tree was the significantly affected by different interaction effects (Table 1). Highest number of effective tillers hill^{-1} (12.33) was recorded by T_0 (control area) and the second highest (10.71) was recorded by T_3 which was statistically similar with treatment T_6 (10.66) followed by treatment T_9 (9.52), T_2 (8.85), T_5 (8.79), T_1 (7.88) and T_4 (7.80). Lowest (6.87) number of effective tillers hill^{-1} was produced in treatment T_7 which may due to the negative effect of mahogany both above and below the ground for growth resources. Sharma and Tiware (1992) reported that the vegetative parameter of rice affected by the negative effects of trees during combined production.

Number of non-effective tillers hill^{-1}: Results of the study revealed that non-effective tillers hill^{-1} of rice was significantly affected by different shading effect of Mahogany tree at 5% level of significance (Table 1). The highest number of non-effective tillers hill^{-1} (3.98) was observed by T_0 (control area) and the second highest (3.44) was observed by T_3 which was statistically similar with treatment T_6 (3.39) and the lowest (2.04) was observed in treatment T_7. Control condition produces the best result due to the absence of interaction effect of mahogany tree. Vitryakon *et. al.* (1993) determined negative

interactions of overstorey plant components increase non-effective tillers, decrease tiller and panicle number hill^{-1} and grains panicle^{-1} and also decreased grain yield of rice during intercropping with trees.

Number of panicles hill^{-1}: There was significant variation in number of panicles hill^{-1} of *Aman* rice due to different treatments grown in association with mahogany tree (Table 2). The result revealed that highest number of panicles hill^{-1} was 8.13 were produced by T_0 (control area). The number of panicles hill^{-1} 7.65 were produced by T_3 which were statistically similar with T_6 (7.43) and the lowest (3.25) was produced by T_7 i.e. 0-12 ft distance from tree base at west orientation. Control produces the best result due to the absence of negative interactions effects by mahogany trees. Baevre (1990) reported that reducing incoming light by 30% and 60% resulted in significant reductions in the number of flowers, percent fruit set, fruit size and yield.

Number of filled grains hill^{-1}: It was observed that number of filled grains hill^{-1} of rice in association with mahogany tree was the significantly affected in case of rice production by different interaction effect (Table 2). The highest number of filled grains hill^{-1} (40.33) was produced by T_0 because control produces the best result due to the absence of shading effect. The second highest number of filled grains hill^{-1} (38.49) was produced by treatment T_3 which was statistically similar with (38.42) was produced by treatment T_6 and the lowest (33.42) was produced by T_7 (0-12 ft distance from tree base at west orientation) which was statistically similar with T_1 (34.21).

Table 4. Morphological parameters of rice in association with mahogany tree at harvesting stage

Treatments	Plant height (cm)	Number of tillers hill^{-1}	Number of Panicles hill^{-1}	No. of filled grains hill^{-1}	No. of unfilled grains hill^{-1}	1000 seed weight (g)
T_0	68.68 a	10.11 a	8.13 a	40.33 a	6.12 g	28.45 a
T_1	62.22 e	5.55 f	4.50 f	34.21 f	12.43 c	20.68 f
T_2	65.29 c	7.58 d	6.12 d	36.88 cd	10.76 d	23.35 d
T_3	67.25 b	9.12 b	7.65 b	38.49 b	7.93 f	25.61 b
T_4	63.42 d	5.28 f	4.34 f	34.16 ef	12.34 c	20.56 f
T_5	65.23 c	7.43 d	6.09 d	36.77 cd	10.68 d	23.28 d
T_6	67.21 b	9.09 b	7.43 b	38.42 b	7.88 f	25.56 b
T_7	52.28 e	4.04 g	3.25 g	33.76 f	15.25 a	18.38 g
T_8	64.26 cd	6.67 e	5.32 e	35.57 de	13.66 b	21.49 e
T_9	66.76 b	8.08 c	6.50 c	37.12 bc	8.36 e	24.76 c
$LSD_{0.01}$	1.09	0.277	0.311	1.34	0.308	0.484
Level of sign.	**	**	**	**	**	**
CV (%)	11.88	9.27	7.88	9.13	13.28	12.35

Mean in column followed by the different letter are significantly different by DMRT at P< 0.01; T_0 = Control area (without tree); T_1, T_2 & T_3 were 0–12 ft., 12-24 ft. & 24 - 36 ft. respectively distance from tree base at south orientation, T_4, T_5 & T_6 were 0-12 ft., 12-24 ft. & 24-36 ft respectively distance from tree base at north orientation, T_7, T_8 & T_9 were 0-12 ft., 12-24 ft. and 24-36 ft. respectively distance from tree base at west orientation.

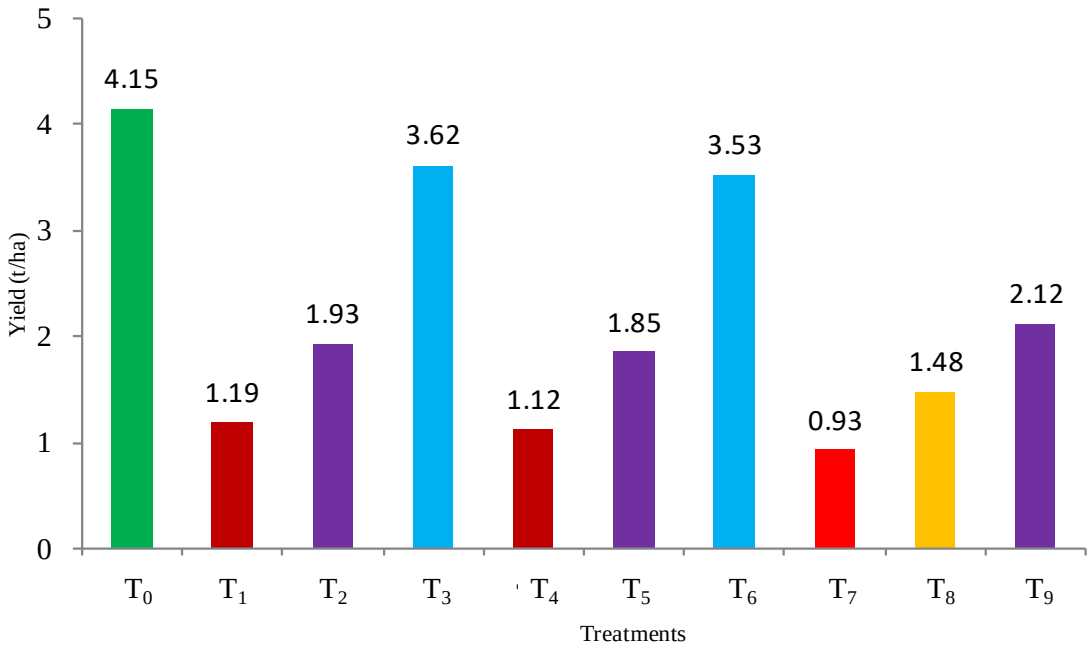

Figure 2. Yield of rice with mahogany tree in different treatments (South side - T_1, T_2 and T_3, North side - T_4, T_5 and T_6 and West side -T_7, T_8 and T_9)

Number of unfilled grains hill^{-1}: Number of unfilled grains hill^{-1} of rice under mahogany tree was the significantly affected by shading effect at harvesting stage by different treatments where the greatest number of unfilled grains hill^{-1} (15.25) was produced by T_7 (Table 2). The second highest number of unfilled grains hill^{-1} (13.66) was produced by treatment T_8 and the lowest (6.12) was produced by T_0 (control area). As the evidence of the result, it is clear that the shade of mahogany tree increases number of unfilled grains hill^{-1} of rice, although the shade of mahogany tree continuously decreases tiller and panicle number hill^{-1} and grains panicle^{-1} and grain yield. Similar type of interaction was observed by Vitryakon *et. al.* (1993) and Milon (2009) in case of wheat.

1000 seed weight (g): The result revealed significantly affected in case of 1000 seed weight of rice in association with mahogany tree by different treatments at harvesting stage where the highest 1000 seed weight (28.45g) was produced by T_0 (Table 2). The second highest number of 1000 seed weight (25.61g) was produced by T_3 which was statistically similar with (25.56g) was produced by T_6 and the lowest (18.38g) was produced by T_7 (0-12 ft distance from tree base at west) that was affected by shade, light, nutrient and moisture content etc. The reason of highest thousand seed weight (g) under shade condition might be due to long time light required assimilates for grains which resulted from higher or photosynthesis. Shukla *et al.* (2008) stated that various plant growth parameters viz. shoot length, dry weight and phosphorus (P) uptake were adversely affected by low light intensity.

Grain yield: It was found that grain yield of rice significantly influenced by mahogany trees (Fig. 2). Yield of rice gradually decreased towards the base of mahogany tree in each side. Among the different side highest yield reduction was found in west side where 77.6, 64.3 and 48.9% reduction were recorded in 0-12, 12-24 and 24-36 ft. distance from tree base i.e. in the treatments T_7, T_8 and T_9. Similar type of yield reduction was recorded in south (T_1-71.3%, T_2-53.5% and T_3-12.8%) and north (T_4-73%, T_5-55.4%and T_6-14.9%) side but numerically slight increase reduction was found in north side (Fig. 2). Lower grain yields under shade were due to the cumulative effect of reduction in the number of effective tillers hill^{-1}, number of grains panicle^{-1} and increase in non-effective tillers hill^{-1}. Similar results have been reported by Jadhav (1987), Chaturvedi and Ingram (1989).

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