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Effect of tree leaf biomass on soil fertility and yield of rice

B.N. Tanzi, M.S.A. Arifin, M.A. Mondol, A.K. Hasan[1] and M.A. Wadud
Department of Agroforestry, [1]Department of Agronomy, Bangladesh agricultural University, Mymensingh- 2202
E-mail: bodrun_nesa@yahoo.com

Abstract: A field experiment was conducted in the Agroforestry Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from July to December 2011 to find out the response of different leaf biomass application on yield contributing characters and yield of rice cv. BR11(Mukta). Seven experimental treatments such as T_1 = kalo koroi leaf biomass, T_2 = Sada koroi leaf biomass, T_3 = Raintree leaf biomass, T_4 = Krishnochura leaf biomass, T_5 = Jhau leaf biomass, T_6 = Recommended fertilizer dose, T_7 = Control were imposed in this study. The experiment was conducted in a Randomized Complete Block Design (RCBD) with three replications. Soil fertility status was determined before and after the study. Yield and yield contributing characters viz. plant height (cm), no. of total tillers hill^{-1}, no. of effective tillers hill^{-1}, panicle length (cm), number of grains panicle^{-1}, 1000-grain weight (g) and grain yield (t ha^{-1}) were recorded. Soil fertility status were examined and changed in different treatments after rice cultivation. After rice cultivation soil pH little increased where biomasses were applied. All the treatments contained green biomass organic matter (%) was improved and Nitrogen (%), phosphorus (ppm), potassium (me/100g soil), sulphur (ppm), zinc (ppm) were decreased where RFD applied due residual effect of fertilizers. Result showed that green leaf biomass had significant effect on the yield contributing characters viz. plant height, panicle length, no. of tillers hill^{-1}, no. of leaves hill^{-1} , leaf size , no. of panicles hill^{-1}, no. of effective tillers hill^{-1}, no. of non-effective tillers hill^{-1}, no. of spikelets panicle^{-1}, 1000-grain weight The highest grain yield 5.86 t ha^{-1} was obtained from Treatment T_6 and second highest grain yield 5.20 t ha^{-1} obtained from T_1 where kalo koroi leaf biomass was applied. Beside the green biomass of kalo koroi, green leaf biomass of krishnochura have good effect on the yield of rice.

Key words: Tree green leaf biomass, *Albizia lebbeck, Albizia procera, Albizia saman, Delonix regia, Casuarina equisetifolia*, rice.

Introduction

Intensive soil cultivation has worldwide resulted in the degradation of agricultural soils, with decreases in soil organic matter and loss of soil structure, adversely affecting soil functioning and causing a long term threat to future yields (Pagliai *et al.*, 2004). Moreover, intensive tillage operations over a long period cause detrimental effect on surface soil as well as hastening the decomposition of soil organic matter (Slentel *et al*. 2007). Tillage degrades the fertility of soils, limits the availability of air and water, intensifies drought stress, consumes fuel and contributes to global warming.

In Bangladesh about 60% of arable soils have below 1.5% organic matter whereas a productive mineral soil should have at least 2.5% organic matter (Rijpma and Jahiruddin, 2004) and the decreasing trend of soil organic matter is continuing. Organic matter depletion is observed in 7.5 million ha of land and declining soil fertility affects 5.6-8.7 million hectares of land (BARC, 2000).

Soil organic matter (SOM) plays an important role as a pool of terrestrial C, in ecosystem productivity, in the functioning of agroecosystems and in cropland fertility. While global society is facing the challenge of climate change due to the rapidly increasing CO_2 in the atmosphere, accumulation of SOM and, hence, C sequestration had been given much attention as a climate change mitigation option at global (FAO, 2001) and regional scales since the late 1990s. Soil organic matter has been identified by many workers as a key factor in maintaining soil fertility and crop production (Sanchez *et al*., 2008). Its maintenance is an essential requirement for increasing and maintaining productivity.

Bangladesh is a small country with a large population. Current population of Bangladesh is 142.32 million and growth rate is 1.34% (BBS, 2011). Most of the people of our country depend on agriculture. The agriculture of our country is governed by intensive rice (*Oryza sativa* L.) cultivation. Rice is staple food of about 142 million people in Bangladesh. Geographic and agronomic conditions of Bangladesh are favourable for rice cultivation. The average yield of rice is low is Bangladesh only 2.43 t ha^{-1} (BBS, 2006). However, it is need of time to increase rice production through increasing the yield per unit area to feed the rapidly growing population. There are many constraints responsible for low yield of rice in Bangladesh. Most of the farmers are poor. So, they can not always afford high input cost of cultivation or modern high yielding varieties. Selection among alternative sources of nutrients and methods for sustaining soil fertility, including green manuring, is an economic decision that depends upon factor prices such as land, labor, and water which are used as inputs to the production system, as well as the prices of inorganic nutrient sources.

Organic farming is the alternate method to reduce the cost of fertilizer and also can improve the soil. Leaf biomass is a very important organic source of soil fertility improvement. The decomposition of leaf litters influence the amount of N availability for plant uptake. Leaf litter supplies the carbon, nitrogen, phosphorus, potassium and other nutrients in soil that are further considered as important indicators of soil productivity and the ecosystem health. Moreover, this leaf lifter has been waste by several ways. So, if we can utilize these materials as a source of organic matter for rice cultivation, then we can reduce the considerable amount of chemical fertilizer like urea.

Materials and Methods

Experimental site and soil: The experiment was carried out at the Field Laboratory of the Department of Agroforestry, Bangladesh Agricultural University, Mymensingh, during the period from July, 2010 to December, 2011. The experimental site was located at 24.75°N latitude and 90.5^{0}E longitude at the mean elevation of 18m above the sea level. The experimental field was medium high land belonging to the Sonatola Soil Series of non-calcareous dark grey flood plain soil type under the agro-ecological zone of Old Brahmaputra Flood Plain (UNDP and FAO, 1988). The soil consisted of sandy loam (silty loam) imperfectly to poorly drain with low permeability.

Layout of the experiment: The experiment was conducted in a Randomized Complete Block Design (RCBD) with three replications. The total numbers of plots were 21. The unit plot size was 3.7 m x 2.2 m. The spacing between blocks was 100 cm and the plots were separated from each other by 40 cm space.

Test crop: BRRI dhan 11 (Mukta), a modern variety of rice, was used as the test crop in this experiment. It grows well all over Bangladesh in aman season. Total growth duration of this variety ranges from 140-145 days from sowing to harvesting. It gives an average yield of 6.5 to 7.0 t/ha under proper management (BRRI, 1991).

Experimental treatment: Experimental treatments were T_1 = Kalo koroi leaf biomass (12 kg/plot), T_2 = Sada koroi leaf biomass (12 kg/plot), T_3 = Raintree leaf biomass (12 kg/plot), T_4 = Krishnochura leaf biomass (12 kg/plot), T_5 = Jhau leaf biomass (12 kg/plot), T_6 = Recommended fertilizer dose (RFD) and T_7 = Control.

Organic materials collection and maintenance: Green leaf biomass like kalo koroi, sada koroi, raintree, krishnochura and jhau leaves, were collected the respective tree of Bangladesh Agricultural University Campus, Mymensingh (Fig. 1). These leaves were separated from the branch. These were cut and used as green leaf biomass. These leaves were applied to the soil and remained in the soil 30 days for decomposed.

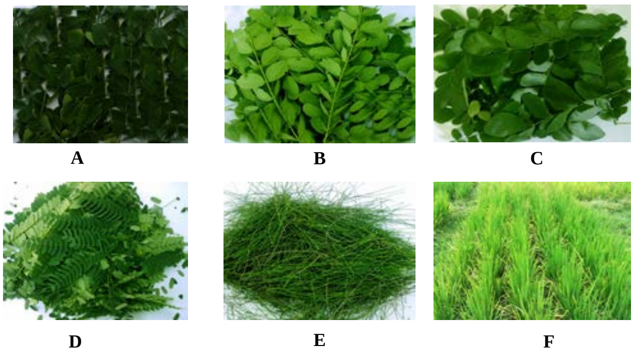

Fig. 1. Experimental view: (A) Green leaf biomass of kalo koroi, (B) Green leaf biomass of sada koroi, (C) Green leaf biomass of Raintree, (D) Green leaf biomass of krishnochura, (E) Green leaf biomass of Jhau, (F) Overall view of experiment.

Fertilizer application: Recommended dose of fertilizers such as Urea 180 kg ha^{-1}, TSP 90 kg ha^{-1}, Gypsum 60 kg ha^{-1} and MOP 40 kg ha^{-1}. Urea was top dressed in three equal splits i.e.15, 30 and 55 days after planting (DAP).

Data collection and recording: The following data were collected and recorded. A) Yield: Grain yield (kg ha^{-1}) and B) Yield components:Plant height (cm), number of total tillers, number of effective tillers $hill^{-1}$, panicle length (cm), number of grains $panicle^{-1}$, 1000-grain weight (g) and grain yield (t ha^{-1}).

Statistical analysis: The recorded data were compiled and analyzed 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.

Results and Discussion

Analysis of soil fertility status:

In this experiment soil was tested to examine the soil fertility status. For this soil samples were collected from the experimental plot before rice seedlings were planted in the field and after harvesting. Collected soil samples were tested in the SRDI Research laboratory. Tested results were presented in the Table 1. After testing results found that the mean of soil pH, organic matter, nitrogen, phosphorus, potassium, sulphur, zinc existing in the treatments. In the field soil average pH, organic matter (%), nitrogen(%), phosphorus (ppm), potassium (me/100g soil), Sulphur (ppm), zinc (ppm) were found 5.00, 0.46, 0.057, 11.737, 13.50, 7.21 and 2.61 respectively. In the different treatments value of soil pH, organic matter, nitrogen, phosphorus, potassium, sulphur and zinc was low and very close to each other. These results were similar to the Susmita (2011) and Arifin (2012). Soil pH in the different treatments did not significantly change after rice cultivation. Among the treatments pH increased because here leaf biomass of kalokoroi (T_1) and Krishnochura (T_4) were applied and they supplied sufficient organic matter to the soil. And in the treatment T_6, pH (4.60) was decreased because in this treatment RFD were applied. Organic matter (%) was increased in the treatment T_1, T_2, T_3, T_4 and T_5 over control (T_7) after cultivation. In these treatments organic matter was increased by the respective green leaf biomass. Maximum Organic matter was increased in the treatment T_1 48.57% over control because in this treatment kalokoroi leaf biomass were applied. Kalo koroi leaves were more soft and succulent. In the treatment T_6 organic matter content was decreased for the residual effect of the application of fertilizers (Table 2). Similar results were also observed by Gani *et al.* (1999) on Jute. Highest N (%) was found in the treatment T_1 (0.062) because of kalokoroi green biomass application and lowest N (%) was found in the treatment control (0.040) because here nothing biomass nor RFD were applied. Similar results were also observed by Haque *et al.* (2001). Phosphorus (ppm), potassium (me/100g), sulphur (%) and zinc (ppm) of soil slightly changed due to various treatments. P content of the soil was increased in the treatment T_1, T_2 and T_4 over the control and these were statistically significant. Highest amount of P (ppm) was found in the treatment T_2 (11.94). P (ppm) was decreased in the treatment T_6 (8.34) due to the residual effect of the fertilizers. In control P content was lowest because here neither fertilizer nor biomass was applied (Table 2). In the treatment T_1 (13.12), T_2 (13.22), T_3 (12.91), T_4(13.18) and T_5 (11.45) where green biomass were applied K content of the soil little decreased after rice cultivation because during growth period plant uptake K but green biomass did not supply this nutrients. Treatment T_6 gave the lowest value of K (me/100g) was 8.33. Sulphur and zinc content was decreased T_1, T_2, T_3 and T_4 because green biomass did not release these nutrients. S (%) of soil in treatment T_6 (6.05) was decreased for residual effect. Initially Zn content of soil was low but after cultivation it was slightly decreased. Zn (ppm) content of the treatment T_1 (2.59), T_2 (2.61), T_3 (2.39), T_4 (2.60) and T_5 (2.28) were decreased because green biomass did not release Zn element to the soil. In the treatment T_6 (1.42) Zn content was lowest in value because of residual effect of fertilizer.

Table 1. Existing soil fertility status before rice cultivation

Treatment	pH	Organic matter (%)	N(%)	P(ppm)	K (me/100g)	S (ppm)	Zn (ppm)
T_1	4.95	0.46	0.055	11.81	13.50	7.23	2.62
T_2	5.00	0.45	0.058	11.75	13.48	7.22	2.63
T_3	5.05	0.45	0.054	11.78	13.51	7.20	2.59
T_4	4.95	0.47	0.059	11.77	13.54	7.19	2.61
T_5	5.05	0.45	0.055	11.65	13.48	7.20	2.62
T_6	4.95	0.45	0.062	11.82	13.51	7.22	2.63
T_7	5.05	0.47	0.058	11.54	13.49	7.23	2.58
Mean	5.00	0.46	0.057	11.737	13.50	7.21	2.61
Level of sig.	NS	NS	NS	NS	NS	NS	NS

T1 = Kalo koroi, T2 = Sada koroi, T3 = Raintree, T4 = Krishnochura, T5 = Jhau, T6 =RFD, T7= Control

Table 2. Soil fertility status in different treatments after rice cultivation season

Treatment	pH	Organic matter(%)	N(%)	P(ppm)	K (me/100g)	S (ppm)	Zn (ppm)
T_1	5.15a	0.52a	0.062a	11.88a	13.12a	7.05a	2.59a
T_2	5.00b	0.50a	0.060a	11.94a	13.22a	7.12a	2.61a
T_3	5.05a	0.47ab	0.058bc	10.84b	12.91ab	6.96b	2.39b
T_4	5.20a	0.52a	0.061a	11.92a	13.18a	7.04a	2.60a
T_5	5.00b	0.46b	0.052c	10.19b	11.45b	6.82b	2.28bc
T_6	4.60c	0.30d	0.040e	8.34c	8.33d	6.05c	1.42d
T_7	5.05b	0.35c	0.048d	6.11d	9.86c	5.72d	2.15c

Means in column followed by the different letter are significantly different by DMRT at $P \leq 0.05$

Growth and yield characteristics of rice

Plant height: Plant height was measured from the ground level of the plant to tip of the leaf. Plant height was recorded in three stages such as 30 DAT, 60 DAT and after harvest. At the initial growth stage or 30 DAT, plant height in the treatment was almost similar except control. Heights plant height was observed in the treatment T_6 (48.30 cm) because recommended fertilizer doses were applied to the soil (Table 3). Lowest value was found in the control (31.50 cm) because no nutrients were applied and soil fertility status was also low. During 60 DAT plant height was recorded. Tallest plant height was observed in treatment T_6 (95.10 cm) for application of fertilizer and fertilizer supplied sufficient nutrient. Second tallest plant height found in treatment T_1 (93.85 cm), T_2 (92 cm) and T_4 (93.30 cm) because green biomass decomposed and added organic matter and nutrients to plant (Table 3). Lowest height was observed in treatment T_7 (57.65 cm). After harvest plant height due to different treatments ranged from 64.30 cm to 98.87 cm and the highest plant height of 98.87 cm was observed in the treatment T_6 (Table 4). Lowest height was observed in treatment T_7 (67.30 cm) because here fertilizer or biomass were not applied.

No. of leaves hill^{-1}: Effect of green biomass of different trees on the number of leaves hill-1 was non-significant in the treatment T_1 (42), T_2 (41), T_4 (42) and T_6 (43) at 30 DAT (Table 3). The highest no. of leaves hill^{-1} was observed in the treatment T_6 (43). The lowest no. of leaves hill^{-1} was observed in control (22) because in control nutrient

elements were supplied. Table 3 showed that at 60 DAP, highest value was found in T_6 (57). Second highest no. of leaves hill-1 was observed in T_1 (49), T_2 (47) and T_4 (48) which were statistically non-significant. Lowest also observed in the control (29).

Leaf size: Highest value of leaf size was observed in T_6 (23.73 cm^2) at 30 DAP. Leaf size of the treatment T_1 (23.67 cm^2), T_2 (22.96 cm^2), T_4 (23.41 cm^2) and T_6 (23.73 cm^2) was statistically non-significant. Table 3 showed that highest value of leaf size was found in the treatment T_6 (36.92 cm^2) because RFD were applied and fertilizer released essential nutrients. And the lowest value of leaf size was found in control treatment (23.44 cm^2).

No. of tillers hill^{-1}: All the treatments gave higher number of tillers hill^{-1} of rice over control at 30 DAT (Table 3). The highest Number of tillers hill^{-1} was observed in T_6 (13) and lowest number of tillers hill^{-1} was observed in control (4). Table 3 showed that, at 60 DAP number of tillers hill^{-1} due to different treatments ranged from 6 to 15 and the highest tiller number 15 was observed in the treatment T_6 and lowest value was observed in control (6). After harvesting, the highest number of tillers hill^{-1} was found in T_1 (16) and T_6 (16) which were statistically non-significant. Lowest value of number of tillers hill^{-1} found in T_7 (7) because no fertilizer or green biomass were applied (Table 4).

No. of panicles hill^{-1}: Number of panicles hill^{-1} due to treatments ranged from 4 to 15. The highest number of panicles hill^{-1} was observed in T_6 (15) because of fertilizer application (Table 4). Treatment T_1 (14) and T_6 (15) were statistically non-significant. Lowest number of panicles hill^{-1} was observed in the treatment T_7 (4) because here neither RFD nor biomass applied.

No. of non-effective tillers hill^{-1}: Non-effective tiller indicates the tiller which does not bear any panicle. Highest value of non-effective tiller was observed in T_5 (3) and T_7 (3) and these were statistically non-significant.

The lowest value of number of non-effective tiller was found in treatment T_6 (1) (Table 4).

Panicle length: Table 5 represented that panicle length of rice was significantly affected by the application of green leaf biomass of different trees. Panicle length due to green leaf biomass of different trees ranges from 11.20 cm to 24.72 cm. Results indicate that the highest value of panicle length was produced 24.72 cm in T_6 because of fertilizer application. Lowest panicle length was observed in the treatment T_7 (11.20 cm) where neither green leaf biomass nor fertilizers were applied to the soil.

No. spikelets panicle^{-1}: No. of spikelets were estimated into three sub-group such as total, filled and unfilled. Tables 5 showed that highest total (230) and filled (195) no. of spikelets were observed in treatment T_6 for fertilizer application and lowest total no. of spikelets (109) and filled (47)were observed in control. For unfilled spikelets, highest value was observed in T_7 (62). Lowest one was found in T_6 (35) because of fertilizer application.

1000-grain weight: 1000-grain weight due to treatments ranged from 13.50 g to 26.62 g. It can be seen that treatment T_6 (RFD) produced the highest grain weight 26.62 g which was significantly higher than that of other treatments. Lowest 1000-grain weight 13.50 g obtained from control.

Table 3. Growth performance of rice in different treatments at 30 DAP & 60 DAP

Treatment	Plant height (cm)		No. of tillers hill-1		No. of leaves hill-1		Leaf size (cm2)	
	30 DAP	60 DAP	30 DAP	60 DAP	30 DAP	60 DAP	30 DAP	60 DAP
T_1	45.10a	93.85b	12a	14a	42a	49b	23.67a	33.19b
T_2	44.80a	92.00bc	11ab	13b	41ab	47b	22.96ab	31.92bc
T_3	43.95b	90.85c	10b	10c	39bc	41c	21.78b	30.81c
T_4	44.75a	93.30b	12a	14a	42a	48b	23.41a	33.11b
T_5	43.10b	85.50d	8c	8d	37c	40c	21.13b	28.61c
T_6	48.30a	95.10a	13a	15a	43a	57a	23.73a	36.92a
T_7	31.50c	57.65e	4d	6e	22d	29d	14.36c	23.44d

Means in column followed by the different letter are significantly different by DMRT at $P \leq 0.05$

Table 4. Yield contributing characteristics of rice in different treatments after harvest

Treatments	Plant height (cm)	No. of tillers hill^{-1}	No. of panicles hill^{-1}	Non-effective tillers hill^{-1}	Panicle length (cm)	No. spikelets panicle^{-1}			1000 grain weight (g)
						Total	Filled	unfilled	
T_1	95.80b	16a	14a	2b	24.20a	205b	158b	47bc	24.51b
T_2	95.44b	14b	13b	1c	23.96b	202bc	160b	42c	22.35c
T_3	93.25c	13b	11c	2b	21.32c	195c	146c	49b	21.92cd
T_4	95.67b	14b	13b	1c	24.10a	208b	165b	43c	24.49b
T_5	91.77c	12c	9c	3a	19.00d	179d	128d	51b	20.11d
T_6	98.87a	16a	15a	1c	24.72a	230a	195a	35d	26.62a
T_7	67.30d	7d	4d	3a	11.20e	109e	47e	62a	13.50e

Means in column followed by the different letter are significantly different by DMRT at $P \leq 0.05$

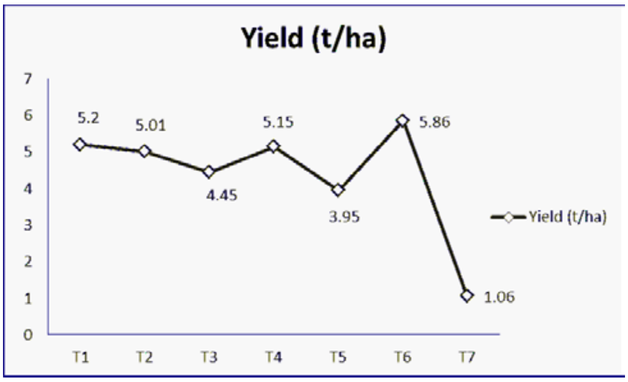

Fig. 2. Yield of rice in different treatments (T_1 = Kalo koroi, T_2 = Sada koroi, T_3 = Rain tree, T_4 = Krishnochura, T_5 = Jhau, T_6 = RFD, T_7 = Control).

Grain yield: The different treatments had significant effect on the grain yield. Except control all the treatments gave higher yield (Fig. 2). Grain yield due to different treatments varied from 1.06 t ha^{-1} to 5.86 t ha^{-1} and highest grain yield 5.86 t ha^{-1} was obtained from the treatment T_6 where recommended fertilizer doses were applied. Second highest yield was observed in T_1 (5.2 t ha^{-1}) because kalo koroi leaf biomass application. Lowest grain yield 1.06 t ha^{-1} was obtained from T_7 where neither fertilizer nor green biomass was applied (Fig.2). Similar results were also observed by Nahar *et al*. (1996), Akter *et al.* (1993) and Zoysa *et al*. (1990).

Soil fertility status is improved in the treatment where only green leaf biomass was applied. The treatment containing green leaf biomass and recommended fertilizer dose slightly deteriorate the soil fertility status because of residual effect of fertilizer. All the yield and yield contributing characters such as plant height, panicle length, no. of tillers hill^{-1}, no. of leaves hill^{-1}, leaf size, no. of panicles hill^{-1}, no. of non-effective tillers hill^{-1}, no. spikelets panicle^{-1}, 1000-grain weight, and grain yield was found best results in the treatment where green leaf biomass and recommended fertilizer dose were applied over control treatment.

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