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Effect of tree leaf biomass on the performance of rice cv. BR11 and subsequent soil health

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Abstract: This study was conducted at the Agroforestry Farm, Department of Agroforestry, Bangladesh Agricultural University, Mymensingh during July to November 2006. In this study, five different tree leaf biomasses (minjiri, ipil-ipil, akashmoni, eucalyptus and mahogoni) were incorporate to the soil to evaluate their effect on the performance of rice cv. BR11 and subsequent soil health and compared with recommended fertilizer as control. The tree leaf biomass significantly influenced the growth, yield and yield contributing characters of rice. The highest grain yield (4.95 t ha^{-1}) was obtained in the recommended fertilizer dose followed by ipil-ipil, minjiri, akashmoni, eucalyptus and mahogoni (4.33, 4.07, 3.91, 3.88 and 3.83 tha^{-1}) respectively. Among the tree leaf biomass, ipil-ipil performed better yield which was the nearest of the recommended fertilizer dose and the treatment of mahogoni gave the lowest yield. Tree leaf biomasses also significantly influenced the health of soil. Highest amount of nutrients (N, P & K) were added to the soil from ipil-ipil leaf biomass and lowest from mahogoni. Thus it appears that tree leaf biomass could use as alternative to chemical fertilizers which is causing soil and environment pollution.

Keywords: Leaf biomass, Rice, Growth, Yield and Soil

Introduction

Rice (*Oryza sativa*) is grown more than hundred countries across the world. It is the staple food for 60 per cent of the world population. For crop production, the presence of organic matter in soil is important. A good soil should have an organic matter content of more than 3.5 per cent. But in Bangladesh, most of the soils have less than 1.7 per cent and some soils have even less than 1 per cent organic matter (Sattar, 2002). Now, it is well agreed that depleted soil fertility is a major constraints for higher crop production in Bangladesh and indeed, yield of several crops are declining in most soils (Bhuiyan, 1991). Tree 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, sulphur and other nutrients in soil that are further considered as important indicators of soil productivity and the ecosystem health. Leaf litter plays a fundamental role in the nutrient turnover and in the transfer of energy between plants and soil, the source of the nutrient being accumulated in the upper most layers of' the soil (Singh, 1978). It has been reported that upland rice production with four N_2 fixing tree species, rice yield was best with *Gliricidia sepium* followed by *Leucaena leucocephala, Cajanus cajan* and *Cassia siamea* (Rathert and Werasopon, 1992). Alley cropped with *Cassia siamea, Gliricidia sepium* and *Flemingia macrophylla,* the yield of maize were increased an acceptable level; it was also add nitrogen in the soil (Yamoah *et al.,* 1986b). Decomposition of tree leaf litter is an integral and significant part of' biochemical nutrient cycling and food webs of floodplain agroforestry system. Decomposition refers to both the physical and chemical breakdown of litter and the mineralization of nutrients (Boulton and Boon, 1991). Through decomposition, the nutrients within leaf' litter are converted into available form for uptake by vegetation and thereby exercising a critical control on vegetation productivity (Groffman *et al.,* 1996). The decomposition and N release rate of leaf litter was in the order of *Tectona grandis* > *Acacia auriculiformis* > Eucalyptus hybrid > *Casuarina equisetifolia*. However, the release of P and K into the available pool was higher in *Casuarina* than eucalyptus (Maharudrappa *et al.*, 2000). Nutrient release in leaf litter decomposition is an important process in nutrient flux in an agroforestry system. Nutrients may be released from leaf litter by leaching or mineralization (Swift *et al.,* 1979). So, the present work was undertaken to determine the effect of different tree leaf biomass on growth and yield of rice cv. BR11 and subsequent health of soil.

Materials and Methods

The research work was conducted at the Agroforestry Farm, Department of Agroforestry, Bangladesh Agricultural University, Mymensingh during the period from July-November, 2006. The experiment site is moderately well drained with a silt loam texture having p^H 6.5 to 6.8, total N 0.061%, available P 7.80 mg kg^{-1} and exchangeable K 0.155 cmol kg^{-1} soil. The experiment was set up in Randomized Complete Block Design with three replications. There were six different treatments as follows:

T_0: Recommended fertilizer dose (RFD)/ Control
T_1: Minjiri (*Cassia siamea*) leaf biomass
T_2: Ipil-ipil (*Leucaena leucocephala*) leaf biomass
T_3: Akashmoni (*Acacia auriculiformis*) leaf biomass
T_4: Eucalyptus (*Eucalyptus camaldulensis*) leaf biomass
T_5: Mahogoni (*Swietenia macrophylla*) leaf biomass

The total number of plot was 6 × 3 = 18; each plot size was 1m × 1m. Rice cv. BR11 was used as the test crop. The selected tree leaf biomasses were collected from the representative trees of Bangladesh Agricultural University Campus and incorporated to the assigned plot before 15 days of transplanting, randomly in each block. 40 days old seedlings of cv. BR11 were transplanted on 29 July 2006 with spacing 20 cm × 15 cm. Two or three healthy seedlings per hill were transplanted in all the plots. After transplanting, necessary cultural operations were done as required. The rice plants were harvested on 18 November 2006 at its full maturity. Five hills were randomly selected and carefully uprooted from each unit plot to record the yield and yield contributing characters *viz.* plant height (cm), number of total tillers hill^{-1}, number of effective tillers hill^{-1}, panicle length (cm), number of grains panicle^{-1} and 1000 grain weight (g). The selected hills were collected before crop harvest and necessary information recorded accordingly. Grain and straw yields were recorded plot wise and expressed as t ha^{-1}. After sampling, the whole plots were harvested when 90% of the grains became golden yellow in colour. An initial soil sample was collected before tree biomass incorporation. Another soil samples were collected from the test plots at 75 days after incorporation or 60 days after transplanting and 125 days after incorporation or after harvesting of rice. The soil samples were analyzed to determine N, P, K release from the selected tree leaf biomass and the improvement of soil status. The total N, available P and exchangeable K were determined following semi-micro Kjeldahl method, modified Olsen method and NH_4OAc extraction method respectively. The data were statistically analyzed to test the level of significance and the means were ranked by Duncan's Multiple Range Test (DMRT).

Results and Discussion

Effect of tree leaf biomass on yield and yield contributing characters of rice cv. BR11

Plant height: Plant height was significantly influenced due to the effect of different treatments (Table 1). The highest (120.17cm) plant height was recorded in recommended fertilizer treatment and the lowest (111.00cm) in the treatment of akashmoni. Among the tree leaf biomass, the highest plant height (118.17cm) was found in the treatment of minjiri which was statistically similar with control.

Total tillers hill^{-1}: The tillering of rice cv. BR11 was significantly affected by the different treatments. The number of total tillers hill^{-1} due to the different treatments ranged from 11.33 to 17.00. The highest number of total tillers hill^{-1} (17.00) was produced by recommended fertilizer treatment and the lowest (11.33) in mahogoni. Among the tree leaf biomass, the treatment of ipil-ipil was produced the highest number of total tillers hill^{-1} (13.67). The second highest was produced in the treatment of minjiri which was identical with the treatments of akashmoni and eucalyptus (Table 1).

Number of effective tillers hill^{-1}: Significantly highest (15.67) number of effective tillers hill^{-1} was observed under recommended fertilizer dose and among the tree leaf biomass, ipil-ipil produced the highest (14.00) no. effective tillers hill^{-1} and lowest (10.00) in mahogoni (Table 1).

Panicle length: The panicle length of rice cv. BR11 was influenced significantly by the incorporation of tree leaf biomass. The panicle length varied from 27.17 to 21.17 cm due to the different treatments. The highest (27.17cm) panicle length was produced in the treatment of recommended fertilizer and the lowest (21.17 cm) was recorded in the treatment of mahogoni. The treatment of ipil-ipil was produced the highest panicle length (25.17 cm) which was the best among the tree leaf biomass (Table 1).

Grains panicle^{-1}: The number of grains panicle^{-1} of rice cv. BR11 was significantly affected by the different treatments. Table 1 showed that highest (118.00) number of grains panicle^{-1} was obtained in the treatment of recommended fertilizer and lowest (104.67) in the treatment of mahogoni. The treatment of ipil-ipil was produced the second highest (115.00) grains panicle^{-1} which was the highest among tree leaf biomass and it was statistically similar to the treatment of minjiri. The results agreement with that of Apostol (1989) who reported that combined application of organic materials and inorganic fertilizer increased the number of tillers hill^{-1}, panicle length, grains panicle^{-1} but separately inorganic fertilizer was best.

1000-grain weight: Table 1 showed that weight of 1000-grains was not significantly affected by different treatments. The highest weight of 1000-grains (25.41g) was obtained in minjiri and the second highest from the treatment of ipil-ipil (25.40 g). The lowest weight of 1000-grains (25.08 g) was observed in the treatment of recommended fertilizer.

Grain yield: Highest (4.95 t ha^{-1}) grain yield was found in recommended fertilizer dose. Grain yield under different tree leaf biomass were minjiri (4.07 t ha^{-1}), ipil-ipil (4.33 t ha^{-1}), akashmoni (3.91 t ha^{-1}), eucalyptus (3.88 t ha^{-1}) and mahogoni (3.83 t ha^{-1}) which was 17.78, 12.53, 21.01, 21.66 and 22.63 % less than recommended fertilizer dose. Rathert and Werasopon (1992) reported that rice yield was best with mineral fertilizer followed by treatments with *Gliricidia sepium*, *Leucaena leucocephala*, *Cajanus cajan* and *Cassia siamea*. The result was partially supported by Nahar *et al*. (1996) where they observed that green manure with *Leucaena leucocephala* produced highest grain yield (4.36 t ha^{-1}) of rice than others treatment.

Straw yield: The straw yield was markedly influenced by the application of tree leaf biomass. The highest straw yield (6.02 t ha^{-1}) was produced by the treatment of recommended fertilizer and the lowest straw yield (4.69 t ha^{-1}) was produced in the treatment of mahogoni. The ipil-ipil treatment was produced straw yield (5.48 t ha^{-1}) which was the highest among tree leaf biomass treatments and the second highest overall (Table 1).

Table1 Effect of different tree leaf biomass on the yield and yield contributing characters of rice cv. BR11

Treatments	Plant height (cm)	Total tillers $hill^{-1}$ (no.)	Effective tillers $hill^{-1}$ (no.)	Panicle length (cm)	Number of grains $panicle^{-1}$	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_0	120.17^{a}	17.00^{a}	15.67^{a}	27.17^{a}	118.00^{a}	25.08	4.95^{a}	6.02^{a}
T_1	118.17^{ab}	13.67^{c}	12.67^{bc}	24.67^{b}	114.67^{b}	25.41	4.07^{c}	5.20^{c}
T_2	115.50^{bc}	15.33^{b}	14.00^{b}	25.17^{b}	115.00^{b}	25.40	4.33^{b}	5.48^{b}
T_3	111.00^{d}	12.33^{cd}	10.67^{de}	21.83^{c}	108.67^{c}	25.22	3.91^{d}	4.85^{d}
T_4	112.67^{cd}	12.67^{cd}	11.67^{cd}	22.17^{c}	108.33^{c}	25.18	3.88^{d}	4.80^{d}
T_5	113.83^{cd}	11.33^{d}	10.00^{e}	21.17^{c}	104.67^{d}	25.18	3.83^{d}	4.69^{e}
Level of significance	**	**	**	**	**	NS	**	**

N, P and K release from tree leaf biomass at 75 and 125 days after incorporation

Total nitrogen: The incorporation of different tree leaf biomass in experimental field influenced as significant changed in nitrogen content in soil. At 75 days after incorporation the release of total N varied from 0.156 to 0.065% due to the different treatments (Table 2). The highest total N (0.156%) was released from the treatment of ipil-ipil and minjiri released the second highest (0.123%). The lowest total N (0.065%) was released in treatment of recommended fertilizer. After harvesting of rice, total N content varied from 0.061 to 0.151% of post harvest soil while that of initial soil was 0.061%. The treatment of ipil-ipil added the highest total N (0.151%) and the lowest (0.061%) was found in treatment where recommended fertilizer was used (Table 2). These results also in agreement with that of Das and Chaturvedi (2003) who reported that the highest decomposition was observed in leaf litter of *Leucaena leucocephala* followed by *Sesbania grandiflora*, *Dalbergia sissoo* and *Eucalyptus tereticornis*. The initial leaf litter concentration (%) of N, P and K were the highest in *L. leucocephala*. The species having the highest N percentage showed the fastest decomposition.

Available phosphorus: Incorporation of tree leaf biomass in rice cv. BR11, the release of available P was influenced significantly due to the different treatment. Table 2 indicated that at 75 days after incorporation, the highest available P (21.60 mg kg^{-1}) was released in soil by ipil-ipil leaf biomass and the lowest available P (11.14 mg kg^{-1}) was released in treatments of akashmoni and eucalyptus which were statistically similar. At 125 days after incorporation or after harvesting of rice, the highest available P (18.35 mg kg^{-1}) was found in ipil-ipil treatment and the lowest available P (8.89 mg kg^{-1}) was found in recommended fertilizer treatment. Guan (1989) found that the available N and P content in soil sample taken from plots with the application of organic materials were significantly higher than the control.

Exchangeable potassium: Table 2 showed that the exchangeable K was released significantly with the application of tree leaf biomass in rice cv. BR11. At 75 days after incorporation, ipil-ipil released the highest exchangeable K (0.267 cmol kg^{-1}) in soil. The treatments of akashmoni and mahogoni released the lowest exchangeable K (0.027 cmol kg^{-1}) in soil which was statistically similar. At 125 days after incorporation table 2 also reveals that exchangeable K in post harvest soils ranged from 0.179 to 0.298 cmol kg^{-1}. The highest exchangeable K (0.298 cmol kg^{-1}) was observed in treatment of mahogoni which was statistically similar with minjiri. The treatment where recommended fertilizer was used found the lowest exchangeable K (0.179 cmol kg^{-1}). Lal *et al*. (2000) reported that mineralization of *Leucaena* leaves yielded the highest amount of mineral nutrients in soil.

Present study clearly indicated that yield and yield contributing characters of rice were significantly influenced by different tree leaf biomass. Only 12-22% yield reduced by different tree leaf biomass but residual effect in soil was positive compared to recommended fertilizer treatment. All nutrients (N, P & K) status in the soil was good condition in almost all leaf biomass as compared with RFD. This is the indication of sustainable production as well as good for environment and also ecologically sounds. Moreover, leaf biomass is a very important organic resource for soil fertility improvement. It supplies essential nutrients like N, P, K, S and others in soil. If we can use tree leaf biomass a source of organic matter for rice cultivation, as is available in agroforestry system, it significantly reduces considerable amount of chemical fertilizers which is economically feasible for our farmers and improve the fertility status of the post harvest soil. So, it can be concluded that the incorporation of tree leaf biomass in the rice field may be the alternatives of chemical fertilizers getting sustainable yield as well as the improvement of soil nutrient status.

Table 2 Nutrient status of soils as affected by different treatments

Treatments	75 DAI			125 DAI		
	Total N (%)	**Available P (mg kg^{-1})**	**Exchangeable K (cmol kg^{-1})**	**Total N (%)**	**Available P (mg kg^{-1})**	**Exchangeable K (cmol kg^{-1})**
T_0	0.061^{d}	8.89^{e}	0.179^{c}	0.061^{d}	12.37^{d}	0.202^{c}
T_1	0.129^{b}	9.75^{d}	0.289^{a}	0.123^{b}	19.39^{b}	0.247^{b}
T_2	0.151^{a}	18.35^{a}	0.185^{c}	0.156^{a}	21.60^{a}	0.267^{a}
T_3	0.123^{b}	12.65^{c}	0.247^{b}	0.100^{c}	11.14^{e}	0.027^{d}
T_4	0.117^{b}	9.05^{de}	0.247^{b}	0.089^{c}	11.14^{e}	0.185^{c}
T_5	0.089^{c}	16.37^{b}	0.298^{a}	0.067^{d}	15.9^{c}	0.027^{d}
Initial soil status	0.061	7.80	0.155	0.061	7.80	0.155
Level of significance	**	**	**	**	**	**

Figures in a column having the same letter (s) do not differ significantly
** = 1% level of significant, NS = Not-significant, DAI= Days after Incorporation

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