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Effect of Tree Litter Application on Lowland Rice Yield in Bangladesh

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ABSTRACT

The effect of tree litters on rice yield (cv. BR11) was evaluated in the study. Four kinds of tree litter, i.e., ipil-ipil or lamtoro (*Leucaena leucocephala* (Lamk) De Witt), sissoo (*Dalbergia sissoo*), akashmoni (*Acacia auriculiformis*) and mander (*Erythrina orientalis*) were incorporated into the soil 15 days before transplanting at rate of 5 ton/ha supplemented with inorganic fertilizers (83 kg N, 48 kg P_20_5, 42 kg K_20, 10 kg S and 3.6 kg Zn/ha). In the control plots only recommended inorganic fertilizer were applied. Results showed that tree litter application had a significantly positive effect on the yield parameters such as plant height, panicle length, tillers per hill, filled grain and index of 1000-grain weight. Grain yield of plots treated with ipil-ipil, sissoo, akashmoni and mander was 5.61, 4.49, 4.95 and 5.36 ton/ha, and the yield increased over control plots 39.6, 11.7, 23.1 and 33.3%, respectively. It is worthy to note that addition of tree litter to inorganic fertilizer produced significantly higher yield than inorganic fertilizers solely. Among the tree litter, ipil-ipil and mander had the greatest increase in rice yield, while akashmoni was intermediate and sissoo was the least.

Key words: Agroforestry residues, rice, sustainable agriculture and tree-based cropping

INTRODUCTION

Bangladesh is a densely populated agro-based country with rice as main staple food. Although the rice production occupies about 80% of total cropped area in the country, the average productivity of rice in Bangladesh is only 2.21 t/ha (BBS, 2004). The rice productivity is quite low in comparison to South Korea and Japan, i.e., 7.00 and 6.22 t/ha, respectively (FAO, 1999).

Poor rice yield in Bangladesh can be ascertained to improper soil management and tillage practices. Chemical fertilizers presently used in rice are neither balanced nor of sufficient quantity for maximum yield. Moreover, continuous use of chemical fertilizers decreases organic matter content and impairs physical and chemical properties of soil in addition to causing micronutrients deficiencies. Sanchez *et a1.* (1987) reported that there is a correlation between a decline in crop yield with continued production using chemical fertilizer and a decline in organic matter.

Sustainable crop production gets more attention in Bangladesh through introduction of agroforestry system, whereby tree litter is used as a supplement and to enhance crop production. Bangladesh has a homestead area of 13,018,415 thousand acres (BBS, 2004) where retention of trees is being encouraged. Thus there is ample opportunity for green manure sources. In Bangladesh, several non government organizations (NGOs) and government organizations encourage farmers to grow green manure crops such as *Sesbania rostrata, S. aculeata, Crotalaria juncia* and *Vigna unguiculata* in crop fields and fallow lands.

Generally, organic matter supplies nutrients and improves nutrient availability (Marschner, 1995). Application of organic matter in dry land has proven to increase stock of slow release nutrients and protects nutrients against leaching. Therefore, maintaining soil organic matter is considered as one of the goals of sustainable land management. Nevertheless, for organic matter application in lowland paddy there is still lack of information in Bangladesh as well as in many other Asian countries.

Several scientists investigated the effect of tree litter incorporation into the paddy field in addition to inorganic fertilizer used. Rathert and Nammuang (1992) reported that application of lopping of *Leucaena leucocephala* at the rate of 30 kg/ha N had similar to application of chemical N at rate of 50 kg/ha on rice yield. Moreover, Nahar *et al.* (1996) pointed out that the highest grain yield was obtained from *Leucaena leucocephala* treated plots than plots applied chemical fertilizer solely. Turkhede *et al.* (1998) observed that incorporation of *Gliricidia* leaves as green manure at 5 ton/ha at transplanting time significantly increased the grain and straw yield of paddy, i.e., 3.2 ton and 5.8

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ton/ha, over no green manuring by 8.68 and 11.21%, respectively. Application of green manure plus chemical fertilizers was found to produce significantly higher yield parameters than chemical fertilizers solely (Bhuiya and Akhand, 1982; Akter *et al.*, 1993). Therefore, integrated use of organic manure and chemical fertilizer would be quite promising not only in providing greater stability in production, but also in maintaining better soil fertility in Bangladesh (Namibiar, 1991). In the present study, the effect of tree litters of ipil-ipil (*Leucaena leucocephala*), sissoo (*Dalbergia sissoo*), akashmoni (*Acacia auriculiformis*) and mander (*Erythrina orientalis)* on lowland rice were evaluated.

MATERIALS AND METHODS

The research was conducted at Agroforestry Department field plots, Bangladesh Agricultural University; Mymensingh during July-December, 2004. The land is situated on agro-ecological zone of the Old Brahmaputra flood plain and it is characterized by non-calcareous dark grey flood plain soil having pH value from 6.5 to 6.8. The soil texture is silty loam with average organic matter content of 1.14%, total nitrogen 0.085% and C/N ratio 13.5 (FAO, 1988). The rice cultivar used in this research was BR11 (Mukta), recommended high yielding transplanting rice. The cultivar grows quickly and can be grown into 20-25 cm depth of water and prefers sandy loam to clay loam. Genetically, BR11 variety is a cross between IR 20 (IR 532-E-576) and IR 5 (IR5-47-2) and widely cultivated throughout Bangladesh in the aman season (July-December). Under proper management, the BR11 variety gains 5.5 to 6.5 ton/ha in the country (BRRI, 1991).

The experiment was carried out in randomized complete block design with four replications with plot size was 20 m square (4.0 m x 2.5 m). Four treatments were carried out, i.e., control (no tree litter), application of Ipil-ipil (*Leucaena leucocephala*), Sissoo (*Dalbergia sissoo*), Akashmoni (*Acacia auriculiformis*) and Mander (*Erythrina orientalis*). Tree litter at rate of 5 ton/ha (compost) was applied 15 days before transplanting. All treatments received inorganic fertilizers according to national recommendation of BRRI (1991), i.e., 83 kg N (urea), 48 kg P_20_5 (TSP), 42 kg K_20 (Muriate of potash), 10 kg S (gypsum) and 3.6 kg Zn/ha (ZnSO4). Fertilizers except urea were incorporated into soil during final land preparation. Urea was applied in three equal installments, i.e., top dressed at 15, 30 and 50 days after transplanting.

The leaves of ipil-ipil, sissoo, akashmoni, and mander were collected from locally grown trees and sun-dried prior to incorporation. The litter was chopped and well mixed with the soil during final land preparation (15 days before transplanting). Rice seedlings of 15 day old were transplanted, two or three per hill with 15 cm × 25 cm spacing, on 6th August 2004. After a heavy rain in the first of July, the land was puddled thoroughly by ploughing and cross ploughing followed by laddering. After planting, plants that died within 10 days of transplanting were replaced. Weeding was done two times prior to top dressing with nitrogen fertilizer. Irrigation and drainage management were done following standard practices. No fungicide and pesticide were sprayed for controlling diseases and insects.

An initial composite soil sample was collected from the experimental site on the 3rd of July, 2004 before incorporation of tree litter followed by other two soil samples after 15 days and 105 days of tree litter incorporation for total N and organic matter content. According to pre-application of nitrogen assessment determined by micro-Kjeldahl method as outlined by Jackson (1967) revealed that N content was 0.072%. Organic carbon of the soil was estimated by wet oxidation method of Wakley and Black (1955). The organic matter content of soil was calculated by multiplying the percent carbon with Van Bemmelen conversion factor 1.724 (Ghosh *et al.*, 1983), the initial value was 1.498 %.

The crop was harvested at full maturity on 25th November 2004. Treatments were harvested and threshed separately, and yield contributing characters viz. Length of panicle, number of grains per panicle, number of unfilled spikelets per panicle and 1000 grain weight were taken from plants from ten hills of each treatment. Grain yield was determined from 1 m square area and expressed as ton/ha. The data analyzed following Duncan's multiple range tests to show significant differences between treatment means (Zaman *et al.*, 1982).

RESULTS AND DISCUSSION

Soil organic matter and total N content

All the treatments containing tree litter were significantly similar with regard to their effect on organic matter and total N content in the soil (Table 1). The control had significantly less soil organic matter than the tree litter treatments. Ipil-ipil, mander sissoo and akashmoni tree litters increased organic matter content over control by 46.94, 44.36, 39.26 and 33.14%, respectively after 15 days of incorporation. Similarly, ipil-ipil, mander, akashmoni and sissoo tree litter increased organic matter content over control by 64.64, 64.36, 56.69 and 49.93%, respectively, at 105 days after incorporation. At 105 DAI, ipil-ipil, mander, akashmoni and sissoo tree litter increased the total N content over control by 39.18, 36.08, 16.49 and 13.4%, respectively (Table 1).

Table 1. Effect of tree litter application in additional to chemical fertilizers on total N and organic matter content of soil at 15 and 105 day after incorporation in lowland paddy

Treatments	15 DAI[z]		105 DAI	
	Nitrogen (%)	Organic matter (%)	Nitrogen (%)	Organic matter (%)
Control	0.074[y]	1.59 b	0.097 b	1.42 b
Ipil-ipil	0.089	2.33 a	0.135 a	2.34 a
Sissoo	0.077	2.13 a	0.110 a	2.21 a
Akashmoni	0.076	2.11 a	0.113 a	2.23 a
Mander	0.084	2.29 a	0.132a	2.33 a
Sig.	NS	*	**	*

[z] Days after litter incorporation
[y] Value in the same column followed by different alphabet are significantly different at DMRT 5%
NS =Non significance; * = Significant at level of P<5%; ** = Significant at level of P<1%

Upon soil analysis, it was revealed that among the tree litters, ipil-ipil (*Leucaena leucocephala)* and mander *(Erythrina orientalis)* was the best in building organic matter and total N content, akashmoni (*Acacia auriculiformis)* was intermediate and sissoo (*Dalbergia sissoo)* was the poorest among them (Table 1). The result was partially in agreement with the findings of several scientists. Haque *et al.* (2001) reported a positive improvement in soil fertility from the application of tree prunings. They also reported that *Samanea saman* and *Dalbergia sissoo* tree prunings markedly improved the levels of N, P, K and organic C in soil. Miah *et al.* (1997) observed that intercropping of *Gliricidia sepium, Acacia auriculiformis* and *Acacia mangium* with upland rice and mungbean increased in organic C by 9%, in total N by 11.2% in available P by 11.2% in exchangeable K by 10.6% in exchangeable Ca by 17.8%.

Production components

Tree litter of different species significantly increased plant height than control, particularly of ipil-ipil application (Table 2). Generally, application of tree litters tended to produce higher plant height. However, application of sissoo litter had statistically similar to that of control. The longest panicle was significantly observed in ipil-ipil treated plots followed by mander, akashmoni and sissoo (Table 2). It is likely that length of panicle is positively correlated to plant height.

Table 2. Effect of tree litter application in additional to chemical fertilizers on yield attributes of lowland paddy

Treatment	Plant height (cm)	Panicle length (cm)	No. effective tiller/hill	Percentage of filled spikelet/ panicle	Total spikelet/panicle	1000-grain weight	Yield (ton/ha)
Control	93.7 b	21.4 c	9.33 b	75.9 c	130.5 c	22.04 b	4.02 c
Ipil-Ipil	106.0 ab	23.9 a	11.33 a	81.9 a	137.7 a	24.30 a	5.61 a
Sissoo	98.9 b	22.1 bc	9.33 b	78.3 b	133.9 b	23.56 ab	4.49 ab
Akashmaoni	99.7 ab	22.5 abc	9.45 b	83.3 a	130.4 c	23.93 a	4.95 ab
Mander	100.0 ab	23.4 abc	11.00 a	81.6 a	135.8 ab	24.01 a	5.36 a
Sig.	*	*	**	**	**	*	**

Value in the same column followed by different alphabet are significantly different at DMRT 5%
* = Significant at level of P<5%; ** = Significant at level of P<1%

Tillering time was not affected by litter application (data not shown). The maximum average number of effective tillers/hill (*c.a.*11) was found in ipil-ipil and mander litter treated plots. Control treatment produced lower number of effective tiller. It was statistically similar to that of sissoo and akashmoni (Table 2). Regarding number of filled spikelet/panicle, the highest number of filled spikelets was found in ipil-ipil litter treated plots (112.8), which was statistically similar to that of mander (110.8) and akashmoni (108.6). The second highest number of filled spikelets/ panicle was observed in sissoo litter treated plots (104.8) while the control produced its lowest value (99.09). Percentage of filled spikelet/panicle

increased significantly by the application of litter, irrespective of species, c.a. 5% higher than control (Table 2). In sissoo litter treated plots, the percentage of filled spikelet tended to be lower than other litters. On the contrary, akashmoni produced the largest percentage than others. Furthermore, the highest number of unfilled spikelets/panicle was observed in control (31.4), which was statistically similar to that of sissoo (21.7). Akashmoni litter produced the least number (21.8), statistically similar to that of ipil-ipil (29.1) and mander litter (25.0). Application of litter tended to reduce unfilled spikelet by about 5% or more. It is worthy to note that application of akashmoni greatly reduced unfilled spikelet than the other litters.

Yield

The weight of 1000 grains (grain index) was significantly increased by application of litter than chemical fertilizer alone. The highest grain index was found in plots treated with ipil-ipil tree litter followed by mander, akashmoni and sissoo, i.e, 10.3, 8.9, 8.6, and 6.9%, respectively, higher than inorganic fertilizers alone did (22.04 g) (Table 2).

Grain yield was significantly higher in litter treated plots compared to the controls (Table 2). Application of ipil-ipil yielded the highest, i.e., 5.61 t/ha, followed by mander, akashmoni and sissoo treated plots.

Under the present investigation, grain yield was significantly influenced by the application of tree litter. This data is supported by previous findings of Apostol (1989), Zoysa *et al*. (1990), Akter *et al.* (1993) and Nahar *et al.* (1996).

Apostol (1989) stated that organic and inorganic fertilizer produced higher length of panicle, productive tillers per hill and grain index. Zoysa *et al*. (1990) reported that incorporation of *Leucaena* green manure increase N uptake throughout the vegetative period and all N rates increased grain yield significantly. Nahar *et al.* (1996) cited that green manure with *Leucaena leucocephala* produced highest grain yield of 4.36 t/ha whereas fertilized (100 kg N/ha) plots produced 4.12 t/ha grain yield of rice. Akter *et al.* (1993) cited that application of green manure plus chemical fertilizer produced significantly higher yield parameters. The higher yield when lowland paddy field applied with particular tree litters presumably could be ascertained to the greater contribution of available nutrients (Table 1).

Green manure incorporation as ipil-ipil, sissoo, akashmoni and mander tree litters increased grain yield by 39.6, 11.7, 23.1 and 33.3 %, respectively, over control where only inorganic mineral fertilizers were used (Table 2). Sissoo application seems gave lower productivity than other species of litter applied. Since the status of soil nitrogen and organic matter as presented in Table 1 were statistically not different, it was probably that the different productivity correlates to the increasing number of spikelet/hill, higher percentage of filled spikelet and grain index.

Chemical fertilizers might be supplemented with tree litters as green manure in lowland paddy. Since synchronization of nutrient release and crop demand is very vital for higher productivity, nutrient release pattern and decomposition rate of tree litter should be taken into consideration prior to their incorporation into the paddy fields. Nevertheless, it is still unclear the decomposition process of organic fertilizer in anaerobic system in lowland paddy.

CONCLUSION

Application of leaf litter of ipil-ipil (*Leucaena leucocephala*), sissoo (*Dalbergia sissoo*), akashmoni (*Acacia auriculiformis*) and mander (*Erythrina orientalis*) at rate 5 ton/ha per application could increase productivity of lowland rice. Higher productivity could be ascertained to higher level of nitrogen and organic matter content in treated plots than control.

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