J. Bangladesh Agril. Univ. 2(2): 231–235, 2004 ISSN 1810-3030

Addition of organic matter through *Sesbania rostrata* relay cropping in rice-rice farming system

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Abstract

A mechanism was tried to develop and enrich soil organic matter and to sustain productivity of the rice-rice cropping systems through its in-built biomass production from Ses*bania rostrata* as a relay crop. In order to develop such mechanism a number of field experiments were conducted with the participation of farmers during 1993 to 1996. Findings revealed that relay cropping of *S. rostrata* did not affect significantly the yields of aus and boro rice indicating its sustainability to fit it into the system. The relay cropping of *S. rostrata* could add up to 35.97 t ha^{-1} of green biomass to the soil depending upon treatments. Incorporation of 15 to 17.5 t ha^{-1} of *S. rostrata* green biomass was as good as application of 80 kg N ha $^{-1}$ for rice yield. Post harvest soil analysis data indicated that 25 t ha^{-1} green biomass of *S. rostrata* was necessary to maintain the current status of soil organic matter.

Keywords: Ecology, Sustainable, *Sesbania rostrata*

Introduction

Soil fertility and its sustainability mostly depend on the organic matter status of the soil. Organic matter status of the soil in the arable lands of Bangladesh has been decreasing day by day resulting in the reduction of crop yield (Islam, 1989). The addition of organic materials to soil through farm yard manures, composts, and organic residues has been reduced considerably because a major portion of these organic residues is used up as fuel (Hossain *et al.*, 1995). Hossain *et al.* (1997) reported the decreasing rate of 0.01% organic matter year^{-1} in the farming lands under AEZ 9. The rapid degradation of organic matter due to temperature factor is a natural inherent problem of the tropical and sub-tropical regions (Thompson and Trich, 1987). The intensive and continuous rice based crop culture, replacement of local varieties by modern one and use of dry and organic wastes as biomass fuel have put negative effect on the status of the soil organic matter (Hossain *et. al.*, 1997). They also predicted that at least nine tons of dry biomass ha^{-1} year^{-1} would be necessary to maintain the current status of soil organic matter. Growing green manuring crops like *S. rostrata* (Yadvinder-Singh *et. al.*, 1984) could easily do it. But in intensive cropping systems farmers do not like to spare 6-8 weeks for growing green manuring crops alone without any immediate cash benefit. If there is an option in the turn around period (between Boro/Aus and Transplant aman rice) to grow *S. rostrata* as intercrop (row mixed or relay) without any significant adverse effect on the yield of the main crop, farmers may be encouraged to produce biomass through this in-built process for maintaining/enriching the organic matter status of the soil.

They are many species of *S. rostrata* among which *S. aculeate* (0.62% N) is largely used in Bangladesh. Now a days *S. rostrata* containing more nitrogen (1.20% N) has attracted the attention of scientists of Bangladesh as a promising species for green manuring and biomass production (FSDRP, 1991). *S. rostrata* propagates through seeds, seedling and stem cutting (Hossain *et al.,* (1990) and thrives well in mist and water logged soils. Considering the above advantages an attempt was undertaken with the objective of developing mechanism to enrich soil organic matter and to sustain productivity of rice-rice cropping systems through biomass production from *S .rostrata.*

Materials and Methods

Seven experiments were conducted in the farmers' fields at Kazirshimla site and on station, Bangladesh Agricultural University, Mymensingh, Bangladesh during 1993 to 1996. The experiments were set up in randomized complete block design with five replications. The unit plot size varied from 20 sq. to 100 sq. m. according to farmers' land availability. The soils of different experimental plots were analyzed before transplanting of rice and after crop harvest to determine the organic matter status.

Two experiments were conducted during the period from March to December 1993, in Aus rice (BR6)- Transplant aman rice (BR11) cropping pattern, *S. aculeate* and *S. rostrata* were relayed with us rice at different planting arrangements -25 cm × 20 cm, 50 cm × 20 cm and no *Sesbania* (rice sole). Top cuttings of *Sesbania* were planted in between rice rows before panicle emergence of Aus rice as per experimental treatment. The same pieces of land were used for the second experiment in Aman rice season. *Sesbania* was incorporated in Aus rice field after 45 days of planting. Green manuring in *situ* and in *vitro* were practiced in Transplant aman rice field to incorporate the same amount of *Sesbania* (17.51 ha^{-1}) in each plot. The treatments included in the experiment were SR, SR+$N_{25\%}$, $N_{50\%}$, SR+$N_{100\%}$ and no urea application i.e. control.

Two experiments were also carried out during November 1993 to December 1994. Rice cultivar BR14 and BR11 were used during Boro and Aman seasons, respectively. In Experiment 3, two factors were included i) *Sesania sp.* e.g. *S. aculeate* and *S. rostrata* and ii) spacing of *Sesbania* as relay crop with rice- 25 cm × 15 cm, 50 cm × 15 cm, 75 cm × 15 cm, 100 cm × 15 cm and control (no *Sesbania*). The seedling of *S. aculeate* and *S. rostrata* were transplanted as relay crop one month before harvesting of Boro rice. The fourth experiment with Transplant aman rice was set up in randomized complete block design with five farmers replications. *Sesbania* biomass production due to relay cropping with Boro rice was incorporated as green manure for Transplant aman rice (Table 3).

In 1996 experiments were conducted during March to December. *S. rostrata* was relayed with Aus rice (BR2) by sowing seeds, Transplanting seedling and planting cuttings. *Sesbania* thus grown was used as green manure for succeeding Transplant aman rice. The experimental treatments were control, Sowing seeds of *S. rostrata* between two rows, Sowings seeds of *S. rostrata* two rows interval, Transplanting seedlings of *S. rostrata* between two rows interval Planting cutting of *S. rostrata* between two rows and Planting cuttings of *S. rostrata* after two rows interval with five farmers replications. Seeds were sown at 48 days after sowing of Aus rice. Seedling and cutting of 50 cm long *S. rostrata* were transplanted and planted, respectively, at 86 days after sowing of Aus rice. The standing *S. rostrata* plants were cut down after harvesting Aus rice and incorporated into the soil of the respective plots. Total incorporated biomass was recorded and these were treated as experimental treatments of the following experiment. The *S. rostrata* biomass incorporated ranged from 5.20 to 11.46 t ha^{-1} (Table 5).

Results and Discussion

Performance of *Sesbania* grown as relay crop with Aus rice

The survival rate of *S. rostrata* was higher (78-87%) than that of *S. aculeate* (12%) (Table 1). The highest amount of green biomass (17.51 t ha^{-1}) was produced by *S. rostrata* with 25 cm × 20 cm spacing. The amount of *S. aculeate* was negligible for which it was not recorded. This might be due to less number of survival plants along with their stunted growth.

Effect of relay cropping of *Sesbania* on the yield of Aus rice

From Table 1 it may be seen that relay planting of *Sesbania* did not exert any significant influence on the yield and yield components of Aus rice. It might be due to no competition of rice with *Sesbania* for space, light and nutrient.

Table 1. Performance of *S. rostrata* and *S. aculeata* grown as relay crop and their effect on the yield of Aus rice

Intercropping (Spacing)	No. of *Sesbania* Cutting planted $plot^{-1}$	%Survival of *Sesbania*	Plant height at harvest (cm)	Wt of green biomass at harvest (t ha^{-1})	Rice yield (t ha^{-1})
Rice + *S. rostrata* (Relayed)					
25 cm x 20 cm	400	87.44	199	17.51	2.75
50 cm x 20 cm	200	78.25	200	10.42	2.35
Rice + *S. aculeata*(Relayed)					
25 cm x 20 cm	400	11.80	51	-	2.69
50 cm x 20 cm	200	11.80	58	-	2.51
Control (Rice sole)	-	-	-	-	2.92

Yield and yield components of Transplant aman rice as influenced by green manure (*Sesbania rostrata*) and nitrogen level

In Expt. 2 it was observed that the yields of Transplant aman rice obtained from different treatments differed significantly (Table 2). The highest grain yield was produced by the treatment SR + $N_{50\%}$ and it was identically followed by the treatments $N_{100\%}$, SR + $N_{25\%}$ and SR + $N_{100\%}$. The lowest grain yield was obtained due to incorporation of *S. rostrata* singly. From the findings it is observed that the incorporation of 17.50 t ha^{-1} *S. rostrata* gave identical grain yields with the treatment where 80 kg N ha^{-1} was used.

Grain yield of Boro rice as influenced by *Sesbania* sp. at different spacings

Results obtained in Expt. 3 revealed that the effect *Sesbania* spacing and their interactions did not exert and significant influence on the yield and yield components of boro rice (Table 3). However, the grain yields were 5.94 and 6.00 t ha^{-1} due to relay cropping of *S. rostrata* and *S. aculeata*, respectively. The grain yields were 5.93, 6.02, 6.26, 5.85 and 5.80 t ha^{-1} due to 25 cm x 15 cm, 50 cm x15 cm, 75 cm x15 cm, 100 cm x15 cm and no *Sesbania* (Control), respectively. The grain yield ranged from 5.72 to 6.26 t ha^{-1} due to interaction between *Sesbania* spp. and *Sesbania* spacing (Table 4).

Table 2. Yield and yield components of Transplant aman rice as influenced by green manure (*S. rostrata*) and nitrogen rate

Treatment (SR + N)*	Plant height (cm)	No. of total tillers hill^{-1}	No. of effective tillers hill^{-1}	Length of panicle (cm)	No. of grains panicle^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
SR + $N_{0\%}$	120.05	12.88	9.98	22.13	104.55	24.50	4.76b	5.9b
SR +$N_{25\%}$	116.40	13.55	9.20	23.01	103.54	23.75	4.89ab	6.01b
SR +$N_{50\%}$	120.55	14.68	9.90	23.43	101.82	23.50	6.00a	6.71a
SR + $N_{100\%}$	121.90	14.58	10.67	23.10	108.21	23.50	5.22a	6.84a
Control	116.60	13.08	9.08	23.16	104.82	23.00	5.06ab	5.83b
CV (%)	2.50	8.62	6.40	2.18	6.89	2.03	4.01	4.34

SR= *S. rostrata* as green manure; N= Nitrogen level; ** The figures, in a column having common letter(s) do not differ significantly whereas dissimilar letters differ significantly

Table 3. Effect of *Sesbania sp.* and spacing grown as relay on the yield of Boro rice and its incorporation effect on the yield of Transplant aman rice

Treatment	Grain yield of Boro rice (t ha^{-1})	Survival rate of *Sesbania* (%)	Green biomass (t ha^{-1})	Grain yield of Transplant aman rice (t ha^{-1})
Sesbania spp.	5.94	88.01a	30.59a	5.43a
S. rostrata	6.00	35.81b	13.31b	5.22b
S. aculeata	NS**	0.01	0.01	0.01
Level of significance				
Sesbania spacing				
25 cm × 15 cm	5.93	58.38c	25.42a	5.46a
50 cm ×15	6.02	69.98a	22.89b	5.43a
75 cm ×15 cm	6.26	58.30c	21.58c	5.35a
100 cm ×15 cm	5.85	60.99b	17.91d	5.33a
Control	5.80	-	-	5.04b
Level of significance	NS	0.01	0.01	0.01

* In a column, figures having common letter (s) do not differ significantly whereas dissimilar letters differ significantly; NS= Not significant

Table 4. Effect of interaction of *Sesbania sp.* and spacing on the yield of boro rice and its incorporation effect on the yield of transplant aman rice and soil organic matter

Interaction (*Sesbania* spp. × Spacing	Grain yield of Boro rice (t ha^{-1})	Survival rate of *Sesbania* (%)	Green biomass (t ha^{-1})	Grain yield of Transplant aman rice (t ha^{-1+})	Organic matter (%)	% organic matter increase or decrease over initial soil
S. rostrata × (25 cm × 15 cm)	5.74	88.35ab	35.97a	5.58	2.00	11
S. rostrata × (50 cm × 15 cm)	5.88	90.90a	30.99b	5.55	1.98	11
S. rostrata × (75 cm × 15 cm)	6.26	85.78b	30.40b	5.50	1.98	11
S. rostrata × (100 cm × 15 cm)	5.93	87.03b	25.00c	5.45	1.95	8
Control	5.88	-	-	5.05	1.77	-2
S. aculeata × (25 cm × 15 cm)	6.11	28.40c	14.87d	5.35	1.90	6
S. aculeata × (50 cm × 15 cm)	6.16	49.05c	14.80d	5.30	1.88	4
S. aculeata × (75 cm × 15 cm)	6.26	30.83e	12.75e	5.20	1.87	4
S. auleata × (100 cm × 15 cm)	5.78	34.95d	10.83f	5.20	1.84	2
Control	5.72	-	-	5.03	1.78	-1
Significance level	NS	0.01	0.01	NS		

* In a column, figures having common letter(s) do not differ significantly whereas dissimilar letters differ significantly; NS= Not significant.

Table 5. Effect of relay cropping on *Sesbania* on the yield of aus rice and its incorporation effect on the yield on transplant aman rice ans soil and soil organic matter

Treatment	Grain yield of aus rice (t ha^{-1})	*Sesbania* biomass (t ha^{-1})	Grain yield of transplant aman rice (t ha^{-1})	Organic matter (%)	% organic matter increase or decrease over initial soil
Control (no *Sesbania*)	2.29	-	3.29b	1.75	-4
Sowing seeds of *Sesbania* between two rows	1.54	10.45	4.02a	2.06	13
Sowings seeds of *Sesbania* two rows interval	1.68	5.20	3.73a	1.90	4
Transplanting seedlings of *Sesbania* between twp rows interval	1.62	11.46	4.06a	2.21	21
Planting cutting of *Sesbania* between two rows	2.13	6.89	3.90a	1.95	7
Planting cuttings of *Sesbania* after two rows interval	1.60	8.21	3.87a	1.98	9
	1.89	5.31	3.72a	1.94	7

* In a column, figures having common letter (s) do not differ significantly whereas dissimilar letters differ significantly.

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