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Effects of rice straw, Sesbania and sulphur on the growth and yield of rice and soil health

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Abstract

A field experiment was carried out on an Old Brahmaputra floodplain soil at Bangladesh Agricultural University Farm, Mymensingh to study the effect of rice straw, sesbania and sulphur on the growth and yield of rice and post-harvest soil characteristics. The results indicated that the dry matter yields of rice plants at maximum tillering stage and panicle emergence stage increased significantly due to the application of rice straw, sesbania and sulphur over the control treatment. Similar results were observed in grain and straw yields of rice. The highest grain yield of 6.733 t ha^{-1} was recorded in the treatment, where rice straw and sulphur were applied together and it was statistically identical with that of sesbania and sulphur fertilizer applied together (6.640 t ha^{-1}). The minimum grain yield of rice was recorded in the control treatment (4.640 t ha^{-1}). The application of rice straw, sesbania and sulphur improved soil quality, particularly when S was applied in combination with either rice straw or sesbania. In post-harvest soils, pH was slightly lowered, while organic matter content, total N, available P and available S contents increased significantly under sesbania and rice straw applied together with S.

Keywords: Rice straw, Sesbania, Sulphur, Rice production, Soil quality

Introduction

The possibility of increasing land area for increased crop production is limited. To attain self-sufficiency in food, it is necessary to boost up rice production through adoption of combined measures, such as use of high yielding varieties of rice, balanced fertilization and manuring. Proper cultural measures and use of IPM practices should, however, be the integral part of rice production package.

Soil fertility has been showing a declining trend over last decade. Organic matter content of most of the soils of Bangladesh has gone down. On average, organic matter of Bangladesh soils is less than 1.5% (BARC, 1997). Rice straw is considered as a good source of organic matter and plant nutrients. Use of green manure, such as sesbania is also a potential source of organic matter and readily available plant nutrients in soils. Sulphur has been rated as the second most deficient nutrient element in agricultural soils of Bangladesh covering approximately 44% of the total cropped area (Hussain, 1990). As such, supplementing croplands with sulphur fertilizer such as gypsum could augment S deficiency in soils with needed fertility and higher rice yield. Haque (1997) reported higher sulphur requirements for increased rice production under wetland rice with phosphate fertilization in Bangladesh.

Sustainable increased rice production in Bangladesh could be possible through integrated use of organic materials such as rice straw/green manure and sulphur along with NPK and in specific cases with micro nutrients, such as Zn and B. It not only provides greater stability in crop production, but also maintains higher soil fertility status. The objective of the present investigation was thus, to study the impact of application of rice straw, sesbania and sulphur along with NPKZn on growth and grain yield of rice as well as on soil quality.

Materials and Methods

The experiment was carried out at Bangladesh Agricultural University farm, Mymensingh under the soil series, 'Sonatola' and Agro-ecological zone of Old Brahmaputra Floodplain. The experiment was conducted in the Aman season (July-November) of 2002. The soil was characterized by silt loam in texture with pH 6.8, organic matter content 2.04%, CEC 12.80 m.e.%, total N 0.20%, available P 11.00 ppm, exchangeable K 0.15 m.e.% and available S 13.50 ppm.

Treatments used in the experiment were: T_1 – Control, T_2 - Rice straw @ 6 t ha^{-1}, T_3 – Sesbania @ 6 t ha^{-1}, T_4 - Sulphur @ 20 kg S ha^{-1}, T_5 - Rice straw @ 6 t ha^{-1} and S @ 20 kg S ha^{-1} and T_6 - Sesbania @ 6 t ha^{-1} and S @ 20 kg S ha^{-1}. Rates of fertilizers used were urea @ 100 kg N, TSP @ 60 kg P_2O_5, MP @ 40 kg K_2O, and ZnO @ 3 kg Zn per hectare. Sulphur was applied from gypsum. One-third of urea along with all other fertilizers including gypsum was applied as basal at the final land preparation. Remaining two-thirds of urea were top dressed in two equal splits at 30 and 60 days after transplanting of rice seedlings. Rice straw and sesbania were chopped into small pieces and then incorporated in the soil two weeks before transplanting of rice seedlings. Seedlings of 35 days old were transplanted in the experimental plots on 12 August 2002. Plant spacing used was 20cm x 20cm. The experiment was laid out in completely randomized block design with three replications of each treatment. BRRI Dhan 30 was used as the test crop. 10 hills per plots were collected randomly for dry matter analysis (oven dry basis) at maximum tillering and panicle emergence stages. Data on yield contributing characteristics were recorded similarly from 10 hills randomly collected from each plot at harvest stage.

Results and Discussion

Dry matter yields of the rice plants were recorded at the maximum tillering and the panicle emergence stages. At maximum tillering stage, dry matter yield of rice plants ranged from 0.536–0.769 t ha^{-1}. The maximum dry matter yield (0.769 t ha^{-1}) was observed in the treatment T_6, (sesbania + S), which showed an increase of 43.4% over the control treatment. Rice straw and S applied together (T_5) produced second highest dry matter yield (0.763 t ha^{-1}) with an increase of 42.3% over the control treatment. The lowest dry matter at maximum tillering stage was obtained in the control treatment (0.536 t ha^{-1}). Application of rice straw, sesbania and S individually as well as when rice straw and sesbania applied in combination with S showed significant improvement on dry matter yield of rice plants over the control treatment (Table 1). During panicle emergence stage, dry matter yield of rice plants rose from 3.120 - 5.207 t ha^{-1}. Dry matter yield significantly increased, when rice straw and sesbania applied in combination with S compared to the control treatment at the panicle emergence stage (Table 1). The highest dry matter yield (5.207 t ha^{-1}) was obtained in T_6 (Sesbania + S) treatment, which showed an increase of 66.9% over the control treatment. The percent increase in dry matter under different treatments ranged from 28.7 to 66.9% over the control treatment. Rice straw and also S increased dry matter yield significantly over sesbania, while among themselves they did not show significant differences on production of dry matter.

Table 1. Effects of rice straw, sesbania and sulphur on dry matter yield of rice at maximum tillering and panicle emergence stages

Treatments	Maximum tillering stage		Panicle emergence stage	
	DM yield ($t\ ha^{-1}$)	Increase over control (%)	DM yield ($t\ ha^{-1}$)	Increase over control (%)
T_1 (Control)	0.536c	--	3.120d	--
T_2 (Rice straw @ 6 $t\ ha^{-1}$)	0.734a	36.9	4.015bc	28.7
T_3 (Sesbania @ 6 $t\ ha^{-1}$)	0.743a	38.5	4.134d	32.5
T_4 (Sulphur @ 20 $kg\ ha^{-1}$)	0.753a	40.4	4.265b	36.7
T_5 (Rice straw @ 6 $t\ ha^{-1}$ + Sulphur @ 20 $kg\ ha^{-1}$)	0.763a	42.3	5.018a	60.8
T_6 (Sesbania @ 6 $t\ ha^{-1}$ + Sulphur @ 20 $kg\ ha^{-1}$)	0.769a	43.4	5.207a	66.9
SE (±)	0.0447	--	0.2422	--
CV (%)	7.37	--	7.37	--

Figures in a column having common letter (s) do not differ significantly at 1% level of significance by DMRT

Data on yield contributing attributes of rice plants such as plant height, effective tillers $hill^{-1}$, panicle length, grains $panicle^{-1}$ and 1000-grain weights were recorded at harvest. Plant height ranged from 107.5 to 115.5 cm. The highest plant height was recorded in treatment T_5 (Rice straw + S). Rice straw and S individually had better effect on plant height over sesbania. Sulphur when added to rice straw increased plant height (Table 2). Again, the treatment with rice straw and S contributed highest number of effective tillers $plant^{-1}$ (15.00). The second highest number of effective tillers $plant^{-1}$ was recorded in treatment with sesbania and S applied together. S again when combined with rice straw or sesbania increased number of effective tillers $plant^{-1}$ significantly. The lowest number of effective tillers $plant^{-1}$ was recorded in control treatment (11.00). The average panicle length ranged from 19.93-23.87 cm. The highest panicle length was recorded in treatment T_5 (rice straw + S). The lowest panicle length was found in control treatment. Rice straw, sesbania and S had showed significant superiority over control treatment on panicle length of rice plants. The treatment T_5 had exerted better effects on production of grain $panicle^{-1}$. It ranged from 130.39-158.93. The lowest number of grains was recorded in control treatment. S when added to either rice straw or sesbania significantly increased number of grain $panicle^{-1}$ (Table 2). The weight of 1000-grain ranged from 20.70 - 23.27g. There were no significant differences on 1000-grain weight among the treatments. S however, was found to have better effects on all yield contributing attributes of rice plants compared to other treatments applied singly such as rice straw and sesbania.

Grain yield of rice significantly increased on application of rice straw, sesbania and S applied either singly or in combination (together) over the control treatment (Table 3). The highest grain yield was produced in T_5 (Rice straw + S) treatment (6.733 $t\ ha^{-1}$). The lowest grain yield was recorded in control treatment (4.640 $t\ ha^{-1}$). The treatments T_5 and T_6 produced identical yields. This indicates that sesbania and rice straw are both effective in increasing yield of rice when combined with S fertilizer (Table 3). The highest percent increase in yield of rice grain over control was 45.10, while similar grain yield increase (43.10%) was also obtained in T_6 over control treatment. Both the sesbania and the S applied singly had better effects over control on straw yield of rice. The maximum straw yield was 8.097 $t\ ha^{-1}$ and it was 39.45% more over control treatment obtained in T_6 (Sesbania + S) treatment. The minimum straw yield of rice was recorded in control treatment (5.806 $t\ ha^{-1}$).

Table 2. Effects of rice straw, sesbsnia and sulphur on yield contributing characteristics of rice

Treatments	Plant height (cm)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	1000-grain weight (g)
T_1 (Control)	107.5e	11.00c	19.93b	130.39g	20.70
T_2 (Rice straw @ 6 t ha^{-1})	113.8abc	12.67abc	22.13a	152.36bc	22.03
T_3 (Sesbania @ 6 t ha^{-1})	112.4bcd	12.00bc	22.21a	151.52bc	22.90
T_4 (Sulphur @ 20 kg ha^{-1})	113.5abc	13.00ab	22.50a	154.50b	23.27
T_5 (Rice straw @ 6 t ha^{-1} + Sulphur @ 20 kg ha^{-1})	115.5a	15.00a	23.87a	158.93a	23.30
T_6 (Sesbania @ 6 t ha^{-1} + Sulphur @ 20 kg ha^{-1})	115.3ab	14.00ab	23.80a	157.09a	23.37
SE (±)	1.332	1.212	1.260	1.553	NS
CV (%)	4.47	10.96	5.22	5.29	6.75

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Table 3. Effects of rice straw, sesbania and Sulphur on grain and straw yields of rice

Treatments	Grain yield (t ha^{-1})	% increase over control	Straw yield (t ha^{-1})	% increase over control
T_1 (Control)	4.640d		5.806d	
T_2 (Rice straw @ 6 t ha^{-1})	5.943b	28.08	7.000cd	20.56
T_3 (Sesbania @ 6 t ha^{-1})	5.927b	27.73	7.080bc	21.94
T_4 (Sulphur @ 20 kg ha^{-1})	6.053b	30.45	7.2000abc	24.00
T_5 (Rice straw @ 6 t ha^{-1} + Sulphur @ 20 kg ha^{-1})	6.640a	43.10	8.010ab	37.96
T_6 (Dhaincha @ 6 t ha^{-1} + Sulphur @ 20 kg ha^{-1})	6.733a	45.10	8.097a	39.45
SE (±)	0.187		0.425	
CV (%)	3.97		7.42	

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pH values in post-harvest soil slightly decreased under the treatments which received rice straw, sesbania and sulphur compared to the control treatment. Application of rice straw, sesbania and S significantly improved organic matter status of the soil. The maximum organic matter content (2.86%) was recorded in the treatment where rice straw applied singly. Total N and available P in post-harvest soil also increased significantly, where rice straw, sesbania and S were applied either singly or rice straw and sesbania applied in combination with S. Rice straw application increased the exchangeable K content of the of the post-harvest soil over control (Table 4).

The investigation indicates that application of organic materials such as sesbania and rice straw as well as S with usual practice of NPK application can greatly increase rice production and improve soil health.

Table 4. **Effects of rice straw, sesbania and sulphur on the characteristics of post-harvest soil**

Treatments	pH	Organic Matter (%)	Total N (%)	Available P (ppm)	Available S (ppm)	Exchangeable K (m.e.%)
T_1 (Control)	6.5	1.69f	0.192f	12.05c	12.41c	0.136bc
T_2 (Rice straw @ 6 t ha^{-1})	6.2	2.86a	0.245bc	13.25ab	13.43abc	0.155a
T_3 (Sesbania @ 6 t ha^{-1})	6.2	2.69b	0.247bc	13.69a	13.95abc	0.149abc
T_4 (Sulphur @ 20 kg ha^{-1})	6.3	2.17c	0.252ab	13.82a	14.10abc	0.141abc
Rice straw @ 6 t ha^{-1} + Sulphur @ 20 kg ha^{-1})	6.1	2.57b	0.268a	14.03a	14.80ab	0.153ab
Sesbania @ 6 t ha^{-1} + Sulphur @ 20 kg ha^{-1})	6.2	2.66b	0.269a	14.26a	15.02a	0.143abc
SE (±)	NS	0.073	0.008	0.488	0.488	0.008
CV (%)	7.73	4.05	5.99	4.62	4.62	3.43
Initial soil	6.8	2.04	0.20	11.00	13.50	0.15

Figures in a column having common letter (s) did not differ significantly at 1% level of significance by DMRT

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