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Effects of Surface Placement of Sesbania Debris Prior to Incorporation into the Soil on Growth of Rice and Soil Properties

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ABSTRACT

In a rain-fed farmer's paddy field, sesbania debris was utilized as a green manure according to the previously proposed technique, i.e. the surface placement of sesbania debris prior to incorporation into the submerged soil. The technique was confirmed to be very effective not only in avoiding the adverse effect of the applied debris which in turn enhanced growth and yield of rice but also in improving soil properties. A low input technology was suggested basing on the results of the current and the previous experiments and other available information.

Keywords : organic acids, paddy soil, *Sesbania rostrata*, surface placement of green manure

INTRODUCTION

A previous pot experiment (Patcharapreecha *et al.*, 1993a) confirmed effectiveness of the surface placement of sesbania debris prior to incorporation into the submerged soil in avoiding the adverse effect of application of sesbania debris on growth of the paddy rice. However, this technique must be tested in the field.

Accordingly, in the present experiment, the technique was applied in a rain-fed farmer's field to examine its feasibility and effectiveness in enhancing growth and yield of rice. In addition, effects of the technique on improving soil properties were also examined.

MATERIALS AND METHODS

Field

A paddy field at Ban Non Muang, Khon Kaen Province, was selected. The paddy field was rain-fed and located at the upper part of a slope.

The following were 3 reasons for selecting the paddy field as the site of the field trial : (1) the soil used for the previous pot experiment (Patcharapreecha *et al.*, 1993a) was collected from a paddy field adjacent to the present field trial, the properties of these 2 soils being very similar; (2) the paddy field was located in proximity to Khon Kaen University and (3) the person who took care of the previous pot experiment was the owner of the paddy field and well accustomed to the proposed technique.

Sesbania

Sesbania rostrata was sown in an upland field inside Khon Kaen University campus and left growing for more than 90 days. Its above ground part was air dried and cut into pieces of about 10 cm long. The pertinent properties are shown in Table 1.

Preparation of the plots and cultivation of rice plant

The paddy field was plowed and harrowed on July 18, 1990, after in had been submerged for a few months. On the second day, twenty one days old rice seedlings were transplanted in most parts of the paddy field without fertilizer. They were considered as a check plot (Ch plot). On the same day, a part of the paddy field was surrounded by a small and low border and divided into 3 small plots (1 m x 3 m) : C plot (ammonium sulfate: 12 kg N/rai), S plot (sesbania debris: 1.25 t DM/rai) and 2S plot (sesbania debris: 2.5 t DM/rri). The amount of N contained in the sesbania debris in S plot was the same as in C plot. Small and low borders were constructed between the plots also. In addition, plastic fences were installed on these borders

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to prohibit free exchange of water-soluble substances between different plots through flood water. The soils of the 3 small plots were care fully leveled by hand. Ammonium sulfate was evenly applied on the soil surface of the C plot. The plot was transplanted in the same way as Ch plot. sesbania debris was placed as evenly as possible on the soil surface of S and 2S plots (Figure 1). After on week, the surface-placed sesbania debris were incorporated into the soil and ten 28 days old rice seedlings which were taken from the same rice-nursery bed as the for C and Ch plots were transplanted. Finally, an adjoining rectangular area (1 m x 3 m) of S plot was surrounded with the borders and plastic fences in the same way as the 3 plots to prepare a representative of Ch plot. All these agricultural practices were done by the farmer.

Observation of the experiment

The soils and the rice plants were frequently observed for their performances during cultivation period.

Survey of rice and soil at harvest

On Nov. 22, 1990, each plot was divided into 3 equal parts and rice plants in each part were examined for its growth and yield to get appropriate average values. After harvesting, the soil was observed and examined for sorting, bulk density, moisture content and plant debris according to Wada and Kanazawa (1970).

Table 1 Chemical properties of *Sesbania rostrata* at 90 days.

Total N (%)	Organic C (%)	C/N	Water soluble carbohydrate (mg/g)	%P
1.76	27.41	15.57	285.52	0.103

Table 2 Effects of *S. rostrata* on growth of RD-6 rice grown and yield in Re Soil.

Tmt.	Culm Length (cm)	Straw Wt. (g/m^2)	Wt. of winnowed paddy (g/m^2)
1	116.3	876	466
2	104.6	420	258
3	108.6	636	403
4	97.3	470	273

1 = 2.5 t. *S. rostrata*/rai (2S)
2 = 12 kg N as $(NH_4)_2SO_4$/rai (C)
3 = 1.25 t. *S. rostrata*/rai (S)
4 = control (farmer's practice)

RESULTS AND DISCUSSION

Decomposition of the surface-placed sesbania debris

The sesbania debris was soaked in the flood water during the whole period of its surface-placement. After three days of surface placement, the debris smelt very bad. The flood water was dark in color and its surface was covered with film of ferric hydroxide (Figure 2). These clearly indicated that the surface placed sesbania debris was mainly anaerobically decomposed and the submerged soil, at least its upper part, was strongly reduced.

After one week of surface placement, most of the bad smell disappeared, the flood water become pale, stem of the debris became brownish and soft (Figure 3) and leaves of the sesbania debris being hardly recognized. These suggested that after one week, decomposition of palatable parts of the surface-placed debris in both S and 2S plots was more or less completed.

Growth of rice plants

The transplanted rice seedlings appeared healthy in both S and 2S plots in a few days after transplanting, though their growth was slightly worse than that in C plot. This might be attributed to higher N content in C plot resulted from the ammonium sulfate application.

A few days after transplanting, growth of rice plants in S and 2S plots gradually became better than the in C plot and in Ch plot. Rice leaves in C plot become darker in color and slender in shape than those in S and 2S plots, indicating rather severe P deficiency (Figure 4). After a few months, slight K deficiency was recognized in C plot. On the contrary, no P and K deficiencies were recognized in both S and 2S plots. These observation clearly demonstrated that.

1) a large amount of sesbania debris was safely incorporated into the submerged soil if the sesbania debris was placed at first on the soil surface till its stem became brownish, soft and bad smell disappeared,

2) denitrification loss of the inorganic nitrogen released from the sesbania debris was small because the flood water was kept anaerobic during decomposition of the surface-placed sesbania debris as confirmed by the laboratory experiment (Patcharapreecha

et al. unpublished data).

3) the sesbania debris was not only a good source of nitrogen but also effective sources of phosphorus and potassium and

4) P and K deficiencies became apparent when the rice plants were supplied with only nitrogen probably due to imbalance of the mineral nutrition in the infertile soil.

Yield of rice

Even though a detailed discussion of this topic will be done in a separate paper which will be published elsewhere, a brief description is given below to point out some pertinent features of the enhancing effects of sesbania-debris application on growth and yield of rice at harvest time. As can be clearly seen in Tables 2, culm length, straw weight, weight of winnowed paddy were in the following order: 2S plot > S plot > Ch plot > C plot. These results clearly demonstrated that a large amount of sesbania debris could be applied by the new technique to the paddy field to get high yield without harmful effects and loss of nitrogen which might occur from immediate incorporation of the debris.

Soil physical properties

After incorporation of the sesbania debris, the flood water appeared to be deeper in C plot than in other 2 plots. This was supposed to be caused by slight elevation of the soil surface in S and 2S plot. This supposition was supported by the fact that bulk densities of S and 2S plots were lower than that of C plot at harvest-time (Table 3).

After a dry spell for a few weeks (from July 26 till Aug. 31, 1990). the soils of the experimental plots were somewhat dried and many cracks were developed. Cracks were more remarkable in C plots than in S and 2S plots (Figure 5). This was supposed to be related with difference in thickness of the surface clayey layer which was formed by sorting (accumulation of clayey materials at the top of the plow layer when the submerged plow layer was plowed and harrowed). Actually, at harvest, the rather thick surface clayey layer was present in C plot while the surface clayey layers were hardly noticeable in S and 2S plots. In addition, soil moisture content was lower in C and Ch plots than that in S and 2S plots (Table 3). Probably, the surface clayey layer was not only liable to be dried up but also enhanced evaporation from the underlying layers. Consequently, suppression of sorting by application of sesbania debris might be helpful to keep water during the dry spell. Effects of green manuring on physical properties of soils have not been clearly recognized (MacRae and Mehuys, 1985). In this regard, the above mentioned results afforded some appropriate data in this research field.

Table 3 Effect of S.rostrata on bulk density of the soil.

Tmt	Bulk density (g/cc)
1	1.09
2	1.45
3	1.26
4	1.55

Table 4 Soil properties after harvesting rice.

Tmt	Moisture oven dry basis (%)	Avai. P (ppm)	Total N (%)	Extractable K (ppm)
1	21.60	11.68	0.054	40.65
2	17.14	3.86	0.026	28.95
3	23.14	5.51	0.037	37.65
4	18.81	8.73	0.039	29.75

Decomposition of debris in soil

Many sesbania stems were observed on the soil surface of S and 2S plots at the harvest time. The stems were also present in the plow layer. Plant debris of various sizes from to plow layer of each plot were isolated according to Wada and Kanazawas (1970). Observations of coarse plant debris by naked eye and under a binocular microscope at low magnifications showed that the leaves were almost completely lost while the stems kept their appearance. Detailed observations of the debris, which were stained with lactophenol cotton blue, under a microscope equipped with an analyzer and a polarizer revealed that most of the cell walls of the stems were not seriously attacked by microorganisms and still contained intact cellulose, though other parts of the cells were heavily colonized by microorganisms (Figure 6 and 7). These observations implied that decomposition process of the leaves was much different from that of the stems. Probably, leaves and palatable tissues of the stems contributed to supply mineral nutrients to rice plants and other tissues of the stems helped make the plow layer porous. These observations must by especially remarkable with sesbania of old ages which had strongly lignified



Figure 1 Sesbania debris was placed as evenly as possible on the soil surface.



Figure 2 Flood water was dark in color and its surface was covered with $Fe(OH)_3$.



Figure 3 Afer one week's surface placement, flood water became pale and the sesbania debris became brownish.



Figure 4 P-deficiency in C plot.

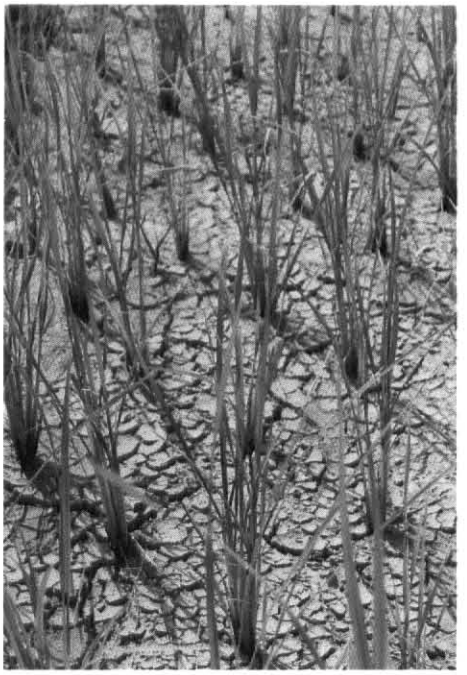


Figure 5 Crack development in C plots druing dry spell period.

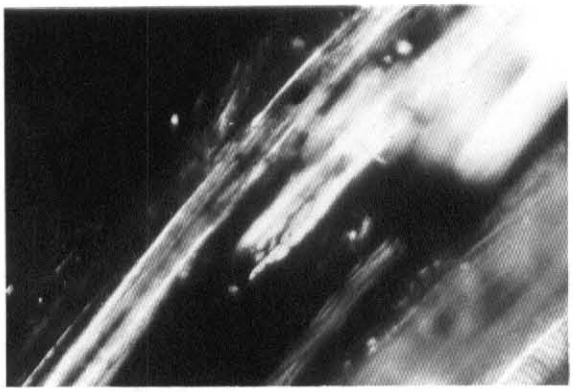


Figure 6 Under polarizer (200x) Sesbania stems were not attacked by microorganism and still contained intact ellulose. other parts of cells were heavily colonized by microorganisms.

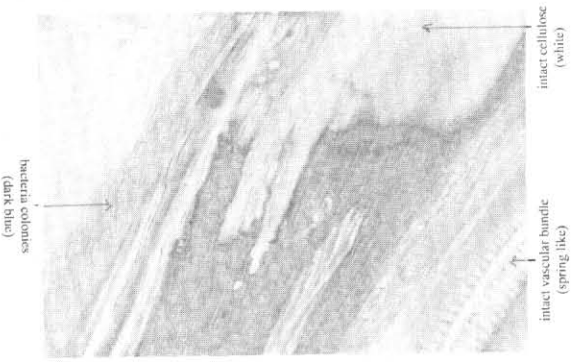


Figure 7 Schematic figure showing decomposition of sesbania debris (Cross Nichole 200x).

stems.

Soil chemical properties

Among S, 2S and C plots, contents of available macronutrients after the harvesting (Table 3) were in the following order : 2S plot > S plot > C plot. This result suggested that a part of the nutrients contained in the sesbania debris remained in the soil and contributed to the soil fertility.

Soil fauna and flora

As mentioned above, the surface-placed sesbania debris induced development of reductive state in the flood water. This implied that the oxidized layer was absent and nitrification-denitrification was inhibited before incorporation of the debris into the soil. In addition, some pathogenic fungi, which could survive in the oxidized layer when the soil was submerged (Stover, 1955), were expected to be killed by the surface placement of the debris.

GENERAL DISCUSSION

When the results of the present experiments are combined with those of the previous experiments (Patcharapreecha *et al.*, 1990, 1991, 1992, 1993a,b) and other information, the following low input technology to improve and to sustain rice-based agriculture on rain-fed infertile sandy soils in Northeast Thailand con be proposed.

1. *Sesbania rostrata* is cultivated by being applied with phosphate rock powder in a paddy field before rice. Growth of the plant is promoted by P and other micro-nutrients from the phosphate rock powder and K from soil and water.

2. The sesbania debris is applied to the submerged soil according to the above mentioned technique to minimize accumulation of organic acids which are toxic to rice seedlings.

3. The applied phosphate rock keeps soil pH high so the toxicity of organic acids, if they accumulate in the soil, is not serious.

4. Zn-deficiency is not induced in rice plant even at high soil pH in the presence of the applied phosphate rock, because Zn may by supplied directly from the phosphate rock or indirectly through debris of sesbania which takes up Zn from the phosphate rock (Patcharapreecha *et al.*, unpublished data).

5. Water-regime of the soil is improved with the applied sesbania debris. This may be helpful for paddy rice during the period when rainfall is deficient.

6. Growth and yield of rice are enhanced by being abundantly supplied with mineral nutrients (P, K and micro-nutrients as well as N) and water.

7. Soil fertility is increased by being enriched with organic matter and various nutrients.

8. The desirable effects of phosphate rock on plants and the soil continue for several years (Patcharapreecha *et al.*, 1993b).

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