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SESBANIA ROSTRATA GREEN MANURE AND THE NITROGEN CONTENT OF RICE CROP AND SOIL

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Summary—The effects of four treatments upon the N content of rice crop and soil in 1 m^2 irrigated microplots were compared: (1) PK fertilization + *Sesbania rostrata* (inoculated stems) ploughed in as green manure when it was 52 days old, (2) PK fertilization + *S. rostrata* (non-inoculated stems) ploughed in as green manure, (3) PK fertilization + ammonium sulphate (60 kg N ha^{-1}), (4) PK fertilization alone (control).

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Table 1. Influence of green manuring and application of N fertilizer on grain yield of rice and N content of rice crop and soil

Treatments	Grain yield ($g\,m^{-2}$)	N content of rice crop ($g\,m^{-2}$)	Soil N content ($g\,m^{-2}$) Fraction <2 mm	Fraction >2 mm	Total
(1) *S. rostrata* green manure (inoculated stems)	596 ± 125a	18.2 ± 4.5a	147 ± 11.8ac	27.1 ± 9.4a	174.4 ± 16.3a
(2) *S. rostrata* green manure (non inoculated stems)	571 ± 116a	16.8 ± 3.0a	149.2 ± 11.6a	30.0 ± 7.3a	179.2 ± 12.5a
(3) Fertilization ($60\,kg\,N\,ha^{-1}$)	381 ± 29b	7.2 ± 0.6b	135.5 ± 6.6bc	3.1 ± 1.3b	138.6 ± 5.3b
(4) Control	212 ± 40c	4.0 ± 0.8c	128.8 ± 11.6b	3.6 ± 0.7b	132.4 ± 12.2b

Figures followed by the same letter do not differ significantly, $P = 0.05$.

Plant and soil sampling

Rice crop. At harvest time, the rice tops were cut just above the crown. Grain and straw were separated by hand, dried at about 60°C and ground into powder.

Soil. In each plot we dug out a 20 (width) × 40 (length) × 50 (depth) cm soil sample from under two rice hills. Each soil sample (weighing about 44.8 kg) was sieved (<2 mm) to separate the mineral soil (fraction < 2 mm) from the plant debris (fraction >2 mm including undecomposed debris of *S. rostrata* stems and leaves which had been incorporated and the root litter of *S. rostrata* and rice). The mineral soil was air dried and carefully homogenized. Plant debris was washed in running water, dried at about 60°C and ground into powder. Samples of soil and plant debris were carefully partitioned into subsamples of 1 g (soil) or 100 mg (plant debris) for N analysis.

Nitrogen analyses

Nitrogen was analyzed according to a microkjeldahl procedure involving H_2O_2 (G. Rinaudo, unpublished Thesis Dr Eng., Montpellier University, 1970). For each individual sample of soil or plant material there were three replications. Statistical analyses were carried out using the mean of the three individual analyses related to each plot.

RESULTS

Both the inoculated and non-inoculated stems of *S. rostrata* exhibited profuse nodulation, probably because the non-inoculated plants were contaminated, the specific *Rhizobium* strain being carried by the air or insects. Thus the results of treatments (1) and (2) did not differ significantly (Table 1) and in the following discussion the data from treatments (1) and (2) affecting the N content of the mineral soil (fraction <2 mm), but markedly augmented the amount of N in the plant debris (fraction >2 mm). Such debris appeared to be the soil N reserve that might be exploited by a subsequent crop, an hypothesis that is currently being investigated.

Comparison of chemical N fertilizer application (treatment 3) to the control (treatment 4)

The application of $60\,kg\,N\,ha^{-1}$ increased the grain yield by $169\,g\,m^{-2}$ ($1.69\,t\,ha^{-1}$), but did not significantly increase the soil N content.

Tentative estimate of N_2 fixed by S. rostrata

If we take into account the lower estimate for the exportation of N by the whole crop ($135 - 46 = 89\,kg\,N\,ha^{-1}$) and for the N added to the soil ($444 - 266 = 178\,kg\,N\,ha^{-1}$), the amount of N_2 fixed by *S. rostrata* during its 52 days growth was at least $89 + 178 = 267\,kg\,N\,ha^{-1}$. Thus, one third of N_2 fixed was transferred to the crop and two thirds remained in the soil.

DISCUSSION

It is well known that rice soils have an exceptional ability to benefit from the input of N resulting from the activities of phototrophic and heterotrophic N_2-fixing microorganisms. However, this input is at most *ca.* $40\,kg\,N\,ha^{-1}\,crop^{-1}$, an average of 25–30 $kg\,N\,ha^{-1}\,crop^{-1}$ originating from the activity of blue-green algae (Venkataraman, 1979; Roger and Kulasooriya, 1980), 0–30 $kg\,N\,ha^{-1}\,crop^{-1}$ being fixed by heterotrophic bacteria (Dommergues and Rinaudo, 1979). Another rough estimate of N_2 that is spontaneously fixed in rice fields can be deduced from the average rice yield in countries that use very low levels or no N fertilizers (namely Bangladesh, India, meet the requirements of crops yielding more than 2 t grain ha^{-1}, it is necessary to add exogenous N to the rice field either as chemical fertilizer or as organic or green manures.

The application of chemical N fertilizer (treatment 3) resulted in an increase of 169 g m^{-2} (1.69 t ha^{-1}) in the grain yield. If we assume that the production of 100 kg of grain requires 2 kg of N, the reported increase of 1.69 t ha^{-1} would necessitate 34 kg N ha^{-1}. Since 60 kg of N chemical fertilizer ha^{-1} was applied, the efficiency of the fertilizer was *ca.* 57%, a figure which could be expected since the fertilizer was surface applied. On that basis, the application of *S. rostrata* green manure resulted in a grain yield increase of 372 g m^{-2} which would be equivalent to that obtained by the use of *ca.* 130 kg N fertilizer. Thus *S. rostrata* as green manure appears to be a satisfactory substitute for chemical N fertilization. Moreover, it should be emphasized that after the rice harvest the soil N status was significantly improved, which could benefit a subsequent rice crop.

Trials on a larger scale are under way to confirm the high N_2-fixing potential of stem nodulating *S. rostrata* and its effect on the rice grain yield and soil N content in the field.

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