NITROGEN FIXATION IN WATERLOGGED PADDY SOIL, WITH SPECIAL EMPHASIS ON RICE STRAW APPLICATION

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Abstract

In greenhouse studies, the incorporation of up to 6.0 tonne/ha of rice straw into paddy soil, in general, reduced the nitrogenase activity in rice plant roots but increased the activity in waterlogged soil. It did not affect the dry matter yields at 9-weeks after transplanting. The use of urea to compensate for the immobilized nitrogen due to rice straw decomposition, in general, reduced nitrogenase activity in the rice plant roots, tended to decrease the number of nitrogen fixing aerobic bacteria, did not affect nitrogen content of plants, but increased dry matter production.

Abstrak

Penelitian yang dilakukan di rumah kaca menunjukkan bahwa pembenaman jerami padi sebanyak 6 ton/ha ke dalam tanah sawah akan mengurangi aktifitas nitrogenase pada perakaran padi sawah, akan tetapi aktifitas tersebut meningkat pada tanah yang tergenang. Perlakuan ini tidak mempengaruhi berat kering tanaman pada minggu kesembilan setelah dipindahkan dari persemaian.

Penambahan urea untuk memenuhi kebutuhan nitrogen yang terimmobilisasi dalam proses perombakan jerami umumnya mengurangi aktifitas nitrogenase pada perakaran padi. Urea yang diberikan ini cenderung mengurangi jumlah bakteri penambat nitrogen yang aerob, dan tidak mempengaruhi kandungan nitrogen tanaman, akan tetapi meningkatkan berat kering tanaman.

Introduction

Farmers in Java commonly use rice straw for paddy rice soil amendment which is called "walik dami". Little information is available, however, concerning the effect of rice straw on nitrogenase activity and rice yields.

Available data confirmed that nitrogen fixation in waterlogged paddy soils is an important process and apparently provides nitrogen for the rice plant (3, 8, 12). Undoubtedly the rice root system also favours the nitrogenase activity of nitrogen fixing bacteria (5, 6, 10, 11).

The objectives of the present experiments were to study the effect of applied rice straw on nitrogenase activity and yield of dry matter. Urea was added to compensate for the immobilized nitrogen due to rice straw decomposition.

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Material and Methods

Soils. The soil.(regosol) used was obtained from a paddy field near Bulaksumur, Yogyakarta. Analyses were as follows : total N 0.04%, organic matter 2.04%, C.E.C. 8.16% (me %) and pH of 6.1.

Rice straw. The rice straw come from a local paddy and was chopped to an average length of 2. cm. It had a nitrogen content of 2.17%.

Soil fertilization. The fertilizers used were urea and triple superphosphate (TSP). Urea was applied at three intervals, using a rate of 30 kg N per ha. TSP was added as a basal fertilizer at planting time using 30 kg of P_2O_5 per ha.

Experiment. Most of the experiments were conducted in the greenhouse, Faculty of Agriculture, Gadjah Mada University. Three week old rice seedlings (IR. 36) were transplanted in pots containing 3.5 kg of soil. Just before transplanting, the soils were treated with rice straw and N-P fertilizers. A factorial completely randomized design (CRD) was used in these investigations.

Gas analyses (acetylene reduction analysis). Nitrogenase activity of the fresh roots and soil samples was studied by the acetylene reduction technique at 3-week intervals. The root samples were washed with water and placed in test tubes which were closed with venoject seals. Ten per cent of the atmosphere within the test tube was then replaced by acetylene gas. The tubes were preincubated for 12 hours and 5 hours, respectively at a room temperature of 28° to 30°C (4). The samples were assayed for ethylene by injection into a Fisher 2400 series Gas Chromatograph with alumina column (9).

Microbial Count. After the nitrogenase activity assay, the number of aerobic and anaerobic nitrogen fixing bacteria were determined by the Most Probable Number (MPN) method (1, 7). The numbers of bacteria were related to fresh weight of roots.

Plant analysis. The total N content of the rice plant was determined by the micro Kjeldahl method (1, 2).

Results and Discussion

The data on acetylene reduction analysis in the rice roots system are given in Table 1. It can be observed that in general amendment of rice straw to waterlogged paddy soil decreased the acetylene reduction activity without the addition of urea. With the use of urea, results were less consistent in the earlier stages of plant growth than at the later sampling period.

Table 1. **Nitrogen fixing (acetylene reduction) activity in the rice root system.**

Week after planting	Fertilizer	Rice straw added, tonne/ha		
		0	3	6
		nM/g d.w. roots/5 hrs		
3	Nil	387.95	170.03	111.45
	Urea	25.11	99.61	161.25
6	Nil	93.56	87.30	21.61
	Urea	56.21	524.12	35.76
9	Nil	16.16	trace	38.82
	Urea	88.02	26.70	trace

The effect on the nitrogenase activity by the quantity of rice straw incorporated into waterlogged soil is shown in Table 2. In general nitrogenase activity increased with the rates of rice straw and as plants became older. Similar results were demonstrated by Charluvu and Rao (5) and Reddy and Patrick (8).

Table 2. **Nitrogenase fixing (acetylene reduction) activity of the waterlogged paddy rice soil.**

Weeks after transplanting	Rice straw introduction, tonne/ha		
	0	3	6
	nM/g soil/24 hrs		
3	0.26	0.14	0.51
6	14.84	2.59	4.81
9	7.21	19.69	27.97

The Most Probable Number of nitrogen fixing bacteria are listed in Table 3. There was no correlation between nitrogenase activity and nitrogen fixing bacteria density. Although numbers fluctuated, urea usually decreased the number of both aerobic and anaerobic bacteria. This was most obvious as the plants became older and more dramatic for the anaerobic type. The effect of rice straw was inconsistent and no definite trend could be established.

Table 3. **Most Probable Number of aerobic and anaerobic nitrogen fixing bacteria in the rice roots of straw-treated paddy.**

Weeks after transplanting	Fertilizer	MPN of rice roots x 10^3/g		
		Rice straw added, tonne/ha		
		0	3	6
Anaerobic				
3	Nil	—	6.5	13.5
	Urea	11.5	—	—
6	Nil	13.5	251.5	68.0
	Urea	8.0	13.5	11.5
9	Nil	19.0	335.0	460.0
	Urea	240.0	240.0	121.5
Aerobic				
3	Nil	69.00	85.50	150.000
	Urea	1.35	—	0.65
6	Nil	2.90	1.60	1.20
	Urea	1.60	0.40	1.70
9	Nil	28.50	—	9.00
	Urea	0.65	2.00	0.90

The analysis nitrogen content of rice plants is given in Table 4. There were no consistent trends in regard to the rice straw and urea treatments. The total nitrogen content of rice at 9 weeks after planting had become constant for both treatments.

Table 4. **Total nitrogen content of rice plant tissue (mg/250 mg of tissue).**

Weeks after transplanting	Fertilizer	Rice straw added, tonne/ha		
		0	3	6
3	Nil	3.13	3.34	3.18
	Urea	2.90	3.07	3.34
6	Nil	2.70	2.41	4.48
	Urea	2.85	2.79	3.07
9	Nil	2.26	1.92	2.21
	Urea	2.21	2.21	2.19

The dry matter yields of rice plants are shown in Table 5. Addition of urea increased dry weight except at the 9-week sampling period and 6.0 tonne straw treatment. There were no significant differences in yields among the straw treatments. Thus from the view point of rice straw application, there will be no apparent detrimental effect of its incorporation into the rice paddy during the early stage of seedling growth. Under the conditions of the present studies, nitrogenase activity in the rice root system, as influenced by addition of straw, did not alter dry matter yields.

Table 5. **Yield of rice plant dry matter (g. plant)**

Weeks after transplanting	Fertilizer	Rice straw added, tonne/ha		
		0	3	6
3	Nil	40.7	4.34	4.54
	Urea	7.69	6.67	7.05
6	Nil	9.54	10.99	8.97
	Urea	11.14	12.83	12.41
7	Nil	19.67	21.08	21.22
	Urea	24.20	23.16	21.53

Acknowledgements

We thank Prof. Loy V. Crowder for constructive comments. This investigation was carried out at the Departement of Microbiology, Faculty of Agriculture Gadjah Mada University.

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