CELLULOLYTIC BACTERIAL CONSORTIUM ACCELERATE RICE STRAW DECOMPOSITION

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INTRODUCTION

Rice is the staple food in Malaysia, Indonesia, Thailand, India and many other Asian countries and in Malaysia, nearly 0.6 billion ha of land is being used for growing rice (Malaysian Agricultural Research and Development Institute 2008). Rice cultivation produces large quantities of straw waste, ranging from about 2 to 9 tons/ha globally. In many countries including Malaysia, rice straw is generally burnt directly on the fields causing greenhouse emissions (Badrinath et al. 2006) and can exacerbate global warming problems. Rice straw consists mainly of cellulose and hemicelluloses encrusted in lignin, and contain only small amounts of protein. The higher content of these cellulosic materials in the rice straw compared to other protein-rich grains such as wheat and barley make rice straw more resistant to microbial decomposition (Parr et al. 1992). Decomposed rice straw is a rich source of organic material that can be utilized by the plants; particularly when the C:N ratio is enriched by the activities of the soil bacteria, thus increasing the supply of nutrients and maintaining soil fertility. This paper describes the decomposition of rice straw using cellulolytic bacterial consortium (CBC) which has been isolated from a rice growing area in Tanjung Karang Selangor.

MATERIALS AND METHODS

Isolation and screening of bacteria strains

Bacterial cultures were isolated from the soil, the rhizosphere and rice straws obtained from the Malaysian Agricultural Research and Development Institute (MARDI) station at Tanjung Karang, Selangor, Malaysia. The bacterial cultures were screened qualitatively, by the zone of clearing on a minimal medium using cellulose as the sole carbon source, using Carboxy methyl cellulose (CMC) (2%), xylan (0.5%), xyloglucan (0.1%) and galactomanan (0.1%) as substrates by the method of Kasana et al. (2008) and Abde-Sater et al. (2001) with modifications.

Decomposition of rice straw by bacterial culture

A litter bag experiment was carried out in a greenhouse in the Faculty of Science and Technology, Universiti Kebangsaan Malaysia, using natural lighting at 28-32^{o}C. Rice straw (25.0 g) was put in a litter bag (15x30cm) and the bag sprayed with 5% CBC) in nutrient broth before being buried into clay soil (20.0 kg) in containers (35cm x 32cm x 50cm). The bags were then placed horizontally in each pot at a depth of 5cm and was left for 15, 30, 45 and 60 days, and the litter bag in the soil turned over every week. Water was added and maintained at a level of 3–5cm above the soil surface. The litter bags containing

the rice straws were collected at day 15, 30, 45 and 60, washed in water and dried in the oven at 50°C until it attained constant weights. Percentage loss of rice straw weight during these period was then determined and analyzed statistically using Statistical Analysis System software.

The dried rice straw was then ground to become powder and passed through a 63 µm sieve. The samples were then analyzed for their carbon and nitrogen contents using CHNS-O analyzer (Fison) (Beare et al. 2002). In another experiment, urea and straw was used in place of CBC and straw. Each treatment was replicated three times; and control experiment comprise of straw without bacterial culture.

RESULTS AND DISCUSSIONS

A total of 10 bacterial isolates which are capable of completely hydrolyzing carboxy methyl cellulose (CMC), xylan, xyloglucan and galactomanan were isolated from the soil, rice straw and rhizophere of rice plants. These bacterial isolates were taken as a consortium culture to test for the ability to decompose rice straw pieces under greenhouse conditions.

Figure 1 shows the percentage loss of rice straw over a period of 60 days when incubated with rice straw + CBC, and rice straw + urea, compared to control. Addition of both CBC and urea significantly increased the biomass loss from rice straw (6.33-20.33% of controls) from 15 until 60 days of treatment. However, the decomposition of rice straw was shown to be significantly higher in the presence of urea compared to CBC, particularly at the shorter incubation time of up to 45 days, but not significantly different at 60 days. In this regards, it is of interest to see that the C:N ratio of rice straw, which is an indication of fortification of the N at the expense of C, in the presence of both CBC and urea are almost similar for periods up to 45 days (Figure 2). The C:N ratio only increased after 60 days of treatment, but this is too long a period to wait before seeds can be sowed to the plot. The CBC was comparable in terms of its ability to increase C:N ratio which is important when assessing the available nitrogen sources from soil.

Kumar et al. (2008) also reported a high C:N ratio of rice straw in the field (87.6:1) which dropped to 14.6:1 when inoculated with a consortium of fungal strains for 90 days. Pathak et al. (2006) similarly reported improved C:N ratio when rice straw was treated with microbes. CBC, consisting of a group of bacteria that can produce enzymes capable of decomposing the mainly celluloses and hemicelluloses components of the rice straw as well as the lignin into much simpler molecules, is potentially useful to be applied to the field to increase rice yields.

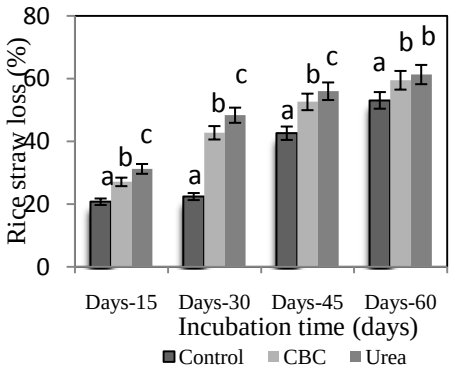

Figure 1. Rice straw weight loss when incubated with CBC, urea and in the control; different letters indicate significant difference for percent rice straw loss (P<0.005, n=3).

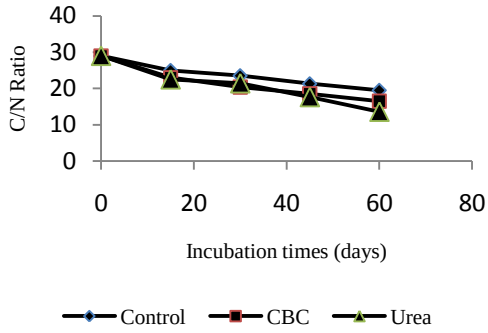

Figure 2. C/N ratio during the composting of rice straw using CBC, urea compared to urea and control.

CONCLUSIONS

Cellulolytic bacterial consortium (CBC) capable of enhancing decomposition of cellulose materials from rice straw has been successfully isolated. When rice straw was incubated with CBC, it was found that biomass loss was highest and C:N ratio was optimal at 45 days. Cellulolytic bacteria consortium application during the incorporation of rice straw into rice fields can help farmers in managing rice straw in the field.

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REFERENCE

Abdel-Sater, M.A. and El-Said, A.H.M. 2001. Xylan-decomposing fungi and xylanolytic activity in agricultural and industrial waste. International Biodeterioration and Biodegradation. 47:15-21.

Badrinath, K.V.S. Kiranchand, T.R and Krisna, V.P. 2006. Agricultur crop burning in the Indo-Genetic plains-a study using IRS-P6AwiFS satelit data. Curr Sci. 91: 1085-1089.

Beare, M.H, Wilson, P.E, Fraser, P.M and Butler, R.C. 2002. Management effects on barleys straw decomposition, Nitrogen Release, and prop production. Division S-4 Soil Fertility and Plant Nutrition. Soil Sci.Soc.Am. Journal. 66: 848-856.

Kasana, R.C.Salwan, R., Dhar, H., Dutt, ., Gulati, A. 2008. A rapid and easy merhode for detection of microbial cellulases on agar plates using gram's iodine. Curr microbial. 57:503-507.

Kumar, A. Gaind, S and Nain, L. 2008. Evaluation of thermophilic fungal consortium for paddy straw composting. Biodegradation. 19: 395-402.

Parr, J.F., Papendick, R.I., Hornick, S.B., Meyer, R.E., 1992. Soil quality: attributes and relationship to alternative and sustainable agriculture. American Journal of Alternative Agriculture 7, 5–11.

Pathak, H.,Singh,R., Bhatia, A.,Jain,N. 2006. Recycling of rice straw to improve wheat yield and soil fertility and reduce athmospheric pollution. Paddy Water Environ. 4:111-117.