Rice Production with Effective Microorganisms: Impact on Rice and Soil

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Abstract : *Rice is the backbone of the agricultural economy and the staple food of most people in the Asia Pacific Region. The increase in area planted, introduction of high-yielding varieties, and extensive use of chemical fertilisers and pesticides increased rice production. However, these gains also contributed to environmental pollution, biological imbalances, health hazards, and soil degradation. More sustainable alternatives have been sought to address these concerns and meet the food demand of the increasing population. Effective microorganisms (EM) technology was studied at the Faculty of Agriculture, University of the Ryukyus, Okinawa, Japan from March 1998 to November 1999 to evaluate its impact on rice production and soil properties.*

EM application with rice straw as organic substrate promoted the development of vigorous root system, sustained the growth and yield of rice better than rice straw alone, and comparable with chemical fertilizer. It also increased the diversity of soil organisms, improved the soil tilth, and soil nutrients.

Its effect on ratoon production includes higher hill viability, healthier and vigorous tillers, and higher yield levels than rice straw alone and comparable or in some cases higher than chemical fertiliser. Stubble cutting height of 10 and 15 cm for ratoon production were better than 5 cm. Although the yield obtained from 10 and 15 cm cutting height were comparable, 10 cm cutting height produced better grain quality. The effects of 100 and 250 l ha-1 EM foliar rates were more stable than the other rates.

Introduction

In the Asia-Pacific region, rice is life, politics, and economics because it is the staple food and source of livelihood of the majority of their people, and a major propeller of national development. The introduction of high-yielding varieties that needed more chemical fertilisers and pesticides increased rice production, which resulted in self-sufficiency or surplus for many rice-producing countries. However, it also led to environmental pollution, biological imbalances, and soil deterioration. Alternative technologies has been sought to address these concerns while maintaining high yield levels to feed the increasing population. One of these is effective microorganisms (EM) technology that utilizes a group of naturally occurring beneficial microorganisms as an added dimension of organic-based production system. EM is applied as soil and plant inoculant to increase microbial diversity and activity in the soil and on the phyllosphere of plants that complement the indigenous species in improving the soil health (Higa and

Parr, 1994) and suppress pathogenic species while facilitating the decomposition of organic materials and synthesizing nutrients essential for plant growth and yield (Higa, 1998).

This paper presents the results of the effects of EM using rice straw as the organic substrate in rice production and soil properties.

Materials and Methods

The experiment was conducted at the University of the Ryukyus, Okinawa, Japan from March 1998 to November 1999 under greenhouse using box planters with a dimension of 50 x 100 x 30 cm. Rice straw (RS) at 10 t ha^{-1} plus EM Bokashi at 3 t ha^{-1} , and EM extended solution at 50, 100, 250, and 500 l ha^{-1} were compared with chemical fertilisers (CF) at 120-40-40 kg NPK ha^{-1} and rice straw alone (RS at 10 t ha^{-1}). The experimental design was randomised complete block design (RCBD) replicated 3 times. Fifteen plants (3 rows x 5 hills) were planted per box planter. The soil type was silty clay locally known as Jahgaru. The rice variety used was Hanoibi.
Each box planter was filled with 60 kg soil then submerged with water for at least 3 days before mixing. Surface application of chopped rice straw in EM treatments was done 10 days before transplanting followed by the application of EM Bokashi and extended EM solution. RS treatment was also applied at the same time with EM treatments. Mixing of soil in the box planters was done five days later. The CF treatment was applied with two-thirds of the nitrogen and all phosphorus and potassium requirements one day before transplanting. Final mixing and levelling was done one day before transplanting. Extended EM solution was applied in EM treatments immediately after transplanting then followed every two weeks thereafter up to crop maturity. The remaining nitrogen requirement in CF treatment was applied 45 days after transplanting. The water level was maintained at 2-5 cm level throughout the growing period. Harvesting was done when 80% of the grains were mature.

Immediately after harvesting the main crop, the stubbles in each row were cut at 5, 10, and 15 cm above the ground per box planter for ratoon experiment. The same treatments were used except that rice straw was applied as mulch at cutting time and the chemical fertilizer was applied at cutting and 30 days after cutting.

The data were statistically analysed using the Kruskal Walis test.

Results and Discussion

The soil microbial population of EM treatments although numerically higher was statistically comparable with RS and CF treatments in both the main and ratoon rice crop. The microbial population was also noted to increase linearly with EM rates. The result can be influenced by factors such as soil properties, food source, and competition with indigenous species, which affect the predominance of the introduced organisms mentioned by Higa and Wididana (1991). Moreover, they claimed that microbial inoculation readily balances the composition of each microbial group by reducing the inoculum density of several pathogenic microorganisms and increasing the number of beneficial microorganisms. EM application was noted to enhance the decomposition process and straw incorporation through the aid of other attracted soil organisms. The substrate of Bokashi formulation such as rice bran, fishmeal, and soybean meal was noted to attract and enhance the activity of soil organisms (Corales et al, 1999). The nutrient content of the soil in EM treatments was also slightly increased. Xu et al. (1998), Yamada et al. (1998) and Sangakkara et al. (1998) reported that EM application increases soil nutrient content. The availability of soil nitrogen (N) in the different rice growth stages showed that there was a gradual and steady increase up to the reproductive stage then declined towards crop maturity in the EM treated plots. In contrast, chemical fertiliser had high soil N at the vegetative stage with a very slight increase at the reproductive stage then declined at crop maturity. In RS treatment, the soil N only increased at the reproductive stage and continued to increase up to crop maturity.

The number of tillers produced in EM treatments was comparable with CF treatment in both the main and ratoon crop (Table 1). The EM-treated plants during the main crop rice had bigger root strand and higher root-shoot biomass ratio than CF and RS treatments. EM application also delayed leaf senescence at crop maturity. These growth characteristics are pre-conditions of a successful ratoon crop establishment (Cuevas-Perez, 1980; Samson, 1980). However Xu et al. (1998) and Yamada et al. (1998) mentioned that most of these effects are the result of the activity of beneficial soil microorganisms.

Table 1. Number of Tillers of the Main and Ratoon Crop at Harvest

Treatment	Main Crop Tillers (hill^{-1})	Ratoon Crop Tillers (hill^{-1})		
		5 cm	10 cm	15 cm
RS	3.0 c	1.0 B	3.9 b	4.7 b
CF	8.3 b	4.2 a	7.3 ab	8.7 a
RS + EM50	10.7 a	4.4 a	8.3 a	9.1 a
RS + EM100	10.0 ab	5.2 a	7.9 a	9.1 a
RS + EM250	11.3 a	3.9 a	8.2 a	10.8 a
RS+EM 500	8.7 b	4.4 a	8.2 a	10.0 a

Means followed by the same letter are not significantly different at 5% level using DMRT.

As shown in Table 2, the yield of EM was comparable with CF treatment and significantly higher than RS treatment in the main and ratoon crops. The yield in EM treatments was 46 to 59% higher than RS treatment in the main crop and 58 to 85% in the ratoon crop. The result indicated that EM inoculation can improve the efficiency of rice straw and can sustain yield levels comparable with chemical fertilizers. This obtained result was in consonance with the findings of Xu et al. (1998) on the effects of EM inoculation.

Table 2. Grain Yield of Main and Ratoon Rice Crops. Dry Weight

Treatment	Main Crop Yield (g box^{-1})	Ratoon Crop Yield (g box^{-1})		
		5 cm	10 cm	15 cm
RS	70.03 b	18.0 c	72.0 b	66.9 d
CF	152.07 a	48.0 b	204.3 a	129.9 c
RS + EM50	154.12 a	61.8 b	206.1 a	162.0 c
RS + EM100	169.08 a	50.4 b	237.6 a	183.6 ab
RS + EM250	167.09 a	118.8 a	222.9 a	204.0 a
RS+EM 500	130.69 ab	112.5 a	225.5 a	166.5 abc

Means followed by the same letter are not significantly different at 5% level using DMRT.

The effects of EM rates on soil properties, and growth and yield of rice in both the main crop and the ratoon crop were comparable, more stable results were noted in 100 and 250 l ha^{-1} rates. Ratoon crops from 10 or 15 cm stubble cutting height had better performance than 5 cm cutting height. The yield obtained from 10 and 15 cm cutting height were not statistically different, but 10 cm cutting height had better grain quality.

Conclusions

The results of the study showed that microbial inoculation increased the population and diversity of soil organisms. The increase in soil biota enhanced the decomposition of rice straw and also made the soil surface soft which facilitated the incorporation process of rice straw. Microbial inoculation enhanced the efficiency of rice straw by sustaining better nutrient status and improving the soil tilth, which enhance better growth and development of rice. The utilization of rice straw and microbial inoculant also sustained yield levels comparable with chemical fertilizer.

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