Nature Farming Research in Myanmar: Effect of Organic Amendments and EM on Rice Production

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Abstract
The effects of organic amendments, Effective Microorganisms (EM) and chemical fertilizers on consecutive rice plantings were studied in 1991. The use of *Sesbania rostrata* as a green manure was a promising substitute for nitrogen fertilizer in rice production. Rice straw treatments produced significantly lower yields than those of chemical fertilizers because of microbial immobilization of inorganic soil nitrogen. However, experimental results suggested that addition of EM enhanced the decomposition of rice straw and minimized the immobilization of soil nitrogen. Hence, EM provided a potential advantage for ensuring the availability of soil nitrogen for the rice crop when it was added to soil amended with locally-available organic matter such as comparatively low-cost rice straw.

Introduction

In recent years, conventional chemical farming practices, which substantially increased crop yields, have created numerous problems for mankind. Groundwater pollution is considered a result of chemical farming practices. Adverse human and animal health effects are caused by residual and cumulative agricultural chemicals used for crop protection. Excessive soil erosion caused by conventional farming systems has seriously reduced soil fertility and crop productivity. Also, higher costs of agricultural chemicals will significantly lower the net cash returns to farmers. The fundamental problems of conventional chemical agriculture have motivated agriculturists worldwide to seek alternative methods of farming (Parr and Hornick, 1991).

Among the alternative farming practices that have emerged in recent years, Kyusei Nature Farming appears to be one of the most promising methods for overcoming problems of conventional chemical farming. In this farming method, Effective Microorganisms (EM), including photosynthetic bacteria, actinomycetes, yeasts, and lactic acid bacteria, are applied to the soil as mixed cultures to enhance the availability of soil nutrients, increase humus formation, suppress weeds, and control plant diseases and pathogens (Higa, 1989; Sangakhara, 1991).

Although the use of synthetic chemicals such as fertilizers and pesticides have been well established in Myanmar agriculture, the actual quantities being used are far lower than the recommended optimum levels. Consequently, it is noteworthy that there have been few if any adverse effects on natural ecosystems or serious environmental pollution from excessive use of such synthetic chemicals.

However, under the changing socioeconomic conditions, i.e., increasing costs of agricultural chemicals, fuel, and labor, local farmers have had extreme difficulty in sustaining agricultural production as well as in deriving a net profit for themselves. Hence, the formulation and adoption of low-input technologies to achieve sustainability, not only in production but also in profitability, have become an important consideration in today's agriculture. Therefore, it was decided to study 1) the effect of organic amendments and effective microorganisms (EM) on crop production, and 2) the feasibility and adaptability of Kyusei Nature Farming or EM Nature Farming systems under the agroclimatic and environmental conditions of the Union of Myanmar.

Accordingly, during the 1990 growing season, an experiment was conducted using a split-plot design with 2 levels of main-plot and 4 levels of subplot treatments, replicated 4 times. Paddy rice was the test crop. The experimental data obtained from the 1990 growing season were statistically analyzed and presented at the Second International Conference on Kyusei Nature Farming that was held in Brazil in 1991 (Myint, 1994). As indicated at that conference, it was decided to repeat the experiment during the 1991 growing season using the same experimental design and test crop in

order to study the long-term effect of EM technology on consecutive crops. Accordingly, the following experiment was conducted from June to December 1991 at the same sites as in 1990.
The principal objectives of the research reported in this paper were: 1) to determine the long-term effect of organic amendments and EM on consecutive rice crops; 2) to assess the feasibility and adaptability of Kyusei Nature Farming or EM Nature Farming systems under the regional conditions of the Union of Myanmar; and 3) to formulate an agricultural system which would be economically and environmentally beneficial to local farmers.

Materials and Methods

This experiment was conducted in 1991 at the Institute of Agriculture, Yezin, 140 kilometers north of Yangon in the Union of Myanmar. The area has two distinct seasons: a dry season which occurs from October to April followed by a wet season. During the dry season there is a cold period from December to February after which the temperature tends to increase.
The soil type is a black Vertisol, generally containing about 40 percent clay; it is plastic, sticky when wet, and very hard when dry. Analytical data for the experimental soils are presented in Table 1. The test crop was paddy rice, locally known as "Manawthukha" variety; its original name is Mashuri M. This variety supposedly originated in Malaysia. It is a semi-dwarf type with a plant height of less than 110 cm, and it has a droopy panicle axis.

Table 1. Soil Properties for the Three Experimental Conditions.

Soil Proparties	Experimental Condition		
	Pot	Microplot	Field
pH	5.8	6.8	5.3
Organic carbon (%)	0.98	1.22	0.78
Total nitrogen (%)	0.07	0.12	0.08
Cation exchange capacity (meq/100g)	8.7	9.8	10.1
Available P_2O_5 (kg/ha)	14.0	34.9	36.9
Exchange potassium (meq/100g)	0.3	0.2	0.2
Exchange calcium (meq/100g)	5.9	7.7	5.4
Exchange magnesium (meq/100g)	2.1	2.2	2.2

The experiment was a split-plot design. The main-plot treatments were 2 levels of EM: treatment E1 with EM, and treatment E2 without EM. The subplot treatments included: treatment T1, control; treatment T2, recommended fertilizer practice; treatment T3, organic amendment (OM-1); and treatment T4, organic amendment (OM-2). The experiment was replicated four times to minimize the standard error.
For the main plot treatment E1, the EM 4 suspensions of effective microorganisms were diluted 1: 1000 and then applied 5 different times at a rate of 10 liters per hectare as follows;

1st application- incorporated into the soil 2 weeks before transplanting;
2nd application- sprayed onto the soil and plants 2 weeks after transplanting;
3rd application- sprayed onto the soil and plants 3 weeks after transplanting;
4th application- sprayed onto the soil and plants 4 weeks after transplanting;
5th application- sprayed onto the soil and plants 6 weeks after transplanting.

EM suspensions were not applied to treatment E2.
For treatment T1, no fertilizer and no organic amendments were applied. For treatment T2, urea fertilizer was applied at the rate of 40 kg N per hectare in a split-plot design; two-thirds of the total N was applied as a basal treatment prior to transplanting, and the remaining one-third was applied at the panicle initiation stage. Triple superphosphate was applied at the rate of 30 kg P_20_5 per hectare as a single basal treatment. For treatment T3, rice straw (OM-1) with a C:N ratio of 72:1 was applied at the rate of 10 tons per hectare as one of the organic amendments. For treatment T4, 60-day old green manure, *Sesbania rostrata*, (OM-2) was applied at the rate of 10 tons (fresh weight) per hectare. *Sesbania rostrata* at this stage of growth has a C:N ratio of 12:1. *Sesbania*

rostrata is a stem nodulating West African species which grows well in standing water.

The experiments were conducted simultaneously under the following conditions: 1) pots in a screen-house; 2) microplots in cement tanks; and 3) field plots at the University Farm.

Pot Experiment

Five kg of soil was placed into each of thirty-two glazed earthenware pots with a diameter of 23 cm and a height of 30 cm.

Microplot Experiment

Thirty-two cement tanks, each having a surface area of one square meter and a height of 25 cm, were filled with soil; 30-day old rice seedlings were transplanted with a spacing of 20 cm between rows and 15 cm between hills.

Field Experiment

At the University Farm, the plot size was 6 by 3 meters, with a total area of 18 square meters. The 30-day old rice seedlings were transplanted with a spacing of 20 cm between rows and 15 cm between hills. Each plot consisted of 600 hills.

Several yield components of rice were used to study the effect of main-plot and subplot treatments on growth and yield in 1991. They were:

- a) plant height at 30 days after transplanting (DAT),
- b) plant height at 45 DAT,
- c) plant height at 60 DAT,
- d) number of effective tillers per hill,
- e) grain yield,
- f) straw yield,
- g) biomass yield, and
- h) panicle length.

The variance between the means of treatment data were statistically analyzed using an analysis of variance (ANOVA) procedure. The range of the means for the treatments were also tested using Duncan's Multiple Range Test (DMRT).

Results and Discussion

Pot Experiment

Plant Height at 45 Days after Transplanting. Analysis of variance indicated that there was a statistically significant difference between the mean plant heights related to the subplot treatments at the 1% level (Table 2 and Table 17). The effect of the subplot treatments on plant height were in the order of: fertilizer ≧ rice straw ≧ green manure ≧ control. The DMRT test indicated that the height of plants with the green manure and the rice straw treatments were comparable to that of the fertilizer treated plants.

Table 2. Effect of Chemical Fertilizer, Organic Amendments and Effective Microorganisms on Rice Plant Height at 45 Days after Transplanting (Pot Experiment).

Treatment	With EM (cm)	Without EM (cm)	Difference	EM Effect (%)
Control	53.0	51.0	2.0	3.9
Fertilizer	64.1	67.6	-3.5	-5.2
Rice straw	64.5	59.6	4.9	8.2
Green manure	59.1	62.2	-3.1	-5.0

A positive effect of EM on plant height at 45 DAT was observed when the soil was amended with rice straw (8.2 percent increase) while a negative effect of EM on plant height was observed when the soil was amended with green manure or fertilizer (Table 2).

Plant Height at 60 Days after Transplanting. The trends for effectiveness of main-plot and subplot treatments on plant height at 60 DAT were similar to those at 45 DAT (Table 17). Effect of EM on plant height when the soil was amended with rice straw was found to be positive; the effect of EM was small or negative when the soil was treated with fertilizer or green manure (Table 3).

Table 3. Effect of Chemical Fertilizer, Organic Amendments and Effective Microorganisms on Rice Plant Height at 60 Days after Transplanting (Pot Experiment).

Treatment	With EM (cm)	Without EM (cm)	Difference	EM Effect (%)
Control	57.0	57.0	0	0
Fertilizer	67.5	67.0	0.5	0.75
Rice straw	67.0	62.4	4.6	7.37
Green manure	69.0	71.5	-2.5	-3.5

The inhibition of nitrogen fixation by microorganisms in EM 4 under high N conditions may have contributed to the negative effects of EM. Observations on the negative effect of EM in the presence of fertilizer N has been reported (Hussain et al., 1992; Myint, 199la,b; Sharifuddin et al., 1992). The apparent inhibition of certain microorganisms to fix N when adequate amounts of soil N are available has also been reported (Gray and Williams, 1971).

Effective Tiller Numbers. Table 17 indicates that there is a significant difference between the effective tiller numbers of the subplot treatments at the 1% level of probability. The effect of treatment on effective tiller numbers is in the order of: green manure > fertilizer > rice straw = control.

EM was found to have a positive effect on rice tiller numbers at 60 DAT in all the subplot treatments except for the control plots. Results indicate that a readily available supply of soil organic matter for soil microorganisms may, indeed, enhance the beneficial effects of EM (Table 4).

Table 4. Effect of Chemical Fertilizer, Organic Amendments and Effective Microorganisms on Rice Tiller Numbers (Pot Experiment).

Treatment	With EM (No./hill)	Without EM (No./hill)	Difference	EM Effect (%)
Control	11.8	12.2	-0.4	-3.3
Fertilizer	16.8	15.0	1.8	12.0
Rice straw	12.5	11.8	0.7	5.9
Green manure	18.0	17.8	0.2	1.1

Grain Yield Per Hill. Table 17 indicates that there is a significant difference between the mean grain yield/hill of the subplot treatments at the 1 % level of probability. The effect of the subplot treatments is in the order of: green manure > fertilizer = rice straw > control. Results (Table 5) indicate that the fertilizer treatment provided significantly greater yields than rice straw alone. This is not surprising since it is known that crop residues with high C:N ratios can readily cause microbial immobilization of inorganic soil N. However, EM added to rice straw resulted in a grain yield which was equivalent to that of the fertilizer treatment. This suggests that EM enhanced the decomposition of rice straw and the mineralization of organic N which, in turn, minimized the immobilization of soil N.

Table 5. Effect of Chemical Fertilizer, Organic Amendments and Effective Microorganisms on Rice Grain Yield (Pot Experiment).

Treatment	With EM (g/hill)	Without EM (g/hill)	Difference	EM Effect (%)
Control	19.5	17.5	2.0	11.4
Fertilizer	29.2	26.9	2.3	8.5
Rice straw	29.3	20.7	8.6	41.5
Green manure	37.7	35.3	2.4	6.8

Straw Yield Per Hill. The differences between the subplot treatments on mean straw yield was highly significant at the 1 % level (Table 17). The effect of EM on the mean straw yield/hill was positive in all cases (Table 6). It is interesting to note that percentage increase in straw yield with the addition of EM was much greater for the control and rice straw treatments than for the fertilizer and green manure treatments.

Table 6. Effect of Chemical Fertilizer, Organic Amendments and Effective Microorganisms on Rice Straw Yield (Pot Experiment).

Treatment	With EM (g/hill)	Without EM (g/hill)	Difference	EM Effect (%)
Control	27.0	21.4	5.6	26.2
Fertilizer	29.7	28.7	1.0	3.5
Rice straw	23.9	21.1	2.8	13.3
Green manure	26.8	26.3	0.5	1.9

Biomass Yield Per Hill. Table 17 indicates that there are significant differences between the mean biomass (yield/hill) for subplot treatments at the 1 % level. The effect of subplot treatment on biomass is in the order of: green manure > fertilizer > rice straw > control. The effect of EM on biomass yield was positive in all cases. Among the subplot treatments, EM had a greater effect on increasing biomass yield when the soil was amended with rice straw compared with other subplot treatments (Table 7).

Table 7. Effect of Chemical Fertilizer, Organic Amendments and Effective Microorganisms on Rice Biomass Yield (Pot Experiment).

Treatment	With EM (g/hill)	Without EM (g/hill)	Difference	EM Effect (%)
Control	46.5	39.0	7.5	19.2
Fertilizer	59.0	55.6	3.4	6.1
Rice straw	53.4	41.8	11.6	27.7
Green manure	64.4	61.6	2.8	4.5

Panicle Length. Table 17 indicates that there are significant differences between the mean panicle length of the four subplot treatments at the 1 % level. Table 8 shows that EM applied in combination with either chemical fertilizer or organic residue amendments, has a positive effect on the length of the panicle.

Table 8. Effect of Chemical Fertilizer, Organic Amendments and Effective Microorganisms on Rice Panicle Length (Pot Experiment).

Treatment	With EM (cm)	Without EM (cm)	Difference	EM Effect (%)
Control	15.4	15.3	0.1	0.6
Fertilizer	16.2	15.9	0.3	1.9
Rice straw	17.8	17.2	0.6	3.5
Green manure	17.4	17.2	0.2	1.2

Microplot Experiment

The analysis of variance revealed that the differences between the effects of the subplot treatments on the yield components of paddy rice were statistically significant either at the 5% level or 1 % level of probability. The data are summarized in Table 17.

The effects of EM on growth parameters are shown in Tables 9 through 15. The effect of green manure, *Sesbania rostrata,* on the treatment means of yield components of paddy rice was similar to or, in some cases, even greater than those of plots treated with the recommended level of chemical fertilizer. Visual observations indicated that the EM-treated plants grew better than those which did not receive EM. EM-treated plants were more vigorous, and the leaves had a darker green color than plants without EM. A high incidence of crop lodging at the harvest stage was observed fur plants without EM, while plants treated with EM showed no sign of lodging throughout the experimental period.

Table 9. Effect of Chemical Fertilizer, Organic Amendments and Effective Microorganisms on Rice Plant Height at 30 Days after Transplanting (Microplot Experiment).

Treatment	With EM (cm)	Without EM (cm)	Difference	EM Effect (%)
Control	48.7	45.4	3.3	7.3
Fertilizer	49.7	48.6	1.1	2.3
Rice straw	48.7	43.1	1.9	13.0
Green manure	51.5	49.6	1.9	3.8

Table 10. Effect of Chemical Fertilizer, Organic Amendments and Effective Microorganisms on Rice Plant Height at 45 Days after Transplanting (Microplot Experiment).

Treatment	With EM (cm)	Without EM (cm)	Difference	EM Effect (%)
Control	53.2	50.5	2.7	5.3
Fertilizer	58.5	55.4	3.1	5.6
Rice straw	54.4	49.8	4.6	9.2
Green manure	56.2	55.0	1.2	2.2

Table 11. Effect of Chemical Fertilizer, Organic Amendments and Effective Microorganisms on Rice Plant Height at 60 Days after Transplanting (Microplot Experiment).

Treatment	With EM (cm)	Without EM (cm)	Difference	EM Effect (%)
Control	59.4	56.1	3.3	5.9
Fertilizer	64.9	63.6	1.3	2.0
Rice straw	61.4	55.7	5.7	10.2
Green manure	61.4	60.3	1.1	1.8

Table 12. Effect of Chemical Fertilizer, Organic Amendments and Effective Microorganisms on Rice Tiller Numbers (Microplot Experiment).

Treatment	With EM (No./hill)	Without EM (No./hill)	Difference	EM Effect (%)
Control	9.7	9.5	0.2	2.1
Fertilizer	10.9	11.7	-0.8	-6.8
Rice straw	10.2	9.3	0.9	9.7
Green manure	10.4	10.0	0.2	2.0

Table 13. Effect of Chemical Fertilizer, Organic Amendments and Effective Microorganisms on Rice Grain Yield (Microplot Experiment).

Treatment	With EM (g/hill)	Without EM (g/hill)	Difference	EM Effect (%)
Control	19.8	17.9	1.9	10.6
Fertilizer	22.2	23.7	-1.5	-6.3
Rice straw	20.0	17.1	2.9	17.0
Green manure	21.4	20.2	1.2	5.9

Table 14. Effect of Chemical Fertilizer, Organic Amendments and Effective Microorganisms on Rice Straw Yield (Microplot Experiment).

Treatment	With EM (g/hill)	Without EM (g/hill)	Difference	EM Effect (%)
Control	16.4	14.7	1.7	11.6
Fertilizer	19.1	18.2	0.9	4.9
Rice straw	16.4	14.5	1.9	13.1
Green manure	17.1	17.7	-0.6	-3.4

Table 15. Effect of Chemical Fertilizer, Organic Amendments and Effective Microorganisms on Rice Biomass Yield (Microplot Experiment).

Treatment	With EM (g/hill)	Without EM (g/hill)	Difference	EM Effect (%)
Control	36.2	32.6	3.6	11.0
Fertilizer	41.4	41.8	-0.4	-1.0
Rice straw	36.4	31.6	4.8	15.2
Green manure	38.5	38.0	0.5	1.3

Table 16. Effect of Effective Microorganisms (EM) on Yield Components of Paddy Rice in 1991.

Yield Component	Average of Subplot Treatments		Difference
	With EM	Without EM	
Pot Experiment			
Plant height at 45 DAT (cm)	60.2	60.1	0.1
Plant height at 60 DAT (cm)	65.1	64.5	0.6
Effective tillers (No./hill)	14.8	14.2	0.6
Grain yield (g/hill)	28.9	25.1	3.8
Straw yield (g/hill)	26.8	24.4	2.4
Biomass yield (g/hill)	55.8	49.5	6.3
Panicle length (cm)	16.7	16.4	0.3
Microplot Experiment			
Plant height at 30 DAT (cm)	49.6	46.7	2.9
Plant height at 45 DAT (cm)	55.6	52.7	2.9
Plant height at 60 DAT (cm)	61.8	58.9	2.9
Effective tillers (No./hill)	10.3	10.1	0.2
Grain yield (g/hill)	20.8	19.7	1.1
Straw yield (g/hill)	17.2	16.3	0.9
Biomass yield (g/hill)	38.1	36.0	2.1
Grain yield (g/m^2)	667.8	31.2	36.6
Straw yield (g/m^2)	552.1	520.0	32.1
Biomass yield (g/m^2)	1219.8	151.2	68.6

Table 17. Effect of Amendments on Yield Components of Paddy Rice in 1991.

Yield Component	Average of Main-plot Treatments				Significance: F-test Probability
	T1	T2	T3	T4	
Pot Experiment					
Plant height at 45 DAT (cm)	52b	65.9a	62.1a	60.7a	**(1%)
Plant height at 60 DAT (cm)	57c	67.2ab	64.7b	70.2a	**(1%)
Effective tillers (No./hill)	12c	15.9b	12.1c	17.9a	**(1%)
Grain yield (g/hill)	18.5c	28.1b	25b	36.5a	**(1%)
Straw yield (g/hill)	24.2bc	29.2a	22.5c	26.5ab	**(1%)
Biomass yield (g/hill)	42.7d	57.2b	47.6c	63a	**(1%)
Panicle length (cm)	15.4c	16b	17.5a	17.3a	**(1%)
Microplot Experiment					
Plant height at 30 DAT (cm)	47bc	49.2ab	45.9c	50.5a	*(5%)
Plant height at 45 DAT (cm)	51.8b	57a	52.1b	55.6a	**(1%)
Plant height at 60 DAT (cm)	57.8b	64.2a	58.6b	60.8ab	*(5%)
Effective tillers (No./hill)	9.6b	11.3a	9.7b	10.2b	**(1%)
Grain yield (g/hill)	18.9b	23a	18.6b	20.8ab	**(1%)
Straw yield (g/hill)	15.5b	18.6a	15.4b	17.4ab	**(1%)
Biomass yield (g/hill)	34.4b	41.6a	34b	38.2ab	**(1%)
Grain yield (g/m^2)	603.3b	734.8a	594b	665.6ab	**(1%)
Straw yield (g/m^2)	497.2b	596.5a	493.3b	557.2ab	**(1%)
Biomass yield (g/m^2)	1100.8b	1331.2a	1087.2b	1222.8ab	**(1%)

Treatments: T1, control; T2, fertilizer; T3, rice straw; T4, green manure.
Mean values on a line followed by a common letter are not significantly different at the 5% level by DMRT.

Table 18. Effect of Chemical Fertilizer, Organic Amendments and Effective Microorganisms on Rice Plant Height at 45 Days after Transplanting for 1990 and 1991.

Treatment	With EM (cm)	Without EM (cm)	Difference
Control	59.3a	57.7b	1.6ns
Fertilizer	61.4a	59.6b	1.8ns
Rice straw	59.8a	54.7c	5.1**
Green manure	61.6a	62.3a	-0.7ns

Column means sharing a common letter are not significantly different at the 5% level by DMRT.
** = significant at 1% level, ns = not significant.

The difference in crop performance of EM-treated and untreated main-plots were more visible at an early stage of growth (i.e., vegetative stage) than at the later stage (i.e., reproductive stage). The results show that the positive effects of EM on all yield components are consistent (Table 16). An analysis of variance for grain yield (g/hill) for the second consecutive rice crop grown on the same plots indicated that the difference in the mean grain yield for EM-treated and untreated plots was statistically significant at the 5% level. A positive effect of EM on crop production was clearly beginning to take effect with the second cropping season. The effectiveness of EM on crop production in subsequent years has also been reported (Chowdhury et al., 1992; Higa, 1989; Hussain et al., 1992; Panchaban, 1991).

The combined analysis for two successive years (1990 and 1991) show that differences for plant height at 45 DAT were not only statistically significant for the subplot treatments but also the interactions were statistically significant between the main-plot and subplot treatments

When the experimental data were further tested, the results indicated that the differences in mean plant height of rice at 45 DAT between the EM-treated and untreated plots were statistically different at the 1 % level when the soil was amended with rice straw. The effect of EM on plant height was not significant for the control or for soil amended with fertilizer and green manure (*Sesbania rostrata*) (Table 18).

Field Experiment

Results from the field experiment were erratic because of several uncontrollable factors, for example, soil heterogeneity, non-uniformity of soil moisture, and plant destruction by birds and rodents. The experimental site has a serious soil heterogeneity problem. Leveling the soil during the preparation stage reduced the slope, but may have exacerbated the heterogeneity problem. Because of the slope and a poor irrigation system, attempts to maintain uniform moisture levels throughout the experimental site were not always successful. Birds and rodents were a very serious problem. Because the neighboring paddy fields were harvested about 2 to 3 weeks earlier than usual, pests (birds and rodents) from all over the farm destroyed more than 50 percent of the crop on the experimental plots which made the results even more erratic. Despite these differences, however, the performance of EM-treated plants were generally better than those of untreated plants.

Summary and Conclusions

The following conclusions can be drawn from the data:

1. Subplot treatments had significantly different effects on yield components of paddy rice.
2. Application of green manure (*Sesbania rostrata*) at a rate of 10 tons per hectare was equally effective as chemical fertilizer applied at the currently recommended rate of 40 kg N and 30 kg P_20_5 per hectare.
3. The addition of *Sesbania rostrata* as a green manure at least two months prior to planting of the cash crop (paddy rice) may not be acceptable to local farmers because of the extra work involved. It is also essential to maintain soil moisture at a proper level to grow the green manure crop successfully; this may be difficult in rainfed areas. Sometimes land may not be available to grow a green manure crop if the farmer is already double or triple cropping in a single year.

4. Visual observations show that the use of Effective Microorganisms (EM) improved crop growth of paddy rice particularly at the vegetative stage. The effect of EM was positive for all observations made for the three experiments conducted in 1991
5. Grain yield with the EM treatment was significantly greater than without EM in 1991. It is important to note that treatment differences were not statistically significant for the first year crop (harvested in 1990). This indicated that the effect of EM on grain yield was gradual over time.
6. It was observed that the positive effects of EM on yield components of rice were more pronounced when the soil was amended with rice straw. However, slightly positive or negative effects of EM on several yield components were observed when the soil was treated with fertilizer or green manure; the nitrogen fixing capacity of microorganisms in the EM 4 inoculant may have been suppressed by high soil N levels.
7. Visual observations indicated that rice plants grown in soils amended with rice straw were darker green at harvest than plants grown in soil amended with chemical fertilizer. This may indicate that N became available at a later stage of growth because of a slow rate of straw decomposition.
8. The EM-treated rice plants had an earlier floral initiation and seed maturity than the untreated plants. This suggests that the N immobilization effect of rice straw (high C:N ratio) on the crop was minimized by the activity of EM.
9. Results indicated that the fertilizer treatment provided significantly higher yields than rice straw applied alone. This was not surprising since it is well known that crop residues with high C:N ratios can readily cause microbial immobilization of inorganic soil N. However, when EM was added to the rice straw, grain yield was equivalent to that of the fertilizer treatment. This suggests that EM enhanced the decomposition of rice straw and possibly minimized immobilization of soil N. Since rice straw is in abundance in Myanmar and is available at a comparatively low cost, EM might provide a potential advantage to ensure that soil N remains available for the rice crop, even to the harvest stage.

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