Effect of EM on the Growth and Yield of Rice and Beans

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Abstract

Compacted soils and weeds are often serious problems in agriculture. Upland rice soil was treated with 440 ml ha^{-1} of EM. After treatment, weed seeds geminated uniformly and were harrowed into the soil as a green manure; the fields remained free of weeds until harvest. Rice survived a six-week dry period and the yield was 261 percent more than the yield from herbicide-treated rice that suffered from drought. A second experiment utilizing beans was conducted with two levels of organic matter (OM), i.e., 7 and 14 Mg ha^{-1} and six levels of EM ranging from 0.4 to 8.8 liters ha^{-1}. Bean yields on plots that received 7Mg ha^{-1} of OM decreased with increased levels of EM. At the highest rate of EM (8.8 liters ha^{-1}), the bean yield was 28 percent lower for the 7Mg ha^{-1} OM level compared with the 14 Mg ha^{-1} OM level. The highest bean level was obtained with 14 Mg ha^{-1} of OM and 1.1 liters ha^{-1} of EM, which was 126 percent more than with 7Mg ha^{-1} of OM and the same rate of EM. Soil chemical and physical analyses confirmed this trend. The data seem to indicate that there is a specific ratio between EM and OM to achieve optimum results. Under tropical conditions, the ratio appears to be about 80 to 100 ml $EMMg^{-1}$ of OM. When EM was applied to the leaves before 9:00 a.m., bean yields increased 12. 8 percent over the control.

Introduction

Herbicides work best when soils have very low levels of organic matter (OM) (Herwig, 1977); high levels of OM may diminish the effect of herbicides. Thus, to achieve optimum results from the use of herbicides, organic residues at the soil surface are often burned. However, burning of residues, especially with low levels of OM, may result in a decrease in soil porosity, particularly the macropores (Basselman, 1971; Primavesi, 1990). This, in turn may lower the soil's productivity potential. Moreover, a significant decrease in soil porosity can slow infiltration of rainfall, accelerate runoff, and increase soil erosion and flooding. According to Larson and Allmaras (1971) poor water infiltration is often associated with poor aeration and retarded root development. As a result, plant metabolism slows down, nutrients are partially reduced and frequently become phytotoxic (i.e., SO_3^{-2} changes to H_2S or Mn^{+3} changes to Mn^{+2}) and plants absorb less of these reduced nutrients (Hallsworth and Crawford, 1965; Mengel and Kirkby, 1978).

Upland rice has to be kept weed free in order to produce good yields. In larger areas mechanical weeding becomes impracticable because it requires supplementary manual weeding within the rice rows. Consequently, the use of herbicides has become the main method for weed control in rice.

Weed control with EM appears to be a potential solution for the problem since EM responds best with high levels of soil organic matter, a situation that also helps farmers to maintain the productivity of their soils (Higa, 1991).

Materials and Methods

Experiment I

Experiment I compared the yield of rice from plots of 3 x 10 m with three applications of EM. At the same time, larger areas were planted with the following treatments:

1. Mechanical weeding.
2. Propanil herbicide applied at the rate of 10 liters ha^{-1} (4.0 liters ha^{-1} of active ingredient).
3 Soil treated with EM at a rate of 440 ml ha^{-1}

Before sowing, all rice seeds were treated with a solution of 1 % copper sulphate; the rice field received 3 kg ha^{-1} copper sulphate on the soil to prevent blast (*Piricularia oryzae*) (Primavesi et al., 1971). The variety IAC 164 was planted on December 31, much later than the recommended date because a very dry spring did not allow a successful EM treatment.

Weeds were mechanically removed four times for treatment 1. For treatment 2, propanil, a post-emergence herbicide, was sprayed when the principal weed (*Brachiaria plantginea*) was forming its 3rd and 4th leaves. Attempts were made to keep the herbicide from rice leaves; however, some contact was made and some leaves yellowed but then recovered about 8 days later. Only after three consecutive rainy days was there a massive emergence of weeds. In 10 days the weeds were 40 to 50 cm high and were then harrowed into the soil as a green manure. The plots were planted immediately.

When the experiment was repeated one year later, it was found that tropical weeds begin growth only during their normal germination period. EM did not stimulate an earlier emergence. In temperate climates where there is only one growing period, this problem does not exist.

Experiment II

Two levels of OM (7 and 14 Mg ha^{-1}) and 6 levels of EM (0, 0.4, 1.1, 2.2, 4.4 and 8.8 liters ha^{-1}) were used. Plots were 2 x 5 m (10 m^2) with 1.5 m between plots to avoid possible EM interference on adjacent plots. The "Carioquinha" bean variety was planted in four rows with 40 cm between rows. The 7 kg/plot OM level received only the stubble, stalks and roots of a corn crop. The 14 kg/plot OM level received an additional 7 kg of corn residue (stover and cobs). EM was applied to the OM which was then harrowed into the soil.

Weeds did not emerge where organic residues were applied. Weed populations were generally low in other plots because it was early in the season. The plots were harrowed again, treated with Fosmag (Ca 13%, P 13%, Mg 2%, S 8% and Zn 0.5%) at 200 kg ha^{-1} and then planted to beans.

Results and Discussion

Experiment I

Rice in the EM-treated plots ripened uniformly; each head had 240 to 290 spikelets and only 5 percent of the spikelets were sterile because of drought. The herbicide-treated rice suffered severely from the drought; it ripened unevenly and the heads had only 68 to 92 spikelets and 17 percent of them were sterile. According to the Brazilian Enterprise of Agricultural Research (EMBRAPA) hormones and auxins found in green manure can stimulate plant growth (EMBRAPA, 1992). Rice grown on EM-treated soil was not damaged during a four-week dry period because the soil was well-structured. The EM-treated plots yielded 126 percent more than the herbicide-treated plots.

Based on the research results, relevant questions are: How can such a small amount of EM (0.4 liter ha^{-1}) have such a large effect ? Why didn't the use of EM in the two following years improve the soil as shown by its physical and chemical analyses?

Conventional agriculture with residue burning and deep plowing during a very dry year actually loosened the soil to a greater extent than a 2-year EM regime (Table 1). On the other hand, soil improvement during the first year of EM application was rather dramatic as indicated by reduced compaction to a depth of 15 cm and increased soil porosity (Table 2). The data shows that soil porosity decreased as bulk density increased. During the second year, a hard soil layer developed at the 15-cm depth. As shown in Table 3, the analysis of soil chemical properties associated with various treatments did not indicate significant differences. The effects of lime and fertilizer applications in the conventional agriculture treatment were not indicated by the analysis. The fallow and first year EM treatments were quite similar. In the second year of EM treatment, there was a slight decrease in phosphorus. Because greater differences had been expected, another experiment was conducted to verify these results.

Table 1. Effect of Conventional Agriculture, Fallow, and Two Years of EM Treatment on Soil Compaction.

Soil Depth (cm)	Conv.Agric. (kg/cm^{-2})	Fallow (kg/cm^{-2})	EM:Year 1 (kg/cm^{-2})	EM:Year 2 (kg/cm^{-2})
5	1.5	1.6	0.25	1.5
10	2	1.9	1	2.5
15	2	2.25	1.75	2.6
20	1.6	2.4	3.25	2.5
25	1.5	2.5	2.75	2.75

Soil compaction was measured at the depths indicated using a penetrometer.
Crop residues associated with treatments at time of penetrometer measurements were:

1. Conventional agriculture - corn
2. Fallow - none
3. EM:year 1 - rice
4. EM:year 2 - corn

Table 2. Effect of Two Years of EM Treatment on Soil Porosity, Bulk Density, and Particle Density.

EM	Depth (cm)	Macropores (%)	Micropores (%)	Total pores (%)	Bulk density ($g\ cm^{-3}$)	Particle density ($g\ cm^{-3}$)
Year1	10	22	13.2	35.2	1.44	2.22
	20	16.2	18.3	34.5	1.68	2.57
Year2	10	20	11.2	31.2	1.55	2.25
	15	15.7	14.8	30.5	1.88	2.7

Table 3. Effect of Conventional Agriculture, Fallow, and Two Years of EM Treatment on Soil Chemical Properties.

Treatment	pH ($CaCl_2$)	OM (%)	P ($\mu g\ dm^{-3}$)	K	Ca	Mg	H+Al	CEC	Base Sat. (%)
				($cmol_c\ Kg^{-1}$)					
Conv.Agric.	4	1.1	6	0.1	2.1	0.7	3.4	6.3	46
Fallow	5	1.6	34	0.16	3.3	1.3	2.5	7.3	66
EM:Year1	4.9	2.2	36	0.12	2.7	0.6	2.5	5.9	58
EM:Year2	4.6	1.7	14	0.16	2.6	0.8	2.8	6.4	56

Experiment II

On plots which received 7 kg of OM, increased amounts of EM resulted in slightly decreased bean yields. At the 8.8 liters ha^{-1} EM level, the bean yield was 28 percent lower for the 7 kg/plot OM level compared with OM applied at 14 kg/plot. Plots which received 14 kg of OM had average bean yields that were 70 percent higher than the control. However, the most effective application rate of EM in this study was 1.1 liters ha^{-1}. When this rate of EM was applied with the high level of OM (14 kg/plot), the bean yield was 126 percent greater than at the low OM level (7 kg/plot). In a field test with two foliar applications of EM at 0.05 percent, yields were 12 percent higher but only when EM was applied before 9:00 a.m. When EM was applied later in the day under full sunlight, negative effects appeared because of the lower leaf turgor and the very hot temperatures of the tropical climate.

Conclusions

The benefits of EM were optimized with application of a green manure from weed growth. This combination decreased soil compaction and bulk density, and increased soil porosity which, in turn, increased crop yields. The EM-treated fields remained weed-free. The proper use of EM requires adequate soil moisture which may delay planting when soil conditions are dry and there is no irrigation. The effective quantities of OM and EM may be distinctly proportional. For plots receiving OM at a rate of 14 Mg ha^{-1} it was necessary to apply 1.1 liters ha^{-1} of EM. This suggests that larger quantities of EM should be applied as the application rate of OM is increased. Under the tropical conditions of this study, the EM:OM ratio is about 80 to 100 ml of EM for each 1 Mg of OM added to the soil.

In less active soils under temperate climatic conditions, the EM:OM ratio may have to be increased to achieve the desired results (i.e., the amount of EM may have to be increased relative to the amount of OM applied). EM can significantly improve soil physical properties and crop yields provided that a sufficient amount of organic matter is added to the soil.

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