Seed Treatment With EM and Micronutrients for Controlling Rice and Maize Diseases

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Abstract

A study was conducted to determine whether seed treatment of rice and maize with Effective Microorganisms (EM) and micro nutrients could reduce the incidence of disease and parasite injury, and prevent nutrient imbalances after germination. Potassium and certain micro nutrient metals (e.g., copper, zinc and manganese) are essential activators of enzyme systems for the biosynthesis of organic compounds in plants. Foliar analysis of rice plants affected with blast (caused by the fungal pathogen *Piricularia oryzae* Cav.) showed low Cu and Mn levels proportional to nutrient ratios involving nitrogen (N: Cu), phosphorus (P:Mn), and iron (Fe:Mn). When Cu and Mn were applied to soil results were inconclusive. However, when seeds were treated directly with Cu and Mn, results were highly significant and no blast occurred. All treatments were applied with and without EM. The EM treatments increased rice yields significantly, and decreased the level of blast infestation but did not prevent it.

Maize plants without prior seed treatment were found to have a low Zn content and 20 percent of the seedlings were infested and destroyed by the stem borer *Elasmopalpus lignosellus*. Seeds treated with zinc sulfate ($ZnSO_4$) produced healthy seedlings and were not attacked by this pathogen. Another insect pest of maize is *Spodoptera frugiperda* the larvae of which destroys the tassel and main shoot of plants. Seed and soil treatment with boric acid (H_3BO_3) prevented infestation and injury by this pathogen.

When EM was applied to maize plants without Fosmag (a fertilizer containing P, Ca, Mg, S and Zn) there was no increase in yield. However, when EM was applied with Fosmag, maize yield increased significantly, especially when applied with Skrill (a micro nutrient fertilizer mixture). Results indicate that EM has its greatest effect in highly fertile soils that receive regular applications of organic amendments, and less so in marginal soils.

Introduction

Plant parasites and pathogens attack those plants that "offer" substances that these organisms can utilize in their growth and development (Galli et al., 1968). According to Chaboussou (1981), most of these substances are intermediate products because the necessary enzyme activators that would transform them to final products are lacking. Enzyme activators to catalyze such reactions are most often micro nutrient metals (Primavesi and Primavesi, 1964, 1965, 1967; Bussler, 1968; Trolldenier, 1968; Katalymov, 1969; Primavesi et al., 1971; Bergmann and Neubert, 1976; Primavesi, 1972, 1990, 1992, 1996).

Micro nutrient levels in soils may be a) deficient from repeated cropping without replenishment or b) unavailable to plants because of unfavorable soil chemical and physical properties such as extreme soil pH and compaction. Seeds of crop plants must contain adequate micro nutrient reserves to support germination and early seedling growth (Müller, 1972). If seeds contain inadequate levels of micro nutrients, then even if they are applied to soil later on and absorbed by the plant, they are not utilized efficiently and the plant does poorly.

This hypothesis was tested and confirmed in the classical experiments of Bakurdzhieva (1970) who reported that severe symptoms of molybdenum deficiency by cauliflower could not be corrected by either foliar or soil application of Mo, even though tissue analysis showed that high levels of Mo had been absorbed but not utilized by the plant. This is a strong indication that the uptake and efficient utilization of applied Mo depends on an adequate amount of Mo in the seed.

This paper reports the results of a field study to determine whether this hypothesis could be extended to seed treatment with EM and micro nutrients for control of rice and maize diseases and parasites.

Materials and Methods

Rice Experiment

The experimental area was divided into two blocks. The soil in Block 1 was treated with Effective Microorganisms (EM) at a rate of 1.1 liters ha^{-1} of stock solution to stimulate the germination and emergence of weed seeds. After the weed biomass had reached a height of 40 cm it was harrowed into the soil as a green manure. The field then remained weed-free until harvest of the rice crop. Block 2 was managed with mechanical weeding. Both blocks were fertilized with Fosmag at a rate of 150 kg ha^{-1}. Fosmag is a mixed fertilizer which contains 18% P_2O_5; 13% CaO; 3.5% MgO; 8.0% S and 0.6% ZnO. The following treatments were imposed over the two blocks in randomized, replicated 4 x 5 m plots:

- Controls ; Block 1 with EM and Block 2 without EM.
- $CuSO_4$ applied to soil at 2.5 kg ha^{-1}.
- $CuSO_4$ applied to seed (1% solution); $CuSO_4$ applied to soil at 2.5 kg ha^{-1}.
- $CuSO_4$ and $MnSO_4$ applied to seed (1% solution); $CuSO_4$ and $MnSO_4$ applied to soil at 2.5 kg ha^{-1} and 6.0 kg ha^{-1}, respectively.
- $MnSO_4$ applied to seed (1% solution); $MnSO_4$ applied to soil at 6.0 kg ha^{-1}.

Maize Experiment

The experimental area was treated with dolomitic limestone (containing 28% CaO and 19% MgO) at a rate of 1,000 kg ha^{-1}. Crop residue (straw and stubble) was applied uniformly at a rate of 12,000 kg ha^{-1}. The area was then divided into two blocks; the soil in Block 1 received no additional nutrients while Block 2 received 200 kg ha^{-1} of Fosmag. The following treatments were imposed over the two Blocks in randomized, replicated 3.2 x 5.0 m plots:

- Controls: Block 1 without Fosmag and Block 2 with Fosmag.
- EM stock solution applied to seed; EM diluted to 0.02% (1:5,000) and applied to soil and foliage 10, 20 and 30 days after emergence.
- Skrill (salts of desalinized sea water) applied to seed 6% solution; Skrill applied to soil and foliage (1.5% solution) 10, 20 and 30 days after emergence.
- EM and Skrill applied to seed and foliage.
- Boric acid applied to seed (0.03% solution); Boric acid applied to soil at 3.0 kg ha^{-1}
- $ZnSO_4$ applied to seed (0.03% solution); $ZnSO_4$ applied to soil at 5 kg ha^{-1}.

Counting of *Elasmopalpus* was performed 2 weeks after seedling emergence, and for *Spodoptera* 8 and 12 weeks after emergence.

Results and Discussion

Rice Experiment

Probably the most devastating disease of rice is blast (*Piricularia oryzae* Cav.), and there are no pesticides that can effectively control the disease. Extensive tissue analysis of healthy and blast-affected rice plants was not very revealing when comparing individual nutrients. However, when nutrient ratios were compared it showed a general imbalance of nutrients in the diseased plants, with especially low levels of copper and manganese (Table 1).

Table 1. Nutrient Ratios of Healthy and Blast-Affected Rice Plants.

Nutrient ratios	Healthy plants	Blast-affected plants
Ca:Mg	1.5	2.9
K:Ca	8.0	4.0
P:S	6.4	2.2
N:Cu	35.0	54.7
P:Mn	35.0	118.4
Fe:Mn	2.3	6.0

Counting the number of culms/plant, grains/head, and white heads showed early infestation of *Piricularia* as indicated by blast; late infestation was indicated by "rotten neck". All seeds were infected with *Piricularia* spores prior to planting. Seed and soil treatments with EM and micro nutrients increased rice yields and decreased the level of infestation by *Piricularia*. The non-EM control was highly infested with *Piricularia*, but the EM control less so because EM tended to suppress the disease. Rice yields were higher for all micro nutrient treatments due to EM. Copper applied to soil alone did not provide adequate control of the disease. However, Cu applied to both seed and soil gave good control. Disease control improved markedly when Cu + Mn was applied to seed and soil, which also resulted in the highest rice yields. Manganese alone applied to seed and soil was able to delay the infestation but could not effectively control the disease. Overall, rice yields due to EM were 26 to 47 percent higher for treatments in Block 1 (biological weeding) compared with Block 2 (mechanical weeding). Part of this can be attributed to the weed biomass that was incorporated as a green manure crop prior to planting. This provided a source of carbon and energy for the EM cultures which, in turn, helped to improve soil physical conditions for optimum plant growth.

Maize Experiment

Results of the maize experiment, in which Fosmag, EM, Skrill and several micro nutrients were applied to both seed and soil, showed that maize yields for all treatments were higher in Block 2 (with Fosmag) compared with Block 1 (without Fosmag). The higher yields also reflected a corresponding decrease in the incidence of *Spodoptera* and *Elasmopalpus*. The EM and EM + Skrill treatments in Block 2 were particularly effective in suppressing these diseases and resulted in maize yields that were 30 percent higher than for the other treatments. This is indicative of both the parasite-suppressive function of EM and it's ability to render beneficial effects on plant growth and yield (Higa, 1983). Boron alone in Block 2 provided reasonably good control of *Spodoptera*, while zinc alone had some suppressive effect on *Elasmopalpus*.

Economic Analysis of Ecological and Conventional Farming Systems for Maize

Table 2 presents an economic assessment of ecological and conventional farming systems for maize production which compares their various inputs, costs, yields and net returns. The ecological system is based on crop rotation, organic amendments, Fosmag, EM, Skrill and micro nutrient applications; however, the conventional system is based on heavy use of chemical fertilizers and pesticides for intensive cash crop production. While maize yields are somewhat lower for the ecological system, the input costs per hectare are almost 8 times higher for the conventional system ($399.10) compared with the ecological system ($51.33). Consequently, the net returns per hectare for the ecological farming system was $464.33 compared with $250.90 for the conventional system. The ecological system also ensures a higher level of soil quality and productivity, food safety and quality, and environmental protection.

Table 2. An Economic Comparison of Ecological and Conventional Farming Systems for Maize Production Based on Input Costs, Crop Yields and Net Returns per Hectare.

Ecological system		Conventional system	
Inputs	**Cost (US $)**	**Inputs**	**Cost (US $)**
200kg ha^{-1} Fosmag	36.00	2,000kg ha^{-1} NPK	334.00
150ml ha^{-1} EM	0.45	300kg ha^{-1} urea	54.50
7.5liters ha^{-1} Skrill	9.00	1 liter ha^{-1} herbicide	4.60
3kg ha^{-1} boric acid	1.98	0.2liter ha^{-1} pesticide	4.80
5kg ha^{-1} zink sulfate	3.50	1 liter ha^{-1} pesticide	1.20
Total cost	51.33	Total cost	399.10
Yield: 4,760kg ha^{-1}		Yield: 6,000kg ha^{-1}	
Yield value:	515.66	Yield value:	650.00
Net returns:	464.33	Net returns:	250.90

Conclusions

EM produced higher crop yields and effectively suppressed certain disease organisms in moderately fertile soils treated with organic amendments. However, EM was less effective on infertile, marginal soils. This study showed that some rice disease pathogens and maize parasites can be suppressed and controlled by treating micro nutrient deficiencies. Micro nutrients applied solely to the soil can have a low efficacy when crop seeds are deficient in these elements. However, when the seed was treated with the limiting micro nutrient, as well as the soil, an acceptable level of disease control was achieved.

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