# Effect of EM on the Growth and Yield of Crops

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## Abstract

Field and pot experiments were conducted during 1992-93 in Bangladesh to test the influence of Effective Microorganisms (EM) on growth and yield of onion, string bean and chili pepper. Soil amendments included chemical fertilizer (recommended levels of N-P-K), rice straw, and cow dung applied with or without EM. The yield of onion showed a statistically non-significant increase as a result of the EM application in combination with all of the soil amendments. The highest onion yield was obtained when EM was used in combination with cow dung and was greater than that produced by chemical fertilizer alone. EM increased leaf chlorophyll and yield of string bean significantly. The highest yield of chili peppers was obtained with EM but was not significantly different than the other soil amendments.

## Introduction

The Government of Bangladesh has been trying to narrow the chronic gap between the actual food requirement for the country and the amount of food produced. With introduction of chemical fertilizers, pesticides and high-yielding crop varieties in the 1960's, food production has kept up with the increase in population but without a reduction in the food supply deficit. Nevertheless, the shift from organic to chemical agriculture was reasonably successful. But the national average crop yields are still very low because the poorer/ smaller farmers often cannot afford to buy costly agrichemicals and because of the fear of contaminating the soil. Such situations lead to a continuing cycle of low yields, soil degradation, loss of soil fertility, and decline in productivity. Subsistence farmers are in need of appropriate low-input/sustainable farming and management practices that can help to overcome these barriers and constraints.

In some cases, soil productivity has started to decline as a result of chemical fertilizer use (Khadem, 1993) and the accompanying water pollution is resulting in fish diseases. Some of the special rice varieties are reportedly losing their characteristic flavor because of excessive fertilizer use (Anon., 1993), and hence, the cultivation of Kataribhog rice is threatened. Agricultural scientists and the Government of Bangladesh have become very concerned about the use of agricultural chemicals. In order to have a 50-percent increase in food production to meet the increased demand expected by the year 2000, the necessarily large increases in fertilizer use will create not only soil fertility problems but also ecological imbalances in flora and fauna (Haque, 1993).

Thus, the Government of Bangladesh has taken actions similar to other countries by emphasizing the implementation of integrated pest management (IPM) programs to reduce pesticide use and the likely consequence of environmental degradation. To maintain the intrinsic natural power of the soil and to minimize environmental degradation we must adopt more sustainable farming systems. A number of farming methods have been discussed that may help us to reach the goal of sustainable agriculture including nature farming, natural farming, organic farming, alternative agriculture, low-input/agriculture, biodynamic farming and ecological farming. It may not be possible to replace all agrichemicals used in agriculture today immediately with organic or natural methods. However, the newly developed EM technology which uses EM and organic amendments together, appears to be a promising technology for Bangladesh. This paper reports additional results of experiments undertaken to test the efficacy of EM technology for crop Production in Bangladesh. Results on the first phase of EM research in Bangladesh were ported earlier (Chowdhury, 1991; Chowdhury et al., 1994).

## Materials and Methods

Field and pot experiments were conducted during 1992-93. The climate at the experimental site is tropical with high temperatures and heavy rainfall from April to September and dry period with relatively lower temperatures from October to March. The soil is classified as red brown terrace soil with a very low organic matter content (0.55 percent) and total nitrogen content of 0.09 percent.

The experiments with onion (*Allium cepa* L.) and string bean (*Vigna sequipedalis* L.) were conducted in field plots while chili peppers (*Capsicum fulctescens* L.) were grown in pots. Treatments were as follows:

Factor A : EM treatment

1. with EM
2. without EM

Factor B : Soil amendments

1. Control (C)
2. Cow dung @ 10 t/ha (CD)
3. Rice straw @ 10 t/ha (RS)
4. Recommended N-P-K fertilizer rate (F)

The rice straw treatment was not included in the experiment with chili peppers. Field experiments were replicated three times in a split-plot design; the chili pepper experiment as replicated 6 times in a randomized complete block design.

Organic matter was spread and incorporated into the soil in the plots after EM (diluted 1:1000) was applied at a rate of 1 liter/$m^2$. EM was applied three weeks prior to planting the crops. The field plots measured 6 x 3 m; the pot size was 45 cm (diameter).

Nineteen-day old string bean seedlings were transplanted on June 28, 1992 with a spacing 100 x 75 cm. One-month old onion seedlings were transplanted on December 14, 1992 with a spacing of 20 x 10 cm. Crop varieties were Taherpur for onion, Top Green for ring bean and Balujuri for chili pepper. The recommended N:P:K fertilizer rates (kg/ha) ere: onion, 46:36:76; string bean, 21:44:28; and chili pepper, 64:44:41. Fertilizers were applied basally except for string bean where nitrogen was top-dressed in split applications at and 40 days after transplanting.

Weeding and other cultural operations were performed when needed. Aphids had to be controlled on string bean by regular spraying of an insecticide (Nogos). Periodic onion harvests were statistically analyzed.

## Results and Discussion

Of the three experiments reported here, the onion and string bean experiments were generally satisfactory; the experiment with chili pepper was less so because of poor crop growth which resulted from excessive rainfall during the growth period. The interaction between EM and soil amendments was statistically non-significant in all cases.

### Onion

Total biomass of the onion crop was significantly greater in the EM plots than the non EM plots for the first and third harvests, i.e., 64 and 78 days after transplanting, respectively. At the second harvest, however, the difference in total biomass between EM and non EM plots was non-significant (Table 1).

Among the soil amendment treatments, there were almost no statistically significant differences in total biomass at the second and third harvests (Table 1), but the biomass in the control plots was relatively less. Differences in biomass between the control and fertilizer plots was statistically non-significant and may be the result of better stand establishment the control plots than in the fertilizer-amended plots.

**Table 1. Effect of EM and Soil Amendments on Dry Weight Yield of Onion Plants.**

| Treatments | Days After Transplanting | | |
|---|---|---|---|
| | 64 | 71 | 78 |
| | (g/plot) | | |
| EM | 27.2a | 46.1a | 47.5a |
| No EM | 20.5b | 37.0b | 37.0b |
| Control | 17.7b | 35.5b | 34.4b |
| Rice straw | 23.6ab | 41.9ab | 42.3ab |
| Cow dung | 28.0a | 43.5ab | 49.4a |
| Fertilizer | 26.1a | 45.3a | 42.9ab |
| CV (%) | 16.1 | 20.3 | 17.1 |

Treatment means in a column sharing the same letter are not significantly different at the 5% level of probability.

Table 2 indicates that EM application significantly increased the dry weight of onion bulbs at 67 and 85 days after transplanting. However, no statistical differences were found at 71 and 78 days after transplanting. The dry weights of the bulbs were statistically the same for the soil amendment treatments of rice straw, cow dung and fertilizer at all four harvests. Dry weight per bulb was considerably lower in the control plot (Table 2).

**Table 2. Effect of EM and Soil Amendments on Dry Weight Yield of Onion Bulbs.**

| Treatments | Days After Transplanting | | | |
|---|---|---|---|---|
| | 67 | 71 | 78 | 85 |
| | (g/bulb) | | | |
| EM | 1.1a | 2.4 | 4.5a | 5.3a |
| No EM | 0.8b | 2.6 | 3b | 3.7b |
| Control | 0.4b | 2.3 | 2.3b | 3.3b |
| Rice straw | 1.1a | 2.3 | 4.5a | 5.0a |
| Cow dung | 1.3a | 3.2 | 4.1a | 4.7a |
| Fertilizer | 1.0a | 2.3 | 4.1a | 4.9a |
| CV (%) | 47.3 | 31.2 | 43.5 | 14.1 |

Treatment means in a column sharing the same letter are not significantly different at the 5% level of probability.

The influence of EM was very pronounced on root dry weight per plant (Table 3). At all four harvests, the root mass was greater in the EM plots than in the plots without EM. This difference may be the result of EM application and was statistically significant at 71 and 78 days after transplanting. With regard to the soil amendment treatments, the control and rice straw plots were similar in the production of root mass for all the harvests. The plots with cow dung and fertilizer produced significantly greater root mass per plant than the control and rice straw plots on day 85 after transplanting.

The effect of EM and soil amendments on fresh weight per bulb, number of bulbs per $m^2$ and yield of onion are presented in Table 4. Application of EM significantly increased the individual bulb fresh weight from 20.3 to 23.2 g indicating that the bulb size was increased as a result of EM application. Soil amendments also influenced the individual onion weight with cow dung and fertilizer producing the biggest bulbs. However, there was no significant difference between either of these amendments and the EM treatment.

**Table 3. Effect of EM and Soil Amendments on Dry Weight Yield of Onion Roots.**

| Treatments | Days After Transplanting | | | |
|---|---|---|---|---|
| | 67 | 71 | 78 | 85 |
| | (mg/plant) | | | |
| EM | 66 | 231a | 208a | 241 |
| No EM | 52 | 72b | 25b | 214 |
| Control | 50 | 118 | 151 | 183b |
| Rice straw | 50 | 137 | 152 | 194b |
| Cow dung | 68 | 165 | 197 | 257a |
| Fertilizer | 68 | 185 | 167 | 274a |
| CV (%) | 47.3 | 31.2 | 43.5 | 14.1 |

Treatment means in a column sharing the same letter are not significantly different at the 5% level of probability.

**Table 4. Effect of EM and Soil Amendments on Onion Production.**

| Treatments | Fresh Weight (g/bulb) | Number (bulbs/m$^2$) | Yield (t/ha) |
|---|---|---|---|
| EM | 23.2a | 30.1a | 7,0a |
| No EM | 20.3b | 28.8b | 5.8b |
| Control | 17.5c | 31.3a | 5.6b |
| Rice straw | 21.7b | 30.5a | 6.5ab |
| Cow dung | 24.4a | 29.6ab | 7.2a |
| Fertilizer | 23.8a | 26.3b | 6.3ab |
| CV (%) | 9 | 9.7 | 11.3 |

Treatment means in a column sharing the same letter are not significantly different at the 5% level of probability.

The number of bulbs per m$^2$ was slightly increased from 28.8 to 30.1 because of EM. The fertilizer plots produced significantly lower numbers of bulbs per m$^2$ compared with the rice straw and control treatments which may have resulted from a lower stand establishment in the fertilizer plots.

There was a 16-percent increase in onion yields from the EM application which accrued mainly from larger bulbs and a slightly greater number of bulbs per unit area. The larger root mass that resulted from EM application resulted in the production of larger plants (Table 1). Thus, the larger plants produced larger bulbs in the EM plots, resulting in increased yield. There are many reports that EM increases crop yield (Arakawa, 1991; Chowdhury et al., 1994; Lee, 1994; Minami and Higa, 1994)

Although the interaction between EM and soil amendments was non-significant, the results show that EM increased onion yield consistently with all soil amendment treatments. The magnitude of increase in yield per unit area as a result of the application of EM was 19, 10, 25 and 26 percent for the control, rice straw, cow dung and fertilizer, respectively.

The effect of EM on various soil chemical and physical properties was measured after harvest including pH, bulk density, organic carbon, total nitrogen, CEC, and exchangeable cations. The data, however, are inconsistent and it is difficult to draw any valid conclusions about the changes in soil properties as a result of EM application. The time necessary for such changes in soil properties to occur and become evident according to standard methods of measurement may not have been allowed by this experiment.

**String Bean**

Although EM did not significantly influence the root and shoot weight of string bean, it significantly increased the number and weight of nodules (Table 5). Rice straw produced the lowest shoot and root weight while the highest was produced by the fertilizer treatment probably because of the higher nutrient availability. The greatest number and weight of nodules were produced in plots treated with cow dung.

**Table 5. Effect of EM and Soil Amendments on Root and Shoot Weight of String Bean and Number of Root Nodules.**

| Treatments | Weight per Plant | | Nobules per Plant | |
|---|---|---|---|---|
| | Root (g) | Shoot (g) | Number | Weight (g) |
| EM | 74.6a | 447a | 127a | 9.4a |
| No EM | 68.1b | 437b | 101b | 5.7c |
| Control | 67.8b | 437b | 112a | 7.2b |
| Rice straw | 57.6c | 428c | 97b | 6.2c |
| Cow dung | 75.4a | 446a | 129a | 9.2a |
| Fertilizer | 84.5a | 457a | 122a | 7.8b |
| CV (%) | 7.4 | 4.9 | 3 | 3.4 |

Treatment means in a column sharing the same letter are not significantly different at the 5% level of probability.

From Table 6 it is clear that EM had a slight negative effect on protein and beta-carotene content, and a positive effect on the total chlorophyll content. These data, however, are preliminary and additional studies will need to be conducted to verify the results.

The number and weight of pods per plant and yield per unit area are presented in Table 7. All these characters were positively and significantly influenced by EM application. Yield was increased by about 9 percent, from 6.6 to 7.2 t/ha, as a result of EM. The increase in yield may have resulted from the higher number and weight of pods per plant that, in turn, may be attributed to a greater photosynthetic capacity based on the higher EM-induced chlorophyll content in the leaves. All soil treatments were statistically different from one another with the fertilizer treatment producing the greatest yield followed by the cow dung, rice straw and control treatments.

No statistical differences were found in yield between the plots treated with fertilizer compared with plots treated with cow dung plus EM. This suggests the possibility of replacing chemical fertilizer with EM when used in combination with cow dung.

**Table 6. Effect of EM on Seed Protein, Chlorophyll and Beta-Carotene Content of String Bean.**

| Treatments | Seed Protein (%) | Total Chlorophyll (mg/g) | Bata-Carotene (mg/g) |
|---|---|---|---|
| EM | 24.8 | 2.3a | 0.2 |
| No EM | 25.2 | 1.1b | 0.2 |
| CV (%) | 3.8 | 6 | 46.7 |

Treatment means in a column sharing the same letter are not significantly different at the 5% level of probability.

**Table 7. Effect of EM and Soil Amendments on Yield of String Bean.**

| Treatments | Pods per Plant | | Pod Yield | Increase |
|---|---|---|---|---|
| | Number | Weight (g) | (t/ha) | (%) |
| EM | 17.9a | 562a | 7.2a | 18 |
| No EM | 15.5c | 516b | 6.6b | 8.2 |
| Control | 16.3bc | 482c | 6.1c | |
| Rice straw | 15.4c | 407d | 5.0d | -18 |
| Cow dung | 17.1b | 610a | 7.9b | 29.5 |
| Fertilizer | 18.3a | 657a | 8.7a | 42.6 |
| CV (%) | 9.9 | 15.4 | 6.1 | |

**Chili Pepper**

Because of the overall poor growth of the chili pepper plants as a result of adverse weather conditions, only the yield per plant data are considered. The application of EM did not appear to enhance the yield of chili pepper when used in combination with cow dung, but did increase yield by as much as 28 percent when used in combination with N-P-K fertilizer; however, the differences were not significant. Lee (1994) and Chowdhury et al. (1994) reported a much greater effect of EM on the yield of chili pepper.

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