Effect of Organic Amendments and EM on the Growth and Yield of Crops and on Soil Properties

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Abstract

Several crops were studied in field plots to determine the effect of compost and effective microorganisms (EM) on growth and yield, and on soil chemical properties. In studies with Chinese cabbage and red peppers, growth and yield of the plants were greater in the second year than in the first. Results of first year studies with lettuce, cabbage, and rice were not as clearly defined. Improvements in the growth of lettuce may have been related to the increased source of nutrients from the EM + compost. Production of cabbage with EM was similar to the N-P-K fertilizer treatment. However, insect pests were not completely controlled and the commercial value of the cabbage was reduced. Rice yields in the EM + compost treated plots were similar to those in the N-P-K plots, the EM + compost treatment map have supplied the nutrients for equivalent productivity. During the growing season with red pepper, both EM solution and EM + compost increased the levels of available P_2O_5, Ca, and Mg in the soil. After rice harvest, soil in the EM-treated plots was found to have a higher P_2O_5 concentration compared with the other treatments.

Introduction

Effective microorganisms (EM) are reputed to improve the productivity of crops and soils, and to enhance the value of composted residues. The objectives of this study were to determine the effect of EM treatment on the growth and yield of crops, and on the chemical properties of the soils.

Materials and Methods

The studies were conducted in 1990 and 1991 at Keumkok-dong, Suwon, Korea. The crops included Chinese cabbage and red peppers (second year study) and lettuce, cabbage and rice (first year study). Specific information for each crop follows.

Chinese cabbage (cultivar Jeongsang) was grown in vinyl pots, transplanted on May 13, 1991, and fertilized with N-P-K at rates of 32-20-27 kg/10 ares (1 are = 0.01 hectare; the abbreviation for "are" is a). The plot size was 9.9 m^2. EM treatments were applied as follows:

1) Plowing period:
   Plowed after application of compost, EM-fermented compost and a diluted mixture of EM 2,3,4 applied to soil at a rate of 1000 liters/10 a 10 days before transplanting. Dilutions were EM 2, 1:1000; EM 3, 1:2000; EM 4, 1:4000. All dilutions were made with distilled water.
2) Transplanting date:
   A diluted mixture of EM cultures was sprayed on soil. Dilutions were EM 2, 1:1000; EM 3, 1:2000; EM 4, 1:4000. All dilutions were made with distilled water.
3) Seedling stage:
   Foliar application of EM 4 at the time of transplanting.
4) Growing stage:
   EM was applied 3 times during the growing period as a diluted mixture of EM 2, EM 3 , and EM 4, and applied twice as EM-fermented compost.

The treatments were:

T1: no fertilizer; no compost
T2: fertilizer; no compost
T3: no fertilizer; 1 ton of compost /10 a; 90 kg/10 a of EM-fermented compost
T4: no fertilizer; 2 ton of compost/10 a; 180 kg/10 a of EM-fermented compost

The experimental design as shown by the diagram was a split-plot with 3 replications and 4 treatments both with and without EM.

With EM -	T2 + EM	T2 + EM	T3 +EM	T4+EM
Without EM -	T1	T2	T3	T4

Red pepper plants (cultivar Dabokkeon) were grown in vinyl pots, transplanted on May 16, 1991, and fertilized with N-P-K at rates of 20-15-22 kg/10 a. The plot size was 3.3 m^2. EM cultures were applied at the seedling stage, plowing period, and transplanting date as for Chinese cabbage. During the growing period, EM was applied 5 times as a mixed solution of EM 2, EM 3, and EM 4, and applied twice as EM-fermented compost. The experimental design was the same as for the Chinese cabbage experiment.

Lettuce (cultivar Chokchima) was grown in vinyl pots and transplanted on May 16, 1991. It was fertilized with N-P-K at rates of 20-10-15 kg/10 a. Plot size was 4.5 m^2. EM applications were the same as for the Chinese cabbage experiment, except that no compost was used. The experimental design was the same as for the Chinese cabbage experiment.

Cabbage (cultivar Sakye) was grown in vinyl pots and transplanted on May 16, 1991. It was fertilized with N-P-K at rates of 25-15-25 kg/10 a. Plot size was 5.0 m^2. EM was applied in the Chinese cabbage experiment, except that no compost was used. The experimental design was the same as for the Chinese cabbage experiment.

Rice (variety Minehikari) was mechanically transplanted on May 25, 1991, and fertilized with N-P-K at rates of 15-9-11 kg/10 a. EM was applied 4 times as a mixed solution of EM 2, EM 3, and EM 4, and twice as EM-fermented compost. Plot size was 100 m^2. In the T2 plot, fertilizer was mixed with fungicides and insecticides and applied 4 times during the growing period at recommended rates.

The treatments were:

- T1: no fertilizer; no compost
- T2: fertilizer; no compost
- T3: no fertilizer; 100 kg/10 a of EM-fermented compost
- T4: no fertilizer; 200 kg/10 a of EM-fermented compost

The experimental design was a randomized block design with 3 replications.

The EM-fermented compost had the following formulations.

Type I:	Rice bran	40 kg
	Chaff	15 kg
	Straw (rice)	15 kg
	Molasses (diluted 1:500)	
	EM 2,3 and 4 (diluted 1:500)	
	Water	50 liters

Type II:	Rice bran	70 kg
	Fish meal	25 kg
	Oil cake	50 kg
	Molasses (diluted 1:500)	
	EM 2,3 and 4 (diluted 1:500)	
	Water	60 liters

Results and Discussion

Growth and Yield of Crops

In 1990, head formation of Chinese cabbage was observed only in the T2 and T2+EM treatments which were the only treatments to receive fertilizer. This suggests that the level and availability of certain nutrients may have been inadequate for the other treatments during the first year. Plants in all treatments produced heads and increased in growth and yield in 1991. The effect of the EM application was greater in 1991 than in 1990 (Table 1) suggesting that additional time was required for EM cultures to become established and manifest their beneficial effects.

Table 1. Growth, Yield and Disease Incidence for Chinese Cabbage as Affected by Application of Effective Microorganisms.

Treatment	Head Formation (%)			Weight (kg / plant)			Yield (kg / 10 a)			Soft Rot (%)		
	1990	1991	D	1990	1991	D	1990	1991	D	1990	1991	D
T1	0	99	+99	0.61	2.26a	+1.65	2,196	7,458	+5,262	14.8	1.0	-13.8
T1+EM	0	99	+99	0.97	2.39a	+1.42	3,492	7,887	+4,395	5.5	2.0	-3.5
T2	100	97	-3	2.03	2.17a	+0.14	7,308	7,161	-147	13.3	11.1	-2.2
T2+EM	100	100	0	2.16	2.77a	+0.61	7,776	9,141	+1,365	6.3	8.1	+1.8
T3	0	96	+96	1.00	2.20a	+1.20	3,600	7,260	+3,660	7.7	2.0	-5.7
T3+EM	0	93	+93	1.13	2.42a	+1.29	4,068	7,986	+3,918	4.7	2.0	-2.7
T4	0	100	+100	0.80	2.56a	+1.76	2,880	8,448	+5,568	3.7	1.0	-2.7
T4+EM	0	100	+100	1.18	2.47a	+1.29	4,248	8,151	+3,903	2.8	1.0	-1.8

Column means sharing a common letter are not significantly different at the 5% level of probability by Duncan's Multiple Range Test.
D = Difference between 1990 and 1991.

In 1991, except for treatments T1 and T2 (which received no compost), growth and yield of red pepper were significantly increased when compared with the 1990 results (Table 2). This increase probably resulted from the cumulative effects of EM and EM-fermented compost in 1991 which helped to improve soil quality and productivity.

The yield of lettuce (Table 3) was significantly lower for treatments T1 and T1+EM which received no fertilizer and no compost. It is very likely that the level of plant nutrients was inadequate to sustain higher yields. There were no significant yield differences among the other treatments; this would indicate that the EM-fermented compost was utilized as an initial source of nutrients. It is important to point out that most of the microorganisms in EM cultures require a source of organic matter for carbon and energy. Thus, if organic matter is not available, their effectiveness will be limited as these results indicate.

Similar results to that of lettuce were obtained with cabbage in 1991, i.e., yields were significantly lower for the T1 and T1+EM treatments (Table 4). All other treatments gave similar yields, and in the same range as would be expected from a chemical-based, conventional farming system using recommended rates of N-P-K fertilizer. Head formation was observed for all treatments. The cabbage needed to be sprayed frequently with EM 5 in order to control insect pests. EM 5 did not control the common cabbage worm and diamond back moth; therefore, the commercial value of the cabbage was reduced. Further development of EM 5 to control pests is required.

Table 2. Growth and Yield of Red Pepper as Affected by Application of Effective Microorganisms.

Treatment	Plant Height (cm)			Fruits (no./plant)			Yield (kg/10a)		
	1990	1991	D	1990	1991	D	1990	1991	D
T1	39.4	46.5d	+7.1	6.6	8.0d	+1.4	221.1	334.8	+113.7
T1+EM	62.0	63.3abc	+1.3	14.3	17.4b	+3.1	478.8	728.2	+249.4
T2	62.6	56.6c	-6.0	16.5	13.1c	-3.4	552.4	548.2	-4.2
T2+EM	64.7	64.7ab	0	13.7	17.8b	+4.1	458.7	744.9	+286.2
T3	43.0	57.9bc	-5.1	7.1	14.8bc	+7.7	237.7	619.4	+381.7
T3+EM	62.7	65.1ab	+2.4	17.9	22.1a	+4.2	599.3	924.9	+325.6
T4	49.4	58.5bc	+9.1	7.6	16.7b	+9.1	254.4	698.9	+444.5
T4+EM	67.7	67.4a	-0.3	15.1	22.7a	+7.6	505.5	950.0	+444.5

Column means sharing a common letter are not significantly different at the 5% level of probability by Duncan's Multiple Range Test.
D =Difference between 1990 and 1991.

Table 3. Yield of Lettuce as Affected by Application of Effective Microorganisms.

Treatment	Fresh Weight (kg/10 plants)	Yield (kg/10a)
T1	0.50b	594
T1+EM	0.71b	843
T2	1.22a	1449
T2+EM	1.32a	1568
T3	1.04a	1235
T3+EM	1.14a	1354
T4	1.19a	1414
T4+EM	1.26a	1497

Column means sharing a common letter are not significantly different at the 5% level of probability by Duncan's Multiple Range Test.

Table 4. Yield of Cabbage as Affected by Application of Effective Microorganisms.

Treatment	Fresh Weight (kg/plants)	Yield (kg/10a)
T1	1.74c	10,336
T1+EM	1.92bc	11,405
T2	2.17ab	12,890
T2+EM	2.28ab	13,543
T3	2.10abc	12,474
T3+EM	2.31a	13,721
T4	2.04abc	12,118
T4+EM	2.01abc	11,939

Column means sharing a common letter are not significantly different at the 5% level of probability by Duncan's Multiple Range Test,

In 1991, yields of rice in the EM treatments were only 70 to 80 percent of those with the recommended rates of N-P-K fertilizer in 1990 (Table 5). EM-fermented compost treatments significantly increased growth compared with the control, and were similar in yield to the T2 treatment which received the recommended rate of N-P-K fertilizer. In 1991, EM solutions were sprayed on the crop and EM-fermented compost was used as an initial and supplementary carbon and nutrient source.

Table 5. Growth and Yield of Rice as Affected by Application of Effective Microorganisms.

Treatment	Culm Lengths (cm)	Ear Lengths (cm)	Panicles (no./hill)	Rice Yield (kg/10a)	Yield Index (%)
T1	68.1b	17.3ab	17.5b	665b	84
T2	77.0a	17.0b	23.9a	779a	100
T3	71.6ab	17.3ab	23.8a	776a	98
T4	73.5ab	18.2a	23.5a	794a	101

Column means sharing a common letter are not significantly different at the 5% Probability level by Duncan's Multiple Range Test.

Chemical Properties of Soil

Some changes in the chemical properties of the soils were observed after crops had been harvested. For example, in the red pepper study the application of EM and EM-fermented compost resulted in a significant increase in the levels of available P_2O_5, Ca and Mg over that of the other treatments (Table 6). A similar result was obtained after rice harvest where a significant increase in the soil content of available P_2O_5 occurred from the application of EM and EM-fermented compost.

Table 6. Chemical Properties of Soils after Harvest of Red Pepper as Affected by Application of Effective Microorganisms.

Treatment	pH	OM (%)	P_2O_5 (ppm)	Exchangeable Cations (meq/100 g) K	Ca	Mg	Total N (%)	C/N Ratio
T1	4.3	1.64	184	0.16	2.38	0.59	0.08	11.9
T1+EM	4.6	1.60	447	0.38	3.73	0.92	0.09	10.3
T2	4.3	1.60	266	0.66	2.01	0.62	0.08	11.6
T2+EM	4.4	1.74	420	0.71	2.16	0.53	0.09	11.2
T3	4.4	1.64	236	0.30	2.97	0.72	0.08	11.9
T3+EM	4.6	1.83	463	0.31	3.76	1.06	0.10	10.6
T4	4.4	1.60	243	0.36	3.24	0.83	0.08	11.6

Summary and Conclusions

These results indicate that cultures of effective microorganisms (EM) have the potential to enhance the growth and yield of crops. EM can be particularly effective when applied to soils along with an organic amendment or as EM-fermented compost. This is important because many of the microorganisms in EM cultures need a readily available supply of organic matter as a carbon and energy source. EM can markedly increase the rate of mineralization of organic amendments into plant available nutrients. However, these results suggest that in some cases a certain “time of transition” may be required for EM cultures to become established in soils so that they can express their beneficial effects. This is exemplified by the fact that the crop yields during 1991 from the application of EM+compost and EM-fermented compost were significantly higher than in 1990.