Effect of EM and EM-Fermented Compost On the Growth and Yield of Rice and Vegetable Crops in Korea

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Abstract.

Experiments were conducted to investigate the effects of EM-fermented compost on the growth and yield of various crops. EM-fermented compost was applied to soil at a rate of 300 kilograms per 10 are; the yield of rice was increased by 16 percent over the average yield for Korea. Growth and yield of lettuce, leaf radish, chinese cabbage and carrot were increased with EM-fermented compost treatments compared with chemical fertilizer treatments. Red peppers cultivated with EM-fermented compost were normal but red peppers in the fertilizer plots were affected by damping-off disease caused by *Fusarium* spp. that began two weeks after planting. In the red pepper experiments, EM-fermented compost was relatively effective for controlling soil-borne diseases.

Introduction

Korean farmers have traditionally used chemical fertilizers and other agricultural chemicals in crop production, but the result of those activities has been environmentally destructive. Each year the cycle is repeated and the inputs of fertilizers and agricultural chemicals have to be increased to sustain production. Worldwide, agriculturists are now emphasizing that soil quality and productivity need to be improved and maintained to ensure optimum crop yields and nutritious food for a growing population (Higa, 1991).

In the late 1970's, some Korean farmers and farmer groups began to use low input / sustainable (LISA) farming methods that reduce the need for chemical fertilizers and other agricultural chemicals and increase the use of composts and biological products (Lin, 1991; Minami and Higa, 1994). However, farmers are faced with many problems in compost production such as rural labor shortages. Rural youth leave the farms to seek employment in industrial and urban centers; consequently, the proportion of older farmers is increasing. Crop yields have decreased by 20 to 40 percent and product quality has also declined, mainly because of soil degradation and loss of productivity from poor farming practices.

Many farmers have become interested in EM technology as a means of restoring soil productivity. Effective Microorganisms or EM are mixed culture inoculants of beneficial microorganisms developed by Professor Teruo Higa at the University of the Ryukyus, Okinawa, Japan. There is increasing evidence that EM can increase the microbial balance and diversity of agriculture soils and improve soil quality, and the growth, yield and quality of crops (Higa and Wididana, 1991; Pairintra and Pakdee, 1994).

Thus, the purpose of this study was to determine the effect of EM and EM-fermented compost on the growth and yield of rice and vegetable crops in Korea.

Materials and Methods

Experiment 1. Effect of EM and EM-Fermented Compost on Rice Production Nature Farming Research Center.

In the autumn of 1991, paddy rice was harvested, the straw was scattered on the surface of the paddy field, and EM (diluted 1:200) was sprayed on the field surface at the rate of 1 liter per 10 are. On April 20, 1992, the plots were treated with 60 percent of the total amount of EM-fermented compost to be used and then plowed. Ten days before transplanting, water was applied to the paddy field and then the field was plowed three days before transplanting on May 16. Another 20 percent of the fermented compost was applied 14 days after transplanting, while the remaining 20 percent was applied before shoot development. Each month, EM (diluted 1:1000) was applied at the rate of 100 liters per 10 are. EM-fermented compost was applied at rates of 100 kg (T1), 200 kg (T2), and 300 kg (T3) per 10 are, respectively, and was repeated three times for each treatment. Each plot was 198 m^2; the rice variety was Akybare.

Agricultural Experiment Station (Rural Development Administration).

In 1991, rice was harvested by combine and all of the straw was returned to the surface of the paddy field where the experiments were conducted. The soil was treated with chemical fertilizer including N-P-K at rates of 11, 7, and 8kg per 10are, respectively, for treatment T1; 1/2 of the chemical fertilizer rate plus 400 kg of EM-fermented compost per 10 are for T2; untreated control (i.e., no fertilizer or compost per 10 are) for T3; and no fertilizer but EM-fermented compost at 400 kg per 10 are for T4. The four treatments were replicated five times.

An insecticide and a fungicide were applied at four different times for treatment T1; and two times for treatment T2. No fungicide or insecticide was applied to treatments T3 and T4. Herbicides were applied two times for treatment T1 and once for T2; treatments T3 and T4 were weeded once by hand. EM was sprayed five times for treatments T2 and T4 but was not applied on T1 and T3.

Experiment 2. Effect of EM and EM-Fermented Compost on Red Pepper

The Dabokhen variety of red pepper was grown in vinyl pots and transplanted on May 5th. Treatments were: T1, chemical fertilizer (N-P-K:32-20-27 kg per 10 are); T2 and T3, chemical fertilizer was not used but EM-fermented compost was applied at rates 100 kg per 10 are for T2 and 200 kg per 10 are for T3. Sixty percent of the total fertilizer was applied 2 weeks before planting, 20 percent applied 2 weeks after planting, and 20 percent applied during the mid-growth period on July 20th. Each plot was 30 m^2. EM was diluted 1:1000 with water and sprayed three different times during the growth period at 1000 liters per 10 are.

Experiment 3. Effect of EM and EM-Fermented Compost on Spring Vegetables

Two kinds of vegetables were seeded in the same plots on April 16, i.e., leaf radish and altari (leaf and root radish). Treatments were chemical fertilizer (N-P-K) applied at rates of 18-12-16 kg per 10 are for T1; EM-fermented compost applied at 100 kg per 10 are for T2, 200 kg per 10 are for T3, and 300 kg per 10 are for T4. Each of the four treatments was replicated three times. The plot area was 14 m^2. Pesticide chemicals were not applied on any treatments; EM was not sprayed on treatment T1. The EM stock solution was diluted 1 : 1000 with water and applied three times during the growth period at a rate of 1000 liters per 10 are on treatments T2, T3, and T4.

Experiment 4. Effect of EM and EM-fermented Compost on Autumn Vegetables

Three kinds of crops were seeded in the same plots on August 11, i.e., Chinese cabbage, radish, and carrot. Chinese cabbage treatments were: T1, conventional fertilizer (N-P-K:32-20-27 kg per 10 are); T2, T3, and T4, EM-fermented compost at 100, 200 and 300 kg per 10 are, respectively. Radish treatments were: T1, conventional fertilizer (N-P-K:25-15-24 kg per 10 are); T2, T3 and T4 were the same as for Chinese cabbage. For carrot, the treatments were: T1, conventional fertilizer (N-P-K:20-15-17 kg per 10 are); T2, T3, T4 were the same as for Chinese cabbage. The plot area was 6.6 m^2. EM was diluted 1 : 1000 with water and sprayed three times during the growth period at a rate of 1000 liters per 10 are. Pesticide chemicals were not sprayed on any plots.

Results and Discussion

These experiments compared the effect of EM-fermented compost on growth and yield of vegetables, including paddy rice, under natural conditions with and without the application of chemical fertilizer (Lin, 1991; Minami and Higa, 1994).

The experiment on paddy rice conducted at the Nature Farming Research Center (Table 1) showed a statistically significant increase in culm length, number of panicles, and yield of rice with increasing levels of EM-fermented compost. At 300 kg per 10 are of EM-fermented compost, 549 kg of milled rice was harvested; this yield is 16 percent greater than the average yield of 475 kg for paddy rice in Korea. However, the application of 100 kg of EM-fermented compost per 10 are reduced rice yield by 23 percent compared with the average Korean rice yield. These results indicate that the national average rice yield can be increased with the addition of EM-fermented compost at rates above 200 kg per 10 are. Rice blast, which is one of the main causes for reduction of paddy rice yield, was not considered to be a factor in these results.

Table 1. Effects of EM and EM-Fermented Compost on Rice Growth and Yield at the Nature Farming Research Center (1992 Crop).

Treatments	Culm Length (cm)	Ear Length (cm)	Panicles (No./hill)	Yield	
				Milled Rice (kg/10a)	Index (%)
T1	72.2b	17.6b	18.6b	364.5c	100
T2	75.2b	18.3a	21.5b	477.0b	131
T3	80.5a	18.1ab	25.8a	549.0a	159

Paddy rice was harvested in autumn 1991; straw was scattered on the field surface and sprayed with EM. Treatments included addition of EM-fermented compost at 100 (T1), 200 (T2), or 300 (T3) kg/10a, respectively. The abbreviation for are is "a".

The average yield of paddy rice in Korea is 475 kg/10a.

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

The experiment on paddy rice conducted at the Agricultural Experiment Station in 1992 (Table 2) showed that rice yield was increased by 7 percent with 400 kg per 10 are of EM-fermented compost plus one-half of the amount of fertilizer applied to the fertilizer only plots. The addition of 400 kg of compost alone per 10 are increased rice yield by 5 percent over the fertilized control. EM alone sprayed onto the plots also increased rice yield without the use of chemical fertilizer. There were no significant differences in soil chemical properties among the treatments except for P_2O_5, which was higher for T4 (Table 3).

Table 2. Effects of EM and EM-Fermented Compost on Rice Growth and Yield at the Agricultural Experiment Station (1992 Crop).

Treatment	Panicles (No.-hill)	Weight of 1000 Grains (g)	Yield	
			Milled Rice (kg/10a)	Index (%)
T1	15.6	21.8	557	100
T2	20.3	21.2	596	107
T3	17.8	21.4	574	103
T4	18.2	21.6	582	105

Rice was harvested in 1991 and straw returned to the surface of the field. Treatments for 1992 included: T1, chemical fertilizer (N-P-K:11-7-8 kg per 10 a); T2, chemical fertilizer (one-half rate) with EM-fermented compost at 400 kg per 10 a; T3, untreated (no amendments) control; T4, EM-fermented compost only at 400 kg per 10 a.

Table 3. Chemical Properties of Soils During the Rice Heading Period at the Agricultural Experiment Station, Rural Development Administration (1992 Crop).

Treatment	pH (1:5)	OM (%)	T-N (%)	K	Ca	Mg	Na	CEC	Ave.P_2O_5 (ppm)	Ave.SiO_2 (ppm)
				(meq/	100g	Soil)				
T1	5.8	1.67	0.14	0.29	1.72	1.63	0.11	10.7	72	62
T2	5.8	1.28	0.14	0.2	1.91	1.65	0.13	13.8	75	56
T3	5.8	1.21	0.14	0.16	1.64	1.57	0.12	13	69	45
T4	5.8	1.2	0.14	0.19	1.87	1.63	0.13	13.3	85	52

Rice harvested in 1991 and straw returned to the surface of the field.

Treatments for 1992 included: T1, chemical fertilizer; T2, chemical fertilizer with EM-fermented compost; T3, untreated (no amendments) control; T4, EM-fermented compost.

Red pepper is a very important condiment crop in Korea. It provides economic profitability for the farm household. As shown in Table 4, damping-off by *Fusarium* spp. was severe for the fertilizer treatment T1; it began about two weeks after transplanting. During the growing season, 50 percent of the red pepper plants died, which adversely affected yield. In the treatments with EM-fermented compost, only 2 percent of the plants were affected by this soil-borne fungal pathogen, which caused a major difference in the incidence of the disease. Yields progressively increased as increased rates of EM-fermented compost were applied to the soil; for example, 860 kg of yield were obtained with 100 kg of compost and 971 kg of yield with 200 kg of compost. The incidence of *Phytophthora* blight, which generally causes much damage in red peppers, was apparently suppressed by EM-fermented compost.

Table 4. Effects of EM and EM-Fermented Compost on Growth, Yield and Disease Incidence in Red Pepper (1992 Crop).

Treatment	Plant Height (cm)	Fruits (No./plant)	Yield (kg/10a)	Yield Index (%)	Damping-off (%)
T1	62.6a	26.7ab	481	100	50
T2	59.3b	25.6b	860	179	2
T3	63.7a	28.9a	971	202	2

Treatments included: T1, chemical fertilizer; T2 and T3, EM-fermented compost at 100 and 200 kg/10 a plus EM sprayed over plots three different times during the growth period.

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

The yield of leaf radish and altari, which are spring vegetables, did not show any differences between treatments at the 5 percent level with Duncan's Multiple Range Test; yields were similar to the chemical fertilizer treatment (Table 5). Also, no differences in yield were apparent with increased applications of EM-fermented compost. Therefore, it is likely that the amount of EM-fermented compost was adequate at about 100 kg per 10 are. Growth was favorable throughout the season and there was no incidence of disease. The experiment with autumn vegetables was conducted in the same plots after the harvest of the spring vegetables. Chinese cabbage, radish and carrot were planted in August. With the chemical fertilizer treatment as the control (T1, at 100 percent), the yield of Chinese cabbage was increased by 9, 16, and 41 percent with inputs of 100, 200, and 300 kg of EM-fermented compost per 10 are, respectively (Table 6).

Table 5. Effects of EM and EM-Fermented Compost on Growth and Yield of Leaf Radish and Altari (1992 Crop).

Treatment	Fresh Weight		Yield		Yield Index	
	Leaf Radish (g/plant)	Altari (g/plant)	Leaf Radish (kg/10a)	Altari (kg/10a)	Leaf Radish (%)	Altari (%)
T1	77	140	4259a	5526a	100	100
T2	70	133	3822a	5525a	90	95
T3	76	146	4213a	5756a	99	104
T4	79	149	4374a	5871a	103	106

Treatments included: T1 chemical fertilizer; T2, T3, and T4, EM-fermented compost at 100, 200, and 300 kg/10a, respectively, plus EM sprayed over the plots.

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

Table 6. Effects of EM and EM-Fermented Compost on Growth and Yield of Chinese Cabbage (1992 Crop).

Treatment	Fresh Weight (kg/plant)	Yield (kg/10a)	Yield Index (%)
T1	3.3	16,640b	100
T2	3.5	18,200b	109
T3	3.7	19,240b	116
T4	4.5	23,400a	141

Treatments included: T1 chemical fertilizer; T2, T3 and T4, EM-fermented compost at 100, 200 and 300 kg/10a, respectively, plus EM sprayed over plots.

The yield of radish was increased by 1, 16, and 27 percent over the fertilizer treatment with an input of 100, 200, and 300 kg of EM-fermented compost per 10 are, respectively (Table 7).

Table 7. Effects of EM and EM-Fermented Compost on Growth and Yield of Radish (1992 Crop).

Treatment	Fresh Weight (kg/plant)	Yield (kg/10a)	Yield Index (%)
T1	1.1	10,186b	100
T2	1.1	10,281b	101
T3	1.2	11,805ab	116
T4	1.4	12,947a	127

Treatments included: T1, chemical fertilizer; T2, T3 and T4, EM-fermented compost at 100, 200 and 300 kg/10a, respectively, plus EM sprayed over plots.

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

As shown in Table 8, the yield of carrot was reduced by 8 and 4 percent, and increased by 4 percent with inputs of 100, 200, and 300 kg of EM-fermented compost per 10 are, respectively. Crop response to the EM-fermented compost treatments were similar to that of the chemical fertilizer treatment.

Table 8. Effects of EM and EM-Fermented Compost on Growth and Yield of Carrot (1992 Crop).

Treatment	Fresh Weight (kg/plant)	Yield (kg/10a)	Yield Index (%)
T1	440	7,920a	100
T2	405	7,287a	92
T3	422	7,603a	96
T4	460	8,280a	104

Treatments included: T1, chemical fertilizer; T2, T3 and T4, EM-fermented compost at 100, 200 and 300 kg/10a, respectively, plus EM sprayed over plots.

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

Conclusions

The results of these experiments show that the yield of paddy rice increased over that of conventional farming by 5 to 20 percent when (a) all straw from the previous crop was returned to the paddy field, (b) 200 to 400 kg of EM-fermented compost was applied per 10 are, and (c) EM was sprayed once during the growth period.

The results from the spring and autumn vegetable crops (2 crops per year), including chinese cabbage, indicated that yields similar to those of conventional farming could be obtained by adding 100 to 200 kg of EM-fermented compost per 10 are and spraying the plots several times with EM solutions. The EM-fermented compost effectively suppressed the incidence of certain soil-borne plant diseases, but was less effective on insect pests.

The increased growth and yield response of vegetable crops to the application of EM-fermented compost can be attributed at least in part to the conservation of soil moisture during the growing season (Panchaban, 1991). Direct and indirect effects of EM on soil fertility, crop production, and crop protection were also apparent.

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