Role of EM to Sustain Crop Production in Pakistan

T. Hussain, T. Javid, G. Jilani, M. Jamil and M.A. Haq
University of Agriculture, Faisalabad, Pakistan

Abstract

A number of short and long-term studies were conducted in Pakistan during 1990s to evaluate the usefulness of Effective Microorganisms (EM) and organic amendments, and their effect on the yield of different crops. The results of the first study on rice crop showed that both NPK fertilizers and EM-Bokashi (EM-fermented organic manure) gave statistically similar yield. In second study, comparision was made between chemical fertilizers and EM in green manured field for paddy and wheat yield. Data depicted that EM application gave paddy yield higher than NPK fertilizers treatment. Regarding wheat yield, NPK fertilizers gave yield significantly higher than with EM-Bokashi + EM treatment which may be due to the reason that no organic matter was added in the soil. In another study on cotton crop revealed that the maximum number of bolls plant^{-1}, and seed cotton yield resulted from NPK fertilizers followed by FYM + EM. Integration of mineral and organic sources of N with EM inoculum was made for rice, wheat and cotton. Data revealed that the integrated use of mineral fertilizers with organic matter, and biological inoculation gave higher paddy, wheat, and cotton yield as compared with fertilizer application alone. It was concluded that EM application to soil enhances the utility of organic amendments towards improving and sustaining the crop yields.

Introduction

Soil is the world's most vital component for food and fiber production: preservation of this critical natural resource is paramount for protecting the environment, and ensuring that current and future populations are healthy and wellfed. In many countries of the world, soils are being degraded at an alarming rate by wind and water erosion, desertification, and salinization resulting from misuse, and improper farming practices. The goal of agricultural sustainability relates directly to maintaining a healthy soil that is resilient to stresses imposed on it wither by natural forces or farming practices. Thus, a truly sustainable farming system is one in which the beneficial effects of various conservation practices equal or exceed the harmful effects of degradative processes (Parr and Hornick, 1992).

The health of the world's soils over time is now on the agendas of various private and public institutions. Attention to soil health helps reduce the need for chemical pesticides and fertilizers, and their attendant potential for pollution.

Under changing socioeconomic conditions, it is difficult to sustain agricultural production as well as net profit. Hence, the adoption of low-input technologies to achieve sustainability, not only in production but also in profitability, have become an important consideration in today's agriculture.

Among low-input technologies, Kyusei Nature Farming appears to be one of the most promising methods for overcoming the problems of conventional chemical farming. In this farming method, Effective Microorganisms (EM), including photosynthetic bacteria, actinomycetes, yeasts, and lactic acid bacteria, are applied to the soil as a mixed culture to enhance the availability of soil nutrients, increase humus formation, suppress weeds, control plant diseases and pathogens (Myint, 1996). Higa and Kinjo (1991) showed an increase in humus content of a soil amended with organic materials and inoculated with EM. Arakawa (1991) reported that EM improved the crop yield, suppresses the insect attack and diseases, and also reduces the need for agrochemicals. Hussain et al (1996) reported that Nature Farming along with the added dimension of EM could improve soil quality and the growth and yield of crops without the use of chemical fertilizers and pesticides. Therefore, research focusing on the effect of EM on soil and crop quality for sustainable crop production is justified and should be continued.

Experiments and Results

This paper comprises of many studies which were conducted with the objective to evaluate the usefulness of EM-Technology in Pakistan. The brief description of their methodology along with the results are described in the following paragraphs.

1. Paddy Yield as Affected by EM Application

A field study in micro plots with rice as a test crop was conducted to evaluate the individual and combined effect of EM-Bokashi (EM fermented compost) and fertilizers on paddy yield. Randomized Complete Block Design (RCBD) was followed with 3 replications. Cemented brick-wall lysimeter-type micro plots having size 2m x 1m were used to grow the crop. Rice seedlings were transplanted with a spacing of 25 cm between rows and hills as well. Three seedlings hill^{-1} were planted with following treatments: control; NPK and Zn @ 120, 90, 60 and 20 kg ha^{-1}, respectively; EM-Bokashi @ 1/2 t ha^{-1}; EM-Bokashi @ 1 t ha^{-1}; and EM-Bokashi @ 1/2 t ha^{-1} + NPK and Zn @ 60, 45, 30 and 10 kg ha^{-1}, respectively. These treatments were applied before transplanting and the crop was allowed to mature. At maturity, yield was computed out at moisture level 14 percent.

The data given in Table 1 showed that all treatments improved straw/paddy yield over control. The highest value resulted from NPK fertilizer treatment followed by EM-Bokashi treatments. Yield differences especially for paddy between NPK fertilizer treatment and the EM-Bokashi treatments were non-significant except the treatment with lower rate of EM-Bokashi. Improvement in yield with lower rate of EM-Bokashi was 75 percent more than control. However, this value was 146 percent for NPK fertilizers treatment. EM-Bokashi at higher rates, and at lower rates with NPK fertilizers improved paddy yield 141 percent and 129 percent respectively more than control. The increased yield with EM application may have been caused by the production of growth enhancing compounds such as IAA and gibberelins which may have positively influenced plant growth and yield (Chowdhry et al 1994).

Table 1. Paddy Yield (t ha^{-1}) as Affected by EM Application

Treatments	Straw Yield	Paddy Yield Increase Over Control	
T1 : Control	1.88	2.01 c	--
T2 : NPK & Zn (120 – 90 –60 –20 Kg ha^{-1})	11.52 a	4.95 a	146
T3 : EM-Bokashi (1/2 t ha^{-1})	9.93 c	3.51 b	75
T4 : EM-Bokashi (1 t ha^{-1})	10.44 b	4.63 a	129
T5 : EM Bokashi (1/2 t ha^{-1}) + ½ NPK & Zn	10.42 b	4.86 a	141

Treatment means followed by same letter(s) are statistically alike at 5 percent probability level

2. EM vs. Chemical Fertilizers in Green Manured Field for Paddy and Wheat Yield

Rice crop was transplanted in two blocks (each of 1/5 hectare size) in which green manure was incorporated. In one block, recommended NPK fertilizer @ 120-90-60 kg ha^{-1}, respectively was applied and in second block EM was applied @ 10 *l* ha^{-1} with 4 irrigation. 2/3rd dose of N and full doses of P and K were applied at transplanting and the remaining 1/3rd N was applied 40 days after transplanting. Paddy yield was recorded at harvest. After rice crop, wheat was sown with same layout as in rice with the treatment as: EM-Bokashi @ 1000 kg ha^{-1} + EM @ 10 *l* ha^{-1} (4 times) was applied in one block and the other with recommended dose of NPK fertilizers. 2/3rd dose of N and full doses of P and K were applied at sowing and remaining N was applied 40 days after sowing. At harvest, wheat yield was recorded.

Comparison of chemical fertilizers and EM for paddy and wheat yield is shown in Table 2. Data depicted that EM application to a green manured field gave paddy yield significantly higher than that with green manure plus NPK fertilizer treatment. Minami and Higa (1994) reported that paddy yield was higher with EM application as compared to the yield obtained with chemical fertilizers. Regarding wheat yield, NPK fertilizer treatment gave yield significantly higher than with EM-

Bokashi + EM treatment. The possible reason could be that no organic matter was added in the soil. Anuar et al (1995) reported similar results while working on maize crop that EM application did not enhance the cob yield, however, addition of chicken dung increased the cob yield of maize.

Table 2. Comparison of Chemical Fertilizers and EM for Paddy and Wheat Yield

Treatments	Paddy Yield (kg ha^{-1})
GM + NPK fertilizers	2408 b
GM + EM	2908 a

Treatments	Wheat Yield (kg ha^{-1})
EM – Bokashi + EM	1675 b
NPK Fertilizers	2560 a

Treatment means followed by same letter(s) are statistically alike at 5 percent probability level.

3. Effect of Organic Amendment and EM on Cotton Crop

A field experiment was conducted to study the prospects of cotton cultivation with EM-Technology. The experiment was laid out according to split plot in RCBD with 3 replications having individual plot size of $16m^2$ (4m x 4m). Two varieties of cotton Cim–1100 and Krishma were grown in the main blocks with line to line distance of 60 cm and 30 cm plant to plant distance. The treatments were: control; FYM @ 120-85-60 kg ha^{-1}, respectively. Half dose of N and full dose of P and K were applied at sowing while remaining half dose of N at flowering stage. FYM was incorporated into the soil before sowing. EM @ 60 *l* ha^{-1} was applied with each irrigation. Data regarding number of both $plant^{-1}$, average boll weight, and seed cotton yield were taken at maturity.

The data given (Tables 3,4 and 5) revealed that all treatments have a significant positive effect on number of bolls $plant^{-1}$, boll weight, and seed cotton yield. The highest values resulted from NPK fertilizer treatment followed by FYM + EM, and FYM treatments except in case of boll weight where FYM + EM treatment showed highest values followed by NPK fertilizer treatment. All the parameters were increased with FYM treatment, but increased to a greater extent with FYM + EM application. Sangakkara et al. (1995) also reported that the yields of all crops were enhanced with organic matter, and to a greater extent with EM.

Table 3. Effect of Organic Amendment and EM on Average Number of Bolls Plant –1 of Cotton Crop.

Treatments	Cim - 1100	Krishma	Mean
Control	20.00	23.90	21.90 d
FYM	27.50	34.10	30.80 c
FYM + EM	36.30	39.10	38.70 b
NPK Fertilizers	42.20	46.70	44.40 a
Mean	**32.10**	**35.90**	

Treatment mans followed by same letter(s) are statistically alike at 5% probability level.

Table 4. Effect of Organic Amendment and EM on Average Boll Weight (g) of Cotton

Treatments	Cim - 1100	Krishma	Mean
Control	6.40	6.80	6.60 d
FYM	10.30	10.60	10.50 c
FYM + EM	12.90	13.30	13.10 a
NPK Fertilizers	11.30	12.80	12.10 b
Mean	**10.30**	**10.90**	

Treatment mans followed by same letter(s) are statistically alike at 5% probability level

Table 5. Effect of Organic Amendment and EM on Seed Cotton Yield (kg ha^{-1})

Treatments	Cim - 1100	Krishma	Mean
Control	962.50	936.80	949.70 c
FYM	1866.50	1778.80	1832.00 b
FYM + EM	2272.80	2124.00	2198.00 ab
NPK Fertilizers	3017.50	2100.60	2559.00 a
Mean	2029.80	1735.10	

Treatment mans followed by same letter(s) are statistically alike at 5% probability level

4. Integration of Organic and Mineral Sources of N along with EM Inoculum for Economical Rice-Wheat Production

A field experiment with rice as a test crop was conducted according to Split Plot Design with 3 replications having main plot size of 26.5m x 8m and sub-plot size was 4m x 8m. Plant to plant and row to row distance was maintained at 25 cm. The sub-plot treatments were: control (without N); 100 percent mineral N; 75 percent mineral N + 25 percent organic N; 50 percent mineral N + 50 percent organic N; 25 percent mineral N + 75 percent organic N; and 100 percent organic N. The effect of these treatments was studied with and without EM in main plots. Forty days old green manure (*Sesbania spp*.) was incorporated into the soil one month before transplanting rice as a organic source of N, and urea was used as a mineral source. NPK + Zn fertilizers were applied @ 120-90-60 and 20 kg ha^{-1}, respectively. 2/3rd dose of N was applied at transplanting and the remaining dose was applied 40 days after transplanting. Nitrogen was applied in sub-plots as a treatment, and P, K fertilizers were applied in whole field as a blanket application. EM @ 30 *l* ha^{-1} was applied with each irrigation. Paddy yield was recorded at maturity. After rice harvest, experiment on wheat crop was conducted with same layout, and with same treatments. In this experiment, 1 ft row to row distance was maintained. FYM was incorporated into the soil before sowing as a source of organic N, and urea as a mineral source of N. NPK fertilizers were applied @ 120-90-60 kg ha^{-1}, respectively. Half N was applied at sowing and remaining half with first irrigation. Phosphorous and K fertilizers were applied in whole field as a blanket application. EM @ 30 *l* ha^{-1} was applied with each irrigation. Wheat yield was recorded at maturity.

Paddy Yield

The data given (Table 6) showed that the EM treated plots gave higher paddy yield than non-EM treated plots but were statistically non-significant. The data further indicated the significant superiority of all treatments over control. The maximum paddy yield was recorded in the treatment where integration of 50 percent mineral N + 50 percent organic N was made followed by 75 percent mineral N+ 20 percent organic N, and 25 percent mineral N + 75 percent organic N treatment. However, all treatments were statistically similar except 50 percent mineral N + 50 percent organic N treatment, and control. Main et al. (1988) reported that N fertilizer use efficiency for rice can be enhanced by green manuring with *Sesbania* and at lower rate of N fertilizer application.

Table 6. Effect of Mineral and Organic Sources of N Integrated with EM Inoculum on Paddy Yield (Kg ha^{-1})

	Treatments	Paddy Yield (kg ha^{-1})		
		EM	**No EM**	**Mean**
T_1 :	Control	2000^{NS}	1729	1864 c
T_2 :	100 % mineral N	2479	2736	2607 b
T_3 :	75 % mineral N + 25 % org. N	2907	2550	2729 b
T_4 :	50% mineral N + 50 % org. N	3764	3514	3639 a
T_5 :	25 % mineral N + 75 % org. N	2836	2450	2643 b
T_6 :	100 % organic N	2735	2407	2571 b
	Mean	**2787 A**	**2564 A**	

Treatment means followed by same letter(s) are statistically alike at 5% probability level.

Wheat Yield

The data given in (Table 7) revealed that EM treated plots gave higher wheat yield than non-EM treated plots but were statistically non-significant. All treatments gave significantly higher wheat yield over control. The maximum wheat yield was recorded in 50 percent mineral N + 50 percent organic N treatment followed by 100 percent mineral N but both were statistically similar. 25 percent mineral N + 75 percent organic N treatment gave somewhat higher wheat yield but showed non-significant difference with 75 percent mineral N + 25 percent organic N treatment. Higher wheat yield was recorded in 100 percent organic N treatment than control but both were statistically alike. Ahmad (1994) also reported that the integrated use of mineral fertilizers with crop residues, green manures, BNF sources and organic matter of animal origin can be used for sustainable crop production in major agro-ecological zones of the country.

Table 7. Effect of Mineral and Organic Sources of N Integrated with EM Inoculum on Wheat Yield (kg ha^{-1})

	Treatments	**Wheat Yield (kg ha^{-1})**		
		EM	**No EM**	**Mean**
T_1 :	Control	1393^{NS}	1250	1321 d
T_2 :	100 % mineral N	3183	3393	3288 a
T_3 :	75 % mineral N + 25 % org. N	2231	2346	2288 b
T_4 :	50% mineral N + 50 % org. N	3683	3028	3355 a
T_5 :	25 % mineral N + 75 % org. N	2558	2198	2378 b
T_6 :	100 % organic N	1829	1598	1713 cd
	Mean	**2479 A**	**2302 A**	

Treatment means followed by same letter(s) are statistically alike at 5% probability level.

5. Effect of Mineral and Organic Sources of N Integrated with EM Inoculum for Nitrogen Management in Cotton

A field experiment on cotton crop conducted followed split plot in RCBD with 3 replications having sub-plot size 4m X 4m. The treatments were : control (without N); 100 percent mineral N; 50 percent mineral N + 50 percent organic N; 100 percent organic N; EM alone; 100 percent mineral N+EM; 100 percent organic N + EM; 50 percent mineral N + 50 percent organic N + EM. These treatments were applied in sub-plots and EM in main plots. NPK fertilizers were applied @ 100-75-50 kg ha^{-1}, respectively. FYM containing 1.4 percent N was incorporated into the soil before sowing as a organic source. Urea was used as a mineral source. Half dose of N was applied as blanket application. EM @ 30 *l* ha^{-1} was applied with each irrigation. Data regarding number of bolls plant^{-1} and seed cotton yield was recorded at maturity.

The data collected in all the above mentioned studies were subjected to statistical analysis by standard procedures (Steel and Torrie, 1986), and the treatments means were compared by Duncan's Multiple Range Test (Duncan, 1955)

Bolls plant^{-1}

Number of bolls plant^{-1} given in Table 8 showed that the integration of plant nutrient (mineral and organic) with an without EM gave a statistically non-significant difference. However, all the treatments gave a statistically significant difference over control. The maximum values were recorded in 50 percent mineral N + 50 percent organic N with and without EM, and both were statistically similar followed by 100 percent mineral N + EM, and 100 percent mineral N treatment and these two treatments also showed a non-significant difference with each other. 100 percent organic N with and without EM treatments were statistically alike but showed higher values than control. EM alone treatment gave higher value of bolls plant^{-1} but statistically non-significant with control.

Table 8. Effect of Mineral and Organic Sources of N Integrated with EM Inoculum on Number of Bolls Plant^{-1} in Cotton

	Treatments	Bolls Plant^{-1}
T_1	Control (without N)	20.9 d
T_2	100 % mineral N	44.7 b
T_3	50 % mineral N + 50% org. N	46.6 ab
T_4	100 % org. N.	30.5 c
T_5	EM alone	23.4 d
T_6	100 % mineral N + EM	44.8 b
T_7	100 % org. N + EM	35.2 bc
T_8	50 % mineral N + 50 % org. N + EM	47.2 a

Treatment means followed by same letter (s) are statistically alike at 5% probability level.

Seed Cotton Yield

The data regarding seed cotton yield (Table 9) depicted the significant positive response of EM over no EM treatments except that of 100 percent mineral N treatment with and without EM showed statistically non-significant results. All the treatments showed a significant increase in seed cotton yield over control except EM alone treatment which gave higher seed cotton yield than control but was statistically non-significant. The maximum seed cotton yield was recorded in 50 percent mineral N + 50 percent organic N + EM treatment followed by 100 percent mineral N + EM, and 50 percent mineral N + 50 percent organic N treatment. The treatment in which 100 percent organic N + EM was applied showed statistically a non-significant difference with 100 percent mineral N treatment. The minimum seed cotton yield was recorded in control. Singh et al. (1977) reported that the combined application of N fertilizer and biological inoculation gave higher yield as compared with fertilizer application alone.

Table 9. Effect of Mineral and Organic Sources of N Integrated with EM Inoculum on Seed Cotton Yield (kg ha^{-1})

	Treatments	Seed Cotton Yeild (kg ha^{-1})
T_1	Control (without N)	1192 d
T_2	100 % mineral N	2990 b
T_3	50 % mineral N + 50% org. N	3146 b
T_4	100 % org. N.	2055 c
T_5	EM alone	1395 d
T_6	100 % mineral N + EM	3184 b
T_7	100 % org. N + EM	2750 b
T_8	50 % mineral N + 50 % org. N + EM	3411 a

Treatment means followed by same letter (s) are statistically alike at 5% probability level.

References

Ahamad, N. 1994. Integrated plant nutrient systems improves fertilizer use efficiency (FUE), crop productivity and environment. p. 28-46, In: Proc. 4th Nat. Cong. of Soil Sci. May 24-26, 1992, Islamabad, Pakistan.

Anuar, A.R., H.A.H. Sharifuddin, M.F. Shahbuddin and A.R. Zaharah. 1995. Effectiveness of Effective Microorganisms (EM) on maize grown on sandy tin tailings. p. 42-54. In: H.A.H. Sharifuddin, A.R. Anuar, and M.F. Shahbuddin (eds.). Proc. 2nd Conf. on Effective Microorganisms (EM). Nov. 17-19, 1993, Saraburi, Thailand.

Arakawa, Y. 1991. Kyusei Nature Farming in Japan. p. 20-23. In: J.F. Parr, S.B. Hornic, and C.E. Whitman (eds.). Proc. 1st Intl. Conf. on Kyusei Nature Farming. Oct. 17-21, 1989, Khon Kaen, Thailand.

Chowdhry, A.R., M.M. Hussain, M.S. Mia, A.J.M.S. Karim, J. Haider, N.I. Bhuyan and K. Shaifuddin. 1994. Effect of organic amendments and EM on crop production in Bangladesh. p. 155-163. In: J.F. Parr, S.B. Hornick, and M.E. Simpson (eds.). Proc. 2nd Intl. Conf. Kyusei Nature Farming. Oct. 7-11. 1991, Piracicaba, SP, Brazil.

Duncan, D.B. 1955. Multiple Range and Multiple F-Test Biometrics, 11:1-43.

Higa, T. and S. Kinjo. 1991. Effect of lactic acid fermentation bacteria on plant growth and humus formation. p. 140-147. In: J.F. Parr, S.B. Hornick, and C.E. Whitman (eds.). Proc. 1st Intl. Conf. on Kyusei Nature Farming. U.S. Dept. of Agri. Washington, D.C., USA.

Hussain, T., G. Jilani, M. Yaseen and M.A. Abbas. 1996. The Asia-Pacific Natural Agriculture Network (APNAN) : A Case Study for Regional Research. p. 163-167. In: J.F. Parr, S.B. Hornick, and M.E. Simpson (eds.) Proc. 3rd Intl. Conf. on Kyusei Nature Farming. Oct. 5-7, 1993, California, USA.

Mian, M.A., M. Aslam and M. Khalid. 1988. Fertilizer use feeiciency in rice as influenced by organic manuring. p. 285-293. In: Proc. 1st Nat. Cong. Soil Sci., Oct. 6-8, 1985, Lahore, Pakistan.

Minami, T. and T. Higa. 1994. Kyusei Nature Farming in Japan: Effect of EM on the yield of paddy rice. p. 97-102. In: J.F. Parr, S.B. Hornick, and M.E. Simpson (eds.). Proc. 2nd Intl. Conf. on Kyusei Nature Farming. Oct. 7-11, 1991, Piracicaba, SP, Brazil.

Myint, C.C. 1996. Nature farming research in Myanmar : Effect of organic amendments and EM on rice production. p. 151-162. In: J.F. Parr, S.B. Hornick, and M.E. Simpson (eds.). Proc. 3rd Intl. Conf. on Kyusei Nature Farming. Oct. 5-7, 1993, California, USA.

Parr, J.F. and S.B. Hornick, 1992. Agricultural use of organic amendments : a historical perspective. Amer. J. Alt. Agri. 7(4) : 181-189.

Sangakkara, U.R., B. Marambe, A.M.U. Attanayake and E.R. Piyadasa. 1995. Nutrient utilization efficiencies of selected crops growm with effective microorganisms in organic system. p. 25. Absts. 4th Intl. Conf. on Kyusei Nature Farming. June, 19-21, 1995, Paris, France.

Singh, C.M., B.R. Sood and Modgi. 1977. Effect of nitrogen, azotobacter and farm yard manure on maize in Kula Valley (H.P.). Food Farming and Agriculture : 8 (10): 1-3.

Steel, R.G.D. and J.H. Torrie. 1986. Principles and Procedures of Statistics. 2nd Ed. McGraw Hill Book Co. Inc., New York. 187 p.