Kyusei Nature Farming in Japan: Effect of EM on the Yield of Paddy Rice

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Introduction

Kyusei Nature Farming is a method of producing crops that excludes the use of chemical fertilizers and pesticides. However, for many years there has been a lack of understanding by gardeners on exactly what is involved in Kyusei Nature Farming and how the stated requirements can be achieved. Farmers need to be informed of specific procedures and practices on how to increase their crop yields and productivity through efficient management of inputs, and especially how to control plant diseases, insects and weeds without chemicals. Consequently, the adoption of Kyusei Nature Farming has been limited mainly to a small group of dedicated farmers who produce organically-grown foods for an equally dedicated clientele.

The advent of effective microorganisms (EM) now offers the means to overcome the problems of farming without synthetic agricultural chemicals, and to substantially increase the yield and quality of crops, and the long-term productivity, fertility and health of our soils. Indeed, EM technology provides an added dimension and a unique opportunity for revitalizing Kyusei Nature Farming.

This paper reports the results of a study from 1986 to 1990 on the production of paddy rice by Kyusei Nature Farming methods, with and without EM, compared with conventional farming practices. The comparison is based on the yield of paddy rice and the cost of production inputs per unit area.

Materials and Methods

The study was conducted in cooperation with 38 rice farmers in Fnkui Prefecture, Japan. The yield of paddy rice for Kyusei Nature Farming alone was compared to the yield for Kyusei Nature Farming with EM. These yields were also compared with those for conventional farming in nearby areas. Because the farmers began using EM in different years, they were divided into the following four groups.

Group A: 8 farmers who started using EM in 1987.
Group B: 10 farmers who started using EM in 1988.
Group C: 10 farmers who started using EM in 1989.
Group D: 10 farmers who converted from conventional farming to Kyusei Nature Farming with EM in 1990.

Rice yields are reported as the weight of hulled rice obtained per unit area. The Koshihikari variety of paddy rice was predominantly grown by most farmers except where indicated.

Rice seedlings were transplanted into paddies from early to mid-May, and rice was harvested in late September. After harvest, all remaining residues of rice straw, chaff, and bran were incorporated by plowing. At this time one liter each of EM 2, 3, and 4 stock cultures was diluted with water at 1:1000, 1:2000, and 1:1000 (EM:water), respectively, and sprayed over field areas of 10 ares (1 are = 0.01 hectare; 10 ares = 0.1 hectare; the abbreviation for are is "a"). In addition, an EM 4 solution diluted at 1:1000 was sprayed over the fields before transplanting the rice seedlings (at the time of puddling) to accelerate the germination of weed seeds which were then plowed and killed through another puddling. After transplanting, a mixed suspension of EM 2 and 3 or EM 2, 3 , and 4 was sprayed over the fields once a month until a month prior to harvest.

Table 1 shows a schedule of treatment applications for the production of paddy rice in three crop years (1988 to 1990) for one of the farmers who participated in this study.

Table 1. Schedule of Treatment Applications for the Production of Paddy Rice in Three Crop Years by a Farmer Who Participated in the Kyusei Nature Farming/EM Study.

Treatments	Year/Date of Treatment Applications		
	1988	1989	1990
Soil Conditioners Applied (kg/10 a)	Oct 13 (1987): 300 kg fossilized shells, 100 kg carbonized chaff.	Mar. 15: 200 kg fossilized shells	Mar. 19: 300 kg fossilized shells.
Organic Matter Applied (kg/10 a)	Sep. 22 (1987): 360 kg rice straw. Mar. 30: 300 kg rice bran	Sep. 22 (1988): 480 kg rice straw.	Sep. 18 (1989): 360 kg rice straw. Oct. 17: 300 kg rice bran
Transplanting	May 17	May 9	May 11
EM Applied	Mar. 30 EM 4 (1:1000)	Oct. 15 (1988): EM 2, 3, 4 (1:1000, 1:2000, l:1000)	Oct. 17 (1989) EM 4 (1:1000)
	May 17: EM 2, 3 (1:1000, 1:2000)	Mar. 15: EM 4 (1:500)	Oct. 20: EM 4 (1:1000)
	Jun l: EM 2, 3 (1:1000, 1:2000)	Apr. 20: EM 4 (1:l000)	Mar. 19: EM 4 (1:1000)
	Jul. 2: EM2, 3 (1:l000, 1:2000)	May 28: EM2, 3,4 (l:1000, 1:2000, 1:5000)	Apr. 20: EM 4 (1:1000)
	Aug 7: EM 2, 3 (1:1000, 1:2000)	Jun 19: EM 2, 3, 4 (1:l000, l:2000, l :2000)	Jun. 23: EM 2, 3 (1:1000, 1:2000)
		Jun. 29: EM 2, 3, 4 (1:1000, 1:2000, l:1000)	Jul. 20: EM 2, 3 (1:1000, 1:2000)
		Jul. 24: EM 2, 3, 4 (1:1000, 1:2000, 1:1000)	
		Aug. 15: EM 2, 3, 4 (1:l000, 1:2000, 1:1000)	
Crop Harvested	Sep. 22	Sep. 18	Sep. 20

Results and Discussion

Tables 2 through 5 report the change in paddy rice yields and yield indices resulting from Kyusei Nature Farming with and without EM technology in Fnkui Prefecture for consecutive years during the study. Rice yields will vary from site to site depending on agroecological conditions and management practices. Thus, the yield index represents a percentage change in yields from Kyusei Nature Farming, with or without EM technology, compared with the average yield expected from conventional farming designated as 100.

Table 2 reports the rice yields and yield indices of 8 farmers in Group A who switched from conventional farming to Kyusei Nature Farming in 1986 and used EM from 1987 through 1990. Crop yields have often been reported to decrease in the year following conversion from conventional to nature farming methods and this was the case in 1986. However, rice yields tended to increase during 1987, the first year that EM was used in conjunction with Kyusei Nature Farming. This highly positive result can be attributed to the beneficial effects of EM. With a few exceptions, the yields and yield indices were also higher during the succeeding years than those reported in 1986. The yield indices show that there was a general increase in the number of farmers whose yields exceeded or approached the average expected yield from conventional farming.

The large decrease in yield reported by farmer No. 3 in 1989 resulted from an insufficient amount of organic matter applied to the paddy. Adequate amounts of composts or other organic amendments must be applied regularly to provide a source of carbon and energy to sustain the growth and activity of many of the microorganisms in EM cultures after inoculation into soil.

Table 2. Yield and Yield Index of Paddy Rice Obtained by Farmers in Group A Who Practiced Kyusei Nature Farming in Combination with EM Technology from 1987 through 1990 in Fukui Prefecture.*

Farmer Participant	No EM Applied		EM Applied							
	1986		1987		1988		1989		1990	
	Yield	Index	Yield	Index	Yield	Index	Yield	Index	Yield	Index
1	600	117	600	118	540	111	540	111	660	128
2	-	-	588	125	600	126	540	117	516	108
3	240	50	420	89	480	101	260	56	510	107
4	420	94	540	100	450	102	-	-	480	107
5	420	82	480	95	546	106	600	120	540	105
6	420	74	478	90	517	93	545	102	540	97
7	360	81	390	87	480	109	390	89	390	87
8	360	64	558	104	570	103	540	101	420	75

* The yield of hulled rice is expressed as kg/10 a. The yield index is the relative percentage change in rice yields obtained from Kyusei Nature Farming with EM technology compared with the average yield expected from conventional farming designated as 100. Farmers 1 and 2 switched from conventional farming to Kyusei Nature Farming in 1987, All other farmers made this change in 1986. Farmer 1 grew the Kaguramochi variety of paddy rice; all others grew the Koshihikari variety.

Table 3 reports the changes in the yield of paddy rice and the yield indices that farmers in Group B achieved by practicing Kyusei Nature Farming in combination with EM for three years. With few exceptions, these farmers experienced an increase in their rice yields during the first year of EM application. The yield indices show that the number of farmers whose yields exceeded the average yield from conventional farming increased from four in 1987 when no EM was applied, to seven the first year EM was used. This was followed by seven the second year, and ten the third year. These results strongly suggest that with proper and timely use of EM farmers can make a successful transition from conventional farming to Kyusei Nature Farming that will be sustainable over the long-run. This conclusion is reinforced by the data shown in Tables 4 and 5.

Table 3. Yield and Yield Index of Paddy Rice Obtained by Farmers in Group B Who Practiced Kyusei Nature Farming in Combination with EM Technology from 1988 through 1990 in Fukui Prefecture.*

Farmer Participant	No EM Applied		EM Applied					
	1987		1988		1989		1990	
	Yield	Index	Yield	Index	Yield	Index	Yield	Index
1	540	114	600	126	500	108	600	126
2	450	105	540	131	375	91	540	124
3	480	107	360	81	480	110	535	119
4	500	94	540	98	630	118	660	118
5	390	87	450	102	480	110	510	114
6	396	95	414	101	450	111	480	114
7	480	95	480	94	500	100	560	109
8	450	89	552	108	555	111	550	107
9	480	107	510	115	360	83	480	107
10	360	76	480	101	360	78	510	107

* The yield of hulled rice is expressed as kg/10 a, The yield index is the relative percentage change in rice yields obtained from Kyusei Nature Farming/EM technology compared with the average yield expected from conventional farming designated as 100,
Farmer 4 grew the Kaguramochi variety of paddy rice; all others grew the Koshihikari variety.

Table 4. Yield and Yield Index of Paddy Rice Obtained by Farmers in Group C Who Practiced Kyusei Nature Farming in Combination With EM Technology during 1989 and 1990 in Fukui Prefecture.*

Farmer Participant	No EM Applied		EM Applied			
	1988		1989		1990	
	Yield	Index	Yield	Index	Yield	Index
1	-	-	450	88	570	108
2	450	92	450	93	540	105
3	480	117	450	109	450	104
4	540	105	540	107	510	98
5	480	94	480	96	450	87
6	375	79	335	72	412	86
7	266	56	333	72	390	82
8	230	48	276	60	390	82
9	-	-	300	60	420	82
10	-	-	420	79	420	75

*The yield of hulled rice is expressed as kg/10 a. The yield index is the relative percentage change in rice yields obtained from Kyusei Nature Farming/EM technology compared with the average yield expected from conventional farming designated as 100.
Farmers 1-5 and 9-10 switched from conventional farming to Kyusei Nature Farming in 1989.

Table 5. Yield and Yield Index of Paddy Rice Obtained by Farmers in Group D Who Practiced Kyusei Nature Farming Alone in 1988 and in Combination with EM Technology during 1989 in Fukui Prefecture.*

Farmer Participant	No EM Applied		EM Applied	
	1988		1989	
	Yield	Index	Yield	Index
1	540	107	545	106
2	480	99	540	105
3	300	69	472	105
4	-	-	540	104
5	540	100	570	101
6	450	107	430	98
7	420	84	510	97
8	390	95	420	97
9	545	102	540	97
10	480	93	500	95

*The yield of hulled rice is expressed as kg/10 a. The yield index is the relative percentage change in rice yields obtained from Kyusei Nature Farming/EM technology compared with the average yield expected from conventional farming designated as 100.
All farmers in Group D switched from conventional farming to Kyusei Nature Farming in 1988.

While the results of this study show that EM in combination with Kyusei Nature Farming methods can help to overcome the problems of transition from conventional farming, the question is whether the cost of implementing this nature farming system and the expected yields will be economically competitive with conventional farming. Table 6 shows that the 1990 estimated cost of materials for paddy rice production with Kyusei Nature Fanning is about ¥19,100/10 a (aver-age of the four groups) compared with ¥34,765/l0 a for conventional farming, or a little more than half. Moreover, the rice yield for Kyusei Nature Farming was 486 kg/10 a (average of the four groups) compared with 448 kg/10 a for conventional farming. Table 7 provides a more complete accounting of the estimated 1990 cost of materials that would be used per 10 a for paddy rice production by conventional farming in Fnkui Prefecture.

Table 6. Estimated 1990 Cost of Materials and Yield of Paddy Rice Produced from Conventional Farming Methods Compared with Kyusei Nature Farming in Combination with EM Technology in Fukui Prefecture.*

Production Factors	Cost of Production Inputs and Yields				
	Conventional Farming Methods	Kyusei Nature Farming with EM (Farmer's Groups)			
		A	B	C	D
Chemical fertilizers	21,094	0	0	0	0
Pesticides	13,671	0	0	0	0
EM	0	13,750	12,250	20,000	18,778
Organic Matter	0	2,450	7,515	-	1,682
Total cost (yen)	34,765	16,200	19,765	20,000	20,460
Relative cost (%)	100	46.6	56.9	57.5	58.9
Applied (years)		3	4	3	3
Yield (kg/10 a)	448	525	480	480	460
Relative yield	100	117	107	107	103
Amount of materials applied to 10 a	See Table 7	Rice bran 60 kg EM 5.5 liter	EM fermented compost 150 kg EM 4.5 liter	EM 8 liter	EM fermented compost 13 kg EM 7.5 liter

* Estimated cost of materials for conventional farming were made by the Agricultural Cooperative Association of Tsuruga City, Fukui Prefecture.
Cost of materials: EM = ¥2,500/L; rice bran = ¥40/kg; oil cake = ¥52/kg; fish meal = ¥133/kg.

Table 7. Estimate of the 1990 Cost of Materials Per 10 a for Production of Paddy Rice by Conventional Farming Methods in Fukui Prefecture.

Time/Purpose of Application	Type of Material and Rate of Application		Cost (Yen)
Mid October: fall plowing	Calcium cyanamide	20kg	2,420
	Soluble phosphate	40kg	2,560
Spring	Calcium silicate	200kg	6,200
	Basal dressing No. 1	40kg	3,300
Before transplanting	Basal dressing No. l	10kg	625
Supplementary fertilizer	Basal dressing No. l	10kg	665
Supplementary fertilizer	Potassium silicate	30kg	2,880
Fertilizer for head sprouting	1st: top dressing for Koshihikari	15kg	998
	2nd:top dressing for Koshihikari	15kg	998
	3rd: urea	5kg	248
Pest control:for seed	Pesticide for Bakanaae Disease	0.5%	31
:for seedlings	Pesticide for damping-off	5liter	790
Before transplanting	Herbicide A	500ml	1,960
After transplanting	Herbicide B	3kg	3,670
At mid-season drainage	Herbicide C	3kg	2,360
At flooding	Herbicide D	3kg	2,360
At flooding	Pesticide for rice blast and sheath blight	3kg	2,020
At flooding	Pesticide for rice insects, leafhoppers, and stink bugs	3kg	1,480
		Total	34,765

Conclusions

The results of this study have shown rather conclusively that with the proper use of EM farmers can make a successful transition from conventional farming to Kyusei Nature Farming for the production of paddy rice, and without an initial decrease in yield. EM is an added dimension that can overcome many chemical, physical and microbiological problems in the soil environment that affect the yield, health and quality of crops. EM can also reduce and eventually eliminate the farmer's dependency on chemical fertilizers and pesticides. The actual cost of materials for production of paddy rice with Kyusei Nature Farming in combination with EM was little more than half the costs needed for conventional farming. Also, the yield of paddy rice was significantly higher for the Kyusei Nature Farming/EM system compared with conventional farming.