Crop Yields and Soil Organic Matter as Affected by Kyusei Nature Farming and EM Technology

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***Abstract**: Organic or nature farming systems are becoming a principal component of agricultural practices of both developing and developed countries. However, the productivity of organic systems is low in comparison to the conventional chemical farming systems. Thus different technologies are being developed to overcome this setback and promote yields and provide returns to investment of farmers, especially in the developing world.*

The technology of Effective Microorganisms (EM) extensively used in Kyusei Nature Farming utilizing microbes found in all ecosystems has been cited as a technology to overcome the above problem. Thus, a long-term study was carried out to determine the usefulness of EM on crop yields and maintenance of soil organic matter, Yields of crops grown with three types of organic matter and EM increased over time when compared to yields of conventional organic systems. More importantly soil organic matter contents were also increased over time, even with EM. This was in contrast to the common belief of the decline of organic matter with the application of inoculants, especially in tropical soils. The potential of using EM made with microbes available locally, as advocated in Kyusei Nature Farming for sustainable crop production in tropical organic systems is presented.

Introduction

Agriculture and more specifically crop production intensified and industrialized its activities in the 1940's. Petrochemical resources, chemical fertilizers, growth regulators and crop protection measures were widely used. This resulted in significant increases in crop productivity, an achievement known as the green revolution (Harwood, 1990). However, this revolution was not without problems, which became evident in recent times. These were the damage to the ecosystems, pollution and destruction of natural resources and food contamination (Tzeng, 1996). Hence concepts of sustainable agriculture were developed, where emphasis was placed upon the use of natural substances in place of synthetic agrochemicals. The concept of organic agriculture, which was practised before the advent of the green revolution was reawakened with greater dynamism to overcome these setbacks (Lampkin, 1994).

Organic farming, as practised today also has setbacks. Amongst these, low yields are considered as a primary problem, Yields derived from organic systems range from 50 – 75 percent of the conventional systems (Padel and Lampkin, 1994). Therefore, produce from organic systems need premium prices for achieving economic benefits.

In the recent past, techniques have been developed to enhance productivity of organic cropping systems. Amongst these, a reuse of an age old system, that of the use of microbes has gathered momentum. For example, Bjorkman (1995) report the use of rhizospheric fungi in maintaining healthy soils, while Casale et al., (1995) indicate the use of urban and agricultural wastes for the delivery of microbial biocontrol agents. However, a much simpler concept was developed in Japan in the 1970's to utilize a mixture of naturally occurring microbes, to develop EM (Effective Microorganisms). The species included photosynthetic bacteria, lactic acid bacteria, ray fungi, yeast and Actinomyces, and were blended together to develop the solutions of EM. This was successfully used in organic farming to enhance productivity and to develop a more conducive ecosystem.

Soil organic matter is considered to be the key to sustainable agriculture (Swift and Woomer, 1993). However, due to the accelerated breakdown of organic matter with applications of microbial solutions such as EM, especially in tropical degraded soils, there was a concern of developing further degradation of the ecosystems. Hence a long term study was initiated in 1990 to evaluate the usefulness of solution of EM in conventional organic farming systems where organic matter is used. The changes in soil organic matter with and without the use of EM was also determined to evaluate the existence of detrimental effects of this microbial solution.

Materials and Methods

The long term experiment was carried out at the Experimental Unit of the University of Peradeniya, Sri Lanka located in the mid-country intermediate zone of the island. The agricultural seasons of the country, divided on the basis of rainfall into wet (October – February) and dry (April – August) were used for the study.

The main rainfall received in the wet season range from 1050 – 1125 mm per season while that of the dry season varied between 450 – 550 mm. The soil of the site was an Alfiisol with a sandy loam texture, pH (1:2.5 H_2O) of 6.04 + 0.45 and an organic carbon content of 1.05 percent. The experiments initiated in 1990 wet season had 7 treatments. These were the use of leaves of three legumes, cattle manure of rice straw as additives at a rate equivalent to 8 MT per ha (800 g m^2), with and without EM. A plot with no additives was also maintained in each replicate for comparison. The crops used were mung bean (*Vigna radiata* L Wilczek variety MI 5) in the wet season and tomato (*Lycospersicon esculentum* L variety Marglobe) in the dry season, in all plots.

The experiment conducted within a randomised block design had 7 treatments and 3 replicates. Individual plots were 4 x 3 m. The plots receiving EM were separated from others by a 50 cm alley.

At the onset of each season, the plots were manually tilled, and organic matter applied 14 days before planting and incorporated. The EM was applied soon after the application of organic matter at a rate equivalent to 6 litres per ha, at a dilution of 1:500 onto the predetermined plots. Seeds of mungbean or uniform seedlings of tomato were planted 14 days later and managed as per local recommendations. At the important growth stages of each crop, EM was sprayed onto plants in plots that received the microbial solution at the inception. The rate was equivalent to 0.5 litres per ha, diluted 1:1000 times. No agrochemicals were used.

Crop yields were determined at maturity and at the end of the first, third and fifth year, organic carbon contents were determined in all plots utp a depth of 30 cm.

The data was subjected to statistical analysis using a General Linear Model to determine the significance of treatment differences.

Results and Discussion

Crop production in the tropics require added nutrients, primarily due to the low organic matter contents and degraded nature of soils (Swift and Woomer, 1993). This is again observed in this study where yields of mungbean and tomato grown without organic matter were significantly low (Table 1). This implies that all non chemical agricultural systems require the addition of organic matter to facilitate crop growth and yields.

Table 1. Effect of Organic Matter and Effective Micro-organisms on Yield of Mungbean and Tomato

Organic Matter	**Application of EM**	**Yield (g. m^{-2})**					
A.Mungbean (Wet season)		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Sx (n=15)**
Legume Leaves	No	215	241	252	259	258	8.15
	Yes	306	348	404	436	452	6.59
Rice Straw	No	135	162	195	218	226	7.81
	Yes	174	208	255	281	298	11.50
Cattle Manure	No	182	226	251	249	256	8.01
	Yes	231	286	341	375	381	15.42
No Additives		75	69	64	52	61	7.11
Probability	(Organic matter)	0.015	0.028	0.004	0.041	0.038	
	(EM)	0.022	0.019	0.040	0.031	0.029	
Interaction	(P = 0.05)	*	*	*	NS	*	
B.Tomato (Dry Season)							
Legume Leaves	No	1245	1224	1314	1342	1318	15.14
	Yes	1526	1580	1685	1745	1819	95.27
Rice Straw	No	955	1042	1094	1125	1104	19.01
	Yes	1104	1358	1448	1515	1566	50.36
Cattle Manure	No	1140	1395	1452	1495	1480	34.88
	Yes	1268	1405	1499	1605	1684	40.90
No. Additives		708	684	715	674	688	15.48
Probability	(Organic matter)	0.025	0.019	0.035	0.044	0.009	
	(EM)	0.041	0.038	0.034	0.021	0.036	
Interaction	(P = 0.05)	NS	*	*	NS	*	

Application of organic matter had different effects on yields. The supply of rice straw produced the lowest increment in yields, primarily due to its lower nutrient content and high C:N ratio. In contrast, application of cattle manure and to a greater extent legume leaves enhanced yields significantly. These materials with higher nutrient contents and low C:N ratios have the capacity to provide nutrients to crops at a more rapid rate through microbial decomposition.

Addition of organic matter in the wet season had a greater impact on yields. Application of straw in the first wet season increased yields of mungbeans by 80 percent when compared to that obtained without organic matter, in comparison to a 27 percent increment in tomato in the dry season of the same year. This could be attributed to the requirement of moisture for microbial activity which activates organic matter breakdown and releases nutrients for crop growth.

In both seasons, yields of plots not supplied with organic matter decline with time. It was greater in the dry season. Addition of organic matter, especially cattle manure and legume leaves enhanced yields significantly upto three years and stabilised thereafter. In contrast, although yields were lower when straw was added, productivity increased beyond three years, especially in the dry season. This is an important factor, as regular application of lower quality organic matter as done in most tropical regions, becomes a prerequisite for maintaining productivity.

More importantly, application of EM enhanced yields of all organic systems from the first season. Thereafter the yields show a rising trend in all seasons. The beneficial effect of EM was observed over time, and did not reach stability during the 5 years of experimentation. Furthermore, yield increments observed at the end of 5 years were significantly greater than in the absence of this microbial solution. In the final season, application of EM to legume leaves increased yields of mungbean and tomato by 67 percent and 19 percent respectively over that of the first season. Similarly, application of EM to cattle manure enhanced yields of mungbean and tomato by 64 percent and 32 percent respectively in the last season. In rice straw the increments with EM in the fifth season were 71 percent and 41 percent for mungbean and tomato respectively. This clearly illustrated the benefits of using this microbial solution to increase yields and more importantly, to continue the yield increments with time. In addition, the impact of EM was greater in the wet season, which could be attributed to the requirement of moisture for microbial activity. The results also highlight the benefits of using good quality organic matter with low C:N ratios irrespective of the season or crop to obtain the highest yields with EM.

One important feature was the ability of EM to enhance crop yields with the use of low quality manures such as rice straw, which is readily available in most developing regions. In the wet season, the increment in yields of mungbean when grown with EM and rice straw after 5 years was some 71 percent than the first season. In the dry season the comparative increment in tomato was 41 percent. These values are greater than those obtained with the other organic materials. This has a significant impact in organic farming systems of the developing world, where organic matter available for crop production is generally of a low quality.

A common notion in existence is that microbial solutions which release nutrients rapidly, decomposes organic matter at a faster rate than normal. Hence, one could argue that application of EM would also deplete organic matter levels in soils rather than enhance it, which is important in maintaining sustainability.

The non inclusion of organic matter depleted organic carbon contents of soils (Table 2), a common phenomenon observed in tropical crop production. Application of organic matter at a rate equivalent to 10 MT per ha build up organic matter contents. The most significant impact was with rice straw, which has a slow rate of decomposition due to the high C:N ratio.

Table 2. Effect of Organic Matter and EM on Organic Carbon Content of Soil over Five Years

Organic Matter	Application of EM	% Organic Carbon in Soils			
		Year 1	Year 3	Year 5	Sx (n=9)
Legume Leaves	No	1.14	1.18	1.24	0.011
	Yes	1.27	1.23	1.25	0.004
Rice Straw	No	1.18	1.21	1.27	0.021
	Yes	1.19	1.23	1.29	0.005
Cattle Manure	No	1.10	1.16	1.23	0.11
	Yes	1.12	1.15	1.24	0.05
No. Additives		1.01	0.95	0.86	0.14
Probability	(Organic matter)	0.041	0.028	0.038	
	EM	0.009	0.033	0.015	
Interaction	(P = 0.05)	*	NS	*	

* Organic carbon measured at the end of the second cropping season of the respective years

In contrast to expectations, EM also build up organic matter contents in soils. This is due to the phenomenon of fermentation of organic matter by EM rather than decomposition. This process releases nutrients and organic compounds such as amino acids which are utilized by plants (Higa, 1996). Therefore, EM could easily be used by farmers to enahance yields of organic systems while maintaining sustainability, without fears of depleting soil organic matter and thereby soil quality.

Conclusions This study carried out over 5 years illustrated that organic matter is a prerequisite for organic farming. The use of good quality organic matter such as leaves of legumes or animal manures has a greater impact on yields, irrespective of season. The use of more common low quality organic materials such as rice straw does not increase yield rapidly, but has a long term beneficial impact. These materials also enhanced soil organic matter.

EM a microbial solution becoming popular in many countries enhanced yields of organic systems. It also had the capacity of increasing yields over a long period of time. EM also builds up organic matter. Hence, the application of Effective Micro-organisms, which consist of commonly available species in all ecosystems, produces three important and useful benefits. These are (i) increasing of crop yields, (ii) building up of soil organic matter to maintain sustainability and (iii) enhancing the utility value of low quality organic materials commonly used in tropical farming systems with time.

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