Effect of EM on Vegetable Production in Sri Lanka: An Economic Analysis

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Abstract

Crop production in traditional organic farming systems of the tropics is characterized by the use of available agricultural wastes as soil conditioners and biofertilizers. However, the output in terms of economic yield is generally low. This results in marginal profitability for those farmers who practice organic farming methods. The technology of Effective Microorganisms (EM), now advocated as an important dimension of Kyusei Nature Farming, has been shown to increase the yield and, quality of tropical crops in organic farming systems. In the present study, EM cultures were applied to traditional organic systems that utilized only organic amendments (i.e., crop residues and animal manures). For three years, crop yields, production costs and net returns were monitored. The selected crops were sweet potato (*Ipomoea batatas* L.) and bush bean (*Phaseolus vulgaris* L.). Yields of these two crops were increased significantly from the application of EM to the traditional organic system. Even though the overall production costs were increased from the purchase and application of EM, net returns due to EM increased over time. Thus, most organic farmers could afford to adopt EM technology and readily obtain a significant increase in net returns and profitability.

Introduction

The demand for organically-grown food crops is expected to increase markedly in the years ahead as consumers become more concerned about pesticide residues in the human diet (Tietz, 1990). Consequently, organic crop and livestock production systems are gaining popularity in both developed and developing countries (IFIA, 1992). Traditional organic farming systems have evolved in developing countries mainly because farmers could not afford the cost of agrichemicals (i.e., chemical fertilizers and pesticides). Thus, most small holder, subsistence-level farmers utilize available crop residues, animal manures and off-farm vegetative materials as organic amendments to supply plant nutrients and maintain soil productivity. Nevertheless, the yields of food crops grown in these systems are generally low and of poor quality (Pulschen and Lutzeyer, 1993). Since organically-grown crops in developing countries have considerable potential for export to developed countries, national governments (i.e., ministries of agriculture) need to assess the economic feasibility of these farming systems and determine how they might be improved (Schaus, 1991; Keulen and de Vries, 1993).

Many methods and technologies have been recommended for improving the economic feasibility of tropical farming systems (Miller and Kay, 1993). Among these are the use of microbial inoculants to improve plant growth and yield in problem soils (Dobereiner, 1994). Another of these new technologies is that of Effective Microorganisms (EM), which consists of naturally-occurring, mixed cultures of beneficial microorganisms developed by Professor Teruo Higa at the University of the Ryukyus, Okinawa, Japan (Higa, 1991). Research has shown that EM microbial inoculants can improve soil quality and the growth, yield, quality and protection of crops, especially in organic farming systems (Higa and Parr, 1994).

Thus, EM appears to be a useful technology for enhancing the economic feasibility of organic farming systems. Because such information was limited, the present study was conducted to determine the effect of different commonly-used organic amendments applied with and without EM on the yield of selected food crops, and to assess the economic feasibility of using EM in traditional organic farming systems.

The study was conducted at the University of Peradeniya, located in the mid-country intermediate zone of Sri Lanka, during the wet seasons (October to March) of 1991, 1992 and 1993. The selected crops were sweet potato (*Ipomoea batatas* L., var. Wariyapola) and bush bean (*Phaseolus vulgaris* L., var. Wade) which are commonly grown through-out the region.

Treatments included the following organic amendments:

1. Control (non-organic) — no organic amendments applied.
2. Legume leaves (mainly from Gliricidia) — C:N ratio 15.4.
3. Rice straw — C:N ratio 52.6.
4. Cattle manure — C:N ratio 12.2.

All amendments were applied to individual plots (3 x 4 m) at a rate of 8 metric tons per hectare, with or without EM, according to a randomized block design with three replicates per treatment for each crop. A control treatment, without organic amendments or EM, was included for comparison. Thus, a total of seven treatments were applied to the same plots in all three years to avoid confounding of residual effects. Precautions were taken to prevent contamination of the non-EM plots with those which received EM.

At the beginning of each season, the organic amendments were applied to the appropriate plots with or without EM. Designated plots were spray-applied with EM after a 1:500 dilution and at a rate equivalent to 10 liters/ha of EM stock solution. The organic amendments (with or without EM) were incorporated into the soil by tilling, and the two crops (i.e., sweet potato and bush bean) were planted two weeks later. The crops were managed according to recommendations of the Sri Lankan Department of Agriculture (1989) without any agrichemicals applied. The EM stock solution was diluted 1:1,000 and spray-applied at the V2, R1 and R4 growth stages of each crop, at a rate equivalent to 3 liters/ha of EM stock solution. Weeding was done manually on two occasions.

The sweet potato crop was harvested at maturity (R8 stage) and bush bean at the fresh pod (R6) growth stage. The expenses incurred in crop management for all three years were recorded, Means were calculated for the organic farming systems with and without EM. Economics of costs and net returns were based on current market values. A uniform pricing policy was adopted to overcome any discrepancies in making comparisons between years.

Results and Discussion

Crop Yields

As shown in Table 1, the organic amendments significantly and progressively increased the yields of sweet potato and bush bean over three years of the study. For example, the mean yield increment for sweet potato from application of organic amendments was 48 percent the first year and 95 percent the third year, compared with the control plots. The mean yield increments for bush bean due to organic amendments during these same years were 47 and 204 percent, respectively, compared with the untreated control plots. The organic amendments had a greater effect on increasing bush bean yields than on sweet potato. The low yields of both crops in the untreated control plots emphasizes the need for inputs to sustain some minimal level of soil fertility and productivity. A low-input system may be sustainable, but a no-input system will probably not be.

Table 1. Effect of EM and Organic Amendments on Yields of Sweet Potato and Bush Bean over Three Years in Organic Farming Systems.

Treatments	Sweet potato (kg/ha)				Bush bean (kg/ha)			
	Year1	Year2	Year3	Sx	Year1	Year2	Year3	Sx
Legume leaves	5125	5580	6204	46.2	2240	3172	4250	51.5
Rice straw	4404	4884	5256	21.5	1985	2440	3216	30.4
Cattle manure	5590	5985	6704	58.2	2408	3208	4415	40.2
Legume leaves+EM	6056	6104	8456	90.6	2885	3942	5240	45.9
Rice straw+EM	5196	5420	6994	75.8	2425	3204	4450	68.2
Cattle manure+EM	6584	6658	7040	50.5	3036	4108	5426	71.5
Control	3400	3156	3090	86.4	1485	1304	1299	42.9
Sx	124.7	86.8	140.4		156.4	99.5	80.4	

The application of EM with the organic amendments further enhanced the yields of both crops, thereby confirming similar results reported earlier (Parr et al., 1994). In the first year, the application of EM with organic amendments increased the mean yields of sweet potato by 17 percent compared with plots which received organic amendments alone. Likewise, the first year mean yield increase for bush bean due to EM was 25 percent greater than from organic amendments alone.

The mean yield increments for both crops in the third year from EM and organic amendments were greater than the first year. For example, the yields of sweet potato and bush bean from plots treated with EM and organic amendments were 23 and 27 percent greater, respectively, compared with plots which received only the organic amendments. The third-year yield increments for sweet potato and bush bean from plots treated with EM and the organic amendments were 87 and 280 percent greater, respectively, compared with the untreated control plots.

These results clearly indicate the potential benefits that can be obtained from the use of EM in organic farming systems. It also shows that the efficacy of EM in these systems progressively increased with time. The results can likely be attributed to changes in the soil microflora and microfauna, and in the plant rhizosphere, that are beneficial to plant growth and health (Sangakkara, 1996). This may help to explain why EM had a greater beneficial effect on bush bean, a legume crop with a microbial symbiotic relationship. Also, the beneficial effects of EM on soil chemical and physical properties have been widely reported (Higa, 1994).

Economic Analysis

The economic advantages of using organic amendments both with and without EM for the production of food crops are shown in Tables 2 and 3, based on a benefit: cost analysis. The net returns from either crop grown without organic amendments (i.e., the untreated controls) were low and further declined with time. This is the typical situation for most subsistence-level, tropical farming systems where the lack of essential inputs is not economically sustainable, and soon leads to financial instability of the farm family. Obviously, such marginal and unsustainable farming systems would benefit greatly from the proper and regular additions of organic amendments to improve and maintain soil productivity and sustainability.

Table 2. Effect of EM and Organic Amendments on the Benefit:Cost Analysis of Sweet Potato Yields and Sales over Three Years in Organic Farming Systems.

Costs, Income and Benefits	Control (untreated)		Organic inputs		Organic inputs+EM	
	Year1	Year3	Year1	Year3	Year1	Year3
Costs						
Labor (100 SLR/day)	24,000	24,000	24,000	24,000	24,000	24,000
Planting	500	500	500	500	500	500
Organic materials			12,000	12,000	12,000	12,000
EM purchase					1,500	1,500
EM application					2,500	2,500
Total costs	24,500	24,500	36,500	36,500	40,500	40,500
Cost over control			12,000	12,000	16,000	16,000
Cost of using EM					4,000	4,000
Income						
Produce (25 SLR/kg)	48,000	37,080	60,475	72,650	71,340	97,960
Income over control			12,475	35,570	23,340	60,880
Income from EM					10,865	25,310
Benefit: Cost (B:C)						
B:C over control			1.04	2.96	1.46	3.80
B:C from using EM					2.72	6.33

SLR = Sri Lankan Rupee. Exchange rate: $1.00 USD = Rs 48 SLR.

Cost and income from organic systems are based on the mean costs and returns of three organic amendments, i.e., legume leaves, rice straw and cattle manure.

Table 3. Effect of EM and Organic Amendments on the Benefit : Cost Analysis of Bush Bean Yields and Sales over Three Years in Organic Farming Systems.

Costs, Income and Benefits	Control (untreated)		Organic inputs		Organic inputs+EM	
	Year1	Year3	Year1	Year3	Year1	Year3
Costs						
Labor (100 SLR/day)	30,000	30,000	30,000	30,000	30,000	30,000
Planting	1,500	1,500	1,500	1,500	1,500	1,500
Organic materials			12,000	12,000	12,000	12,000
EM purchase					1,500	1,500
EM application					2,500	2,500
Total costs	31,500	31,500	43,500	43,500	47,500	47,500
Cost over control			12,000	12,000	16,000	16,000
Cost of using EM					4,000	4,000
Income						
Produce (25 SLR/kg)	37,125	32,475	55,275	99,000	69,550	125,960
Income over control			18,150	66,525	32,425	93,485
Income from EM					14,275	26,960
Benefit:Cost (B:C)						
B:C over control			1.51	5.54	2.03	5.84
B:C from using EM					3.57	6.74

SLR = Sri Lankan Rupee. Exchange rate: $1.00 USD = Rs 48 SLR.

Cost and income from organic systems are based on the mean costs and returns of three organic amendments, i.e., legume leaves, rice straw and cattle manure.

The application of organic amendments during the first year increased the benefit: cost ratios of sweet potato and bush bean by 1.04 and 1.51, respectively. The net profit realized from the bean crop was substantially higher than that of sweet potato in the first year which could be attributed to the low level of soil fertility. The yield of legume crops in these impoverished soils often do reasonably well compared with crops such as sweet potato that would likely be deficient in nitrogen, at least initially. Interestingly, by the third year, the benefit: cost ratio of sweet potato and bush bean grown with organic amendments increased to 2.96 and 5.54, respectively. This indicates that the application of organic amendments to this soil was more profitable with bush bean than sweet potato. The increased benefit: cost ratio for these crops is largely due to the improvement in soil quality rendered by the organic amendments and also to a more favorable root surface-rhizosphere relationship (Mengel and Kirkby, 1987; Sangakkara, 1996).

The application of EM in addition to the organic amendments further increased the benefit: cost ratios, compared with the amendments alone. In the first year, the organic amendments + EM increased the benefit: cost ratios of sweet potato and bush bean by 1.46 and 2.03, respectively, as reported in Tables 2 and 3. Thus, the profit increment is significant even in the first year despite the increased cost of purchasing and applying EM. In the third year, the benefit: cost ratios of sweet potato and bush bean increased to 3.80 and 5.84, respectively. These results strongly suggest that farmers could increase their net returns significantly by applying EM with available organic amendments.

A comparison of the benefit: cost ratios from application of organic amendments with and without EM (Tables 2 and 3) shows that it would have been more profitable to include EM even with the extra cost (RS 4,000) of doing so. In the first year, the additional cost of EM was offset by increases in the benefit: cost returns of 2.72 and 3.57 for sweet potato and bush bean, respectively; while in the third year, the benefits due to EM increased the returns by 6.32 and 6.74 for sweet potato and bush bean, respectively. Again, this clearly indicates that farmers practicing organic methods of crop production could derive considerable benefits from applying EM, especially over the long-term.

The increased cost of EM as an input is well-justified because crop yields increase with time. When the additional benefits of EM on the soil-plant ecosystem are considered, the utility value of this technology is increased accordingly. Research has shown that EM has the capacity to transform the rhizosphere of plants into a more favorable microbial environment to sustain arable crop production (Higa, 1994; Sangakkara, 1996).

Conclusions

Most small holder, subsistence-level organic farming systems are economically unsustainable mainly because nutrients and energy are continually removed in producing crops without sufficient inputs to replace them. EM is a proven technology for increasing the growth, yield and quality of crops in organic farming systems. Farmers that utilize organic methods and practices could benefit considerably from applying EM in conjunction with available organic amendments. EM can help to enhance the productivity and long-term economic sustainability of these small holder units.

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