Influence of Method of Application of Effective Microorganisms on Growth and Yields of Selected Crops

U. R. Sangakkara and B. Marambe
Faculty of Agriculture, University of Peradeniya, Sri Lanka

Abstract
Effective Microorganism (EM) solutions have been proven to be very useful and effective in a diverse range of environments, both under field and plant house conditions. The beneficial role of these microbial solutions stems from the ability to break down organic matter, thereby providing plant nutrients, and enhancing soil physical and chemical properties. However, different systems adopt different methods of applying EM ranging from soil or foliar application to composting. But, the results of different methods of application could vary significantly. Thus, a field study evaluated different methods of applying EM on growth and yields of two important vegetables, namely frenchbeans and tomato, when grown with two types of organic matter.
Foliar application of EM on two occasions after planting produced the lowest yields. In contrast, applying EM to organic matter added to the field plus two foliar applications produced the highest yield. Yields obtained by the addition of organic matter composed at an external location with EM prior to field application along with two foliar applications were marginally lower. The yields produced by plants supplied with EM in other forms were intermediate to these treatments, irrespective of seasons. The study illustrated the benefits of in situ composting of organic matter with EM and foliar applications at important growth stages to maintain high yields of the selected vegetables.

Introduction
Microorganisms enhance the efficacy of organic farming systems (Dobreiner, 1994, Parr et al, 1994), due to their role in decompostion of manures, symbiotic and fermentative processes. History records their use in agriculture from ancient times, especially for making compost and in symbiotic processes, highlighted by *Rhizobium*. In the recent past, solutions of microbes for organic farming systems have been developed by many countries and organizations. Amongst these, Effective Microorganisms, popularly known as EM, produced by the University of the Ryukyus, Okinawa, Japan in the early 1980's have gathered much prominence in many regions of the world (Parr et al, 1997). The role of EM in agriculture has been reported as one of decomposing organic matter, while enhancing the qualities of the rhizosphere. Thus crop yields have been enhanced on a sustainable basis in organic systems, and environmental quality preserved (Parr et al, 1997).
Effective Microorganisms solutions contain a mixture of five genera of organisms, namely Actinomycetes, Ray fungi, Photosynthetic bacteria, Yeasts and Lactic acid bacteria (Higa, 1994). These are contained in a molasses base at a pH below 4.0. The use of EM in crop production is either by direct application to the soil, to organic matter spread on the soil surface or to the plant. However, it can be used in composting organic matter at a different location and this material applied to the soil prior to planting (APNAN, 1995). Research (e.g. Parr et.al. 1997) illustrate the different methods of applying EM in crop production, all of which report beneficial results of using this solution in a wide range of environments. However, a comparative study on the effectiveness of different methods of EM application has not been reported. As the method of EM application could influence the efficacy of the microbial solution, a field experiment evaluated the merits of applying this inoculum in a variety of methods. The study utilized two commonly grown vegetables in the tropics, and the organic matter selected were based on their application by smallholder farmers of the developing countries to enhance soil fertility.

Materials and Methods
The study was carried out at the Experimental Station of the University of Peradeniya, Sri Lanka over the wet season (October – February) of 1995/96. The site was located on an Ultisol

(Rhododult) and the plots had been utilized for experiments with EM for over 2 years. The pH of the soil (1: 2.5 H_2O) was 6.14 $\pm$ 0.42, with an organic matter content of 0.96 percent $\pm$ 0.12 percent and a CEC of 12.24 m eq/100 g soil.

The selcted crops namely tomato (*Lycospersicon esculentum* L., var-Marglobe) and common bean (*Phaseolus vulgaris* L., var Wade) were grown on separate plots (3 x 4 m) as recommended for conditions of Sri Lanka by the Department of Agriculture (1990). The organic manures used were leaves of leguminous trees (Leucaena and Gliricidia in a ratio of 1:1) or rice straw, applied at a rate of 10 mt per hecatare (1 kg per sq. m on a fresh wt basis)

The treatments of the experiment were as follows;

- Bare soil
- EM applied onto leaves
- Application of legume leaves or straw onto plot
- EM applied onto legume leaves or straw spread on plots
- EM applied onto legume leaves or straw followed by two sprays to leaves of the crop
- EM applied to heaped legume leaves or straw at an external location and applied to the plots at the same rate as for *in situ* applications
- The above treatment combined with two sprays of EM onto the leaves of the crop

Each crop was subjected to these 13 treatments laid out within a randomized block design with four replicates. No chemical fertilizers were applied. Care was taken to prevent cross contamination of the EM treated and non treated plots, by having adequate borders.

EM was applied to the soil or the organic matter at a dilution of 1 : 500. The rate used was equivalent to 5 litres of EM solution per ha. In the plots where the organic matter was placed *in situ*, the material was spread evenly on plots two weeks before planting and EM applied. Thereafter, the organic matter was mixed into the soil. In the ex situ applications, the organic matter was heaped, EM sprayed 20 days before planting and mixed. Thereafter, this heap was covered with black polythene. The partially composted material was spread onto the plots three days before planting and mixed into the soil.

Foliar applications of EM was carried out at V6/R1 and R4 growth stages at a dilution of 1:1000 and at a rate of 3 l per ha. The crops were entirely rainfed and were weeded on two occasions. Crops were harvested at maturity and fresh weights of tomato fruits and bean pods were determined. The data was subjected to appropriate statistical analysis to determine the significance of the observed differences.

Results and Discussion

Application of an additive enhanced yields of tomato significantly (Table 1). This clearly presented the degraded nature of the soil, which is common in most tropical smallholder farming units.

Application of EM to the bare soil enhanced yields by 9 percent when compared to that obtained from the control plots to which organic matter or the inoculum was not added (control plots). Foliar application of EM alone increased yields by 10 percent over the control. This suggested that application of EM alone to soil or plants at important growth stages produce similar results.

The benefits of applying organic matter, especially material such as legume leaves with a low C:N ratio is clearly evident in this study. Thus application of legume leaves or rice straw increased yields of tomato to a greater extent than when EM was applied alone. Thus under tropical conditions, organic matter has a significant role in maintaining productivity of cropping systems, confirming reports of Pretty (1996). The application of microbial inoculants alone does not help enhance yields in degraded soils. Application of EM to legume leaves or straw spread on the soil surface increased yields of tomato by 10 percent and 6 percent when compared to yields of plots receiving the organic matter alone. In contrast, *ex situ* composting of the same organic matter with EM and spreading the material produced lower yields (7 percent and 5 percent with legume leaves and straw respectively). This showed the advantage of composting organic matter *in situ* with EM, especially as the process is rapid with this inoculant (Higa 1994). Furthermore, composting *in situ* could retain any nutrient released in the process within the rhizosphere, and avoid transportation costs. Foliar application combined with soil application increased yields further. A greater increase in yields is seen when organic matter is composted *in situ*, especially with material such as legume leaves. This clearly presented the usefulness of applying EM to organic matter at planting along with foliar applications, to derive the optimal results of the inoculant.

Table 1. Effect of Method of EM Application on Growth and Yield of Tomato

Treatment	Yield (g/m^2)
Bare soil	742
Soil + EM	816
EM to leaves	821
Legume leaves	1245
Legume leaves + EM (in situ)	1380
Legume leaves + EM (in situ) + spray	1456
Legume leaves + EM (ex situ)	1341
Legume leaves + EM (ex situ) + spray	1402
Rice straw	996
Rice straw + EM (in situ)	1061
Rice straw + EM (in situ) + spray	1124
Rice straw + EM (ex situ)	1049
Rice straw + EM (ex situ) + spray	1096
LDS (P=0.05)	16.09

The effects of the selected organic materials and method of application of EM on yields of beans was similar to that of tomato (Table 2). This confirmed the benefits of using organic matter with a low C:N ratio, irrespective of the use of EM, to enhance yields of tropical food crops. This could be attributed to its higher nutrient content, especially nitrogen and its rapid decomposition. Application of EM enhances its efficacy to a greater extent.

Table 2. Growth and Yield of Frenchbean as Affected by Method of EM Application

Treatment	Yield (g/m^2)
Bare soil	225
Soil + EM	250
EM to leaves	241
Legume leaves	324
Legume leaves + EM (in situ)	368
Legume leaves + EM (in situ) + spray	395
Legume leaves + EM (ex situ)	350
Legume leaves + EM (ex situ) + spray	312
Rice straw	276
Rice straw + EM (in situ)	299
Rice straw + EM (in situ) + spray	315
Rice straw + EM (ex situ)	298
Rice straw + EM (ex situ) + spray	309
LDS (P=0.05)	4.89

Application of EM to a given organic matter *in situ* coupled with foliar application at important growth stages produce the highest yields in beans. This again could be attributed to the retention of nutrients during decomposing, and the vigour imparted to the plant by foliar sprays (Higa, 1994).
An interesting aspect of this study was the yield increments caused by the two types of organic matter and EM. The increment in yield is greater in beans than in tomato. For example, in situ

composting of legume leaves with EM with foliar application increased yields of beans by 21 percent, when compared to the application of organic matter alone. The comparative increase in yields of tomato was 17 percent. Thus crops such as legumes having other symbiotic processes such as nitrogen fixation in the rhizosphere could benefit to a greater extent by the use of EM, which also enhances these biological processes (Sangakkara 1997).

Conclusion

The effectiveness of the solutions of EM can be increased by many processes. However, smallholder farmers need simple techniques to obtain the optimum results from their inputs. Thus, the method of application of EM could enhance the efficacy of the inoculant, which could be successfully carried out by most farmers.

This study revealed that application of EM to organic matter spread on the ground is the best method for composting organic matter. This could be followed up with two foliar applications of EM to maintain crop vigour. This would ensure the highest yields from crops grown in nature farming systems of the tropics using the technology of Effective Microorganisms.

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