EM Application Studies on a Low Organic Matter Soil in India

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Abstract : *The combination of low organic matter and high contents of gravel and stone is a soil fertility constraint faced by small farmers in semi-arid regions. Because inputs such as farmyard manure are too expensive, alternative soil amendment options are being investigated in a long-term study on a sandy clay soil of high pH in Pune, India. Out of the eight treatments in the study, four included the use of Effective Microorganisms (EM) in the form of compost, soil and foliar spray or in combination with other amendments. Experiments have been completed for four consecutive seasons and the yields of onion, soybean and carrot are presented. Results show non-significant yield increases of 12-16% over the control treatment after the third season. Soil analysis did not show differences among the treatments in soil nutrient content or electrical conductivity. In spite of the relatively smaller quantities of organic matter applied, for example 2.0 t ha^{-1} season^{-1} of EM compost, and summer temperatures exceeding 40^{o}C, favourable crop and soil responses have been observed in two years with EM application. Hence soil amendment with EM technology is a promising alternative for degraded farmlands in dry areas.*

Introduction

A major constraint to crop production in dry tropical environments is the low soil organic matter content and biological activity. In many highly eroded soils, what remains as the surface layer is a mixture of stones, gravel and soil particles. Although such soils are unsuitable for annual crop production, small farmers are forced to cultivate them because of the pressure on land. In some parts of India, fortunately, the parent material is basalt. It has lower resistance to weathering than most other rocks and breaks up easily (Gerrard, 1988). This attribute has to be taken advantage of in the management of these soils to improve their productivity over a period of time.

The conventional method of building up soil organic matter is through the application of manures such as farmyard manure and various compost preparations (Lopez-Real, 1990). There is also a build up of literature on the successful use of the Effective Microorganisms (EM) technology for increasing crop yields through natural farming methods (Higa, 1998). The quantity of EM products or traditional organic manures applied is usually in the 7.0 - 10 t ha^{-1} range (Tandon, 1994), but much higher rates of application are also reported (Tester, 1990). Biomass availability being a major limitation for farmers in the tropics, the quantity of straw and other agricultural by-products they can spare for use as manure is small. Therefore, the fertility improvement strategy for these soils has to be one that functions within the quantity and quality confines of the available biomass and builds up the biological activity of the soil over a period of time. In this regard, nature farming with EM technology is an attractive option that is simple and affordable to small farmers.

Recognising the almost inert state of soil biological activity and the prevailing crisis with regard to availability of biomass for recycling, long-term crop experimentation is in progress on a soil of low fertility. The specific objective of the study is to examine the effect of EM applications on soil productivity. It is expected that the findings of this study will help evolve appropriate soil fertility management practices.

Materials and Methods

The study was initiated in the post-rainy season of 1999 at the Central Research Station of BAIF Development Research Foundation. The station is in the rain shadow tract of Pune district in Maharashtra, India. The soil of the experimental field is a sandy clay which had an organic carbon content of 1.20% and a pH of 8.25. The cropping pattern of the area is such that a rainy season crop is grown during June to October and a post-rainy season crop from November onwards. Maximum/minimum temperatures are 36^o/20^{o}C and 25^o/05^{o}C, respectively, during the rainy and post-rainy seasons. The average annual rainfall is 450 mm, received during the months of June to October. Because of the erratic nature of the rainfall, irrigation may be necessary even during the rainy season. The post-rainy season crop is entirely dependent on irrigation.

The treatments of the study are the application of soil amendments for the enhancement of crop nutrition. The response to soil treatment is being investigated with crops grown every season in a randomised complete block design with four replications. The plots are 5.0 x 5.0 m and separated by a 1.0 m path. The treatments are: 1) Control, 2) Recommended crop nutrition for each crop, 3) EM soil and foliar spray 1:500 dilution at 1.0 l m^{-2} at weekly intervals 4) EM compost at 2.0 t ha^{-1}, 5) flyash 20 t ha^{-1}, 6) flyash 10 t ha^{-1} + EM soil spray, 7) EM compost 1.0 t and flyash 10 t ha^{-1} and 8) Bioplin (a commercial product) 1:200 dilution at 25 ml m^2 weekly foliar spray. Flyash application was discontinued after the post-rainy season crop of 2000; instead, farmyard manure was applied at 2.0 t ha^{-1} in treatments 5 and 6, and 1.0 t ha^{-1} in treatment 7. The EM compost was made with soybean husk and wheat in a 1:1 ratio.

The post-rainy season crops of 1999 and 2000, respectively, were onion (*Allium cepa*, local variety) and carrot (*Daucus carota*, Pusa Red) while soybean (*Glycine max*, variety MACS-450) was the rainy season crop for both 2000 and 2001. Land was prepared as per the standard method for each crop and the soil amendments were applied before transplanting onion or sowing of other crops. Recommended spacing and agronomic practices were followed for all crops. Soil samples of the upper 15 cm layer were analysed at the end of the rainy season of 2001. At crop maturity, yield and yield components were determined and treatment differences were tested for significance using the analysis of variance method.

Results and Discussion

Degraded soils such as the one in which the present study is being conducted tend to show a high degree of heterogeneity even within a small area. Nevertheless, considering the soil and the nature of the investigation, the coefficients of variation for the various parameters measured in the present study were within acceptable limits. Results of the first trial carried out during the post-rainy season of 1999 are presented in Table 1. The yield of onion was not significantly influenced by treatments, but minor differences were observed. It appears that the quantity and quality of EM compost applied were not substantial enough to make a yield difference in the first season of application. Moreover, as the land was under leguminous trees earlier, it probably had adequate native fertility, as reflected by the relatively high yield of the control treatment.

Bulb size was significantly larger when Bioplin, a commercial biological fertility enhancer, was applied to the soil. Bulbs of the EM spray and compost application treatments were similar in size to the control and fertiliser applied treatments. In the flyash treatments, the bulb size was adversely affected, probably due to soil compaction. The results of the second crop, soybean in the rainy season of 2000, also did not show significant differences in yield components or grain yield (Table 2). The highest grain yield was in plots receiving a mixture of flyash and EM compost. This combination seemed to have benefited from the mineral nutrients in flyash as well as the organic attributes of EM compost.

Table 1. Yield Parameters of Post-Rainy Season Onion (1999) and Rainy Season Soybean (2000)

Treatment	Onion		Soybean	
	Bulb size, g	Yield, t ha^{-1}	100 seed wt., g	Grain yield, t ha^{-1}
Control	48.6	14.9	12.54	2.29
NPK	50.7	15.5	14.61	2.30
EM soil + foliar spray	48.6	14.8	13.40	1.97
EM compost	48.6	15.2	14.39	2.16
Flyash	46.0	15.4	13.52	2.11
EM spray + Flyash	44.9	15.6	12.23	1.85
EM compost + Flyash	45.0	13.6	13.61	2.38
Bioplin	57.7	18.6	13.76	2.13
SE±	3.93	1.33	0.42	0.15

Favourable effects of EM compost were perceptible in the third crop since the beginning of the study. In the post-rainy season trial of the year 2000, the highest yield was obtained with the treatment receiving EM compost. Although the difference was not significant, it was 16% more than the control and 12% more than the fertiliser-applied plots. The yield component contributing to the higher yield was root diameter (Table 1), which is also a determinant of consumer preference.

Table 2. Yield Parameters of Post-Rainy Season Carrot (2000) and Rainy Season Soybean (2001).

Treatment	Carrot		Soybean	
	Root girth, Cm	Yield, t ha^{-1}	100 seed wt., g	Grain yield, t ha^{-1}
Control	3.08	16.13	15.77	2.32
NPK	2.98	16.88	16.07	2.64
EM soil and foliar spray	3.24	16.09	16.34	2.45
EM compost	3.28	18.79	15.93	2.60
Farmyard manure (FYM)	3.04	16.82	16.26	2.49
EM spray + FYM	3.06	15.36	15.66	2.54
EM compost + FYM	3.13	16.44	16.52	2.64
Bioplin	3.34	16.03	16.36	2.66
SE±	0.20	1.52	0.31	0.20

Yield trends of the 2001 soybean were similar to that of the carrot crop of the previous season. Treatments that received soil ameliorants produced 7.0 to 15% more grain than the untreated control, but the differences were again not significant. The lower yield of the control is indicative of the waning of the natural fertility in the untreated plots. On the other hand, all the biological fertility enhancers in the study seemed to have a positive effect on soybean. This is evident in EM-treated plots producing soybean grain yields comparable to that of the treatment receiving the recommended dose of fertiliser. Although the tendency is to attribute yield increments to favourable changes in soil fertility, the role of photosynthetic bacteria cannot be ignored as seen in the increase of soybean yield, though marginal, in the EM sprayed treatment.

Stability of yields is an important consideration while introducing new technologies. There are many instances where small farmers adopted new technologies, but realised later that they are unsustainable. As a simple measurement of sustainability, the yields obtained with selected treatments are expressed as a percentage of the control (Figure 1). Differences were small in the first season, but most of the treatments had values less than 100% in the second season as the yield of the control treatment was relatively high. Thereafter, the treated plots yielded more than the control and the trend is generally upward. Although two years is too short a period to make a conclusion with regard to sustainability, the results are indeed encouraging.

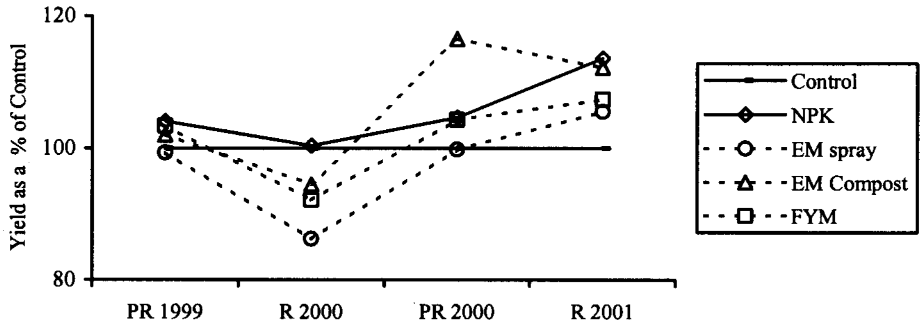

Figure 1. Stability of Crop Yields During Four Years of Cropping

The experimental period of two years during which four crops were cultivated sequentially did not result in pronounced changes in soil characteristics. This is similar to the experience with repeated incorporation of large quantities of green manure that have showed no detectable enhancement of soil fertility. Although the biomass applied in the present study was smaller than usual green manure applications, the comparative microbial population introduced must have been greater. Whether a rapid improvement in soil fertility could be brought about by the incorporation of both biomass and beneficial microorganisms like EM need to be investigated.

Conclusions

Experimentation with organic soil ameliorants showed that 2.0 t ha^{-1}, applied as EM compost or farmyard manure, was not adequate to make a difference in onion and soybean yields, respectively, in the first and second seasons. Favourable effects were perceptible in the third crop since the beginning of the study when plots receiving EM compost yielded 16% more soybean grains than the control. These trends continued during the next season as well when the yield advantage was 12%. Results show that even relatively small quantities of organic matter application can be beneficial if it is done every season. Soybean husk and wheat straw in a 1:1 ratio composted with EM is as effective as farmyard manure.

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