Effect of EM on Peanut Production and Soil Fertility in the Red Soil Region of China

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Abstract

Peanut is one of the most important oil crops in the Red Soil Region of China. However, yields are relatively low, averaging only about 1500 kg/ha. A three-year study was conducted to evaluate the effect of EM, a microbial inoculant obtained from Japan, on soil nutrient transformations, changes in the types and numbers of soil microorganisms, germination percentage, and yield of peanut. Two treatments were applied: a) organic manure (OM) and b) organic manure and EM (OM+EM). Application of EM significantly increased the soil content of available nutrients, organic matter, and total N; and lowered the C:N ratio. Soil microbial populations were 1.5 times higher in the OM+EM treatment than for OM alone. The numbers of bacteria, fungi, actinomycetes and N-fixing microorganisms were higher for the OM+EM treatment compared with OM alone.

The application of EM increased peanut germination by 2 to 3 percent and peanut yield by 6.6 to 10.1 percent over the control treatment (OM). EM also significantly increased the total biomass yield and the 100-grain peanut test weight over the control. EM appeared to enhance the resistance of peanut plants to various environmental stresses that commonly occur in the Red Soil Region of China.

Introduction

Red soils occupy approximately 45 percent of the total land area of Jiangxi Province, a subtropical region of China. These soils are characterized by a low organic matter content, low fertility, high acidity, and low permeability to water, air and roots. Crop yields are generally low because of the limitations of these properties on plant growth. For example, the yield of peanut, a major crop of the region, seldom exceeds 1.5 t/ha. Consequently, there has been considerable interest among researchers on the possible use of inoculants of beneficial microorganisms and organic fertilizers (i.e., animal manures) to ameliorate these soil properties and, thereby, increase soil productivity and yield. If this could be done it would allow farmers to reduce their input of chemical fertilizers which often are potential environmental pollutants.

The purpose of this paper was to determine the effect of EM or Effective Microorganisms (a mixed culture of beneficial microorganisms obtained from the International Nature Farming Research Center, Atami, Japan) on soil fertility and yield of peanut grown on newly-cultivated red soils over a three-year period.

Materials and Methods

Soil was collected from the newly-reclaimed grassland of the Red Soil Ecological Experiment Station, and incorporated into $6m^2$ plots with four replications for each treatment. Soil properties were: organic matter content, 0.5%; total N, 0.04%; available K (as K_2O), 85.2 mg/kg; available P (as P_2O_5), 4.8mg/kg; and pH (with KCl), 3.40.

All plots were treated with a basal application of fresh swine manure (i.e., organic manure or OM) at a rate of 22.5t/ha. Potassium chloride was applied to each plot at 600kg/ha; calcium magnesium phosphate at 450kg/ha; and lime at 1,500 kg/ha. All materials except lime were applied by furrowing and banding.

The study consisted of two main treatments:

1. *Organic manure (control)* - Fresh swine manure was diluted with water and sprayed on plots at various intervals. Peanut seeds were soaked in water before planting.
2. *Organic manure + EM* - Fresh swine manure and EM were diluted with water and sprayed on plots at various intervals. Peanut seeds were soaked in EM at a 1:500 dilution for the same time that seeds were water-soaked in Treatment 1. The EM-treated seeds were then mixed with sterilized peat before planting. In both treatments, peanut seeds (variety: Yueyou II) were planted by furrowing and banding at a rate of 300 kg/ha.

Results and Discussion

Effect of EM on Emergence of Peanut Seedlings

Early emergence or rate of emergence of peanut seedlings after planting is highly correlated with ultimate grain yields. Table 1 shows that for all three years of the study, the organic manure + EM treatment gave a slightly higher rate of emergence compared with organic manure alone. Moreover, the OM+EM treatment resulted in healthier and more vigorous seedlings. A lower rate of emergence in 1993 was likely due to excessive rainfall. Even so, the higher rate of emergence with OM+EM indicates that EM could be very beneficial in promoting seedling emergence under unfavorable agroclimatic conditions.

Table 1. Effect of Organic Manure and Effective Microorganisms on the Percentage Emergence of Peanut Seedlings during 1992-94.

Year	Organic manure	Organic manure + EM
	(% emergence)	
1992	85.0	87.5
1993	79.2	81.0
1994	94.3	97.2

Effect of EM on Yield Parameters of Peanut

Table 2 shows that EM caused a dramatic increase in certain yield parameters of peanut when it was applied with organic manure compared with OM alone. Plots that received EM produced an average of 225 kg/ha more fresh biomass and higher grain yields throughout the study. The average grain yield was 10.1, 6.6, and 9.4 percent higher due to EM for each of the three years, respectively. However, the yield increase was significantly higher statistically in 1992 only. The test weight of 100 seeds due to EM was higher than the control in 1992 and 1993, but not in 1994. Peanut yields were lower in 1993 than either of the other two years mainly due to cool weather and excessive rainfall. Such conditions cause a marked increase in vegetative growth and total biomass production compared with the other years.

Table 2. Effect of Organic Manure and Effective Microorganisms on Yield Parameters of Peanut during 1992-94.

Year	Treatments	Total biomass (t/ha)	Test weight (g)	Grain yield (t/ha)	Yield increase (%)
1992	OM	9.75	65	3.25b	10.1
	OM+EM	11.67	68	3.58a	
1993	OM	11.06	59	2.52a	6.6
	OM+EM	13.57	62	2.68a	
1994	OM	9.73	63	3.22a	9.4
	OM+EM	10.82	61	3.39a	

OM = Organic manure, (fresh swine manure applied at a rate of 22.5 t/ha).
EM = Effective Microorganisms.
Total biomass is reported on a fresh weight basis.
Test weight is the weight of 100 peanut seeds (i.e., grains).
Peanut grain yields for individual years sharing the same letters are not significantly different at the 5% level of probability.

Effect of EM on Soil Fertility Parameters

The data reported in Table 3 shows that the application of EM to soil with organic manure (OM+EM) resulted in higher levels of soil organic matter, total N, extractable N by alkaline hydrolysis, available P and K and a higher soil C:N ratio. These results strongly indicate that EM increased the magnitude of these parameters over both the unfertilized control and OM applied alone. Moreover, these parameters are vital to restoring the fertility and productivity of agricultural soils.

Table 3. Effect of Organic Manure and Effective Microorganisms on Soil Fertility Parameters.

Treatments	SOM (%)	TKN (%)	Extract.N (mg/kg)	Avail.K (k_2O) (mg/kg)	Avail.P (P_2O_5) (mg/kg)	C:N
Control	0.50	0.03	40.3	85.2	4.8	8.0
OM	1.41	0.06	64.9	235.0	30.7	12.6
OM+EM	1.59	0.07	71.2	264.0	54.5	12.3

Control = Unfertilized soil.
OM = Organic manure (fresh swine manure applied at a rate of 22.5 t/ha).
EM = Effective Microorganisms.
SOM = Soil organic matter.
TKN = Total Kjeldahl nitrogen.
Extractable nitrogen was determined by alkaline hydrolysis.
Available K is expressed as K_2O; available P is expressed as P_2O_5.

Effect of EM on the Types and Numbers of Soil Microorganisms

Soil microorganisms are the driving force behind all of the biochemical processes and transformations that occur in soils. Their numbers and activities often are a direct indication of soil quality, fertility and productivity, Table 4 shows that the inoculation of plots with EM, which is a mixed culture of many beneficial microorganisms, markedly increased the types and numbers of soil microorganisms. This indicates that the EM microorganisms had become established in the red soil and were capable of improving soil quality and the growth, yield and quality of crops.

Table 4. Effect of Organic Manure and Effective Microorganisms on Populations of Soil Microorganisms.

Treatments	Bacteria	Fungi	Actinomycetes	N-Fixing bacteria	Total
	(number of organisms)				
Organic manure	$4.4x10^6$	$7.3x10^4$	$1.0x10^6$	$1.3x10^4$	$5.4x10^6$
Organic manure+EM	$11.7x10^6$	$8.1x10^4$	$1.5x10^6$	$2.2x10^4$	$13.3x10^6$

Prospects for Development and Application of EM Technology in China

In 1991, in cooperation with the International Nature Farming Research Center, Atami, Japan, the Institute of Soil Science, Chinese Academy of Sciences and the Jiangsu International Cultural Exchange Center, established the first EM Biotechnological Laboratory in China and the Jiangsu EM Biotechnology Development Center in Nanjing. During the past three years, a large number of EM application experiments have been conducted on various soils, grain and oil crops, fruit trees and vegetables, and as an additive in poultry and livestock feeds in Jiangsu, Zhejiang, Jiangxi and Henan Provinces. The results of these experiments are summarized as follows:

1. EM was particularly effective in fertile orchard soils and increased the production of vegetable crops, oil crops, and grain crops by 15, 10, and 8 percent, respectively.
2. EM promoted earlier maturity of leafy vegetables both fruit and vegetables. It raised the fruit-bearing rate of citrus and enhanced the growth of some nursery stocks.
3. EM increased the sugar content of sweet corn and watermelon.
4. EM increased the content of amino acids and water-extractable compounds in tea leaves, and increased tea yield by 20 percent.
5. EM enhanced soil nutrient transformations and increased plant available nutrients and soil microbial populations which favor the improvement of soil physico-chemical properties and soil quality.
6. When used as an additive in poultry and swine rations, EM stimulated appetite, promoted disease resistance, softened excrement, and suppressed foul odors.
7. When applied with manure, EM can reduce the need for chemical fertilizers and pesticides which improves a farmer’s profitability and protects the environment.

Conclusions

Our results have shown consistently that when EM is applied to soils with proper amounts of good quality organic materials, it can markedly improve soil quality and increase the growth and yield of crops. EM technology represents a particularly valuable component for future crop and livestock production systems as we strive for a more sustainable agriculture. Research and development efforts should now focus on the mode-of-action of mechanisms of how EM can elicit beneficial effects on soil quality, crop yield and quality, plant protection, and the environment.