Research and Development of Nature Farming Systems With Effective Microorganisms in India

A. Ahmed
Agriculture and Extension Division Center for Development Studies, New Delhi, India

Abstract

The EM Research and Development Program in India was formally inaugurated in March 1994. However, EM was first applied to Indian soils in May 1993 and since then has been used extensively by farmers on a wide variety of crops including cereals, pulses, vegetables, sugarcane, oil seeds and fruits. The impact of EM on the yield and quality of these crops has been encouraging. The land area that has been treated with EM in India and the number of farmers involved has increased significantly. Through meetings, mass media, demonstrations, and on-farm trials, EM technology has been extended to more than two million farmers and applied to some 2,000 hectares of farmland.

This is indicative of the growing interest in the use of EM and its potential benefit to Indian agriculture. Especially where soil productivity has declined because of poor soil management and intensive farming practices. India must seek new and improved technologies for achieving a long-term sustainability of it's agricultural lands in order to meet the food and fiber requirements of an expanding population. Results thus far suggest that EM may contribute significantly to achieving this goal. This paper presents a summary of the effects of EM on the growth and yield of different crops in India.

Experiment 1: Effect of EM on the Growth and Yield of Wheat

Background

Wheat (*Triticum aestivum* L.) is the second most important cereal crop grown in India, rice being the first. It is extensively cultivated throughout the country over a wide range of different soil types and agroclimatic conditions. About 75 percent of the total wheat area is planted in dryland or rainfed farming systems in mid-October, and 25 percent as an irrigated crop in November. Most of the wheat is consumed in-country as breads and as various processed food products. In view of the demand for this commodity, an experiment was conducted to determine if EM could increase the growth and yield of wheat under irrigated conditions in Uttar Pradesh.

Methods and Materials

This experiment was conducted by the Center for Development Studies (CDS) Project on farmer's fields during the Rabi season (dry season) of 1994-95 at the village of Radharani, Mathura District, Uttar Pradesh. Seedbed preparation for sowing wheat (*Triticum aestivum* L.) var. HD-1553 at 100 kg/ha was done according to the farmer's conventional practices. EM was first applied at the time of initial plowing (2.5 liters/ha of EM stock solution diluted with water); the second EM application was 25 days after sowing at the first irrigation and applied in irrigation water; the third EM application was 45 days after sowing at the second irrigation and applied in irrigation water; the fourth EM application was 75 days after sowing and applied in irrigation water. Finally, EM was foliar-applied to wheat plants 90-95 days after sowing-EM was diluted 1:1,000 with after and applied at a rate of 2,500 liters/ha.

The EM treatments were applied with and without the following soil amendments:

- Farmyard manure (FYM) 20 metric tons/ha.
- Compost (EM-Bokashi) 10metric tons/ha.
- Chemical fertilizer N-P-K (120-60-40 kg/ha) applied as urea, diammonium phosphate and potassium chloride.
- Green manure (GM) (*Dhaincha*).

The soil was of loamy texture with a pH of 7.5.

Results and Discussion

As shown in Table 1, EM alone gave higher wheat yields of biomass, grain and straw than FYM applied alone. Moreover, the yields from EM alone were equivalent to those obtained with NPK alone. The highest yields of these three parameters were obtained when EM was applied with NPK and FYM + NPK, respectively. This indicated that EM can significantly enhance the effect and efficiency of NPK and FYM in crop production. The results suggest that EM may be able to partially replace chemical fertilizers in some crop production systems.

Table 1. Effect of EM, Chemical Fertilizer and Organic Amendments on Total Biomass, Grain and Straw Yield, and Harvest Index of Wheat (Experiment 1).

Treatments	Biomass (kg/ha)	Grain (kg/ha)	Straw (kg/ha)	Harvest index (%)
EM	10,506	4,152	6,258	39.52
FYM	9,529	3,995	5,423	41.92
NPK	10,190	4,195	5,773	41.17
EM+FYM	10,235	4,264	5,862	41.66
FYM+NPK	10,564	4,336	6,156	41.04
EM+NPK	11,008	4,588	6,337	41.68
EM+FYM+NPK	11,317	4,748	6,380	41.95
EM+Compost	10,251	4,270	5,875	41.65
EM+GM	10,295	4,285	5,905	41.62

Experiment 2: Effect of EM on the Growth and Yield of Sugarcane

Background

Sugarcane (*Saccharum officinarum* L.) is the main source of sugar in India. The state of Uttar Pradesh accounts for 57 percent of the total acreage and 47 percent of India's annual production. In view of the commercial importance of this crop an experiment was conducted to determine the effect of EM on (a) the growth and yield of sugarcane and (b) the incidence and severity of red-rot disease of sugarcane.

Methods and Materials

This experiment was conducted by CDS during 1991-95 on farmer's fields in the Ghaziabad District of Uttar Pradesh. The sugarcane seed pieces (var. COJ 64) were treated with EM diluted 1:600 and applied at 600 liters/ha to rows/furrows in early April; a basal fertilizer application was made; and three irrigations were applied at 15-day intervals after shoot emergence.

EM was first applied at the time of seedbed preparation (3 liters/ha of stock solution diluted with water); the second and third EM applications were applied in irrigation water during the first and second irrigations. A final EM application was sprayed on the crop at a dilution of 1:800 in June.

The soil was of loamy texture; rather high in organic matter; slightly alkaline with a pH of 7.5; and high in available potassium - consequently, this macro nutrient was not applied in the following treatments:

- NP alone:
  174 kg N/ha applied as urea and 92 kg P/ha applied as diammonium phosphate (DAP)
- FYM + NP:
  FYM applied at 20 metric tons/ha; 110 kg N/ha applied as urea; and 46 kg P/ha applied as DAP.
- EM + FYM + NP:
  FYM applied at 20 metric tons/ha; 101kg N/ha applied as urea and DAP; 23 kg P/ha applied as DAP; and 10 liters of EM stock solution/ha.

Results and Discussion

Table 2 reports the effect of EM, chemical fertilizer and farmyard manure on the shoot length and yield of sugarcane. There was little difference in shoot length between the NP and FYM + NP

treatments, although cane yield was somewhat higher for NP compared with FYM + NP. It appears that the addition of FYM actually depressed the cane yield. However, the addition of EM to FYM + NP resulted in the greatest shoot length and highest cane yield. This suggests that EM likely enhanced the decomposition and mineralization of FYM, and increased the efficient utilization of available nutrients by the growing crop. It was also noted that the incidence of red-rot disease in sugarcane was significantly lower in the EM-treated fields compared with the non-EM treated fields. This indicated that EM provided a measure of biocontrol against this particular disease.

Table 2. Effect of EM, Chemical Fertilizer and Farmyard Manure on Shoot Length and Yield of Sugarcane (Experiment 2).

Treatments	Shoot length (cm)	Cane yield (mt/ha)
NP	202.5	138.7
FYM+NP	195.0	123.2
EM+FYM+NP	221.4	156.8

Experiment 3: Effect of EM on the Growth and Yield of Cucurbits

Background

Cucurbit crops in India are produced mainly by small landholders for local markets. A wide variety of cucurbits are grown throughout the country with the selection based on consumer preference, climatic conditions, and soil type. In view of the importance of these crops to small farmers and the local economy, a field experiment was conducted to assess the effect of EM on the growth and yield of muskmelon (*Cucumis melo* L.), watermelon (*Citrullus vulgaris* L.), pumpkin (*Cucurbita maschala* L.), bottle gourd (*Lagenaria cicenaria* L.), long melon (*Cucumis melo* L.), and cucumber (*Cucumis sativus* L.).

Methods and Materials

This experiment was conducted by CDS on farmer's fields during 1994-95 in the Mathura District of Uttar Pradesh. The soil type was sandy, well-aerated and well-drained, with a low water-holding capacity and low organic matter content. This "Doaba soil" is considered to be particularly suited to the production of cucurbit crops. The experimental layout consisted of a series of one cubic meter pits which were excavated, the soil mixed with 25 kg FYM, and then refilled. All crops were sown in December with 6 to 8 seeds per pit and later thinned to 3 to 4 vigorous plants.

EM was diluted 1:800 with water and 10 liters were applied to appropriate pits at the same time that FYM was applied, i.e., before sowing. Seeds for the EM treatments were soaked briefly in the 1:800 (EM : water) dilution before sowing. EM was diluted 1:800 and spray-applied to crops according to designated treatments four times, i.e., one week after germination and 60, 90 and 120 days after sowing. The following treatments were applied:

- FYM+ N:
  25 kg FYM per pit; urea applied at a rate of 184 kg N/ha (half applied 8 weeks after sowing and half at flowering).
- EM + FYM:
  25 kg FYM per pit; EM diluted 1:800 for seed treatment and spray-applied to crops four times during the growth period.
- EM + FYM + N:
  25 kg FYM per pit; EM diluted 1:800 for seed treatment and spray-applied to crops four times during the growth period; urea applied at a rate of 69 kg N/ha (half applied 8 weeks after sowing and half at flowering).

Results and Discussion

The effects of EM, nitrogen fertilizer and farmyard manure on the average fruit weight and yield of the cucurbit crops are reported in Tables 3 and 4. The highest fruit weight and yield for all crops

were obtained with the EM + FYM + N treatment and the lowest for the EM + FYM treatment. The FYM + N treatment resulted in the second highest fruit weight and yield of crops. These results suggest that the EM + FYM treatment may have been somewhat lacking in available nitrogen and, thus, unable to sustain higher yields. Nevertheless, when EM was applied with FYM + N it is apparent that EM significantly increased the fruit weight and yield of all six crops without exception. Moreover, it was observed that EM increased the crop seed germination percentage, the number of plant internodes and leaves, early flowering, and fruiting percentage, compared with the non-EM treatment.

Table 3. Effect of EM, Nitrogen Fertilizer and Farmyard Manure on the Average Fruit Weight and Yield of Muskmelon, Watermelon and Pumpkin (Experiment 3).

Treatments	Muskmelon		Watermelon		Pumpkin	
	Weight (kg)	Yield (mt/ha)	Weight (kg)	Yield (mt/ha)	Weight (kg)	Yield (mt/ha)
FYM+N	1.35	0.94	7.00	22.63	7.25	33.83
EM+FYM	1.12	0.81	6.80	20.42	6.95	28.94
EM+FYM+N	1.58	1.10	7.50	25.82	7.75	38.53

Table 4. Effect of EM, Nitrogen Fertilizer and Farmyard Manure on the Average Fruit Weight and Yield of Bottle Gourd, Long Melon and Cucumber (Experiment 3).

Treatments	Bottle gourd		Long melon		Cucumber	
	Weight (kg)	Yield (mt/ha)	Weight (kg)	Yield (mt/ha)	Weight (kg)	Yield (mt/ha)
FYM+N	2.00	33.26	0.18	0.67	0.15	0.82
EM+FYM	1.80	28.08	0.16	0.58	0.13	0.73
EM+FYM+N	2.25	37.05	0.22	0.78	0.16	0.90

Experiment 4: Effect of EM on the Growth and Yield of Sunflower

Background

Sunflower (*Helianthus annus* L.) has become an important oilseed crop in India following its introduction in 1969. Nevertheless, there has been a continuing shortfall in the production of sunflower and other oilseed crops in India. This has made it necessary to import edible cooking oils to alleviate shortages. In view of this, a field experiment was conducted to determine whether EM could significantly increase the growth and yield of sunflower.

Methods and Materials

This experiment was conducted by CDS on farmer's fields during 1994-95 in the Mathura District of Uttar Pradesh. The soil was of loamy texture and slightly alkaline (pH 7.5). The following treatments were applied:

- Control:
  No chemical fertilizer or EM applied.
- Chemical fertilizer:
  N-P-K (40-30-40 kg/ha) applied as urea, diammonium phosphate, and potassium chloride.
- EM + FYM:
  FYM applied at 20 metric tons/ha; EM applied at a 8 liters/ha in irrigation water at the pre-sowing stage; EM applied in irrigation water at 30 and 60 days after sowing; EM diluted 1:800 (EM : water) and sprayed on the crop before flowering.

Sunflower seed (hybrid var. NSFH-9) was sown on March 2, 1995. Crop management practices followed local recommendations.

Results and Discussion

The effect of treatments on the growth and yield of sunflower is shown in Table 5. Growth parameters and yield were highest for EM applied with FYM and followed the order of EM + FYM > NPK > control. The seed germination percentage, leaves per plant, plant height, flower size and seed yield were significantly higher for EM + FYM than for NPK or the control. One can speculate that EM enhanced the decomposition and mineralization of FYM, thereby releasing nutrients for plant uptake and utilization. It also suggests that nutrient use-efficiency with the EM + FYM treatment is actually greater than with NPK. Another interesting observation was that flowering occurred 10 days earlier for the EM treatment than the non-EM treatments.

Table 5. Effect of EM, Chemical Fertilizer and Farmyard Manure on the Growth and Yield of Sunflower (Experiment 4).

Treatments	Germination (%)	Leaves/plant (No.)	Plant height (cm)	Flower diameter (cm)	Seed yield (kg/ha)
Control	78	14.5	160	10.7	755
NPK	80	18.5	174	12.5	1075
EM+FYM	95	20.3	186	16.8	1340

The average number of leaves per plant and average plant height were recorded 60 days after sowing.

Experiment 5: Effect of EM on the Growth and Yield of Barley

Barley (*Hordeum vulgare* L.) is an important cereal crop grown during the dry season in northern India. It is grown in both rainfed and irrigated fanning systems and over a wide range of agroclimatic conditions and soil types. It has a wide variety of uses including processed food products and animal feeds. An experiment was conducted to determine whether EM could enhance the beneficial effects of FYM and NPK on the growth and yield of barley.

Methods and Materials

This experiment was conducted by CDS on farmer's fields during 1994-95 in the Mathura District of Uttar Pradesh. The soil was of loamy texture and slightly alkaline (pH 7.5). The following treatments were applied:

- EM:
  EM was first applied before sowing at a rate of 2.5 liters/ha of stock solution diluted and applied with water; applied with irrigation water 30 days (tillering stage) and 60 days (flowering stage) after sowing; diluted 1:1,000 and spray-applied on plants 90-95 days after sowing.
- Chemical fertilizer:
  N-P-K (40-20-20 kg/ha) was applied as urea, diammonium phosphate, and potassium chloride.
- EM + FYM:
  FYM applied at 10 metric tons/ha; EM applied in the same manner as described earlier.
- EM + NPK:
  EM and NPK applied in the same manner as described earlier.

Barley was sown on March 11, 1994. Crop management practices followed local recommendations.

Results and Discussion

The effects of EM, chemical fertilizer, and farmyard manure on total biomass, grain and straw yield, and harvest index of barley are shown in Table 6. The highest yields of bio-mass, grain and straw resulted when EM was applied with NPK. The second highest yields were obtained with the EM + FYM treatment. It is readily apparent that EM applied with NPK markedly increased these yield parameters over those obtained from either EM or NPK alone. The fact that there was little difference between these two singular treatments is of considerable interest because it indicates that EM (at least in this experiment) ensured an adequate level of available nutrients to the crop and, in this regard, was equivalent to the NPK treatment.

There was little difference in the harvest index values although the highest value was associated with the EM + NPK treatment. A treatment that should be included in any future follow-up experiment is FYM alone which would provide a useful basis of comparison.

Table 6. Effect of EM, Chemical Fertilizer and Farmyard Manure on Total Biomass, Grain and Straw Yield, and Harvest Index of Barley (Experiment 5).

Treatments	Biomass (kg/ha)	Grain (kg/ha)	Straw (kg/ha)	Harvest index (%)
EM	10,136	4,525	5,610	44.64
NPK	10,041	4,500	5,525	44.82
EM+FYM	10,638	4,707	5,930	44.24
EM+NPK	11,016	4,960	6,055	45.02