Research and Extension Activities for The Development of EM Technology in Pakistan

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Abstract

Emphasis has been placed on the use of Effective Microorganisms (EM) for crop production in Pakistan since 1990. For this purpose, a number of activities are in progress. The more recent studies include a long-term experiment on rice-wheat rotation, which showed enhanced crop yield and improved physical characteristics of soil with EM in combination with organic manures. Field demonstrations on rice comparing EM-BlOKASHT with chemical fertilizers at nine sites showed similar yields. A lysimeteric study on a wheat crop under controlled conditions showed that the application of EM BIOKASHT along with 50 % of NPK fertilizer produced yields comparable to that obtained with full NPK fertilizer. The response of maize fodder to the application of EM and mycorrhizae showed that the combination of EM and mycorrhizae gave the best yield. Total soluble sugars, increased in citrus juice contents and average weights of fruits were enhanced by EM. The results of two experiments in which EM was applied to the broiler chicks in drinking water with different dilutions showed that EM increased the weight of chicks considerably.

The Nature Farming Research Centre (NFRC) of Pakistan is carrying out an active research and development programme on EM over the past five years. Two national level and a number of local seminars were held on Nature Farming and their proceedings were published. A large research and development farm has also been launched. Government agencies were approached to assist in the installation of an EM manufacturing pilot plant.

Extension activities are also in progress for the dissemination of EM-Technology. A large number of field demonstration trials are being carried out at the small as well as progressive farmers fields to demonstrate EM-Technology thereby stimulating the farmers to develop an interest in EM. The programme is running together with farmers of different regions. The programme of education, training and extension service is already being implemented partially under the NFRC and it will be spread throughout the country. Further activities are the establishment of a Nature Farming Complex (NFC), which covers all the aspects of nature farming such as research, development, cooperation, coordination, education, training and poor farmers' welfare.

Introduction

In developing countries like Pakistan, one of the key-issues identified as an obstacle for sustainable development is the growth of present population. This is likely to be doubled over the next two decades. Obviously, this would create an imbalance in the crucial relationship between population, resources, environment and development. The research that resulted in the green revolution has saved millions from starving to death over the past two decades, but population increases are fast overtaking food security. Therefore, the need for increased

production and high yields has built up. The need to increase production and high yield has led to the frequent excessive use of chemical fertilizers and pesticides in both developed and developing countries. The agricultural revolution brought in new methods of highly mechanized and chemical farming which greatly increased production. However, it also brought new challenges in the economics of agriculture, food quality, and to the environment.

Low-input sustainable agriculture is likely to be the focal point for future cropping systems. There is increasing concern that one must decrease the use of chemical fertilizers and pesticides in agriculture. Therefore, organic farming movements have been initiated in many parts of the world. Application of organic matter alone is not considered sufficient to replace the use of agrochemical to sustain crop yield. Most animal manure is returned to the land. Its nutrients, however. are often inefficiently used as a result of poor storage and application particles (U.S. Department of Agriculture, 1978; Smith, 1988).

The technology of Effective Microorganisms (EM) developed at the University of Ryukyus, Okinawa, Japan, has been identified as a potential method for increasing the utility value of most organic manures. The microorganisms, when applied in the correct manner, improve the rhizosphere by transforming the microflora and microfauna (Higa, 1988). Effective Microorganism (EM) inoculum is a mixed culture of beneficial microbes which now offers the means to overcome the problems of farming without synthetic agricultural chemicals, and to increase the yield and quality of crops, and along with the long-term productivity, fertility and health of soils. EM is a liquid culture which contains many species of coexisting microorganisms such as photosynthetic N-fixing bacteria, lactobacilli, ray fungi, yeasts and molds. This paper reports the research and activities for the development of EM-Technology in Pakistan.

Materials and Methods

Long-Term Experiment on Rice-Wheat

A long-term field experiment on rice-wheat cropping system was initiated in 1990. It was laid out according to split-plot design with three replications. The sub-plot treatments were: control; fertilizer $N\text{-}P_2O_5\text{-}K_2O$ (120-90-60) kg ha^{-1} respectively; *Sesbania aculeate* green manure (GM) @ 20 t ha^{-1}; and farm yard manure (FYM) @ 20 t ha^{-1}. The effects of these treatments was studied with and without the application of EM in main plots. At crop maturity, yields on the both rice and wheat crops were collected, and physical characteristics of the soil were determined at the end of five years.

Field Demonstrations of EM-BIOKASHT on Rice

Demonstrations in fields of farmers in the rice belt of in the Punjab Province were carried out at 16 sites in 1994. Organic material based inoculum of EM (BIOKASHT) was prepared and applied @ 1000 kg ha^{-1} to the rice crop. There were only two treatments viz. Farmer practice of $N\text{-}P_2O_5\text{-}ZnSO_4$ fertilizers (80-57-12.5) Kg ha^{-1}, respectively; and EM-BIOKASHT @ 1000 kg ha^{-1}. Rice was planted in 1/5 hectare with fertilizer application and 1/5 hectare with EM-BIOKASHT application. At the time of harvest, paddy yield was recorded only from 9 sites.

Effect of EM-BIOKASHT on Wheat

An experiment in 2m x 1m lysimeters was conducted with wheat using a randomized complete block design (RCBD) with three replications. The treatments were a control with no fertilizers control; fertilizer N-P_2O_5-K_2O (120-90-60) kg ha^{-1}; and half fertilizer plus EM-BIOKASHT @ 500 kg ha^{-1}. At crop maturity grain yield of the crop was recorded.

Interaction of EM with VA-Mycorrhizae

A pot experiment using a completely randomized design (CRD) having three replications was conducted with maize. The treatments were: control with no additives; EM4 alone, mycorrhizae alone; and EM4 plus mycorrhizae. The EM4 was applied weekly along with irrigation water. whereas, the mycorrhizae was applied before sowing. The fresh biomass of maize fodder was recorded at 15,30,45 and 60 days after sowing.

Improvements of Citrus Fruit Quality with EM

A trial on two varieties of fruiting citrus plants was conducted in 1994. The treatments were a control; EM4 @ 40 ml per plant; and EM4 @ 80 ml per plant with each irrigation. EM4 was applied from flowering stage up to fruit maturity. Data on total soluble sugars, fruit juice contents and average single fruit weight was recorded.

Poultry Production with EM

The usefulness of EM in poultry production was also studied during 1994-95. The experiment was conducted on broiler chicks by giving them EM4 in drinking water regularly from 3rd week through 6th week of growth in two experiments. In the first experiment conducted in the Animal Nutrition Department (Trial A) the treatments were: a control; EM4 dilutions of 1:250; 1:500 and 1:750. In the second experiment conducted in the poultry Husbandry Department (Trial B), the treatments were: control; EM4 dilution 1:400; EM4 dilution 1:800; and EM4 dilution 1: 1200. The weight gain in chicks after six weeks of growth was recorded and percent increase in weight over control was also calculated.

The data collected in all the above mentioned experiments was subjected to statistical analysis by standard procedures (Steel and Torrie, 1980), and the treatment means were compared by Duncan's Multiple Range Test (Duncan, 1955).

Results and Discussion

The results of the above mentioned experiments are discussed respectively:

1. The effect of different treatments with and without EM4 the yield of rice and wheat is shown in Figures 1 and 2 respectively. In the sub-plot treatments, the EM application increased the paddy yield. The maximum percent increase (16.03 %) over control was found by the EM application alone. The fertilizer plus EM treatment gave the lowest percent increase, however, this treatment gave the maximum paddy yield. The lower response to microbial inoculation along with N fertilizer was observed because, a soil rich in nitrate inhibits nitrogen fixation (National Research Council, 1989). Poonyarit et al., (1993) reported that the yield of rice was maximum when EM plus recommended rates of fertilizer were

applied. They observed significant yield increase with the application of EM. Wheat grain yield was also affected similarly (Figure 2). However, the percent increase due to EM application in all the treatments except with fertilizer was higher when compared to that in rice. Karim et al. , (1993) also reported that yield of wheat increased directly by the addition of EM, manure and N fertilizer, They observed higher yield increase with EM plus organic manures as compared to EM plus N fertilizer. In this long-term study, the effect of organic amendments and EM application was also seen on physical characteristics of soil. It was observed that saturation percentage of the soil was significantly increased with EM application and the change was more pronounced along with farm yard manure application (Figure 3). The bulk density of the soil was decreased with EM application (Figure 4). Maximum percent decrease (2.5%) was in farm yard manure plus EM treatment. Green manure had very little effect on bulk density of the soil as the fresh biomass was very difficult to be thoroughly incorporated in soil and it remained floating on the soil surface during rice season. Higa and Wididana (1991) also reported a significant decrease in bulk density of the soil by the application of EM.

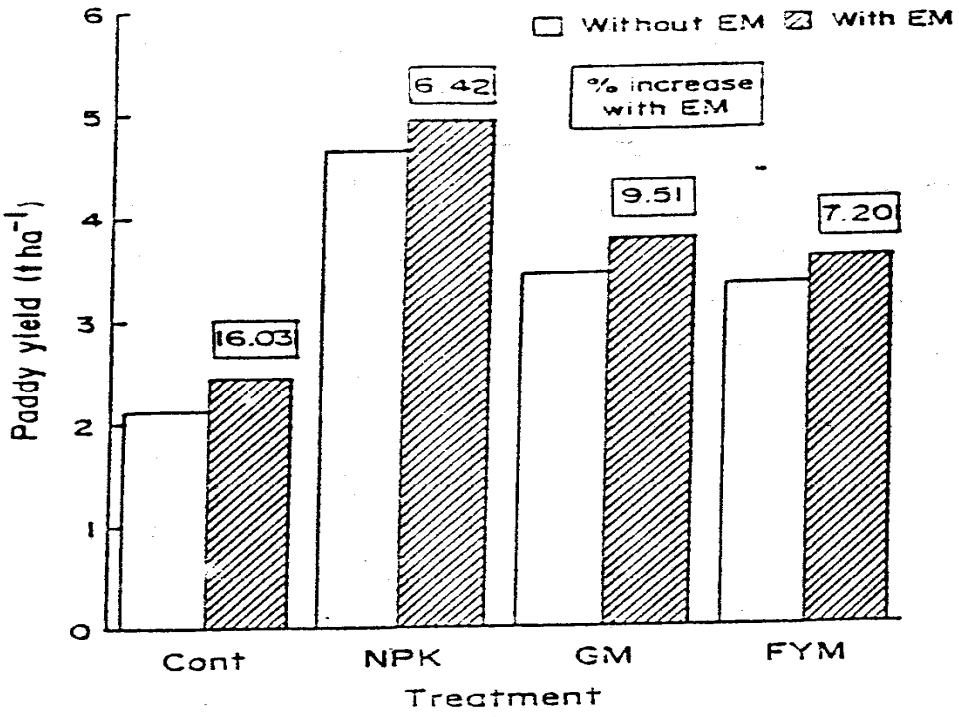

Figure 1. Effect of Organic Amendments and EM Application on The Paddy Yield (t ha^{-1}) of Rice. Average of 5 years (1990-94)

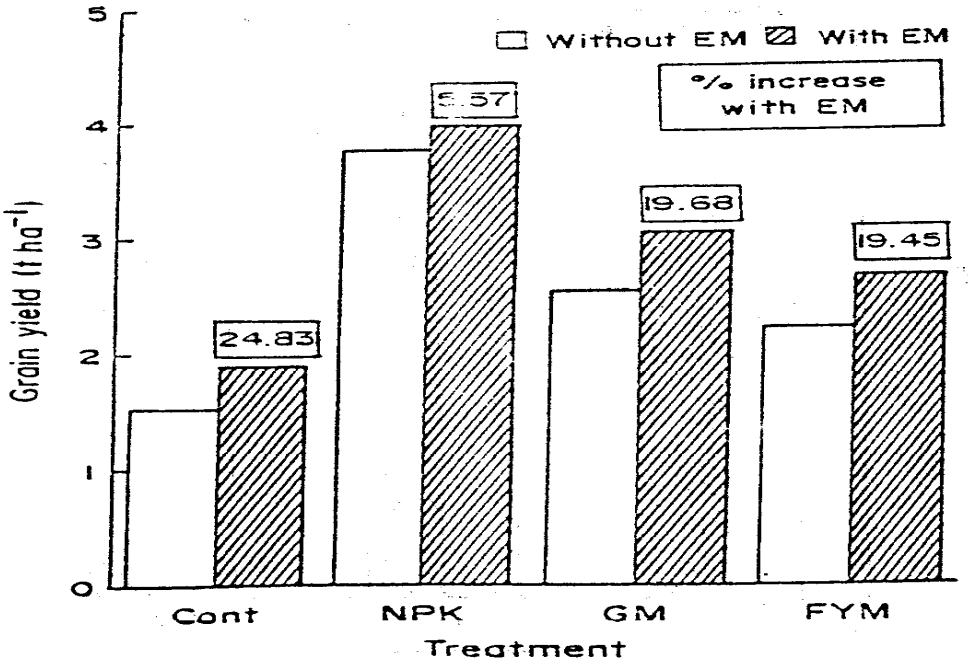

Figure 2. Effect of Organic Amendments and EM Application on The Green Yield (t ha^{-1}) of Wheat. Average of 5 years (1991-95)

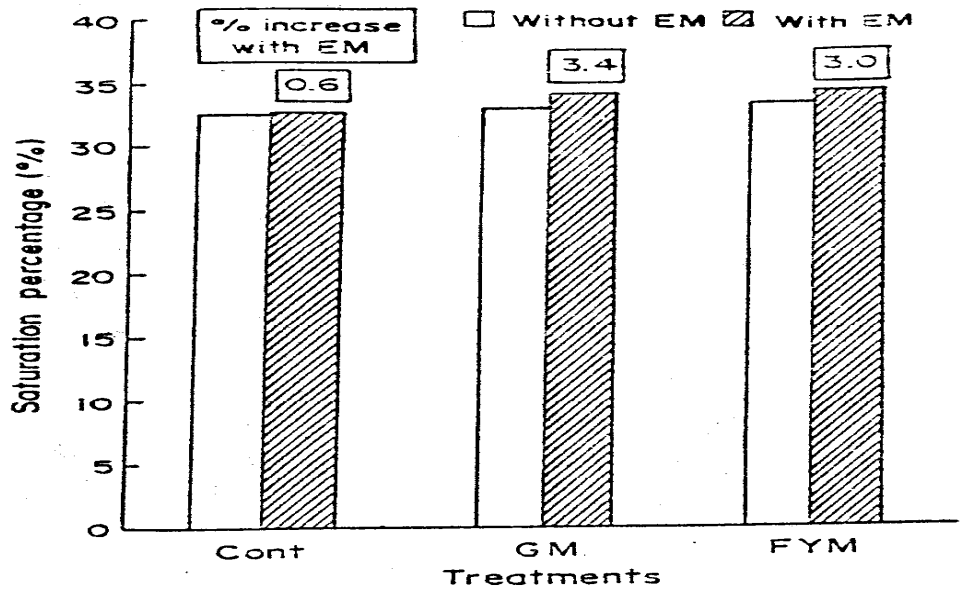

Figure 3. Effect of Organic Amendments and EM Application on The Saturation percentage (%) of Soil (After 5 Years).

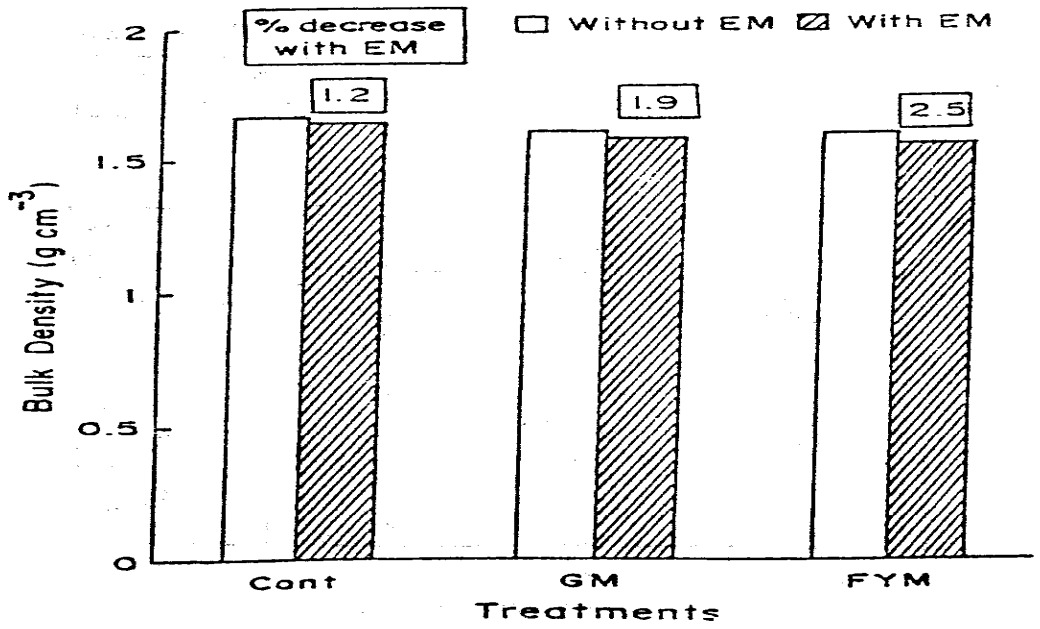

Figure 4. Effect of Organic Amendments and EM Application on Bulk Density (gcm^{-3}) of Soil (After 5 Years).

2. Comparison of EM-BIOKASHT with chemical fertilizer for paddy showed similar yields with both treatments applied without organic manuring. In some cases EM-BIOKASHT yield more than that with mineral fertilizer, however, the average of nine sites gave non significant differences (Table 1). Similar studies were also reported by Minami and Higa (1994), and the results indicated that in most of the cases the paddy yield was higher with EM application in the following years as compared that with chemical fertilizers in the previous years.

Table 1. Comparative effect of chemical fertilizers and EM-BIOKASHT on the paddy yield (kg ha^{-1}) of rice in farmers' fields.

Farmer participant	Fertilizer	EM-BIOKASHT
1	4360	4670
2	3240	5330
3	2920	2200
4	4100	3330
5	4990	4360
6	3480	3660
7	3380	2960
8	3900	3670
9	2370	2830
Average	3638	3634

3. Effect of EM-BIOKASHT and fertilizer on the grain yield of wheat in lysimeters is shown in Figure 5. The data revealed the superiority of all treatments over the control. The

maximum yield was obtained in fertilizer treatment followed by the other treatments. While comparing the rates of EM-BIOKASHT, a higher grain yield was recorded from the treatment where BIOKASHT was applied @ 1000 kg ha^{-1}. Karim et al., (1993) also observed similar trend of EM plus half fertilizer treatment on the yield and yield parameters of wheat in Bangladesh.

4. The yield data of all the harvests revealed that the combination of EM and mycorrhizae gave best yields followed by mycorrhizae alone and EM alone treatments (Figure 6). The maximum yield with the combine application of both the microbial inocula was due to their role in enhancing the nutrient uptake by the plants. Mycorrhizae fungi are important in the uptake of nutrients from soil and in the establishment of vigorous seedling growth in many crop and nursery species (Gerdeman, 1976). Mycorrhizae improve the nutritional status and survival of many plants. Mycorrhizae also increase phosphorus availability to plants when it is limiting and may benefit symbiotic N_2-fixation and biocontrol relationships (Elliott and Lynch. 1995). In contrast, the EM solubilize the inorganic nutrients in soil, and substantial increase in soil phosphorus due to EM application was recorded (Higa and Wididana, 1991).

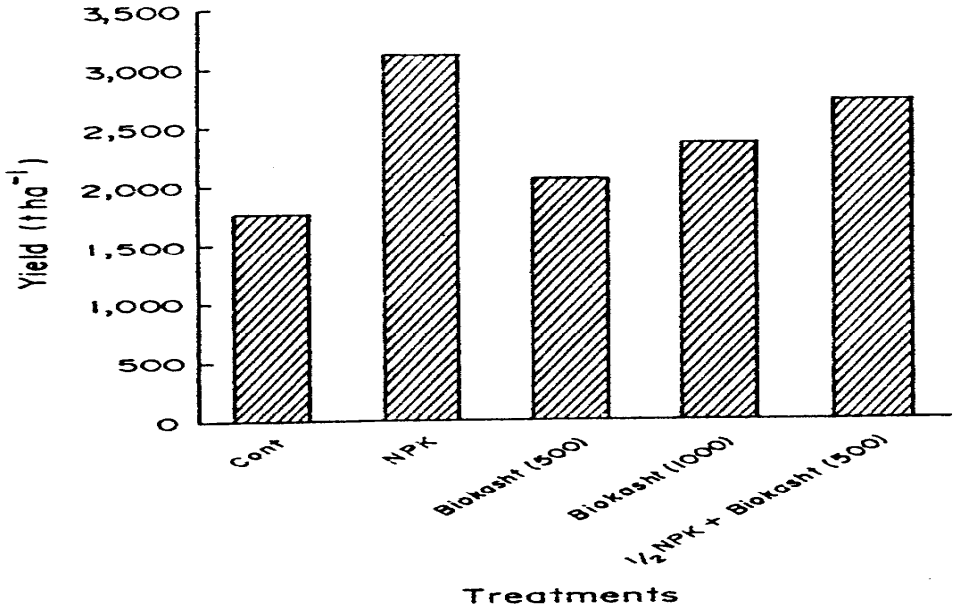

Figure 5. Effect of EM-Biokasht and NPK Fertilizer on The Grain Yield (t ha^{-1}) of Wheat

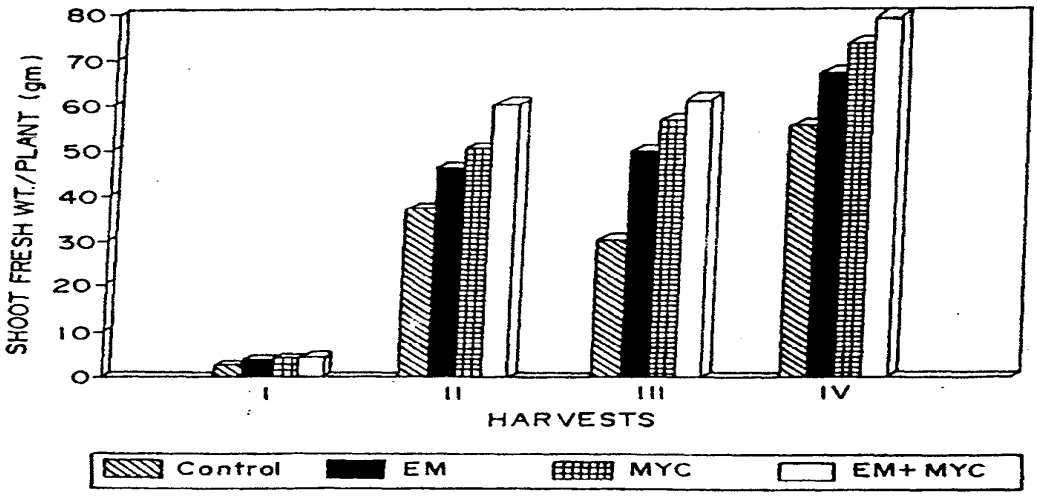

Figure 6. Effect of EM and Mychorrhizae on The Fresh Shoot Weight (g plant^{-1}) of Maize

5. The total soluble sugars, fruit juice contents and fruit weight of Valencia-late and Kinnow varieties of citrus is shown in Table 2. It revealed that a higher concentration of EM4 applied at the rate of 80 ml plant^{-1} showed best result in both varieties. All the parameters (such as total soluble sugars, fruit juice percentage and the weight of fruit) were increased by the application of EM4. Waluyo (1993) also reported that the fruit weight of water apple, starfruit and acerola was significantly increased with the application of BOKASHI and EM.

Table 2. Effect of EM application on the quality and fruit weight of citrus.

Varieties /Treatments	Total soluble Sugars (%)	Fruit juice contents (%)	Single fruit weight (g)
Variety A (Valencia late)			
Control	10.2	46.46	187.4
EM4 @40 ml plant^{-1}	10.3	49.32	189.9
EM4 @80 ml plant^{-1}	10.7	51.47	191.2
Variety B (Kinnow)			
Control	10.20	46.18	172.5
EM4 @40 ml plant^{-1}	10.26	48.42	172.5
EM4 @80 ml plant^{-1}	10.70	49.98	181.7

6. All the EM treatments gave higher chicks weight when compared to the control (Figure 7). The maximum weight gain and % increase over the control treatment was recorded when EM4 was applied at a dilution of 1:500 followed by treatment with a EM4 dilution of 1:750. Poultry Trial B showed that all the treatments gave higher weight over control (Figure 8). Weight increased by further dilution and the maximum weight gain and % increase over control was recorded in the treatment where EM4 was used in a 1:1200 dilution followed by 1:800 dilution treatment. Qiguo (1994) also studied the effect of EM as a feed additive on poultry in China, and reported that EM increased the weight of poultry and increased the feed conversion ratio.

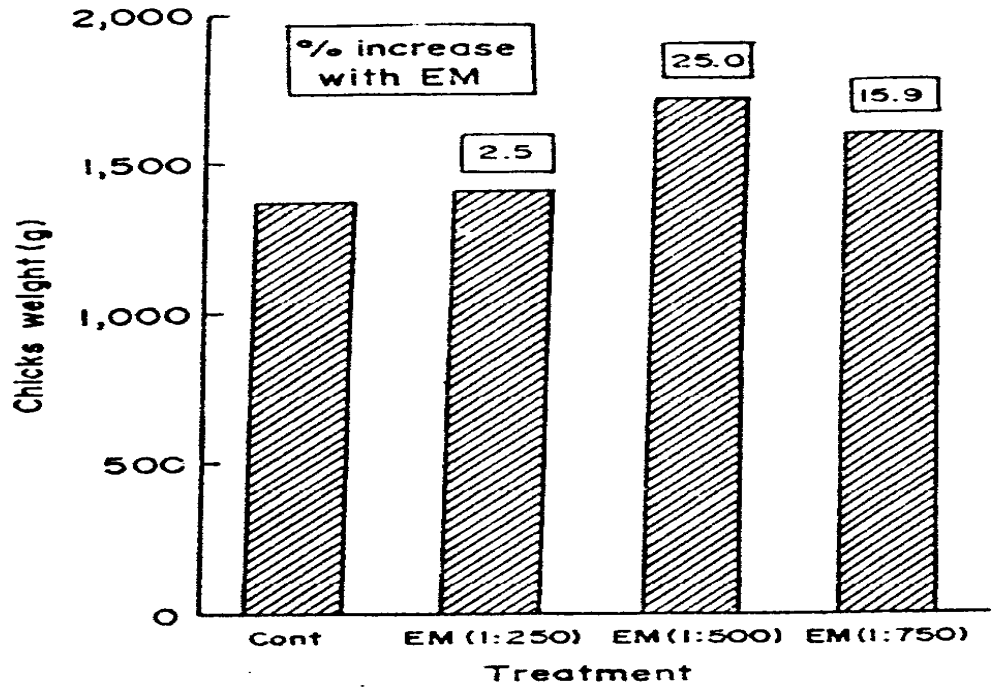

Figure 7. Effect of EM on The Weight (g) of Broiler chicks (Trial A).

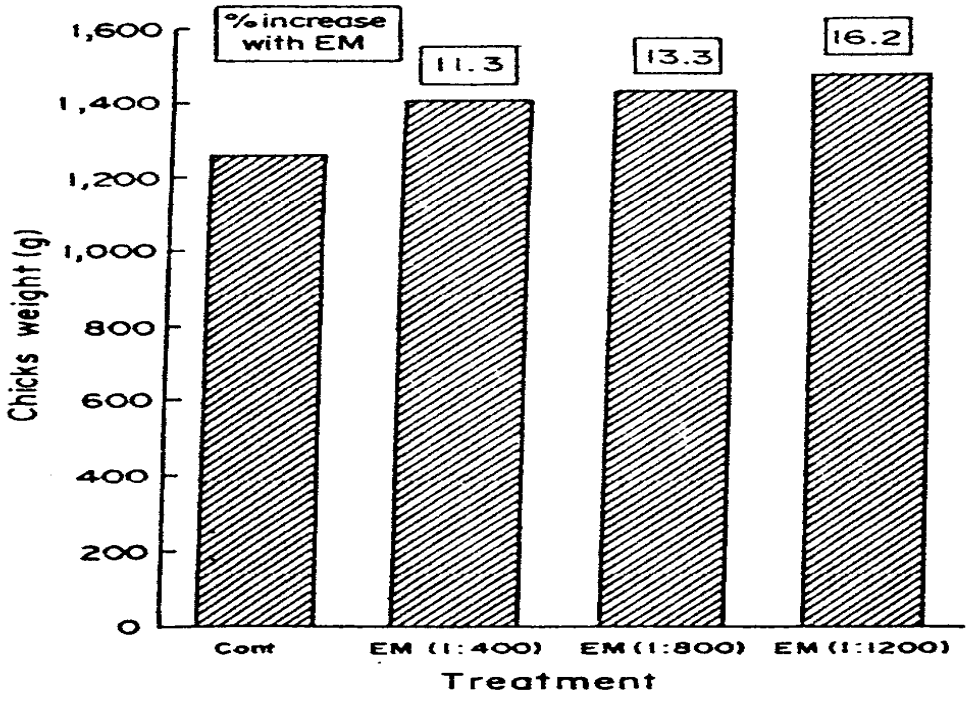

Figure 8. Effect of EM on The Weight (g) of Broiler chicks (Trial B).

Activities for The Development of EM Technology in Pakistan

Along with the adaptive research, activities are also in progress for the dissemination of EM-Technology in Pakistan. The following achievements have been made to date.

1. Nature Farming Research and Development Network (NFRDN): to involve the

interdisciplinary scientists from different departments, this network was formed in 1992 for cooperation in the development of EM-Technology.

2. Nature Farming Research Centre (NFRC): NFRC was established in 1993 with the objective of to making new findings especially with EM-Technology for sustaining soil fertility, biological pest control, environmental pollution control, livestock production and waste management.
3. Nature Farming Research and Development Foundation (NFRDF): This foundation was registered by the government in 1994 to control and finance all the research and developmental activities of EM Technology for the farmers of the country.
4. Advanced Training to the Scientists: The scientific staff of NFRC received training in from Japan and Thailand on EM-Technology.
5. EM Production Unit: A small production unit to culture different types of EM4 from EM2 and for the preparation of EM BIOKASHT has been established to fulfil the requirements of a limited number of farmers in different agro-ecological zones of the country for demonstration purpose.
6. EM Manufacturing Pilot Plant: Government agencies were approached to assist in the installation of an EM manufacturing pilot plant.
7. Advanced EM-Technology Laboratory: An advanced EM-Technology Laboratory equipped with latest instruments has been established with the purpose of maintaining the quality of EM and BIOKASHT during ,preparation: and at farmers' fields.
8. Nature Farming Complex (NFRC)-Saraburi Model: A plan has been made to establish NFC in line with the Saraburi model in Thailand. NFC will cover all the aspects of nature farming (research, development, cooperation, coordination, education of EM-Technology) in Pakistan.
9. Seminars and Conferences on Nature Farming: Two national and a number of local seminars were held on Nature Farming and their proceedings were published. Special seminars are held in the universities, research institutes and farmers' forums for general awareness to the public about EM-Technology. In addition, papers about agricultural production and biotechnology are also presented in different national and international conferences.
10. Research at Postgraduate Level: Three Ph.D. students are actively engaged in EM-Technology research and about 20 students have been awarded the M.Sc. Agri. degree using EM Technology in various disciplines of agriculture.
11. Publications on EM-Technology: For the general public, EM literature is published in Pakistani language (Urdu). The research papers are regularly published in journals and in proceedings of seminars and conferences. Further, reading material , books etc. are also published for highlighting EM-Technology among the scientists.
12. Field days programme for the farmers: The programme is running together with farmers of different regions to show them EM demonstration trials. In this way they get inspired about EM-Technology and could also learn more by demonstrations in the fields.
13. Nature Farming Research Farm: A big research and development farm has also been established for EM-Technology at Khurrianwaia, in Faisalabad.

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