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EM and VAM Technology in Pakistan
VI: Effect of EM (Effective Microorganisms) on VA Mycorrhizal Development and Subsequent Crop Growth and Yield in Sunflower

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Abstract
A field experiment was conducted to observe the VA mycorrhizal colonization and subsequent growth and yield of EM (Effective Microorganisms) treated and non-treated sunflower plants, at two growth stages viz., 40 and 70 days after sowing (DAS). In 40-day old plants, EM supported mycorrhizal association, which resulted in a parallel increase in number and biomass of leaves as well as stem length while stem biomass remained almost unaffected. Root growth was, however, slightly suppressed by EM application at this growth stage. EM failed to induce any remarkable change in extent of mycorrhizal infection 70 DAS. However, the arbuscular infection was enhanced by EM application that resulted in a parallel increase in vegetative and reproductive growth of the plant.

Introduction
Sunflower (*Helianthus annuus* L.) is an important oilseed crop. World-wide interest in the cultivation of this crop was aroused during 1960 and by 1980, it was the second most important source of vegetable oil in the world (Sackston, 1981). It is a short duration crop and can be fitted well in our present cropping system without bearing any major change in agricultural set up. In 1991-92, 63328 hectares of the crop were grown and a total production of 68312 m. Tons was obtained in Pakistan. Efforts are underway to further increase the area under sunflower as well as its yield to bridge the edible oil gap in the country which is increasing at a rate of 11 percent per annum (Beg, 1983). Fertilizers as a source of plant nutrients and pesticide as plant protection measure are being used to increase the crop production. However, imbalance and frequent use of these agrochemicals have polluted the environment to a great extent. Concern is growing that food produced under such farm management may not be safe or of good quality. This has shifted the scientific approach towards some alternative measures.

In the recent past some successful efforts have been made to at least partially substitute chemicals with natural substances to minimize the bad effects of the formers. One such effort was made by Higa (1986) who isolated some beneficial microorganisms from the soil and called them effective microorganisms (EM). EM culture consists of 80 species of co-existing microorganisms such as photosynthetic and nitrogen fixing bacteria, yeast and lactobacilli, which improve crop yield by increasing photosynthesis, nitrogen fixation, controlling soil diseases arid accelerating decomposition of lignin materials in the soil (Hussain *et al*., 1994a). Many workers have reported increase in crop growth by the application of EM (Minami and Higa, 1994; Sangakkara, 1994; Sangakkara and Higa, 1994). Very encouraging results of increase in crop yield by the application of EM have also been observed in Pakistan (Rashid *et al*., 1993; Hussain *et al*., 1993; Javaid *et al*., 1995; 1997). The present study aimed to determine the effect of EM application on crop growth, yield and VA mycorrhizal development in sunflower.

Materials and Methods
Partly decomposed green manure (leaves of trees and grass) was moistened with dilute suspension of EM in water (1:500), packed in airtight polythene bags and left for 7 days in a dark room for further decomposition. Adequate amount of this treated manure was mixed in soil of 2 x 3 m plot. A similar plot received the same amount of manure without EM treatment to be used as control. Sunflower seeds were sown in three rows in each plot with 45 cm plant to plant distance. EM was also applied at a 1:1000 dilution in the respective plot soon after seed sowing and at 15 day intervals till final harvest. Extreme care was taken to avoid cross contamination of soil in plot not receiving EM. Hand weeding was performed when required. Plants were harvested 40 and 70 days after sowing. At each harvest 6 plants of each treatment were carefully uprooted and various parameters regarding vegetative and reproductive growth were recorded. All the data were analyzed statistically by applying t-test.

A part of roots was stained following the procedure of Phillips and Hayman (1970) for VAM infection study, Extent of VAM infection was measured by slide length method (Giovannetti and Mosse, 1980).

Results and Discussion
The EM application had a direct influence on shoot growth. Number of leaves was significant ($p<0.05$) greater in EM treated than non-treated plants 40 days after sowing (DAS). However, the effect of EM on fresh and dry biomass of leaves was insignificant at this growth stage. In 70 days old plants although EM declined the leaves number yet the leaf biomass production was increased significantly due to

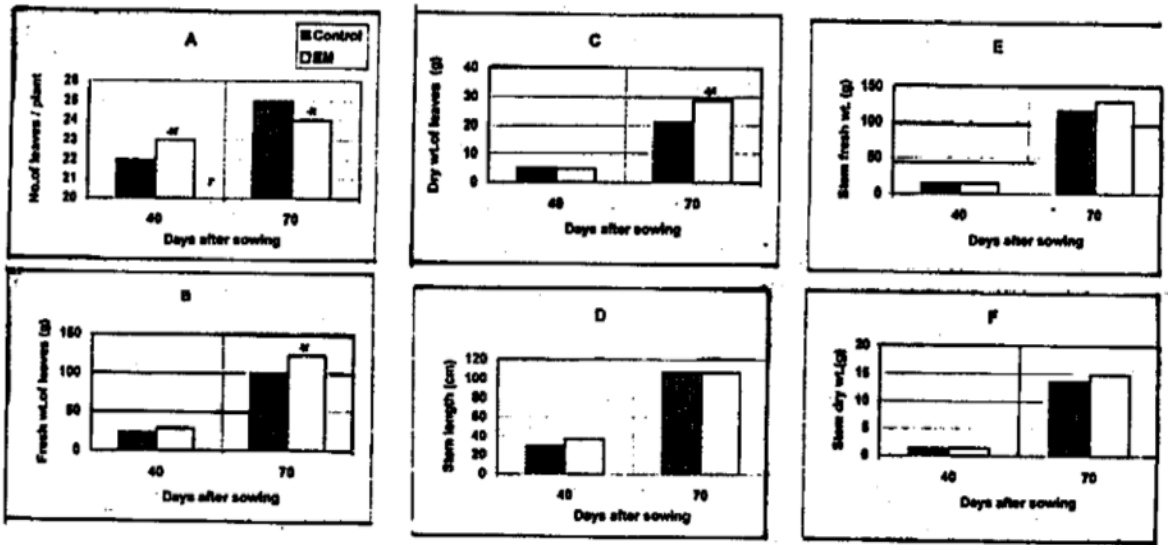

Fig. 1(A-F): Effect of EM on shoot growth of sunflower.
*Differ significantly as determined by t-test.

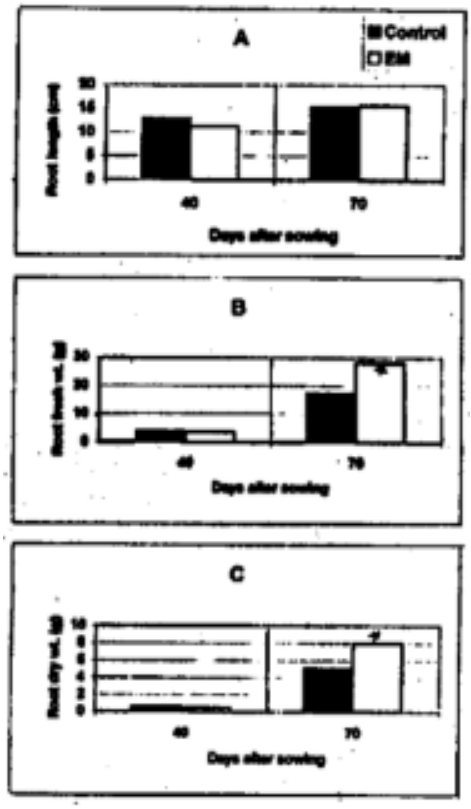

Fig. 2(A-C): Effect of EM on root growth of sunflower.
*Differ significantly as determined by t-test.

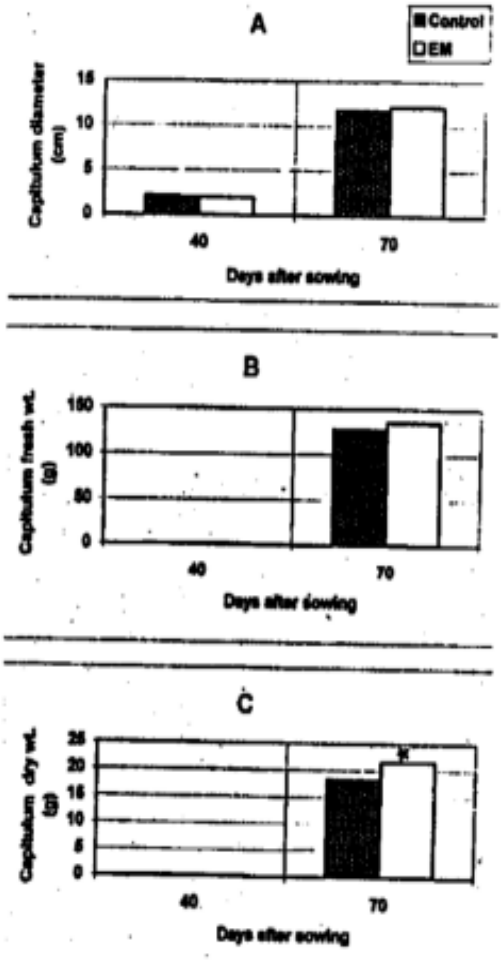

Fig. 3(A-C): Effect of EM on capitulum growth of sunflower.
*Differ significantly as determined by t-test.

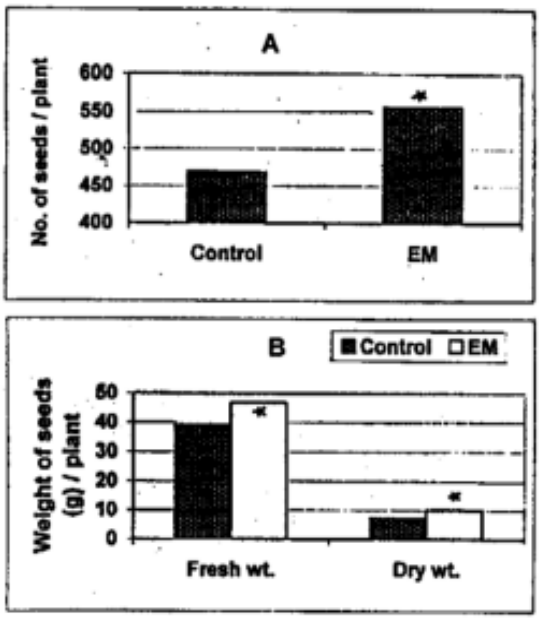

Fig. 4(A-B): Effect of EM on yield in 70 days old sunflower plants.
*Differ significantly as determined by t-test.

increase in leaf size. Response of stem growth to EM application at the two growth stages was similar to that of leaves (Fig. 1). Root growth was suppressed by EM up to 40 days growth and increased thereafter (Fig. 2).

No detectable effect of EM on capitulum growth was observed 40 DAS. However, 70 DAS an increase in diameter and biomass was recorded due to EM application (Fig. 3). The most remarkable effect of EM was observed on yield. The number as well as fresh and dry weight of seeds of EM treated plants were significantly greater as compared to non-treated plants (Fig. 4). Similar beneficial effects of EM application on rice (Minami and Higa, 1994), legumes (Sangakkara and Higa, 1994), vegetables (Sangakkara and Higa, 1994) and sugarcane (Punyaprueg, 1993) have also been reported earlier. This enhanced growth and yield may be attributed to the reported ability of EM to decompose organic matter thus releasing nutrients for plant growth (Higa, 1989). However, the results of the present study differ from Higa (1989), Lin (1991), Panchaban (1991) and Bajwa *et al*. (1997) who reported that effect of EM on crop growth and yield was usually not evident or even adverse in the first test crop. It seems probable that response of a crop to EM application, particularly in the first year, varies from crop to crop and from soil to soil.

EM supported mycorrhizal colonization in 40 days old plants with a parallel increase in plant vegetative growth. The EM failed to induce any remarkable change in extent of VAM infection 70 DAS, however, arbuscular infection was enhanced at this growth stage that resulted in a parallel

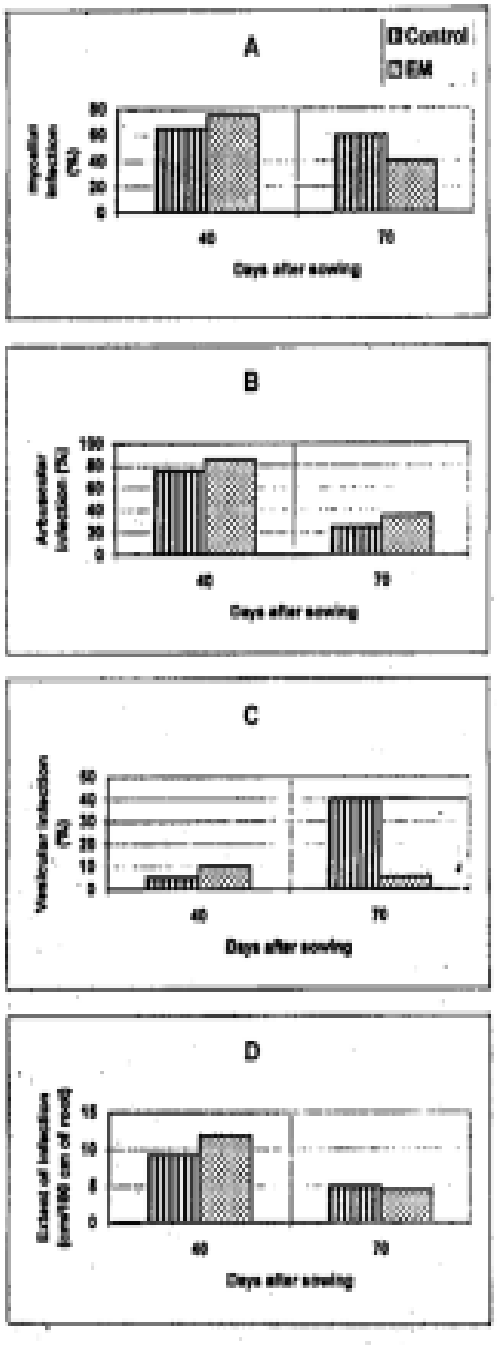

Fig. 5(A-D): Effect of EM on VA mycorrhizal development in sunflower.

stimulation in vegetative and reproductive growth of the host plant (Fig. 5). Similar effect of EM application on VAM colonization and crop growth in maize *(Zea mays* L.) has also been reported by Bajwa and Jilani (1994).

The results of this study have shown rather conclusively that with the use of EM and organic manure farmers can increase the yield of sunflower without using the chemical fertilizers. However, these results represent the effect of first year application of EM with one type of organic amendment. Generally crop growth tends to increase gradually as subsequent crops are grown (Higa, 1989; Arakawa, 1991). Furthermore, crop response to EM varies with different organic matters (Sangakkara and Higa, 1994; Hussain *et al*., 1994b). Therefore, further investigation of long term effectiveness of EM and organic amendments on yield of sunflower is needed.

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