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Role of effective microorganisms (EM) in waste water treatment and on the growth parameters and yield of *Vigna mungo* Linn. in the NDB soil series of Thiruvarur District, Tamil Nadu, India.

J. Victoria and N. Uma Maheswari

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PG and Research Department of Microbiology, STET Women's College, Sundarakkottai, Mannargudi - 614 016, Tamil Nadu, India.

Abstract

Effective microorganisms (EM) are a group of commercial biofertilizer that contains a mixture of co-existing beneficial microorganisms collected from natural environments. Predominantly it consists of species of photosynthetic and lactic acid bacteria, yeast and actinomycetes. The present study was undertaken to determine the efficiency of Effective Microorganisms (EM). EM was purchased from the office of *'Ecopro'* Auroville, Auroshilpam, Tamilnadu, India. The waste water was collected from the STET Women's College, Sudarakkottai, Mannargudi, Tamilnadu. The waste water parameters such as odour, pH, DO, BOD, COD, TDS, TS, TSS, nitrate and phosphate were determined before and after the treatment of wastewater, to observe the efficiency of the selected process. All the parameters showed an elevated level in the raw sewage but after treatment there was a steady reduction after 5, 10, 15 and 20 days of incubation. No reduction was observed in the level of DO. All the parameters were reduced to tolerable environmental standard. Then the EM treated waste water was utilized for testing the ability to improve the yield of the cultivation of secondary crop, *Vigna mungo* L. Soil samples were collected from Thiruthuraipoondi, Thiruvarur District ,Tamilnadu, India which consisted of Nedumbalam (Ndb) soil series, one of the soil series of Thiruvarur District. The experimental set up was designed randomly having EM alone (T1), Treated waste water alone (T2), EM plus Treated waste water (T3) and control (C). Among the treatments studied, T3 showed the highest growth parameters and yield of the crop plant when compared to other treatments proving the efficiency of EM and recycling of waste water.

Keywords: *Vigna radiata*, Effective microorganisms (EM), Secondary crop, Treatments, Sewage, Incubation.

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INTRODUCTION

Increase on the human population affects our future in many ways. One of them is environmental stress and its effects on human and plants. Plants, due to their roles in the carbon cycle, are also nutrient sources for humans and animals (Zhou *et al.*, 2009). Environmental pollution is a major stress factor for human and plants. Thats why many researches focus on this subject and try to create more resistance against these factors. One of them is to increase the immune system of human and plants and provide better photosynthesis and all related physiologic activities (Parr and Higa, 1994; Okorski *et al.*, 2008; Ke *et al.*, 2009; Datla *et al.*, 2004). The organic matter transformations by soil microorganisms and the development of soils can be described as disease-inducing, disease-suppressive and zymogenic or synthetic. Hence manipulation of the soil environment with exogenous microogranism can either directly or indirectly influence various microbe mediated involve soil fertility and crop productivity.

Effective Microorganism (EM) known as EM can be described as a consortium of beneficial microorganisms (primarily photosynthetic and lactic acid bacteria, yeast, actinomycetes, and fermenting fungi) that can be applied as inoculants to increase the microbial diversity of soil (Kleiber *et al.*, 2014; Sigstad *et al.*, 2013; Abd, 2014; Namsivayam *et al.*, 2011).

The functions of benefical microorganisms include,(i) fixation of atmospheric nitrogen, (ii) decomposition of organic wastes and residues , (iii)suppression of soil-borne pathogens, (iv) recycling and increased availability of plant nutrients, (v) degradation of toxicants including pesticides, (vi) production of antibiotics and other bioactive compounds, (vii) production of simple organic molecules for plant uptake, (viii) complexation of heavy metals to limit plant uptake, (ix) solubilization of insoluble nutrient sources and (x) production of polysaccharides to improve soil aggregation (Parr and Higa, 1994; Szymanski and Patterson, 2003).

*Corresponding Author :
email: *victoriasuthakar@gmail.com*

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Many different EM forms are widely used in health, agriculture and waste treatment. EM has a great ability of enhancing maturity and furthermore it can help reaching the same level of compost maturity much faster. And there was no odour from the compost in which EM was used in the stable phase. It was one-week faster to reach the same degree of SOUR and R/N ratio for the 3-week process. Incorporation of efficient microorganisms (EM) potentialized the biological soil activity and contributing to a quick humification of fresh organic matter (Heo *et al.*, 2008; Valarini *et al.*, 2003). Plants can't be imagined without soil. Therefore, plant-soil interactions are the important key factor for these physiologic activities. Studies conducted indicate that EM (Effective Microorganisms) may influence development conditions for microorganisms living in a given soil, thus affecting plant growth and development. Moreover, Effective Microorganisms may have an effect on the availability of nutrients (Kleiber *et al.*, 2014).

Effective Microorganisms (EM) is an inoculum consisting of many naturally occurring beneficial microorganisms used widely in nature and organic farming (Diver, 2001), and also defined as a group of microorganisms having an attractive effect on living forms and environment and explained as the multiculture of aerobic and anaerobic microorganisms that exist compatibly (EM Trading, 2000). It contains selected species of microorganisms such as *Lactobacillus casei*, the lactic acid bacterium, *Rhodopseudomonas palustris*, the photosynthetic bacterium, *Saccharomyces cerevisiae*, the yeast and *Streptomyces albus*, the actinomycete coexist in a liquid medium mutually compatible with each other. Sweet sour taste and smell with a pH of below 3.5 were the major characteristics, which should be stored in an air tight good grade plastic container with provisions to release gas periodically or by opening the container for small quantities. The container should be stored in the temperature between 15 and 20 °C. Little fluctuations cannot affect the solution.

EM improves the quality of the soil and irrigation water system, for seed treatment, as organic sprays which enhance the photosynthesis and control of pests, insects and diseases. Its persistence and dependability on the existing environmental condition were increased and protection was offered against unfavourable condition. Better results from EM can be obtained when mixed with suitable ingredients (Javaid *et al.*, 2008).Since the chemical fertilizers are not capable of sustaining the quality of soil, not cost effective and beyond the reach to most of the farmers, and sometimes cause loss of biodiversity, the organic farming with EM has become a viable alternatives to the chemical fertilizers (Chrispaul *et al.*, 2010).

Waste water contains organic materials from living forms or synthetic organic compounds enter through a number of ways as human wastes, detergents and industrial sources. In the treatment of domestic waste water microorganisms play an important role in the breakdown of many organic pollutants. The major role of microbes in on site systems (septic tanks) is the degradation of organic wastes, however some microbes such as bacteria and viruses can cause health problems to humans (Harris *et al.*, 1998). The reason for using EM species is the production of organic acids, enzymes, antioxidants and metallic chelates (Higa and Chinen,1998). Antioxidant environment created by EM enhances the solid liquid separation, the basis for cleaning waste water. In India, soils with low organic content favour the usage of waste water with organic matter as organic amendment and nutrient supply to soil. Though there are numerous benefits in using waste water precautions should be taken to avoid environmental risk. The earlier studies showed that the effect of effluents varied from crop to crop. Waste water approximately consists of 99.9% water, 0.02 to 0.08% suspended solids and other soluble organic and inorganic substances. It is weak in nature that is the BOD level is normally low and rich in N and P.In this background the present article deals with the role of EM in the waste water treatment and on the growth parameters and yield of *Vigna mungo* L. in Nedumbalam soil series of Thiruvarur district of Tamilnadu.

MATERIALS AND METHODS

Collection and analysis of waste water sample

The waste water was collected in a sterilized plastic container from the women's hostel of Sengamala Thayaar Educational Trust Women's College, Sundarakkottai, Mannargudi (Tk), Thiruvarur (Dt). Immediately after collection, the waste water was brought to the laboratory for further analysis. The collected waste water sample was subjected to physico-chemical parameters analysis. The laboratory experiment was conducted to evaluate the effect of EM on waste water treatment with three replicates and untreated control. The physico-chemical properties such as pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) , Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Total Solids (TS), Total Suspended Solids (TSS), Nitrate (N) and Phosphate (P) of the waste water samples were analysed before and after the addition of activated EM solution (APHA, 1989).

Collection of soil sample

Soil samples were collected from Thiruthuraipoondi, Thiruvarur District ,Tamilnadu, India which included Nedumbalam (Ndb) soil series ,one of the soil series of Thiruvarur District (Soil Atlas, 2012). Five spots were fixed in a plot for taking one composite mixture of the soil. The surface of the field was scrapped away to obtain a uniformly thick slice of soil from the plough

depth from each place. A V-shaped cut was made with a spade to remove 1 to 2 cm slice of soil. The sample collected on the blade of the spade was put in a clean bucket. In the same way the samples were collected from all the spots selected for one sampling unit. Thus the samples were collected on the clean paper and mixed thoroughly. Then the samples were spread evenly and divided into four equal parts. The two opposite quarters were rejected and the remaining samples were mixed. The same process was repeated until the reach of half kg of soil. The sample was collected in a clean bag and marked properly. The mouth of the bag was tied carefully.The same soil was also collected for pot culturing of the plants of *Vigna mungo* for testing the efficiency of EM on the growth parameters and yield of the plants.

Analysis of soil samples

Ndb soil series samples thus collected were first air dried at room temperature, then crushed using a porcelain mortar and pestle, sieved and stored for further analysis (Kalaivani and Sukumaran, 2013).The physicochemical parameters such as the pH (Ghosh *et al.*, 2004), temperature, EC, moisture content, organic carbon (Walkley and Black,1934) , available nitrogen (Subbiah and Asija,1956), available phosphate (Olsen *et al.*, 1954), available potassium (Toth and Prince, 1949), available sulphur (Bhargava and Ragupathi, 1993), calcium and magnesium (Cheng and Bray, 1951) were tested before and after the pot culture of *Vigna mungo* L. using EM and waste water treated with EM.

Studies on the growth promoting efficiency of Effective microorganisms in pot culture experiment

A Pot culture experiment was conducted using the Ndb series soil of Thiruvarur district as the culture medium. Three treatments (T1, T2 and T3) and control (C) pots were maintained. Seeds of *Vigna radiata* were surface sterilized with 1% sodium hypochlorite for 3 min followed by several washings with sterilized water.The randomized experimental design was set up, T1 - EM alone, T2 –Treated Waste water alone, T3 - EM+ EM treated Waste water, C – Control. Seeds were sown in the pots. Each treatment was replicated 3 times.

Activation (EMa) of EM stock solution and application schedule (APNAN, 1995)

Effective microorganisms (EM) as EM stock liquid culture used in this study was purchased from the office of *'Ecopro'* Auroville, Auroshilpam, Tamilnadu, India with had a mixture of lactic acid bacterium, *Lactobacillus casei* (10^5), photosynthetic bacterium, *Rhodopseudomonas palustris* (10^1) and Yeast, *Saccharomyces cerevisiae*. EM solution is a yellowish liquid with a pleasant odour and sweet sour taste with a pH of 3 and stored in cool place without refrigeration (Ahmed John *et al.*, 2007). For most applications EM stock solution was "extended or activated" prior to use. One litre of the EM stock solution and 1kg of jaggery were mixed with 20 liters of water,and it was ensured that the water was clean and free from chlorine. The container used was of good- grade plastics. For the period of activation, the container was placed in shade at ambient temperature (20- 40 °C) without exposure to strong temperature fluctuations. Extended EM (abbreviated as EMe or EMa) was ready after 5-10 days. It was indicated by a pH of 3.5 or lower and a pleasant sweet sour smell. After activation the EM solution was diluted 1:1000 by adding sterilized water. The respective EM treated plots received dilute EM solution (1:1000) at 2 L / m^2 at fortnight interval throughout the experimental period.

Analysis of plant growth parameters of cultivated plants

Plants were harvested after 35 and 60 days after sowing at flowering and maturity stages, respectively. At flowering stage, alternative plants were harvested from each pot so that more space would be available to the remaining growing plants. At each harvest, plants were uprooted along with the rhizospheric soil and the following parameters were studied. Height of the plant (in cm), shoot length (in cm), root length (in cm), number of leaves (per plant), leaf fresh weight (in mg),leaf dry weight(in mg), number of nodules(per plant), carbohydrate, protein and chlorophyll contents were recorded at both the harvesting and flowering stage. Number of flowers was recorded in flowering stage only. Root fresh weight (in mg), root dry weight (in mg), number of pods (per plant), length of the pods (in cm) and yield (in gms) were recorded at maturation. All the data were analyzed statistically by applying Duncan's Multiple Range 't' test (Steel and Torrie, 1980) to separate the treatment means using SPSS .

RESULTS

Analysis of physico chemical properties before and after the treatment of waste water

The collected waste water sample was analysed for the physico-chemical properties such as pH, BOD, COD, TS, TDS, TSS, nitrate and phosphate contents and recorded. Analysis of the treated waste water revealed that there was a steady decrease in the values of all the parameters except the dissolved oxygen level. They reached the environmental standard levels after treatment with the Effective Microorganisms (Table-1).

Analysis of physico chemical properties of Ndb soil series

Physico-chemical parameters of the Ndb soil series were analysed using the standard methods for soil analysis. The soil's physical parameters, primary, secondary and micro nutrients were analysed and the results were recorded (Table-2).

Table 1. Physico - Chemical Parameters of EM treated waste water

S.No	Parameter	Untreated Waste Water	Treated Waste Incubation time			
			5	10	15	20
1	pH	7	7	5.4	4.7	3.5
2	Dissolved Oxygen (mg/l)	10.4	10	15	19	20
3	Biochemical Oxygen Demand (mg/l)	28.4	28	18	15	12
4	Chemical Oxygen Demand (mg/l)	54.4	54	50	43	32
5	Total Solids (mg/l)	94	94	88	80	71
6	Total Dissolved Solids (mg/l)	60	60	58	52	48
7	Total Suspended Solids (mg/l)	34	34	30	28	23
8	Nitrate (mg/l)	6.7	6.7	5.9	2.8	1.6
9	Phosphate (mg/l)	3.2	3.2	2.7	2.2	1

Values are mean

Table 2. Analysis of physico-chemical parameters of Ndb soil

S.No	Physico-chemical parameters	Before cultivation	After cultivation
1	Soil colour	Dark Brown	Dark Brown
2	Soil texture	Clay loam	Clay loam
3	Soil pH	7.8	7.3
4	Electrical Conductivity (dsm^{-1})	1	0.08
5	Salinity	NS	NS
	Primary Nutrients		
6	Organic Carbon (%)	0.59	0.7
7	Nitrogen (Kg/ac)	121.1	132.5
8	Phosphorus (Kg/ac)	4.56	6.23
9	Potassium (Kg/ac	284	295
	Secondary Nutrients		
10	Calcium(ppm)	9.4	10.2
11	Magnesium (ppm)	9.8	10.4
12	Sulphur (mg/l)	33	34
	Micronutrients		
13	Iron (%)	7.72	8..12
14	Zinc (%)	1.11	1.98
15	Manganese (%)	3.23	4.15
16	Copper (%)	2.63	2.77
17	Molybdenum (%)	3.82	3.97

The effective soil depth for the collection of soil sample was less than 100cm. Clay Loam (CL) in nature and greyish brown in colour. Before treatment, the pH of the soil was 7.8 revealing the mildly alkaline condition. The Electrical conductivity (EC) observed was 1.0 dsm^{-1} due to the non-saline nature. The primary nutrients such as organic carbon, nitrogen, phosphorus and potassium were 0.59(g/mg), 121.1, 4.56 and 284(mg/kg) respectively. The secondary nutrients such as calcium, magnesium and sulphur were 9.4(ppm), 9.8 (ppm) and 33 (mg/l) respectively. The values obtained from the analysis of the micronutrients such as iron, zinc, manganese, copper and molybdenum were 8.42, 1.18, 4.11, 2.77 and 4.17 (µg/g) respectively.

After treatment of *Vigna mungo L.* with EM, the pH of the soil was reduced to 7.5. Electrical conductivity (EC) observed was 0.9 dsm^{-1}. The primary nutrients, organic carbon, nitrogen, phosphorus and potassium were 0.59(g/mg), 119.1, 4.56 and 284 (mg/kg) respectively. The secondary nutrients calcium, magnesium and sulphur were 9.7 (ppm), 9.9 (ppm) and 36 (mg/l) respectively. Analysis of the micronutrients such as iron, zinc, manganese, copper and molybdenum showed the values of 8.44, 1.21, 4.23, 2.80 and 4.27(µg/g) respectively.

Effect of EM and treated waste water on the growth parameters and yield of *Vigna mungo* L. in Ndb soil series are given in Table 3,4 and 5.

Height of the plant

All the treatments showed the increase in the height of the plants. The treatments showed significant differences ($p \leq 0.05$) for the tested parameter at flowering and maturity stages. The pots inoculated with EM and treated waste water showed increased height followed by EM alone, untreated waste water and control. The total height included both shoot and root length of the plant. At flowering stage, height of the plant in Ndb series, the treatment T3 (29.90 cm) showed the maximum height followed by T1 (29.80cm), T2 (27.46 cm) and C (27.10cm). At the stage of maturity also T3 (33.03cm) showed the maximum height which was followed by T1 (32.90cm), T2 (30.47cm) and C (30.40cm). Both T1 and T3 and T2 and control showed nearly similar results revealing the activity of Effective Microorganisms.

Shoot length

Shoot growth occurred in all the treatments over the experimental period. There were significant differences in shoot length among the treatments ($p \leq 0.05$). The treatment T3 containing effective microorganisms and treated waste water showed the highest (24.61cm) shoot length at the flowering when compared to all other treatments (T1-24.11cm and T2-23.00cm) and uninoculated Control (22.07 cm). At the stage of maturity, T3 (26.60cm) showed the higher growth than T1 (26.10cm) followed by T2 (25.23cm) and Control (24.17cm).

Root length

Length of the roots was increased highly at the stage of maturity when compared to flowering stage in all

Table 3. Analysis of growth parameters of *Vigna mungo* l. at the stage of flowering- grown in Ndb series of soil

S.No	Treatments	Growth parameters								
		Height	Shoot length	Internodal Length	No. of leaves	No. of flowers	Root length	Leaf fresh weight	Leaf dry weight	No. of nodules
		(in cm)	(in cm)	(in cm)	(per plant)	(per plant)	(in cm)	(mg/plant)	(mg/plant)	(per plant)
1	T1	29.80a	24.11a	3.36a	23.41a	17.33a	5.80a	13.66a	8.92a	21.33a
2	T2	27.46b	23.00b	2.96b	21.50b	15.33b	5.19b	12.66b	7.43b	20.33b
3	T3	29.90a	24.61c	3.38a	23.66a	17.33c	6.35c	14.66c	9.57c	23.66c
4	C	27.10b	22.07d	2.94c	18.42c	12.33d	4.12d	11.33d	6.22d	18.66d

Values are mean, having the same letters does not show significant difference ($P \leq 0.05$) by Duncan's Multiple Range 't' Test

Table 4. Analysis of growth parameters of *Vigna mungo* L. at the stage of maturity - grown in Ndb series of soil

S.No	Treatments	Growth parameters											
		Height	Shoot length	Internodal Length (in cm)	No. of leaves	Root length	Leaf fresh weight	Leaf Dry weight	No.of nodules	Root fresh weight	Root dry weight	Pod length	No.of pods (per plant)	Yield (in gms)
		(in cm)	(in cm)		(per plant)	(in cm)	(mg/plant)	(mg/plant)	(per plant)	(mg/plant)	(mg/plant)	(in cm)		
1	T1	32.90a	26.10a	5.32a	26.67a	7.22a	15.76a	3.92a	16.33a	5.03a	1.27a	3.62a	23.66a	3.41a
2	T2	30.40b	25.23b	5.88b	25.17b	6.88c	14.67b	3.67b	13.00b	4.33b	1.14b	3.11b	21.67b	3.07b
3	T3	33.03a	26.60c	5.24a	28.00c	7.63b	16.76a	4.17a	16.67a	5.40c	1.34c	3.61c	24.33c	3.47c
4	C	29.47b	24.17d	4.89c	24.33d	6.81c	14.33c	2.58b	12.33b	4.23b	1.11d	2.09b	21.33d	1.95d

Values are mean, having the same letters does not show significant difference ($P \leq 0.05$) by Duncan's Multiple Range 't' Test

Table 5. Analysis of total chlorophyll, carbohydrate and protein content of *Vigna mungo* L. at the stage of flowering and maturity – grown in Ndb series of soil

S.No.	Treatments	Flowering stage					Maturity stage				
		Chlorophyll					Chlorophyll				
		Chl-a	Chl-b	Total Chl	Carbohydrate	Protein	Chl-a	Chl-b	Total Chl	Carbohydrate	Protein
1	T1	0.19	0.163	0.344	18.52a	79.81a	0.14	0.124	0.268	14.52a	39.81a
2	T2	0.18	0.146	0.322	17.32b	77.43b	0.13	0.105	0.237	13.32b	37.41b
3	T3	0.19	0.158	0.348	18.82c	80.13c	0.15	0.126	0.272	14.62c	4/.12c
4	C	0.17	0.142	0.31	16.42d	74.11d	0.13	0.102	0.23	12.42d	34.11d

Values are mean, having the same letters does not show significant difference ($P \leq 0.05$) by Duncan's Multiple Range 't' Test for carbohydrate and protein analysis.

the treatments. The root length of the plants was significant in the EM amended treatments and insignificant with T2 and control. The untreated waste water treatment showed significance with the control. At stage of flowering, T3 showed the higher root length (6.35cm) than T1 (5.80 cm), T2 (5.19cm) and Control (4.12cm). At maturity, T3 (7.63cm) was higher than T1 (7.22cm), T2 (6.88cm) and Control (6.81cm).

Number of leaves

Application of EM enhanced the leaf production in the treatments. The treatments T1 (23.41/plant) and T3 (23.46/plant) did not show significant differences ($P \leq 0.05$) in the production of leaves. T2 (21.50/plant) and Control (18.42/plant) showed significance in their results for the production of leaves at the flowering. The treatment T1 (26.67/plant) and T3 (28.00/plant) did not show significant differences ($P \leq 0.05$) in the production of leaves. T2 (25.17/plant) and Control (24.33/plant) showed significance in their results for the production of leaves at the stage of maturity.

Leaf fresh weight

Plants inoculated with EM and treated waste water recorded the highest leaf fresh weight followed by the

EM, untreated waste water and control at both the flowering and maturity stage. At the stage of flowering, T1 (13.66 mg/plant) and T3 (14.66 mg/plant) showed significance in their results and T2 (12.66 mg/plant) and C (11.33mg/plant) showed significant results i.e., the leaf fresh weight of EM amended treatments had slightly similar results and the unamended treatments also showed the same. T1 (15.76mg/plant) and T3 (16.76mg/plant) showed significance in their results of increasing the leaf fresh weight when compared to control (14.33mg/plant) at the stage of maturity.

Root fresh weight

Maximum root fresh weight was recorded in the treatments inoculated with EM. There were significant differences among the treatments for this parameter. At maturity, the treatments (T1 and T3) with EM showed significance and the treatments unamended with EM (T2 and Control) showed significance at ($P \leq 0.05$) i.e., T1 (5.03 mg/plant) and T3 (5.40 mg/plant), T2 (4.33 mg/plant) and Control (4.23 mg/plant).

Root dry weight

Maximum root dry weight was recorded in the treatments inoculated with EM. There were significant differences among the treatments for this parameter at maturity ($P \leq 0.05$) i.e., T1 (1. mg/plant), T3 (1.28 mg/plant), T2(1.08) and Control (1.04 mg/plant).

Number of flowers

The parameter, number of flowers was studied at the flowering stage.Maximum number of flowers reflects maximum the number of pods and the yield. Treatments, T1(16.00/plant) and T3(16.98/plant) showed significance in their results and T2 (15.33/plant) and C (14.11/plant) showed significance which represents that the number of flowers in the EM amended soils showed significance and the unamended soils showed the results as such of control ($P \leq 0.05$).

Number of nodules

Number of nodules was studied at both the flowering and maturity stage. The parameter showed the reduction in the number at maturity stage when compared to the flowering stage due to the decomposition of the nodules. The increase in the nodule numbers was observed in response to EM treatment when compared to others. When the nodule number increases, it increases the fixation of nitrogen in the soil and thus improving the plant growth and yield. T3 (23.33/plant) showed highest nodule number followed by T1 (23.00/plant), T2 (20.16 /plant) and Control (18.54/plant). The results were more significant ($P \leq 0.05$) for the EM treatments than the others. At the maturity, T3 (15.65/plant) showed more number of root nodules than the other treatments T1 (15.54/plant), T2 (12.33/plant), and Control (11.60/plant).

Number of pods (per plant)

Vigna mungo L. showed increased number of pods in pots treated with EM, T1 and T3 showed a significant ($P \leq 0.05$) result when compared to other treatment and control. In T3 (22.66/plant) the number of pods was significantly high showing the best result of the parameter, followed by T1 (22.33/plant), T2 (20.00/plant) and Control (19.33/plant).

Length of the pods

Length of the pods was studied for analyzing the improvement of seed yield per plant. Increased pod length was observed in the treatment T3 (3.48/plant) followed by T1(3.26/plant). T1 and T3 which showed significant ($P \leq 0.05$) results, and the treatments T2 (2.62/plant) and C (2.58/plant) showed the significant results.

Yield (gms)

Yield of the plants was increased due to increase in all the parameters studied above. There were significant differences ($P \leq 0.05$) in the yield of the plants. Treatment T3(3.26 g/plant) showed the higher yield when compared to other treatments,T1(3.21 g/plant), T2 (2.97g/plant) and C (1.92 g/plant). Thus, the result revealed that yield of the plant was significantly increased due to the amendment of EM to the soil.

Carbohydrate Content

Increased carbohydrate content was observed in the treatments inoculated with EM. All the treatments showed significant differences ($P \leq 0.05$) in the carbohydrate content. At the flowering stage, treatment T3 (18.51 mg/g) showed the highest carbohydrate content than T1 (17.73mg/g), T2 (16. 01mg/g) and Control (15.82mg/g). At maturity, T3 (14.51mg/g) showed significant increase in the carbohydrate content followed by T1 (13.73mg/g), T2 (12.01mg/g) and Control (11.82mg/g).

Protein content

Protein content of the plants was increased in the EM amended soils when compared to unamended treatments. All the treatments showed significant differences ($P \leq 0.05$) in the protein content. At the flowering stage the treatments showed higher protein content than the maturity stage. During the flowering stage, treatment T3 (76.82mg/g) showed significant increase in the protein content followed by T1 (75.62mg/g), T2 (70.43mg/g) and Control (70.16mg/g). At the stage of maturity, treatment T3 (36.81mg/g) showed significant increase in the protein content followed by T1 (35.62 mg/g), T2 (33.42 mg/g) and Control (30.17mg/g).

Chlorophyll content

The chlorophyll content of the plants was increased due to treatment with EM. Generally increase in chlorophyll content resulted in the increase of the synthesis of carbohydrate and protein thus resulted in increase in the yield of the plants. The total chlorophyll was calculated by analyzing the chlorophyll- a and chlorophyll- b contents of the plants. T3 showed the highest chlorophyll content followed by T1, T2 and control. 0.348, 0.344,0.322 and 0.310 mg/g and 0.272,0.268,0.237 and 0.230 mg/g were the amount of chlorophyll obtained from the treatments T3,T1,T2 and Control at both the flowering and maturity stage respectively.

DISCUSSION

Effective Microorganisms play a vital role in the treatment of waste water and increase in the growth and yield of crop plants. EM treated domestic sewage showed distinct reduction in all the tested parameters under all the tested incubation period. It has been reported that total dissolved solid was found to be reduced from 2160 mg/lit to 1012, 940 and 901 mg/lit. pH was also reduced from 9.0 to 8.4, 7.4 and 7.1 alkalinity was reduced from 59 mg/lit to 41, 37 and 21 mg/lit, the BOD was reduced from 2.8 to 2.1, 1.5 and 0.9, no reduction was observed in DO content and the COD was decreased from 164 to 141, 112 and 112 and 109 mg/lit at the respective incubation time (Karthick Raja Namasivayam, 2011).In the present study, it was found that the BOD in raw wastewater was 28.4 mg/l and after EM treatment, 5 to 20 days, the level of BOD was decreased from 28.0 to 11.5 mg/l.

Analysis of all the generated data of untreated and treated wastewater samples showed that pH, BOD, COD, TS, TDS, TSS, nitrate and phosphate contents of treated water were reduced to tolerable environmental standard and the DO level of the treated waste water was increased. The results obtained for all the parameters were better at 20th day of incubation (Table 1). Based on results obtained from the treatment it is suggested as one of the easy methods which could be applied locally to convert the waste into byproduct that could help to reduce the environmental pollution.

The results from the study indicate that inoculation of *Vigna mungo* L. with Effective Microorganisms increased the height of the plant (in cm), internodal length (in cm), shoot length (in cm), root Length (in cm), number of leaves (per plant), leaf fresh weight (in mg), leaf dry weight(in mg), number of flowers (per plant), number of nodules (per plant), root fresh weight (in mg), root dry weight (in mg), number of pods (per plant), length of the pods(in cm) and yield (in gms), carbohydrate, protein and chlorophyll contents. Increase in leaf number, leaf fresh and dry weight increase the photosynthetic activity of the plants. Generally increase in leaf area and number resulted in higher rates of photosynthesis and thus increase the plant growth. For plants, a high rate of net carbon assimilation can result in higher biomass accumulation, favouring further growth and reproduction. The position and distribution of leaves along shoot influences the sink strength of the plants. During early stages of leaf growth, synthesis of chlorophyll, proteins and structural compounds is high resulting in high catabolic rates to support energy needs by the plants. Inoculation of Effective Microorganisms can increase the available nutrition for plant roots and improve photosynthesis (Beadle, 1993). Likewise in this study, the inoculation of Effective Microorganisms increased the leaf number and leaf fresh and dry weight of the plant *Vigna mungo* L. thus increasing the photosynthetic activity.

Increase in chlorophyll contents of pigweed may contribute to increased photosynthetic activity. The synthesis and degradation of the photosynthetic pigments are normally associated with the photosynthetic efficiency of the plants and their growth adaptability to different environments (Sharma and Namdeo, 1999). In this study, chlorophyll a and b contents of the plants were increased in all the treatments whereas the treatments inoculated with effective microorganisms showed relatively higher rate of chlorophyll synthesis. When the chlorophyll content increases it increases the synthesis of protein and carbohydrate contents, and thus increasing the growth parameters and yield of the plants. Increase in leaf chlorophyll content could in turn lead to increased protein synthesis of the plants and this could have a direct consequence on the plant growth and photosynthesis (Hendry *et al.*, 1983).

Nitrogen is one of the essential nurtrients invoved as a constituent of biomolecules such as nucleic acids, coenzymes and proteins (Grant and Bailey,1993), any deviation in these constituents would inhibit the growth and yield of plants. Protein concentrations in plants tend to increase with fertility level of the growth medium (Higa and Widhana, 1991). In this study, there was the increase in the number of nodules at the flowering stage, which directly indicate the increase in the nitrogen fixation thus increasing the nitrogen content of the plants, which directly associated with the growth, productivity and yield of the plant.

In general, Effective Microorganisms produced a direct impact on growth and yield of *Vigna mungo* L. Previous studies have demonstrated a consistent positive response with the use of EM in crop production and indicate the potential of this technology to reduce fertilizer use and increase the yield and quality of crops.

CONCLUSION

The results of this study reveal that the inoculation of Effective Microorganisms for the cultivation of *Vigna*

mungo L. improved all the growth parameters, carbohydrate, protein and chlorophyll content of the plant. EM already having many beneficial potentialities, it produced more effects along with waste water treated with EM. Although waste water having much more nutrients, it showed more effects on plant growth on combination with Effective microorganisms. Day by day, the application of chemical fertilizers to the soil will make it sterile in the future i.e., making it inorganic and unfavourable for cultivation of crops. Thus to prevent environmental pollution and to reduce the extensive use of chemical fertilizers, the effective microorganisms can be recommended to the farmers to ensure public health and a sustainable agriculture. Steps have to be taken to introduce organic farming to the agrarians to achieve the goal of protecting the fertility of their cultivable lands.

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