Effect of Compost Derived From Decomposed Fruit Wastes by Effective Microorganism (EM) Technology on Plant Growth Parameters of *Vigna mungo*

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**Abstract**

In the present study, the plant growth promoting effect of compost derived from decomposed fruit wastes by commercial formulation of Effective Microorganisms (EM-1) on plant growth parameters of *Vigna mungo* discussed. Effective Microorganisms (EM), a culture of co-existing beneficial microorganisms predominantly consisting of lactic acid bacteria, photosynthetic bacteria, yeast, fermenting fungi and actinomycetes that are claimed to enhance the decomposition of organic matter which in turn improves the soil fertility. In the present study, the fruit wastes were effectively decomposed by applied effective microorganisms with complete reduction of volume of wastes, development of pleasant odour and formation of finely dispersed nutritious compost with 672.0, 708.0, 2927.0, 13.02 mg/kg and 35.1% of total nitrogen, phosphorous, potassium, humic acid and organic carbon. The plant growth parameters such as shoot length, leaf surface area, and total chlorophyll, height of the plant, total leaves and branches emerged in the plant, total foliage density/plant was increased in compost treated plants and distinct reduction in pest infestation and disease spots were recorded. As in plant growth parameters, compost treated plot reveals maximum phyllosphere, soil heterotrophic microbial population and soil nutrients via total nitrogen, phosphorous, potassium, organic carbon and humic acid. Total yield and cost benefit ratio was also increased in compost treated plots.

**Keywords:** Effective microorganisms; Compost; *Vigna mungo*; Plant growth parameters

**Introduction**

Farmers have adopted the strategy of increasing crop yields by applying large amounts of chemical fertilizers and pesticides. At present, however, the negative effects of heavy applications of chemical inputs, in terms of production, environment and quality deteriorations are becoming apparent [1]. The ultimate goal of sustainable agriculture is to develop farming systems that are productive, energy conserving, environmentally sound conserving of natural resources such as soil and water and thus ensure food safety and quality. Organic agriculture has much in common with sustainable agriculture. The same stress is placed upon the use of renewable resources, conservation of resources and the maintenance of environmental quality without using chemical inputs. Microbial inoculant is one way organic farmer is able to increase yield and quality of crops without a large investment of money and labour [2,3].

A microbial inoculant containing many kinds of naturally occurring beneficial microbes called ‘Effective Microorganisms’ has been used widely in nature and organic farming. The concept of Effective Microorganisms was developed by Japanese horticulturist Teuro Higa from the University of Ryukyus in Japan. He reported in the 1970s that a combination of approximately 80 different microorganisms is capable of positively influencing decomposing organic matter such that it reverts into a life promoting process. The studies have shown that EM may have a number of applications, including agriculture, livestock, gardening, landscaping, composting, bioremediation, cleaning septic tanks, algal control and household uses [4]. The application of EM will improve soil and irrigation water. It can be used in seed treatment. It can be used to make organic sprays for the enhancement of photosynthesis and control of insects, pests and diseases [5-7]. In the present study the effect of compost derived from fruit wastes decomposition by commercial formulation of Effective Microorganisms (EM-1) on plant growth parameters of *Vigna mungo* under micro plot assay was studied.

**Materials and Methods**

**Effective Microorganisms (EM-1)**

The liquid stock culture of the EM-1 used in the study was supplied by Environ Biotech and contained a mixture of lactic acid bacteria *Lactobacillus plantarum*, *Candida utilis*, *Streptomyces albus* EM-1 is available in a dormant state and requires activation before application and the activation was performed as per the instruction given by manufacturer. Activation involves the addition of 20 litres of water and 2 kilograms of Jaggery (pure cane sugar) to 1 litre of dormant EM. The mixture was poured into a clean airtight plastic container with no air left in the container. The container was stored away from direct sunlight at ambient temperatures for 8 to 10 days. The gas was released from every day until fermentation completed. During the period of activation, a white layer of actinomycetes formed on the top of the solution accompanied by a pleasant smell and acidic pH within the range of 4.0.

**Fruit and vegetable waste decomposition by EM-1**

**Sample collection:** Fresh fruit wastes (Banana, orange, mosambi, pomegranate, guava, pineapple, and apple) were collected from retail

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Humic acid was determined by Tripathi et al. [9] spectrophotometric method and Walkley-Black method respectively. [8], ammonium molybdate ascorbic acid method, atomic absorption and finely dispersed compost samples were used for nutrient analysis. and used for further study. Evaluation of nutritional parameters of compost

The collected compost obtained after the decomposition of wastes was evaluated for nutrient parameters such as Nitrogen (N), Phosphorous (P), Potassium (K), organic carbon and humic acid. Dried and finely dispersed compost samples were used for nutrient analysis. N,P,K and organic carbon evaluated by the modified method of Keith [8], ammonium molybdate ascorbic acid method, atomic absorption spectrophotometric method and Walkley-Black method respectively. Humic acid was determined by Tripathi et al. [9].

Sample preparation: About 2 gram of the dried and finely dispersed compost was transferred to 1250 ml of Erlenmeyer flask and 50 ml of extract and 0.01 M CaSO4 and 2 M KCl was added, kept the mixture in the orbital shaker at 30°C for 30 minutes. The mixture was filtered through Whatman No.2 filter paper. The filtrate thus obtained used for analysis

Total nitrogen analysis: Total nitrogen was evaluated adopting modified method of Keith [8] with nitrate electrode using known standards.

Total phosphorous analysis: Total phosphorous was determined by ammonium molybdate ascorbic acid method with known concentration of working standards, 2 ml of the sample was mixed with 8 ml of concentrated ammonium paramolybdate (0.1 M) and ascorbic acid (1 M). Absorbance of the reaction mixture was read at 882 nm in colorimeter.

Total potassium analysis: Adopting atomic absorption spectrophotometric method, total potassium was determined with working known standards. 2 ml of the aliquot of the working standard and sample was mixed with 5 ml of lanthanum working solution and total potassium was measured by atomic spectrophotometer at wavelength of 422.7 nm.

Organic carbon analysis: Organic carbon was measured by Walkley-Black method. 2 ml aliquot of the sample with 10 ml of K2Cr2O7, 20 ml of concentrated H2SO4, 10 ml of 85% H2PO4 was titrated against 0.5 M Fe+3 using ferroin as an indicator.

Humic acid analysis: 10 gm of the compost sample was mixed with 100 ml of distilled water and 4 gm of sodium hydroxide, mixed well and the suspension was filtered through Whatman No. 1 filter paper, the collected precipitate was dried overnight at 45°C. The dry weight thus obtained was considered as humic acid [9].

Evaluation of plant growth parameters

Description of the plot and application of compost: The micro plot with the size of 5x3 m leaving a gangway of one meter has been maintained for this study. Vigna mungo was sown during second week of November 2010 at a spacing of 30×10 cm and regularly water was sprayed without conventional agriculture practices, chemical synthetic fertilizers and pesticides were not applied. During 20 days of seeding emergence, 3% of compost was applied (Average Recommendation (AR) for field application kg/ha’) during evening time at less wind velocity. Control plot was sprayed with water only. Three replications were maintained.

Plant growth parameters study: After treatment, the shoot length, height of the plant, leaf surface area, total new branches emerged, total foliage density pest infestation and pathogenic invasion, phyllosphere microbial population, chlorophyll content was studied every 20 days after treatment. In addition, soil heterotrophic microbial population in compost applied plot was also studied. Total soil nitrogen, phosphorous, potassium, organic carbon was evaluated after 40 and 80 days of application as described earlier.

Cost Benefit Ratio: The total yield and cost benefit ratio was determined by measuring the total quantity of the gram obtained after harvesting and cost benefit ratio was calculated by using the following formula [10].

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\text{Cost Benefit Ratio} = \frac{\text{Total gain}}{\text{Total cost of cultivation}}
\]

Results and Discussion

Decomposition of wastes

In the case of fruit wastes, the decomposition process was started after the application of the EM which was visualized clearly after the 5th day of EM application by appearance of actinomycetes and fungi growth. A sharp decrease in volume and decolourization, development of pleasant odour, changes in physical texture and less water activity was seen. The same observation was occurring rapidly in the successive days. The complete decomposition was clearly observed on the 25th day, which clearly identified by sharp decrease in volume (3/4th of the volume) complete decolourization, complete absence of water content and complete conversation of finely ground powder which clearly reveals the decomposition of fruit wastes into fine powder (Figure 1b).

Nutritional parameters of compost

All the tested nutritional parameters except total phosphorous and organic carbon were significantly increased (P<0.05) in compost derived from EM-1 treated fruit wastes. Total nitrogen, phosphorus and potassium of the compost reveal 672,708 and 2927 mg/kg (Figure 1c), 35.1% of organic carbon and 13.02 mg/kg of humic acid (Table 4). But distinct reduction in all the nutritional parameters was recorded in control which reveals 587, 898 and 991 mg/kg of total nitrogen, phosphorus, potassium, 51.4% of organic carbon and 0.79 mg/kg of humic acid.

Plant growth parameters

Distinct differences in all the tested plant growth parameters were recorded in compost treated plots. This was a significant difference (P<0.05) in shoot length, total height of the plant, leaf number per plant, leaf surface area, total new branch emerged, total foliage count.
per plant was observed. In compost treated plots 22.0, 28.0, 32.0, 37.5, 38.0, 40.0, 25.0, 26.5, 27.0 cm. The leaf surface area in compost treated plants was increased 5.0, 5.4, 5.6, 5.9 and 6.2 cm and 5.0, 5.3, 5.6, 5.6 and 5.7 cm in control. The total height of the plant was also increased in compost treated plots 25.0, 31.0, 34.0, 39.1, 39.0, 40.5 cm and control plots recorded 24.0, 26.0, 27.0, 28.0 and 30.0 cm respectively.

Table 1: Effect of compost on growth parameters of Vigna mungo

| S.No | Treatment | Plant Growth Parameters | Pre Treatment | Days After Treatment |
|------|-----------|-------------------------|---------------|---------------------|
|      |           |                         |              | 20th | 40th | 60th | 80th |
| 1.   | Control   | Length of the shoot (cm) | 22.0±0.1      | 24.0±1.1 | 25.5±0.2 | 26.5±0.1 | 27.0±0.4 |
| 2.   | Test      |                          | 23.0±0.3      | 28.0±1.2 | 32.0±0.4 | 37.5±0.1 | 38.0±0.6 |
| 3.   | Control   | Leaf surface area (cm)   | 5.0±1.3       | 5.3±0.4 | 5.6±0.2 | 5.6±0.6 | 5.7±0.4 |
| 4.   | Test      |                          | 5.0±0.4       | 5.4±1.5 | 5.6±0.4 | 5.9±1.1 | 6.2±0.4 |
| 5.   | Control   | Height of the plant (cm) | 24.0±0.3      | 26.0±0.4 | 27.0±0.1 | 28.0±0.4 | 30.0±1.4 |
| 6.   | Test      |                          | 25.0±0.4      | 31.0±0.7 | 34.0±0.1 | 39.1±0.3 | 40.5±0.5 |
| 7.   | Control   | Total new branches emerged / plant | 1.0±0.2 | 2.0±0.3 | 2.0±0.4 | 3.0±1.2 | 3.0±0.4 |
| 8.   | Test      |                          | 1.0±0.2       | 2.0±0.8 | 3.0±0.4 | 5.0±0.3 | 6.0±0.5 |
| 9.   | Control   | Total foliage count / plant | 15.0±0.3 | 22.0±0.4 | 28.0±0.1 | 31.0±1.4 | 37.0±0.6 |
| 10.  | Test      |                          | 15.0±0.2      | 29.0±0.4 | 34.0±0.4 | 37.0±0.1 | 40.0±0.4 |

*Mean of five replications
* Significant at P > 0.05 level by DMRT
and 32.6×10⁶ CFU/g after the treatment. No distinct changes were observed in microbial population of control plot. Soil microbial population of compost treated plot reveals maximum population in all the tested time periods. Bacterial count 39.6×10⁷ recorded during pre treatment increased to 39.6×10⁸, 48.6×10⁸, 50.8×10⁸ and 4.7×10⁹ CFU/g, actinomycetes count 48.6×10⁵ recorded before the treatment increased to 57.3×10⁶, 68.7×10⁶, 9.6×10⁷ and 10.3×10⁷ CFU/g whereas mould and yeast population was increased at the respective tested time period from 54.4×10³ to 74.3×10³, 5.8×10⁴, 38.2×10⁴ and 8.7×10⁵ CFU/g. But least microbial population was recorded in control. Soil nutrient analysis of compost treated plot reveals a sharp increase in all the soil tested parameters. 981 mg/kg, 901 mg/kg, 3014 mg/kg, 36.5 % and 21.0 mg/kg of total nitrogen, phosphorous, potassium, organic carbon and humic acid was increased. This is the first attempt of studying the effect of compost derived from decomposed fruit wastes by applied effective microorganisms (EM) with 672.0, 708.0, 2927.0, 13.02 mg/kg and 35.1% of total nitrogen, phosphorous, potassium, organic carbon and humic acid content.

### Table 2: Effect of compost on pest infestation/plant, disease spots/plant and chlorophyll content (g.) on Vigna mungo

| S.No | Treatment Parameters                  | Pre Treatment | Days After Treatment |
|------|--------------------------------------|---------------|---------------------|
|      |                                       | 20th          | 40th                | 60th                | 80th                |
| 1.   | Control Peat infestation per plant   | 0.37±0.3      | 0.5±0.4             | 0.62±0.1            | 1.0±0.3             | 1.25±0.3            |
| 2.   | Test                                 | 1.0±1.2       | 0.8±0.4             | 0.6±0.4             | 0.5±0.1             | 0.5±0.3             |
| 3.   | Control Disease spots per plant      | 1.62±0.5      | 2.10±0.1            | 2.01±1.0            | 3.01±0.3            | 3.37±0.4            |
| 4.   | Test                                 | 0.70±0.5      | 0.61±0.4            | 0.40±1.1            | 0.30±0.4            | 0.25±0.3            |
| 5.   | Control Chlorophyll content          | 0.32±0.4      | 0.35±0.5            | 0.37±0.3            | 0.41±0.1            | 0.43±0.1            |
| 6.   | Test                                 | 0.32±0.2      | 0.51±1.1            | 0.76±0.2            | 0.80±0.4            | 0.94±1.1            |

*Mean of five replications

### Total yield and cost benefit ratio

Maximum production of Vigna mungo (1097.12 kg/ha⁻¹) was recorded in compost treated plots while 581.22 kg/ha⁻¹ in control plots (Table 7). Cost benefit ratio was also in compost treated plots which reveals 1:1.93 and 1:01 in control plots.

A major problem facing municipalities throughout the world is the treatment, disposal and or recycling of solid wastes. Generally solid waste from a municipality consists of biodegradable organic materials. At the present time, there are a number of methods being used to dispose of the solid wastes in a landfill. Although there are many methods used, it requires the selection of the correct method focusing on efficient and environmentally safe disposal. New technology is being produced to assist the organic waste treatment, conforming to strict environmental regulations. One of those new technologies being proposed is the use of effective microorganisms [11]. Effective Microorganisms (EM), a culture of coexisting beneficial microorganism predominantly consisting of lactic acid bacteria, photosynthetic bacteria, yeast, fermenting fungi and actinomycetes that are claimed to enhance microbial turnover in soil and thus known to increase soil macronutrients and increases plant growth, yield and treatment of sewages or effluents [12,13]. In the present study, the fruit wastes decomposed into compost by Effective Microorganism (EM-1) with 672.0, 708.0, 2927.0, 13.02 mg/kg and 35.1% of total nitrogen, phosphorous, potassium, humic acid and organic carbon. Previous studies have demonstrated a consistent positive response with the use of effective microorganisms in crop production and indicate the potential of this technology to reduce fertilizer use and increase the yield and quality of crops [14-18]. This is the first attempt of studying the effect of compost derived from fruit waste decomposition by effective microorganism on growth parameters of Vigna mungo under micro plot assay. In the present study, the fruit wastes were effectively decomposed by applied effective microorganisms with complete reduction of volume of wastes, development of pleasant odour and formation of finely dispersed nutrients compost with high nutrient value except total phosphorous and organic carbon. But, total nitrogen content was increased. This is due to increased microbial activity continues in the casts and results in an increased rate of mineralization rate of organic nitrogen and consequent further increase in concentration of NO₄⁻ [11]. However, organic carbon was decreased in compost due to the organic carbon is lost as CO₂ during decomposition which thus results in lower organic carbon content.

The effect of compost on plant growth parameters of Vigna mungo under micro plot assay reveals that the plant growth parameters of V. mungo was increased. Increased plant growth probably reflects the supply of various nutrient factors in the compost as 672.0, 708.0, 2927.0, 13.02 mg/kg and 35.1% of total nitrogen, phosphorous, potassium, humic acid and organic carbon. Nitrogen and phosphorous is one of the essential nutrients involved as a constituent of bio molecules such as nucleic acids, coenzymes and proteins [19]. Humic
It is also one of the major element which improves soil fertility and increasing the availability of nutrient elements and consequently affected the plant growth. Increase in the number of leaves with high chlorophyll content, leaf area are common occurrences in plants that are provided with proper nutrition and this can increase the photosynthetic activity of the plants. Increase in leaf area and number of leaves should result to higher rates of photosynthesis hence increased plant growth. For plants, a high rate of net carbon assimilation can result in higher biomass accumulation, favouring future growth and reproduction. The position and distribution of leaves along the 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. The nutrient factors supplied from the compost increased the phyllosphere, soil microbial population and soil nutrients. In the present study, the increased nutrients provided by the compost derived from decomposed fruit wastes by Effective Microorganism (EM-1) favoured the plant growth parameters of *Vigna mungo*, soil nutrient factors which in turn increased the yield and cost benefit ratio. The direct influence of compost derived from fruit wastes decomposition by effective microorganism technology with EM-1 on plant growth parameters of *Vigna mungo* recorded maximum yield of grain and cost benefit ratio suggests the effective management of solid wastes into high nutritious organic fertilizer which lead a new way in organic waste treatment and generation of compost as the effective organic fertilizer to improve the crop productivity and yield. Further study under field trial will be helpful to exploit the principle of compost derived from fruit waste decomposition by Effective Microorganism (EM) for improved organic farming.

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Table 4: Organic carbon (%) and humic acid content (mg/kg) of compost

| S.No | Parameters | Control | Treatment |
|------|------------|---------|-----------|
| 1.   | Total yield | 581.22 kg/ha<sup>1</sup> | 1097.12 kg/ha<sup>1</sup> |
| 2.   | Cost benefit ratio | 21.0 | 1:01 |

Table 5: Total nitrogen, phosphorous and potassium (mg/kg) of compost treated plot soil

| S.No | Parameters | Control | Treatment |
|------|------------|---------|-----------|
| 1.   | Nitrogen   | 521     | 981       |
| 2.   | Phosphorus | 612     | 901       |
| 3.   | Potassium  | 610     | 3014      |

Table 6: Organic carbon (%) and humic acid content (mg/kg) of compost treated soil

| Organic carbon (%) | Humic acid (mg/kg) |
|--------------------|--------------------|
| Control            | Treatment          |
| 11.1               | 3.0                |
| 36.5               | 21.0               |

Table 7: Total yield and cost benefit ratio of compost treated *Vigna mungo*