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APPLICATION OF EFFECTIVE MICROORGANISMS ON SOIL AND MAIZE

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ABSTRACT

This study aimed to investigate the effect of effective microorganisms (EM) on the chemical and physical properties of the soils and the subsequent effects of the application of such soils to the plantation of maize. Experiments were conducted to evaluate the effectiveness of EM in improving the organic materials in the soils and hence the nutrient content and the yield of maize. Two formulations of fertilizers were prepared: (i) quail dung, rice brain, Tongkat Ali, water, molasses, EM activation solution and (ii) quail dung, saw dust, palm kernel cake, zeolite water, molasses, EM activation solution. Pure soil was also use as control. The results showed that EM can increase the concentration of macronutrient and micronutrient for the quail dung following EM treatment compared to quail dung without EM treatment. The physical properties of the soils such as moisture and ash content have also been significantly increased with EM treatment. These results showed that EM positively increased the organic materials, nutrient content and the dry matter of the fertilizer. EM fermented compost has also promoted the health of the maize plant as all maize produced were free from visible nutritional deficiency symptoms. On the other hand, in the absence of EM, deficiency symptoms were found on the grains, ears corns and leaves of the maize plant. These results indicated that the application of EM promoted plant growth, grain yield and the photosynthetic activity of the maize by increasing root development and root activity. It was concluded that the incorporation of a mixture of EM intensified the biological soil activity and improved the physical and chemical soil properties, hence contributing healthier plant growth and development.

Key Words : Effective microorganisms, Compost, Maize, Nutrient deficiencies

1.0 INTRODUCTION

The preparation for agricultural fertilizer has improved significantly with the advancement in science and technology. Farmers can now use various types of micro and macro chemical fertilizers to improve soil fertility and productivity. Due to the relatively high price of chemical fertilizers, macro fertilizers (NPK) are generally applied only to the roots, where as micro fertilizers are applied to the leaves. The application of chemical fertilizers to improve soil fertility and productivity remains quite costly. In addition, repetitive and overuse of these fertilizers also tend to disturbs the balance of the microorganism population in the soil, which results in the acceleration of the growth rate of pathogen population in the soil [1].

Application and management of organic matter as organic fertilizers are the methods to improve growth environment for plants in order to increase and to optimize the benefits of fertilizer use and soil productivity. Organic matter is a biological buffer

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which plays a very important role in maintaining the balanced supply of available nutrients for the plant. There is a significant correlation between soil organic matter content and soil productivity. The higher the soil organic matter content, the higher the soil productivity [2]. However, animal manure needs to be used in a large quality in order to achieve the desired result. Utilization of raw animal manure will lead to several undesirable effects such as acidification of soil, poor sanitation that cause negative effect on human health and increased pest incidence and diseases and weed problem [3].

EM can be used to promote soil fertility and soil quality, reduces or eliminates the use of inorganic inputs, enhances crops yields and quality, accelerates the production of quality fertilizer by promoting fermentation and decomposition of waste and organic matter used in agriculture and lowers the hazards of continued cropping in open and greenhouse environments.

2.0 METHODOLOGY

2.1 Preparation of EM Activated Solution (EMAS)

The plastic container of 20L was used to accommodate the fermentation process of EMAS. Firstly, 18L of water was added into the container, this is followed by the addition of 1L of EM-1 and 1L of molasses. The container was capped tightly and placed on an orbital shaker at 200 rpm for 15 min at room temperature to dissolve the molasses. Then the container was left for 5-15 days in a warm but shaded area and kept from direct sunlight. The suitable temperatures for the fermentation of EMAS are from 30°C to 40 °C. The cap was opened for a while once a day to release any gases generated during the fermentation. EMAS is ready to be used when the pH drops below 3.5 and presents a sweet and sour smell.

2.2 Preparation of EM fermented compost

The EM fermented compost consists of quail dung, rice bran and saw dust in a ratio of 1:1:1. The compost contains 3% (v/w) of EMAS and 3% (w/w) of molasses from the total mass of the quail dung, rice bran and saw dust. Molasses was dissolved in the EMAS before being poured into the organic matters. The solution was poured gradually and mixes well with the organic matters. There should be no drainage of excess water while the compost mixture was grasped tight in one's palm. The moisture content of the compost was analysed. The initial moisture content should be within 30-40%. The compost was covered over with a large sheet of gunny sack to maintain an aerobic state. The temperature should be kept around 35-45°C. The temperatures were checked regularly using a normal thermometer. The fermenting period was more than 2-4 days. It was ready to be used when it gave a sweet fermented smell and white mold on the compost.

2.3 Chemical Analysis of Soil and Composts

The chemical analysis on the soil and all composts covered nitrogen, phosphorous, potassium, sulphur, magnesium, calcium, boron, chlorine, copper, iron, manganese, zinc, nickel and molybdenum. All the chemical analysis was conducted according to the MERCK methods that were analogous to the EPA and US Standard Methods [4].

To determine the effect of EM on the composting of bio-organic fertilizer, the macronutrients and micronutrients of two composts and soil as control were analyzed and compared. The compost consists of quail dung, saw dust, palm kernel cake, zeolite water, molasses and EM activation solution. The compost was labelled as +EM. The compost which has similar compost composition as +EM but was lack of the EM activation solution was labelled as –EM.

2.4 Physical Analysis of Soil and Composts

The physical analysis of the soil and composts covered the determination of ash and water content. Both analysis were determined according to Malaysian Standard (1973). For moisture content analysis, 5g of sample was accurately weighted in a dish and dried in an oven at 105°C for about 1 day. The sampled was then cooled in a desiccator and weighted. For the determination of ash, 5g of sample was accurately weighted in a dish and the material was ignited with the flame of suitable burner for about 5 days. The sample was transferred into a muffled furnace until grey ash was obtained. It was then cooled in a dessicator and weighted.

2.5 Application of Compost to the Maize Plant

Three plots of land with the dimension of 2 m x 0.5 m each were prepared. For the first plot, soil was used as a control, the second plot consisted of soil that was supplement with EM fermented compost and the third plot was for the soil supplemented with quail dung without EM. For the second and the third plots, 6 kg of fertilizer were applied.

For the second plot, the seeds were soaked in the EMAS diluted solution (1000x dilution) for about 5 minutes before seeding or planted on the plot. Throughout the germination as well as the vegetative growth phase of the crop, the diluted solution of EMAS was sprayed onto the plants for once a week.

2.6 Physical Evaluation of the Maize Plants

The physical size and yield of each plant will be observed and recorded throughout the process to identify the effect of Compost to the crops.

3.0 RESULTS AND DISCUSSION

3.1 Preparation of EM-Fermented Compost

Table 1 shows the composition for two preparations of the composts.

Table 1 Formulation of compost

Composition of Fertilizer	Sample 1	Sample 2
Quail dung, kg	15.8	16.2
Rice Bran, kg	7	-
Tongkat Ali chips, kg	7	-
Saw dust, kg	-	5.6
Palm kernel cake (PKC), kg	-	18.2
Zeolite. Kg	-	1.6
Water , L	12	16
Molasses, L	0.9	1.2
EMAS, L	0.9	1.2

Temperature was used as the main indicator to determine the success of the fermentation of Fertilizer. Figure 1 shows the changes of temperature during the composting process for both samples. There are four important stages during this process. First stage represented the initial stages when the raw materials have not undergone any decomposition. The initial stages for both samples were on the first day when the temperatures were at ambient air (32 °C).

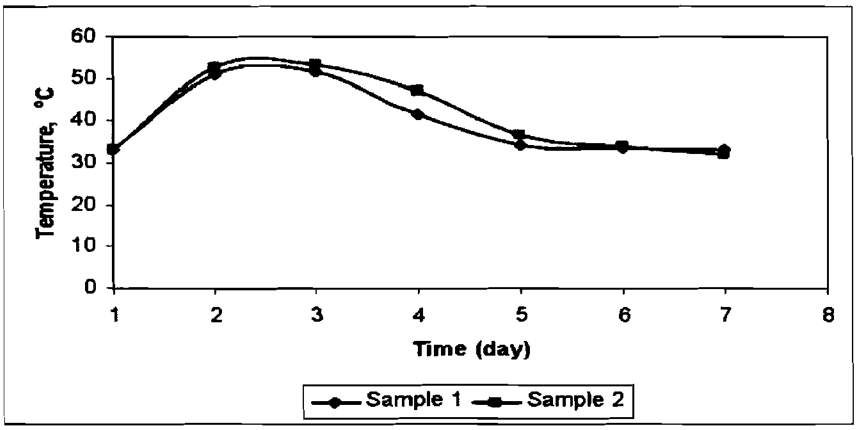


Figure 1 Temperature changes during composting

On the second day of composting, the temperature increased from ambient temperature to the maximum temperatures between 50 °C and 55 °C (thermophilic phase). Both samples have similar pattern of maximum temperatures. It shows that both samples underwent significant level of microbes activities by the mesophilic and thermophilic microorganisms. This is a critical phase to ensure the success of the composting process. The heat generated during composting contributed to the destruction of the pathogens [5]. Besides that different hydrolytic extracellular enzymes will be released by the microbes in the compost, which are involved in the depolymerization of larger compounds to smaller fragments. These materials are water-soluble and consist of different constituents of organic wastes [5].

After five days of composting, the temperature gradually decreased to ambient levels of between 30 °C to 35 °C, marking the end of the thermophilic phase. From Figure 1, both samples took seven days to stabilize to the temperature. This was the end of the bio-oxidative phase, when organic matter became more stabilized, the decomposition rate or the microbial activities on the organic matter have decreased [6]. The final stage was the maturation phase, which involved the longest duration of stabilization intended to produce highly stabilized and humid mature compost that was free of phytotoxicity. The entire process took one month before the compost could be used as a stable compost. The use of immature compost could cause phytotoxic effects as well as causing deficiency of nitrogen to plants that would reduce plant yield [6].

3.2 Analysis of Soil and Composts

3.2.1 Chemical Analysis

Primary Macronutrient

Three samples, namely the soil as control, -EM and +EM were analysed for the primary macronutrients, namely the nitrogen (N), phosphorus (P), and potassium (K). Comparisons of the analysis results for nitrogen and phosphorus are shown in Figure 2 and potassium in Figure 3.

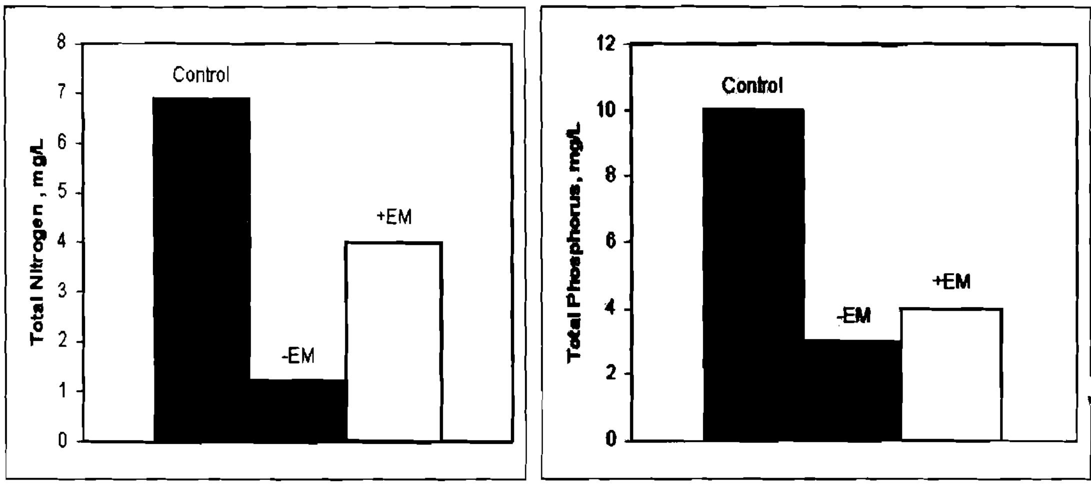


Figure 2: Comparisons of the analysis results for nitrogen and phosphorus for fertilizers with EM treatment (+EM) and without EM treatment (-EM) and soil as control.

From Figure 2, the control has higher concentration of nitrogen compared to samples +EM and –EM. During composting, all the soluble nitrogen compounds and the proteins are decomposed. Typically half of the nitrogen is transformed to ammonia and lost by volatilization [7]. However, from Figure 2, the sample +EM has a higher nitrogen concentration compared to +EM. As a result, EM technology can increase the nitrogen concentration in the animal manure. Similar pattern of results is also observed for the total phosphorus content. Animal manure and municipal waste are generally excellent sources of phosphorus (P), with manure accounting for 98% of organic P applied to cropland [8]. The form and content of P in fresh animal waste varies greatly depending on the P content of the feed, species and age of animals. The storage and handling of the manure can also change the nutrient content of the manure. From Figure 2, the P content in sample +EM was higher than that of -EM. In general, insoluble phosphate compound (organic and inorganic) in soil is not available for the plant. EM is assumed to be able to dissolve phosphate compound that is available and absorbable by the plant root. As such EM treatment in soil can increase P_2O_5content [1].

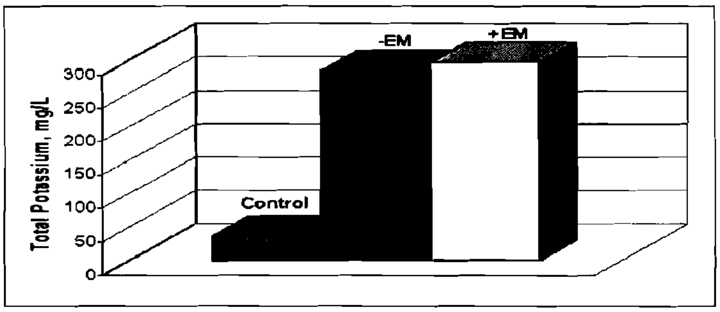


Figure 3 Potassium analysis

Potassium (K) is absorbed by plants in larger amount than any other nutrient except for N. Figure 3 shows there was significant difference in P content between composts and the control. Quail dung can supply high content of potassium to the composts. Potassium in organic waste (manures) occurs predominantly as soluble inorganic K^+. In animal manures, K content ranges between 0.2 and 2% of the dry matter. Therefore, waste materials can supply sufficient quantities of plant available K, depending on the rate applied [8]. From Figure 3, it is evidenced that the potassium content in the quail dung has been enhanced by EM treatment. With EM treatment, it could provide hi h organic matter to the soil. The organic matter has the ability to hold potassium ion in the organic manure.

Secondary Macronutrient and Micronutrient

Table 1 shows the summary of the analysis on secondary macronutrients and micronutrients for the samples –EM, +EM and the soil as control.

Table 1: Secondary macronutrients and micronutrients analysis for different samples of fertilizers and soil as control

Nutrients (mg/L)	Control	- EM	+ EM
Calcium	63	175.33	303.3
Magnesium	31	112.5	155
Chlorine	89	74	28
Sulfur	0.01	0.04	0.03
Boron	1.5	1.453	1.66
Cuprum	0.13	1.8	6.43
Iron	1.1	6.3	4.5
Manganese	1.14	1.367	1.933

Zinc	23.94	23.54	25.39
Mo	<1	0.39	1.67
Nickel	0.33	7.05	19

Table 1 shows the composition of secondary macronutrient and micronutrient of the fertilizers +EM and –EM and the soil as control. From Table 1, it shows that the fertilizers consisted mainly of the quail dung could supply higher content of macronutrients and micronutrients as compared to the control. For the comparison between +EM and -EM, it is shown that EM increased the nutrients of the fertilizer except for sulphur, chlorine and iron. Micronutrients are the elements which are essential for the plant growth, they are required in much smaller amounts than those of the primary nutrients such as nitrogen, phosphorus and potassium. When EM cultures are applied to the soil, they stimulate the decomposition of the organic wastes and residues thereby releasing inorganic nutrients for plant uptake [9]. EM increases fermentation and decomposition of organic matter and releases greater quantities of these essential elements in inorganic and organic forms. Once applied to the soil, the fertilizer enhances the fertility of the soil and thereby its quality and sustainability [10].

3.2.2 Physical Properties

Figure 4 shows the comparison of moisture content between fertilizers with and without EM treatment.

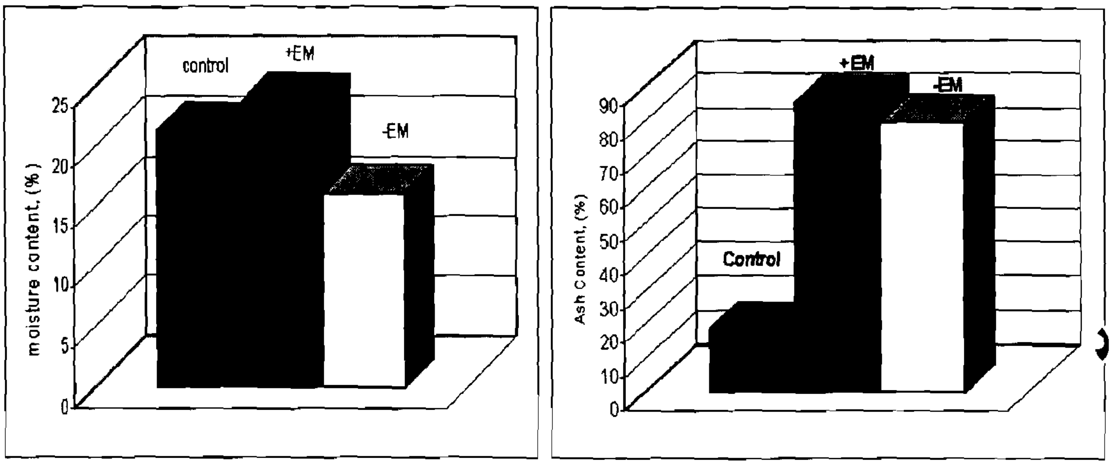


Figure 4 Analysis of physical properties

From Figure 4, it is shown that the fertilizer with EM treatment (+EM) has a higher percentage of moisture (24%) compared to fertilizer without EM treatment (-EM) (16%). For ash content analysis, sample +EM also showed a higher percentage (85%) than sample –EM this (79%). The control has the lowest percentage of ash content.

These results indicate that EM can enhance the physical properties of the fertilizer especially for moisture and ash contents. Ash content is a measure of the total amount of minerals that exist. Ash is the inorganic residue remaining after the water and organic matter have been removed by heating in the presence of oxidizing agents. It provides a measure of the total amount of minerals within the fertilizer. A higher percentage of ash content shows that the fertilizers have a higher percentage of minerals present. Meanwhile, moisture content is related with the changes in water holding capacities. The presence of organic matter increases water-holding capacities. The application of EM enhances these parameters which in turn induces greater benefits to the soil physical properties [10]. Organic matter is of great importance for the maintenance of soil, i.e. soil structure, soil bioactivity, soil exchange capacity and water holding capacity [12]. Microbes in the compost pile produce hydrolytic extracellular enzymes to depolymerize the larger compounds to smaller fragments that are water-soluble and assimilated by microorganisms in the compost [11].

3.3 Results for the Application of Compost to the Growth of Maize

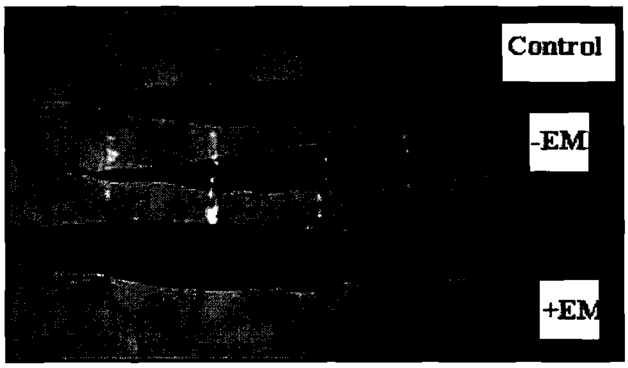
3.3.1 Effects on the Growth of Maize

Table 2 summaries the comparison of plant height, diameter of the stem, length and width of the leaf and the yield of the maize planting on three different plot of lands, namely on soil as control, land plot supplemented with fertilizer either with EM treatment (+EM) or without EM treatment (-EM).

Table 2: Effect of fertilizer on the growth of maize

Treatment	Plant Height (cm)	Diameter of stem (cm)	Length of Leaf (cm)	Width of Leaf (cm)	Maize Yield (for 4 plants)
Control (soil)	85	4.9	16	5	0
+EM	138	7.0	60	6.6	8
-EM	104	5.3	46	5.5	5

In all cases, the summaries show that maize which was grown using fertilizer treated with EM (+EM) gave best growth in terms of all criteria as evaluated in Table 2. The growth of the leave and the size of the leaves are further illustrated in Figure 5 and 6 respectively.



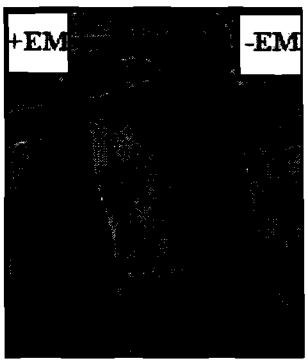


Figure 5 Different lengths and widths of maize's leaves. **Figure 6** Effect to grain's size.

Figure 6 shows that the grain produced from land supplemented with EM treated fertilizer (+EM) has a large diameter compared to that planted using fertilizer without EM treatment (-EM).

From Figure 7, the effect of EM treatment on the growth of root is shown. There were a lot of root on the soil surface for the plant that have been supplemented with +EM, followed by those treated –EM and the least root on the soil surface for the control. Only plants which received sufficient nutrient will have a good growth of root.

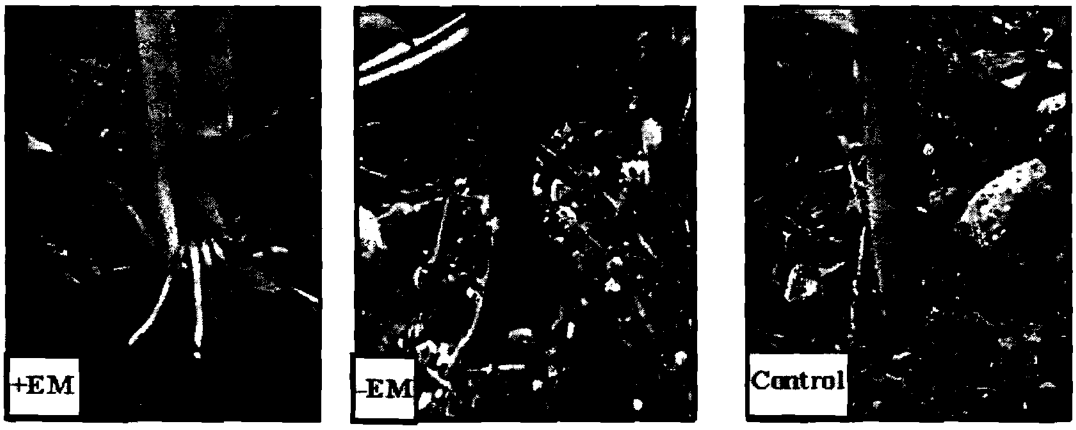


Figure 7 Root growth for soil with different treatments

The results shows that organic matter is important in maintaining crop yields of organic systems and that EM increases the capacity to improve yield, thus maintaining productivity and sustainability. All of these benefits could be attributed to the development of the soil by organic matter following treatment with the EM, which provides a conducive rhizosphere for plant growth [10].

3.3.2 Diagnosis of Nutritional Deficiencies on Maize's Growth

During this research, the deficiency symptoms were found on grains, ears corns and leaves of the plant. From Figure 8, the grains produced with EM treatment have a complete grain filling compared to that using fertilizer without EM treatment. This was due to the deficiency in potassium that occurred in the plant where the fertilizer used was not supplemented with the EM [14].

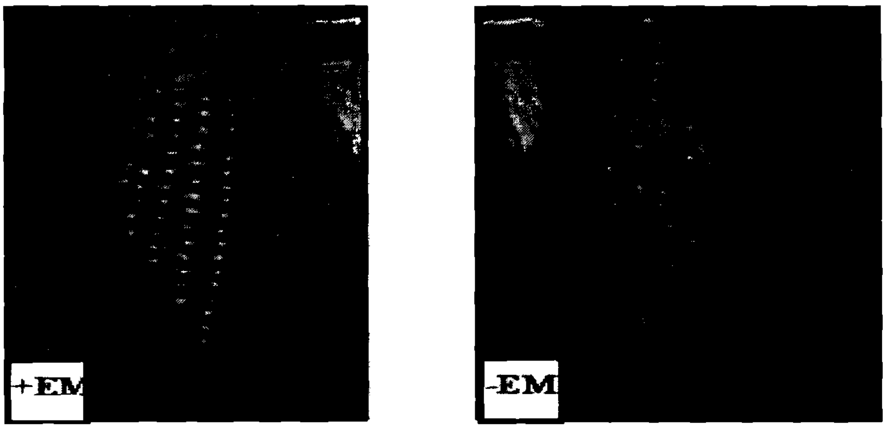


Figure 8: Maize that was planted with fertilizer without EM treatment (-EM) has shown deficiency in the grain filling as compared to that supplemented with EM (+EM).

The nutrient deficiency can also be identified based on corn ears. From Figure 9, the maize planted with –EM has the ears that were chaffy and unfilled. This result indicated that the fertilizer -EM experienced deficiencies in boron and potassium [14].

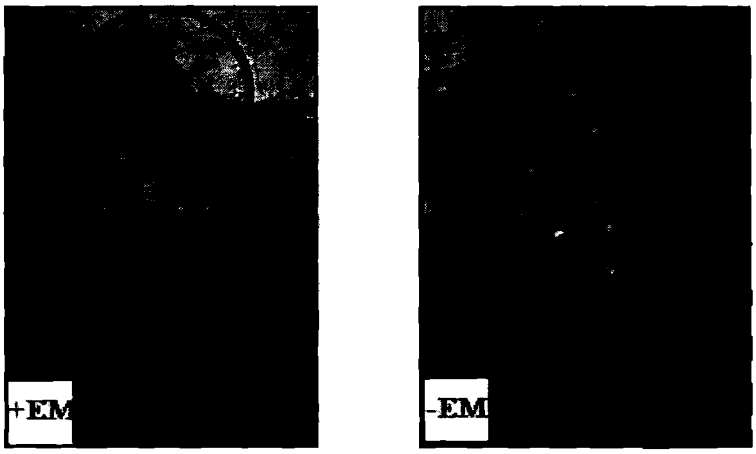


Figure 9: Maize that was planted with fertilizer without EM treatment (-EM) has shown deficiency in the ears as compared to that supplemented with EM (+EM)

In addition, the deficiency symptoms on the leaves of the maize plant have also been evaluated as shown in Figure 10..

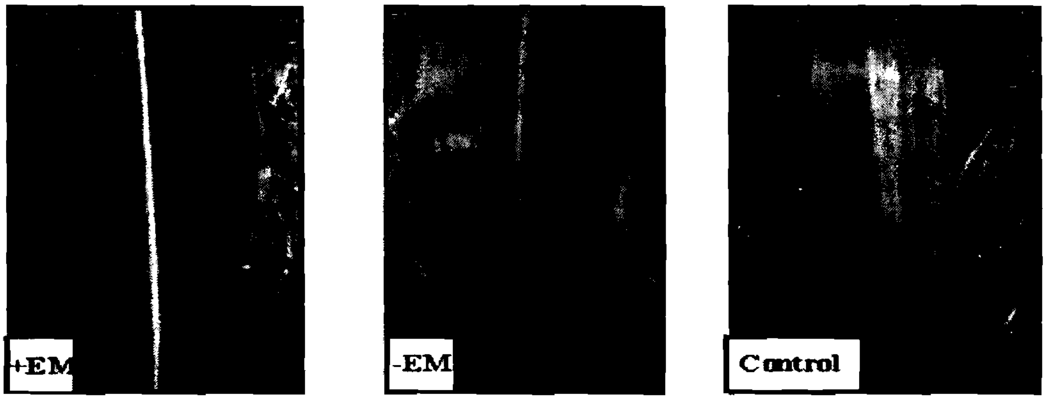


Figure 10 Maize leaves from maize that were planted with fertilizers without EM treatment (-EM) has shown deficiency in manganese where yellow streak marks were observed on the leaves as compared to that supplemented with EM (+EM)

From Figure 10, it is shown that the maize planted on control soil land has experience serious deficiencies in nitrogen and iron. Iron deficiency is mainly manifested by yellow leaves due to low levels of chlorophyll [14]. Leaf yellowing first appears on the younger upper leaves in the interveinal tissues. Nitrogen-deficient leaves generally appear usually pale green or yellowish, as it lacks adequate chlorophyll. The plant also showed deficiency in manganese. This was evidenced from the symptoms appeared on the uppermost of the mature leaves as interveinal chlorosis or streaked [14] as shown in Figure 10, samples –EM and control.

Through the treatment with EM, microorganisms in EM appear to suppress the development of harmful plant pathogens at the leaf surface, thereby providing a measure of plant protection through biocontrol [9]. The pigmented yeast and bacteria that colonized on the surfaces of the leaves could afford some protection to the plant from excessive exposure to direct sunlight [9]. The application leads to increase formation of chlorophyll, the green pigment of plants, which participates in the absorption of solar energy and its transformation into the energy of chemical relations of organic compounds in plants [13].

4.0 CONCLUSIONS

The temperature profiles showed that composting needed 30 days for complete maturation of the fertilizer. The results showed that the application of EM enhanced the chemical properties of the soil in terms of macronutrients and micronutrients. The physical properties in terms of water holding capacity and mineral contents have also been improved. Following the application of EM-fermented compost on the plantation of maize, the maize experienced better growth in terms of larger dimensions of leave, stem and grain size as compared to those not treated with EM. The yield of the maize and the root formation on the soil surface have also been improved.

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