EVALUATION OF EFFECTIVE MICROORGANISMS (EM) TECHNOLOGY ON MAIZE (*Zea mays* L.) GROWTH, DEVELOPMENT AND YIELD IN MOROGORO TANZANIA

RESEARCH REPORT

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PREPARED BY

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ABSTRACT.

The field experiment was conducted at Tushikamane Centre Kilakala, Morogoro Tanzania to investigate the effect of EM technology on maize (*Zea mays* L.) growth, development and yield. Maize is a major cereal consumed; over 80% of population depends on maize for food in Tanzania. Low soil fertility, insect pests and diseases are among the primary constraints in maize production. This is due to continuous cultivation without fertilizing the soil, poor and lack of proper measures to control pest and diseases. Most farmers in both rural and urban areas of Tanzania are not aware with the use of organic fertilizers especially the EM (Effective Microorganism) technology in agriculture to increase crop yield without the use of agricultural chemicals or artificial fertilizers, the method of farming is inexpensive, capable of producing high-quality products, high yield produces and preserving the environment. Therefore, this research work mainly aimed at studying the efficiency of EM technology on maize (*Zea mays* L.) crop performance in the field.

Five treatments comprising of EM technology EM-Bokashi, Bokashi and EM-A, EM-FPE and EM-5, combination of Bokashi, EM-A, EMFPE and EM5, and absolute control were compared in a randomized complete block design with three replications. Bokashi leaves (3.7%N) at 1851.9kg/ha, 200 mls of EMA mixed with water to make a 2L solution, EMFPE and EM5 were mixed with water at 200mls to get a 2L solution which was sprayed thrice a week scheduled for application. Three weeks were scheduled for application of EM.

Application of EM-Bokashi produced an average yield of 3.06 $tonha^{-1}$, EM-Bokashi and EM-A produced grain yield of 3.24 $tonha^{-1}$, EMFPE and EM-5 produced 3.11 $tonha^{-1}$ and, application of all EM-Bokashi, EM-A, EMFPE and EM-5 produced grain yield of 3.51 $tonha^{-1}$, while absolute control produced 2.12 $tonha^{-1}$. Application of EM improved maize crop yield.

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Our deepest appreciation and thanks to colleagues from Sokoine University of Agriculture (SUA) for their challenges, advice and logistic support to ensure that the research was accomplished successful. Also Tanzania Meteorological Agency (TMA) Eastern Zone Morogoro Station for providing climatic data.

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Since it has been difficult to mention everybody, we thank all people who participated either directly or indirectly during field activities, laboratory activities, data compilation, data analysis and interpretation, and report writing. God bless you all.

P. S. Saidia

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DECLARATION

This project report is the original work of Bustani ya Tushikamane – Garden of Solidarity under the research study entitled *"Evaluation of EM Technology on Maize (Zea Mays L.) Growth, Development and Yield in Morogoro, Tanzania"*.

It has not been submitted to any other institution for any award, presentation or approval and all the stages of this study were done in collaboration between Bustani ya Tushikamane (Alexander Wostry, Janet Maro, Haji Halidi and Doto Richardi) and Researchers (Paul Saidia and Daudi Chilagane).

Signed.....

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ABBREVIATIONS AND ACRONYMS

APNAN	Asia Pacific Natural Agriculture Network
ARI	Agriculture Research Institute
ATI	Agricultural Training Institute
BACAS	The Bureau for Agricultural Consultancy and Advisory Service
CEC	Cation Exchange Capacity
EM	Effective Microorganisms
EMA	Activated EM
FPE	Fermented Plant Extract
K	Potassium
MAFC	Ministry of Agriculture Food Security and Cooperatives
N	Nitrogen
P	Phosphorus
SUA	Sokoine University of Agriculture
SADC	Southern African Development Community
TDM	Total Dry Matter

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information.

Maize (*Zea mays* L) is the main staple crop in Tanzania. It is the major cereal consumed and estimated that the average consumption is 113kg per year, over 80% of population depends on maize as food in Tanzania. The national maize consumption is estimated to be three million tons per year. Maize contributes 60% of dietary calories and more than 50% of utilizable protein to Tanzanians. The crop is cultivated on an average of two million hectares, which is about 45% of the cultivated area in the Country (Kaliba *et al*, 2000, Katinila *et al*, 1998 and Kitenge *et al*, 2004) the crop is grown on mainly during the main season "masika" and also during the second season "vuli". Food is the basic necessity for human beings. Because of the importance of soil fertility in food production it is fitting to trace the highlights in our understanding and development of sound soil fertility practices to farmers. The actual fertility of some soils is decreasing, because greater quantities of plant nutrients are being removed than are being added (Tisdale *et al*, 1985).

There is a slow growth of maize output or production relative to a population growth. One of the main problems causing low maize production is fertility of the soil being low. If a soil is to produce crops successfully, it must have, among other things, an adequate supply of all the necessary nutrients which plants take from the soil. Not only must be required nutrient elements be present in forms that plants can use, but also there should be a rough balance between them in accordance with the amounts needed by the plants. If any of these elements is lacking or if it is present in improper proportions, normal plant growth will not occur (Foth and Turk, 1972).

Also this crop is affected by insect pests which cause serious damage, loss of the produces and finally low production. Therefore in areas like Morogoro and other maize producing regions falling in the trend of maize production is attributed by decreasing in soil fertility and insect pests' infestation.

1.2 Problem Statement and Justification.

Currently, there has been a declining trend in maize production in Tanzania. The 2008/09 National food production for maize was 3,424,984 tons while the requirement being 4,131,782 tons the deficit is 706,797 tons, total food produced was estimated to 12% below the trend value, this is according to The Ministry of Agriculture Food Security and Cooperatives (MAFC, 2009). This is due to a number of factors that include low soil fertility and pests infestations such as stem borers.

Farmers are continuously cultivating crops without fertilizing the soil. This is because most of them do not have enough knowledge, skills and information about various alternative fertilizers which are organic and that can be prepared by them. Most farmers in both rural and urban areas of Tanzania particularly Morogoro are not aware with the use of organic fertilizers especially the EM (Effective Microorganism) technology in agriculture. In agriculture, EM technology makes it possible to increase crop yields without the use of agricultural chemicals or artificial fertilizers, the method of farming is inexpensive, capable of producing high-quality products, high yield produces and preserving the environment (Higa and Kanal, 1998).

Also most farmers in Morogoro are engaging themselves in maize production. After a long discussion with farmers or people visiting the information office at Bustani ya Tushikamane for consultation about organic farming, a large number of people are dealing with maize crop. Moreover, most farmers signing the register or visitors' book in the office seem to be interested in maize production.

1.3 Objectives

1.3.1 Overall objective.

This research work aims at studying the efficiency of EM technology on maize (*Zea mays* L.) crop performance in the field.

1.3.2 Specific objectives.

i. To assess the influence of EM-Bokashi on maize growth and development.

ii. To investigate the effect of EM-FPE and EM-5 in maize growth, development and yield.

iii. To evaluate the outcome of mixing EM-Bokashi, EMA, EMFPE, and EM5 on maize yield and quality.

CHAPTER TWO

2.0. LITERATURE REVIEW

2.1 Organic Manure.

Organic manures are natural products used by farmers to provide food (plant nutrients) for the crop plants. There are a number of organic manures like farmyard manure, green manures, compost prepared from crop residues and other farm wastes, oil cakes, and biological wastes - animal bones, slaughter house refuse.

Organic manures increase the organic matter in the soil. Organic matter in turn releases the plant food in available form for the use of crops. However, organic manures should not be seen only as carriers of plant food. These manures also enable a soil to hold more water and also helps to improve the drainage in clay soils.

They provide organic acids that help to dissolve soil nutrients and make them available for the plants. This is according to the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) (Diwarkar, 2004).

Natural fertilizers have a lot of advantages including the following: prevent soil nutrients from leaching, to fix and hold soil nutrients in an insoluble organic form which when mineralized by soil microorganism supply the plant with 'a gentle stream' of nutrient throughout their life period. Also organic manure increase soil nitrogen from nitrogen fixation, moreover organic fertilizers provide a wide spectrum of plant nutrients. Natural manures supply some organic matter which persists in the form of humus in the soil and improve its physical properties. Furthermore, organic manure encourages insects and worms to burrow into the ground thus improving permeability to a large extent (Onwueme and Sinha, 1999; Uwizeyimana, 1997).

Additionally, other benefits of organic manure consist of increasing moisture retention in the soil, greater movement and availability of phosphorus and micronutrients due to complexation, improve soil structure with corresponding increase in infiltration rate and decrease in soil bulk density, also increase buffering capacity against drastic changes in pH, and complexation of aluminium ion (Al^{3+}) thereby reducing its toxicity (Tisdale et al, 1985).

The presence of organic manure on the soil surface has some effects on soil physical properties such as reducing impact of rain drop on soil surface which might cause splash erosion. Also reducing evaporation and excessive heating and allowing microbiological activity to occur at optimum temperature (Uwizeyimana, 1997).

2.2 EM Technology.

According to Higa and Kanal (1998) and Takash Kyan *et al* (1999) EM is an abbreviation for "Effective Microorganisms" or for the group comprising a heterogeneous collection of effective microorganisms that affect the world of nature in a positive manner. EM is also the term applied to the liquid concentrate comprising very large numbers of such effective microorganisms that have been extracted from the natural world and coexist harmoniously in a liquid state. These microorganisms include lactic acid bacteria (*Lactobacillus Spp*), yeast (*Saccharomyces spp*), photosynthetic bacteria (*Rhodopseudomonas spp*), actinomycetes and fermenting fungi (Takash Kyan *et al.*, 1999). This is the technology which originated from Japan and was developed by a distinguished professor of horticulture Dr. Teruo Higa in the early 1980s at the University of the Kyukus, Okinawa Japan. The application of EM technology offers the potential solution to the problems of food, environment, and medical issues.

These microorganisms enhance fermentation, creating substances that are effective and useful. Raising the quality level of the soil, air, or the human body, works to our benefits because it creates a situation that enables all microorganisms to be led in the direction of regeneration which makes things vital, alive and maintained in a good state of health. The EM technology is used to prepare organic manures such as EM-Bokashi and other compost manures for soil fertilization as well as pesticides such as EM-FPE and EM-5 that prevent insect pest infestations.

2.3 Application of EM.

EM prevents damage experienced by pests to crops and fertilizes the soil. Therefore, this leads into increased harvests, also improves quality of the agricultural produces leading into higher prices.

Used in agriculture, EM technology makes it possible to increase crop yields to twice or thrice what they are at present, and do so without the use of agro chemicals or artificial fertilizers, produces are superior in quality. The EM agricultural techniques make it possible to remedy the root causes of low productivity in agriculture, but would also be capable of regenerating soil exhausted and impoverished by the use of artificial fertilizers and agricultural chemicals. Also, crops grown with EM farming techniques do not rot easily during transportation. Furthermore, EM technology is achieving similarly impressive results for fruit farming and flower cultivation. This technology promotes the so called integrated farming system, EM technology has a wide range of applications including, apart from crop farming, in livestock operations, and in the protection of the environment to create a system that generates zero wastes.

EM technology is applied to raising healthy livestock such as poultry, hogs (pigs) and others that can be turned into a source of income and savings which will enable the farmer to build up capital (Higa and Kanal, 1998 and Takash Kyan *et al*, 1999).

Moreover, EM technology facilitates recycling of materials which would otherwise be wasteful and pollute the environment. Domestic wastes can be treated with EM to make a fertilizer. Poultry droppings treated with EM, hog manure treated with EM, and any excess excreta as well as solid waste can be used in cultivation of fruit trees and other crops. Applied to the environment, EM has the ability to transform almost all the pollutants, waste, and refuse we find so distasteful and troublesome, turning them back into an unpolluted state, thereby rendering them materials with the potential to be recycled simply because the effective microorganisms that constitute EM basically thrive in a polluted environment (Higa and Kanal, 1998 and Takash Kyan *et al*, 1999).

2.4 Preparations of EM.

According to the information from the EMshop (2008) and Takash Kyan *et al* (1999), there are several ways to prepare and use EM technology as follows.

EM-A or Activated EM (or Activated EM-1) is made by mixing EM-1 with molasses and water and fermenting for about 3 to 5 days in a tightly closed container (preferably plastic so it can expand) until the pH drops below 4.0. Activated EM is mainly for economic reasons. For example, a gallon of EM-1 can be made into 22 gallons of Activated EM (at 1:1:20 ratio) or in agriculture (100 litres of good quality water + 5 litres of EM + 5 litres or kg of molasses).

The activated EM-1 can be used in the same way as the EM-1, but should be used within 30days after the pH drops below 4.0. Activated EM can be made by the user or available through an authorized Activated EM Service Provider. Activated EM is not meant to be a commercially packaged product.

EM- Bokashi. The term Bokashi has been used in Japan for a long time by farmers. It refers to organic materials that have been fermented with EM and made for good fertilizer. The farmers would find and gather certain materials (for mineral content and microbial contributions), including such things as mountain moss, and ferment them in a pit, for example. However, the results could be unpredictable and finding the materials was not always easy or convenient.

With EM-1, it became very easy to consistently produce Bokashi. Bokashi is ready for use in four to ten days, although organic matter is not well decomposed as in traditional compost. The application of bokashi to soil provides a medium for EM to develop as well as nutrients to crops. Materials for making bokashi include plants, animal sources, EM-1, molasses and water, example 100 litres or kg rice bran, 25 litres oil cake, 25 litres fish meal, 150ml EM, 150ml molasses and 15litres water can be used to prepare bokashi. The standard ingredient for EM Bokashi for farm use in the U.S. is wheat bran treated with a solution of EM-1, molasses and water.

In other parts of the world, rice bran is used since it's more readily available and cheaper. Sometimes other materials are added, such as fish meal and oil cake, for nutrient and mineral content, depending on use. EM Bokashi is also used to treat food waste and recycle them as quality fertilizer.

EM Bokashi can be made at home or can be purchased ready-made. EM Bokashi Mud Balls (or EM Bokashi Balls) are made with the sludge (mud) from the bottom of a polluted body of water (river, lake, bay, etc.).

When the EM Bokashi Mud Balls are fermented and ready, they are then thrown into that same body of water at various spots in order to decrease the pollutants and clean the water.

EM-1 is a brownish liquid containing a mixture of microorganisms. EM-1 is produced through a fermentation process and consists of water, molasses, lactic acid bacteria, yeast, and phototrophic bacteria. The specific combination of microorganisms is the key to its effectiveness. The microorganisms are all natural, non-pathogenic, non-toxic, and classified as Bio safety Level 1. Items that are Bio safety Level 1 (BSL-1) are known NOT to cause diseases in healthy human adults. The classification is based on assessment of the potential risk using U.S. Public Health Service guidelines and also as provided by the American Type Culture Collection (ATCC) scientific advisory committees. All lactic acid bacteria and yeasts used for EM-1 production are on U.S. Food and Drug Administration's (UFDA) GRAS list (Generally Recognized as Safe). Also, in the United States, the EM-1 products are OMRI Listed. OMRI is the Organic Materials Review Institute and when a product is "OMRI Listed" the product has been reviewed and determined to be allowed for use in organic production. Organic growers can then use these OMRI Listed products and still have their operation maintain their organic certification. EM-1 is the core product with which all other EM products and EM materials are produced.

EM-5, also known in Japan as Stochu (or Sutochu). It is used to directly apply to plants (not while it's flowering though) to deter (make unpalatable to) pests, it is a non toxic chemical free insect repellant that prevents pest and disease problems in crops. It is made with EM-1, molasses, vinegar, and spirits (40% alcohol, such as vodka or tequila). Sometimes spices are also added, such as garlic and hot pepper. Standard materials are for example, 600ml water, 100ml molasses, 100ml vinegar, 100ml distilled spirit and 100ml EM-1. It is sprayed to wet the crop before incidence of pests and diseases at regular intervals normally morning time or after heavy rains.

EM-FPE or FPE is a Fermented Plant Extract. Also known as Green Grass Liquid Fertilizer. It is made by cutting fresh grass and weeds (discarding flowers, flower buds, and wilted parts) and mixing with EM-1, molasses and sea water. It is left to ferment in an air-tight container for about 10-14 days. After fermentation, the liquid is extracted and used as a liquid fertilizer, often diluted in water, and the solid remains are also used as fertilizer.

Preparation of a standard EM FPE includes 14 litres (2-3 kg) chopped fresh weeds, 14 litres water, 420ml molasses and 420ml EM-1. It should be used within 90 days of preparation. It is applied by watering into soil or spraying to crops to wet plants and should be applied after crop emergence before pests and disease incidence as a prophylactic measure. If this practice is not carried out and problems appear, EMFPE need to be applied daily until the problem is overcome. EMFPE can be applied once or twice weekly, directly onto plants; the spraying is done during morning or after rains at regular intervals. The efficacy of EMFPE can be enhanced if mixed with EM-5 in equal proportions.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Pre- Planting Information and Land Preparation.

The experiment was conducted at "Bustani ya Tushikamane-Kilimo Hai", Tushikamane Centre, Kilakala Road-Morogoro municipal Tanzania. The site was previously cultivated with egg plants, and later on there was no crop cultivated until when this trial was established.

Land preparation was done properly two weeks before sowing seeds by hand hoes. Also racks were used for leveling.

3.2 Materials and Their Preparation.

EM technology in agriculture includes EM-Bokashi, EM-A, EM-FPE and EM-5. But EM-1 (EM stock solution) is a key component. The EM-1 at "Bustani ya Tushikamane" was imported from Kenya and Austria and it was used to prepare Bokashi, EMA, EMFPE and EM5 as shown in Figure 1.

EM-A was prepared from EM-1, molasses and clean water (free from chlorine and dirty) into a bucket. One litre of EM-1, one litre of molasses and eighteen litres of water were mixed in a bucket of 20L capacity. Water was boiled to about 35 ^{0}C to facilitate thoroughly mixing of materials. After boiling water, molasses was added in order to mix thoroughly because it takes a time for molasses to dissolve in water. Molasses was dissolved first in five litres of water and poured into a clean 20L plastic bucket. Then EM-1 was added and water topped to get 20 litres, and the ratio was 1:1:18 for EM-1, molasses and water respectively. The bucket was closed tightly and stored in a cool place for ten days. The EM-A was ready for use.

EM-Bokashi was prepared from domestic wastes, wastes from market places like fruits especially banana and round potato and grass weeds from the farm, and EM-A in a 20L plastic bucket. Domestic wastes and weeds were collected and put into a bucket, then 100mls of EM-A was mixed with 1L of water and added in a bucket. Then, the bucket was closed tightly and left to decompose in a storage area for EM and after 10days EM-Bokashi was ready for application in the field.

EM-FPE was prepared from fresh plant materials, clean-unchlorinated water, molasses and EM-1 in a 20L plastic bucket. 3kg of chopped fresh weeds which have medicinal value (Mexican marigold, Neem tree leaves, Aloe vera leaves, immature pawpaw fruit), 1L molasses, 1L EM-1 and 15L water. Then, the bucket was closed tightly; few holes were made by a needle for air circulation and kept for 10days in a storage chamber.

EM-5 was prepared from 1L molasses, 1L EM-1, 18L water, 1L vinegar, and 250g hot pepper and 250g garlic in a plastic bucket. Water was boiled for about 35 ^{0}C; molasses was added, then EM-1, vinegar, pepper and garlic, and 1L ethyl alcohol “Konyagi”. The bucket was closed tightly and kept in storage chamber for 10 days.

(a)

(b)

(c)

Figure 1: Preparation of EM-A, EM-FPE/ 5 (a and b), and EM storage (c)

3.3 Experimental Layout and Treatment Application.

Plot dimensions included the spacing of “Situka” maize variety which was 75cm x 30cm, number of rows was four (4) giving 300cm (3.0m) length of the plot, number of stands per row was 6 giving 180cm (1.8m) wide. Therefore area of the plot was 3m X 1.8m giving 5.4 m^2.

Number of treatments was five (5). Number of replications was three (3) and, the distance between one plot or replication and another was one meter (1.0m), thus a length of 3m X 5 treatments + 6m giving 21m length of the experimental area. The width of the experimental area was 1.8m X 3 replications + 4m giving 9.4m wide. The grand total was 21m X 9.4m, giving a total area 197.4 m^2. Total number of plots or experimental unit was fifteen (15).

Details are shown in figure 2 below.

Plot area was 3m X 1.8m and the total experimental area was 21m X 9.4m giving 197.4 m^2.

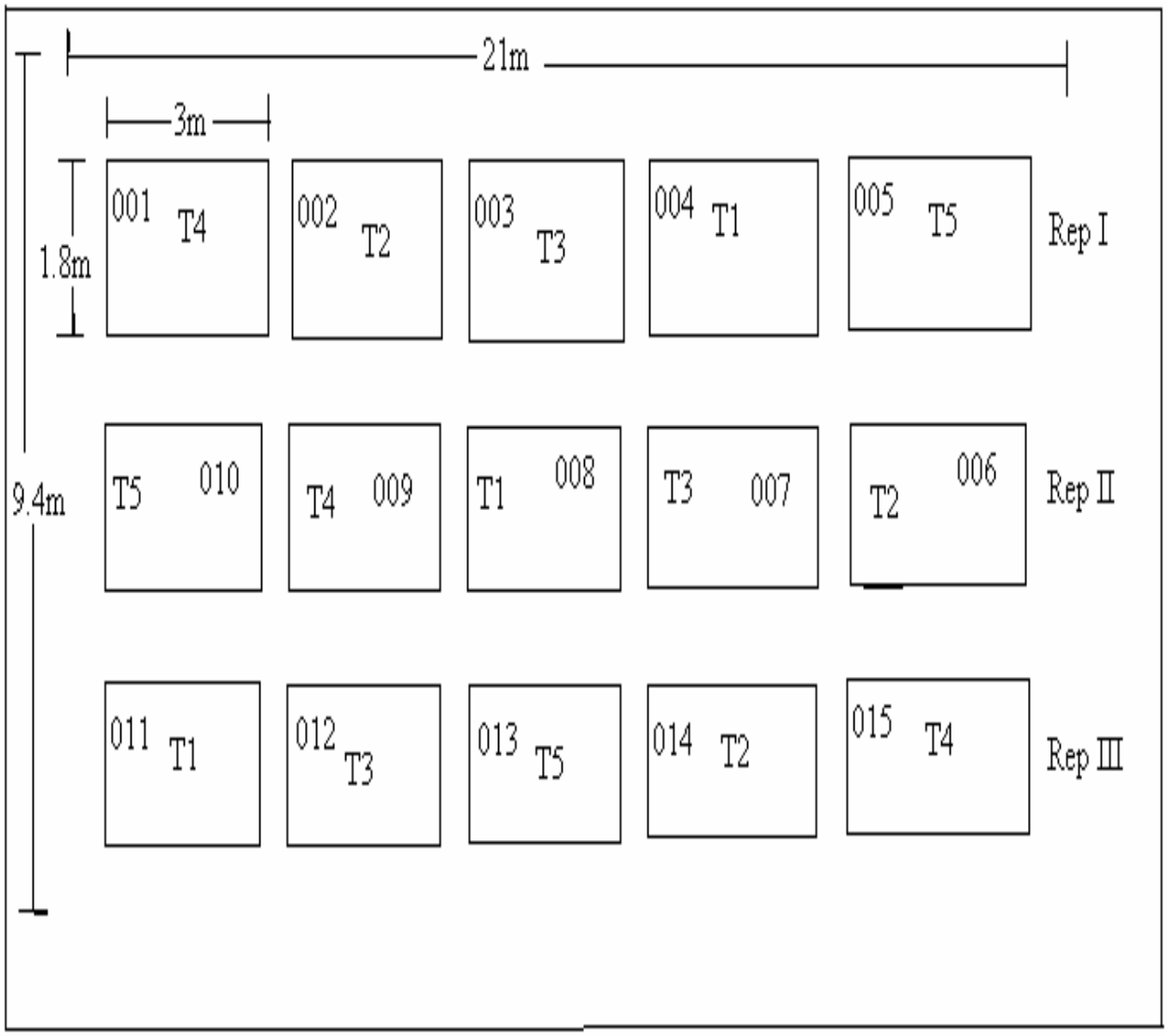

Figure 2: Detailed experimental area and layout

Key:

01-015 refers to plot numbers

T1-T5 refers to treatment numbers

Rep I, Rep II and Rep III refers to replication numbers.

Experimental layout in the field was done according to Gomez and Gomez (1984) as the randomized complete block design (RCBD).

There were five treatments applied and these included:

T1- Bokashi

T2- Bokashi and EM-A

T3- EM-FPE and EM-5

T4- Bokashi, EM-A, EM-FPE, and EM-5

T5- Control or farmers' practices.

According to laboratory analysis done 2009 by Mosha and Menya Sokoine University of Agriculture (SUA) Department of Soil Science (Personal communication), Bokashi–leaves contain 3.7%Nitrogen.

Fertilizers were applied as recommended for the crop in eastern zone of Tanzania by Kanyeka *et al*.(2007) which is 60kgN/ha and 20kg P_2O_5/ha.

Therefore, EM-Bokashi was applied during planting at the rate of 1kg/plot (1851.9kg/ha). EM-A was applied during vegetative growth of the crop. EM-FPE and EM-5 were applied during growth stages as botanical pesticides (bio pesticides) and on the other hand they fertilize the soil.

Other agronomic practices were done as recommended in Morogoro.

3.4 Application of EM in the Field for Crop Production.

EM was applied as Bokashi, EM-A, EM-FPE and EM-5 during maize crop production. EM-Bokashi was applied during planting, while others were applied during vegetative growth stages of the crop.

Bokashi was applied only once during planting at the rate of 1kg/plot which was equivalent to 1851.9kg/ha (68kgN/ha), Bokashi leaves contain 3.7%N.

EM-A was applied during vegetative stages of maize crop, in a first week of application 12th April 2010. Then a second week of application was 26th April 2010 and the third week of application was 10th May 2010. The application was done on Monday, Wednesday and Friday of a week scheduled for application. The rate of application was 100mls EM-A mixed with 1 litre of water in a hand sprayer and only 2L of EMA and water was enough for each plot. Capacity of a hand sprayer used was 1L.

Therefore 200mls of EM-A was mixed with water to make a solution of 2000mls (2L) and detergent soap was also added as adjuvant to improve stickiness of EM-A to plants and soil.

EM-FPE and EM-5 were also applied during vegetative growth stages of the crop after emergency up to immediately before tasseling. The schedule and application rate as well as addition of adjuvant was similar to EM-A as described for EM-A. In the first week of 12th April 2010, second week of 26th April and the third week of 10th May 2010 the application was done three fold per each scheduled week that is Monday, Wednesday and Friday. Application rate was 200mls of EM-FPE/ EM-5 per plot. Dilution rate was 1ml EM to 10mls water.

3.5 Agronomic and Protection Measures.

Planting was done on 24 March 2010 by dibbing two seeds, three seeds per hole were placed at 5cm depth with spacing of 75cm inter-row and 30cm intra-row and well covered by soil as described by Kanyeka *et al*. (2007).

Thinning was done two weeks after planting purposely to remain with only one plant per hill. Other agronomic and protection measures like weeding, irrigation, protection against vermin and harvest were carried out as described by Kanyeka *et al*. (2007). Also dry grasses were applied as mulching material to create conducive environment for EM.

3.6 Data Collection

3.6.1 Soil characteristics.

Laboratory soil analysis at a site was done in the Department of Soil Science laboratory at SUA, Morogoro as shown in Table 2. Particle size (soil texture), soil pH, CEC, total N, available P, and exchangeable bases such as potassium (K) were analyzed in the soil sample.

The particle size distribution was determined by Bouyoucos hydrometer method after dispersing the soil with sodium hexametaphosphate solution (Day, 1965). The textural class was determined by using USDA textural class triangle (USDA, 1975). Soil pH was determined in water at a soil ratio of 1:2.5 using pH meter as outlined by Mclean (1982). The cation exchange capacity (CEC) was determined by use of ammonium acetate saturation method (Rhodes, 1982). Potassium (K) extraction was done by 1M Ammonium acetate at pH7 and then exchangeable K was determined by using flame spectrometer.

Total N was determined by micro- Kijeldahl digestion followed by the distillation and titration as described by Bremmer and Mulvaney (1982). Bray- I method was used to determine phosphorus (P) concentration in the soil using the method described by Murphy and Riley (1962).

3.6.2 Weather data.

Weather data were collected at Tanzania Meteorological Agency (TMA) station Morogoro. Weather elements that were collected during the cropping season are shown in Table 1 and Appendix 1. Rainfall (mm), maximum and minimum temperature (^{0}C), relative humidity (RH %) during morning and evening were collected daily from January to May 2010. Methods for measuring weather elements are as described by TMA (2010). The weather data were then calculated in terms of weekly average basis and monthly basis, except for rainfall where the subtotal and grand total for the cropping season were calculated as shown in Table 1.

3.6.3 Plant population, height, stem girth, and crop yields.

3.6.3.1 Plant population (plants m^{-2}) determination.

Plant population was taken 25 days after planting and at harvest time (100 days after planting); plants from all the four rows in each plot were counted and recorded. Then, calculation was done to get number of plants per m^{-2} area from 5.4 m^{-2} area of the plot.

3.6.3.2 Plant height determination (cm).

Plant height at 25 days after planting (vegetative stage; V-1), at 52 days after planting (at early flowering stage) and at 60 days after planting (silking stages) were measured from two plants (second and fourth plants) from each of the two central rows and an average was obtained. The total number of four (4) plants per plot was used to determine the plant height. Measurement was done by using a tap measure.

3.6.3.3 Stem girth determination (cm).

Stem girth at fourth leaf stage 25 days after planting and at early tasseling time 52 days after planting were measured from two plants (second and fourth plants) from each of the two central rows and an average was obtained.

The total number of four (4) plants per plot was used to determine the stem girth. Measurement was done by using a string and a ruler which is marked 30 cm long.

3.6.3.4 Seed yield (m^{-2}) and yield components determination.

A sample of four ears from each plot was selected, shelled and 100 seeds taken from each of the sample and their weights were measured by weighing balance. The seeds and four cobs of each sample were dried as described by IBSNAT (1990). Weight of seeds, 100 seeds and four cobs on each sample were measured by using digital weighing machine in the Department of Crop Science and Production (DCSP) Laboratory at Sokoine University of Agriculture (SUA).

Shelling percentage, number of seeds, weight of seeds and cobs were calculated according to IBSNAT (1990).

Shelling percentage = [(weight of seeds/weight of ear) x100].

Seed no. (seeds/m^2) = [{Ear wt undried X (seed subsample wt undried/ ear subsample wt undried) X (100/ 100 seed wt)} / Harvest area].

Seed weight dry (g/ m^2) = [{Ear wt undried X (seed subsample wt dry / ear subsample wt undried)} / Harvest area].

Cob weight dry (g/ m^2) = [{Ear wt undried X (cob subsample wt dry / ear subsample wt undried)} / Harvest area].

3.6.4 Days to various growth stages.

Days to various growth stages were recorded as described by Hanway (1963) planting to emergence 6 days, fourth leaf stage was observed 25 days after planting, first tasseling was observed 52 days after planting, 75% tasseling was observed 60 days after planting. Grain filling stage was recorded 67 days after planting; milk stage was attained 74 days after planting. Physiological maturity was observed 81 days after planting, and harvest maturity was 100 days after planting.

3.7 Data Analysis and Interpretation.

Data collected were analysed using the MSTAT- C statistical programme. The analysis included the analysis of variance (ANOVA) using the following statistical model.

Statistical model;

$Y_{ij} = \mu + t_i + b_j + e_{ij}$, i = 1, 2,…t, j = 1, 2,…, r.

Where: μ is the overall mean

t_i is the effect of level I for factor A

e_{ij} is the residual or error term.

Observation of the $_i$th treatment from the $_j$th block = general mean + $_i$th treatment effect + $_j$th block effect + experimental error component.

The mean separation test was done using Duncan Multiple Range Test (DMRT). All analyses were done at $P < 0.05$ (Russel and Gupta, 1989).

However, it is only crop growth, development and yield variables that were subjected to statistical analysis as shown in appendix 4.

CHAPTER FOUR

4.0 RESULTS

4.1 Weather and Soil Data.

The weather data taken include temperature (^{0}C) both maximum and minimum, relative humidity (RH %) and rainfall (mm). During the cropping season March to June, the smallest amount of rainfall was 6.40mm on June with an average of 1.28mm per month, while the highest amount of rainfall was 32.94mm on April with an average of 6.59mm per month. The grand total amount of rainfall was 63.79mm for four months (March to June) and an overall rainfall average was 15.95mm during the cropping season.

An average temperature ranged from 29.09 ^{0}C to 32.65 ^{0}C for maximum temperature while 17.82 ^{0}C to 22.97 ^{0}C for minimum temperature, an overall average temperature was 30.43 ^{0}C and 20.66 ^{0}C for maximum and minimum temperature respectively during the cropping season. The highest temperature was 32.65 ^{0}C on March and the lowest temperature was 17.82 ^{0}C on June. The maximum and minimum temperature was high in March 32.65 ^{0}C and 22.97 ^{0}C while in June average temperature was low for both maximum and minimum temperature 29.09 ^{0}C and 17.82 ^{0}C respectively.

The relative humidity average was 84.69% at 9 am and 58.01% at 3 am during the cropping season. The relative humidity was very high in April and May 88.23% and 88.53% for morning hours while 62.61% and 66.33% for evening hours respectively. There was the lowest relative humidity on March 78.77% for morning hours and 50.01% for evening hours on June.

Soil data included texture (54% sand, 7%silt, and 39% clay), soil pH 7.73 mild alkaline, total nitrogen 0.17% low to medium, available phosphorus 5.78 mgP/kg low, Cation exchange capacity (CEC) 15 cmol (+)/kg medium and exchangeable base potassium very high.

Table 1 Average weather data during the cropping season (March - June 2010)

Month	Week	Characteristics				
		Temperature ^{0}C		RH (%)		Rainfall
		Maximum	Minimum	9 am	3 pm	mm
March	1	33.41	22.96	78.43	51.29	6.30
	2	34.01	23.54	72.71	42.29	0.00
	3	33.87	23.41	72.29	42.57	0.03
	4	30.71	22.39	85.43	68.29	6.09
	5	31.23	22.53	85.00	61.00	0.00
	Subtotal	-	-	-	-	12.42
	Average	32.65	22.97	78.77	53.09	2.48
April	1	30.66	21.44	88.14	65.29	4.80
	2	31.20	21.39	87.71	62.29	3.74
	3	31.66	21.93	81.86	59.86	11.06
	4	29.89	21.36	89.43	68.71	7.84
	5	28.10	21.80	94.00	75.50	5.50
	Subtotal	-	-	-	-	32.94
	Average	30.30	21.58	88.23	66.33	6.59
May	1	28.51	21.51	93.00	71.43	5.03
	2	30.07	20.26	89.00	64.14	3.19
	3	30.54	18.46	82.71	54.00	1.71
	4	29.10	20.90	90.29	65.14	2.00
	5	30.20	20.17	87.67	58.33	0.10
	Subtotal	-	-	-	-	12.03
	Average	29.68	20.26	88.53	62.61	2.41
June	1	28.74	18.17	82.57	57.14	0.00
	2	29.70	17.76	84.29	51.43	3.80
	3	28.20	18.59	80.14	51.14	0.00
	4	28.93	17.13	84.57	46.86	2.60
	5	29.90	17.45	84.50	43 50	0.00
	Subtotal	-	-	-	-	6.40
	Average	29.09	17.82	83.21	50.01	1.28
Grand total		-	-	-	-	63.79
Grand mean		30.43	20.66	84.69	58.01	15.95

Source: TMA Morogoro (2010)

Table 2. Soil physical and chemical characteristics at the site of the experiment (Tushikamane - Kilakala)

S/No.	Soil characteristic	Value	Remark(s)
	Physical characteristics		
1.	Soil particle analysis		
	Sand	54%	Textural class
	Silt	7%	Sand clay soil
	Clay	39%	
	Chemical characteristics		
1.	Soil pH	7.73	Mild alkaline
2.	Total Nitrogen	0.17%	Medium N
3.	Extractable Phosphorus	5.78 mg/kg	Low P
4.	CEC	15 cmol (+)/kg	Medium
5.	Exchangeable bases		
	Potassium ion (K^+)	3.99 cmol (+)/kg	Very high

4.2 Days to Different Growth Stages of Maize Crop.

The crop emergence was observed six (6) days after planting while fourth leaf stage was 25 days after planting. On average first and 75% tasseling was observed 52 and 60 days after planting respectively, while 67 and 74 days for grain filling and milk stage. The crop reached physiological maturity 81 days after planting and harvest maturity 100 days after planting.

Table 3. Days to different crop growth stages

Growth stage	Days	Date
Planting	0	24.3.2010
Crop emergence	6	29.3.2010
Fourth leaf stage	25	17.4.2010
First tasseling	52	14.5.2010
75% tasseling	60	22.5.2010
Grain filling (Kernels in blister)	67	29.5.2010
Milk stage	74	04.6.2010
Physiological maturity	81	11.6.2010
Harvest maturity	100	30.6.2010

4.3 Plant Population

At fourth leaf stage plant population was high in plots where Bokashi and EM-A was applied 4.44 plants per m^2 while the lowest was 4.197 plant per m^2. There was variation in plant population with a coefficient of variation (CV) 2.96% and a standard deviation (Std) 0.07.

Also there was a variation in plant population at harvest, the CV was 4.45% and a Std was 0.11, the highest was 4.32plants per m^2 in plots where EMFPE and EM-5 were applied while the lowest was 3.947 plants per m^2. The expected plant population was 4.4444 plants per m^2.

Table 4. Plant population of maize crop at fourth leaf stage and harvest maturity

Treatment applied	Plants per m^2 at fourth leaf	Plants per m^2 at harvest
Control	4.320	3.950
Bokashi	4.257	4.133
Bokashi and EM-A	4.441	4.317
EMFPE and EM-5	4.380	4.320
Bokashi, EMA, EMFPE and EM5	4.197	3.947
Grand Mean	4.319	4.13
CV %	2.96	4.45
Std±	0.07	0.11

4.4 The Influence of EM on Stem Girth and Plant Height of Maize Crop

There were statistical differences among treatments applied on stem girth and plant height at $P \leq 0.05$ during the fourth leaf stage. Application of Bokashi, EM-A, EMFPE and EM-5 produced maize plants with very high stem girth 5.627cm as compared with control plot at fourth leaf stage and 8.693 cm as compared to control plot at early tasseling.

Also application of EM technology produced very high plant about 45.167cm, 149.083cm and 232.96cm as compared to control plots during fourth leaf stage, early tasseling and silking stages respectively.

Table 5. The effect of EM technology on maize stem girth at fourth leaf stage and early tasseling

Treatment applied	stem girth at 4^{th} leaf (cm)	stem girth at early tasseling (cm)
Control	4.580	7.437
Bokashi	4.277	7.187
Bokashi and EM-A	5.197	8.120
EM-FPE and EM-5	5.243	8.087
Bokashi,EMA,EMFPE and EM5	5.627	8.693
Grand Mean	4.99	7.778
CV %	9.11	7.210
Std$\pm$	0.26	0.329

Table 6. The influence of EM on maize plant height at fourth leaf stage, early tasseling and silking

Treatment applied	Plant height at 4^{th} leaf (cm)	Plant height at early tassel (cm)	Plant height at silking (cm)
Control	35.833	125.500	221.917
Bokashi	31.750	108.083	204.917
Bokashi and EM-A	40.667	132.333	231.750
EMFPE and EM-5	38.417	140.500	232.960
Bokashi,EMA,FPE and EM5	45.167	149.083	220.250
Grand Mean	38.367	131.100	222.359
CV %	9.72	11.24	9.61
Std±	2.154	8.51	12.342

4.5 Total Dry Matter (TDM) and Weight of Ears

The highest dry matter on maize crop was produced in plots where Bokashi and EM-A were applied 1209.86 gm^{-2} and the lowest TDM was 955.59 gm^{-2} in control plot.

Also application of Bokashi, EM-A, EMFPE and EM-5 produced husked and de-husked ears with very high weight 598.76 gm^{-2} and 499.33 gm^{-2} compared to control plot respectively.

Table 7. The effect of EM on TDM of maize crop and weight of ears

Treatment applied	TDM gm^{-2}.	Weight of husked ear in gm^{-2}.	Weight of de-husked ear in gm^{-2}.
Control	955.593	450.247	353.643
Bokashi	1006.173	530.840	438.270
Bokashi and EM-A	1209.867	598.767	493.830
EMFPE and EM-5	1129.620	586.420	499.333
Bokashi,EMA,EMFPE and EM5	1080.247	598.763	496.913
Grand Mean	1076.300	553.007	456.398
CV %	19.91	23.68	25.40
Std±	123.7303	75.598	66.934

4.6 The Influence of EM on Shelling Percentage, Number of Seeds and Weight of Seeds

Plots where EM was applied had large shelling percentage 78.21% while control plot had the lowest shelling percentage 59.16%. Application of Bokashi produced the largest number of seeds 1645 seeds per m^2 and control plot produced the lowest number of seeds 1129 seeds per m^2. Application of EM technology produced seeds with very high weight 385g m^2 and 351g m^2 before and after oven drying as compared to control plot.

Table 8. The effect of EM on shelling percentage and number of seeds

Treatment applied	Shelling percentage (%)	Number of seeds per m^2.
Control	59.160	1129.333
Bokashi	68.343	1645.667
Bokashi and EM-A	65.883	1444.667
EM-FPE and EM-5	62.400	1451.000
Bokashi,EMA,EMFPE and EM5	78.213	1311.000
Grand Mean	66.800	1396.333
CV %	12.77	28.24
Std±	4.926	227.7036

Table 9. The influence of EM on weight of seeds before oven drying and dry seed weight

Treatment applied	Seed weight BOD gm^{-2}	Dry seed weight gm^{-2}	Seed weight $Kgha^{-1}$
Control	213.580	211.513	2115.13
Bokashi	308.643	306.610	3066.10
Bokashi and EMA	330.247	324.120	3241.20
EMFPE and EM5	315.313	310.837	3108.37
Bokashi,EMA,FPE and EM5	385.803	351.433	3514.33
Grand Mean	310.717	320.303	3203.03
CV %	31.11	26.43	26.43
Std+	55.808	48.877	488.77

(a)

(b)

(c)

(d)

Figure 3: Researchers assessing the field (a and b), maize plant before the application of EM-5 and EM-FPE (c and d)

(a)

(b)

Figure 4: Mulches application (a), and maize crop after EM-FPE and EM-5 application (b)

Figure 5: Effect of EM on maize, 'situka' variety yield and quality

CHAPTER FIVE

5.0 DISCUSSION

5.1 Weather and Soil

The rainfall data recorded was below the amount of rainfall expected in the area for proper growth of maize crop; the total amount of rainfall was 63.79mm for four months (March to June), the rainfall was poor, unreliable and unevenly distributed as shown in Table 1 and Appendix 1.

The water balance of the crop is determined by evapotranspiration, rainfall and soil characteristics. Reported values for seasonal evapotranspiration of maize vary widely 440mm to 1000mm and are influenced by available water and local environmental parameters (Musick and Dusek, 1980; Eck, 1984). Water deficit reduces crop yields. The rainfall during the maize growing period should be in the range of 460 to 600mm, and in the tropics maize does best with 600 to 900mm of rain during the growing season (Fageria *et al*, 1997).

Deficiency of water during any growth stage of the crop can reduce grain yield. Water stress during vegetative development reduces expansion of leaves, stems and roots and ultimately affects the development of reproductive organs and potential grain yield (Denmead and Shaw, 1960). Two weeks before and after grain filling stage and milk stage there was moisture stress on the research plots (Table 2 and Appendix 1). Maize crop is very sensitive to drought stress during pollination, when delayed emergence of silks may reduce fertilization and subsequent grain yield as a result of fewer seed numbers (Herrero and Johnson, 1981). Drought stress as late as two to three weeks following 50% silking may also reduce seed number (Frey, 1981).

Drought during the linear growth phase of kernel development primarily affects mean kernel weight by reducing assimilate production or duration of grain fill, or by a combination of both factors (Jones and Simmons, 1983). Kernels at the tip of the ear often develop poorly when water stress occurs during the seed filling period (Tollenaar and Daynard, 1978). In general, maize grain yield is particularly sensitive to water deficits that coincide with the tasseling – silking period and approximately two weeks after silking (Otegui *et al*, 1995). The number of kernels per plant is defined during this period.

Fageria *et al* (1997) reported that optimum temperature at tasseling is 21 to 30 ^{0}C, high temperature promotes respiration.

According to Chang (1981) the average respiration loss is about 25% of the photosynthetic rate in the temperate zone and about 35% in the tropics. High temperature, particularly at night shortens the grain filling period, thereby reducing the yield (Jones *et al*, 1981; Wilson *et al*, 1973). Jones *et al* (1981) reported that high temperature increases the rate of grain filling but greatly reduces the duration of grain-filling period, whereas low temperatures cause an inverse response. The grain yield of maize, like that of small grains, it is higher at lower temperatures because of an increase in the length of the grain-filling period and greater partitioning of postanthesis dry matter to grain (Hunter *et al*, 1977).

"Situka" is a maize variety tolerant to drought and low nitrogen environment which grows well in areas with moderate rainfall, this variety requires 110 to 120 days to reach maturity and yields about 4 – 6tonha^{-1} under optimal management (Kitenge *et al*, 2004 and Kanyeka *et al*, 2007). In our plots "situka" maize variety attained maturity 100 days after planting as shown in Table 2.
The grain yield of maize increases due to increase in the length of the grain-filling period and greater partitioning of postanthesis dry matter to grain (Hunter *et al*, 1977). Therefore, decrease in duration of a crop to reach maturity has negative impact on grain yields in maize crop.

Soil characteristics in the site was at low to medium fertile, plant nutrients were low to medium available, soil pH was slightly alkaline as shown in Table 2. In general the soils at the site used were of low to medium fertility according to BACAS (2008).

5.2 Response of Maize Plants to EM Technology

Stem girth during fourth leaf stage and early tasseling was high in plots where EM technology was applied as shown in Table 5. Application of EM technology in agriculture is important because plant growth is more improved as compared to control plot, maize crop responded positively and plants were more vigor, thick stems, tall plants and strong due to EM application as shown in Table 5 and Table 6 as well as in Figure 4. According to Takash *et al* (1999) EM in agriculture promotes germination and growth in crop plants, increases the efficacy of organic matter as fertilizer and improves the physical, chemical and biological environment of the soil.

EM also enhances photosynthetic capacity of plants, develops resistance of plants to pests and diseases as well as suppressing soil borne pathogens and pests as shown in Figure 3 and Figure 4. Application of organic manure produced more vigor plants because during breakdown process, macro elements and micro elements are made available to the plants (FSSA-MVSA, 2007). Organic matter in the soil increases the availability of phosphorus (P) for the plant uptake by forming complexes with iron and aluminium in the acid and calcium in alkaline soils, competes for adsorption positions and displaces adsorbed P. P is very important for root development, flowering, fruiting, seed formation, strength of straws in cereal crops and helping to prevent lodging and crop maturation (Brady, 1984).

5.3 Effect of EM technology on Yield

There was a variation in total dry matter produced in experimental units due to application of EM technology. Large amount of total dry matter of maize plants and ears were produced in plots where EM was applied as compared to control plots as shown in Table 7. Also, there was high shelling percentage, large number of seeds per unit area and large weight of seeds per unit area compared to control plot due to application of EM as shown in Table 8 and Table 9. This is because natural or organic fertilizers prevent soil nutrients from leaching, fix and hold soil nutrients in an insoluble organic form which when mineralized by soil microorganism supply the plant with a gentle stream of nutrients throughout their life period, also provide a wide spectrum of plant nutrients (Onwueme and Sinha, 1999; and Uwizeyimana, 1997). Application of organic manure promotes growth, development and yields in crops because during breakdown process, macro elements and micro elements are made available which are essential and beneficial to the plants (FSSA-MVSA, 2007).

Application of EM technology is significant in agriculture has improved the grain yield as compared to the absolute control treatment. Application of EM-Bokashi produced an average yield of 306.61 gm^{-2} (3.06 $tonha^{-1}$), EM-Bokashi and EM-A produced grain yield of 324.12 gm^{-2} (3.24 $tonha^{-1}$), EMFPE and EM-5 produced 310.837 gm^{-2} (3.11 $tonha^{-1}$) and, application of all EM-Bokashi, EM-A, EMFPE and EM-5 produced grain yield of 351.433 gm^{-2} (3.51 $tonha^{-1}$).

According to the EMshop (2008) and Takash Kyan *et al* (1999), Bokashi is the organic materials that have been fermented with EM and made for good fertilizer, it has higher nutrient contents and fermentation takes short time about two weeks compared to traditional prepared compost manure. Therefore, if EM- Bokashi is applied before or during planting releases plant nutrients in the soil which are available for the plant in a similar manner as other organic manures such as farmyard manure and compost manure. Once application rate recommended in farmyard manure is also used to apply EM- Bokashi, the later performs better and is more efficient than the former one, because EM-Bokashi leaves contain 3.7%N while, farmyard manure contain about 0.5%N (Onwueme and Sinha, 1999). Furthermore, Bokashi is applied during planting while EM-A is a liquid fertilizer applied during vegetative growth stages, this is necessary in order to supply nutrients to crops and improves soil fertility.

EMFPE as reported by the EMshop (2008) and Takash Kyan *et al* (1999) is a fermented plant extract used as a liquid fertilizer diluted into water and applied after crop emergency. Also, it is applied by watering into soil or spraying to crops to wet plants and should be applied after crop emergence before pests and disease incidence as a prophylactic measure. If this practice is not carried out and problems appear, EMFPE need to be applied daily until the problem is overcome. EM-5 is directly applied into plants to deter pests; it is a non toxic chemical free insect repellant that prevents pest and disease problems in crops. Therefore, EMFPE and EM-5 apart from preventing pests and diseases in crops also provide plant nutrients as shown in Figure 3.

EM technology makes it possible to increase crop yields without the use of agricultural chemicals or artificial fertilizers, the method of farming is inexpensive, capable of producing high-quality products, high yield produces and preserving the environment (Higa and Kanal, 1998) as shown in Figure 4 and Figure 5.

6.0 CONCLUSION AND RECOMMENDATIONS.

Ideally, the technology of effective microorganisms (EM) in agriculture is important for production of safe and nutritious food to enhance human health, development of economic and spiritual benefits to both farmers (producers) and consumers. Also, EM technology ensures sustainability and ease of practice by every person, conservation of the environment, as well as production of sufficient food of high quality for the increasing population.

Application of bokashi during planting, followed by regular spraying of EM-A improves crop growth due to addition of plant nutrients in the soil and directly to plants. Also, EM-FPE and EM-5 are very important in preventing pests and diseases to plant and should be sprayed at regular intervals after crop emergence and before flowering. Application of bokashi, EM-A, EMFPE and EM5 gave good response of maize crop from vegetative growth stages, reproductive up to yield.

EM technology in crop production will enable farmers to overcome problems of low soil fertility, insect pests and diseases at low production costs and increase yields. By so doing, this improves food and income security to small holder farmers.

EM reduces the costs of farming overtime. At the onset, a farmer would have to spray EM several times throughout the season; large quantities may also be needed to realize benefits in a short period of time. However, soil conditions change with the addition of EM and eventually the amount required declines because the soil accumulates organic matter and become more fertile. Once an equilibrium is reached, a farmer may need only to apply bokashi treated manure to the soil along with post harvest residues and EM-A. The quantity to be applied in the future will depend on weather or climatic conditions at that time, although it would be much lower than at the inception.

Also, there is a need to conduct more researches about EM technology in various areas (zones) in Tanzania. In crop production a number of food and cash crops such as maize, rice, cotton and others should be researched to investigate the response on EM. It is important to emphasize on soil fertility improvement and management of pests and diseases in crops which are of economic important.

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APPENDICES.

APPENDIX 1
Detailed daily weather data during the cropping season January to June 2010

TANZANIA MET. AGENCY
STATION:
MOROGORO

January 2010

	Temperature		Relative Humidity		Sunshine	Rain	Pressure	
DATE	MAX ℃	MIN ℃	RH% 9am	RH% 3pm	Hours	R/F(mm)	hPa 9am	hPa 3pm
1	30.5	22.2	86	92	4.0	16.1	951.6	949.2
2	31.6	22.8	87	58	4.1	7.4	952.1	948.8
3	29.8	22.1	89	64	2.0	0.0	954.0	950.3
4	31.0	21.7	81	63	10.5	0.0	953.2	949.8
5	32.6	22.9	75	60	7.4	24.6	952.3	948.0
6	30.0	21.5	95	59	3.9	8.1	952	948.3
7	32.0	21.7	72	55	6.9	1.2	950.6	947.3
8	27.8	22.5	90	75	1.4	2.5	952.4	950.3
9	31.3	21.0	74	57	5.4	5.5	952.0	949.4
10	29.6	22.4	92	84	3.6	6.9	951.9	949.0
11	29.5	24.8	83	68	1.5	25	952.5	948.9
12	29.2	22.0	91	68	6.5	0.0	953.1	949.4
13	28.7	22.4	74	61	7.1	0.0	952.8	950.4
14	29.6	22.5	75	56	10.8	0.0	954.5	951.5
15	31.0	22	68	54	11.0	0.0	955.6	953.5
16	31.6	22.5	65	54	7.3	0.0	956.4	953.8
17	31.2	21.7	78	53	10.9	0.0	956.7	953.1
18	31.5	22.0	75	51	11.1	0.0	956.6	952.7
19	31.5	21.4	75	43	11.2	0.0	955.0	952.5
20	32.0	20.7	87	52	10.2	0.0	954.5	951.5
21	32.8	22.0	73	51	11.1	0.0	953.9	950.1
22	33.0	22.0	76	52	10.6	0.0	954.2	949.7
23	32.1	23.0	81	48	9.1	0.0	953.9	949.4
24	32.7	22.1	67	47	11.0	0.0	952.5	948.6
25	32.5	23.3	82	56	7.5	0.0	951.7	947.6

26	33.3	23.0	82	52	8.2	0.0	952.0	948.5
27	32.0	23.0	81	51	5.0	0.0	952.0	948.3
28	33.5	23.8	75	42	11.0	0.0	952.4	958.5
29	32.6	22.9	77	53	9.4	0.0	952.9	949.4
30	32.5	23.6	78	59	10.3	0.0	953.1	950.6
31	33.3	23.4	75	50	10.3	0.0	954.4	951.3

Feb-10

DATE	MAX	MIN	**RH0600**	**RH1200**	**S/S**	R/F	**PR0600z**	**PR1200z**
1	34.3	23.5	75	41	10.3	0.0	953.5	949.5
2	32.8	23.4	68	37	10.6	0.0	952.4	948.3
3	30.6	24.2	76	49	11.2	0.0	952.2	948.1
4	33.5	23.9	76	49	6.8	0.0	953.5	941.0
5	31.3	22.8	76	85	6.6	43.2	952.5	949.8
6	29.5	20.5	75	58	4.3	11.9	951.1	948.7
7	31.3	22.4	91	56	9.1	0.0	952.5	949.9
8	31.7	22.2	81	46	1.7	0.0	953.7	959.3
9	31.5	20.5	81	54	10.6	0.0	954.1	950.0
10	32.4	20.8	82	51	10.6	0.0	953.5	949.5
11	33.2	23.0	85	55	9.4	0.0	954.8	951.3
12	32.6	22.0	83	57	6.0	0.0	953.0	949.4
13	32.6	23.5	80	51	9.3	0.0	954.1	950.3
14	32.6	22.5	77	47	3.3	0.0	952.4	949.3
15	33.6	21.5	79	43	10.3	0.0	951.7	947.3
16	33.8	22.4	84	45	10.6	0.0	952.7	949.4
17	33.7	23.1	82	48	9.3	5.4	954.3	950.3
18	34.0	23.2	83	46	8.9	9.9	954.1	949.7
19	30.8	21.0	82	70	7.0	0.0	954.3	950.9
20	31.6	24.0	78	58	4.0	2.2	953.5	949.5
21	31.5	22.5	85	58	3.5	8.0	953.0	949.6
22	31.0	22.8	85	64	3.5	0.0	953.5	949.7
23	32.0	22.8	78	61	5.6	0.0	953.7	950.0
24	32.5	22.4	77	53	10.2	0.0	953.2	948.4
25	33.4	20.5	82	43	7.3	0.0	951.6	948.2
26	32.5	22.0	79	53	9.8	0.0	952.8	949.6

27	33.0	21.4	72	48	6.9	0.0	953.4	950.4
28	33.5	21.1	78	52	8.7	0.0	952.6	948.8
29								
30								
31								

Mar-10

DATE	MAX	MIN	RH0600	RH1200	S/S	R/F	PR0600z	PR1200z
1	33.5	22.7	73	45	9.8	0.0	953.3	949.4
2	34.5	24.1	79	44	10.1	34.8	954.7	950.1
3	33.0	22.5	88	54	7.7	0.0	955.6	951.9
4	33.2	23.6	86	57	7.6	0.0	954.3	951.0
5	34.2	23.6	60	59	9.4	8.9	953.4	949.2
6	32.8	22.9	81	50	10.9	0.4	954.2	949.4
7	32.7	21.3	82	50	8.8	0.0	954.9	950.5
8	33.0	21.4	80	49	7.4	0.0	955.0	951.1
9	33.2	23.4	71	48	9.2	0.0	954.0	949.6
10	33.6	24.0	75	44	10.4	0.0	953.7	949.6
11	34.5	24.0	67	39	10.5	0.0	954.2	950.1
12	34.2	23.8	70	40	10.0	0.0	954.4	950.1
13	35.0	24.4	74	37	10.5	0.0	952.3	948.6
14	34.6	23.8	72	39	10.4	0.0	951.6	947.5
15	35.2	25.3	73	40	10.4	0.0	953.4	949.2
16	35.0	24.9	76	41	7.6	0.2	953.5	949.1
17	33.0	24.3	64	45	8.4	0.0	954.0	951.3
18	34.2	22.2	72	38	10.1	0.0	955.1	951.2
19	34.4	23.0	70	35	10.7	0.0	955.4	951.8
20	31.8	20.9	77	54	3.6	0.0	954.6	951.3
21	33.5	23.3	74	45	9.3	0.0	955.0	950.4
22	33.8	21.2	79	47	5.8	5.5	953.3	948.5
23	31.8	21.7	79	68	5.1	2.9	951.4	947.8
24	28.0	23.0	86	91	1.8	13.5	952.2	949.2

25	30.5	22.6	90	66	5.5	2.8	953.3	950.2
26	31.6	22.0	89	71	8.1	2.1	954.2	950.3
27	30.8	23.4	91	70	5.9	6.1	953.4	950.4
28	28.5	22.8	84	65	5.4	9.7	953.7	949.2
29	29.8	23.1	90	73	6.0	0.0	955.5	953.1
30	31.7	22.2	89	60	7.1	0.0	956.3	952.8
31	32.2	22.3	76	50	9.4	0.0	955.4	951.9

Apr-10

Date	**Max**	**Min**	**RH0600**	**RH1200**	**Sun/hrs**	**R/F**	**PR0600z**	**PR1200z**
1	32.2	21.2	82	60	6.5	0.0	954.9	951.4
2	31.7	22.0	94	57	6.2	4.1	955.1	951.0
3	32.4	20.8	86	50	9.6	1.9	954.5	949.6
4	28.9	21.6	95	89	3.4	12.3	953.5	951.1
5	30.0	21.5	87	62	7.0	0.5	954.3	950.9
6	29.4	21.8	88	68	6.8	0.5	953.9	950.3
7	30.0	21.2	85	71	5.9	14.3	953.8	950.8
8	32.3	21.8	86	58	9.3	1.1	954.6	952.1
9	29.6	22.1	88	75	7.7	8.5	955.7	952.2
10	31.5	21.0	79	60	8.3	1.8	954.7	949.8
11	31.0	21.0	91	60	7.1	9.0	953.0	949.3
12	31.2	21.2	86	62	7.4	0.0	954.5	951.3
13	32.3	21.0	87	56	10.2	4.1	954.7	951.5
14	30.5	21.6	97	65	5.3	1.7	953.3	951.0
15	29.4	22.0	68	64	4.6	0.0	955.1	952.7
16	31.2	21.5	61	61	6.4	44.0	954.9	952.2
17	31.4	21.8	87	65	8.4	1.0	956.5	952.9
18	32.1	21.8	89	54	9.3	29.2	956.1	951.9
19	32.3	21.9	89	59	6.3	3.2	954.7	951.5
20	32.2	22.0	89	60	8.4	0.0	955.0	951.7
21	33.0	22.5	90	56	8.1	0.0	955.5	951.2
22	28.2	20.9	86	74	6.7	0.5	954.3	952.2

23	30.3	22.0	90	84	7.2	19.9	956.1	949.3
24	31.4	21.3	88	57	9.6	0.0	956.5	952.8
25	32.5	20.9	86	55	10.4	6.1	954.9	951.1
26	30.7	20.6	87	62	9.0	2.6	955.3	951.8
27	29.7	22.0	95	64	2.5	15.4	955.9	952.8
28	26.4	21.8	94	85	0.1	10.4	955.7	953.1
29	27.2	22.0	96	81	0.4	5.1	954.9	952.3
30	29.0	21.6	92	70	4.7	5.9	953.3	950.8
31								

May-10

	Max	**Min**	**RH0600**	**RH1200**	**Sun/hrs**	**R/F**	**PR0600z**	**PR1200z**
1	30.2	22.0	91	64	6.2	5.9	954.3	951.4
2	28.5	21.6	95	75	2.0	13.3	954.8	951.9
3	28.4	22.2	94	67	1.6	1.3	953.7	951.5
4	28.5	21.7	91	68	3.3	0.2	953.1	950.2
5	29.1	21.8	92	72	5.2	0.0	955.0	952.0
6	23.8	20.8	91	96	0.0	0.0	953.4	953.2
7	31.1	20.5	97	58	9.0	14.5	955.1	951.8
8	29.1	20.9	90	72	8.1	0.7	955.0	952.2
9	29.9	21.2	91	74	6.9	19.6	955.6	952.0
10	30.2	18.7	87	65	8.9	0.0	954.5	951.6
11	31.2	20.9	88	55	11.2	0.0	954.9	951.8
12	28.2	19.6	85	84	4.7	0.0	956.0	954.5
13	31.2	20.0	90	55	8.6	0.8	956.8	953.9
14	30.7	20.5	92	44	9.3	1.2	956.6	953.4
15	30.4	19.6	84	58	9.7	0.0	956.6	953.5
16	31.5	17.6	88	50	10.9	0.0	955.9	952.8
17	29.4	22.0	84	58	8.3	0.0	955.9	952.9
18	30.0	16.4	68	45	11.2	0.0	955.1	951.7
19	30.6	16.6	78	57	10.3	0.0	956.1	952.7
20	30.6	17.7	90	51	9.9	0.0	956.6	953.3

21	31.3	19.3	87	59	6.7	12.0	955.7	952.7
22	27.5	21.2	94	76	1.7	2.6	955.3	952.4
23	29.5	21.2	92	69	3.6	5.6	956.1	952.2
24	30.5	19.6	92	62	7.0	0.0	955.8	952.9
25	30.5	21.0	87	54	8.4	TR	955.4	952.1
26	30.6	21.3	90	59	8.3	0.0	956.6	953.4
27	27.6	20.5	90	65	4.4	5.2	955.9	953.0
28	27.5	21.5	87	71	2.5	0.6	956.3	954.7
29	30.8	20.2	87	72	10.2	0.0	957.0	953.9
30	30.5	20.3	90	61	9.0	0.3	958.0	954.9
31	29.3	20.0	86	42	9.1	0.0	955.7	957.0

June 2010 met data

			9am	3pm	
	Max℃	**Min℃**	**RH**	**RH%**	**R/F**
1	30.2	18.2	81	56	0.0
2	30.5	18.4	79	59	0.0
3	27.8	18.6	85	63	0.0
4	29.0	20.0	86	56	0.0
5	27.5	19.0	80	63	0.0
6	28.8	17.0	87	49	0.0
7	27.4	16.0	80	54	0.0
8	29.4	15.2	71	50	0.0
9	28.7	19.9	78	56	TR
10	30.0	19.3	92	59	3.8
11	30.3	18.3	88	43	0.0
12	29.5	17.1	82	52	0.0
13	30.0	17.3	90	48	0.0
14	30.0	17.2	89	52	0.0
15	30.1	18.1	86	43	0.0
16	28.3	17.7	91	56	0.0
17	30.0	17.4	81	42	0.0
18	26.7	18.3	82	60	0.0
19	27.0	19.9	81	55	0.0
20	28.0	18.5	74	51	0.0
21	27.3	20.2	66	51	0.0
22	27.8	15.4	78	49	0.0
23	29.5	15.5	82	52	1.4
24	30.0	18.2	90	43	1.2
25	29.3	19.5	90	45	0.0
26	27.4	20.0	84	50	0.0
27	28.6	15.8	82	46	0.0
28	29.9	15.5	86	43	0.0
29	30.8	18.4	83	39	0.0
30	29.0	16.5	86	48	0.0
31					
Sum	**868.8**	**536.4**	**2490**	**1533.0**	**6.4**
Mean	**29.0**	**17.9**	**83**	**51.1**	**0.2**

APPENDIX 2

The example of data analysis of variance (ANOVA) table from the MSTAT-C output

A N A L Y S I S O F V A R I A N C E T ABLE FOR STEM GIRTH AT V-1 (cm)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.409	0.204	0.9919	
2	Factor A	4	3.567	0.892	4.3273	0.0373
-3	Error	8	1.649	0.206		
	Total	14	5.625			

Coefficient of Variation: 9.11%

s_ for means group 1: 0.2030 Number of Observations: 5

y

s_ for means group 2: 0.2621 Number of Observations: 3

y

A N A L Y S I S O F V A R I A N C E T A B L E FOR PLANT HEIGHT AT V-1 (cm)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	49.308	24.654	1.7712	0.2308
2	Factor A	4	305.192	76.298	5.4813	0.0201
-3	Error	8	111.358	13.920		
	Total	14	465.858			

Coefficient of Variation: 9.72%

s_ for means group 1: 1.6685 Number of Observations: 5

y

s_ for means group 2: 2.1540 Number of Observations: 3

y

APPENDIX 3

The example of data analysis of mean separation test from the MSTAT-C

Data File: TUSHIKAMANE

Title: ispm

Case Range: 22 - 26

Variable 5: STEM GIRTH AT V-1 (CM)

Function: RANGE

Error Mean Square = 0.2060

Error Degrees of Freedom = 8

No. of observations to calculate a mean = 3

Duncan's Multiple Range Test

LSD value = 0.8546

s_ = 0.2620 at alpha = 0.050

x

Original Order			Ranked Order		
Mean	1 =	4.277 C	Mean	4 =	5.627 A
Mean	2 =	5.197 AB	Mean	3 =	5.243 AB
Mean	3 =	5.243 AB	Mean	2 =	5.197 AB
Mean	4 =	5.627 A	Mean	5 =	4.580 BC
Mean	5 =	4.580 BC	Mean	1 =	4.277 C

Mean separation test continued….

Data File: TUSHIKAMANE

Title: ispm

Case Range: 22 - 26

Variable 7: PLANT HEIGHT AT V-1 (CM)

Function: RANGE

Error Mean Square = 13.92

Error Degrees of Freedom = 8

No. of observations to calculate a mean = 3

Duncan's Multiple Range Test

LSD value = 7.025

s_ = 2.154 at alpha = 0.050

x

Original Order			Ranked Order		
Mean	1 = 31.75	C	Mean	4 = 45.17	A
Mean	2 = 40.67	AB	Mean	2 = 40.67	AB
Mean	3 = 38.42	ABC	Mean	3 = 38.42	ABC
Mean	4 = 45.17	A	Mean	5 = 35.83	BC
Mean	5 = 35.83	BC	Mean	1 = 31.75	C

APPENDIX 4

Summary of Analysis of Variance (ANOVA) Tables for variables analysed indicating the level of significance

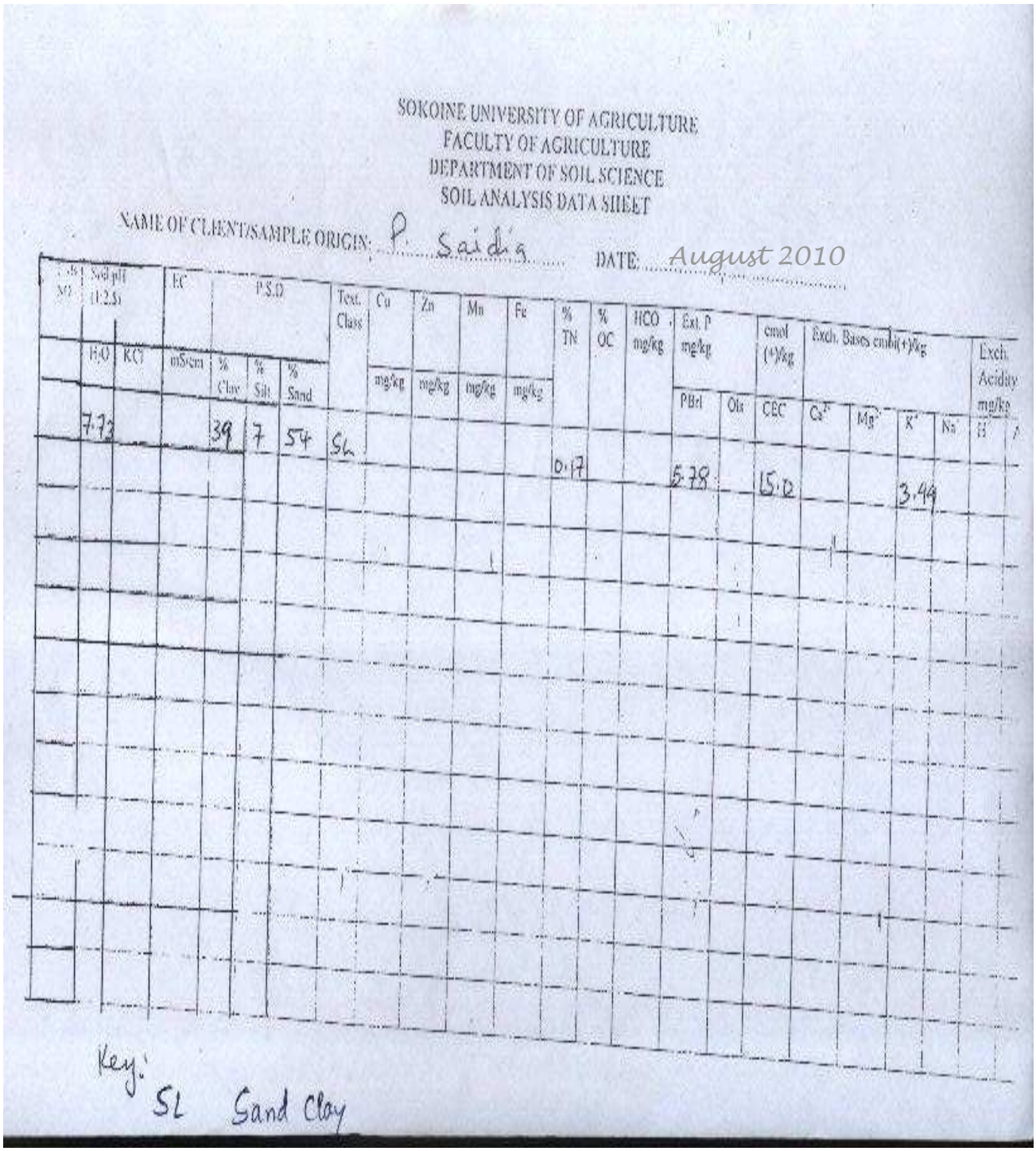
S/NO	VARIABLE ANALYSED	REPLICATION	TREATMENT
1	Plant population per m^2 at V-1	ns	ns
2	Plant population per m^2 at harvest	ns	ns
3	Stem girth at V-1 (cm)	ns	*
4	Stem girth at early tasseling/ boot (cm)	ns	ns
5	Plant height at V-1 (cm)	ns	*
6	Plant height at early tasseling/ boot (cm)	ns	ns
7	Plant height at silking (cm)	ns	ns
8	Total dry matter (TDM) g/m^2.	ns	ns
9	Weight of husked ear g/m^2.	ns	ns
10	Weight of de-husked ear g/m^2.	ns	ns
11	Seed weight before drying (bod) g/m^2.	ns	ns
12	Shelling percentage (%)	ns	ns
13	Number of rows in cobs	ns	ns
14	Length of ear filled with grain (cm)	ns	ns
15	Number of seeds per m^2.	ns	ns
16	Dry seed weight g/m^2.	ns	ns
17	100 seed weight (g)	ns	ns

Key: * Refers to significant at a level at $P \leq 0.05$

ns Refers to non significance at a level at $P \leq 0.05$.

APPENDIX 5.

Soil analysis laboratory datasheet.



SOKOINE UNIVERSITY OF AGRICULTURE
FACULTY OF AGRICULTURE
DEPARTMENT OF SOIL SCIENCE
SOIL ANALYSIS DATA SHEET

NAME OF CLIENT/SAMPLE ORIGIN: P. Saidia DATE: August 2010

S/No	Soil pH (1:2.5)		EC	P.S.D			Text. Class	Cu	Zn	Mn	Fe	% TN	% OC	HCO$_3$	Ext. P		cmol (+)/kg	Exch. Bases cmol(+)/kg				Exch. Acidity
	H_2O	KCl	mS/cm	% Clay	% Silt	% Sand		mg/kg	mg/kg	mg/kg	mg/kg			mg/kg	PBrl	Ols	CEC	Ca^{2+}	Mg^{2+}	K^+	Na^+	H^+
	7.72			39	7	54	SL					0.17			5.78		15.12			3.49		

Key: SL Sand Clay

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FACULTY OF AGRICULTURE
DEPARTMENT OF SOIL SCIENCE

SOIL ANALYSIS DATA SHEET

NAME OF SAMPLE ORIGIN: Mosha & Menya DATE: June 2009

Lab. No.	Soil pH (1:2.5)		EC	PSD			Textural Class	TN	OC	OM	Brl Ext. P	CEC	Exch.bases(Cmol(+)kg)			
	H_2O	KCl	MS/cm	Clay %	Silt %	Sand %		%	%	%	Mg/kg	(Cmol(+)/kg)	Ca^{2+}	Mg^{2+}	K^+	Na^+
Soil 1	6.94							0.11	0.89		438	18.9				
											%					
Leaves Kuku								3.85			0.42					
Leaves –								3.78			0.42					
					Am											

E. Kafu
Analyst
2/7/09

DEPARTMENT OF SOIL SCIENCE
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Bustani ya Tushikamane is a Sustainable/Organic Agriculture Project in Morogoro which offers information dissemination through training, extension, research and demonstration. The information office is located at Tushikamane Centre in Kilakala, Morogoro and it was officially opened in August 2009.

The project works in collaboration with other NGOs, farmers, institutions, individuals and students from Sokoine University of Agriculture.