Utilization of Effective Microorganisms Commercial Organic Agriculture – A Case Study from New Zealand

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Abstract

The effect of EM on onion and sheep production on a commercial organic farm are reported, and the problems of broad acre application of EM are discussed.

A trial in 1995 compared EM with a range of organic fertilisers in onion production, EM gave the second highest yield which was significantly greater than the control. In addition EM gave the highest percentage of first grade onions.

In 1996 1.3 ha of onion were intensively sprayed with EM from 6 weeks post emergence to 4 weeks before lifting. The crop yielded much higher than previous onion crops (53 tonnes/ha). However fungal diseases became a major problem in storage causing loss of 50 % of the crop. A potential loss of US $ 15,000. Could this loss have been averted by the application of EM over the entire growing period including seed treatment with EM ?

The growth rates of sheep and lambs grazing on EM treated pasture and drinking water were compared in a separate trial. EM lambs had higher liveweight gains for the first three and last weighing and has a higher overall liveweight gain. There was no significant difference between the ewe liveweights. Internal parasite faecal egg numbers were lower in the EM treated lambs.

The EM application recommendations for Asia-Pacific Natural Agricultural Network (APNAN) countries are difficult to implement in a New Zealand farming context. Alternative application methods are discussed including the use of tractor mounted spraying equipment applying between 200 L to 1000 L of water per hectare, irrigation applying 250,000 L to 300,000 L of water per hectare and the use of EM in livestock water systems.

Introduction

Harts Creek Farm is farmed in partnership by Tim Chamberlain his wife Rose and his parents. The farm located in Canterbury in the South Island of New Zealand is a 160 ha mixed cropping and livestock operation with fertile heavy soils suited to both intensive cropping and sheep/cattle pastoral farming. It started a conversion programme in 1986 to organics and currently 132 ha of the 160 ha are managed and certified for organic production. Effective Microorganisms (EM) was introduced to the farm in 1994 by the visit of Professor Dr. Teruo Higa. Since then EM has been applied to pastures and crops and EM trials have been conducted on onions (Daly, 1995), and sheep (Chamberlain 1996) which are currently the most difficult production systems on the farm. Further on-farm trials are being conducted to increase the understanding of the use of EM on a large scale in order to improve the efficiency of broadacre applications and economic returns.

Our aim is to use EM and Kyusei Nature Farming, to increase productivity, food quality and profitability under certified organic production. This paper outlines our farming operation, the results of using EM, our broadacre application techniques and our thoughts for the future.

Materials and Methods

Farm details

Table 1 lists details of the physical and climatic attributes of Harts Creek Farm.

Table 1. Details of Harts Creek Farm and Local Climatic Data

Size :	160 ha
Average field size :	6 ha
Number of fields :	26
Altitude :	20m a.s.l.
Rainfall:	600 mm evenly distributed through year
Temperature range:	January mean 16.4 C; July mean 5.7 C.
Soils :	Heavy silt loam over clay (40mm topsoil), high natural fertility
Irrigation:	Overhead sprinklers from underground wells
Crops : pasture	45:55 ratio
Crops	Peas, beans, carrots, onions, dandelion, linseed
Livestock	Sheep (1000) cattle (100)

1995 Onion Trial

Onions (*Alium capa* cv. "Pukekohe Long Keeper") were grown on a "Wakanui" silt loam soil (Kear et al., 1967), prepared by rotary hoeing in August after a winter green feed crop. The field has previously been in ryegrass/white clover pasture for four years. Soil test values on 5 September for 0-15 cm. Depth were :pH 5.8; with quick test values of, phosphorus 15; sulphate-sulphur 9; potassium 5; magnesium 19 and calcium 8 (Lee et al., 1991). The trial was direct seeded using a precision seeder in 1.5 m wide beds with four rows at 300 mm spacing between the rows, and a spacing of 60 mm between seeds. There were four replicates with a plot size of 5m by 1.5 m. The treatments are listed in Table 2.

Table 2. Onion Trial Treatments

Treatment	**Application rate**
Control	0
Reactive phosphate rock (RPR)	1000 kg ha^{-1}
Biophos	1000 kg ha^{-1}
Blood & Bone side dressing	600 kg ha^{-1}
RPR plus Blood & Bone	1000 kg ha-1 + 600 kg ha^{-1}
Seasure	250 g ha^{-1}(3)
EM	10/ha^{-1} (3)
Farmers mix	950 kg ha^{-1}

EM was applied at a rate of 10 L ha^{-1} with 10 L ha^{-1} of molasses mixed into water, applied at 10,000 L ha^{-1} through a watering can onto crop foliage on November 11, December 22 and January 20. Crop vigour was accessed visually at bulbing (January 22). At harvest (March 7) the field dried onions were graded and weighed.

1996 Onion Crop

In 1996 1.3 ha of onions, grown to Bio-Gro organic certified standards, were sprayed fortnightly with WM1 from 6 weeks after emergence to 4 weeks before harvest. The onions followed a crop of organic peas under-sown with an over-wintering grass sward. A custom fertilizer mix consisting of 60 percent blood and bone, 30 percent reactive rock phosphate 10 percent sulphur minerals, was applied at rate of 1 tonne to the hectare two months after onion emergence. The crop has a pre-emergence herbicide application with "Greenscape" a fatty acid herbicide derived from coconuts. Due to a large weed seed bank the crop was machine hoed on a fortnightly basis for three months. One hand weeding took place. The crop was due to be harvested between 50 percent to 75 leaf fall. 30 mm of rain fell four days before harvest was planned after a prolonged dry spell of two months. This prohibited mechanized access for 4 days. During this time a considerable proportion of the onions swelled and split. The crop also experienced delayed drying and leaf removal.

Sheep and Lamb Trial

Forty in-lamb, two tooth ewes were randomly selected and split into two groups, an EM treatment group and a control. The trial was started on 31 July 1996 just as the ewes began to give birth.

EM at a rate of 10 L with 10 L of molasses in 200 L of water per ha was applied to the pasture using a tractor mounted crop aprayer, every two weeks. EM was applied in damp weather or to dew. A trough dispenser was used to add EM to the water supply of the EM group animal. The ewes were first weighed on the 31 of July, then six weeks later after lambing, and then approximately every two weeks.

Broadacre application

The EM application manual for APNAN countries recommends applying EM1 (diluted solution 1:1000) at a rate of 5,000 L to 50,000 L per hectare. Due to the extensive nature of farming in New Zealand and the lack of suitable equipment applying these rates of liquids to land is difficult. Water and liquid application equipment is generally designed for large scale irrigation or for agrichemical application. Irrigation equipment is designed to apply 250,000 L of water or more per hectare, while agrichemical spray equipment is designed to apply between 100 L to 1000 L of water per hectare. Three principal techniques are used for applying EM on Harts Creek Farm.

1. Low volume with tractor mounted spraying equipment
2. High volume with field irrigation equipment
3. Metered dosing of stock water

Spraying equipment is used to apply EM1 in water at a rate between 200 L to 1000 L water per hectare depending on the area and value of the crop. This is ideally done immediately before, after or during rain, or when there is a dew on the ground.

With irrigation equipment EM1 solution is fed into the irrigation water which is applied at between 250,000 L to 300,000 L of water per ha. This is equivalent to 25 mm to 30 mm of rain.

For livestock drinking water, EM1 without molasses is injected into the water at a rate of 1:1000 EM: water.

For the irrigation and spraying techniques EM stock solution from Japan is brewed up in closed plastic containers at a rate of 1 L EM stock solution : 1 L molasses : 200 L water and brewed till the pH falls below 4.0. This is then used as secondary EM stock solution.

The secondary brewing up process takes place in open topped 200 L steel drums. This is generally made up at least 24 hours in advance of application to ensure that the EM has completely brewed.

The area used was 1,062.72 m^2. The geographic location and climatic conditions during 1996 are presented in Table 1 and Figure 1., respectively.

Table 1. Location and Ecology of the Test Site.

North Latitude	12°08’
West Longitude	86°10’
Altitude	76 m
Average Annual Temperature	26.8°C
Average Annual Precipitation	1,608 mm
Relative Humidity	15 %

Source : Nicaraguan Institute of Territorial Studies, (INETER) 1997

Soil Type

The soil types belong to the La Calera (LCA) series, which have been derived from lacustrine and alluvial sediments, and consist of poorly drained, black surface, calcareous soils, which contain salts and are high in exchangeable sodium; the texture is open, sandy.

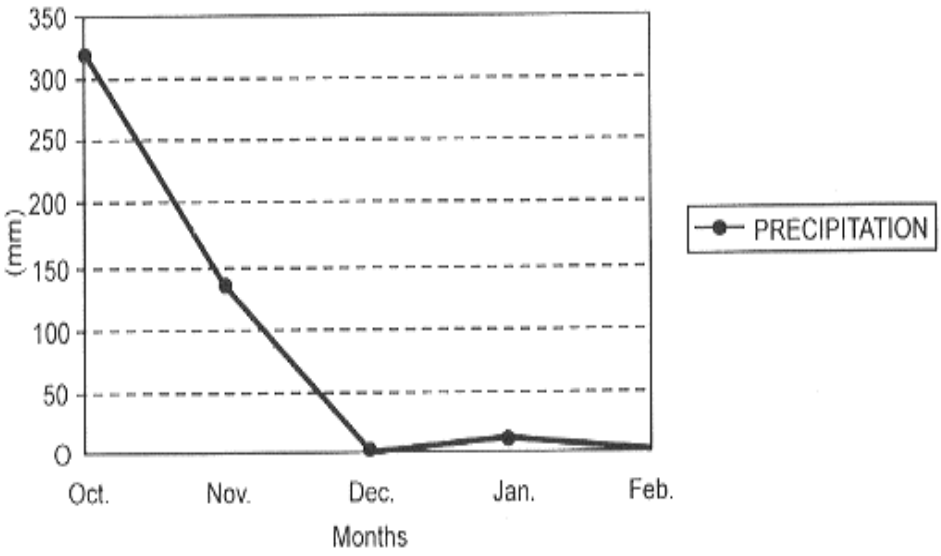

Figure 1. Monthly Precipitation and Average Registered in the Months of October 1996 to February 1997 in the UNA, Managua (INETER 1997).

Table 2. Chemical Properties of the Soil in which the Study of the Effect of Four Types of Biofertilizers was Carried Out

pH	P	K	Mg	Ca	MO	N	Clay	Silt	Sand
7.9	1.5 ppm	1.8 ppm	1.3 ppm	18.0 ppm	4.0%	0.16%	12.5%	27.5%	60.0%

Source : Soil and Water Laboratory, UNA 1996

A unifactorial arrangement in sketches of random complete blocks (B.C.A.) was used with six treatments and three repetitions.

Table 3. Treatment Descriptions

Treatment # 1	Rice husks + Chicken manure + Sawdust + EM
Treatment # 2	Rice husks + Cow manure + Sawdust + EM
Treatment # 3	Rice husks + Coffee pulp + Sawdust + EM
Treatment # 4	Rice husks + Chicken manure + Cow manure + EM
Treatment # 5	Relative Control (Complete 12-24-12. Urea 48%)
Treatment # 6	Absolute Control, without additions

Table 4. Proportions Used in the Production of the EM-Bokashi Treatments

Treatment	Rice Husks	Chicken Manure	Cow Manure	Sawdust	Coffee Pulp
No. 1	2	1	-	1	-
No. 2	2	-	-	1	-
No. 3	2	-	-	1	1
No. 4	2	1	1	-	-

The preparation of EM-Bokashi was carried our on October 7, 1996.

Table 5. Proportions Used in the Dilution of EM

Molasses	EM	Water
1	1	1

Approximately 36.36 kg (80 lbs) of the EM-Bokashi treatment was prepared and placed in polyethylene bags with a capacity of approximately 10.18 kg, each. Then, each one of the bags was hermetically sealed and allowed to ferment in a warm, dark area for 14 days. Once the fermentation period was complete, the EM-Bokashi mixtures were dried for a period of six days, and finally the

biofertilizers were stored for later incorporation into the soil.
The experimental parcels consisted of six strips, 6.56 m long by 8.0 m wide. Three repetitions were made for each treatment, resulting in a total test area of 1, 062.72 m^2. The preparation of the ground was carried our under a conventional cultivation system. It was initiated by cleaning the ground, one plowing step, and two grading steps. The sowing was performed manually, placing three seeds at a time with a distance of 0.62 m between rows and a distance of 0.40 m between plants. Sowing was performed on November 7, 1996, using seed variety NB-6, which has a cycle of 110 to 115 and an average potential yield of 3,894-4,543 kg/ha. This variety has free pollination and is tolerant to growing thick (MAG, 1993).
Fertilization consisted of incorporating the EM-Bokashi treatments into their respective experimental parcels, seven days prior to sowing at a rate of 2.021 kg/m^2. The relative control parcels were treated the day of sowing with a 12-24-12 (NPK) formulation at a rate of 130 kg/ha. A 46 percent urea nitrogen fertilizer was also added to the relative control parcels at a rate of 64.69 kg/ha, thirty days after sowing.
Weeds were controlled mechanically (by hoeing) in two stages at 15 and 40 days after sowing. The last precipitation of the rainy season was utilized. In addition, eight watering by aspersion were made at intervals of 1-2 irrigation per week. Phytosanitary treatment was performed during the critical period of the crop growth. EM5 and EM-Fermented Plant Extract were applied at a dilution of 300/liter as well as Neem at a dilution of 400/liter to control *Dalbulus maidis L* and *Diabrotica sp*. Harvesting was performed manually at the completion of the crop cycle, 110 days after sowing.

Results
Statistical analysis of the data was made using the SAS statistical package, by means of the ANOVA procedure using the average values obtained from the experimental parcels. The evaluation was made by means of the statistical analysis of variance and separation of averages of multiple rank according to the Tukey method at 95 percent confidence.

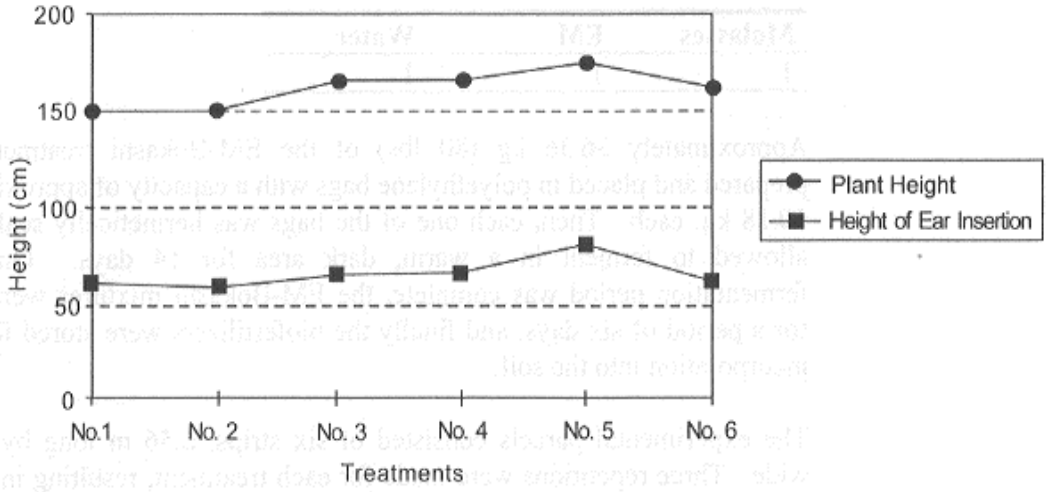

Figure 2. Effect of EM-Bokashi on the Variables of Plant Height and Height of Ear Insertion

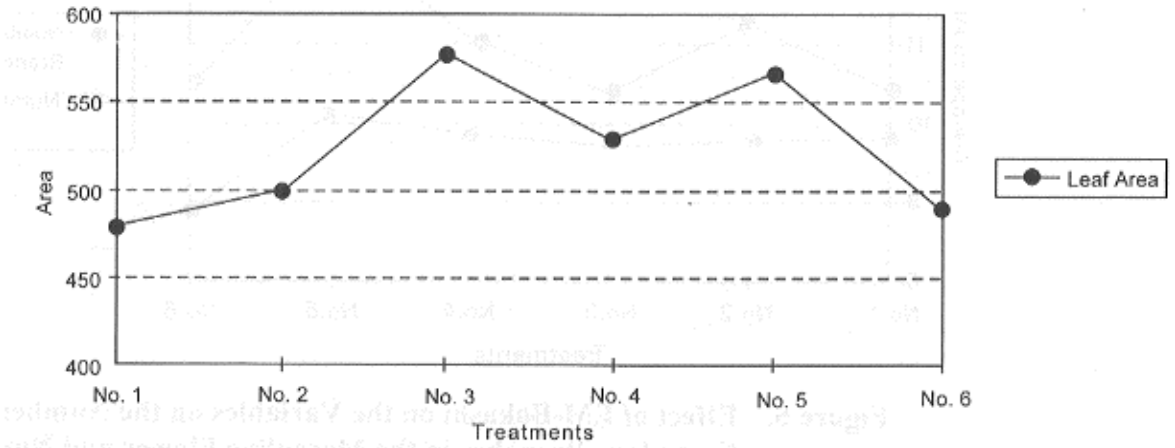

Figure 3. Effect of EM-Bokashi on the Variable of Leaf Area
Statistically Significant Difference Present

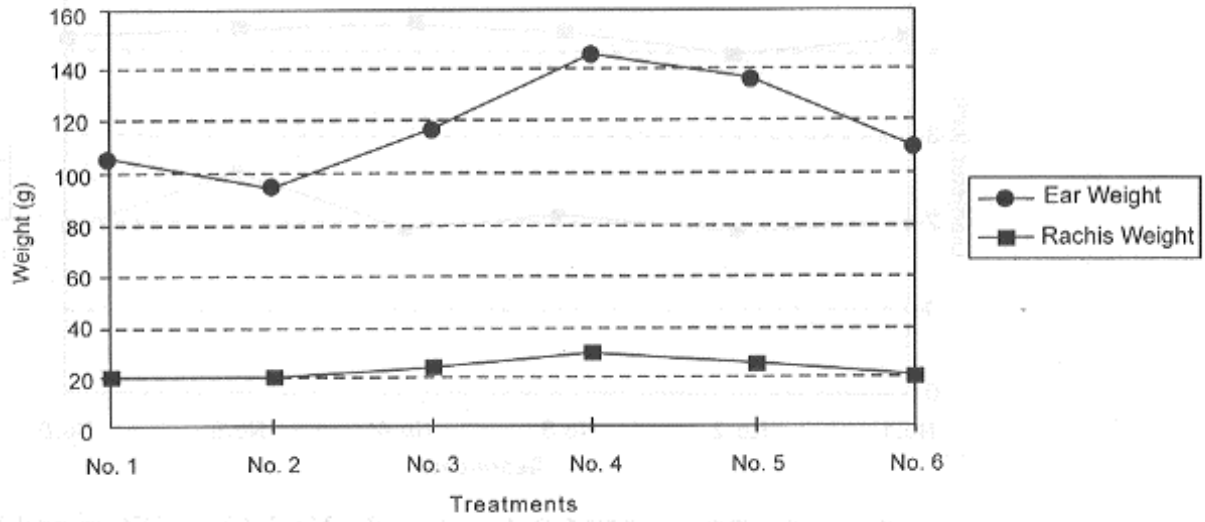

Figure 4. Effect of EM-Bokashi on the Variables of Ear and Rachis Weight
Statistically Significant Difference Present

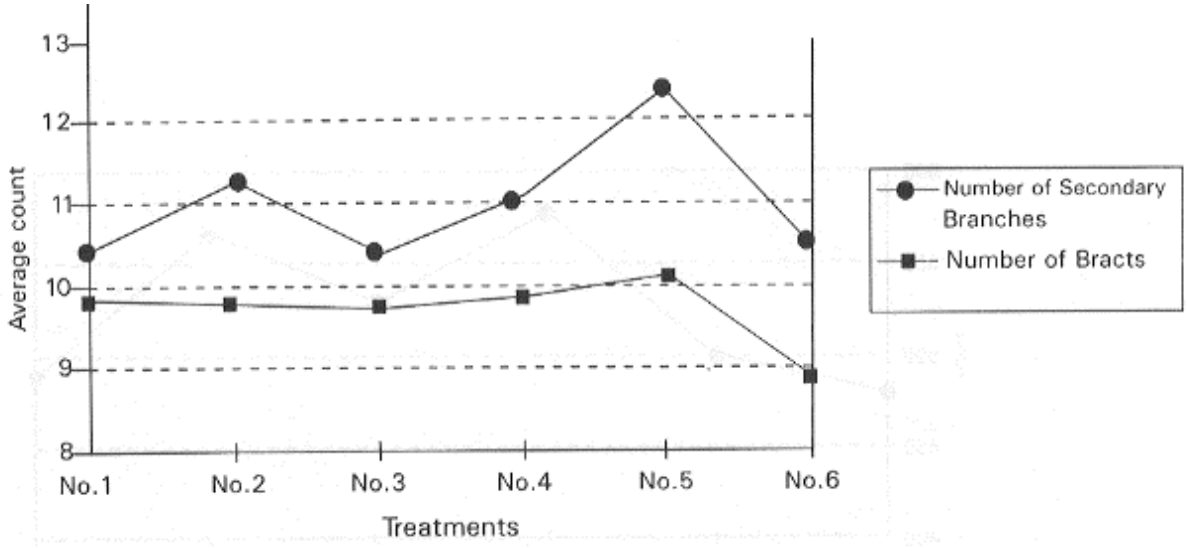

Figure 5. Effect of EM-Bokashi on the Variables on the Number of Secondary Branches in the sculine Flower and Number of Bracts in the Corn

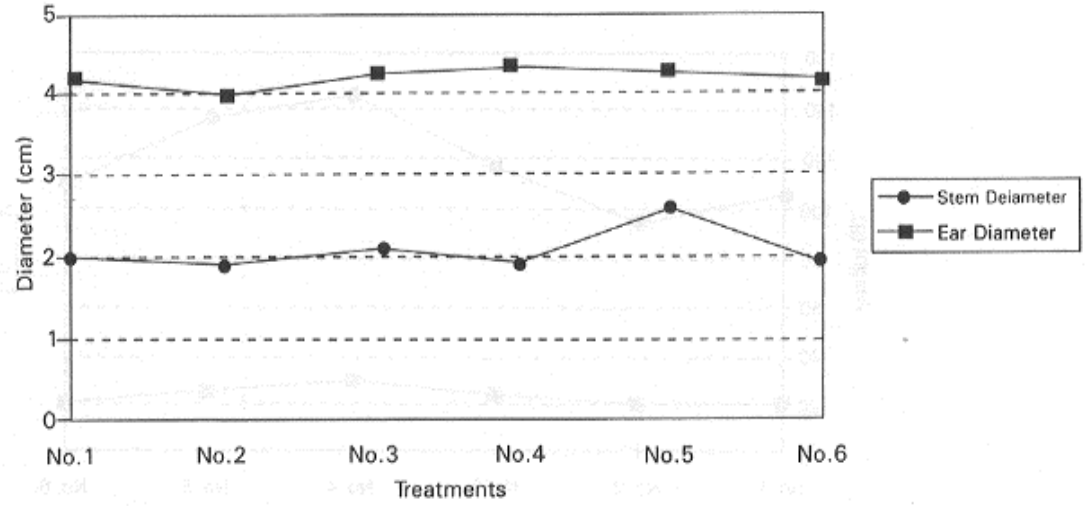

Figure 6. Effect of EM-Bokashi on the Variables of Stem and Ear Diameter

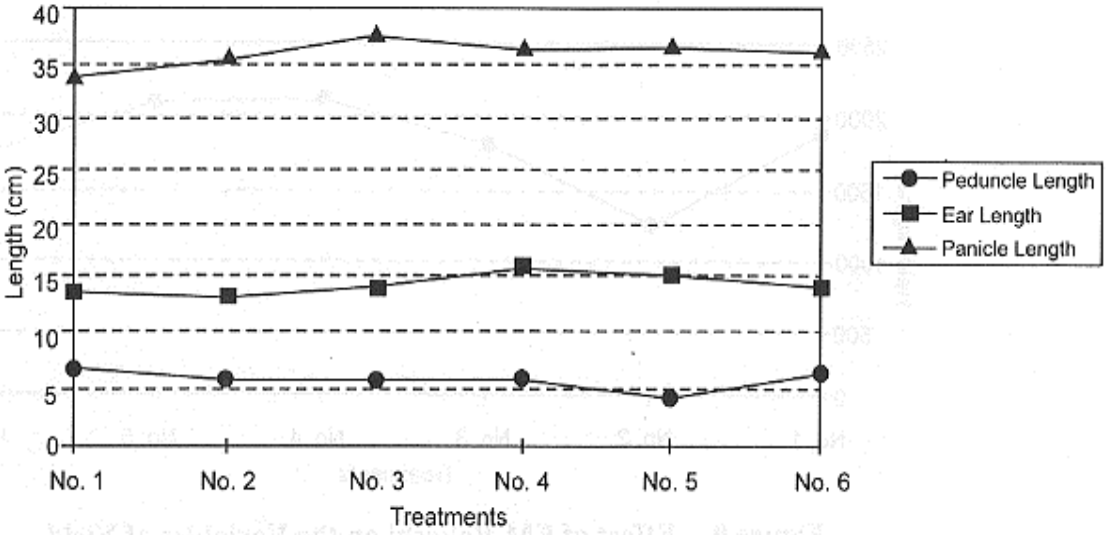

Figure 7. Effect of EM-Bokashi on the Variables of Peduncle, Ear and Panicle length
Statistically Significant Difference present in ear and panicle results.

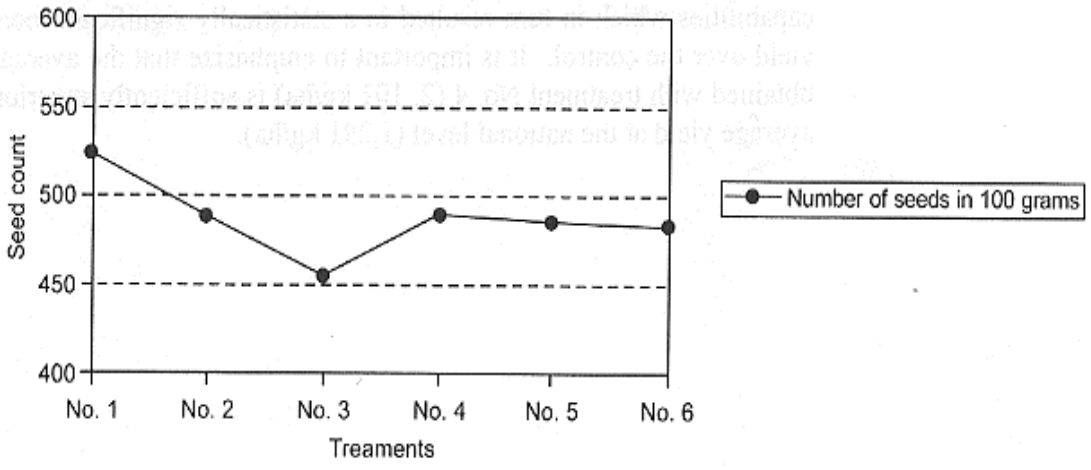

Figure 8. Effects of EM-Bokashi on the Number of Seeds in 100 grams of Corn

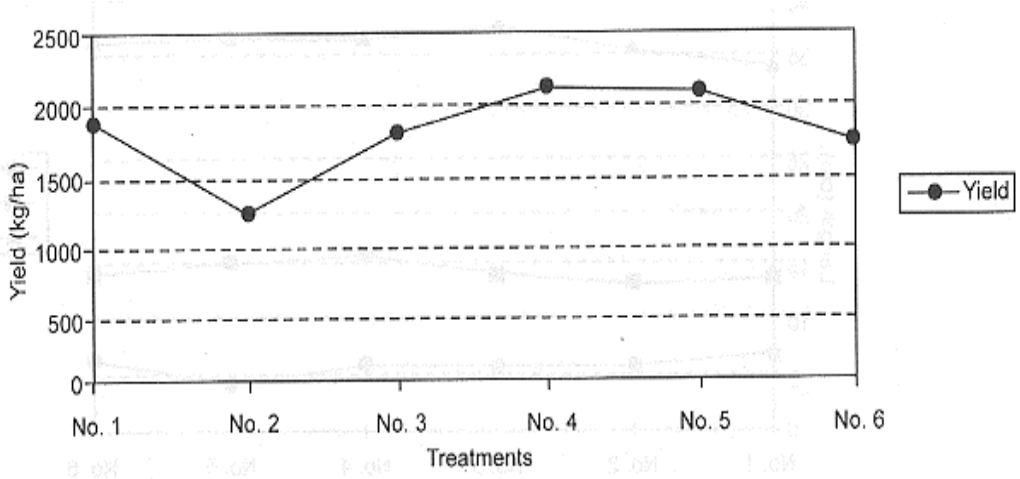

Figure 9. Effect of EM-Bokashi on the Variables of Yield

Conclusions

The EM-Bokashi biofertilizer has a significant effect on the yield and some components of the yield, such as the weight of the ear, diameter of the ear, and weight of the rachis. There was also a significant difference in the growth and development in the total surface area of the corn leaves as well as in the length of the panicle, or the central axis of the male flower. These results show that the corn plants treated with EM-Bokashi tended to grow more efficiently. Available nutrients were utilized to increase leaf surface area which led to improved photosynthetic capabilities which in turn resulted in a statistically significant increase in yield over the control. It is important to emphasize that the average yield obtained with treatment No. 4 (2,101 kg/ha) is sufficiently superior to the average yield at the national level (1,291 kg/ha).