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Effect of Bio Fertilizer With Varying Levels of Mineral Fertilizer on Maize (*Zea Mays*.L) Growth

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ABSTRACT

Repeated use of agricultural land over several years has created severe reduction of soil fertility and a disproportion in the store of nutrients available attributable to widening gap between nutrient removal and supplier. Bio fertilizers have been renowned as alternative to augment mineral fertilizers to increase soil fertility for crop production in sustainable agriculture. A study was therefore conducted with the objective to establish optimum levels of microbial fertilizer and mineral fertilizer on some characteristics of maize plant. Ten treatment levels of varying levels of microbial consortium bio fertilizer and mineral fertilizer combinations were laid out in a Randomized Complete Block Design (RCBD) and replicated three times. There was significant (P<0.05) degree of influence for application of combinations of bio fertilizer with mineral fertilizer at varying levels on plant growth characteristics. Stem girth and fresh weight were maximum at Trt9, plant height was maximum at Trt7, dry weight was maximum at Trt3, and P content and N content was supreme at Trt9 and Trt6 respectively. Further research should be carried out to establish the combination that provides the best results for all parameters.

***Key Words**: Microbial consortium bio fertilizer, mineral fertilizers, maize, growth.*

INTRODUCTION

Providing food security for an increasing world population under transient climate conditions has been one of the great challenges faced by the agricultural sector. [1-6] With more than seven billion people to feed, the productive yield of crops needs to be higher, more sustainable, and more efficient worldwide. Productivity is not only the plant growth per hectare in the field. It is also defined by the fitness, food production, and healthy development of plants. [7,2] Most losses in food production are due to diseases caused by different pathogens and pests, the effect of which is augmented by abiotic stresses such as heat and drought. The degree of dependence on natural resources [8] and the impact of climate change on drought incidence play a key role in amplifying this challenge. Accordingly, possible global intensifications of drought conditions is of great concern for any agricultural area. This is particularly true for tropical developing countries because of their high dependence on rain fed systems. [9]

Low soil fertility is currently a food security problem in many developing countries, particularly in Africa and South Asia. [10-12] Africa and South Asia are also among the region's most at risk of food insecurity [11,13,14] and to deteriorating soil health due to climate change. [15] Proper soil management has the potential to drastically reduce food security issues in these regions. In sub-Saharan Africa, the total NPK requirement per ha per year range from 24.5 to 176 kg NPK/ha. [16] Continuous use of agricultural land over several years has created an imbalance in the store of nutrients available. Also, increase in cropping density and introduction of high yielding varieties have caused considerable drain of nitrogen and crops showed a positive response to the addition of nitrogen in the soil. Serious depletion of soil fertility due to widening gap between nutrient removal and suppliers [17] has affected crop productivity. However, organic and inorganic fertilizers are the major categories of fertilizers used by smallholder farmers. The inorganic fertilizers are in the form of ammonium nitrate, urea, rock phosphate, potassium chloride and potassium sulphate. [18]

With the growing environmental concerns, the sole dependence on chemical input based agriculture is being replaced by integrated multi- approach involving conjunctive use of both organic and inorganic sources. According to Remesh, [17] the use of organic manures particularly bio-fertilizers are the only option to improve the soil organic carbon for sustenance of soil quality and future productivity. This biotechnology and microbiological science products such as phyto stimulator, bio pesticides and bio fertilizers improve crop nutrient efficiency. [19,20] Bio fertilizers are eco-friendly and supply the nutrient input of biological origin for plants. They are not only important for the reduction of quality chemical fertilizers but also for providing better yield in sustainable agriculture. Bio fertilizers have been identified as alternatives to chemical fertilizers to increase soil fertility for crop production in sustainable farming. [21]

Biofertilizers improve nutrient uptake, plant growth and plant tolerance to abiotic and biotic stress. [22,23] With this view, the objective of this study was to determine optimum levels of microbial fertilizers and mineral fertilizers on some characteristics of maize plant.

RESEARCH METHODOLOGY

Site Description

The experiment was conducted at Africa University Farm located at 18°53’70.3” South and 32°36’27.9” East and at an altitude of 1131m. The mean annual precipitation is approximately 800-1000 mm with most of rain falling between December and February. The average summer temperature is 27ºC and winter temperature is about 7ºC. The soil at AU farm is a red sandy clay loam, Fersiallitic 5E soil under Zimbabwe soil classification system (Nyamapfene, 1991).

Experimental Design, Treatments And Establishment

This field experimental study was conducted to determine the effect of a bio fertilizer on growth and development of maize crop at varying levels in combination with mineral fertilizer. All experimental treatments were laid out in a Randomized Complete Block Design (RCBD) with three replications. Maize grains were surface sterilized by immersing in 70% ethanol for 2 min and then in 0.2% sodium hypochlorite (NaoCl) for 3 min. Seeds to be washed several times with sterile distilled water.

The bio fertilizer selected for this study contain *Bacillus amyloliquefaciens (*Contains at least 1.0×10^7 colony forming units per gram dry weight of the product), *Paenibacillus polymyxa, Rhodobacter capsulatus, Lactobacillus acidophillus, Saccharomyces cerevisiae, Trichoderma harzianum, Aspergillus oryzae, diatomaceous earth and organic matter*

Treatments levels that were applied were as follows;

Trt1 - Control (No mineral fert, No biofert)
Trt2 - Mineral Fert 100% (Recommended Dose of Fert)
Trt3 - Biofert *(*microbial consortium*)*
Trt4 - Mineral Fert 100%+BioFert (microbial consortium) 100%
Trt5 - Mineral Fert 75% + BioFert 100%
Trt6 - Mineral Fert 50% + BioFert 100%
Trt7 - Mineral Fert 75% + BioFert 75%
Trt8 - Mineral Fert 75% + BioFert 50%
Trt9 - Mineral Fert 50% + BioFert 75%
Trt10 - Mineral Fert 50% + BioFert 50%

Pre-germinated seeds by soaking for 16 hrs were planted at different treatment level of mineral fertilizer and microbial consortium bio fertilizer and replicated three times. The seeds were sown at 2 to 3 cm depth. The plots were watered every 72 hrs with equal amount of water. Application of N:P:K and Bio fertilizer: the full dose of mineral fertilizer (N:P:K) was applied using Compound D (7:14:7) at a rate of 15g/plant at the time of planting. Nitrogen as AN was applied in three equal splits at 7, 14 and 21 days after plant emergence. Bio fertilizer microbial consortium was applied at a full rate of 1 g/plant to the soil immediately before planting of the seeds.

Data collection:

Data were collected 60DAP from 5 plants. An average was calculated for each parameter and recorded. The different parameters such as stem girth was measured using a vernier calipers , plant height was measured using a meter rule, fresh weight was measured using a digital scale and dry weight was determined by oven drying the plant sample at 65 ^{o}C and then weighing using a digital scale. Biochemical Analysis for total tissue N was determined using the Kjeldahl digestion and P concentration in plant extraction according to Kuo, (1996).

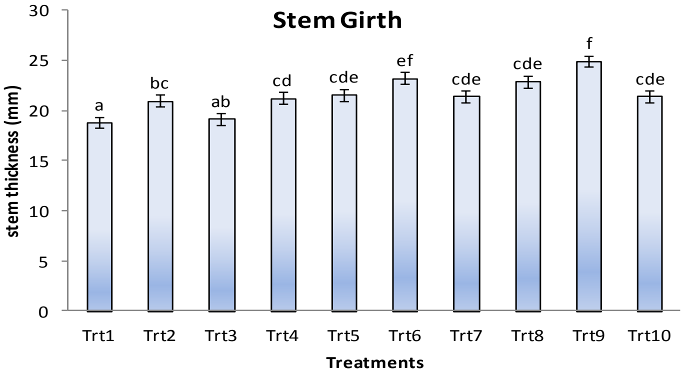
Statistical Analyses Of Experimental Data

Data collected was statistically analyzed using the GenStat Analysis of Variance (ANOVA) software and differences between means were determined using the Least Significant Difference (LSD) test at P=0.05 level.

RESULTS

Stem Girth

Data pertaining to stem girth was significant (P<0.05) as is shown in Figure 1.



**Figures not sharing a common letter differ significantly at 0.05 probability.*

Key

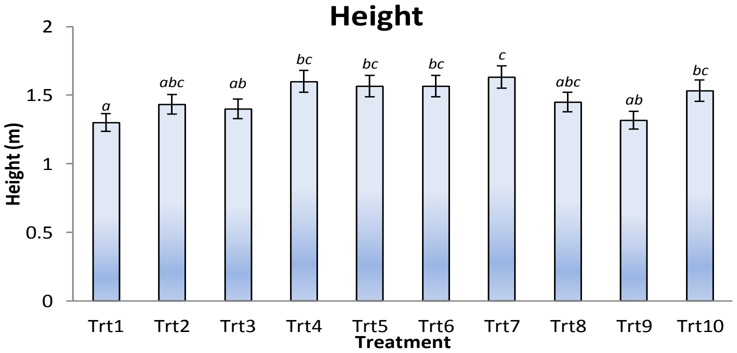
Trt1 - Control (No mineral fert, No biofert)
Trt2 - Mineral Fert 100% (Recommended Dose of Fert)
Trt3 - Biofert *(*microbial consortium*)*
Trt4 - Mineral Fert 100%+BioFert (microbial consortium) 100%
Trt5 - Mineral Fert 75% + BioFert 100%
Trt6 - Mineral Fert 50% + BioFert 100%
Trt7 - Mineral Fert 75% + BioFert 75%
Trt8 - Mineral Fert 75% + BioFert 50%
Trt9 - Mineral Fert 50% + BioFert 75%
Trt10 - Mineral Fert 50% + BioFert 50%

Figure 1. Effect of bio fertilizer on stem girth

All treatments were numerically higher for stem girth when compared to the control (*Trt1*). It is interesting to note that all treatments with a combination of mineral fertilizer and bio fertilizer performed significantly (P<0.05) better than recommended dose of mineral fertilizer (*Trt2*) and 100% microbial consortium (*Trt3*). The highest stem girth (24.92mm) was recorded for Trt9 followed by Trt6 (23.25mm) which was not significantly (P>0.05) different from *Trt9*. The mean stem girth recorded was 21.48mm.

Plant Height

Data for plant height is shown in Figure 2.



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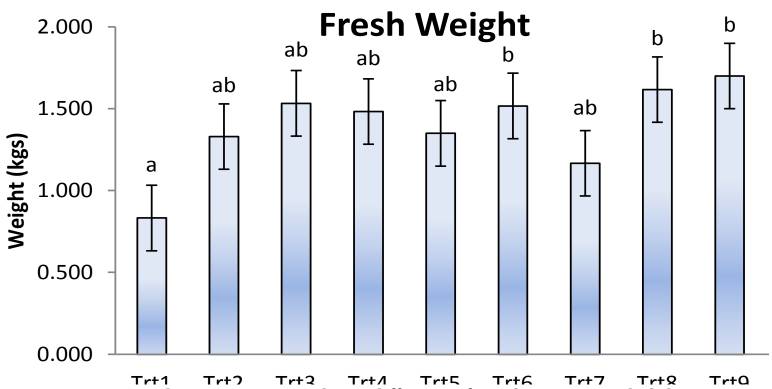
Trt6 - Mineral Fert 50% + BioFert 100%
Trt7 - Mineral Fert 75% + BioFert 75%
Trt8 - Mineral Fert 75% + BioFert 50%
Trt9 - Mineral Fert 50% + BioFert 75%
Trt10 - Mineral Fert 50% + BioFert 50%

Figure 2. Effect of bio fertilizer on plant height

Numerically, all the treatments performed better than the control (*Trt1*). Plant height for *Trt1* was not significantly (P>0.05) different from that of *Trt2, Trt3, Trt8* and *Trt9*. Also important to note is the results for *Trt1* and *Trt2* where not significantly (P>0.05) different from each other for plant height. The tallest plants were recorded from *Trt7* which were statistically not significant (P>0.05) different from *Trt4, Trt5, Trt6, Trt8* and *Trt10.*

Fresh Weight

Figure 3 shows that the results for fresh weight recorded was significantly (P<0.05) different from each other. Numerically, the fresh weights for *Trt1* to *Trt10* were higher than that recorded for the Control. The highest fresh weight was significantly recorded from *Trt6*, *Trt8* and *Trt9*. Most of the treatments with a combination of mineral fertilizer and bio fertilizer produced higher fresh weight than mineral fertilizer at 100% recommended full dose. Bio fertilizer alone produced fresh weight which was higher than recommended full dose of mineral fertilizer.



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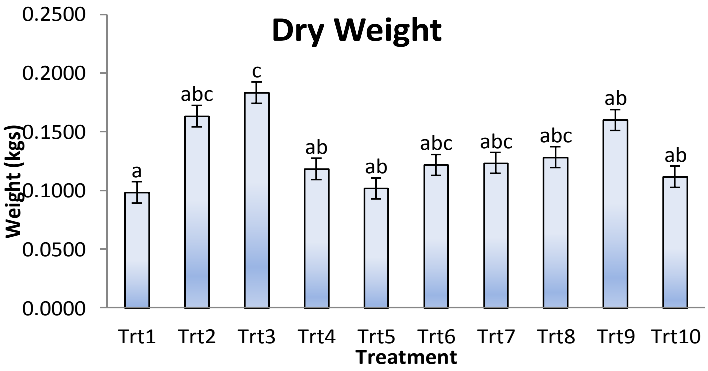
Trt8 - Mineral Fert 75% + BioFert 50%
Trt9 - Mineral Fert 50% + BioFert 75%
Trt10 - Mineral Fert 50% + BioFert 50%

Figure 3. Effect of bio fertilizer on fresh weight

Dry Weight



**Figures not sharing a common letter differ significantly at 0.05 probability.*

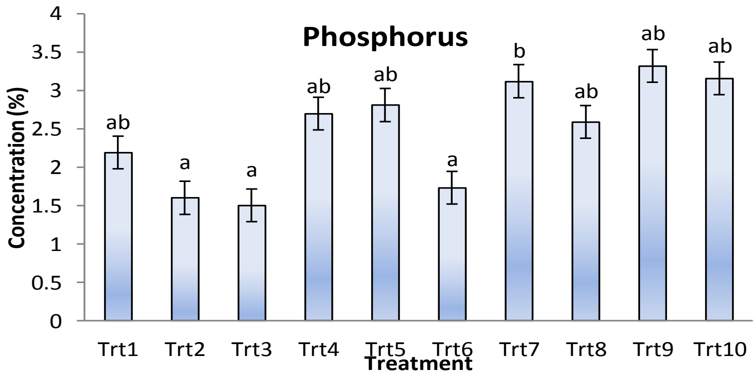
Key:

Trt1 - Control (No mineral fert, No biofert)	**Trt6** - Mineral Fert 50% + BioFert 100%
Trt2 - Mineral Fert 100% (Recommended Dose of Fert)	**Trt7** - Mineral Fert 75% + BioFert 75%
Trt3 - Biofert *(*microbial consortium*)*	**Trt8** - Mineral Fert 75% + BioFert 50%
Trt4 - Mineral Fert 100%+BioFert (microbial consortium) 100%	**Trt9** - Mineral Fert 50% + BioFert 75%
Trt5 - Mineral Fert 75% + BioFert 100%	**Trt10** - Mineral Fert 50% + BioFert 50%

Figure 4. Effect of bio fertilizer on dry weight

Results pertaining to dry weight are shown in Figure 4. All other treatments performed better that the T*rt*10 and numerically, *Trt1* and *Trt3* outperformed all the other treatments. *Trt3* had the highest dry weight. The highest rate of mineral fertilizer and bio fertilizer did not perform better than treatments where lower application rates were used.

Phosphorus Concentration



**Figures not sharing a common letter differ significantly at 0.05 probability.*

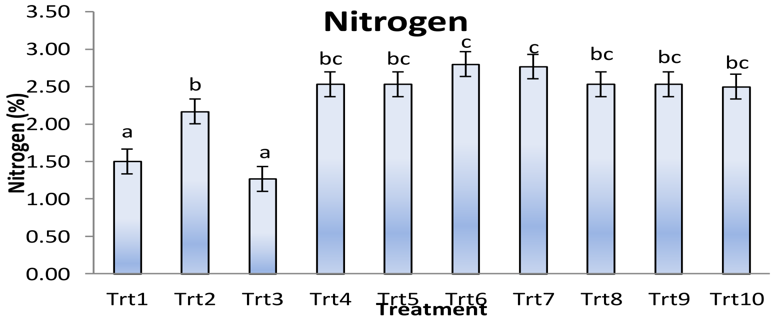
Key:

Trt1 - Control (No mineral fert, No biofert)	**Trt6** - Mineral Fert 50% + BioFert 100%
Trt2 - Mineral Fert 100% (Recommended Dose of Fert)	**Trt7** - Mineral Fert 75% + BioFert 75%
Trt3 - Biofert *(*microbial consortium*)*	**Trt8** - Mineral Fert 75% + BioFert 50%
Trt4 - Mineral Fert 100%+BioFert (microbial consortium) 100%	**Trt9** - Mineral Fert 50% + BioFert 75%
Trt5 - Mineral Fert 75% + BioFert 100%	**Trt10** - Mineral Fert 50% + BioFert 50%

Figure 5. Effect of bio fertilizer on Phosphorus content

Data relating to effect of different treatments on phosphorus (P) level is shown in Figure 5. The highest level of P was recorded from *Trt7*, *Trt9* and *Trt10*. Results revealed that generally, combinations of both mineral fertilizer and bio fertilizer performed better but not at maximum rate as seen for *Trt4* and *Trt5*. The mineral fertilizer when applied alone did not produce any more P% in the plant tissue than when it was applied together with the bio fertilizer and vice versa.

Nitrogen Concentration



**Figures not sharing a common letter differ significantly at 0.05 probability.*

Key:

Trt1 - Control (No mineral fert, No biofert)
Trt2 - Mineral Fert 100% (Recommended Dose of Fert)
Trt3 - Biofert *(microbial consortium)*
Trt4 - Mineral Fert 100%+BioFert (microbial consortium) 100%
Trt5 - Mineral Fert 75% + BioFert 100%
Trt6 - Mineral Fert 50% + BioFert 100%
Trt7 - Mineral Fert 75% + BioFert 75%
Trt8 - Mineral Fert 75% + BioFert 50%
Trt9 - Mineral Fert 50% + BioFert 75%
Trt10 - Mineral Fert 50% + BioFert 50%

Figure 6. Effect of bio fertilizer on Nitrogen content

Results for nitrogen uptake as affected by the different treatment combination of mineral fertilizer and bio fertilizer are shown in Figure 6. The control treatment and *Trt3* were not statistically different from each other and also recorded the lowest nitrogen content from the plant tissue. *Trt6* and *Trt7* numerically recorded the highest tissue nitrogen content but statistically these were not significantly from *Trt4*, *Trt5*, *Trt8*, *Trt9* and *Trt10*. Mineral fertilizer alone or bio fertilizer alone did not produce higher tissue nitrogen than when they were applied in combination at any level.

DISCUSSION

The statistical significant ($P<0.05$) improvement on all the parameters that were measured as a result of the combined effect of mineral fertilizer and bio fertilizer in comparison to control treatment, and treatments with microbial consortium alone and recommended dose of mineral fertilizer alone indicates the usefulness of bio fertilizers.

The considerable improvement in plant growth as a consequence of the bio fertilizer, particularly the diatomaceous earth and organic matters component, addition may perhaps have resulted from superior pH, EC and soil fertility leading to enhanced nutrient absorption as reported by some authors. [24-26] Also, the bio fertilizer could have augmented uptake of mineral nutrients in the plants resulting in more chlorophyll content and carbohydrate synthesis leading to amplified cell division and enlargement of the cell size thus resulting in bigger stem girth, height of the plant and fresh weight. The significant improved aboveground growth as a consequence of addition of bio fertilizer was also reported by Wange & Kale, [27] Prabhu *et al*. [28] and Anburani & Manivannan. [29]

On the other hand, as indicated by Major *et al*, [30] improved aboveground growth achieved by the application of integrated nutrient management of microbial consortium bio fertilizer and mineral fertilizers may possibly be by reason of improved nutrition associative symbiosis augmented production of growth hormones akin to IAA, GA_3 and cytokinins and enhanced nutrient availability and uptake through the sorptive capacity of the bio fertilizer. Comparable findings were also recorded by Nanthakumar and Veeraragavathatham, [31] who observed bigger plant growth parameters amid combined application of inorganic and bio fertilizers in brinjal.

Increased dry matter in consequence of nutrient application could be accredited to a balanced nutrient uptake by plants which lead to more cell division and enlargement bringing about shoot growth and development. Improved dry matter may well also be ascribed to production of plant growth hormonal substances and acquirement and accessibility of nutrients which sustained the plant vegetative development.

The more tissue nitrogen and phosphorus than control in all the treatments could be because of the acquisition or uptake of nitrogen due to long-drawn-out root surface area through improved root growth and root hair development. [32,33] Organic acid synthesis and exudation [34] might also have improved the expression of NO_3^-, NH_4^+, and PO_4^- transporters. [33] Milosevic et al. [35] reported that bacterial count leads to increase in N uptake. The phosphate-solubilizing *Bacillus* stimulates plant growth through enhanced P nutrition [36,37] and increasing the uptake of N, P, K and Fe. [38] *T. harzianum* increases the solubility of P and micronutrients such as Zn, Cu, Fe and Mg all plant nutrients with low solubility [39] and this enhances growth of the roots and the above ground parts of the plant. The improved tissue N and P could be attributed to *T. harzianum* since it enhances mineral nutrition through solubilization and/or uptake of mineral nutrients (e.g. N, P, Fe, Mn, Zn, Cu). [40-42]

CONCLUSION

The objective of this study was aimed determine an optimum level of application of the bio fertilizers with varying levels of mineral fertilizers in maize production. The study results revealed significant improved plant growth as a result of application of combinations of bio fertilizer with mineral fertilizer. There was varying degree of influence of biofertiliser on growth parameters; stem girth was maximum at Mineral Fert 50% + BioFert 75%, plant height was maximum at Mineral Fert 75% + BioFert 75%, fresh weight was maximum at Mineral Fert 50% + BioFert 75%, dry weight was maximum at Biofert (microbial consortium) alone, phosphorus content was maximum at Mineral Fert 50% + BioFert 75%, and nitrogen content was maximum at Mineral Fert 50% + BioFert 100%. Further research should be carried out to establish the combination that provides the best results for all parameters. It would be interesting to see how the influence of biofertiliser and different parameters correlate to final yield.

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