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Date: September, 2024

EFFICACY TRIAL REPORT TO THE KENYA PLANT HEALTH INSPECTORATE SERVICE (KEPHIS)

Reference: Permit No. KEPHIS/HQ/3/59/Vol. 5/961

Title: **EFFICACY OF MICROFERTILE PLANT BIOSTIMULANT ON THE GROWTH, YIELD AND QUALITY OF MAIZE**

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ABSTRACT

The findings presented in this report are for the single season efficacy trial conducted in four sites to evaluate the effectiveness of Microfertile Plant on the growth, yield and quality attributes of maize in different agro-ecological zones in Kenya. The treatment plots measured 4m long and 3 m wide were arranged in a randomized complete block design (RCBD) and they were replicated three times. The treatments consisted of the Untreated Control, Microfertile Plant (3L/acre), Microfertile Plant (4L/acre), Microfertile Plant (5L/acre) and the Reference Product-Macarena. The treatments have been applied once at 3-weeks after planting and were applied other two time at an interval of 21 days.

There were significant differences between the treatments on the growth, yield and quality of maize harvested across the four study sites. The three applications of MICROFERTILE PLANT on maize increased the stand establishment in all the four sites with over 90% exhibited while the conventional practice treatment alone showed a stand count establishment of as low as 83%. There were significant differences between the treatments on the days to physiological maturity of maize where due to the escapism metabolism of the plants the untreated control peaked earlier compared to the treated plots. The ear length of the maize was significantly increased through application of MICROFERTILE PLANT and all the three rates of 3.0, 4.0 and 5.0 l/acre had more efficacy than the reference product. This explains the importance of proper establishment of the root system which supports efficient and effective of all essential elements required by the plants reproductive development. The application of MICROFERTILE PLANT at the highest rate of 5.0 l/acre significantly increased the grain yield of maize by 37%, 27%, 48% and 43% in Nakuru, Kirinyaga, Machakos and Kirinyaga respectively compared to the untreated control. The application of the medium and low rates of MICROFERTILE PLANT still however showed significantly comparable effect on the maize grain yield in Kirinyaga with a yield increase of 23% and 27% compared to the untreated while significantly lower effectiveness were recorded in Makuru, Machakos and Murang'a.

Based on the consistent results exhibited across the four sites we recommend that MICROFERTILE PLANT be registered for commercial purposes in Kenya as an organic biostimulant at the rate of 5l per acre and be applied as foliar every 21-days.

INTRODUCTION

1.1. Introduction

ekolive Germany GmbH is seeking registration of Microfertile Plant, an organic liquid biostimulant containing dissolved silicified rock rich in all microelements, Chlorella microalgae, and other types of plant growth promoting bacteria on cereals. Tulip Agriconsult Limited received permission from the Kenya Plant Health Inspectorate Services (KEPHIS); to evaluate the efficacy of Microfertile Plant for commercial registration purposes in Kenya.

Five (5) treatments were used in this evaluation, three treatment rates of Microfertile Plant at the lowest rate (3L/acre), medium rate (4L/acre) and high rate (5L/acre) were compared to the standard fertilizer program, Macarena as the reference product at the recommended rate of 1L/acre and an untreated control (Standard Practice). Macarena is registered in Kenya by Twiga Chemicals as an organic biostimulant which is biologically derived through proprietary MAC technology, a multi-stage fermentation process. Metabolically Active Compounds produced from marine algae during this process enhances photosynthesis and higher anti-oxidant content leading to abiotic stress management in plants. Macarena was selected as reference product because they have similar mode of action as the test product and targeting same specific crops.

Maize (Zea mays L.) is the most important grain crop in Kenya and is produced throughout the country under diverse environments. The 2018-19 FAOSTAT show that more than 2.1 million ha of Kenya's 5.3 million ha of all crops harvested area was occupied by maize. In other words, maize accounts for 40% of all crop area in Kenya. The Ministry of Agriculture data for 2018 indicate that maize accounts for more than 51% of all staples grown in this country. Other major crops include common bean, sorghum, cowpea, wheat, pigeon pea, potato, tea, millet, coffee, other pulses and oilseeds, among others. Kenya's per capita maize consumption is estimated at 103 kg/person/year, compared to 73 kg for Tanzania, 52 kg for Ethiopia, and 31 kg for Uganda. In spite of its huge importance for food security and economic wellbeing of the country, the productivity and production have not shown significant improvements over the years. The current yield is estimated at 1622 kg/ha, with average production of nearly 3.5 million tons. Increases in maize production in Kenya resulted from area expansion rather than from increases in productivity.

Traditional farming practices are no longer capable of meeting Kenya's maize production requirements, consequently, widespread application of scientific methods is essential. Foremost, the farming community mush know the potential of the land under cultivation and the essential crop husbandry measures necessary to achieve the maximum possible maize yields without compromising the land's productive sustainability. Successful maize production depends on the correct application of production inputs that will sustain the environment as well as agricultural production and if the efficacy trial conducted by KEPHIS on this product deem successful the product will serve as one solution to the production of cereals in the country.

1.2. Product Background and Mode of Action

Microfertile® plant is an organic liquid biostimulant containing dissolved silicified rock rich in all microelements, Chlorella microalgae, and other types of plant growth promoting bacteria such as Thiobacillus and their valuable metabolites (oxaloacetic acid, pyruvic acid, and antifreeze proteins) with a pH value of 7-8. It is particularly suitable for the formation of green matter and increases resistance to cold and frost. In summary, it has the following benefits;

- Increase availability of nutrients to plants and improved germination.
- Increased nutrient and chlorophyll content.
- Increased yield and green biomass.
- Improved plant development and growth.
- Improved plant strength.
- It is particularly suitable for the formation of green matter and increases the plant's resistance to abiotic stress.

Composition

Dry Matter	0,224%
Nitrogen	0.052%
Potassium as K_2O	0.033%
Alkaline Compnents	0.54 %%
Probiotic bacteria.	$10x10^{10}$ CFU/g

1.3. Objective

i. To determine the efficacy of Microfertile Plant on the growth, yield and quality of maize.
ii. To evaluate the minimum most effective rate of Microfertile Plant on the growth, yield and quality of maize.
iii. To determine the phytotoxicity ofMicrofertile Plant on maize.

MATERIALS AND METHODS

2.1. Study sites

Trials were conducted at the Tulip Agriconsult trial fields in Kithini-Machakos County, Ngata-Nakuru County, Karii-Kirinyaga County and Makutano-Murang'a County. It was applied 1 cropping season for maize variety Haraka WH 101 from Western Seed Company which was cultivated in open field and irrigated by drip system.

2.2. Treatments

The treatments outlined in table 1 were compared in this experiment.

Table 1: Experimental treatments

	Treatment	Product rate per acre	Product rate per L of water
1	Untreated control	-	-
2	Microfertile Plant	3.0 L	30 ml
3	Microfertile Plant	4.0 L	40 ml
4	Microfertile Plant	5.0 L	50 ml
5	Macarena	0.25 L	10 ml

2.3. Experimental Design

This evaluation was conducted in open field grown maize variety Haraka WH 101 from Western Seed Company, Kenya. The experiments were laid out in a Randomized Complete Block Design (RCBD), and treatments replicated 3 times (Figure 1). Experimental plots measured 4m by 3m = 12 m^2 each and the spacing between plots was 1.0 m and 1.0 m between replicates. In total, 15 experimental plots of each crop were raised as per the guidelines in table 2. The rest of the cultural practices were done as per the standard operating practice of the specific crop (*Ceretis paribus*).

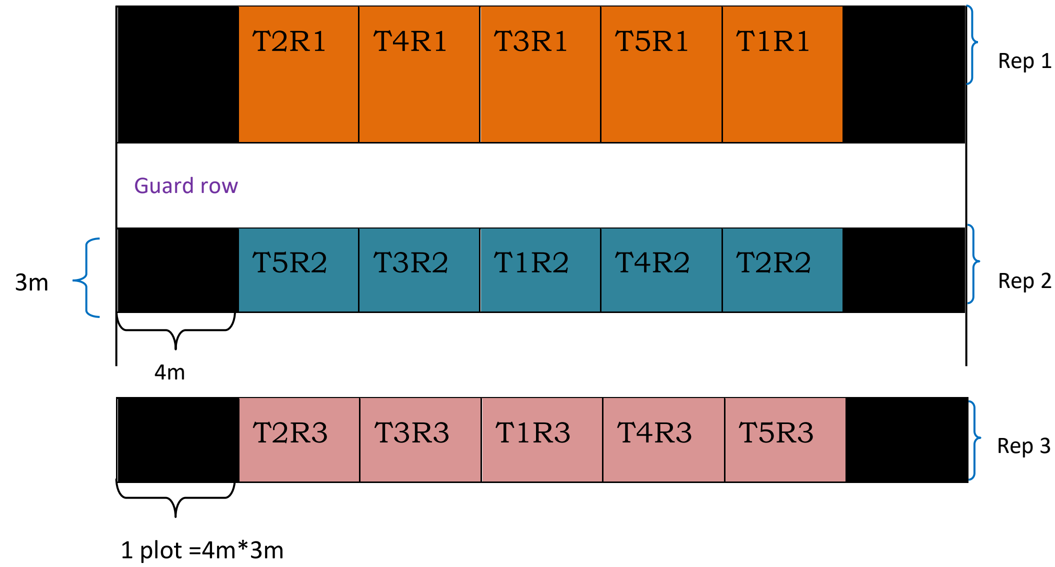

Figure 1. Trial field layout, measurements are in meters

Crop	Plant spacing	Plant population/m^2	Total plant population per plot
Maize	**75cm*25cm**	**6 plants**	**64 plants**

2.4 Sampling plants

After establishment of the desired plants to the treatment plots, ten (10) sampling plants were selected in the net area (6m^2) each plot by randomisation. The sampling plants were tagged for the purpose of assessments of target parameters. The outer 0.5 m^2 on either sides of each plot served as buffer zones between treated plots.

2.5 Treatment Application

Treatments were applied as foliar by spraying using a knapsack sprayer fitted with a hollow cone nozzle. Measuring cylinders were used to achieve accurate measure of the liquid biostimulants. Spray volume of 250 litres per hectare was used to achieve spray coverage of 95-100%. A polythene barrier was used to prevent drift within adjacent plots during treatment application. Conventional fertilizers were applied according to recommended/standard application practices i.e. NPK 23:23 at 5g/plant at planting and as CAN at 5g/plant as a top dress in split top-dress application with Ammonium Sulphate at tasselling at the rate of 5g per plant. The application of fertilizers was considered the positive untreated control while on all the MICROFERTILE

PLANT treatments the fertilizers were applied as follows 75 kg/acre of NPK 23:23:0; 75kg/acre of CAN in two-splits and no Ammonium Sulphate at tasselling as done on the conventional practice treatments where 100 kg/acre of NPK 23:23:0, CAN and AS was applied at planting, top-dressing and at tasselling respectively.

2.6 Number of Applications

Foliar application of Microfertile Plant was done at 3 weeks after planting and other two applications were done at 21-day intervals or as per manufacturer recommendation. **NB:** Conventional fertilizers was applied according to standard application practices for the crop and Reference product applied once at planting.

2.7 Assessment of phytotoxicity

Assessment of phytotoxicity due to Microfertile Plant application was done by checking crops reactions associated with phytotoxicity such as withering, deformation, chlorosis, drying, and bleaching appearances in all treatments. Phytotoxicity was assessed weekly after each treatment application alongside the targeted assessments. The intensity of such reaction on the crop was scored on a scale of 0-5 (Table 2).

Table 2: Severity score of phytotoxicity

Rating	Incidence of affected plants
None	No plants affected
Slight	< 9% of plants affected
Medium	10 – 29% of plants affected
Strong	> 30% of plants affected

ASSESSMENT AND DATA COLLECTION

3.1 Data collection

Five plants for Maize were sampled and tagged per plot for data collection. The following data on growth and yield of the crop were collected.

Crop	Parameter	Frequency	Duration
Maize	1. Stand Count 2. Plant height (cm) 3. Root zone diameter (cm) 4. Cob length (cm) 5. Number of grains per cob 6. Cob weight (g) 7. Days to anthesis, tasselling and maturity 8. Grain yield 9. 1000-grain mass	At vegetative stage At flowering At harvesting	Crop Cycle

	10. Soil change characteristics at the end of trial compared to before start of trial		

3.2 Harvesting

Harvesting of the experimental crops was done as provided in the guidelines in table below.

Crop	Harvesting stage	Grading
Maize	Mature cobs when 75% of the leaves and cobs have turned brown and fallen over for grain yield and green maize when the silk begins to dry up and the kernel feel stiff, the ear is ripe.	Marketable and unmarketable

Yield will be translated into tons/ha and tabulated to obtain mean yield per treatment

3.3 Statistical Analysis

Data obtained were subjected to analysis of variance using GenStat (Payne *et al.,* 2004). Means were separated using Duncan's Multiple Range Test at the $p<0.05$ (Mead *et. al.,* 2003)

Treatment combinations on each unit of the design

Block	1	2	3
Plots			
1	2	5	2
2	4	3	3
3	3	1	1
4	5	4	4
5	1	2	5

Treatment factors are listed in the order: Treat1.

3.4 Meteorological Data

The meteorological data during the trial periods were collected and presented.

RESULTS AND DISCUSSION

Assessment Schedule

Assessment is being done on growth and later on yield and quality parameters of maize and assessment and applications of treatments were done as shown below.

Table 3. Activity, treatment application and assessment schedule

Application Date	Date of Assessment	DAST	Activity
05.05.2024	05.05.2024	N/A	Land Preparation
08.05.2024	08.05.2024	N/A	Harrowing
12.05.2024	12.05.2024	N/A	Demarcation of plots
13.05.2024	13.05.2024	N/A	Planting
13.05.2024	13.05.2024	Baseline	Reference Treatment Application
03.06.2024	03.06.2024	21 DAST	First Treatment Application, Pesticide Spray, Data Collection
24.06.2024	24.06.2024	42 DAST	Second Treatment Application, First Split-Top-dress Application, Pesticide Spray, Data Collection
15.07.2024	15.07.2024	63 DAST	Third/Last Treatment Application, Second Split-Top-dress Application, Pesticide Spray, Data Collection
	18.07.2024	N/A	Data Collection
	26.08.2024	NA	Final Harvesting and Data Collection

Effect of treatments on the growth parameters of maize

There were significant differences between the growth and quality parameters of maize due to treatment application in Nakuru (Table 4). In the treatments where MICROFERTILE PLANT was applied there was significant increase on stand count which was higher but significantly comparable to the reference product while the lowest was recorded under the untreated control. Also, the quality parameters of maize viz the ear length were significantly increased on the MICROFERTILE PLANT treatments where the longest were under the highest rate. Increased growth parameters with the application of MICROFERTILE PLANT at different concentration might be due to improvement in the physiological functions, structural function and stimulation of plant vigour as the active ingredients are strong promoters of shoot and root growth by stimulating the cell division and differentiation. Besides, applied biostimulants have also provided some essential nutrient elements which are absorbed through leaves.

Table 4: Influence of treatments on the stand count, days to maturity and the ear length of maize in Nakuru

Treatment	Stand Count (%)	Days to Maturity	Ear Length (cm)
Control	83 b	99 b	10.0 c
Microfertile Plant 3l/acre	90 a	101 b	13.3 ab
Microfertile Plant 4l/acre	92 a	102 ab	13.7 a
Microfertile Plant 5l/acre	92 a	101 ab	14.6 a
Macarena	87 ab	103 a	12.0 b
P-Value	**0.026**	**0.038**	**0.001**
LSD	**5.798**	**2.503**	**1.556**

Treatments with the same letter along the columns are not significantly different according to DMRT at P≤0.05.

In Kirinyaga, it was observed that MICROFERTILE PLANT application significantly increased the establishment of the crop stand to harvesting with 100% observed on the two higher rates and 99% on the 3L application of MICROFERTILE PLANT (Table 5). The ear length was increased significantly with the application of the three rates of MICROFERTILE PLANT organic biostimulant and had longer cobs compared to the untreated control and also the reference product. Gao et al. (2020) emphasised that the interaction between different biostimulants increase soil nutrient content and their availability to plants.

Table 5: Influence of treatments on the stand count, days to maturity and the ear length of maize in Kirinyaga

Treatment	Stand Count (%)	Days to Maturity	Ear Length (cm)
Control	94 b	97 b	10.8 c
Microfertile Plant 3l/acre	99 a	99 b	15.0 a
Microfertile Plant 4l/acre	100 a	100 ab	14.3 a
Microfertile Plant 5l/acre	100 a	99 b	15.7 a
Macarena	99 a	102 a	13.0 b
P-Value	**0.058**	**0.042**	**0.006**
LSD	**3.694**	**3.197**	**2.119**

Treatments with the same letter along the columns are not significantly different according to DMRT at P≤0.05.

Significant differences (P≤0.05) were observed in Machakos on the MICROFERTILE PLANT trial where the test treatments were applied and were comparable to the reference product in increasing the growth parameters i.e. the stand establishment with over 95% at harvesting (Table 6). The application of MICROFERTILE PLANT at the three rates also significantly increased the cob size and were averagely longer than that of the reference product and with over 4 cm longer than the untreated control probably because of the nutritional composition compared to single application of fertilizers alone that were added to the soil. The positive influence compared to the untreated control shows the efficacy of MICROFERTILE PLANT and if used judiciously with the other nutritional soil supplements there would be greater fertility and nutritional improvement for the plants and the soil notwithstanding.

Table 6: Effect of test treatments on stand count, days to maturity and the ear length of maize in Machakos

Treatment	Stand Count (%)	Days to Maturity	Ear Length (cm)
Control	89 b	92 c	7.3 c
Microfertile Plant 3l/acre	95 a	95 b	10.7 ab
Microfertile Plant 4l/acre	98 a	97 ab	11.0 a
Microfertile Plant 5l/acre	97 a	96 ab	11.0 a
Macarena	94 ab	98 a	9.0 b
P-Value	**0.03**	**0.014**	**0.008**
LSD	**5.219**	**2.479**	**1.898**

Treatments with the same letter along the columns are not significantly different according to DMRT at P≤0.05.

In Murang'a, there were great and significant increases on the growth and quality of maize due to application of MICROFERTILE PLANT compared to the untreated control (Table 7). A 2-4cm increase was recorded on the ear length of maize through application of the three rates of MICROFEERTILE PLANT which majorly facilitated by increased uptake through the biostimulant application which is supported by Yakhinet al. (2017; Abbott et al. (2018); Jiménez-Arias et al. (2022) as an additional nutrient input (Ördög et al. 2021). Plant biostimulants are designated as metabolic enhancers, plant strengtheners, biofertilizers, plant probiotics and biostimulants-tors (Sible et al. 2021) and modify plant physiological processes in a way that provides benefits for growth or development, or stress response upon their application.

Table 7: Influence of treatments stand count, days to maturity and the ear length of maize in Murang'a

Treatment	Stand Count (%)	Days to Maturity	Ear Length (cm)
Control	85 b	104 b	8.0 c
Microfertile Plant 3l/acre	95 a	106 ab	10.7 ab
Microfertile Plant 4l/acre	95 a	106 ab	12.3 a
Microfertile Plant 5l/acre	98 a	106 ab	12.0 a
Macarena	92 a	108 a	10.3 b
P-Value	**0.011**	**0.015**	**0.003**
LSD	**6.111**	**2.048**	**1.612**

Treatments with the same letter along the columns are not significantly different according to DMRT at P≤0.05.

Effect of treatments on yield parameters of maize

Treatments differed significantly (P≤0.05) on the grain yield after three consecutive applications of treatments in Nakuru (Table 8). Application of the three levels of MICROFERTILE PLANT were as effective as the reference product while application of the highest rate of MICROFERTILE PLANT had significantly the highest grain yield. This was so because MICROFERTILE PLANT only enhances the effectiveness and efficiency of the applied nutritional supplements. Overall, other studies show that application of biostimulants improve uptake of nutrient plants (Tejada et al. 2016, Gao et al. 2020; Ördög et al. 2021; Al-Temimi and Al-Hilfy 2022) which improves the quality attributes of maize grain. The nutrients such as nitrogen and magnesium contribute to the improvement of amino acids, starch and protein content in maize grains.

Table 8: Influence of treatments on the grain yield of maize in Nakuru

Treatment	Grain Yield (tons/ha)	Percent yield increase per treatment compared to the untreated control
Control	5.15 d	
Microfertile Plant 3l/acre	6.14 b	19%
Microfertile Plant 4l/acre	6.66 ab	29%
Microfertile Plant 5l/acre	7.04 a	37%
Macarena	5.76 c	12%
P-Value	**<.001**	
LSD	**0.5727**	

Treatments with the same letter along the columns are not significantly different according to DMRT at P≤0.05.

Application of MICROFERTILE PLANT increased the grain yield of maize in Kirinyaga significantly due to the improvement of uptake of nutrients and proper mobilization (Table 9). The application of MICROFERTILE PLANT at the rates of 3, 4 and 5 l/acre significantly increased the marketable grain yield of maize by 23%, 27% and 27% respectively compared to the untreated control, which was majorly attributed to effectiveness of the actives in the biostimulant on the soil and plant. This was comparable to the reference product which had 17% yield increase compared to the untreated control.

Table 9: Treatment effect on the grain yield of maize in Kirinyaga in the MICROFERTILE PLANT efficacy trial

Treatment	Grain Yield (tons/ha)	Percent yield increase per treatment compared to the untreated control
Control	5.53 b	
Microfertile Plant 3l/acre	6.78 a	23%
Microfertile Plant 4l/acre	7.00 a	27%
Microfertile Plant 5l/acre	7.01 a	27%
Macarena	6.48 ab	17%
P-Value	**0.039**	
LSD	**0.969**	

Treatments with the same letter along the columns are not significantly different according to DMRT at P≤0.05.

The yield components in Machakos showed a decrease compared to the other sites but there were significant differences between the treatments with the same trend as other sites recorded with addition of MICROFERTILE PLANT organic biostimulant (Table 10). The highest yield increase was recorded on the highest rate of the test product with 48% compared to the untreated control.

Table 10: Mean marketable grain yield as influenced by treatments application in Machakos

Treatment	Grain Yield (tons/ha)	Percent yield increase per treatment compared to the untreated control
Control	3.09 c	
Microfertile Plant 3l/acre	3.97 b	28%
Microfertile Plant 4l/acre	4.13 ab	34%
Microfertile Plant 5l/acre	4.56 a	48%
Macarena	3.66 b	18%
P-Value	**<.001**	
LSD	**0.5175**	

Treatments with the same letter along the columns are not significantly different according to DMRT at P≤0.05. RFP-Recommended Fertilizer Program

Significant differences were observed in Murang'a after application of treatments on the mean grain yield (Table 11). The application of MICROFERTILE PLANT at the rates of 3, 4 and 5 l/acre significantly increased the marketable grain yield of maize by 28%, 39% and 43% respectively compared to the untreated control, which was majorly attributed to effectiveness of the actives in the biostimulant on the soil and plant. This was comparable to the reference product which had 27% yield increase compared to the untreated control.

Table 11: Mean marketable grain yield as influenced by treatments application in Murang'a

Treatment	Grain Yield (tons/ha)	Percent yield increase per treatment compared to the untreated control
Control	4.39 c	
Microfertile Plant 3l/acre	5.64 b	28%
Microfertile Plant 4l/acre	6.09 ab	39%
Microfertile Plant 5l/acre	6.29 a	43%
Macarena	5.58 b	27%
P-Value	**<.001**	
LSD	**0.5002**	

Treatments with the same letter along the columns are not significantly different according to DMRT at P≤0.05. RFP-Recommended Fertilizer Program

CONCLUSION

Application of MICROFERTILE PLANT at the rate of 5L in significantly increased the growth, quality and yield components of maize across the four sites in Kenya. The highest rate of the test product had the highest significant influence on most of the parameters and was consistent across the four sites.

RECOMMENDATION

In view of the consistent results recorded from the four sites, we recommend that MICROFERTILE PLANT be registered in Kenya for cereals at the rate of 5L per acre or 100 ml per 20-l knapsack sprayer. It should be applied as a foliar at 21-day intervals with a maximum of three applications during the crop cycle starting at early vegetative stage.

Plate 1. Planting of maize seeds (Haraka WH 01 variety) at the Tulip Agriconsult trial site at Makutano in Murang'a County under the Microfertile Plant KEPHIS trial in May 2024

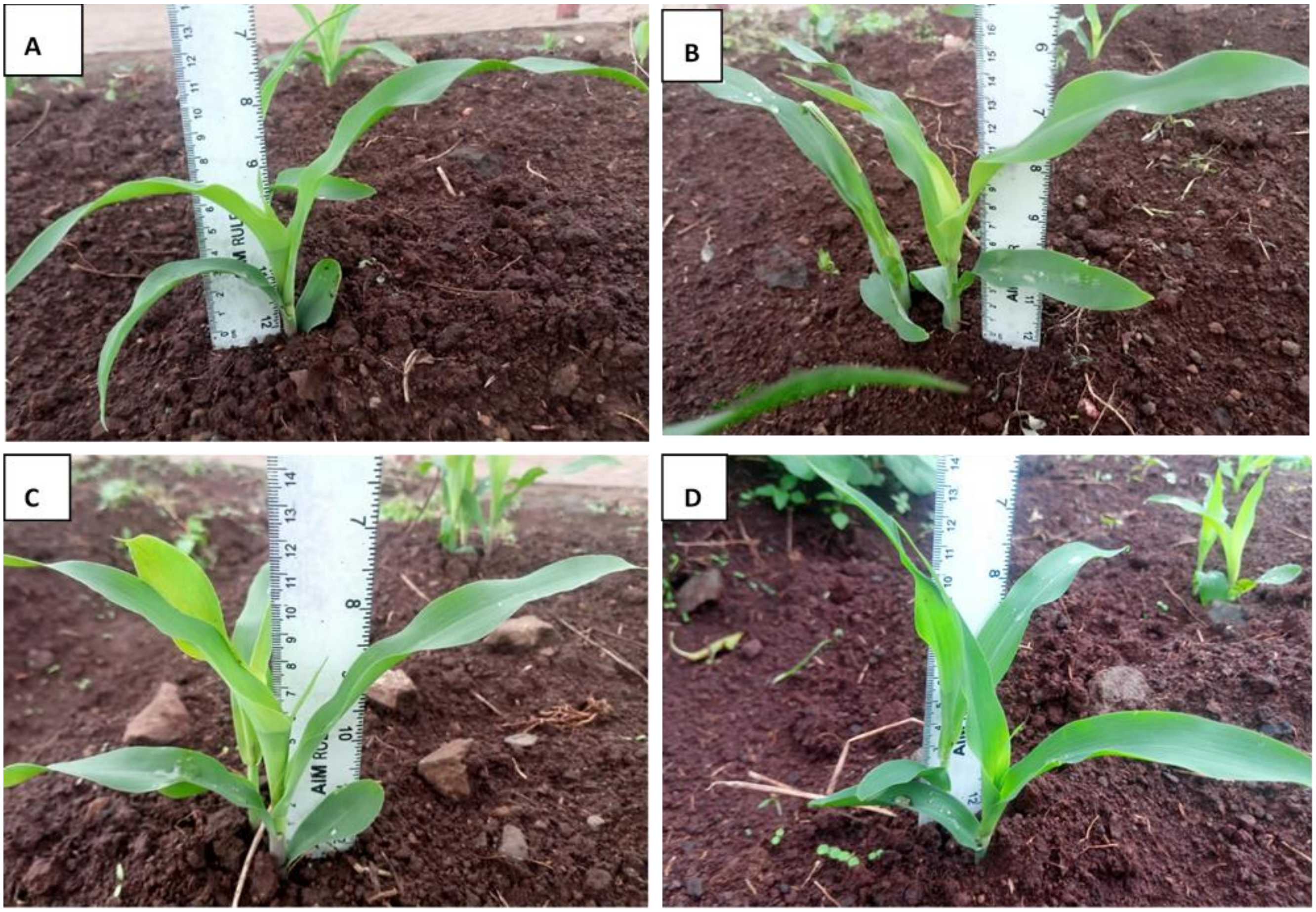

Plate 2. Untreated Control plot (A), Microfertile Plant Low Rate plot (B), Microfertile Plant Medium Rate plot (C) and Microfertile Plant High Rate plot (D) at the Tulip Agriconsult trial site at Karii in Kirinyaga County exhibiting no differences on V5 maize before treatment application

Plate 3. First application of Microfertile Plant already showing positive response on the left compared to untreated control on the right

Plate 4. The root biomass of maize as influenced by different treatments at Ngata in Kenya as follows; the Untreated Control (left), medium rate of Microfertile Plant (middle) and high rate of Microfertile Plant (right).

Plate 5. Side-by-side root biomass orientation of different treatments viz Untreated Control (left), medium rate of Microfertile Plant (middle) and high rate of Microfertile Plant (right) at Ngata-Nakuru in Kenya.

Plate 6. The cob development phase of maize in Kirinyaga, Kenya exhibiting the influence of the three rates of Microfertile Plant from the lowest (left), medium (middle) and highest (right).

Plate 7. Maize cob filling under the three rates of Microfertile Plant; low (left), medium (middle) & high (right).

Plate 8. Harvested cobs with the Untreated Control (left) and Microfertile high rate (right) in Kirinyaga County during the long rains season on the Microfertile Plant Trial, 2024 in Kenya

Plate 9. Microfertile Plant high rate cob (top) compared to the Untreated Control cob (below)

APPENDICES

Appendix 1: Cultural Practices and Trial Plan for maize

Product	Microfertile Plant		
Trial Crop	Maize "*Haraka WH 01*"		
Target parameters	Stand count %, Plant height (cm), Root zone diameter (cm), Days to tasseling, anthesis and maturity, Complete cobs per plant, Ear length, Number of grains per cob, Grain yield (tons/ha), 1000-Seed mass, Soil change characteristics		
No. of trial seasons	1 Season		
Trial site	Ngata-Nakuru County, Karii-Kirinyaga County, Makutano-Murang'a County and Kithini-Machakos County		
Crop Seasons	**Site**	**Start**	**Completion**
	Kithini	**05.05.2024**	**20.08.2024**
	Waruhiu	**05.05.2024**	**23.08.2024**
	Karii	**05.05.2024**	**24.08.2024**
	Makutano	**05.05.2024**	**26.08.2024**
Soil type	Alluvial sand		
Fertilizer use	Planting: NPK (23:23:0) @125kg/ha Vegetative stage: CAN (26%N) @125kg/ha Tasseling: AS (21%N; 24%S) @100kg/ha		
Suggested Insecticide and Fungicide use	**Non-Target Pesticide**	**AI**	**Target pest/ disease**
	Actara 25WDG	Thiamethoxam 250g/kg	Cutworms
	Protap 500 WP	Monosultap 400g/kg+Buprofezin 100g/kg	Aphids and Thrips
	Coragen 20 SC	Chlorantraniliprole 200g/L	FAW/Caterpillars
	Occasion Star 200 SC	Emmactin Benzoate 40g/l+Indoxacarb 160g/l	FAW
Watering	**Drip irrigation**	Planting – 2 weeks = 20m^3/ha 3 – 4 weeks = 30 m^3/ha	

Appendix 2: Monthly weather data during the trial period in Karii-Kirinyaga

Date	Max. Temp ^{0}C	Min. Temp ^{0}C	Rainfall (mm)
20.05.2024	30.3	13.5	68
20.06.2024	30	13.3	55
20.07.2024	30	13.3	38
20.08.2024	29	12.3	18

Source of Data: Tulip weather station

Appendix 3: Monthly weather data during the trial period in Ngata-Nakuru

Date	Max. Temp ^{0}C	Min. Temp ^{0}C	Rainfall (mm)
20.05.2024	20.8	9.9	74
20.06.2024	20.5	9.2	44
20.07.2024	19.8	10.5	25
20.08.2024	19.7	8.2	32

Source of Data: Tulip weather station

Appendix 4: Monthly weather data during the trial period in Kithini-Machakos

Date	Max. Temp ^{0}C	Min. Temp ^{0}C	Rainfall (mm)
20.05.2024	27.9	17.3	23
20.06.2024	25.6	14.4	2
20.07.2024	24.5	14.9	0
20.08.2024	26.6	15.4	3

Source of Data: Tulip weather station

Appendix 5: Weather data during the trial period in Maragua-Murang'a

Date	Max. Temp ^{0}C	Min. Temp ^{0}C	Rainfall (mm)
20.05.2024	21.8	8.2	81
20.06.2024	21.3	7.1	66
20.07.2024	27.8	12.8	8
20.08.2024	21.3	7.1	66

Source of Data: Tulip weather station