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Effect of Tokyo8 on soil Fertility Improvement and Maize Grain Yield Production

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Abstract

Evaluation of Tokyo8 bio-fertilizers regarding their effects on soil fertility and maize grain yield production were evaluated at Chitedze, Lunyangwa and Bvumbwe during 2023/24 season. Field trials were conducted with 9 treatments laid out in RCBD with replicates. Each treatment had a plot size of 5m by 6 ridges spaced at 0.75m. One maize seed was planted per station spaced at 25cm. Generally, the results indicated significant maize grain yield differences (P<0.001) among the fertilizer treatments. The highest maize grain yields of 5112, 4481, and 5404 kg/ha were obtained at Chitedze, Lunyangwa and Bvumbwe respectively when a combined fertilizer treatment of Tokyo8 plus chemical fertilizer was applied. While the lowest mean grain yield across three sites was 1001kg/ha obtained when no fertiliser was applied. The mean grain yields (4231kg/ha) obtained in the treatment where a combined application of half rate of chemical fertilizer plus Tokyo8 biofertilizer was also same as the grain yield (4116 kg/ha) obtained when full rate of chemical fertiliser was applied. The use of Tokyo biofertiliser reduced use of chemical by half to obtain same maize grain yield. There was over 15 to 200% maize grain yield increase over the zero control with application of Tokyo8 bio-fertilizer at the three trial sites.

1.0 Introduction

Soil ecosystem possesses rich diversity than any other ecosystem with complex interactions between living and non-living entities. These living forms habituated in soil are crucial for supporting qualitative plant growth (Uppal et al., 2017). Numerous microbial communities in soil show synergistic and antagonistic interactions among themselves, resulting in benefit and harm to either or both the associated members. The association holds accountability for nutrients recycling and energy drift, resulting in the availability of macronutrients unavailable and insoluble forms of rhizospheric nutrients, crucial for vital processes in plants, e.g., act as co-factors of various phyto-enzyme and redox mediators. These microbes have various functions in the soil ecosystem. Figure 1 and 2 summaries some of the role microbes play in relation to plant growth. Plant growth promoting rhizobacteria (PGPR) are known to enhance plant growth by increasing these macronutrients availability during their plant root colonization. In comparison to any other genera, Pseudomonas is the most favored bioinoculant due to its significant properties in both plant growth and phytopathogen control during its synergistic association with the host plant. These properties include siderophore production, phosphate solubilization, nitrogen fixation, phenazines, antibiotics, and induced systemic resistance carried out by various Pseudomonas species like Pseudomonas fluorescens, Pseudomonas putida, and Pseudomonas syringae. The association of Pseudomonas with crop plants procures several secretory and electron-based feedback mechanisms in order to regulate the plant growth and phytopathogen control activities through the secretion of several phytohormones (auxins, gibberellins, Indole-3-acetic acid), secondary metabolites (flavonoids) and enzymes (aminocyclopropane-1-carboxylate, phenylalanine ammonia-lyase). Ecologically significant applications of Pseudomonas in biocontrol and bioaugmentation are crucial for maintaining food security (Sah et al., 2021). Consequently, plants get their nourishment by absorbing nutrients from various sources such as (i) decayed plants and animals composed of organic matter; (ii) soil that occurs as silt, sand, and clay of different particle sizes and water holding capacities.

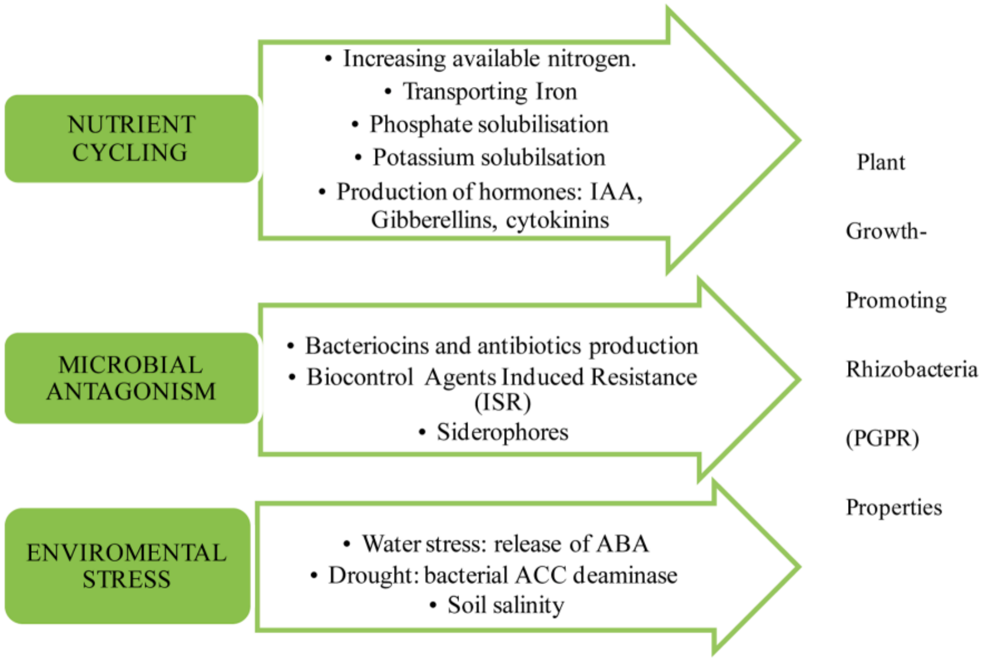

Fig. 1. Plant Growth Promoting Properties of Pseudomonas through nutrient cycling, microbial antagonism, and environmental stress.

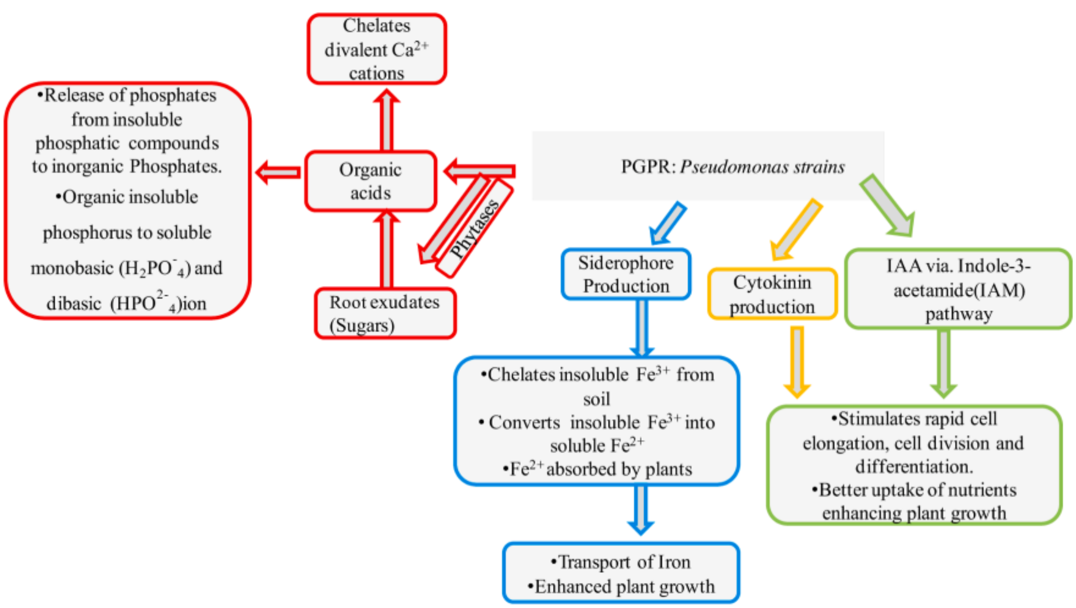

Fig. 2. Plant Growth Promoting Properties of Pseudomonas in solubilizing nutrients and releasing plant growth regulators.

However, for the past decades, utilization of chemical fertilizers and insecticides coupled with poor soil health management practices throughout the years had shown adverse effect on soil quality, fertility and ecology (Garrido-Sanz et al., 2017). There has been an imbalance in the sustainable soil health maintenance and crop production. Practices such as burning of crop residues, crop residue transfer and other several competitive agricultural practices like overgrazing and traditional tilling are responsible for the deterioration of cultivable topsoil.

In Malawi soil microbial populations are becoming limited. This is so because in Malawi most of the soils are highly weathered, infertile, and low in soil organic matter (OM) and soil nutrients. The main reason is because of the continuous cultivation of crops and burning of crop residues on the same piece of land with little inputs added leading to severe nutrient mining. Maida and Chilima (1976) reported that continuous cultivation without inorganic fertilizer and manure application resulted in a marked decrease in total organic matter, nitrogen (N) and exchangeable potassium (K), magnesium (Mg) and calcium (Ca). Soil fertility decline among smallholder farmers is the major factor responsible for the food insecurity in the country (Chilimba et al, 2007). Soil productivity can be improved and maintained through use of organic and inorganic fertilizers. This is in-line with Malawi Fertiliser Policy and Soil Health and Fertiliozer Strategy for Malawi. In view of this, the use of chemical fertilizers has been advocated for many years to replace the depleted nutrients. However, most smallholder farmers are unable to access inorganic fertilizers due to the high cost. Carr (1997) reported that the use of fertilizer by farmers has declined to almost 40% due to increased fertilizer prices. Recently, fertilizer prices have tripled since early 2020 and remain volatile, putting a stable supply of fertilizer out of reach of many small farmer (Malpass D., 2022). The high cost of fertilizers negatively affects farmer margins, undermine production, contribute to high food prices, and exacerbate food insecurity. It is estimated that an average African farmer pays for potassium fertiliser nearly twice as much as their counterparts in Europe and America (Chiwona, 2020; Chiwona et al., 2020).

So as to combat this situation, various biotechnological methods manage the fusion of conventional organic harvest techniques to chief elements required for promoting rhizobial competency. The isolation of specific beneficial microbes and their formulation into biofertilisers has helped to effectively benefit in optimization of soil health productivity and crop production. Plant promotional rhizobial modification methods (like sustainable, active rhizobia and self-regulation) are called biocontrol, bioaugmentation, and biostimulation (Bhadauria et al., 2010). The additional microbial strains present in the rhizobial regions may interact positively or negatively with local microbes to raise active metabolism and colonization by decreasing various microbial infections caused by parasites (Garcia-Seco et al., 2013). Approximately 1 billion species of bacteria exist on Earth. Out of them, 5000 species identified yet (Sah and Singh, 2016). Moreover, surface soil microbes present on the Earth consider around 10 billion microbes per gram. One gram of that soil contains approximately 4000 distinct bacterial genomes. These units estimate an enormous mass diversity significance while showing the progressive competition in the rhizospheric complement (Sah and Singh, 2016). The total percentage value of the microbes present in the soil constituents is Alteromonadales, and Legionellale (Chu et al., 2019). Several strains of Pseudomonas veronii abundantly found, approx 38%, with a proportion of all bacterial communities present in the rhizosphere (Qessaoui et al., 2019).

In order to restore soil health and improve sustainable crop yield production, various bio fertilisers have been globally in USA, China, India, Europe, Japan and etc. developed and tested and proved to improve soil health and sustainable crop yield production. Research studies on use of inoculants or bio-fertilisers in combination with organic or inorganic have shown significant positive changes in soil health and crop yield production. In other evaluation studies, on bio-fertilisers have chown that a combination of Mycorrhiza fungi and phosphate solubilising bacteria had effects on maize agronomic traits and improved water stress tolerance (Table 1). Similar results were obtained by Ehteshami et al. (2009) who reported that Mycorrhiza fungies and phosphate-solubilising bacteria increased traits.

Table 1. Means comparison of measured traits of corn under different fertilizer treatments and drought stress conditions using Duncan's multiple range test.

	Row No./ Ear	Kernel No./ Row	300 Kernel Weight (gr)	Ear Length (cm)	Total Yield (ton/ha)	Percent colonization (%)	Harvest index (%)
Irrigation							
Normal irrigation	14.456a	49.22a	78.004a	21.222a	12.087a	45.47a	52.42a
Low drought stress	14.26a	45.82a	70.712a	19.807a	9.9712b	43.03b	45.37b
Severe drought stress	12.444a	25.479b	52.089b	14.41b	3.5507c	32.75c	28.20c
Fertilizer							
b1	14.445a	42.95ab	69.858ab	18.9263ab	9.3667b	57.93a	45.68a
b2	14.6303a	45.25a	72.44a	20.2215a	10.352a	23.39b	46.72a
b3	13.746a	39.39b	65.239bc	18.121bc	7.815c	27.07d	38.08b
b4	13.574a	39.013b	65.644bc	18.3509b	8.7463b	47.07c	43.44a
b5	12.21b	34.27c	61.487c	16.7778c	6.4014d	16.63e	36.07b

Other results on composting using inoculums have led to production of high compost quality in accordance with SNI 19-7030-2004 standards (Table 2). This was due to the added microbes that were effective in converting C-organic from raw materials and the high degradation activity of inoculants. Trichoderma, one of the microbial inoculants, could stabilize the C/N ratio, increased nitrogen (N), phosphorus (P), and potassium (K) in compost (Siddiquee et al., 2013).

Table 2. Weight of final compost product (Source: Simarmata et al., 2021)

No	Treatment	Weight of raw material (kg)	Weight of compost product (kg)*)	Yield (%)*)
1	J1 (Pro)	60	44.1 ± 3.15	73.5 ± 5.25
2	J2 (PSM)	60	32 ± 3.6	53.3 ± 6
3	D1 (Pro)	100	78 ± 2.78	78 ± 2.78
4	D2 (PSM)	100	63 ± 3	63 ± 3
5	R1 (Pro)	100	30 ± 2.64	30 ± 2.65
6	R2 (PSM)	100	31 ± 2.29	31 ± 2.29

Note: J1=Compost product from raw material of straw with Pro inoculum, J2= Straw with PSM inoculum, D1= Leaves with Pro inoculum, D2= Leaves with PSM inoculum, R1= Grass with Pro inoculum, R2= Grass with PSM inoculum. Pro = commercial inoculum, PSM = Plant Symbiotic Microbes-inoculum, *) values are expressed as mean ± SD (n=3).

In some studies of biofertilisers that use Pseudomonas species isolated from environmental matrices have shown to degrade polyethylene, polypropylene, polyvinyl chloride, polystyrene, polyurethane, polyethylene terephthalate, polyethylene succinate, polyethylene glycol and polyvinyl alcohol at varying degrees of efficiency (Wilkes and Aristilde, 2017).

In Japan they developed green eco-friendly biofertiliser called microbial bio-fertilizers manufactured by Tokyo8 a company based in Japan. The bio-fertilizers is claimed to restore soil health and rejuvenate its soil productivity and have many advantages that includes significantly improving crop yield production. The bio-fertilizers are beneficial to the soil and plants. They are able to soften and aerate hard pan soils and make them crumble and increase nutrient availability to the plants. They are able to accelerate plant growth, strengthen plant immune system, greatly increase pest resistance and crops are protected from plant diseases. Tokyo8 is claimed to remove about 20% of harmful insects in the ground through breaking of the lifecycle. Farmers can reduce by at least 30% the amount of fertilizer use when Tokyo8 is combined with organic manure. The product can increase the crop yield in the range of 15%-30%-begin with compared to chemicals and the increase can go up much higher depending on the situation. The test results of bio-fertilizers by farmers and research institutes in different crops have shown to improve soil fertility and increase crop yields. The fertilizer has been tested with crops, such as rice, maize, beans and various vegetables, such as carrots. The product has been tested and used in countries that include Japan, Thailand and Tanzania. In all the tested countries the crop yields increased from over 20%-50% depending on the crop and country.

Although literature review has demonstrated that bio-fertilizers are promising in improvement of soil productivity and crop production, their field evaluation has not been done in Malawi. At the same time farmers are using these bio-chemical fertilizers in maize production without adequate information such as optimal application rates and their effects on soil fertility. There is no scientific, Malawi field data about the Tokyo8 bio-fertilizers on their performance on soil fertility improvement and crop responses on yield production. Therefore, the purpose of this work was to evaluate the effects of Tokyo8 bio-fertilizers on the improvement of soil fertility and maize crop yield production under Malawian field conditions.

2.0 Objectives

- To evaluate the effect of Tokyo8 bio-fertilizers on soil fertility improvement.
- To evaluate the effect of Tokyo8 bio-fertilizers on maize grain yield production.
- To evaluate the profitability analysis of using Tokyo8 in production of maize grain yield.

3.0 Materials and Methods

3.1 Nutrient composition of bio-fertilizer

Laboratory analysis results indicated that Tokyo8 contained beneficial microbes that include Streptomyces, Pseudomonas (table 2). The total plate count is 1.5×10^6 CFU/ml. The analyzed microorganisms exist in the natural environment.

3.2 Evaluation Field Trials of Tokyo8

The evaluation field trials were conducted on station at Chitedze, Bvumbwe and Lunyangwa and on-farm at Chitedze during 2023/24 season. Maize was grown on plot sizes of 5m by 6 ridges spaced at 0.75m. The ridges were 25cms high. The Treatments were laid as RCBD with 4 replicates. The treatments are given in table 1 below:

Table 1: Fertiliser treatments for the field evaluation trials

No	Treatment Description	Amount Applied (Kg/Ha)

		Manure	23:10:5+6S+1Zn	Urea	Total N
1	zero (no fertilizer)	0	0	0	
2	Full Rate chemical fertilizer	0	200	100	110
3	Tokyo8 only	0	0	0	0
4	Tokyo8 + ¼ Chem Fert Rate	0	50	25	27.5
5	Tokyo8 + ½ Chem Fert Rate	0	100	50	55
6	Tokyo8 + Full Chem Fert Rate	0	200	100	110
7	Manure Only	2750	0	0	110
8	Tokyo8 + 1/2Organic Manure	1375	0	0	55
9	Tokyo8 + Organic Manure	2750	0	0	110

3.3 Mixing of Tokyo8 with Chemical Fertilizer
Then Tokyo8 was spread on top of organic manure and the two were evenly mixed. The chemical fertilizer was applied the same day.

3.4 Tracing of Tokyo8 bio-fertilizer microbes in the inoculated soil fields
Soil samples were collected before Tokyo8 application and soon after crop harvesting. Data on microbial populations were also collected. Microbial culturing media such as Xzapex Agar for soil were used for culturing and for the identification of the microbial population in the Tokyo8 and in the inoculated soil samples. The results are not yet included here.

3.5 Data analysis
All crop yield data collected was subjected to statistical analysis at 95% level of confidence by scientific software called GENSTAT.

4.0 Results and Discussions
4.1 Characterization and Analysis of the Tokyo8
The results of microbial laboratory characterization and analysis of Tokyo8 are given in table 2. The results indicate that Tokyo8 contained three different genus of microbes which are important in decomposing and solubilizing plant nutrients. The amounts of colony forming units are within the requirements for bio-fertilisers.

Table 2: characterization and analysis of Tokyo8 (Results analysed by Tanzania Research Institute)

S/N	Parameters Units	Analysis Composition						Method Used
		TEST			Average±Uncertainty	Detection Limit	Limit of Quantification	
		1	2	3				
1	Pseodomonas spp (CFU/mL)	$8.47*10^8$	$8.47*10^8$	$9.47*10^8$	NA	NA	NA	ISO 14046 .2014
2	Streptomyces Sp (CFU/mL)	$5.32*10^2$	$5.44*10^2$	$5.32*10^2$	NA	NA	NA	
3	Saccharomyces Sp (CFU/mL)	$3.13*10^5$	$4.56*10^5$	$3.13*10^5$	NA	NA	NA	
4	As (mg/kg)	0.001649	0.001650	0.001650	0.001649667±5.77E-07	0.001155	0.0035	AOAC 2006.03
5	Cd (mg/kg)	0.00808	0.0081	0.0081	0.008093333± 1.15E-05	0.004708	0.014267	
6	Hg (mg/kg)	0.00385	0.0039	0.0039	0.003883333±2.89E-05	0.024531	0.074337	
7	Se (mg/kg)	0.00239	0.0024	0.0024	0.002396667±5.77E-06	0.00795	0.02409	
8	Pb (mg/kg)	0.002051	0.00211	0.00211	0.002090333±3.41E-5	0.053776	0.162958	
9	Cr (mg/kg)	0.001	0.0013	0.0013	0.0012±0.000173	0.476314	1.443376	

4.2 Field Soil test results

The soil analysis results are given in table 3 for Chitedze, Bvumbwe and Zombwe Research Stations. Generally, the results indicate that the soil texture was sandy clay loam at Chitedze and sandy loam to loamy sand at Bvumbwe and Zombwe. The soil textures were suitable for maize cultivation in the three trials sites. In case of the soil nutrients, generally the results indicate that there was low natural soil fertility in all the 3 trials sites. The results indicate N, P, K were low at all trials sites except for P at Bvumbwe which was medium. In case of Mg and Zn were low at Bvumbwe and Zombwe. These results implied that with the low natural soil fertility at all the 3 sites implied that we would expect positive response of the maize grain yield to the application of Kynopop and conventional urea top dressing fertilizer.

Table 3: Soil data for the field plots at Chitedze, Bvumbwe and Zombwe Research Stations during 2019-20 Season

	Soil properties in the trial sites					
Parameter	**Zombwe**		**Bvumbwe**		**Chitedze**	
Depth (cm)	**0- 20**	**20-40**	**0-20**	**20-40**	**0-20**	**20-40**
% Clay	25	25	6	8	3.14	7.14
% Silt	2	4	14	14	10	10
Tex. Class	SCL	SCL	SL	SL	S	LS
$pH_{(H2O)}$	5.13	5.17	5.63	6.11	6.10	6.45
% OC	0.67	1.41	0.63	0.66	0.60	0.69
%OM	1.15	2.43	1.08	1.13	1.03	1.18
%N	0.06	0.12	0.05	0.06	0.05	0.06
P (ug/g)	6.49	3.28	8	7	24.21	20.60
K (cmol/Kg)	0.12	0.04	0.05	0.03	0.01	0.01
Ca (cmol/Kg)	2.85	2.85	2.93	3.94	0.63	0.77
Mg (cmol/Kg)	1.74	1.64	0.23	0.25	0.01	0.04
Zn (ug/g)	6.99	7.47			0.04	0.03

4.3 Climatic Conditions

The rainfall and temperature data are given in Appendix 2a and Appendix 2b. The information shows that the climatic conditions were favourable for maize crop production. This means the amount of annual rainfall and temperature range was adequate to get optimum maize grain yields and had no negative impact on maize grain yields.

4.4 Visual maize responses to Tokyo8 with organic and chemical fertilisers

The visual results on the effect of Tokyo8 in combination of organic manure and chemical fertiliser on maize grain yields performance at Chitedze are shown in Plate 1.

The visual results show that there were differences in color of the maize plants and cobs sizes. In the control (TRT 1) the maize plants showed yellow colouration while in TRT 2, and TRT 6 the maize were green and big cobs. The green color is an indication that the maize plants had enough N for its growth unlike the control with yellow colour indicated N deficiency. This implies that the Tokyo8 and fertiliser treatments had N which made the plants green.

Plate 1: Visual effects of bio-fertilizers on Maize crop at Chitedze during 2023/2024 season

4.5 Effect of Tokyo8 application on maize plant height during 2023/222024 season

The results of maize plant height response to application of Tokyo8 obtained at Chitedze, Bvumbwe and Zombwe Research Stations are given in table 4. Generally, the results indicate that there were significant differences in maize plant height at $P=0.05$ among the treatments in all the three trial sites. The maize plant height increased with increased application of fertilizers. The lowest maize plant height was obtained in the zero control treatment (no fertilizer application) in all the three sites. The shortest maize plant heights of 150.3, 106.4 and 114.8cm/plant at Chitedze, Zombwe and Bvumbwe respectively. The tallest maize plant height was obtained at all the sites when Tokyo8 plus half chemical fertiliser was applied with plant heights of 206.4, 204.3 cm/plant at Chitedze, Zombwe respectively and 168.8cm/plant when Tokyo8 plus half fertiliser was applied at Bvumbwe. However, the maize plant heights were taller in Tokyo8 treatment plus fertiliser than in Tokyo8 or chemical fertiliser alone except at Bvumbwe. This could be due to increased nutrient use efficiency. The increase was attributed to synergetic effect of applying Tokyo8 plus Urea. There was reduced loss of nutrients and more were available to the maize crops.

Table 4: Effect of Tokyo8 application on maize plant height at Chitedze, Bvumbwe and Zombwe Research Stations during 2023-2024 rain Season

	Plant Height (cm)			
TRT	**Chitedze**	**Zombwe**	**Bvumbwe**	**Means**
zero (no fertilizer)	150.3	106.4	114.8	123.8
Full Rate chemical fertilizer	196.4	191.1	170.8	186.1
Tokyo8 only	169.8	129.1	159.2	152.7
Tokyo8 + ¼ Chem Fert Rate	178.5	164.3	150.2	164.3
Tokyo8 + ½ Chem Fert Rate	190.7	186.3	168.8	181.9
Tokyo8 + Full Chem Fert Rate	206.4	204.3	168.5	193.1
Tokyo8 + 1/2Organic Manure	169.7	164.5	161.7	165.3
Tokyo8 + Organic Manure	188.3	174.5	166.9	176.6
Means	**181.2**	**165.1**	**157.6**	
CV(%)	4.5	8.2	7.9	
F Value	<.001	<0.001	0.001	
LSD0.05	14.21	23.65	21.92	

4.6 Effect of Tokyo8 on maize grain yields under on-station trials

The results of maize grain yield response to application of Tokyo8 for the 3 on-station trial sites, Chitedze, Bvumbwe and Zombwe Research Stations are given in tables 5 for 2023/24 season. Generally, the results indicate that there were significant maize grain yield productions at *P=0.05* among the treatments in all the three trial sites across the two seasons. The maize grain yields increased with increased application of fertilizers. The lowest maize grain yields were obtained in the zero control treatment (no fertilizer application) in all the three sites with grain yields of 1015, 947 and 1041 Kg/ha at Chitedze, Bvumbwe and Zombwe respectively/ While the highest maize grain yields obtained at Chitedze and Bvumbwe were 6637, 5909kg/ha respectively when 165kg/ha was applied while at Zombwe the highest maize yield obtained was 6583 kg/ha when 110kg/ha was applied. The maize grain yields increased with increased amounts of applied Tokyo8. The quarter rate of Tokyo8 gave the lowest maize grain yields at all the three sites, however, the yields were higher than the control treatment. The increase was almost over 300% times higher than the zero treatment. The Tokyo8 only at 110 kg N/ha was slightly higher than the current recommended chemical fertilizer at the same rate of 110 Kg N/ha at all three sites. The rate of Tokyo8 plus urea at the rate of 110 Kg N/ha gave higher yields than the current recommended inorganic fertilizer rate. The increase was over 20% in maize grain yields. This was attributed to synergetic effect of applying Tokyo8 plus Urea. There was reduced loss of nutrients and more were available to the maize crops.

Table 5: Effect of Tokyo8 application on maize grain yield at Chitedze, Bvumbwe and Zombwe Research Stations during 2023-2024 rain Season

	Grain Yield (kg/ha)			
TRT	**Chitedze**	**Zombwe**	**Bvumbwe**	**Means**
zero (no fertilizer)	1015	947	1041	1001
Full Rate chemical fertilizer	4157	3387	4804	4116
Tokyo8 only	2555	2175	2312	2347
Tokyo8 + ¼ Chem Fert Rate	3059	2723	3066	2949
Tokyo8 + ½ Chem Fert Rate	4172	3854	4666	4231
Tokyo8 + Full Chem Fert Rate	5112	4481	5404	4999
Tokyo8 + ½ Organic Manure	3581	2847	3663	3364
Tokyo8 + full Organic Manure	4369	4090	4680	4380
Means	**3503**	**3063**	**3704**	
CV(%)	7.4	4.6	11.3	
F Value	<0.001	<0.001	<0.001	
LSD0.05	452.1	248.6	734.1	

5.0 Conclusion

The evaluation of Tokyo8 bio-fertilizer was successfully conducted in Chitedze, Bvumbwe and Lunyangwa Research Stations. Generally, the results indicated significant maize grain yield differences ($P<0.001$) among the fertilizer treatments. The highest maize grain yields of 5112, 4481, and 5404 kg/ha were obtained at Chitedze, Lunyangwa and Bvumbwe respectively when a combined fertilizer treatment of Tokyo8 plus chemical fertilizer was applied. The highest maize grain yields of 4369, 4090, and 4680 kg/ha were obtained at Chitedze, Lunyangwa and Bvumbwe respectively when a combined fertilizer treatment of Tokyo8 plus full organic manure was applied. The mean grain yields (4231kg/ha) obtained in the treatment where a combined application of half rate of chemical fertilizer plus Tokyo8 biofertilizer was also same as the grain yield (4116 kg/ha) obtained when full rate of chemical fertiliser was applied. The mean grain yields (4380kg/ha) obtained in the treatment where a combined application of full rate of organic manure plus Tokyo8 biofertilizer was slightly higher than the grain yield (4116 kg/ha) obtained when full rate of chemical fertiliser was applied. The use of Tokyo biofertiliser reduced use of chemical by half to obtain same maize grain yield. There was over 50 to 300% maize grain yield increase over the zero control with application of Tokyo8 bio-fertilizer at the three trial sites.

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