EVALUATION OF MBEYA BASED ORGANIC FERTILISER ON MAIZE YIELD AND YIELD COMPONENTS IN MALAWI

Abstract

The recent boom in organic business in the name of Mbeya manure fertilizer has taken shape in commercialisation without ATCC approval as several implications were at stake. Laboratory and fields experiments were, therefore, conducted to ascertain the quality of the products with and without modifications. The original products, as proclaimed by suppliers, were compared to an inorganic fertilizer control treatment and the modified products by inclusion of specific microorganisms in solubilisation of fixed nutrients and oxidation of ammonia and nitrite. Field layout followed Completely Randomized Block Design with three replications and 5 treatments viz Modified Funani Mbeya fertilizer, Modified Kambeu Mbeya fertilizer, Original Funani Mbeya fertilizer, Original Kambeu Mbeya fertilizer and the recommended inorganic fertilizer for Maize. Besides assessing the grain yield, biomass and nutrient bioavailability, effect of the organic fertiliser on biostimulation was also studied in the rhizospheric soil. Results showed that that there was no significant differences on grain yield and its components between Mbeya based organic fertilisers and inorganic fertilisers. However, maize yield and some parameters (environmental and nutrient content) were higher in modified organic fertiliser.

Key words: ***Funani, Kambeu, Mbeya organic fertilisers, local innovations and Maize***

1. Introduction

In spite the effort by the government to increase the use of inorganic fertilizer by smallholder farmers through the introduction of farm input subsidy program (FISP), smallholder farmer's adoption is low despite of economic implication due to prices [1]. Nutrient variability is a problem when commercial organic fertilizers are used for maize production [2 3]. Knowledge of nutrient values of these organic soil amendments is limited because the nutrients from these sources are gradually released into soils in crop available forms and may be temporally tied up in soil microorganisms or organic matter [4].

Maize production in low to no external input systems (both organic and inorganic) accompanied by degraded soils by smallholder farmers is the major cause of decrease in production [5,6]. There is a need to promote sustainable agriculture which implicates maintenance of soil fertility by combination of inorganic and organic fertilizers. Combining organic and inorganic fertilizers complements the effects of organic and inorganic fertilizers[7]. Organic fertiliser release nutrients slowly for long period of time in the soil, thus ensuring a long residual effect. Bio-stimulation and inoculation are the main ways of viability of organic fertiliser using PGRM for the biological nitrogen fixation (BNF), phosphate, zinc and potassium solubilisation [8]. In Mbeya based organic fertiliser which is a combination of organic and inorganic fertiliser, macro nutrients are mainly supplied by inorganic fertiliser while organic fertiliser provide micronutrients [9].

The main focus of organic agriculture include; to produce highly nutritious and quality yield; to enhance interaction between PGRM and abiotic factors by mimicking cycles and natural systems; to enhance biological cycles by PGRM through biostimulation or inoculation; to improve and maintain soil fertility; to promote recycling of agricultural waste mimicking natural ways; for bioremediation and promoting diversity in the farms; [10–12].

The release of nutrients from organic-based fertilizers depends on the microorganisms, ingredients and processes used[13]. Therefore, predicting nutrient release from organic based fertilizers is challenging [14], however, organic fertiliser application restores degraded soils [15]. There are a number of composts in Malawi practiced by farmers in Malawi viz. Changu, Windrow, Bokashi, Pit and farm yard manure. In spite of having these various forms of compost being widely promoted farmers have opted for Mbeya organic fertilizer, require certification because of its commercial implication. Farmers like Mbeya based organic fertilisers due to price and environmental implication while increasing maize yield.

This research study was done to evaluate the performance of Funani and Kambeu Mbeya based organic fertiliser on improving soil fertility and maize in Malawi

2.0 Methodology

2.1 Study sites

The study was conducted at Chitedze Agricultural Research Station, GPS location 13° 85' S. and 33° 38' E at an altitude of 1,146m above sea level representing medium altitude areas. The same research was expanded to include high potential farming sites in Kasungu, Dowa, and Zomba that used both irrigation and rain-fed farming techniques. In the aforementioned study sites, the study was carried out over the course of two cropping seasons during both the rain-fed and irrigation seasons.

2.2 Treatments and study design

The study had 5 treatments; Modified Funani Mbeya fertilizer, Modified Kambeu Mbeya fertilizer, Original Funani Mbeya fertilizer, Original Kambeu Mbeya fertilizer and the recommended inorganic fertilizer for Maize (Control). The study only employed one medium-maturing maize variety (SC 627).The experiment was conducted in a randomized complete block design (RCBD) with 3 replications. Under on-farm conditions, each farmer hosted the trial as a replicate. All the treatments were subjected to normal management practices for maize production in Malawi under both rain-fed and irrigation conditions. The trial's site had never previously undergone any microorganisms. Composition of mbeya fertiliser was 10 kg chemical fertiliser (NPK or Urea), 10 kg chicken dropping or pig dung, 10 kg maize bran, 20 kg ash and 8 litres of water while the modified mbeya composed of was 6 kg chemical fertiliser (only Urea), 12 kg chicken dropping or pig dung, 12 kg maize bran, 20 kg ash mixed with charcoal 8 litres water and plant growth regulatory microbes (PGRM)

2.3 Data collection and statistical analysis

To establish the initial soil fertility in each field, soil samples were taken and examined for pH, Nitrogen, Phosphorous, Potassium, Calcium, Magnesium, Iron, Manganese, CEC, Organic matter, and Total Carbon. Grain and stover yields were measured from each treatment. From the measured yields, the shelling percentage and harvest index were also computed. Maize plant nutrient content was also analysed to compare and contrast the performance of the treatments.

The collected data on yield and yield components was subjected to analysis of variance (ANOVA) using GenStat 18th edition and Minitab statistical software packages. Significant differences were assessed at 5% level and data mean separation was done using Fisher's protected least significant difference (LSD) procedure. After a preliminary analysis of the data, the fact that the data sets among the sites were not homogeneous led to the need for a separate study for each site. Moreover, separate analyses for irrigation and rain-fed settings were completed.

3.0 Results and Discussion

TABLE 1; Soil analysis results from the samples taken from the various forms of Mbeya organic fertilizer

LAB NO.	Reference sample	Ph.	%OC	%OM	%N	P(ug/g)	K (cmol/kg	Ca (cmol/kg	Mg (cmol/kg
1	Mbeya farmer 1	7.81	0.87	1.49	0.07	111.13	0.04	0.08	0.00
2	Mbeya farmer 1	8.2	0.81	1.39	0.07	123.5	0.01	0.09	0.01
3	Funani Mbeya original	7.77	1.24	2.14	0.11	271.87	0.02	0.3	0.00
4	Kambeu Mbeya modified 1	8.03	1.64	2.83	0.14	282.88	0.04	0.14	0.01
5	Funani Mbeya modified 1	7.18	1.82	3.13	0.16	277.84	0.09	0.23	0.03
6	Kambeu Mbeya modified 1	7.65	2.28	3.93	0.2	274.74	0.13	0.27	0.02
7	Funani Mbeya modified 2	7.69	2.31	3.98	0.2	279.41	0.09	0.29	0.03
8	kambeu Mbeya modified 2	8.25	2.51	4.33	0.22	274.74	0.06	0.3	0.02

Table 2: Initial soil analysis results from the soil samples taken from the various sites where the study was conducted

District	Critical value	Dowa	Dowa	Kasungu	Kasungu	Zomba	Zomba	Lilongwe	Lilongwe
Site	5.2	Nachisaka	Nachisaka	Snathe	Snathe	Masaula	Masaula	Chitedze	Chitedze
Depth	>0.88	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm
pH(water)	1.5	4.98	5.31	5.77	5.04	6.6	7.14	7.55	7.28
%OC	>0.1	0.8	0.89	0.45	0.36	0.09	0.8	0.53	0.86
%OM	15	1.38	1.54	0.78	0.62	0.15	1.38	0.92	1.49
%N	0.2	0.07	0.08	0.04	0.03	0.01	0.07	0.05	0.07
P(Cmol/kg)	0.2	36.8	20.91	13.59	14.13	16.31	18.38	15.22	7.05
K(Cmol/kg)		83	1.3	0.25	0.25	0.4	0.37	0.37	0.29
Ca(Cmol/kg)	0.5	1.61	1.75	0.06	-0.28	0.58	0.39	0.68	0.51
Mg(ug/g)		0.37	0.54	0.06	0.05	0.01	0.01	0.01	0.01
Zn(ug/g)		0.03	0.03	0.06	0.03	0.03	0.03	0.06	0.03
Mn(ug/g)		56.36	56.4	0.35	0.19	1.55	0.72	0.87	0.83
Fe(ug/g)		48.51	53.49	7.36	7.68	1.86	0.95	1.03	1.53
Texture		SCL	SCL	SCL	SCL	SCL	SCL	SCL	SCL

The results (>90) showed no significant changes in terms of yield between organic fertilizers and recommended fertiliser rates as shown in figure 1-4. However, the modification of the two had slightly higher yields and grain nutrient content as shown in figure 1-4, 9 and table 9 and 3. Higher grain yield may be a result of cob weight shown by seed size (table 3-6). The results on PGRM shown in and table 11 expose the danger of inorganic fertiliser on plant growth regulatory microbes. The results give insight why grain produced using inorganic fertilisers have low nutrient contents compared to those grown organically. This brings to the attention of incorporating PGRM in the soil either by biostimulation or inoculation in organic fertilisers or direct to soil which is in line with other studies and regulations in other countries [16–20].

The result of the trial showed that yield was not significantly affected by location or season but modification of organic fertilisers by inoculation with plant growth regulatory microbes (PGRM) gave higher yields. The greater the number and diversity of PGRM increased plant capability for nutrient uptake due to solubilising nutrients, fixation of nitrogen in mbeya based fertilisers. This observation is consistent with studies documented by Khan *et al*., (2017). Higher grain yield observed in the modified Mbeya based organic fertilisers could be attributed to seed size not cob weight or grain weight or harvest index or shelling percentage. Hussain *et al.*, (2013) attributed this to accumulation and photosynthesis at grain filling period and its eventual partitioning to the ear. Partitioning of assimilates to the ear suggested that there could be an increased kernel set which was also reported by Barary et al. (2014)

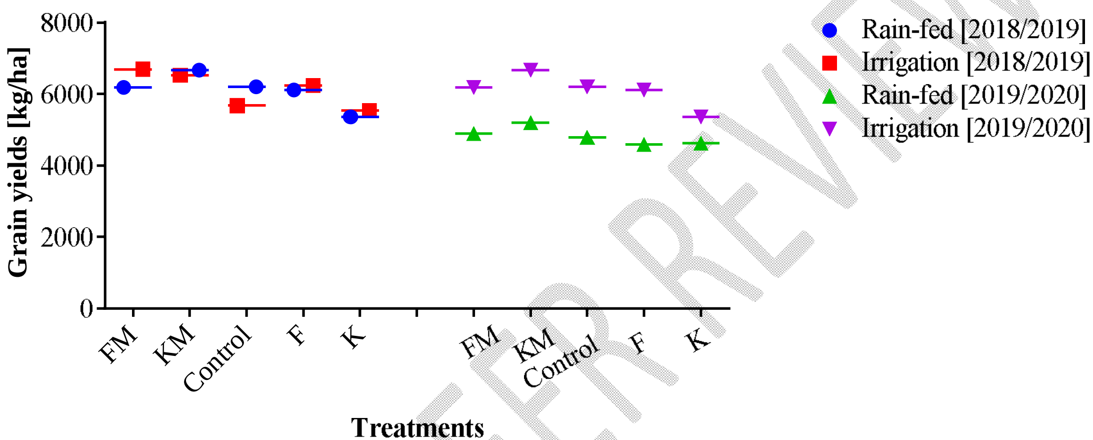
The better performance observed in all sites with irrigation than rain fed could be attributed to the stress related issues. The fertility status of sites had no significant in terms of yield as indicated in the tables which could be as a result of cushioning factor of organic carbon which made the organic fertilisers to provide nutrients based on plant nutrient demand. This was equally reported by Phiri et al. (2020) where it was observed that combined application of organic and inorganic fertiliser gave the highest performance in maize grown in Malawi. Generally, OC in all sites was low indicating the need to restock and buildup OC as shown in table 2. Organic carbon is critical for soil health as it regulates biological, chemical and physical parameters (Khan *et al.*, 2017; Lunze, 2001; Innocent *et al.*, 2009). Buildup of OC in the soil is a gradual process that is contingent on abiotic and biotic soil edaphic factors [27].

However, significant maize grain yields across districts is a result of native soil nutrient levels [28]. However, no significant differences in maize grain yields were observed between the treatments within the districts because of buffer effect of manure. Studies have shown that crop nutrient demand and soil nutrient release is achieved through combined application of organic and inorganic fertilizer [24,26].

The results also show that PGPM inoculated in the Mbeya based treatments (modified Funani and Kambeu) had synergistic effect shown by increase in nutrient content and yields. The correlation between rhizosphere and nutrient content is due to the microbial ability to respond chemo tactically [29–31]. The application of phosphate based fertiliser has a negative impact to PGRM due to heavy metal contamination hence no solubilisation and oxidation of native and applied nutrients. These finding are in agreement with the previous reports that maize grain yield can increase through inoculation of solubilizing and oxidizing microbes [32,33].

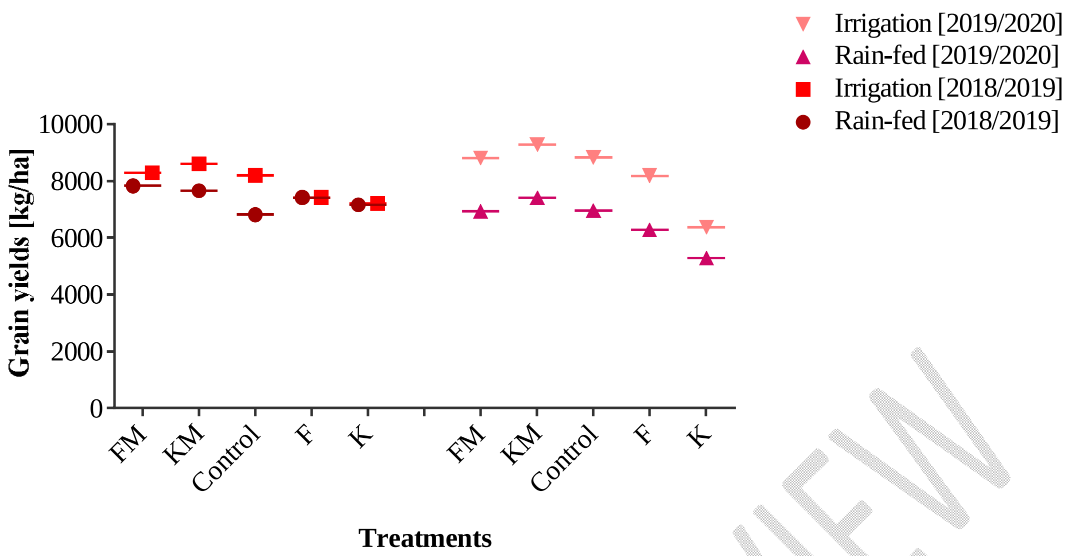
The effect of all treatments, location and season on biomass yield was not significant as shown in figure 5-8. Some researchers found that enhanced N, P, K and Zn released increases grain yield, biomass and 100-seed weight [34].

Grain and biomass (folder) yield increase with the use of organic fertiliser application is of benefit to maize producers [33]. Long term field studies show significant contribution of organic fertiliser for the sustainable soil health and soil fertility [35,36]. Organic fertiliser is responsible for biostimulation and allow their components to interact with each other synergistically, thus, stimulating each other through physically or biologically [37–39].



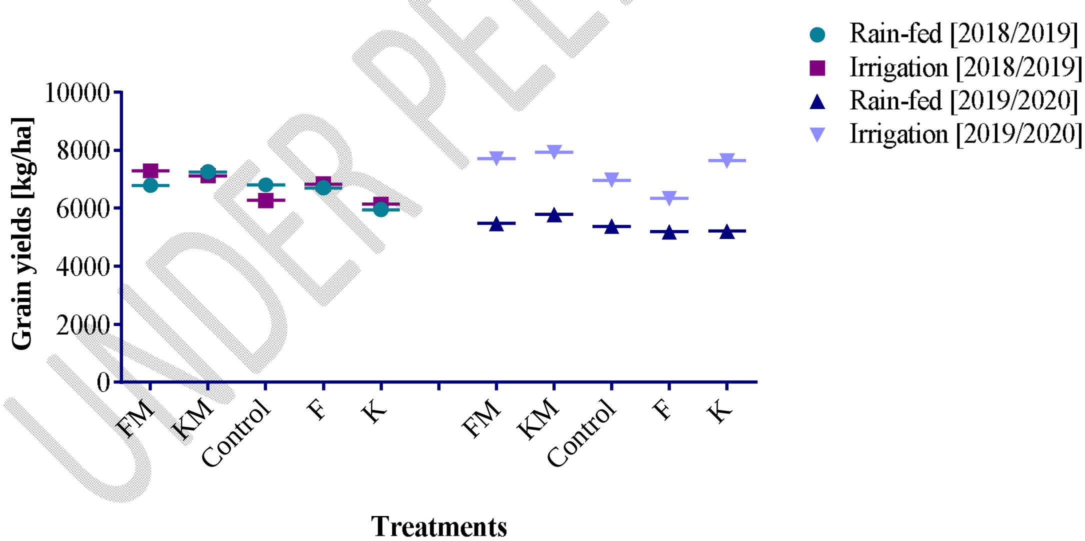
	2018-19 Rain-fed	2018-19 Irrigation	2019-20 Rain-fed	2019-20 Irrigation
Fr(pr)	0.272	0.614	0.923	0.272
LSD	1224	1985	1711	1224
CV%	11	17	19	11

Figure 1; Effect of different fertiliser treatments on grain yield (kg/ha) at Chitedze research station in Lilongwe during 2018/2019 and 2019/2020 cropping seasons under both irrigation and rain-fed conditions



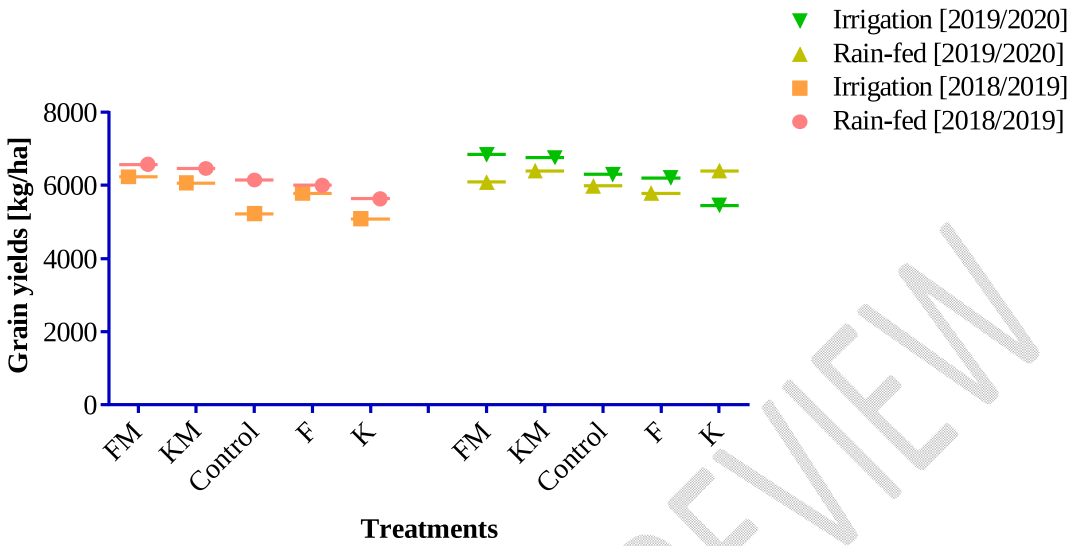
	2018-19 Rain-fed	2018-19 Irrigation	2019-20 Rain-fed	2019-20 Irrigation
Fr(pr)	0.809	0.605	0.139	0.026
LSD	2108	2303	1741	1679
CV%	15	15	14	11

Figure 2; Effect of different fertiliser treatments on grain yield (kg/ha at Masaula EPA in Zomba during 2018/2019 and 2019/2020 cropping seasons under both irrigation and rain-fed conditions



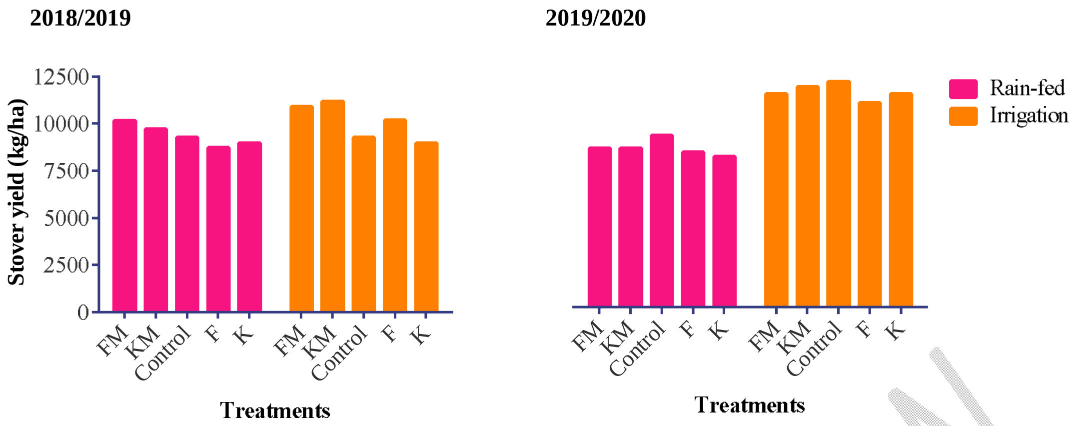
	2018-19 Rain-fed	2018-19 Irrigation	2019-20 Rain-fed	2019-20 Irrigation
Fr(pr)	0.272	0.614	0.923	0.71
LSD	1224	1785	1721	2011
CV%	10	16	17	14

Figure 3; Effect of different fertiliser treatments on grain yield (kg/ha) at Nachisaka EPA in Dowa during 2018/2019 and 2019/2020 cropping seasons under both irrigation and rain-fed conditions



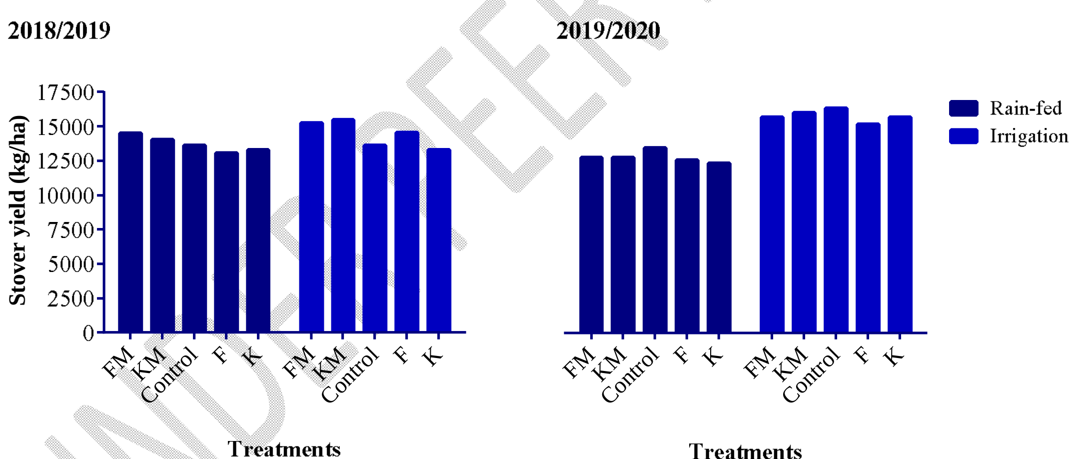
	2018-19 Rain-fed	2018-19 Irrigation	2019-20 Rain-fed	2019-20 Irrigation
Fr(pr)	0.245	0.614	0.923	0.27
LSD	907	1985	1711	1436
CV%	12	19	15	14

Figure 4; Effect of different fertiliser treatments on grain yield (kg/ha at Santhe EPA in Kasungu during 2018/2019 and 2019/2020 cropping seasons under both irrigation and rain-fed conditions



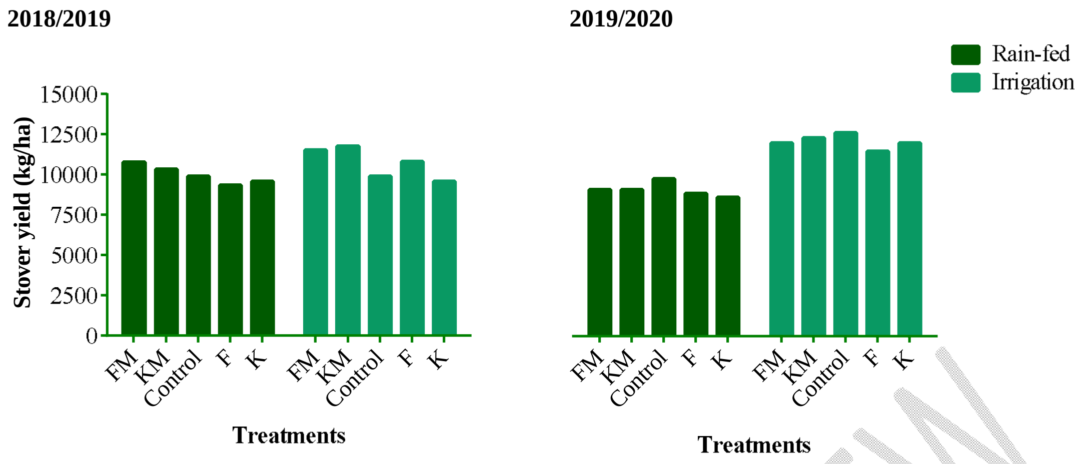
	2018-19	2018-19	2019-20	2019-20
	Rain-fed	*Irrigation*	*Rain-fed*	*Irrigation*
Fr(pr)	0.89	0.148	0.947	0.945
LSD	3619	2075	3323	3321
CV%	21	11	21	15

Figure 5: Effect of different fertiliser treatments on stover yield (kg/ha) at Chitedze research station during 2018/2019 and 2019/2020 cropping seasons under both irrigation and rain-fed conditions



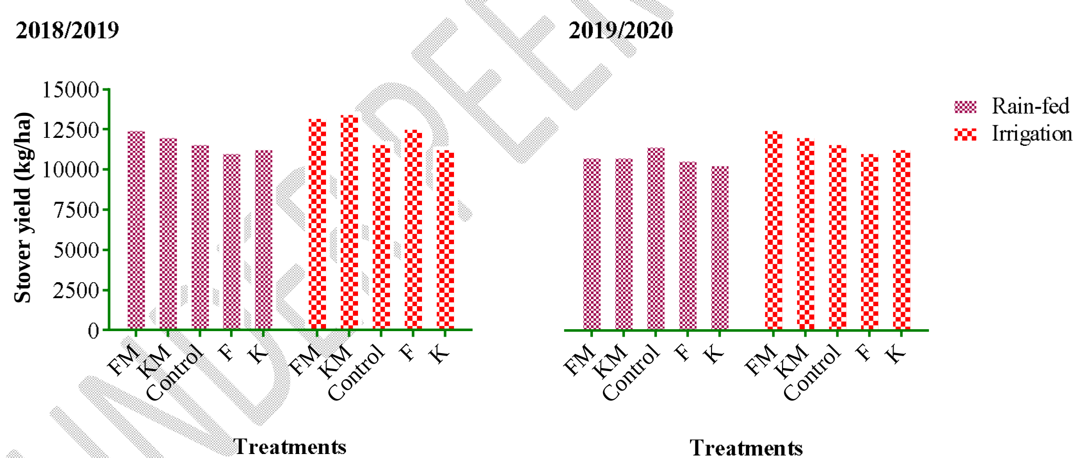
	2018-19	2018-19	2019-20	2019-20
	Rain-fed	*Irrigation*	*Rain-fed*	*Irrigation*
Fr(pr)	0.890	0.148	0.947	0.945
LSD	3619	2075	3323	3321
CV%	14	8	14	11

Figure 6: Effect of different fertiliser treatments on stover yield (kg/ha) at Masaula EPA in Zomba during 2018/2019 and 2019/2020 cropping seasons under both irrigation and rain-fed conditions



	2018-19	2018-19	2019-20	2019-20
	Rain-fed	*Irrigation*	*Rain-fed*	*Irrigation*
Fr(pr)	0.89	0.148	0.947	0.945
LSD	3619	2075	3323	3321
CV%	19	10	20	15

Figure 7: Effect of different fertiliser treatments on stover yield (kg/ha) at Nachisaka EPA in Dowa during 2018/2019 and 2019/2020 cropping seasons under both irrigation and rain-fed conditions



	2018-19	2018-19	2019-20	2019-20
	Rain-fed	*Irrigation*	*Rain-fed*	*Irrigation*
Fr(pr)	0.890	0.148	0.947	0.890
LSD	3619	2075	3323	3619
CV%	16	9	16	16

Figure 8: Effect of different fertiliser treatments on stover yield (kg/ha) at Santhe EPA in Kasungu during 2018/2019 and 2019/2020 cropping seasons under both irrigation and rain-fed conditions

Table 3: Effect of different fertiliser treatments on seed size (100 seed weight in grams) at Chitedze research station in Lilongwe during 2018/2019 and 2019/2020 cropping seasons under both irrigation and rain-fed conditions

Treatment	Cropping season			
	2018-19 Rain-fed	2018-19 Irrigation	2019-20 Rain-fed	2019-20 Irrigation
F	34	36	35	36
K	35	35	35	36
control	36	36	36	37
FM	37	38	36	38
KM	36	37	36	37
Grand means	35	37	36	37
Fr(pr)	0.39	0.117	0.866	0.39
LSD	2.902	2.355	2.108	2.902
CV%	4.4	3.4	3.1	4.2

Table 4; Effect of different fertiliser treatments on seed size (100 seed weight in grams) at Masaula EPA in Zomba during 2018/2019 and 2019/2020 cropping seasons under both irrigation and rain-fed conditions

Treatment	Cropping season			
	2018-19 Rain-fed	2018-19 Irrigation	2019-20 Rain-fed	2019-20 Irrigation
F	36	35	35	38
K	37	36	36	39
control	38	37	37	39
FM	37	38	37	39
KM	36	37	36	37
Grand means	37	37	36	38
Fr(pr)	0.455	0.543	0.718	0.185
LSD	2.967	4.168	3.664	1.884
CV%	4.3	6.1	5.4	2.6

Table 5; Effect of different fertiliser treatments on seed size (100 seed weight in grams) at Nachisaka EPA in Dowa during 2018/2019 and 2019/2020 cropping seasons under both irrigation and rain-fed conditions

Treatment	Cropping season			
	2018-19 Rain-fed	2018-19 Irrigation	2019-20 Rain-fed	2019-20 Irrigation
F	35	37	36	36
K	36	36	36	37
control	37	37	37	38
FM	37	39	37	39
KM	37	38	37	38
Grand means	36	37	37	38
Fr(pr)	0.39	0.117	0.866	0.39
LSD	2.902	2.355	2.208	2.902
CV%	4.2	3.3	3.1	4.1

Table 6; Effect of different fertiliser treatments on seed size (100 seed weight in grams) at Santhe EPA in Kasungu during 2018/2019 and 2019/2020 cropping seasons under both irrigation and rain-fed conditions

Treatment	Cropping season			
	2018-19 Rain-fed	2018-19 Irrigation	2019-20 Rain-fed	2019-20 Irrigation
F	40	42	40	40
K	41	40	39	41
Control	40	38	39	40
FM	39	40	39	39
KM	37	39	38	37
Grand means	40	40	39	40
Fr(pr)	0.005	0.555	0.789	0.005
LSD	1.523	4.323	0.277	1.523
CV%	2	5.8	3.8	2

Table 7; Effect of different fertiliser treatments on shelling % at Chitedze research station in Lilongwe during 2018/2019 and 2019/2020 cropping seasons under both irrigation and rain-fed conditions

Treatment	Cropping season			
	2018-19 Rain-fed	2018-19 Irrigation	2019-20 Rain-fed	2019-20 Irrigation
F	54	69	50	63
K	61	62	50	74
Control	59	64	49	67
FM	57	65	47	47
KM	51	65	50	61
Grand means	56	65	49	65
Fr(pr)	0.827	0.903	0.999	0.873
LSD	22	17	29	32
CV%	21	14	31	26

Table 8; Effect of different fertiliser treatments on shelling % at Masaula EPA in Zomba during 2018/2019 and 2019/2020 cropping seasons under both irrigation and rain-fed conditions

Treatment	Cropping season			
	2018-19 Rain-fed	2018-19 Irrigation	2019-20 Rain-fed	2019-20 Irrigation
F	67	84	70	76
K	71	81	71	87
Control	66	93	71	87
FM	61	69	75	65
KM	68	89	57	55
Grand means	68	84	67	77
Fr(pr)	0.998	0.916	0.812	0.195
LSD	32	47	31	30
CV%	25	30	24	21

Table 9; Effect of different fertiliser treatments on shelling % at Nachisaka EPA in Dowa during 2018/2019 and 2019/2020 cropping seasons under both irrigation and rain-fed conditions

Treatment	Cropping season			
	2018-19 Rain-fed	2018-19 Irrigation	2019-20 Rain-fed	2019-20 Irrigation

F	55	69	52	64
K	62	63	52	74
Control	61	65	51	68
FM	58	66	49	62
KM	53	66	52	62
Grand means	58	66	51	66
Fr(pr)	0.829	0.896	0.999	0.885
LSD	21	16	27	30
CV%	19	13	28	24

Table 10; Effect of different fertiliser treatments on shelling % at Santhe EPA in Kasungu during 2018/2019 and 2019/2020 cropping seasons under both irrigation and rain-fed conditions

Treatment	Cropping season			
	2018-19 Rain-fed	2018-19 Irrigation	2019-20 Rain-fed	2019-20 Irrigation
F	56	60	58	56
K	58	53	58	58
control	57	54	57	57
FM	54	56	55	54
KM	49	54	58	49
Grand means	55	55	57	55
Fr(pr)	0.851	0.891	0.999	0.851
LSD	21	16	29	21
CV%	20	15	27	20

The results show that nitrogen fixing microbes, nitrifying microbes and potassium solubilising microbes (KSM) availability regulates the competitive interaction of other soil microorganisms and thus the relative increase in grain nutrient content which is in line with other studies [40–42]. This is because nitrogen is an important nutrient in the soil and has implication on nutrient uptake, soil microbial diversity and general soil chemistry [2]. The results suggest that nitrifying microorganisms (ammonia and nitrite oxidizing bacteria), which increase urea efficiency, are cause of reduced urea utilization in organic fertilizers based on Mbeya organic.. The efficiency is a result of fast and percentage change to nitrate without loss through ammonia or ammonium as gas [2]

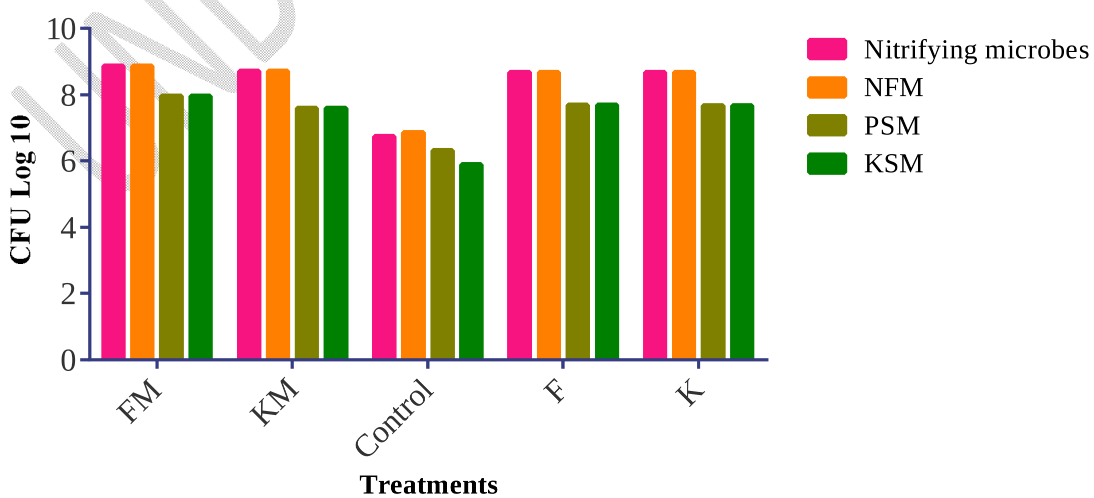


Fig. 9. Mean CFU of PGRM (nitrifying microbes, NFM, PSM) from rhizosphere of different treatments.

Grain nutrient content increase is due to microbial activity through solubilisation, oxidation, sorption, bioremediation and fixation factor [44–48]. In addition to increasing microbial biomass, PGRM injection has been associated with altered microbial community structure and increased functional diversity [45,49–51]. Geisseler and Scow, (2014) found that microbial diversity, in terms of both species richness and evenness, was affected by application of fertiliser without integration of organic fertilisers. Increased microbial biomass and diversity are beneficial for soil quality because soil microorganisms play a key role in soil nutrient cycling and bioremediation. They accelerate the breakdown of organic substances and mineralize the organic nitrogen (N) and phosphorus (P) into plant available inorganic forms.

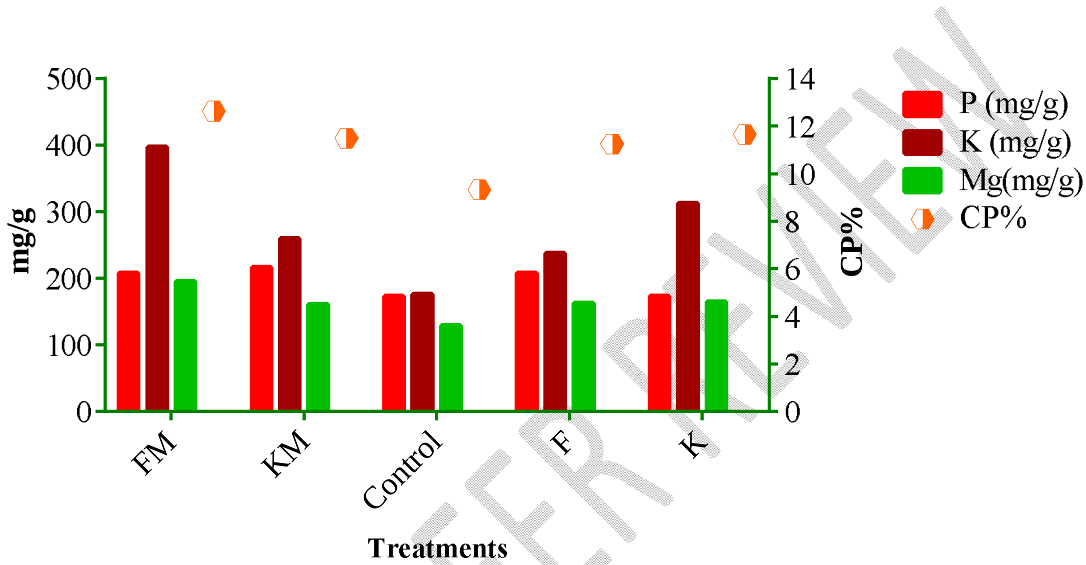


Figure 10; Mean grain nutrient content (P, K, Mg and Crude protein) in the fertilizer treatments.

Table 111; Correlation between different factors in response to the experiment

Microbes	Correlations/pvalue	Yield per ha	Nitrifying microbes	NFM	PSM	KSM	N%	P%	K%
Nitrifying	Correlations/pvalue	-0.047		1.000**	.737**	.742**	0.543**	.661**	.542**
	Sig(2-tailed)	0.777		0	0	0	0	0	0
NFM	Correlations/pvalue	-0.047	1.000*	1.000**	.737**	.742**	0.543**	.661**	.542**
	Sig(2-tailed)	0.777	0	0	0	0	0	0	0
PSM	Correlations/pvalue	-0.063	0.737	0.737	1	999**	0.374*	0.286	.530**
	Sig(2-tailed)	0.702	0	0		0	0.019	0.078	0.001
KSM	Correlations/pvalue	-0.051	0.742	0.742	.999**	1	.380*	0.302	.526**
	Sig(2-tailed)	0.76	0	0	0		0.017	0.062	0.001
		Mg%	Ca%	Cp%	S%	Znppm	Feppm	Mnppm	Cuppm
Nitrifying	Correlations/pvalue	.787**	0.085	.543**	-0.143	-0.384	-0.155	-0.292	-0.085
	Sig(2-tailed)	0	0.737	0	0.571	0.116	0.539	0.239	0.737
NFM	Correlations/pvalue	0.787	0.085	.543**	-0.143	-0.384	-0.155	-0.292	-0.085
	Sig(2-tailed)	0	0.737	0	0.571	0.116	0.539	0.239	0.737
PSM	Correlations/pvalue	0.797	-0.195	.374*	-0.036	-0.428	0.048	-0.41	0.24
	Sig(2-tailed)	0	0.437	0.019	0.886	0.076	0.85	0.091	0.337

KSM	Correlations/pvalue	0.808	-0.186	0.380	-0.04	-0.43	0.052	-0.405	0.232
	Sig(2-tailed)	0	0.461	0.017	0.875	0.075	0.837	0.096	0.353

Conclusion

This study identified the potential of Mbeya-based organic fertilizers in maize cultivation systems in Malawi. Biostimulation to aid in the solubilization of solid minerals using an inexpensive and environmentally friendly system is expected in the research, characterization and evaluation of Mbeya-based organic fertilizers. Study results show positive effects of developing more productive, cost-effective and environmentally friendly maize cultivation systems.

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