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Response of maize grain yield to different sources of organic manure at varied levels of application

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The experimental site was prepared and land used was 1,904 square feet (measuring 1706.88 by 1036.32 m). Varying rates (0.5, 1, and 1.5 kg) of three organic manures (palm kernel cake, bio char, *Gliricidia sepium* and poultry/chicken manure) were applied on maize variety DMR-ESR-yellow. The design was a randomized complete block design in a factorial arrangement with three replications, with a plot size of 4 by 4ft. Each plot consisted of four rows each with seven plant stands. The organic manures were applied one week before planting. Maize was planted at 2 by 2ft using three seeds. Weeding were carried out at 3 and 6 weeks after planting (WAP). Results reveal that significant differences were observed for most of the traits by the application of different treatments in the study. Maximum plant height, stem girth, leaf number, leaf area, grain yield weight was obtained in the treatment where poultry manure (PM) was applied followed by the palm kernel cake (PKC) treatment. Quantitative increase of organic matter enhances water holding capacity of the soil which helps the nutrients mobility in soil. The study indicates that poultry manure is a valuable fertilizer whose use needs to be encouraged. An application rate of 1.5 kg/ha was capable of significantly increasing yields level over the control plot. The application of organic manure highly increases plant height, number of leaves, stem girth and weight of maize grain after harvest.

Key words: Biochar, *Gliricidia sepium* poultry manure.

INTRODUCTION

In spite of substantial fertilizer use in Sierra Leone, the crop yields are not increasing correspondingly, which reflects low fertilizer use efficiency (FUE). Poultry manure is an excellent organic fertilizer, as it contains high nitrogen, phosphorus, potassium and other essential nutrients. In contrast to chemical fertilizer, it adds organic matter to soil which improves soil structures, nutrient retention, aeration, soil moisture holding capacity and water infiltration (Deksissa and Allen, 2008). It was also indicated that poultry manure more readily supplies P to plants than other organic manure sources (Garg and Bahla, 2008).

Organic fertilizers, including farmyard manure, sheep manure and poultry manure may be used for crop production as a substitute of the chemical fertilizers because the importance of the organic manures cannot be overlooked. Worldwide, there is growing interest in the use of organic manures due to depletion in the soil fertility. Economic premiums for certified organic grains have been driving many transition decisions related to the organic farming (Delate and Camberdella, 2004). Continuous use of fertilizers creates potential polluting effect in the environment (Oad et al., 2004). Synthesis of chemical fertilizers consumes a large amount of energy

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and money. However, an organic farming with or without chemical fertilizers seems to be possible solution for these situations (Prabu et al., 2003). The integration of organic sources and synthetic sources of nutrients not only supplies essential nutrients but also has some positive interaction with chemical fertilizers to increase their efficiency and thereby reduce environmental hazards (Ahmad and Rashid, 1996).

Organic farming in agriculture preserves ecosystem. It does not involve use of harmful chemicals and fertilizers; rather symbiotic life forms are cultured, ensuring weed and pest control and optimal soil biological activity, which maintain fertility. Poultry manure is a valuable fertilizer and can serve as a suitable alternative to chemical fertilizer. Poultry manure application registered over 53% increases of N level in the soil, from 0.09% to 0.14 %, and exchangeable cations increased (Boateng et al., 2006). In agriculture, the main reasons for applying PM include the organic amendment of the soil and the provision of nutrients to crops (Warren et al., 2006). Keeping in view the above facts, the present study was therefore, designed to evaluate the Response of maize grain yield to different sources of organic manure at varied levels of application.

Maize (corn) yields are low because most farmers living in the rural area cannot afford to purchase costly chemical fertilizers which are mostly essential elements for its performance. They are likely to use other forms of organic fertilizer as alternative sources of nutrient for their maize productions. Since these are cheap and most time available, but this source of nutrient for maize production is not adequate for commercial purposes as they are only produced on small scale. For commercial production in present day Sierra Leone, the adequate means of fertilizer for meaningful commercial production is the use of inorganic fertilizer. Though they are expensive but they can be acquired in quantity needed. This study attempts to determine the correct rates of green manure fertilizer required for the production of DMR-ESR and improve maize varieties.

MATERIALS AND METHOD

Location of study area

The experiment was conducted during the dry season of 2016 in the inland valley swamp at N.A.T.C, Njala in Southern Sierra Leone. Njala campus is located some 125 m East of Freetown on a generally flat landscape on the banks of River Taia in the Kori Chiefdom of Moyamba District-Southern Sierra Leone. It is equidistant (7 m) from Taiama and mano, and 36 m to the Southern city of Bo. It is situated at an elevated of 50 m above sea level on Latitude 8°06N and Longitude 12°06W.

Description of experimental site

The experiment was conducted during the dry season of 2016 in the inland valley swamp at the National Agricultural Training Centree (N.A.T.C), Njala in Southern Sierra Leone. Njala campus is located some 125 m East of Freetown on a generally flat landscape on the banks of River Taia in the Kori Chiefdom of Moyamba District-Southern Sierra Leone. It is equidistant (7 m) from Taiama and mano, and 36 m to the Southern city of Bo. It is situated at an elevated of 50m above sea level on Latitude 8°06N and Longitude 12°06W.

Climate of the study area

Njala experiences a distinct dry and wet season. The wet seasons is mono-model and last from April to October, while the dry season extends from November to March. The mean temperature ranges from 21°C-23°C for the greater part of the day and night.

Preparation of experimental site

The land was ploughed by native Indian hoe to a depth of about 5-10 cm and harrowed after one week for planting. The total land area selected for this study was 1,904 square feet (measuring 1706.88 by 1036.32 m).

Experimental design

Varying rates (0.5, 1, and 1.5 kg) of three organic manures (Palm Kernel Cake, Bio char, *Gliricidia Sepium*, and poultry/chicken manure) were applied on maize in pocket holes on variety DMR-ESR-yellow. No fertilizer rate was applied on the control. The design was a Randomized Complete Block Design with three replications, with a plot size of 4 by 4ft. Each plot consisted of four rows each with seven plant stands giving to total plant stands of four hundred and twenty stands (420). The organic manures were applied one week before planting using pocket application method. The maize was planted at a spacing of 2ft by 2ft. About three seeds were planted and later thinned to two per hill giving a population of 840 plants per ha. Two hand weeding were carried out at 3 and 6 weeks after planting (WAP).

Date of harvesting and method

Harvesting was done manually after physiological maturity of the crop. It was left to dry in the field and harvested after drying. Purseglove (1981) stated that maturity can be recognized by yellowing of the leaves, yellow dry papery husks, and hard grain with a glossy surface. Maize is usually physiologically mature at about 7-8 weeks after flowering, when the grain contains 35-40% moisture. The method used for harvesting was done manually by hand.

Data collection

Data collection commenced four weeks after planting. Plant height, leaf area, number of leaves, and stem girth/diameter were measured on four tagged/selected plants per plot on two weekly bases. These parameters were measured using a tape measure and they were recorded in centimeters. The data were collected from each of the plants in the 2 middle rows of each plant.

Statistical analysis of data

Data were subjected to analysis of variance (ANOVA) and means were separated using Duncan Multiple Range Test (DMRT) at 0.05 level of significance.

Table 1. Mean stem girth (cm) as affected by soil amendments and rates at 4 WAP.

Soil amendment	Rates of application (kg/plot)			Mean
	0.5	1.0	1.5	
Palm kernel cake (PKC)	4.404	4.088	4.28	4.267[a]
Poultry manure (PM)	6.11	3.964	2.822	4.299[a]
Bio char	2.324	4.448	4.384	3.719[b]
G. sepium	3.722	3.186	5.708	4.205[a]
Control (0kg/plot)				0.982[c]
Mean	2.61	3.33	4.00	

Means column with the same letters has no significant difference at p<0.05.

Table 2. Mean stem girth (cm) as affected by soil amendments and rates at 6 WAP.

Soil amendment	Rate of application (kg/plot)			Mean
	0.5	1.0	1.5	
Palm kernel cake (PKC)	6.86	6.79[a]	6.32	6.79[a]
Poultry manure (PM)	6.26	6.98[a]	7.98	6.98[a]
Bio char	7.8	5.85[b]	4.22	5.85[b]
G. sepium	5.88	6.40[a]	6.66	6.40[a]
Control (0 kg/plot)		3.86c		3.86[c]
Mean	5.775	6.075	6.175	

Means column with the same letters has no significant difference at p<0.05.

RESULTS AND DISCUSSION

Effects of soil amendments and soil amendments rates on mean stem girth at 4 WAP

Analysis using ANOVA revealed significant differences (P<0.05) in mean stem girth at 4 WAP with respect to soil amendment (Table 1). For soil amendment, poultry manure recorded the highest mean stem girth (4.299) which was not statistically different from palm kernel cake (4.205) and *G. sepium* (4.205), followed by bio char manure (3.719). The control plot recorded the least Mean stem girth (0.982c). In the case of rates, 1.5 kg registered the highest mean stem girth across all the soil amendments followed by 1.0 and 1.5 kg.

Effect of soil amendments and rates with respect to mean stem girth at 6 WAP

Analysis using ANOVA revealed significant differences (P<0.05) in mean stem girth at 6 WAP with respect to soil amendment (Table 2).

For soil amendment, poultry manure recorded the highest Mean stem girth (6.98a) which is statistically at par with palm kernel cake (PKC) and *G. sepium* manure, followed by Biochar manure (5.85), whilst the control plot recorded the least leaf area (3.86[c]). In the case of rate, 1.5 kg registered the highest mean stem girth across all the soil amendments followed by 1.0 and 0.5 kg.

Effect of soil amendments and rates with respect to mean stem girth at 8 WAP

Analysis using ANOVA revealed significant differences (P<0.05) in mean stem girth at 8 WAP with respect to soil amendment (Table 3). For soil amendment, poultry manure recorded the highest Mean stem girth (7.89a) which is statistically at par with palm kernel cake (PKC), followed by *G. sepium* (6.65), whilst the control plot recorded the least Mean Stem Girth (4.21d). In the case of rate, 1.5 kg registered the highest mean stem girth across all the soil amendments followed by 1.0 and 0.5 kg.

Effect of soil amendments and rates with respect to mean plant height at 4 WAP

Analysis using ANOVA revealed significant differences (P<0.05) in mean plant height at 4 WAP with respect to soil amendment (Table 4). For soil amendment, poultry manure recorded the highest mean plant height (83.52a) which is statistically at par with palm kernel cake (PKC), followed by *G. sepium* (59.24), whilst the control plot recorded the least mean plant height (42.71).

Table 3. Mean stem girth (cm) as affected by Soil amendments and rates at 8 WAP.

Soil amendment	Rate of application (kg/plot)			Mean
	0.5	1.0	1.5	
Palm Kernel Cake (PKC)	7.70	7.80	7.90	7.80[a]
Poultry Manure (PM)	8.52	6.78	8.36	7.89[a]
Bio char	5.30	5.60	5.50	5.47[c]
G. sepium	4.86	7.18	7.91	6.65[b]
Control (0kg/plot)				4.21[d]
Mean	6.28	6.49	7.14	

Means column with the same letters has no significant difference at p<0.05.

Table 4. Mean plant height (cm) as affected by soil amendments and rates at 4 WAP.

Soil amendment	Rate of application (kg/plot)			Mean
	0.5	1.0	1.5	
Palm kernel cake (PKC)	56.16	79.2	91.04	75.47[a]
Poultry manure (PM)	56.04	81.2	113.32	83.52[a]
G. sepium	42.1	64.52	71.1	59.24[b]
Bio char	38.68	40.86	50.32	43.29[c]
Control (0kg/plot)				42.71[d]
Mean	48.25	66.45	81.45	

Means column with the same letters has no significant difference at p<0.05.

Table 5. Mean plant height (cm) as affected by soil amendments and rates at 6 WAP.

Soil amendment	Rate of application (kg/plot)			Mean
	0.5	1.0	1.5	
Palm kernel cake (PKC)	149.4	131.5	239	173.30b
Poultry manure (PM)	199.28	240.46	270	236.58a
Bio char	232.17	142.74	110.84	161.92b
G. sepium	84.92	169.4	194.4	149.57b
Control (0kg/plot)				63.25c
Mean	141.06	156.18	161.26	

Means column with the same letters has no significant difference at p<0.05.

In the case of rate, 1.5 kg registered the highest mean plant height across all the soil amendments followed by 1.0 and 0.5 kg.

Effect of soil amendments and rates with respect to mean plant height at 6 WAP

Analysis using ANOVA revealed significant differences (P<0.05) in mean plant height at 6 WAP with respect to soil amendment (Table 5). For soil amendment, poultry manure recorded the highest mean plant height (236.58a) followed by Palm Kernel Cake (PKC) which is statistically at par with *G. sepium*, and biochar manure, whilst the control plot recorded the least mean plant height (63.25c). In the case of rate, 1.5 kg registered the highest Mean Plant Height across all the soil amendments followed by 1.0 and 0.5 kg.

Effect of soil amendments and rates with respect to plant height at 8 WAP

Analysis using ANOVA revealed significant differences (P<0.05) in mean plant height at 8 WAP with respect to soil amendment and rate (Table 6).

For soil amendment, poultry manure recorded the highest mean plant height (286.24) which is statistically at

Table 6. Mean plant height(cm) as affected by soil amendments and rates at 8 WAP.

Soil amendment	Rate of application (kg/plot)			Mean
	0.5	1.0	1.5	
Palm kernel cake (PKC)	185.8	192.6	251.2	209.87[a]
Poultry manure (PM)	212.32	327.6	318.8	286.24[a]
G. sepium	255.4	193.2	172.8	207.13[a]
Bio char	133.0	212.0	227.4	190.80[b]
Control (0kg/plot)				148.73[b]
Mean	192.38	210.70	221.60	

Means column with the same letters has no significant difference at p<0.05.

Table 7. Mean plant height (cm) as affected by soil amendments and rates at 10 WAP.

Soil amendment	Rate of application (kg/plot)			Mean
	0.5	1.0	1.5	
Palm Kernel Cake (PKC)	262.6	193.4	176.9	210.97[b]
Poultry Manure (PM)	216.8	386	324.2	309.00[a]
G. sepium	170.2	195.1	225.6	196.97[c]
Bio char	170.2	163.6	224	185.93[c]
Control (0kg/plot)				178.77[c]
Mean	195.53	221.60	246.38	

Means column with the same letters has no significant difference at p<0.05.

par with Palm Kernel Cake (PKC) and *G. sepium* manure, followed by Biochar (190.80), which is statistically at par with the control plot recorded (148.73).

In the case of rate, 1.5 kg registered the highest Mean Plant Height across all the soil amendments followed by 1.0 and 0.5 kg.

Effect of soil amendments and rates with respect to mean plant height at 10 WAP

Analysis using ANOVA revealed significant differences (P<0.05) in mean plant height at 10 WAP with respect to soil amendment (Table 7).

For soil amendment, poultry manure recorded the highest mean plant height (309.00), followed by Palm Kernel Cake (PKC) (210.97), whilst the control plot recorded the least Mean Plant Height (178.77).

This is statistically at par with *G. sepium* and Biochar fertilizer. In the case of rate, 1.5 kg registered the highest Mean Plant Height across all the soil amendments followed by 1.0 and 0.5 kg.

Effect of soil amendments and rates with respect to mean leaf area at 4 WAP

Analysis using ANOVA revealed significant differences (P<0.05) in mean leaf area at 4 WAP with respect to soil amendment (Table 8). For soil amendment, poultry manure recorded the highest mean leaf area (518.67a), followed by Palm Kernel Cake (415.88b), and *G. sepium* (393.24), whilst the control plot recorded the least Mean Leaf Area (166.69e). In the case of rate, 1.5kg registered the highest mean leaf area across all the soil amendments followed by 1.0 and 0.5 kg.

Effect of soil amendments and rates with respect to mean leaf area at 6 WAP

Analysis using ANOVA revealed significant differences (P<0.05) in mean leaf area at 6 WAP with respect to soil amendment (Table 9). For soil amendment, poultry manure recorded the highest mean leaf area (603.65), followed by palm kernel cake (460.62), and *G. sepium* (302.75), whilst the control plot recorded the least mean leaf area (221.69d) which is statistically at par with Bio-char fertilizer. In the case of rate, 1.5 kg registered the highest mean leaf area across all the soil amendments followed by 1.0 and 0.5 kg.

Effect of soil amendments and rates with respect to mean leaf area at 8 WAP

Analysis using ANOVA revealed significant differences (P<0.05) in mean leaf area at 8 WAP with respect to soil

Table 8. Mean Leaf area (cm2) as affected by soil amendments and rates at 4 WAP.

Soil amendment	Rate of application (kg/plot)			Mean
	0.5	1.0	1.5	
Palm Kernel Cake (PKC)	283.37	451.74	512.54	415.88[b]
Poultry Manure (PM)	446.26	610.88	498.87	518.67[a]
G. sepium	228.66	347.65	603.42	393.24[c]
Bio char	237.96	243.41	279.67	253.68[d]
Control (0kg/plot)				166.69[e]
Mean	268.37	369.86	377.97	

Means column with the same letters has no significant difference at p<0.05.

Table 9. Mean Leaf Area (cm2) as affected by soil amendments and rates at 6 WAP.

Soil amendment	Rate of application (kg/plot)			Mean
	0.5	1.0	1.5	
Palm Kernel Cake (PKC)	419.81	425.62	536.42	460.62[b]
Poultry Manure (PM)	536.28	575.02	699.66	603.65[a]
G. sepium	246.40	267.34	394.50	302.75[c]
Bio char	229.96	284.22	299.83	271.34[d]
Control (0kg/plot)				221.69[d]
Mean	350.94	377.71	462.89	

Means column with the same letters has no significant difference at p<0.05.

Table 10. Mean Leaf Area (cm2) as affected by Soil amendments at 8 WAP.

Soil amendment	Rate of application (kg/plot)			Mean
	0.5	1.0	1.5	
Palm Kernel Cake (PKC)	412.01	533.70	736.74	560.82[b]
Poultry Manure (PM)	819.66	806.12	809.46	811.75[a]
G. sepium	457.80	433.04	401.62	430.82[c]
Bio char	89.92	122.22	947.90	386.68[d]
Control (0kg/plot)				347.59[e]
Mean	512.06	537.19	563.98	

Means column with the same letters has no significant difference at p<0.05.

amendment (Table 10). For soil amendment, poultry manure recorded the highest Mean Leaf Area (811.75a), followed by palm kernel cake (PKC) (560.82b), and *G. sepium* (430.82c), whilst the control plot recorded the least Mean Leaf Area (347.59e). In the case of rate, 1.5 kg registered the highest mean leaf area across all the soil amendments followed by 1.0 and 0.5 kg

Effect of soil amendments and rates with respect to mean leaf number at 4 WAP

Analysis using ANOVA revealed significant differences (P<0.05) in mean leaf number at 4 WAP with respect to soil amendment (Table 11). For soil amendment, poultry manure recorded the highest mean leaf number (14.67), followed by Palm Kernel Cake (PKC) (10.33b), and *G. sepium* (9.87), *G. sepium* was however statistically at per with Biochar. Whilst the control plot recorded the least Mean Leaf Number (8.82d). In the case of rate, 1.5 kg registered the highest mean leaf number across all the soil amendments followed by 1.0 and 0.5 kg.

Effect of soil amendments and rates with respect to mean leaf number at 6 WAP

Analysis using ANOVA revealed significant differences

Table 11. Mean leaf number as affected by soil amendments and rates at 4 WAP.

Soil amendment	Rate of application (kg/plot)			Mean
	0.5	1.0	1.5	
Palm Kernel Cake (PKC)	7.40	12.20	11.40	10.33[b]
Poultry Manure (PM)	16.60	13.80	13.60	14.67[a]
G. sepium	8.40	10.40	10.80	9.87[c]
Bio char	7.60	8.40	12.40	9.47[c]
Control (0kg/plot)				8.82[d]
Mean	10.50	11.00	11.26	

Means column with the same letters has no significant difference at p<0.05.

Table 12. Mean leaf number as affected by soil amendments and rates at 6 WAP.

Soil amendment	Rate of application (kg/plot)			Mean
	0.5	1.0	1.5	
Palm kernel cake (PKC)	8.20	11.60	11.20	10.33[b]
Poultry manure (PM)	17.00	14.60	12.60	14.73[a]
G. sepium	11.20	11.40	7.00	9.87[c]
Bio char	8.20	9.40	11.40	9.67[c]
Control (0kg/plot)				9.13[c]
Mean	10.45	10.80	11.80	

Means column with the same letters has no significant difference at p<0.05.

Table 13. Mean leaf number as affected by soil amendments and rates at 8 WAP.

Soil amendment	Rate of application (kg/plot)			Mean
	0.5	1.0	1.5	
Palm kernel cake (PKC)	8.80	11.40	10.60	10.27[b]
Poultry manure (PM)	11.40	10.20	10.00	10.53[a]
G. sepium	11.20	8.80	10.80	10.27[b]
Bio char	9.80	9.60	11.20	10.20[b]
Control (0kg/plot)	5.60	6.40	9.20	7.07[c]
Mean	9.25	9.20	10.15	

Means column with the same letters has no significant difference at p<0.05.

(P<0.05) in mean leaf number at 6 WAP with respect to soil amendment and rate (Table 12). For soil amendment, poultry manure recorded the highest mean leaf number (14.67), followed by palm kernel cake (PKC) (10.33), and *G. sepium* (9.87), *G. sepium* was however statistically at per with bio char and the control plot. In the case of rate, 1.5 kg registered the highest mean leaf number across all the soil amendments followed by 1.0 and 0.5 kg

Effect of soil amendments and rates with respect to mean leaf number at 8 WAP

Analysis using ANOVA revealed significant differences (P<0.05) in mean leaf number at 8 WAP with respect to soil amendment and rate (Table 13). For soil amendment, poultry manure recorded the highest mean leaf number (10.53), followed by palm kernel cake (PKC) (10.27) which is statistically at per with *G. sepium* and biochar, whilst the control plot recorded the least mean Leaf Number (7.07). In the case of rate, 1.5 kg registered the highest mean leaf number across all the soil amendments followed by 1.0 and 0.5 kg.

Effect of soil amendments and rates with respect to mean leaf number at 10 WAP

Analysis using ANOVA revealed no significant differences (P<0.05) in mean leaf number at 10 WAP with

Table 14. Mean leaf number as affected by soil amendments and rates at 10 WAP.

Soil amendment	Rate of application (kg/plot)			Mean
	0.5	1.0	1.5	
Palm kernel cake (PKC)	9.60	11.80	11.40	10.93[a]
Poultry manure (PM)	11.80	10.60	10.60	11.00[a]
G. sepium	12.00	9.20	11.00	10.73[a]
Bio char	11.20	11.75	9.20	10.72[a]
Control (0 kg/plot)				7.13[b]
Mean	10.65	10.70	11.19	

Means column with the same letters has no significant difference at p<0.05.

Table 15. Mean grain yield (kg) as affected by soil amendments.

Soil amendment	Rate of application (kg/plot)			Mean
	0.5	1.0	1.5	
Palm kernel cake (PKC)	0.93	0.80	0.76	0.83[a]
Poultry manure (PM)	0.36	0.60	1.64	0.86[a]
G. sepium	0.51	0.70	0.72	0.64[b]
Bio char	0.14	0.23	0.14	0.17[c]
Control (0 kg/plot)				0.17[c]
Mean	0.38	0.45	0.70	

Means column with the same letters has no significant difference at p<0.05.

respect to soil amendment and rate (Table 14). However, for soil amendment, poultry manure recorded the highest mean leaf number (11.00a), whilst the control plot recorded the least Mean Leaf Number (7.13b). In the case of rate, 1.5 kg registered the highest mean leaf number across all the soil amendments followed by 1.0 and 0.5 kg.

Effect of soil amendments and rates with respect to mean grain yield

Analysis using ANOVA revealed significant differences ($P<0.05$) in mean grain yield with respect to soil amendment (Table 15). For soil amendment, poultry manure recorded the highest mean grain yield (0.86), followed by palm kernel cake (PKC) (0.83), and *G. sepium* (0.64b), whilst the control plot and Bio char recorded the least mean grain yield (0.17). In the case of rate, 1.5 kg registered the highest mean grain yield across all the soil amendments followed by 1.0 and 0.5 kg.

DISCUSSION

Organic fertilizer can be produced from cheap sources, in this way, it is normally discarded in several ways, such as either being burned and or left unattended. As it may be, a few growers are mindful of the advantageous impacts of organic fertilizer and the discharge of plant nutrient that led to a favorable response to plant development. Maize farmers in and around the Moyamba district in the southern part of Sierra Leone and around several other communities are using organic manure to fertilizer crops. In Kori chiefdom, vegetable producers and gardeners commonly apply organic manure to their crops. Therefore, the use of organic fertilizers is a common practice in growing crops among these communities and some farmers around them. In any case, there seems to be little use of organic fertilizers nationwide, and little knowledge is available about the effects of fertilizers on crops.

Dissemination to farms requires detailed information about these organic fertilizers. Therefore, in this study, we seek to evaluate the response of maize grain yields to various organic fertilizer resources at different levels of fertilization.

The research data analysis result showed that the stem girth of the maize stalk at 4, 6 and 8 WAP (Tables 2 to 5) was significantly difference between treatments ($p < 0.05$), poultry manure plot had the largest stem girth around the main stalk of maize for several weeks, while the control plot had the smallest stem girth of maize for several weeks. This can be consistent with the discoveries of Anon (2002). He thinks that organic fertilizers are excellent fertilizer materials because they have a higher nitrogen, phosphorus and potassium content, more accessible than mineral fertilizers, and have a stabilizing effect on the soil, which slowly releases nutrition to crops and also improving soil chemistry.

Average height of maize at 4, 6, 8 and 10 WAP are presented in Table 6 to 9, it shows there is a significant difference between treatments ($p<0.05$). Poultry manure provided the highest average plant height in several weeks. The control plot represents the minimum average plant height. By applying more poultry fertilizers, the necessary nutrients are perfectly provided, and the physical, chemical and biological properties of the soil are improved as a result of which the absorption of nutrients is increased, the cell division and cell elongation of the meristem increases, and thereby improved on the performance of the plants in that plot. This result is similar with the result of Soro (2015) who stated that Poultry manure is widely used as organic fertilizer and it has significant effect on the soil fertility by adding both major and essential nutrients as well as soil organic matter which improve moisture and nutrient retention resulting in increased plant growth and increased size and number of fruits. Previous studies have also shown that the periodic application of organic amendments in an organic farming system can increase soil macroaggregate proportions (Zhang et al., 2020), soil organic matter (SOM) and total N (TN) levels (Liu et al., 2016; Guo et al., 2016), earthworm density (Guo et al., 2016), microbial biomass carbon (MBC) levels, microbial biomass nitrogen (MBN) levels, and enzymatic activities (Liu, 2010), which help to maintain crop yield and food quality (Liu et al., 2016).

Average leaf area of maize at 4, 6 and 8 WAP are presented in Tables 10 to 12, it shows there is a significant difference between treatments ($p < 0.05$). Poultry manure produced the highest average maize leaf area over a few weeks, while the control provided the lowest average maize leaf area over a few weeks. This may be because poultry manure was applied at the right time and at the right age, which can provide adequate higher doses of nitrogen and phosphorus, thereby improving the photosynthetic activity of plants in the plot. This is consistent with the findings of Dulac (1955), who reported changes in the mineral elements of corn, which varied with the age of poultry manure. Additionally, Kaiser (2006) reported that the higher phosphorus content in manure had a stimulating effect on the growth of maize plants. This difference could be confirmed by the lower leaf area in the control plot with little or no nitrogen content. Soro (2015) also report that Poultry manure has been widely used as organic fertilizer and it has significant effect on the soil fertility by adding both major and essential nutrients which are essential for maize plants, and increases maize growth and leaf area as well as soil organic matter which improve moisture and nutrient retention.

Tables 13 to 15 showed the average number of leaves for 4, 6, 8 and 10 WAP, respectively. The table shows that poultry manure showed significantly ($p <0.05$) the highest average leaf number in a few weeks, while the control had the lowest average leaf number of maize. This is because poultry manure contains high levels of nitrogen. Nitrogen is an important part of plant tissue and is beneficial for fast cell division and expansion. Together with sufficient amounts of phosphorus and potassium, it aids in cell division and rapid proliferation and Improves cell size development. This finding is consistent with the results of Kaiser (2006) who reported the higher concentration of phosphorus in manure and it has stimulatory effect of the corn plant growth and leaf number.

Table 15 shows the average weight (in kg) of maize grain after harvest. The results show that the average weight (kg) of the poultry manure plot was significantly ($p < 0.05$) the highest after harvest, and the average weight (kg) of the control maize was the lowest. This is because optimal application of organic matter can provide sufficient nitrogen, which plays an important role in providing energy for seed formation and filling of grains. This shows that using poultry manure as a nutrient source is superior to using it counterparts' manures and improves the time it takes for crops to absorb nutrients. Yes, Kaiser (2006) suggested that poultry manure is a good source of phosphorus that aids in the formation of maize crop seeds formation and has higher weight of 1000 seeds. Similarly, Kolawole (2014), reports that the duration of fertilization will have a significant effect on the yield of corn. According to Kolawole (2014), two weeks of poultry fertilizer application increases corn yield and soil phosphorus content.

CONCLUSION AND RECOMMENDATION

Results reveal that significant differences were observed for most of the traits by the application of different treatments in the study. Maximum plant height, stem girth, leaf number, leaf area, grain yield weight were obtained in treatments where poultry manure (PM) was applied followed by the Palm Kernel Cake (PKC) treatment.

It was also observed in the study that organic fertilizer showed positive response to yield and other plant growth traits of maize crop. Organic farming positively influenced all the essential and beneficial nutrients along with the retention of total organic matter. Quantitative increase of organic matter enhances water holding capacity of the soil which helps the nutrients mobility in soil.

The study indicates that poultry manure is a valuable fertilizer whose use needs to be encouraged. An application rate of 1.5kg/ha was capable of significantly increasing yields level over the control plot.

This study showed that poultry manure application needs to be encouraged for both sustainable soil fertility maintenance and optimum plant growth.

The application of organic manure highly increased plant height, number of leaves, stem girth and weight of maize grain after harvest.

Recommendation

The following recommendations are made Based on the findings of this research; this will serve as a guide to farmers in order to enhance the productivity of maize. When practice by farmers will increase their yield by applying different sources of organic manures at varied levels of application which will influence food security problems in Sierra Leone.

Farmers to use poultry manure and Palm Kernel Cake (PKC) as alternative sources of fertilizers for better yield and yield related traits of maize crop.

It may therefore be recommended that chicken manure at the rate of 1.5kg/ha is more suitable for maize production in the in valley swamp (IVS). Meanwhile, more research into poultry manure, especially rates and methods of application on different crops, and storage/ composting process, is needed. It can also be recommended that this trial be repeated in the second growing season to confirm this result.

CONFLICT OF INTERESTS

I wish to declare that this is our original article generated from our research in our Crop Science Department in the School of Agriculture and Food Science Njala University, Sierra Leone. I wish to state that no conflict of interest could arise.

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