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Effects of Organic Manures on Soil Properties and Performance of Maize and Aerial Yam Intercrop

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Abstract
Aerial yam and maize are important crops that require adequate nutrient management to achieve optimum yield. Study for soil management on aerial yam is particularly low hence the effect of poultry manure on the growth and yield of aerial yam and maize were evaluated in sole and intercrop farming pattern. Treatments were sole maize (SM), sole aerial yam (AY), aerial yam and maize intercrop (A+M), and four levels of poultry manure: 0 tons/ha (Control), 5 tons/ha (PM_5), 10 tons/ha (PM_{10}), and 15 tons/ha (PM_{15}). The experiment was a 3 x 4 factorial in a randomized complete block design (RCBD) in 3 replicates. Changes in soil properties, growth indices and yield were measured. Results showed that bulk density (BD), total porosity, saturation water content and saturated hydraulic conductivity (Ksat) of the soil were significantly improved by the application of poultry manure compared to the control. After treatment application, mean value of bulk density 1.4 and 1.43 g cm^{-1} respectively for PM_{10} and PM_{15} compared to initial value of 1.57 g cm^{-3}. The 15 tons/ha gave the most rapid permeability class for the 3 cropping patterns and followed the same pattern for the values of total porosity, mean weight diameter (MWD) of water stable aggregates and saturation water content. Significant ($p<0.05$) increases in chemical properties and growth and yield of the plants both in intercrop and sole for the PM_{10} and PM_{15} treatments.

Key words: *Poultry manure, spent mushroom substrates, soil properties, crop yield, land equivalent ratio*

Introduction

Soil nutrient depletion and likely fertility degeneration are becoming topical issues among the major causes of decline in crop yield and per-capita food production (Henao and Baanante, 2006). Poor cultivation practices such as continuous cropping could result in low soil fertility through reduction in soil organic matter (SOM), and increase in soil acidity (Aihou *et al*., 2008). In recent times, due to the high cost of inorganic fertilizers, nature of our soils and inherent low nutrient conversion efficiency (AGRA, 2007), attention has moved to organic manures as a superior option.

Beneficial effects of organic soil amendments have been reported to include decrease in soil bulk density, increase in water holding capacity, aggregate stability, saturated hydraulic conductivity, water infiltration rate and biochemical activities (Martens and Frankenberger, 1992; Turner *et al*; 2007). Organic material contributes directly to the building block of SOM, which performs diverse functions in improving the soil physical, chemical and biological properties. The maintenance and management of SOM in a cropped field are central to sustaining soil fertility (Woomer and Swift, 2004).

On the other hand, intercropping is a type of mixed cropping which defined the agricultural practice of cultivating two or more crops in the same space at the same time (Seran and Brintha, 2010). The most important reason of growing two or more crops together is to increase yield per unit area of land and minimize risk of crop failure (Woolley and Davis, 1991). This way, the biological efficiency of intercropping due to exploration of large soil mass cannot be compared to that of mono-cropping (Francis, 1999).

Aerial yam (*Dioscorea bulbifera* L) and maize (*Zea mays* L) are among the high yielding crops in the tropics and sub-tropical regions if adequate soil and nutrient management are provided (Chaudhary, 2003). Low soil fertility is a constraint for enhancing maize and aerial yam productivity because they are high nutrient demanding crops (O'Sullivan and Ernest, 2007). They require well drained soils with optimal moisture regime, sufficient and balanced quantities of required plant nutrients. Maize is a relatively short duration crop and capable of utilizing inputs, more efficiently and potentially capable of producing large quantity of food grains per-unit area (Kamara *et al*., 2014). Aerial yam, otherwise called air potato is one of the most common and wide spread yams of the tropics, grown chiefly for its edible aerial tubers. It is the only edible yam specie native to both Asia and Africa. The African varieties are so distinct from the Asian that their distribution must have taken place in pre historic times (Coursey, 1967).

Maize has received relatively major global scientific attention to improve yields, but most of the studies have been on the use of inorganic fertilizers (Farnham *et al.*, 2003; Hobbs, 2003; McCutcheon, 2007). On the other hand, despite the enormous potential of *D. bulbifera,* the crop is still almost totally neglected, and there is little or no information on the use of organic fertilizers to improve growth and yield of the crop (Morisawa, 1999). Besides planting aerial yam in between other tuber crops as commonly found in farmers' plots, there is the need to intensify studies on the use organic waste such as poultry manure to improve growth and yield this crop. Thus, this study was carried out to determine the effects of different rates of poultry manure on yield and productivity of aerial yam and maize crops in intercrop. The study also evaluated changes in some physical and chemical properties of soil as influenced by the application of poultry manure. This would augment existing information on maize and aerial yam research and reduce dependency on inorganic fertilizers which may induce soil dispersion and reduce soil quality.

Materials and Methods

Study Area and Experimental Design

The field experiment was carried out at the University of Port Harcourt, Faculty of Agriculture, Teaching and Research Farm (04º 15´N; 07º 30´E), in the southern agro-ecological zone. The climate is of the hot humid tropical climate with mean annual seasonal rainfall of about 2400 mm, which can support cultivation of maize and aerial yam (NIMET, 2012). The soil is sandy loam with sand content above 70% at 0-15 cm topsoil (Table 1). Total porosity, water holding capacity and aggregate stability were low. The experiment was laid out as a 3 x 4 factorial in randomized complete block design (RCBD) in 3 replications. Treatments consisted of three (3) cropping patterns viz: sole aerial yam (AY), sole maize (SM), and intercrop aerial yam and maize (A+M), and four rates of poultry manure: 5 tons ha^{-1} (PM_5), 10 tons ha^{-1} (PM_{10}), 15 tons ha^{-1} (PM_{15}) and control without poultry manure (Pm_0). The net experimental area was 0.98 ha which consisted of 48 plots, with 0.5 m spacing between plots, and 1 m between blocks.

Application of Treatments and Planting

Poultry manure was applied and incorporated into the soil and allowed for incubation for 14 days after which planting of the crops were carried out. Planting was done at a distance of 1 m x 1 m for the sole aerial yam sets and 0.50 m x 1 m for the sole maize. The maize was planted in between rows of aerial yam in the intercrop. Planting was done in May 2016. The aerial yam was trained as soon as the vines were long enough to climb the stakes.

Soil Sampling and Crop Data Collection

Undisturbed and disturbed soil samples were collected at 0-15 cm depth at the beginning and end of the experiment. Metal cores were used for collecting the undisturbed samples while a soil auger was used for collection of disturbed soil samples. A total of 48 core samples and 48 representative bulk samples were collected. The bulk samples were air dried at room temperature, sieved through 2 mm mesh and stored in well labeled containers for laboratory analyses. Data on plant height and lea area index (LAI) were collected at 4, 8, and 12 weeks after planting (WAP)

Determination of total leaf area and leaf area index

Total leaf area was calculated as the product the apparent leaf area and correction factor and multiplied by the number of leaves in each plant. Where, apparent leaf area was obtained by multiplying the maximum length by maximum width of the leaf (Shih and Gascho, 1980). Leaf area index was derived by dividing the total leaf area (La) by the ground area P. Where;

$$\text{LAI} = \frac{La}{p} \quad (1)$$

LAI is dimensionless.

Laboratory Analysis

Water stable aggregates

Water stable aggregate by wet-sieving was determined by the method as described by Kemper and Rosenau (1986). In this procedure, bulk soil samples were air-dried and sieved to obtain < 4.75 mm natural aggregates. Fifty grams (50 g) of dry-sieved aggregates were placed on the top most of sieves of different openings sizes 2.0 mm,1.0 mm,0.5 mm and 0.25 mm, pre-soaked by capillary in distilled water for 5 minutes before oscillated vertically in distilled water 20 times. The stable aggregates remaining in each sieve were oven-dried at 50º C for 24 h and weighed. The mass of aggregates <0.25 mm were obtained by the difference between initial mass of sample and the sum of sample weights collected on the 2.0 mm,1.0 mm,0.5 mm and 0.25 mm nest of sieves. The percentage stable aggregates on each sieve represented the water stable aggregate (WSA) was calculated as;

$$\%\text{WSA} = \frac{MR}{MT!} \times \frac{100}{1} \quad (2)$$

where, MR is the mass of resistance aggregates and MT is the total mass of wet-sieved soil.

Mean weight diameter (MWD) of water stable aggregates was calculated by the following equation (Hillel, 2004):

$$\text{MWD} = \sum_{i=1}^{n} \text{XiWi} \quad (3)$$

where, X_i is the mean diameter of each size fraction, and W_i is the weight of aggregates in that size range as a fraction of the total dry weight of the sample analyzed.

Saturated hydraulic conductivity

Saturated hydraulic conductivity (K_{sat}) was determined by the constant-head core technique as described by Reynolds *et al*. (2002). In this method, leachate volume was measured overtime until flow was constant at each time and the final flow rate was determined using the equation.

$$\mathrm{Ksat} = \frac{Q}{AT} \times \frac{L}{\Delta H} \qquad (4)$$

where, Q is the volume of water that flows through a cross sectional area A (cm^2) over a period of time T. L is the length of core in cm and ΔH is the hydraulic head difference in cm.

Bulk Density, Moisture Content, Total Porosity and Particle Size

Bulk density was determined using soil core samples after oven drying the soil at 105ºC using the method of Grossman and Reinsch (2002). Moisture content at saturation after 24 hours was calculated using the formula:

$$\mathrm{WHC} = \frac{Mw - Md}{Md} \qquad (5)$$

where, is the gravitational water content (g g^{-1}), Mw is mass of wet soil and, Md is the mass oven-dried soil. Total Porosity was determined using the proposed method of Flint and Flint (2002). Particle size distribution was determined by the method of Gee and Bauder (1986) after soil dispersion with sodium hexametaphosphate.

Total Nitrogen, Organic matter and pH

Total nitrogen was determined by the modified macro Kjeldehl procedures as described by Bremner and Mulvaney (1982). Total organic carbon was determined by Walkley and Black wet dichromate oxidation method (Nelson and Somners, 1996) and was converted to organic matter by multiplying the organic carbon values by the Van Bemmelen factor of 1.724 (Van der Ploeg *et.al;* 1999). Soil pH was measured with a glass electrode in a 1:2.5 soil water solution (McLean, 1982).

Available Phosphorus and Cation Exchange Capacity

Available Phosphorous was measured by the Bray II soil extraction procedure. Cation exchange capacity (CEC) was determined by the Ammonium acetate displacement method.

Table 1: Some physico-chemical properties of the top soil (0-15 cm) of the site before planting and poultry manure.

Properties	Units	Soil	Poultry manure
Sand	%	73	-
Silt	%	20	-
Clay	%	77	-
Textural class	-	Sandy loam	-
Bulk density	g/cm^3	1.57	-
Total porosity	%	21.8	-
Water holding capacity	%	14	-
Ksat	cm hr^{-1}	6.36	-
Permeability class	-	Slow	-
Mean weight diameter	Mm	0.6	-
pH (H_20)	-	5.20	7.5
Available P	mg kg^{-1}	48.5	-
Total N	g/kg	0.07	4.08
Organic matter	g/kg	1.50	22.2
CEC	C mol kg^{-1}	2.75	-
Base saturation	%	65.09	-
C:N ratio	-	12.4	3.2

CEC- cation exchange capacity

Data analysis
A two-way analysis of variance was carried out using the SAS software (SAS, 2001), and the least significant difference (LSD) of the treatment means was determined at 5% probability. Land equivalent ratio (LER) was used to determine the relative land area required by the sole crop to produce same yields as intercrop and also to determine the yield advantage of the intercropped to the sole plots.

Results and Discussion

Effects on Soil Physical Properties

Results in Table 2 showed that treatments had significant modifications on saturated hydraulic conductivity (Ksat), total porosity (TP), mean weight diameter of water stable aggregates (MWD), and water content (WC) of the soils and non-significant effect on dry bulk density (BD). Significant effects ($p<0.05$) were found in all the measured parameters in PM_{15} for aerial yam- maize intercrop (A+M). For example, MWD of water stable aggregates increased from 0.81mm in control plots to 1.35 mm in PM_{15}. Similarly, TP and Ksat were 41.13% and 39.11 cm h^{-1} respectively, compared to values as low as 22.09% and 13.78 cm h^{-1} respectively, for the control plots.

The results further showed that PM_{10} and PM_{15} did not differ ($p>0.05$) in their effects on these physical properties, although there were marginal increases for PM_{15} in both sole and inter cropping systems. Also sole maize (SM) and sole aerial yam (AY) did not have significant improvement on the dry bulk density most probably due to low soil organic matter (SOM) usually associated with maize crop and aerial yam (Udom and Anozie, 2018; Bokhtiar and Sakurai, 2005; Farnham et al., 2003. Improvement in WC, Ksat and MWD was not surprising; rather it was consistent with previous studies that application of organic manure such as poultry manure improved soil physical properties to some extent (Udom and Lale, 2017). On the other hand, a combined organic litter from aerial yam and maize was responsible for the improvement in bulk density and other parameters for A+M plot. This further confirm that farming practices that encourage deposition of organic litter helped in positive modifications of soil physical conditions (Udom and Ogunwole, 2016; Eskadari, 2012).

Effects on Soil Chemical Properties

Treatments showed non-significant ($p>0.05$) on soil pH with values ranging between 4.7 and 5.5 (Table 3). Soil organic matter was significantly higher due to application of 15 t ha^{-1} poultry manure (PM_{15}) for A+M and SM plots while non-significant marginal increases in total N was found in similar plots. The combined plant litter in the case of A+M and maize stalk may have led to the increase in SOM, while total N was depleted by the maize crop. These results confirmed widely speculated assertions that maize and yams are soil exhaustive crops (Dikinya and Mufwanzala, 2010; Bokhtiar and Sakurai, 2005).

Table 2. Effects of poultry manure rates on soil physical properties at the end of experiment

Treatments	BD ($g\ cm^{-3}$)	Ksat ($cm\ h^{-1}$)	Total porosity (%)	MWD (mm)	WC ($g\ g^{-1}$)	Permeability Class
			A+M			
PM_5	1.57	23.78	32.09	0.92	0.34	Moderately rapid
PM_{10}	1.57	28.38	40.17	1.34	0.36	Rapid
PM_{15}	1.46	39.11	41.13	1.35	0.38	Rapid
Control	1.55	13.78	22.09	0.81	0.24	Slow
LSD(0.05)	NS	10.41	8.46	0.39	0.11	
			SM			
PM_5	1.49	22.42	26.9	0.92	0.32	Moderately rapid
PM_{10}	1.54	23.0	23.05	1.10	0.35	Moderately rapid
PM_{15}	1.52	29.54	33.04	1.34	0.37	Rapid
Control	1.55	14.3	24.98	0.82	0.20	Slow
LSD(0.05)	NS	10.31	7.03	0.32	0.11	
			AY			
PM_5	1.49	23.8	28.82	0.88	0.31	Moderately rapid
PM_{10}	1.4	28.3	24.98	1.24	0.38	Rapid
PM_{15}	1.43	28.3	26.9	1.32	0.39	Rapid
Control	1.54	14.5	24.98	0.85	0.26	Slow
LSD(0.05)	NS	5.89	2.15	0.35	0.10	

NS- non- significant at $p>0.05$, BD-bulk density, Ksat- saturated hydraulic conductivity, MWD- mean weight diameter, WC-water content

Table 3. Effects of poultry manure on soil chemical properties in sole and Intercropping at the end of experiment

Treatments	pH(H_2O)	Avail. P ($mg\ kg^{-1}$)	Total N ($g\ kg^{-1}$)	OM ($g\ kg^{-1}$)	CEC ($C\ mol\ kg^{-1}$)
		A+M			
PM_5	4.7	22.1	1.1	15.0	6,59
PM_{10}	5.2	27.5	1.4	18.0	7.06
PM_{15}	5.2	28.7	1.5	19.0	8.88
Control	4.7	18.4	1.0	6.0	4.98
LSD(0.05)	0.4	8.31	NS	2.55	1.33
		SM			
PM_5	4.7	15.1	0.98	18.3	5.67
PM_{10}	5.0	19.8	0.8	19.5	5.77
PM_{15}	5.0	25.0	0.9	29.0	6.02
Control	4.6	9.8	0.8	10.3	4.33
LSD(0.05)	NS	7.48	NS	8.15	1.16
		AY			
PM_5	5.5	17.5	1.0	13.0	4.26
PM_{10}	5.2	17.8	1.3	10.0	4.89
PM_{15}	5.2	21.9	0.98	11.9	5.76
Control	5.2	5.9	0.6	8.3	4.27
LSD(0.05)	NS	8.75	0.5	NS	1.02

NS- non-significant at $p>0.05$, OM- organic matter, CEC- cation exchange capacity

The soil inherently had sufficient available P which significantly depleted by cropping. For example, in A+M soil, available P decreased from the initial value of 48.5 mg kg^{-1} (Table 1) to 9.8 and 8.75 mg kg^{-1} in SM and AY plots respectively, where poultry manure was not applied (Table 3). However, application of 15 t ha^{-1} PM augmented the available P contents by 155.1% and 271.2% respectively in these plots, indicating continuous cropping without application of manures and/or fallow depletes soil fertility in southern Nigeria (Udom and Ogunwole, 2015; Udom *et al*., 2013)

Cation exchange capacity showed superior increases ($p<0.05$) for PM_{15} in all the plots compared to the Control. Values were 8.88, 6.02 and 5.76 C mol kg-1 soil respectively for A+M, SM and AY plots, corresponding to 80, 39 and 35% increases over the Control (Table 3). This result further confirmed that, like other organic manures, poultry increased SOM and CEC due to proliferation of negative charges at the exchange site (Dikinya and Mufwanzala, 2010. Esawy *et al*., 2009).

Plant Height and Leaf Area Index

The effects of manure growth parameters of the maize and aerial yam are shown in Tables 4 and 5. At 4 WAP, the maize plant showed significant ($p<0.05$) response to treatment and across treatments (Table 4). There was non-significant different in height of aerial yam across the treatments, indicating the slow growth of the crop at aerial yam at establishment growth stage. The highest plant height for sole maize was 78.9 cm which reduced significantly to 68.3 cm (13.5%) for PM_{15} due to intercropping. Similar reductions in heights of maize were obtained across treatments for intercropping. Competition for nutrients and temperature effects may have been responsible for the reduction in plant height, consistent with Mazaheri *et al*. (2006); Mahaptra (2011). The height of maize plant and aerial yam increased significantly ($p<0.05$) from week to weeks for both sole and intercropped.

At 12 WAP, maximum heights of maize PM_{15} treatment were 225.3 cm and 216.3 cm for intercropping and sole, most probably due to completion for light. As the age of the maize plant increased at 12 WAP, the plant canopies tend to increase leading to competition for sunlight which invariable led to elongation of the leaves and consequently, the height of plants. Aerial yam responded favourably to poultry manure application. The PM_{15} consistently favoured the growth of aerial yam. At 8 WAP, growth in height of aerial yam was in the order of PM_{15} > PM_{10} > PM_5 > control. Sole aerial yam showed consistent increase with weeks after planting while there was marginal effect in growth due to intercropping.

Table 4: Effects of poultry manure on plant height (cm) of maize and aerial yam in sole and intercropping

Treatments	Sole maize	Maize in intercrop	Sole aerial yam	aerial yam intercrop
		4 WAP		
PM_5	58.5	53.8	37.4	31.2
PM_{10}	67.4	58.5	80.5	36.6
PM_{15}	78.9	68.3	59.7	39.7
Control	47.9	30.2	45.6	32.7
LSD(0.05) maize = 18.06, maize x PM = 19.59, PM = 4.78, Aerial yam = NS, aerial yam x PM = NS				
		8 WAP		
PM_5	168.4	135.7	109.7	105.8
PM_{10}	167.9	144.5	141.1	109.8
PM_{15}	209.1	175.8	233.5	175.6
Control	126,7	66.8	103.2	80.2
LSD(0.05) Maize = 21.05, maize x PM = 27.2, PM = 5.17, aerial yam = 24.11, aerial yam x PM = 8.66, weeks = 3.16, week x PM = 3.53				
		12 WAP		
PM_5	178.0	180.6	151.2	104.0
PM_{10}	173.1	195.6	167.1	126.9
PM_{15}	216.3	225.3	162.9	157.2
Control	133.0	82.1	124.8	96.4
LSD(0.05) Maize = 35.81, maize x PM = 31.45, PM = 4.94, aerial yam = 38.66, aerial yam x PM = 7.94, weeks = 2.96, weeks x PM = 4.61				

At 8 WAP, sole maize attained a maximum leaf area index (LAI) of 5.2 for PM_{15} and decreased to 4.8 for the same treatment at 12 WAP. This explained that maize and similar plants usually attain maximum LAI during the vegetative growth period and decline towards yield formation and maturity periods (Udom *et al*., 2016). On the other hand, sole aerial yam attained maximum LAI of 3.1 at 12 WAP for PM_{15}, and increased marginally to 3.4 in intercropping. While LAI of sole maize at 8 WAP was high enough to protect the soil from raindrop impact, consistent with Udom *et al*. (2016), sole aerial yam did not did produce sufficient LAI to protect the soil. Therefore, erosion risk index (ERI) would tend to be higher aerial yam is cultivated as sole crop.

Table 5: Effects of poultry manure on leaf area index of maize and aerial yam in sole and intercropping

Treatments	Sole maize	Maize in intercrop	Sole aerial yam	aerial yam intercrop
		4 WAP		
PM_5	1.8	1.6	1.5	1.4
PM_{10}	1.9	1.6	1.9	1.7
PM_{15}	2.9	2.6	2.2	2.3
Control	1.2	0.5	1.3	1.0
LSD(0.05) maize = NS, maize x PM = NS, PM = NS, Aerial yam = NS, aerial yam x PM = NS				
		8 WAP		
PM_5	4.0	2.1	1.4	1.5
PM_{10}	4.4	3.7	1.9	1.5
PM_{15}	5.2	3.8	2.5	1.7
Control	3.4	1.3	1.5	0.5
LSD(0.05) Maize = 1.21, maize x PM = 1.16, PM = 1.46, aerial yam = NS, aerial yam x PM = 1.41, weeks = 1.41, week x PM = 1.84				
		12 WAP		
PM_5	4.5	3.9	2.2	1.7
PM_{10}	4.9	4.3	3,0	1.9
PM_{15}	4.8	4.6	3.1	3.4
Control	4.3	3.5	2.8	1.5
LSD(0.05) Maize = NS, maize x PM = 1.01, PM = 1.03, aerial yam = 1.05, aerial yam x PM = 1.11, weeks = 1.06, weeks x PM = 1.19				

At 8 WAP, sole maize attained a maximum leaf area index (LAI) of 5.2 for PM_{15} and decreased to 4.8 for the same treatment at 12 WAP. This explained that maize and similar plants usually attain maximum LAI during the vegetative growth period and decline towards yield formation and maturity periods (Udom *et al*., 2016). On the other hand, sole aerial yam attained maximum LAI of 3.1 at 12 WAP for PM_{15}, and increased marginally to 3.4 in intercropping. While LAI of sole maize at 8 WAP was high enough to protect the soil from raindrop impact, consistent with Udom et al. (2016), sole aerial yam did not did produce sufficient LAI to protect the soil. Therefore, erosion risk index (ERI) would tend to be higher aerial yam is cultivated as sole crop.

Effects on Yield and Land Equivalent Ratio

There was significant ($p<0.05$) yield response of both maize and aerial yam to PM_{10} and PM $_{15}$ (Table 6). Sole maize was 3.55 and 3.06 kg m^{-2} for PM_{15} and PM_{10} respectively. Aerial yam also showed yield response to the application of poultry manure. Sole aerial yam produced 2.7 and 2.2 kg m^{-2} for PM_{15} and PM_{10} respectively. Increasing soil organic matter (SOM) and humus provided by the poultry manure may have contributed to the high yield increase of maize and aerial yam in manure-applied plots compare to the control. Previous studies such as that of Esawy *et al*. (2009) had found that excellent substrate provided by the humus was responsible for significant crop yield improvement in soil that received organic manure. Land equivalent ratio (LER) which usually describe the yield advantage of intercropping were 1.2, 0.68, 0.99 and 0.96 for PM_5, PM_{10}, PM_{15} and control respectively. Values showed that there was generally no yield advantage in yield for intercropping, indicating that sole maize and aerial yam should be the dominant practice.

Table 6: Effects of rates poultry manure rates on crop yield and land equivalent ratio

Treatments	Yield (kg m-2)				LER
	Sole maize	Maize intercrop	Sole aerial yam	Aerial yam intercrop	
PM_5	1.84	1.3	1.4	0.7	1.2
PM_{10}	3.06	1.79	2.2	0.2	0.68
PM_{15}	3.55	2.98	2.7	0.4	0.99
Control	1.01	0.97	0.97	0.0	0.96

LSD(0.05) Maize = 1.03, maize x PM = 1.89, PM = 1.11, Aerial yam = 1.01, Aerial yam x PM = NS, LER- leaf equivalent ratio

Conclusion

The study revealed that application of poultry manure generally improved the soil physical and chemical properties for growth and productivity of maize and aerial yam. The 15 tons ha^{-1} of poultry manure showed higher improvement for sole maize, whereas, 5 tons ha-1 showed the highest improvement on yield parameters of aerial yam. The PM_{15} was adequate to give high grain yield of maize and aerial yam tubers in this soil. However, 10 tons ha^{-1} poultry manure can be used for cultivation of sole maize, since there was no significant different in performance between PM_{15} and PM_{10}. Land equivalent ration (LER) indicated that intercropping maize and aerial yam did not show significant yield advantage. At 8 WAP, PM_{15} gave the maize crop a maximum leaf area index (LAI) which can protect the soil from rain drop impact.

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