Evaluating The Contribution Of Poultry Manure Application For Sustainable Crop Yield In Cassava (*Manihot Esculenta*)Based Cropping Systems.

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Abstract: The contribution of Poultry manure (10 t ha-^{1}) for sustainable crop yield in cassava based cropping systems (Cassava + Maize, Cassava + Melon, Sole Cassava etc), was evaluated for 5 years of continuous cropping in 2004, 2005, 2006, 2007 and 2008 growing seasons, at Imo State Polytechnic, Ohaji, Nigeria. A split – plot treatment arrangement fitted into Randomized Complete Block design with 3 replicates was used. The seed yield of melon in cassava / melon intercrop was progressively high at 10 t ha^{-1} of poultry manure application with peak (7.8 $^{-1}$) at the 4th and 5th year of planting while in maize + melon intercrop, and melon sole crop, the highest seed yields were recorded at the 3rd year of planting, 6.3 t ha $^{-1}$ and 6.5 t ha^{-1} respectively. The highest root yield (44.2 t ha^{-1}) of cassava was recorded at the 5th year of cropping in cassava/melon intercrop and 10 t ha^{-1} of poultry manure application but in cassava/maize system and sole crop cassava, the highest root yields, (25.8 t ha^{-1}) and(35.6 t ha^{-1}} were recorded at the 4th year of cropping. Irrespective of cropping systems, maize yield peaked at the 4th year of cropping. The highest LER (1.56)in cassava/melon mixture was recorded at the 5th year of cropping while that of cassava/maize (1.39) was recorded at the 4th year of cropping. Soil fertility was effectively sustained up to the 4th year of continuous cropping except in melon plots where it was maintained up to the 5th year with 10 t ha-^{1} of Poultry manure application. [Report and Opinion. 2009;1(6):77-86]. (ISSN: 1553-9873).

Key words: Intercropping, Poultry manure, sustainable crop yield.

Introduction

The use of poultry manure as an alternative to chemical fertilizer by rural farmers, in the South Eastern Nigeria is increasingly becoming popular because of non availability of conventional chemical fertilizers.

This popular choice of poultry manure over other organic manures may be associated with the ease involved in handling it. The manure is readily available and a bag of it (50kg) cost less than a dollar compared with the chemical fertilizer (N – P – K 20:10:10), a bag (50kg) of which cost about 4 dollars in the south eastern part of Nigeria.

Chemical analyses of the poultry manure showed that it contains the basic essential elements needed by crops in reasonable quantity more than some other organic manures and may thus form good alternative to compound chemical fertilizer, like N-P-K fertilizer, especially in the South Eastern Nigeria ,where the soil is heavily acidic (pH < 4.0) due to continuous cropping, improper and continuous application of chemical fertilizers. The use of inorganic fertilizer has been known to increase yam nematode population (*Obigbesan and Amalu 1985*), causes profuse weed growth (*Onochie 1975*) and nitrogen non-point pollution and acidification (*Agboola 1981*).

The superiority of Poultry manure over other organic manure has been confirmed *Hsich and Itsu (1993*) and Janadasa et al *(1997*) have reported that poultry manure application increased soil pH, organic matter, available phosphorus, exchangeable iron. *Djakoto and Stephen (1961)* observed that there was residue of “unexplained benefit” that occurred from the use of poultry manure which was probably connected with the balanced nutrient reserves slowly released during crop growth by the decomposition of the manure.

This unexplained benefit " of poultry manure which was connected with balanced nutrient reserves slowly released may lead to sustainable crop yield.

Poultry manure at much higher rates (10 – 50 tones/hectare) has been reported to give optimum response of marketable yield of *Corchorus olitorus* (*Adejoro 1999*), Cabbage (*Hochmuth et al 1993*), peppers, egg plants, tomatoes and Okra (*Maynard 1991*; *Hussein 1997 and Arotolu 1988.*

I. The present report forms parts of the series of experiments carried out to 1 assess the potential fertilizer value of poultry manure as lt affects the growth performance of the selected crops in cassava based cropping system,

ii. evaluate its effectiveness in sustaining the yields of the selected crops at a higher dose of application

iii. evaluate the incidence of weeds in respect of poultry manure application.

iv. determine its impact on soil physico-chemical properties and

v. assess the cost benefit ratio of each cropping systems as affected by poultry manure.

Materials And Methods

The field trials were conducted during the rainy (March - october) season of 2004, 2005, 2006, 2007, 2008, at the Research farm of Imo State Polytechnic, Umuagwo (Long. 07^{0}0E and Lat. 07^{0}07E). The soil of the experimental site is sandy loam in texture and contained pH 4.5 and organic carbon 0.51%. The soil N(g/kg), P(ppm) and K(cMol./Kg) were 0.31, 7.93 and 0.11 respectively. The region has a hot humid tropical climate and receives 1030mm ralnfall annually. A major part of the rain is received during April – October.

Randomized Complete Block Design (RCBD) with 3 replicates was used. The treatments, Poultry manure 0, 10 t ha^{-1} and Cropping systems (Cassava + Maize, Cassava + Melon, Sole Cassava, Sole maize and sole melon) were combined by split – plot treatment arrangement and fitted into the design used (RCBD). Thus a total of 10 treatment combinations as shown in Table I were used.

The Poultry manure was assigned to the main plots and the crop combinations assigned to the sub plots. Each block or replicate contained 10 plots, giving a total of 30 plots in the whole experiments. Each plot measured 3m x 4m separated from each other within the block of 50cm alley and between blocks by one meter access route.

Samples of the poultry manure were subjected to chemical analysis and the results were presented in Table 2.

The experimental site was under a two year fallow after a two year continuous production of *Telfaria occidentalis* and *Solanum species*.

In the first year of the trial, 2004, the experimental site was cleared, ploughed and experimental plots established. In subsequent years, clearing was done plot by plot. After clearing, the debris including the residues of the various crops which were left after their harvestable portions had been harvested were ploughed into the soil within each plot.

Both cassava and the companion corps were planted on the same day. The cassava cuttings (20cm) were planted slanting at the spacing of 1m x 1m giving a population of 10,000 stands/ha. Planting spacing for melon was 50cm x 50cm giving a population of 40,000 stands/hectare while that of maize was 90cm x 90cm giving a population of 12,345.7 stands/ha. Each plot received 12kg of Poultry manure. Based on the randomization scheme, the manure was spread uniformly on the appropriate plots and then manually incorporated into the soil by tilling to a depth of 30cm using garden fork. Planting was done, 4 days after manure incorporation thereby allowing the manure to set properly.

The farm was weeded manually using hoe, only once at 4 weeks after planting. Samples of weeds were collected using 1m x 1m quadrant, dried and weighed for all treatments for the 5 years of the trials. The weeds were oven dried at 60^{0}c for 30 hours and then weighed. The

alleys of the experimental site were slashed as the weeds come.

Data collection on weed biomass was at every fourth week starting from 4 WAP till 44th WAP. Parameters assessed were root yield of cassava, seed yield of maize and seed yield of melon. Post harvest soil physico-chemical properties of the experimental site were carried out to determine the nutrient status of the soil after each harvest for the five years of the experiment.

Mixture productivity of the various crop mixtures were evaluated to determine whether there was yield advantage in the intercropping systems compared to the sole crops of the individual crops.

Statistical analysis of data collected were carried out using standard analysis of variance(*Anyeagbu 1995*), *Gomez and Gomez (1984)*. The significance of the treatments was determined using standard f-test. To determine the significance of the difference between the means of the treatments, least significant difference (LSD) was computed at the 5% probability level.

Results And Discussion

Soil

The result of the pre- planting soil analysis of the experimental site is shown in Table 3 while the Post harvest soil chemical analysis is shown in Table 10. In all control plots except that of melon plots, the soil after 5 years of continuous cropping became highly acidic less than pH 4.0. Thus continuous cropping on a particular piece of land without any form of conservation renders the soil useless. The soils in these control plots were also low in nutrient contents after the 5 years of cropping. Conversely, the post harvest soil chemical properties showed that application of poultry manure increased the pH status of the soil. Thus application of poultry manure at the rate of 10 t ha^{-1} improved and sustained soil pH for the 5 years of continuous cropping. The mechanism responsible for the neutralization of acidity by organic manure has been proposed by several workers (*Bessho and Bello 1992*, *Yan et al 1993*, *Pocknee and Summer 1997* ,that increase in soil pH obtained on addition of organic materials to the soil was as a result of ion exchange reactions in which the terminal OH^-s of AL or Fe^{++} hydroxyl oxides are replaced by organic anions which are decomposition products of the manure such as Malate, Citrate and Tartrate. *Bessho and Bello (1992*) suggested that the ability of organic manure to increase soil pH was due to the presence of basic cations contained in the organic manure. *Natsher and Schwetnnann (1991)* reported that such basic cations could only be released upon microbial decarboxylation.

The observed (Table 10) improvement in Nitrogen, available phosphorus, organic carbon etc of residual soil nutrient status at 5 years post harvest period in poultry treatments confirmed earlier work by *Sauerlandt and Tietjen (1970), Hiscard 1993*, *Janadasa et al 1997* ,that residual effect of manure, could last well into the third or fourth year of cropping. Thus obtaining a 4 to 5 years sustained soil fertility with application of 10 t ha^{-1} of poultry manure in this trial, confirmed that the report of *Godfery (1976*) of farm yard manure produced a sustained increased in Carbon content.

Component Crop Yields

Melon Application of poultry manure significantly (P>0 05) increased the seed yield of melon, (Table 4). Irrespective of cropping systems, the seed yield of melon in all control plots dropped after 3 years of cropping. The resultant trend was an indication that melon alone could not sustain the soil fertility for a long period of time. In all cropping systems, the seed yield of melon stands received poultry manure increased linearly up to 5th year of cropping. Perhaps the effectiveness of the residual effects of poultry manure was further enhanced by melon. In cassava/melon intercrop, melon stands that received poultry manure produced 38% more seeds than those in the control plots while in maize/melon system, stands of melon that received poultry manure produced 40% more seed than those in the control plots. In melon sole crop areas, stands given poultry manure gave 34% more yield than those in control plots. (Table 4). For the 5 years of trial, the highest seed yield a melon was recorded in cassava/melon intercrop. The reduction in the yield of melon in maize/melon inter crop may be attributed to stronger inter-

specific competition. *Anyaegbu (2008*) attributed the decrease in the root yield of cassava in cassava/maize mixture to competition for growth resources.

Cassava

Application of poultry manure significantly (P>0.05) increased the yield of cassava, (Table 5), irrespective of cropping systems. In control plots, the root yield of cassava decreased steadily with continuous cropping. This was due to depletion of soil nutrients without replacement. In the poultry manure treated cropping systems, cassava/maize and cassava sole crop respectively , the root yield of cassava dropped after the 4th year of cropping but in cassava/melon system, the root yield of cassava increased linearly up to 5th year of cropping (Table 5). In the above situation, intercropping with melon may have boosted the sustainability of the poultry manure in residual nutrient content of the soil. *Fagbamiye (1977) and Ikeorgu (1984)* had reported that melon *(planophile*) improved the yield of companion crops by conserving soil moisture and reducing high noon temperature, thereby making the environment more conducive for plant growth and development.

In maize/cassava mixture and cassava/melon mixture respectively, cassava stands given poultry manure produced 50% more "roots" than those in the control plots while in cassava sole cropping, cassava stands that received poultry manure gave 56% more yield than those in the control plots. Generally, in the 5 years of the trial, the highest root yield was recorded in the cassava/melon intercrop while the lowest was recorded from cassava/maize mixture. *Tran and Nguyen (2001*) in their trial on association of cassava with short duration crops, in South Vietnam reported that the yield of cassava in cassava/ maize intercrop was significantly reduced by competition for nutrients and water or by shading out by tall maize plants.

The seed yield of maize as affected by the 5 year residual effect of poultry manure application is shown on Table 6. Application of Poultry manure significantly (P>0.05) affected the seed yield of maize. In all control plots, the seed yield of maize was generally low and decreased steadily with the 5 year of continuous cropping. In the cassava/maize mixture and sole crop maize where poultry maize was applied, the seed yield of maize increased linearly up to the 3rd year beyond which it decreased steadily (Table 6).

Weed Biomass (G/M^2)

Weed density was significantly high in areas that received poultry manure (P>0.05) compared with the control plots (Table 7). In all cropping systems, weed density decreased steadily after the 3rd year of planting. This trend may be in line with the decreasing fertility status of the soil due to the continuous cropping. The lowest weed weight (68.8g/m) in control plots and(83g/m$^{2)}$ in manure treated areas was recorded in cassava/melon intercrops.

This reduced weed weight in melon/cassava mixture may be attributed to rapid vegetative development of melon with its canopy shading greater area of the plot thus reducing weed infestation. *Zuofa et al (1992)* found 16% and 40% reduction in weediness by intercropping with low growing smoother crops such as groundnut, cowpea or melon.. Thus the advantages of the live-mulching from melon include weed suppression, return of organic matter to the soil and conservation.

Mixture Production

The ratio for combination of cassava and the component crops in 5 year study gives a comparison of intercropping systems with sole cropping, (Table 8) The land equivalent ratio values for intercrops with all the respective combinations were greater than unity in all the seasons. While the yield advantage in this study ranged from 25% to 36% in 2004, 18% to 48% in 2005, 13% to 50% in 2006, 11% to 53% in 2007, it ranged from 11% to 56% in 2008. Averaged over the 5 growing seasons, the highest LER of 1.36 2004, 1.48 in 2005, 1.50 in 2006, 1.53 in 2007 and 1.56 in 2008 were obtained when cassava was intercropped with melon. Melon serving as a cover crop conserved soil moisture, reduced temperature and added organic matter to the soil through its leaves and these were advantageous to the mixture.

Thus the total LER of the mixtures being above 1.0 indicates that higher productivity per unit

area was achieved by intercropping. *Njoku et al (2007)* observed similar results in sweet potato/okra intercropping.

Gross Margin Analysis

In economic terms, cassava intercrops gave more Net returns and Benefit Cost Ratio over sole cropping (Table 9). *Willey (1979)* observed that practical significance of productivity in intercropping could only be fully assessed when related to the actual economic or monetary returns. Throughout the 5 years of trial, highest BCR (43) was obtained from cassava/melon intercropped that received 10 t ha^{-1} of poultry manure application.

Generally, except in cassava/melon intercrop treated with 10 t ha^{-1} of poultry manure, the BCRs in 2004 were higher than those in 2008. This gradual decrease may be associated with the gradual reduction in the residual effect of the manure with time. Moreover, the variable costs of each enterprise (treatment) was higher in 2008 than in 2004. This also may have contributed in the lower BCR experienced in the last year of the trial (2008) compared to those obtained in the first year of the trial (2004).

Table 1. Details of Treatment Combinations

Treatment Combinations	Manure Quantity
Cass + Maize + O (T_1)	Zero manure Application
Cass + Mel + O (T_2)	Zero manure Application
Cass + Maize + 10 t/ha (T_3)	10 t/ha manure applied
Cass + Mel + 10 t/ ha (T_4)	10 t/ha manure applied
Sole cass + O (T_5)	Zero manure application
Sole cass + 10 t/ha (T_6)	10 t/ha manure applied
Sole maize + O (T_7)	Zero manure
Sole Maize + 10 t/ha (T_8)	10 t/ha manure applied
Sole Melon + O (T_9)	Zero manure
Sole melon + 10 t/ha (T_{10})	10 t/ha manure applied

Table 2. Chemical composition of the poultry

Elements	Quantity
N (%)	1.95
P (%)	1.30
K (%)	0.82
Ca (%)	0.07

Na (%)	0.52
Mg(mg/kg)	25.05
Zn(mg/kg)	33.31
Cu(mg/kg)	30.61
Org. C (%)	27.15
Org. matter(%)	50.53
C:N ratio	19.8:1

Table 3. Pre-planting soil physico-chemical analysis of experimental site in 2004

Properties	Values
PH (H_20)	4.3
%Organic Carbon	1.20
% total Nitrogen	0.33
Exch. K+ (Cmol/Kg^{-1})	0.09
Avail P. (ppm)	14.00
CEC (Cmol/Kg^{-1})	4.91

Table 4. Seed yield of melon as affected by poultry manure under different cropping systems for 5 years of continuous cropping. Melon Seed Yield (t/ha)

	Cassava/melon		Maize+melon		Melon Sole crop		
Years	0	10 t/ha	0	10 t/ha	0	10 t/ha	LSD(P>0.05)
1	2.6	5.6	3.5	4.8	2.8	4.8	0.246
2	3.2	6.8	2.7	5.6	3.7	6.7	1.133
3	3.6	7.2	2.3	6.3	3.7	7.3	2.200
4	3.2	7.8	1.8	5.8	2.8	6.5	2.211
5	3.0	7.8	1.6	5.3	2.4	5.7	2.012
Mean	3.12	7.04	2.38	5.56	3.08	6.2	
LSD(P>0.05)	2.214		2.038		1.647		

Table 5. Yield of cassava as affected by Poultry manure under different cropping systems for 5 years of continuous cropping.

	Cassava/maize		Maize + Melon		Cassava Sole crop		LSD
Year	0	10 t/ha	0	10 t/ha	0	10t/ha	LSD(P>0.05)
1	10.6	20.1	10.7	28.6	11.6	20	3.611
2	7.8	23.6	14.2	38.3	10.4	24.6	4.302
3	7.2	25.4	14.2	41.5	8.3	33.5	4.544
4	6.8	25.8	14.2	42.8	6.2	35.6	5.017
5	6.3	23.2	12.6	44.2	4.9	30.6	8.333
Mean	7.7	23.6	13.2	39.1	8.3	28.9	
LSD(P>0.05)	4.817		7.325		4.590		

Table 6. Seed yield of maize as affected by poultry manure application under different cropping systems for 5 years of continuous cropping.

	Cassava/maize		Maize/melon		Cassava maize		LSD
Year	0	10 t/ha	0	10 t/ha	0	10t/ha	LSD(P>0.05)
1	2.0	3.2	2.6	3.6	2.8	3.4	0.167
2	1.5	3.8	2.2	3.8	2.1	4.2	1.001
3	1.2	4.1	2.2	4.2	1.6	4.5	1.235
4	0.8	3.5	2.0	4.5	1.4	4.0	1.014
5	0.6	3.4	2.0	3.8	0.8	3.6	1.240
Mean	1.2	3.6	2.2	4.0	1.7	3.9	
LSD(P>0.05)	0.314		0.623		0.481		

Table 7. Weed biomass (g/m2) as affected by poultry manure over a period of 5 years cropping systems.

	Cassava/maize		Maize/melon		Sole cassava		Sole melon		Sole maize	
Year	0	10	0	10	0	10	0	10	0	10
1	210	225	77	91	241	254	118	214	256	338
2	208	231	74	84	238	248	106	208	248	324

3	204	215	68	83	224	236	98.2	118	242	318
4	189	213	64	81	218	228	88.3	172	214	286
5	142	203	61	76	219	221	712	168	205	254
Mean	190.6	217.4	68.8	83	228	237.4	96.3	190	233	304
LSD(P>0.05)	12.017		11.214		14.282		5.213		21.630	24.619

Table 8. Mixture Productivity of various Component crops assessed by LER as influenced by poultry manure for 5 years of continuous cropping.

Crop combinations	Poultry rate	LER Years of Cropping					LSD(p>0.05)
–		1	2	3	4	5	
Cass + Maize	0	1.25	1.18	1.13	1.11	1.11	0.020
Cass + Mel +	0	1.31	1.24	1.27	1.20	1.18	0.021
Cass + Maize +	10	1.20	1.23	1.25	1.39	1.27	0.022
Cass + Melon +	10	1.36	1.48	1.50	1.53	1.56	0.23
Sole cassava	0	1.0	1.0	1.0	1.0	1.0	-
Sole cassava	10	1.0	1.0	1.0	1.0	1.0	-
Sole maize	0	1.0	1.0	1.0	1.0	1.0	-
Sole maize	10	1.0	1.0	1.0	1.0	1.0	-
Sole melon	0	1.0	1.0	1.0	1.0	1.0	-
Sole melon	10	1.0	1.0	1.0	1.0	1.0	-

Table 9. Gross margin analysis of the different systems/ha 2004 & 2008.

Cropping systems Poultry rates	Total Revenue 000(₦)		Variable Cost 000 (₦)		Gross Margin ,000 (₦)		Benefit Cost Ratio	
	2004	2008	2004	2008	2004	2008	2004	2008
Cass + Maize + 0	342	204	33	36	309	168	9.4	4.7
Cass + Mel + 0	236	216	25	27	211	189	8.4	7.0
Cass + Maize + 10 t/ha	1,075	482	44	46	1031	336	23.4	7.3

Cass + Melon + 10 t/ha	652	764	27	28	624	736	23.1	26.3
Sole cassava + 0	227	184	25	27	202	157	8.1	5.8
Sole cassava + 10	404	335	26	28	378	307	14.5	11
Sole maize + 0	84	63	20	21	63	42	3.1	1.6
Sole maize + 10 t/ha	186	143	22	25	164	116	7.5	4.6
Sole melon + 0	103	98	15	16	108	83	7.2	5.2
Sole melon + 10 t/ha	221	207	21	21	200	186	9.5	8.9

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