EFFECT OF CROP GEOMETRY AND POULTRY MANURE RATES ON THE GROWTH AND YIELD OF YAM/MAIZE/CASSAVA MIXTURES IN A DEGRADED ULTISOL.

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ABSTRACT

A two year study on the effects of crop geometry and poultry manure rates on the growth and yield of Yam/maize/cassava intercrop was conducted at the Teaching and Research farm of the Federal University of Technology, Owerri Nigeria.. The experiment was laid out as a 5x4 factorial in Randomized Complete Block Design replicated three times. The treatments consist of five poultry manure rates namely: 0kg/ha, 5000kg/ha, 10000kg//ha, 15000kg/ha and 20,000kg/ha as well as four different crop geometries viz, Yam/maize/cassava, Yam/maize, Cassava/maize and Yam/cassava respectively. Data on crop growth and yield parameters were collected and subjected to analysis of variance. Mean separation was done using least significant differences at 5% Level of probability. Results indicated that poultry manure reduced soil acidity from 4.48 to 5.88.in 2004 and from 4.36 to 6.98 in 2005. Poultry manure rates significantly (P=0.05) increased cassava and Maize plant heights at 4, 6 and 8 weeks after planting in the various crop geometry. The zero manure had the least crop plant height in all crop combinations. Poultry manure rates and crop geometry significantly influenced the yam tuber yield with 11005kg/ha (highest) observed in the 15000kg/ha manure rate under the Yam/maize/cassava crop geometry, highest mean cassava yield of 14200kg/ha realized from the 20000kg manure rate under the Cassava/maize crop mixture, while highest maize grain yield of 1,400kg/ha was recorded in the 10,000kg/ha manure rate under the yam/maize crop geometry respectively..Based on the result of this study, it is hereby strongly recommended to farmers to adopt the yam/maize/cassava intercrop at 15000kg/ha poultry for increased yield returns from yam and cassava. .

Keywords: *Crop geometry, poultry manure rates, crop yields, yam and cassava.*

INTRODUCTION

Soil fertility management is a critical component of any cropping system designed to enhance and sustain crop productivity. The continuous cropping system of alfisols, ultisols and oxisols in the tropics due to reduced fallow periods has resulted to rapid soil fertility decline (Juo *et al.,* 1995b). Continuous cultivation as practiced by farmers in Nigeria causes a significant decline in soil p^H, exchangeable calcium and magnesium levels, and more pronounced when acidifying mineral fertilizers are used (Ojeniyi 1995, Adepetu *et al* 1979, Juo and kang 1989, Juo *et al*.,1995a).

The management of soil fertility by small scale resource-poor farmers in the tropics has become a major issue as a result of continued soil degradation and rapid population growth (FAO, 1981; U.N. 1989). Major arable soils are often poorly suited to high input agriculture, involving the use of chemical fertilizer and agro-chemicals which has been known to cause soil physical, chemical and biological degradation, respectively. The decline of crop yield under continuous cultivation despite the use of mineral fertilizer has been attributed to factors such as acidification, soil compaction and loss of soil organic matter (Juo *et al.,* 1995a). Thus there is need to use alternative organic mineral sources such as poultry manure to boost soil and crop productivity as rightly reported by Obi and Ebo (1995), who recommended the addition of organic soil amendments to manage and reverse the current trend of soil physical, chemical and biological degradation. Duruigbo *et al.,* (2007) recommended the use of 15tons/ha poultry manure to boost yam/maize/cassava crop mixtures. Crop mixtures have been described as a more stable dynamic biological systems that can withstand natural hazards better than sole crops (Hayward, 1975) However, Ikeorgu *et al.,* (1984) reported that when cassava and maize were planted on the same date, the maize component reduced cassava root yield by 28%. Traditionally farmers in Nigeria normally plant yam and maize first and later cassava is planted possibly to reduce inter-specific competition between yam and cassava. The arrangement of various crops within a mixed cropping system has posed a major problem in realizing increased component crop yields under various intercropping systems. Studies by Ibeawuchi and Ofoh (2000) revealed that crop mixtures of maize/Cassava/cowpea have high compatibility and complementarity with the base crops having significantly higher plant heights. A range of multiple cropping strategies such as strip cropping, relay cropping, staggered planting and intensive mixed intercropping has been used in both tropical and temperate climates and these appear to have great potential for future sustainable crop production systems. Diversity of crops in terms of crop arrangement in the field promotes nutrient recycling,

efficient resource-use by crops of different growth cycles, rooting patterns, canopy architecture and protection against pest/disease damage. Planting intercrops that feature staggered maturity dates such as yam/maize/cassava mixtures takes advantage of variation in peak resource demand for nutrients, water and light (Horwith, 1985).
This study is specifically aimed at investigating the best crop arrangement, and the optimum poultry manure rate needed to enhance the yield of yam/maize/cassava mixtures in a degraded ultisol.

MATERIALS AND METHODS

Location

The two year trial was carried out at the Federal University of Technology Teaching and Research farm Owerri located on latitudes 5^0 27^1, 50^0 23^1 North and longitude 7^0 02^1, 49^0 33^1 East(Handheld GIS) with an elevation of 55m above sea level. Soils of this area belong to the soil mapping unit number 431 i.e. Amakama-Orji-Oguta soil Association (FDALR, 1985) and derived from coastal plain sands (Lekwa and Whiteside, 1986).

Laboratory analysis of soil and manure samples

The pre-planting soil chemical analysis was carried out for the 2004 and 2005 cropping seasons respectively. The chemical properties of the poultry manure used in the experiment were analyzed in the laboratory using the procedures below. Total nitrogen was obtained using micro kjeldahl (Bremner and Mulvancy, 1982) while exchanged calcium, magnesium and potassium were extracted by ammonium acetate at pH 8.0 (Chapman and Pratt, 1965). Calcium and magnesium were measured using atomic absorption spectro-photometry. Soil p^H was estimated electrometrically (Hendershot *et al.,* 1993.) Bray No.2 method was used to extract available phosphorus. Also the percentage organic matter content was determined. The post harvest soil chemical analysis was also determined using the above-mentioned procedures.

Incorporation of poultry manure and planting of component crops.
The experimental design used was a 5 x 4 factorial in Randomized Complete Block Design replicated three times. Shortly after land preparation, the five poultry manure rates namely O,5000, 10000, 15000 and 20000kg/ha, were uniformly broadcast and manually incorporated into experimental plots measuring 5x 5m, by tilling to a depth of 30cm using garden fork. No manure was applied to control plots i.e.0kg/ha. The yam (*Dioscorea rotundata*) setts weighing 200g were planted at 1 x 1 m in holes measuring 45x45x45cm made in the tilled soil and covering it. This gave a seed-rate of 10,000 seed yams/ha. This was followed simultaneously by maize seeds which were sown at a spacing of 1 x 1 m at 3 seeds/hole and later thinned down to 2 seedlings/hole to give a seed-rate of 20,000 plants/ha. Maize was planted on the same row with yam at equidistant crop geometry, but allowing a 50cm feeding area between yam and maize stands. The cassava variety used was TMS 30572 which was cut into 20 cm length and planted in a slanting position at an angle of 45^0 using a spacing of 1 x 1 m to give a plant population of 10,000 plants/ha.The experiment was carried out using a 5x4 factorial in Randomized Complete Block Design replicated three times
The crop growth parameters for yam, maize and cassava were measured and subjected to analysis of variance, while means were compared using the Least Significant Difference at 5% level of probability.

RESULTS AND DISCUSSION

Soil Properties

There were remarkable variations in the pre-planting soil chemical properties when compared with the post-harvest soil chemical properties (Tables 1 and 2). The initial soil pH of 4.43 was increased to 4.49 in 2004 and from 4.36 to 4.84 in 2005 in yam/cassava crop mixture (Tables1 and 2) for the control (0kg/ha) indicating that a simple crop combination of yam/cassava or cassava/maize can ameliorate soil $_p$H in a cropping system. Also soil $_p$H increased from 4.43 to 5.88 in cassava/maize (2004) and 4.36 to 6.98 in the same crop mixture in 2005. This is an indication that poultry manure is capable of neutralizing soil acidity. This agreed with work done by Duruigbo *et al.,* (2007), who reported that poultry manure has the ability to neutralize soil acidity. Furthermore, the mechanism involved in the neutralization of soil acidity by organic manure has been reported by (Pocknee and Summer, 1997, Yan *et al*, 1996, Bessho and Bell 1992, Hue and Amiens, 1989)
The increased residual nutrient status such as nitrogen, organic matter, phosphorus, potassium, calcium and magnesium observed after crop harvest shows that poultry manure could carry a second and third years of cropping without further manure applications (Tables 1 and 2). This also confirmed similar work by Jinadasa *et al*, (1997) who reported that poultry manure has a residual effect on the soil after a cropping session. The soil status after 2005 cropping revealed that the initial soil pH was 4.36 but increased to 6.98 (Alkalinity) after addition of poultry manure. This is remarkable since the poultry manure significantly (0=0.05) increased the plant heights of cassava from 3.5cm (0 manure) to 8.4cm (15000kg/ha) rate and maize from 6.2 cm (0 manure), 9.6cm (20000kg/ha manure rate) for the yam/maize/cassava crop geometry at 4 WAP. A similar trend was observed in the yam/cassava, cassava/maize and yam/maize crop geometries respectively The interaction effect

of poultry manure rate and crop geometry on stand heights of cassava and maize was also significant (P=0.05) at 4 weeks after planting (Table 3)..

The mean plant heights of maize and Tcassava at 6 weeks after planting are presented in (Table 4). Poultry manure rate and crop geometry significantly (P=0.05) influenced maize and cassava plant heights. Highest cassava plant heights of 18.3cm (6WAP) was observed in the Cassava/maize crop geometry at the poultry manure rate of 15000kg/ha with the least cassava plant heights of 10.51cm observed at the 0- manure rate in the yam/maize/cassava crop geometry. Also the maize plant height was highest (15.5cm) at the 20000kg/ha poultry manure rate in the cassava/maize crop geometry at 6 weeks after planting (Table 4). The cassava and maize stand heights increased progressively in response to increasing rates of manure despite the crop arrangement at 8 weeks after planting (Table 5). Crop geometry significantly influenced the heights of Maize and cassava. The increased maize and cassava stand heights with increase in manure rate could be attributed partly due to the high nutrient extraction capacity of maize (a shallow feeder) and cassava (a deep feeder) due to the inter specific competition existing between maize and cassava, thus such competition for light causes both crops to grow taller. This also conforms with work done by Beets (1976), who reported that maize in mixture tend to grow taller to compete for sunlight needed for its photosynthetic activity. Poultry manure and crop geometry had a positive interaction effect on stand heights of maize and cassava.

The mean yields of yam, maize and cassava was significantly (P=0.05) increased by addition of poultry manure. Highest mean yield of yam (11600kg/ha) was observed at the 15000kg/ha poultry manure in the yam/maize/cassava crop geometry while Highest cassava tuber yield of 14200kg/ha was realized from the 20,000kg/ha poultry manure rate in the cassava/maize crop arrangement. Highest maize grain yield of 1400kg/ha was observed in the 10000kg/ha poultry manure rate and yam/maize crop arrangement. Generally the zero manure treatment had the least yield of yam, maize and cassava irrespective of crop geometry, an indication that poultry manure is very rich in nutrients needed for crop growth as confirmed by Follet *et al* (1995), Hsich and Hsu (1993), Jinadasa *et al* (1997), who severally reported the abundance of organic matter, nitrogen, available phosphorus, exchangeable cations and micro-nutrients which are essentially needed for increased crop yields.

Generally we observed that poultry manure and crop geometry significantly increased crop stand heights of maize and cassava .The zero manure rates had the least stand heights of maize and cassava. The mean yields of yam, maize and cassava increased in response to increasing rates of poultry manure, while crop geometry also influenced crop yields.

CONCLUSION

Soils of the study area are highly degraded, acidic and thus require remediation. The use of poultry manure was the best option because it is easily accessable, available and a cheap source of fertilizer.

This experiment revealed that poultry manure could be used as a liming material due to its ability to neutralize soil acidity. It is capable of boosting soil fertility and neutralizes soil acidity because of its complex composition. The application of poultry manure on the experimental plots was found to have residual effects on soil nutrient status and thus can support second and third cropping cycles. Poultry manure and crop geometry significantly increased crop plant heights of maize and cassava at 4, 6 and 8 WAP. The zero manure rates had the least plant heights of maize and cassava. Also, even the simplest crop geometry was able to reduce soil pH.

The mean yield of yam, maize and cassava increased in response to increasing rates of poultry manure, however crop geometry has a significant influence on the yields of yam, maize and cassava. Based on the results of this experiment, the highest yield of Yam (11600kg/ha) was recorded at the 15000kg/ha poultry manure rate in the yam/maize/cassava crop geometry, Highest cassava tuber yield of 14200kg/ha realized from the 20000kg/ha poultry manure rate in the cassava/maize crop geometry, while highest maize yield of 1400kg/ha was observed in the 10000kg/ha poultry manure rate in the yam/maize crop geometry, hence the choice of the crop geometry to adopt depends on the farmers preferences and needs. Also the poultry manure rates of 10000kg/ha, 15000kg/ha or 20000kg/ha could boost crop yields of yam, maize and cassava, while the particular rate to use depends on the crop highly preferred as well as the crop geometry that satisfies the farmers socio-economic interests

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Table 1: Mean soil nutrient and pH status before, and after the experiment in year 2004.

Manure Crop Arrangement Manure Rate	Initial Soil Nutrient Values and pH status Soil Nutrient Values And pH Status After The Experiment Crop Arrangement	N(%) 0.07	OM% 2.19	P cmd/kg) 8.90	K (cmd/kg) 0.08	Ca(cmd/kg) 0.60	Mg (cmd/kg) 0.60	PH In water 4.43
0	Yam/Maize/Cassava	0.04	2.26	7.90	0.05	0.55	0.48	4.45
	Yam/Cassava	0.053	2.76	7.02	0.07	0.58	0.54	4.49
	Cassava/Maize/	0.756	3.19	7.94	0.07	0.58	0.45	4.48
	Yam/Maize	0.804	2.99	7.96	0.07	0.58	0.55	4.48
5000kg/ha	Yam/Maize/Cassava	0.144	2.48	1436	0.22	1.63	0.61	5.29
	Yam/Cassava	0.181	2.35	14.49	0.35	1.66	0.66	5.48
	Cassava/Maize	0.194	2.64	17.48	0.39	1.67	0.67	5.55
	Yam/Maize	0.188	2.71	14.61	0.37	1.67	0.67	5.59
10000kg/ha	Yam/Maize/Cassava	0.162	2.93	18.61	0.56	1.65	0.64	5.29
	Yam/Cassava	0.198	2.80	18.63	0.63	1.69	0.69	5.41`
	Cassava/Maize	0.203	2.97	18.62	0.66	1.72	0.71	5.55
	Yam/Maize	0.214	3.09	18.62	0.66	1.71	0.72	5.59
15000kg/ha	Yam/Maize/Cassava	0.211	3.15	18.64	0.58	1.74	0.74	5.30
	Yam/Cassava	0.221	3.36	18.65	0.68	1.83	0.82	5.50
	Cassava/Maize	0.219	3.33	18.66	0.68	1.97	1.14	5.53
	Yam/Maize	0.248	3.49	18.64	0.68	1.99	0.96	5.59
20000kg/ha	Yam/Maize/Cassava	0.271	3.45	18.58	0.68	1.88	0.89	5.80
	Yam/Maize	0.284	3.46	3.46	0.69	1.99	1.03	5.86
	Cassava/Maize	0.293	3.46	18.66	0.71	2.01	1.03	5.88
	Yam/Maize	0.299	3.47	18.66	0.71	2.00	1.06	5.87

Table 2: Mean soil nutrient and pH status before and after the experiment for year 2005

Initial Soil Nutrient		N(%)	Om(%)	P cmd/kg	K(cmd/kg)	Ca(cmd/kg)	Mg(cmd/kg)	PH In Water
Value And pH Status		0.081	2.34	9.85	0.08	0.95		4.36
	Soil Nutrient Values And PH Status After The Experiment							
Manure Rate	Crop Arrangement							
Okg/ha	Yam/Maize/Cassava	0.08	2.36	8.80	0.08	0.81	0.51	4.66
	Yam/Cassava	0.07	2.29	7.98	0.08	0.71	0.57	4.84
	Cassava/Maize	0.07	2.33	8.70	0.079	0.77	0.55	4.59
	Yam/Maize	0.08	2.35	8.55	0.075	0.86	0.60	4.81
5000kg/ha	Yam/Maize/Cassava	0.12	2.57	10.65	0.19	0.98	0.68	5.46
	Yam/Cassava	0.16	2.48	12.25	0.28	1.02	0.67	6.22
	Cassava/Maize	0.13	2.66	12.13	0.21	1.10	0.71	6.12
	Yam/Maize	0.11	2.88	11.62	0.25	1.05	0.71	6.30
10000kg/ha	Yam/Maize/Cassava	0.19	2.94	14.65	0.44	1.15	0.68	6.05
	Yam/Cassava	0.17	2.87	14.60	0.51	1.46	0.73	5.99
	Cassava/Maize	0.19	2.89	15.05	0.49	1.55	0.75	6.66
	Yam/Maize	0.19	2.90	14.55	0.50	1.45	0.75	6.05
15000kg/ha	Yam/Maize/Cassava	0.24	2.99	14.72	0.42	1.22	0.79	6.98
	Yam/Cassava	0.22	3.05	14.55	0.55	1.61	0.81	6.75
	Cassava/Maize	0.23	3.45	13.85	0.55	1.59	0.85	6.80
	Yam/Maize	0.25	3.55	14.55	0.55	1.60	0.83	6.70
20000kg/ha	Yam/Maize/Cassava	0.26	3.39	14.92	0.48	1.18	0.88	6.49
	Yam/Cassava	0.26	3.49	14.90	0.56	1.55	0.95	5.99
	Cassava/Maize	0.29	3.61	15.05	0.55	1.65	0.89	6.98
	Yam/Maize	0.26	3.49	15.10	0.56	1.56	0.93	6.05

Table 3: Mean plant heights (cm) of maize and cassava at 4 weeks after planting

Treatments Poultry Manure Rates(kg/ha)	Crop Y/M/C C	Geometry M	Y/C C	C/M C	M	Y/M M	Mean Cassava	Maize
O kg/ha	3.5	6.2	3.0	4.5	8.5	6.8	3.6	7.1
50000kg/ha	8.2	9.6	8.2	8.3	8.0	8.6	8.2	8.7
10000kg/ha	6.5	7.4	6.5	6.8	9.5	9.0	6.6	8.6
15000kg/ha	8.4	9.5	6.8	7.8	8.9	8.8	7.5	9.0
20000kg/ha	7.0	9.6	8.2	8.3	8.9	9.6	7.8	9.3
Mean	6.6	8.5	6.5	7.1	8.7	8.5		

LSD (0.05) Poultry manure Rate = 1.46
LSD (0.05) Crop geometry = 0.69
LSD (0.05 Crop Geometry x poultry manure = 1.20

ha = hectares
Y/M/C = Yam/Maize/Cassava
Y/C = Yam/Cassava
C/M = Cassava/Maize
Y/M = Yam/Maize

Table 4: Mean plant heights (cm) of maize and cassava as affected by poultry manure and crop geometry at 6weeks after planting.

Treatments Poultry Manure	Crop Yam/Maize/Cassava	Geometry Yam/Cassava	Cassava/Maize	Yam/Maize				
Rate (kg/ha)	Cassava Height(cm)	Maize Height(cm)	Cassava Height	Cassava Height	Maize Height	Maize Height (cm)	Mean Cassava	Maize
O kg/ha	10:51	10.59	11.5	11.8	10.8	10.5	11.29	10.6
5000kg/ha	13.46	11.9	12.6	14.5	14.51	11.9	113.51	12.77
10000kg/ha	13.80	14.3	14.8	15.2	13.5	12.3	14.6	14.03
15000kg/ha	14.69	14.7	15.3	18.3	13.7	13.5	16.09	13.96
20000kg/ha	14.90	15.5	14.9	14.9	15.5	15.3	14.9	15.43
Mean	10.78	13.39	13.81	14.94	13.60	13.1		

LSD (0.05) Poultry manure Rate = 0.89
LSD (0.05) Crop Geometry = 0.60
LSD (0.05) Poultry manure * Crop Geometry = 1.29

Table 5: Mean plant heights (cm) of maize and cassava at 8 weeks after planting.

Treatments Poultry Manure Rate (kg/ha	Crop Geometry Y/M/C		Y/C	C/M		Y/M	Mean	
	C	M	C	C	M	M	Cassava	Maize
O kg/ha	17.3	25.5	11.9	14.2	28.6	25.5	14.4	26.5
5000kg/ha	18.4	36.5	17.3	25.4	39.4	41.5	20.3	39.1
10000kg/ha	23.2	49.6	22.5	23.5	48.3	42.3	23.0	46.7
15000kg/ha	26.4	47.9	29.7	35.5	48.6	49.9	30.5	48.8
20000kg/ha	35.5	51.7	39.2	38.5	55.7	53.9	37.7	53.7
Mean	24.1	42.2	24.1	27.4	44.1	42.6		

L.S.D (0.05) Poultry manure rate = 2.89
L.S.D (0.05) Crop Geometry = 2.08
L.S.D (0.05) Crop Geometry x Poultry Manure = 4.06

ha = hectare
Y/M/C = Yam/Maize/Cassava
Y/C = Yam/Cassava
C/M = Cassava/Maize
Y/M = Yam/Maize

Table 6: Mean yield of yam/maize/cassava intercrop as affected by poultry manure rates and crop geometry.

Treatments		Mean Component Crop Yield (kg/ha		
Poultry Manure Rate (kg/ha)	Crop Geometry	Yam	Cassava	Maize
0	Y/M/C	8500	9500	395
	Y/C	8280	9550	
	C/M		8200	580
	Y/M	8400		560
	Mean	8393	9083	511
5000	Y/M/C	19880	10,250	805
	Y/C	10,500	10890	
	C/M		11900	693
	Y/M	10750		625
	Mean	10310	11013	707
10000	Y/M/C	10.840	11700	1260
	Y/C	10.300	12150	
	C/M		12500	1305
	Y/M	11800		1400
	Mean	10980	12116	988
15000	Y/M/C	11600	12900	520
	Y/C	11406	12000	
	C/M		13200	950
	Y/M	10,005		1100
	Mean	11003	9366	856
20000	Y/M/C	12350	12500	850
	Y/C	12500	13750	940
	C/M		14200	1200
	Y/M	11300		780
	Mean	8716	10150	942

L.S.D (0.05) Poultry Manure = 932
L.S.D (0.05) crop geometry = 792.5
L.S.D 0.05 Poultry manure x crop geometry =

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