EVALUATION OF COMPLEMENTARY USE OF ORGANIC MANURE FOR SUSTAINABLE WATER YAM PRODUCTION IN UYO, SOUTHEASTERN NIGERIA

Ikeh, A. O.[1*], Ndaeyo, N. U.[1], Akpan, E. A.[2], Udoh, E. I.[2], Akata, O. R.[3]

[1]Department of Crop Science, University of Uyo, Uyo, Nigeria
[2]Department of Crop Science and Horticulture, Akwa Ibom State University
Obio Akpa Campus, Nigeria
[3]Department of Crop Science, University of Calabar , Calabar, Nigeria
*Corresponding author's email:dr_nundaeyo@yahoom.com
Phone number: +2348033934217

Abstract

A two year study was conducted at University of Uyo Teaching and Research Farm, Use Offot, Uyo, Akwa Ibom State in 2009 and 2010 cropping seasons to assess the effects of complementary use of different organic manures on water yam growth and yield, economic returns to management as well as attack by some pests . The experiment was laid out in a randomized complete block design with three replicates. There were 8 fertilizer treatments viz: poultry manure (PM), goat manure (GM), and oil palm bunch ash (OPBA) each at 20 tha^{-1} , OPBA + PM, OPBA + GM and PM + GM each at a ratio of 1:1 (10 tha^{-1} + 10 tha^{-1}), NPK (15:15:15) at 400 kgha^{-1} (a recommended dose of inorganic fertilizer) and control (no soil amendment). Results showed significant differences on vegetative traits, number of days to senescence and yield and yield components of water yam. Treatments that received complementary application of PM + GM produced the highest tuber yield (26.15 and 27.96 tha^{-1} in 2009 and 2010, respectively with corresponding cost- benefit ratios of 14.17 and 15.49,respectively) followed by complementary use of OPBA + PM, (24.22 and 27.03 tha^{-1},respectively). The use of inorganic fertilizer (NPK - 15:15:15) produced 22.60 and 23.81 tha^{-1} of yam tuber with a corresponding cost -benefit ratio of 11.02 and 10.88 in 2009 and 2010, respectively .All organic manure based treatments had no symptom of termite and yam beetle attack. This study indicates strongly the potentials of complementary use of organic manures for sustainable water yam production in Uyo, southeastern Nigeria.

Keywords: *organic manures, complementary use, water yam*

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Introduction

Yam (*Dioscorea spp*.) is an important tuber crop in Nigeria, where it is produced both as food and cash crop (Asumugha *et al*., 2009). Nigeria is the largest world producer of yams with annual production estimated at 26.587 million metric tonnes (FAO, 2006). Yam is recognized as a prestige food crop in many African communities and in Nigeria, especially the Igbo tribes where yam features prominently in many traditional festivities. The ceremonies associated with the yam planting “Nkoyiji” and with harvest “Ahajoku” in Igbo land are often major annual social-cum-religious occasions (Onwueme and Sinha, 1991; Ikeh, 2010). In Ugep community of Cross River State of Nigeria, celebration of new yam festival popularly called ‘Leboku’ has gained international recognition and is already a source of income for the state. Yam also occupies a place in many traditional marriage ceremonies and in special diets for mothers in confinement after child birth (Ihekoronye and Ngoddy, 1985). No other crop in Nigeria or Africa at large is associated with a great amount of social and cultural activities than yam (Ikeh *et. al.*, 2012). The importance of yams in Nigeria revolves on its high calories and its socio-cultural relevance. This partly explains why yam has become expensive as its production (supply) has not kept pace with demand (Kushwaha and Polycarp, 2001). Moreso, it is currently being exported and the demand of the crop internationally has been very encouraging (Ikeorgu, 2010 Personal communication).

Despite the place of yam in southeastern Nigeria in particular and the country at large, it yield is consistently declining principally due to low productivity associated with poor soil fertility status and inappropriate cropping systems and practices in the region (Unamma *et. al.*, 1985). In the past, yam was the first crop to be planted to a land after long fallow because the nutrient requirements of yam are higher than in most other crops (Ano, 2006). Under high soil nutrient status, good yam tuber yield was obtained and the productivity of the system was high and encouraging to farmers (Ndaeyo *et. al.*, 2001) . Currently, fallowing, which yam farmers relied heavily on for soil fertility restoration, has reduced greatly in southeastern Nigeria due to high population pressure, urbanization, and infrastructural development and demand for non – agricultural land (Ndaeyo *et. al.*, 2001). There is no doubt that this will continue as yam as a “heavy feeder” crop is capable of mining over 90% of soil nutrient as dry matter when harvested in form of yam tuber and taken out of farm (Ano *et. al.*, 2003). Obigbesan and Agboola (1978) reported that an average of about 155 kg N, 12.2 kg P, 176 kg K, 3.9 kg Ca and 10.7 kg Mg per hectare are lost from the soil when yam (*Dioscorea rotundata*) tubers were harvested and taken out of the farm.

Consequently, the future and sustainable production of yam would therefore depend on fertilizer application. To achieve this, most farmers in Nigeria apply fertilizer mainly in inorganic form and to a limited extend in organic forms even though many organic manure sources abound. Organic fertilizers are known to have better nutrient attributes compared to inorganic fertilizers. Apart from increasing soil organic matter content, supplying both macro and micro nutrients, releasing nutrients slowly to the soil, organic manure also improves soil physical properties, which enhances crop growth , development and yield This apparently explains why Udoh *et. al.* (2005) noted that before inorganic fertilizers were known, and their use developed, major practices in soil fertility improvement centered on the application of organic manures to the soil. Indeed modern trends in soil and nutrient supply management include emphasis on the roles of manures and mulch. Some of such common farm manures are: livestock and poultry excrements, crop wastes (grains and legumes chaff and stubble; fruit pods, shells and peels; spoilt produced) green manures (grasses, legumes, fresh crops, etc) and sewage sludge. Agboola *et. al.* (1998) and Udoh *et. al.* (2005), stated that what makes organic manures useful and important is their positive effects on soil nutrient supplies, moisture holding capacity and structural characteristics. Organic matter, supplied by organic manure, benefits the soil through binding soil particles together to form aggregates (just as clay does), improving the moisture holding capacity of soil, especially in sandy and loamy soils, improving soil aeration and permeability to water. It also increases the cation exchange capacity of soil (contributes negatively-charge colloids), buffers the soil against excessive or abrupt pH change when soil amendment (alkaline or acid materials are added), favours the formation of metal-organic matter complexes (e.g. with Fe, Mn, Cu, Zn) which enhances the stable availability of these micro-nutrients throughout crop growing period. It is also an important source of the micro, and some secondary macro- nutrients (S, Mg, Fe, Cu) as well as supplies some amounts of N and P to plants, though these have to be converted through mineralization from organic to inorganic forms before crops can absorb them.

Inorganic fertilizers release nutrient fast in the soil but often lost such nutrients rapidly by leaching in porous soil and heavy rainfall areas. Frequent and high rate of inorganic fertilizers use has however been associated with some environmental pollution. Also, this inorganic fertilizer has recently become expensive and scarce in many countries (Ogbonna, 2008) while demand for its products has been on the decline. Therefore, sole dependent on non-chemical method of crop production has received a full attention.

The use of most agrochemicals and quick-release fertilizers is said to be the main cause of crop species imbalances, and formal approval for licensed organic production may require soil to have been free from these two groups of chemicals for at least two years. Control of pests and diseases is achieved by a combination of resistant cultivars and "safe" pesticide derived from plant extracts, by careful rotation of plant species and by the use of naturally occurring predators and parasites. Weeds are controlled by mechanical and heat-producing weed controlling equipment, and by the use of mulches (Adam *et. al*, 1999). The balanced nutrition of the crop is said to have induced greater resistance to pest and diseases, and taste of organically grown food is claimed to be superior to that of conventionally grown produce (Adam *et. al.*, 1999). The organic production of food and non-edible crops at present represents about 2 percent of the European market. The European Community Regulation (1991) as cited by Adam *et. al.* (1999) on the organic production of agricultural products' specify the substance that may be used as "plant-protection products, detergents, fertilizers or soil conditioners" among them are: pine, coir, leaf mould, lignite, recycled landfill, refusedriven humus, seaweed, sewage sludge, spent hops and grains, spent mushroom compost, straws, vermin composts, wood chips/fibre, wood waste, and wood fibre among others (Adam *et al*, 1999).

The use of organic manure in crop production is not new to southeast agricultural zones of Nigeria. Most soil in southern Nigeria and in parts of the humid tropics are acidic due to nature of their parent material, high rainfall regime and intensity and associated leaching of nutrients and weathering (Awodun *et al*, 2007). They are often deficient in essential nutrients after a few years of cropping. Therefore, there is need for sustainable liming and fertilizer application programme. The scarcity, high cost and negative effects of inorganic fertilizer on environment have led to call for organic farming. This is further justified by the fact that organic manures can be easily sourced, cheap, affordable, available all year round, non-toxic, and adoptable and could serve as alternative to inorganic fertilizer.

Organic manures however vary in their chemical composition either due to source, management, species, and age, among others. The effective utilization of combination of manures would immensely contributes to growth and yield of yam. The appropriate fertilizer use should however not only be able to increase the productivity of yam but also improve the fertility status of the soil even after crop harvest. Presently, there is paucity of information in Nigeria on the complementary use of varied organic manure sources for yam production. Therefore, the study reported here was carried in order to fill this gap with specific objectives of evaluating the effects of complementary use of different organic manure sources on water yam growth and yield, economic returns to management as well as attack by some pests in Uyo, southeastern Nigeria.

Materials and Methods

Field studies were conducted for two years at University of Uyo Teaching and Research Farm, Use Offot, Uyo, Akwa Ibom State (latitude $5^0 17^1$N and $5^0 27^1$N, longitude

$7^0 27^1$ and $7^0 58^1$E and altitude, 38.1m above sea level) between April and November of 2009 and 2010 cropping seasons. The soil was an ultisols and had a pH in water value of 5.6, 1.37 % organic matter, 0.10 % total nitrogen, 31.77 mg/kg available P and, exchangeable Ca and Mg of 2.88 and 1.20 mg/kg, respectively. The nutrient composition of the poultry manure was: N 4.71% , P 0.23 % , K 2.75 %, Ca 1.21 %, Mg 0.41 %, Na 0.08 %, Zn 0.19 % Cu 0.001%, Mn 0.06 %, and Fe 0.07 % ; oil palm bunch ash was N 0.82% , P 0.07 % , K 15 %, Ca 0.21 %, Mg 0.08 %, Na 0.10 %, Zn 0.41 %, Cu 0.02%, Mn 0.29 %, and Fe 0.34 % while goat manure was N 4.40 % , P 0.24 % , K 0.77 %, Ca 0.36 %, Mg 0.30 %, Na 0.36 %, Zn 0.21 % Cu 0.003%, Mn 0.07 % ,and Fe 0.08 %

The experiment was laid out in a randomized complete block design with three replicates. There were 8 fertilizer treatments viz: poultry manure (PM), goat manure (GM), and oil palm bunch ash (OPBA) each at 20 tha^{-1}, OPBA + PM, OPBA + GM and PM + GM each at a ratio of 1:1 (10 tha^{-1} + 10 tha^{-1}), NPK (15:15:15) at 400 $kgha^{-1}$ (a recommended dose of inorganic fertilizer) and no soil amendment. The site was cleared and ridges made with tractor mounted implement. Each plot measured 6m x 4m while water yam genotype ,TDa95/18894, obtained from traditional yam barn of National Root Crop Research Institute (NRCRI) ,Umudike, Abia State was used. Yam setts, each weighing one hundred and eighty grammes (180g) were planted on the crest of ridges at a spacing of 1.0 m x 1.0 m to give a crop population of 10,000 ha^{-1}. The organic manures were applied two weeks before planting while inorganic fertilizer (NPK 15:15:15) was applied at 8 weeks after planting (WAP). Weeding was done manually at 2, 4 and 6 months after planting (MAP) while staking was done using a single erect stake method with stakes of about 3 m long. The following growth and yield parameters were assessed; number of leaves per plant, leaf area, number of days to 80% senescence, number of tubers per plant, number of seed tubers per plant, number of ware tubers per plant, total yam tuber yield per hectare and pest attack at harvest. Data collected were subjected to analysis of variance and, mean where significant compared using Duncan Multiple Range Test (Gomez and Gomez, 1984). The monetized aggregate yield was calculated as the productivity (Ikeorgu, 2002).

Results

Number of leaves per plant and Leaf area

The number of yam leaves per plant varied significantly ($P<0.05$) among the fertilizer treatments in all the months sampled except at 2 months after planting (MAP) in 2009 cropping season (Table 1). The complementary use of organic manure had significant increase in the number of leaves per plant compared to sole applications of organic manures, NPK (15:15:15) and the control (no soil amendment). The complementary application of poultry manure and goat manure had 7 – 61 % and 5 – 60 % higher number of leaves than others in 2009 and 2010 cropping seasons, respectively.

The leaf area as influenced by complementary use of organic manures differed significantly ($P<0.05$) at 2, 3, 4 and 5 MAP in both cropping seasons (Table 2). The complementary use of poultry manure + goat manure treatment produced the widest leaf area in all the sampled months irrespective of cropping season. The application of poultry manure alone had the widest leaf area compared to the recommended NPK (15:15:15) rate (400 kg/ha). Leaf area from water yam that received combined application of poultry manure + goat manure was wider than those of other treatments by 2 – 57 and 9 – 59 % at 5 MAP in 2009 and 2010 cropping season ,respectively. The control treatment produced least leaf area in both cropping seasons.

Table 1: Number of water yam leaves as influenced by complementary use of organic manure

Treatment	2009				2010			
	Months after planting				Months after planting			
	2	**3**	**4**	**5**	**2**	**3**	**4**	**5**
OPBA	10.41a	65.73d	121.11e	183.00e	12.33a	86.40e	125.66f	173.36c
PM	11.50a	81.33c	183.40c	231.11c	12.40a	95.33d	175.18d	218.40b
GM	19.55a	75.41c	163.01d	203.12d	14.11a	90.71de	161.33e	216.43b
OPBA + PM	11.25a	125.51a	218.30a	256.13a	14.40a	120.33b	205.15c	266.03a
OPBA + GM	12.25a	125.33a	198.40b	237.88b	12.33a	122.60b	213.43b	260.41a
PM + GM	11.43a	122.66a	22o.14a	275.60a	14.61a	136.31a	240.43a	281.07a
400kg/ha	10.30a	107.33b	189.33b	233.73b	11.30b	122.80c	201.33c	251.11a
Control	10.13a	51.40e	86.30f	108.43f	10.25b	57.33f	80.77a	112.63d

Within each column, means with the same subscript are not significantly different according to Duncan Multiple Range Test.

Table 2: Leaf area of water yam as influenced by complementary use of organic manure

Treatment	2009				2010			
	Months after planting				Months after planting			
	2	3	4	5	2	3	4	5
OPBA	19.33b	24.66c	29.41c	38.77b	18.14b	23.71c	30.31b	40.11bc
PM	20.71ab	29.33ab	30.61c	42.33ab	21.71ab	28.67b	32.40ab	42.71b
GM	16.30c	25.11c	29.40c	38.81b	20.33b	27.30b	31.40ab	38.77c
OPBA + PM	21.15a	32.60a	38.03ab	48.31a	22.41a	33.40a	46.60a	48.78b
OPBA + GM	18.40c	30.41a	41.01a	46.51a	24.60a	32.75a	43.71a	45.11b
PM + GM	23.11a	35.60a	42.33a	49.52a	24.71a	39.09a	48.41a	53.40a
400kg/ha	19.50b	23.60c	33.55c	35.60c	19.70b	21.33c	34.71ab	37.40c
Control	13.12d	15.61d	18.71d	21.22d	12.66c	1`6.49d	21.06c	22.10d

Within each column, means with the same subscript are not significantly different according to Duncan Multiple Range Test.

Number of Days to 80% Senescence and pest attack at Harvest

There was significant difference (P<0.05) between organic manure based treatments and the control in the number of days required to reached 80 % senescence (Table 3). Water yam from the control (no soil amendment) used the least number of days to reach 8o % senescence (163.40 in 2009 and 161.80 days in 2010, respectively). Water yam that received poultry manure + goat manure treatment used more number of days to reach 80 percent senescence in both cropping seasons (199.50 days in 2009 and 198.67 in 2010). The combined application of poultry manure + goat manure delayed the number of days to 80% senescence by 2 – 18% in 2009 and by 2 – 19% 2010 compared to other treatments.

Table 3: Effect of complementary use of organic manure on number of days to 80% senescence and yam tubers pest attack

Treatment	2009			2010		
	Number of days to 80% senescence	Termite attack at harvest	Yam tuber beetle attack	Number of days to 80% senescence	Termite attack at harvest	Yam tuber beetle attack at harvest
OPBA	183.70a	1.00b	1.00b	184.30b	1.00b	1.00b
PM	189.40a	1.30b	1.33b	190.50a	1.30b	1.30b
GM	187.33a	1.45b	1.00b	190.30a	1.30b	1.03b
OPBA + PM	195.30a	1.00b	1.00b	195.70a	1.00b	1.00b
OPBA + GM	196.30a	1.00b	1.00b	198.66a	1.00b	1.00b
PM + GM	199.50a	1.33b	1.40b	198.67a	1.10b	1.33b
400kg/ha	171.33b	1.30b	1.50b	173.03b	1.43b	1.45b
Control	163.40b	2.30a	2.33a	161.80c	2.30a	2.51a

Within each column, means with the same subscript are not significantly different according to Duncan Multiple Range Test.

Table 4: Yield and Yield components of water Yam as Influenced by Complementary Use of Organic Manure

Treatment	2009				2010			
	No. of tubers plant^{-1}	No. of ware tubers plant^{-1}	No. of seed tubers plant^{-1}	Total tuber yield (tha^{-1})	No. of tubers plant^{-1}	No. of ware tubers plant^{-1}	No. of seed tubers plant^{-1}	Total tuber yield (tha^{-1})
OPBA	2.10b	0.00d	2.10a	20.66b	1.50	0.30c	1.20c	23.81b
PM	2.50b	1.10a	1.40a	22.55b	2.10b	1.00b	1.10c	24.33b
GM	2.33b	1.30a	1.03b	20.81b	20.3b	0.33c	1,70b	21.67b
OPBA+ PM	3.33a	1.30a	2.03a	24.33a	4.05a	1.45a	2.60a	27.03a
OPBA+ GM	3.01a	1.45a	1.56a	24.52a	3.40a	1.30a	2.10a	25.17a
PM + GM	3.43a	1.70a	1.73a	26.15a	4.71a	2.00a	2.71a	27.96a
400kg/ha	2.10b	1.10a	1.00b	22.60b	1.30c	0.30c	1.00c	23.81b
Control	1.30c	0.00d	1.30b	10.45c	1.10c	0.00d	1.10c	9.75c

Within each column, means with the same subscript are not significantly different according to Duncan Multiple Range Test.

Pest attack at harvest showed significant differences ($P<0.05$) with the control (no soil amendment) having the highest termite and yam tuber beetle attack (2.30 and 2.33 i.e. moderate attack) in 2009 and 2.30 and 2.51 (moderate attack) in 2010 (Table 3) .The result indicated no symptom of termite and yam tuber beetle attack in treatments that received OPBA either in sole or combined application in both cropping seasons. There was no significant difference in pest attack between recommended NPK (15:15:15) rate and organic manure applied either as sole or combined.

Yield and yield components of water yam

The number of tubers per plant (Table 4) as influenced by complementary application of organic manures differed significantly ($P<0.05$). The combined application of poultry manure + goat manure had the highest number of tubers per plant, 3.43 and 4.71 in 2009 and 2010, respectively. The result also further indicated significant difference between sole applications of organic manure and recommended NPK (15:15:15) rate over the control treatment. The complementary application of OPBA + PM produced about 3 – 62 % more number of yam tubers than other treatments.

The number of seed tubers (tubers less than 1kg weight) per plant differed significantly ($p<0.05$) among the treatment (Table 4). Treatments that received oil palm bunch ash + poultry manure had more number seed tubers per plant (2.10) in 2009 while in 2010, the treatment that received poultry manure + goat manure produced the highest number of seed tubers per plant (2.71) with 4 – 63 % difference above other treatments. The least number of seed tubers per plant was obtained from the NPK (15:15:15) treatment in both cropping seasons.

The number of ware tubers (tubers above 1kg weight) per plant indicated significant differences among the treatments (Table 4). Application of poultry manure + goat manure produced the highest number of ware tubers per plant (1.70 and 2.00 in 2009 and 2010, respectively) and with 15 – 100 and 28 – 100 % difference above other treatments, respectively.

The complementary application of organic manure significantly increase the yam tuber yield compare to control (no soil amendment). The highest tuber yield was obtained from treatments that received complementary application of poultry manure and goat manure

(26. 15 and 27.96 t/ha in 2009 and 2010, respectively) and with percentage yield difference of 8 – 60 % and 3 – 65 %, respectively. There was no significant difference between the sole applications and recommended NPK rate in both cropping seasons. Control treatment (no soil amendment) produced the least tuber yield (10.45 and 9.85 t/ha in 2009 and 2010, respectively).

Cost of Production and Economic Returns to Management

The cost of production and economic returns to management are shown in Table 5 (attached in the end). The highest cost of production was from the treatments that received NPK (15:15:15) which was ₦242,000 and ₦249,500 in 2009 and 2010 ,respectively, while the lowest cost of production was from the control (no soil amendment). The highest return to management (₦2,867,900 and ₦3,234,840) was obtained from complementary application of poultry manure and goat manure in 2009 and 2010 ,respectively which also had the highest cost- benefit ratio (14.17 and 15.49, respectively). The least cost- benefit ratio (5.89 and 5.88) was obtained from the control (no soil amendment) while the recommended rate of NPK had cost-benefit ratios of 11.02 and 10.88 in 2009 and 2010, respectively.

Discussion

The significant effect of sole and complementary use of organic manure over the control (no soil amendment) is attributed to low soil fertility of the experimental site as evidenced by the soil characteristics. It has reported that crop response better to fertility with low nutrient content than soil with high nutrient reserve (Tisdale and Nelson, 1975; Ogbonna, 2008; Ikeh *et al.*, 2012). The observed differences could also be due to the fact that organic manure apart from it unique characteristics of gradual release of nutrient elements to the soil, has also been shown to improve other soil chemical and physical properties which enhance crop growth and development (Stevenson and Ardakani, 1972; Udoh *et al*. 2005; Awodun *et. al.*, 2007). Specifically, the superiority of combined application of poultry manure + goat manure treatment over other treatments is due to the fact that the poultry manure mineralized faster than the complemented goat manure and thus supplied the needed nutrients at the initial growth stage of the water yam while goat manure that required comparatively longer period to mineralize supplied nutrients during the later period of the crop growth.

The variations observed in vegetative traits and yield and yield components of the water yam under complementary use of organic manure are apparently due to differences in the concentrations of macro- and micro- elements supplied by the organic manures (De-Lannoy and Romain, 2001). Findings from earlier studies (Obi and Ekperigin, 2000; Awodun *et al.*, 2007) have confirmed that ash derived from plant sources were effective as liming material and source of nutrients for different crops. No pest attack was recorded on water yam treatments that received oil palm bunch ash (OPBA) either in sole or combination. Also application of organic manure reduced pest attack at harvest compared to no soil amendment. This finding is also in consonance with that reported by Atu (1993) and Engelhard (1989). Engelhard (1989) stated that crop nutrition is widely recognized to affect severity of a range of pests and diseases as crop under nutritional stress is likely to have increased susceptibility to infection. Atu (1993) found that fertilization reduced the incidence of termite damage on tuber. No symptom of pest attack was recorded from treatments that received OPBA and this could be due to high concentration of phosphorus which apparently acted as a repellent and/ or physical poison, causing abrasion of a particular wax and thus exposing pest to death through desiccation.

The highest cost of production was from the treatments that received NPK (15:15:15) while the lowest was from the control (no soil amendment). The highest economic return to management was obtained from complementary application of poultry manure and goat manure. This could be due to the lower cost of the different organic manures compared to the recommended NPK fertilizer rate and their ability to produce high yield. The reduction in tuber yield from NPK fertilizer treatment compared to complementary use of organic manure could be due to poor utilization of NPK fertilizer due to leaching and soil erosion.

Conclusion

Empirical evidence shows that water yam yield will continue to decline in Nigeria due to low soil fertility following shortened fallow periods. This study has however demonstrated that yam can grow and perform well in Uyo with use of organic manures especially when they are combined in order to derive the synergistic benefits. Most organic manures used in this study are inexpensive, locally available, environmental friendly and ecological sound. Therefore, the use of these organic manures as fertilizer will also encourage rekeying of agricultural waste and enhance sustainable water yam production in Uyo, southeastern Nigeria.

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Table 5: Cost of production and economic return to management (N/ha) as influenced by complementary use of organic manure on water yam production

	Complementary use of organic manures in 2009								Complementary use of organic manures in 2010							
	OPBA	PM	GM	OPBA+PM	OPBA + GM	PM+GM	400kg/ha	Control	OPBA	PM	GM	OPBA+PM	OPBA + GM	PM+GM	400kg/ha	Control
(A)																
Cost of production																
Land preparation	49,000	49,000	49,000	49,000	49,000	49,000	49,000	49,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Planting materials	38,000	38,000	38,000	38,000	38,000	38,000	38,000	38,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000
Staking materials	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,500	36,500	36,500	36,500	36,500	36,500	36,500	36,500
Fertilizer/Manure	5,400	9,000	6,600	7,200	6,000	7,800	32,000	-	5,200	9,200	6,400	7,200	5,800	7,800	34,000	-
Labour	87,000	87,000	87,000	87,000	87,000	87,000	87,000	87,000	89,000	89,000	89,000	89,000	89,000	89,000	89,000	89,000
Total cost of production	215,400	219,000	216,600	217,200	216,000	217,800	242,000	210,000	220,700	224,700	221,900	222,700	231,300	223,300	249,500	215,500
(B)	20.66	22.55	20.81	24.33	23.52	26.15	22.60	10.45	23.81	23.33	21.67	27.03	25.17	29.06	22.81	9.75
Tuber yield (t/ha)																
(C)	2437888	2660900	2455580	2870940	2775360	3085700	2666800	1233100	2833390	2895270	2578730	3216570	2995230	3458140	2714390	1160250
Gross Revenue (GR)																
(D)	2222480	2441900	2239980	2653740	2559360	2867900	2424800	1023100	2612690	2670570	2356830	2993870	2773930	3234840	2464890	944750
Return to management (GRI)																
Benefit cost ratio	11.32	12.25	11.34	13.22	12.85	14.17	11.02	5.89	12.84	12.89	11.62	14.44	13.54	15.49	10.88	5.38

(a) Labour costs are planting, weeding, fertilizer/manure application and transportation.

(b) Yield x unit price of ₦118,000 and ₦119,000 per tonnes of yam based on prevailing market price at time of sales in 2009 and 2010 ,respectively.

(c) USS1= N149 and N151 in 2009 2010, respectively.