

# Evaluation of Growth and Yield of Cocoyam on Varying Rates of Organic Manure in a Cocoyam Based-Intercropping System

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**Abstract:** Field experiment was conducted at Akwa Ibom State University teaching and research farm during the 2020 and 2021 cropping seasons to evaluate the growth and yield of cocoyam on varying rates of organic manure in a cocoyam based-intercropping system in Obio Akpa, Akwa Ibom State of Nigeria. Experiment was laid out in a randomized complete block design with three replications. Treatments were four organic manure rates – PM 0 t/ha, PM 2.5 t/ha, PM 5.0 t/ha, PM 7.5 t/ha) and three crop mixtures - Sole Cocoyam, Cocoyam + Maize, Cocoyam + Melon. Result showed significant differences in both the crop mixtures and organic manure rates applied on the plant height, leaf area and stem girth of cocoyam at 2, 4, 6 months after planting respectively. Organic manure PM 2.5 t/ha gave higher plant height, leaf area and stem girth in sole cocoyam, cocoyam + maize, cocoyam + melon and cocoyam + maize + melon at 2, 4, 6 months after planting in both cropping seasons. PM 5.0 t/ha gave higher values of corm and cormels yield, corms and cormels weight, cormels number and cormels length in sole cocoyam, cocoyam + melon and cocoyam + maize + melon in both seasons. PM 2.5 t/ha gave higher values of cormels yield, weight of corm, weight of cormels and length of cormels with Cocoyam + maize. Weight of corms and weight of cormels showed significant differences ( $P < 0.05$ ) on crop mixtures and organic manure in both seasons respectively.

**Keywords:** Cocoyam, Melon, Maize, Poultry Manure

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## 1. Introduction

Declining soil fertility and cocoyam production is a major constraint facing both smallholders and commercial farmers in the south-eastern zone of Nigeria. This is caused by the continuous cultivation of the land without an appropriate soil amendment or addition of adequate external soil inputs. The continuous decline in soil fertility and poor soil management practices are due primarily to the nature of the parent materials, leaching of nutrients and weathering occasioned by heavy rainfalls over a long period of time [23]. According to Chukwu [12] most nutrients such as potassium, phosphorus and nitrogen required by farmers for the production of cocoyam are therefore deficient [30].

Improving fertilizer management is an important option

for improving yield and return to investment in crop production [11]. These, are however managed by the application of soil amendments either organic or inorganic forms of fertilizer. Fertilizers are generally known to increase yields per hectare. It could therefore be said that fertilizers are essentially chemical nutrients (organic and inorganic) desired by plants at different levels and time for good growth and yield [32].

Organic fertilizers are known to be effective in the maintenance of an adequate supply of organic matter into the soil, with attendant improvement in soil physical and chemical conditions and enhanced crop performance [16, 6].

Adequate soil fertility is one of the requirements for profitable crop production [10, 29].

According to Udoh [32] cocoyam responds better to

organic fertilizer than inorganic fertilizers. For organic fertilizer; apart from the particles size distribution resulting from the organic matter, it contributes greatly to the water holding capacity of the soil due to the reduction in inorganic matter content. Organic fertilizer contains the clay humus complexes which forms a good protection against wind and water erosion and helps to promote permeability while simultaneously improving water storage as well as the aggregates stability [18, 4, 35].

Poultry manure is an excellent source of organic phosphorus, potassium and other essential nutrients [14], desirable to improve the fertility of the soil, serve as a source of organic amendment to the soil and provides nutrients to crops [36]. Poultry manure improves soil physical properties significantly by reducing the soil bulk density, temperature and increase the total porosity and moisture content in the soils [2].

Dauda [13] observed that poultry manure is relatively resistant to microbial degradation and helps to sustain cropping systems through better nutrient recycling and improvement in soil physical, chemical and biological properties [25].

Cocoyam is an important staple food crop in Nigeria, ranking third among the roots and tuber crops after yam and cassava. The production of cocoyam has been hampered by poor soil fertility and the attendant management practices. The soils of the South-eastern Nigeria are notably low in organic matter and cannot sustain intensive production of cocoyam. There is a general inherent decline in the ability of the soil to grow crops without reliance on the inputs from outside the system. This however necessitated the study using poultry manure as organic fertilizer at various rates to boost the soil fertility and consequently, the yield on cocoyam.

## 2. Materials and Methods

The research was conducted at the Akwa Ibom State University teaching and research farm Obio Akpa Campus in Oruk Anam Local Government Area, Akwa Ibom State in Nigeria. The farm lies between latitude 4 30°S and 5 30°N and longitude 7.30°W and 8.00°E with an altitude of 38.1 m above sea level and has annual rainfall range between 2000mm - 2600mm with bimodal pattern, which peaks in June and October [27]. The annual temperatures ranges between 24°C and 30°C being highest in the months of February and April, while the relative humidity ranges from 75 - 79% [27]. The vegetation of the place is a tropical rain forest though much of the climatic vegetation has been destroyed and now under arable crops. The experiment was laid out in a Randomized Complete Block (RCBD) with three replications. The sub-treatment plots measured 3 x 6m, main treatment plots measured 18 x 6m and the entire experimental field measured 78 x 22m. The treatments used for the experiment were four organic manure rates – PM 0 t/ha, PM 2.5 t/ha, PM 5.0 t/ha, PM 7.5 t/ha and four crop mixtures - Sole Cocoyam, Cocoyam + Maize, Cocoyam +

Melon and Cocoyam + Maize + Melon. The cocoyam setts with average weight of 0.3kg were planted on the crest of the mounds at 1 x 1 m spacing to give a plant population of 10,000 plants/hectare. The maize seeds were planted at 3 seeds per stand on the side of the mound at 1 x 0.5 m spacing and later thinned to 2 plants per stand. Three melon seeds were planted per stand and later thinned to 2 plants per stand on the crest of the mound at 1 x 1m spacing. The poultry manure was sun cured for about 3days and de-caked before application. The Poultry Manure were applied in band at 2 months after planting (MAP). Weeding was done manually at 4 months' interval after planting while harvesting was done at 4 months after planting for maize, melon and 8 months after planting (MAP) for cocoyam.

The following growth and yield parameters were collected – plant height, leaf area, stem girth for growth and corms and cormels yield, weight of corm and cormels, number of cormels per plant and length of cormels for yield parameters.

The data obtained were subjected to analysis of Variance and treatment means were separated using F- LSD at 5% probability level.

## 3. Result

Results showed significant differences ( $P < 0.05$ ) among the crop mixtures and organic manure rates on the cocoyam height (Table 1). With sole cocoyam and crop mixtures of cocoyam + melon and cocoyam + maize, the organic manure rate of PM 2.5 t/ha gave higher values of cocoyam height at 2, 4, 6 Months After Planting (MAP) in both planting seasons. With crop mixture of cocoyam + maize + melon, organic manure PM 5.0 t/ha gave a higher value. There were significant differences ( $P < 0.05$ ) on the crop mixtures at 2, 4, 6 MAP whereas, the organic manure indicated significant differences ( $P < 0.05$ ) at 2 and 6 MAP respectively.

The effect of crop mixtures and organic manure rates on the leaf area of cocoyam is shown in table 2. Result showed significant differences ( $P < 0.05$ ) at 2, 6 MAP with organic manure application whereas crop mixtures indicated significant differences ( $P < 0.005$ ) at 6 MAP in both planting seasons. Organic manure rate of PM 2.5 t/ha gave a higher value of leaf area at 4 and 6MAP with sole cocoyam. With crop mixtures of cocoyam + melon, cocoyam + maize and cocoyam + maize + melon, organic manure rate of PM 2.5 t/ha recorded the higher values of leaf area at 2, 4, 6 MAP respectively.

Table 3 shows the effect of crop mixtures and organic manure rates on the stem girth of cocoyam. Results showed significant differences ( $P < 0.05$ ) on crop mixtures at 2, 6 MAP whereas organic manure rates indicated significant differences ( $P < 0.05$ ) at 2, 4, 6 MAP in both planting seasons. For sole cocoyam and crop mixtures of cocoyam + melon, cocoyam + maize, and cocoyam + maize + melon, PM 2.5 t/ha gave the higher values of stem girth of cocoyam at 2, 4, 6 MAP in the two years of planting respectively.

Table 4 showed the effect of crop mixtures and organic manure rates on the yield and yield components of cocoyam.

Results indicated significant differences ( $P < 0.05$ ) on the weight of corm, weight of cormels on both crop mixtures and organic manure rates in the two cropping seasons. Organic manure rate of PM 5.0 t/ha gave higher values of corm and cormels yield, corms and cormels weight, cormels number and cormels length in sole cocoyam and crop mixtures of cocoyam + melon and cocoyam + maize + melon in both

seasons. However, with the crop mixture of cocoyam + maize, PM 5.0 t/ha organic manure rate, recorded high values for corm yield and number of corms, whereas high values of cormels yield, weight of corm, weight of cormels and length of cormels were obtained with the application of PM 2.5 t/ha in both seasons.

**Table 1.** Effect of crop mixtures and organic manure on the height of Cocoyam.

Treatments		Months After Planting (cm)(MAP)					
Crop mixtures	Organic manure	2		4		6	
		2020	2021	2020	2021	2020	2021
Sole cocoyam	PM 0 t/ha	51.2	49.5	75.7	74.2	91.9	92.0
	PM 2.5 t/ha	55.13	55.9	85.4	86.1	113.4	140.2
	PM 5.0 t/ha	54.87	53.5	75.2	74.8	93.9	95.2
	PM 7.5 t/ha	47.33	48.4	73.7	72.5	91.7	92.4
Co + Me	PM 0 t/ha	50.8	48.2	76.2	76.0	101.6	110.0
	PM 2.5 t/ha	54.2	54.6	81.3	80.4	109.4	109.8
	PM 5.0 t/ha	50.7	51.0	76.0	75.2	101.0	107.4
	PM 7.5 t/ha	51.3	52.1	75.4	74.8	100.0	105.0
Co + Ma	PM 0 t/ha	48.4	48.7	69.9	68.5	93.8	94.1
	PM 2.5 t/ha	64.0	63.8	96.3	94.4	128.0	127.8
	PM 5.0 t/ha	55.4	56.2	84.6	85.2	112.7	111.8
	PM 7.5 t/ha	55.3	55.8	83.7	83.9	111.0	108.7
Co + Ma + Me	PM 0 t/ha	50.4	49.2	75.0	74.5	98.7	99.1
	PM 2.5 t/ha	54.9	55.0	82.9	83.2	111.5	107.4
	PM 5.0 t/ha	58.0	58.2	87.7	89.1	117.4	116.8
	PM 7.5 t/ha	46.5	47.0	69.3	68.5	93.9	94.1
LSD (0.05) Crop mixture		130.3	131.2	356.7	362.3	533.2	524.3
LSD (0.05) Organic manure		103.2	101.6	NS	NS	183.8	184.1

Co = Cocoyam; Me = Melon; Ma = Maize; PM = Poultry Manure

**Table 2.** Effect of crop mixtures and organic manure on the leaf area of Cocoyam.

Treatments		Months After Planting (cm <sup>2</sup> ) (MAP)					
Crop mixtures	Organic manure	2		4		6	
		2020	2021	2020	2021	2020	2021
Sole cocoyam	PM 0 t/ha	770.6	780.1	1633.6	1634.6	2450.4	2449.6
	PM 2.5 t/ha	889.3	878.9	2008.4	2004.8	3012.6	3025.1
	PM 5.0 t/ha	833.8	840.5	1773.4	1770.4	2660.1	2589.2
	PM 7.5 t/ha	901.2	890.4	1920	1921.1	2880.4	2780.4
Co + Me	PM 0 t/ha	731.8	730.4	1515.8	1510.5	2273.7	2272.4
	PM 2.5 t/ha	1144.7	1201.0	1970.2	1989.4	2955.3	3001.4
	PM 5.0 t/ha	976.5	984.2	1615.9	1605.2	2423.0	2413.6
	PM 7.5 t/ha	1097.6	1101.4	1891.1	1884.2	2836.6	2786.4
Co + Ma	PM 0 t/ha	657.9	661.2	1300.8	1301.1	1951.2	1960.1
	PM 2.5 t/ha	1963.8	1096.1	1961.8	1980.3	2942.8	2975.8
	PM 5.0 t/ha	904.6	911.3	1585.8	1566.7	2887.4	2880.4
	PM 7.5 t/ha	935.8	922.2	1924.9	1904.6	2378.7	2360.5
Co + Me + Ma	PM 0 t/ha	875.6	917.4	1266.0	1301.1	1899.0	1886.8
	PM 2.5 t/ha	1150.3	1210.8	1892.6	1821.2	2839.0	2914.5
	PM 5.0 t/ha	1062.8	1044.5	1500.4	1455.6	2250.6	2250.1
	PM 7.5 t/ha	1047.7	1026.6	1816.7	1801.2	2725.1	2645.2
LSD (0.05) Crop mixture		NS	NS	NS	NS	349.4	325.6
LSD (0.05) Organic manure		14.7	15.1	NS	NS	9.24	9.54

Co = Cocoyam; Me = Melon; Ma = Maize; PM = Poultry Manure

**Table 3.** Effect of crop mixtures and organic manure on the stem girth of Cocoyam.

Treatments		Months After Planting (cm) (MAP)					
Crop mixtures	Organic manure	2		4		6	
		2020	2021	2020	2021	2020	2021
Sole cocoyam	PM 0 t/ha	10.4	10.2	18.2	18.1	27.3	26.8
	PM 2.5 t/ha	14.4	14.2	22.9	22.7	34.3	34.0
	PM 5.0 t/ha	10.4	10.1	19.9	19.0	29.9	28.1
	PM 7.5 t/ha	11.6	11.8	20.1	19.9	31.0	30.1
Co + Me	PM 0 t/ha	7.9	7.4	18.9	18.1	28.3	27.8
	PM 2.5 t/ha	12.4	12.6	22.3	22.2	33.5	34.1
	PM 5.0 t/ha	9.7	8.9	19.6	18.9	29.5	29.7
	PM 7.5 t/ha	10.6	9.6	20.7	20.4	31.1	31.0
Co + Ma	PM 0 t/ha	8.6	8.7	18.1	18.0	27.2	27.0
	PM 2.5 t/ha	11.4	12.0	21.3	22.1	31.9	32.3
	PM 5.0 t/ha	9.5	9.3	19.8	18.9	29.8	28.6
	PM 7.5 t/ha	9.7	9.5	20.2	20.0	30.4	30.1
Co + Me + Ma	PM 0 t/ha	8.6	8.4	18.7	18.3	28.0	28.2
	PM 2.5 t/ha	11.0	11.2	19.7	20.1	29.6	29.8
	PM 5.0 t/ha	8.9	8.8	19.0	18.6	28.6	27.6
	PM 7.5 t/ha	10.5	10.2	19.5	19.4	29.3	29.1
LSD (0.05) Crop mixture		9.2	9.1	NS	NS	23.47	22.6
LSD (0.05) Organic manure		21.6	21.5	29.73	NS	21.84	20.7

Co = Cocoyam; Me = Melon; Ma = Maize; PM = Poultry Manure

**Table 4.** Effect of crop mixtures and organic manure on the yield and yield components of cocoyam.

Treatments		Yield and Yield Components											
Crop mixtures	Organic manure	Corm yield (t/ha)		Cormels yield (t/ha)		Wt. of corm (gms)		Wt. of Cormels (kgs)		No. of cormels		Length of Cormels (cm)	
		2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Sole cocoyam	PM 0 t/ha	4.1	3.1	3.8	3.5	0.52	0.37	0.61	0.54	6.7	5.6	8.7	7.8
	PM 2.5 t/ha	5.9	5.4	3.4	3.3	0.40	0.42	0.32	0.36	4.0	4.5	6.9	6.5
	PM 5.0 t/ha	6.7	6.0	4.3	4.2	0.82	0.80	0.59	0.62	10.6	9.8	9.4	9.2
	PM 7.5 t/ha	3.9	3.3	2.9	3.0	0.63	0.56	0.55	0.48	7.6	6.7	9.6	8.1
Co + Me	PM 0 t/ha	4.8	3.7	2.8	2.4	0.38	0.41	0.47	0.45	7.0	6.5	7.1	6.4
	PM 2.5 t/ha	6.5	6.1	2.7	2.5	0.67	0.70	0.45	0.51	8.0	7.8	8.6	8.4
	PM 5.0 t/ha	7.8	8.2	3.0	2.9	0.80	0.84	0.67	0.70	9.0	8.0	8.6	8.3
	PM 7.5 t/ha	4.9	4.4	3.2	3.5	0.45	0.51	0.34	0.40	6.0	6.8	6.6	6.8
Co + Ma	PM 0 t/ha	3.5	3.2	2.5	2.8	0.26	0.28	0.31	0.30	6.0	5.6	6.9	6.4
	PM 2.5 t/ha	5.8	6.2	3.3	3.2	0.64	0.61	0.35	0.39	6.0	7.2	8.4	8.1
	PM 5.0 t/ha	5.9	5.7	2.7	3.0	0.36	0.47	0.32	0.34	7.0	8.0	7.5	7.0
	PM 7.5 t/ha	4.1	3.8	2.6	2.8	0.61	0.56	0.39	0.38	4.0	4.6	6.9	6.2
Co + Me + Ma	PM 0 t/ha	1.9	2.3	1.3	2.3	0.23	0.21	0.31	0.30	5.0	4.2	6.4	5.4
	PM 2.5 t/ha	5.0	5.6	5.5	6.0	0.54	0.61	0.30	0.35	6.0	5.4	7.9	8.2
	PM 5.0 t/ha	5.5	6.1	3.3	4.1	0.60	0.68	0.44	0.48	7.0	6.2	7.2	7.8
	PM 7.5 t/ha	4.2	4.4	2.5	3.0	0.44	0.54	0.42	0.41	6.0	5.6	6.2	5.4
LSD (0.05) Crop mixture		51.0	NS	NS	6.3	7.0	5.8	7.2	8.4	NS	4.2	NS	3.4
LSD (0.05) Organic manure		3.3	NS	NS	NS	3.8	3.6	3.0	2.6	4.1	3.5	4.2	5.1

Co = Cocoyam; Me = Melon; Ma = Maize; PM = Poultry Manure

## 4. Discussion

The response of crops to applied fertilizer depends on soil organic matter. The quantity of soil organic matter depends on the quality of organic material which can be introduced into the soil either by natural returns through roots, stubbles, sloughed-off roots nodules and root exudates or by artificial application in the form of organic manure which can

otherwise be called organic fertilizers [3]. The use of organic manure will increase the yield of crops thereby making it possible to obtain maximum yields and this will lead to economic benefit for farmers [33]. From the result, higher values of cocoyam height, leaf area and stem girth were recorded with PM 2.5 t/ha on both sole and crop mixtures in the two planting seasons. This finding agrees with [34] that application of poultry manure and potassium at the highest rate produced significantly taller plant with higher leaf area,

dry matter, corm and cormels number. He further asserted that weight of corms and total yield were however optimized at higher rates of poultry manure and potassium [34]. This assertion however agrees with [8] that fertilizers can stimulate crop growth and improve mineral uptake. This was further collaborated by the findings of [28] who opined that the use of organic fertilizer improves crop yields by way of increasing soil fertility and nutrient availability. This explanation holds for increase in leaf area, stem girth and the number of leaves of cocoyam plant.

One of the major reasons for applying poultry manure is because it serves as a source of organic amendment to the soil and provides nutrients to crops [36], improves soil physical properties significantly by reducing soil bulk density, temperature as well as increase total porosity and moisture content in the soils [2]. Poultry manure is very cheap and effective as a good source of nitrogen for sustainable crop production [14], but its availability remains an important issue due to its bulky nature. Poultry manure is an excellent source of organic phosphorus, potassium and other essential nutrients. Farhad [14] stated that poultry manure is recognized as the most desirable organic fertilizer which improves the fertility of the soil by adding essential nutrients as well as organic matter which improves moisture and nutrient retention.

The significant increase in plant height, leaf area and stem girth observed with increase organic manure when compared with the control could be attributed further to the nitrogen content of the applied organic manure. The presence of phosphorus in the organic manure increases the absorption of nitrogen according to [9, 19] which consequently promotes vegetative productions.

The differences in plant heights, leaf area and stem girths probably reflects the differences in the nature of competition between the sole cropping and the crop mixtures in the systems. It also appeared that the important factors of competition were probably light and nutrients.

Intercropping cocoyam with maize and melon tends to promote the vegetative phase of cocoyam. The reduction in the leaf area of the intercropping systems implies that the corm and cormels yields were positively associated with the leaf size in the cropping systems. These agrees with the findings of [15]. Tayo [31] also noted that the decrease in leaf area with advancement in the age of cocoyam was due to senescence of old leaves and outgrowth of small ones.

The corm yield of cocoyam was higher with high organic manure (PM 5.0 t/ha) when compared with the control. The lower rate of organic manure with the attendant lower corm yield can be attributed to the relative competition among the crops. However, cocoyam with melon crop mixtures enhanced cocoyam yield relative to sole cocoyam. This could be attributable to the short life span of melon and subsequent released of residual nitrogen from the leaves to the soil [20]. This further support the findings of [5], who opined the subsequent decay of melon foliage provides additional nutrients and improved soil conditions for cocoyam rapid

growth and production. Murwira [21] and [7] had reported improved nutrient use efficiency with organic fertilizer. Cocoyam being a root crop has a high requirement for potassium as yam and cassava [22, 17, 26]. The potassium content of organic manure is usually high though dependent on the type, makes it suitable for root crops. The corm, corm weight, number of cormels and total yield per hectare were optimised with higher rates of organic manure. This result confirms the findings of [24] that cocoyam requires high poultry manure and higher rates of potassium depending on soil type. This assertion further agrees with [1] who explained that the use of organic fertilizers on crops increased yield.

## 5. Conclusion and Recommendations

The findings of this study generates the following conclusion.

The application of organic manure at PM 2.5 t/ha encourages vegetative growth and development of the cocoyam. Plant height, leaf area and stem girth were highly favoured with the application of organic manure at 2, 4, 6 MAP in both the sole and varied crop mixtures.

Organic manure applied mostly at a higher rate of PM 5.0 t/ha promoted the yield and yield components of cocoyam (corms yields, cormels yields, weight of corm, weight of cormels, number of cormels and length of cormels) in both sole cocoyam and cocoyam crop mixtures.

It is therefore recommended that organic manure should be applied at the rates of PM 2.5 t/ha and PM 5.0 t/ha for both vegetative growth and yield respectively on sole cropping and varied crop mixtures in a farm enterprise.

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## References

- [1] Adediran, J. A. and Banjoko, V. A. (2003). Comparative effectiveness of some compost fertilizer formulations for maize in Nigeria. *Nigerian Journal of Soil Science*. 13: 42-48.
- [2] Agbede, T. M., (2008). Nutrient availability and cocoyam yield under different tillage practices. *Soil and Tillage Research* 99: 1, pp 49-57.
- [3] Agboola, A. A. and J. A. Omueti, (1982). Soil fertility problem and its management in tropical Africa. Paper Presented at the International Institute of Tropical Agriculture, Ibadan Nigeria. PP: 25.
- [4] Ahmed, M., Baiyeri K. P., Echesona B. C. (2012). Growth and Yield responses of ratoon crops of sugar cane to organic mulching materials at Badeggi, *Nigeria. Journal of Arid Agriculture* 21: 109-188.
- [5] Akinyemi, S. S. and Tijani- Eniola, H. (1997). Effect of melon population density intercropped with Plantain on weed control and intercrop productivity. *Nigerian journal of weed Science* 10: 27-34.
- [6] Ano O. A. and Agwu, J. A. (2005). Effects of animal manure on selected soil chemical properties *Journal of Soil Science*. 15: 14-19.

- [7] Ayoola, O. T. and Adeniyi, O. N. (2006). Influence of poultry on yield and yield components of crops under different cropping systems in South West Nigeria. *African Journal of Biotechnology*, 5: 1386-1392.
- [8] Azza, A. M. M., Yassen, A. A. and Sahar, M. Z. (2006). Impact of boron fertilizer on growth under water regime. *World Journal of Agricultural Science*. 2 (4): 412-420.
- [9] Badran, F. S. and Safwat, M. S. (2004). Response of fennel plants to organic manure and bio-fertilizers in replacement of chemical fertilization in Egypt. *Journal of Agricultural Research* 82 (8): 247-256.
- [10] Bello, W. B. and Muhammed Awwal (2008). "Effects of Nitrogen, rate and timing of application on growth and yield of Beet root (*Beta vulgaris*)". *African Journal of Biotechnology*. 7 (15).
- [11] Carkey, R. J (2001) Effect of cowpea residue incorporation and nitrogen application on the productivity of upland rice. National Root Crop Research Institute, Umudike, *Nigerian Research bulletin* 2: 1-12.
- [12] Chukwu, G. O (2002) Effect of organic manure in yam production in Southeastern Nigeria. National Root Crop Research Institute, Umudike (2003). *Annual report* pp 67-68.
- [13] Duada, S. N, Ajayi F. A., Ndor E. (2008). "Growth and Yield of water melon (*Citrullus Lanatus*) as affected by poultry manure application". *Journal of Agriculture and Social Science*, 4: 121-124.
- [14] Farhed W., Saleem M. F. Cheema M. A., Hamed, H. M., (2009). Effect of poultry manure levels on the productivity of spring maize (*Zea mays*). *The Journal of Animal and Plant Sciences*. 19 (3): 122-125.
- [15] Igbokwe, M. C. (1983). Growth and development of colocasia and xanthosoma spp under upland condition. Proceedings of the 2<sup>nd</sup> symposium. ISTEAC. AB, Duala, Cameroun: 14 -19<sup>th</sup> August 1983. Pp 182-184.
- [16] Ikpe F. N. Powel, J. M. (2005), Nutrient cycling practices and changes in soil properties in the Republic of West Africa *Nutritional Cycle, Agroecosystem*, 62: 37-45.
- [17] Kay, E. D. (1987). Root crops: Crop and product digest No. 2, pp 227-228.
- [18] Lal, R. and Greenland, D. J. (1979). Soil physical properties and crop production in the tropics. John Wiley and Sons, London, 551pp.
- [19] Majeed, K. A. and Ali, S. A. (2011). Effect of foliar application of NPK 20:10:10 on some growth characters of food cultivars of Roselle (*Hibiscus sabdariffa* L). *American Journal of plant physiology* 6: 220-227.
- [20] Mba, C. C. (1983). Egusi plant-*Colocynthis citrullus* and soil properties, In: Obiefuna, J. C. (1989). Biological weed control in plantains (*Musa AAB*) with egusi melon (*Colocynthis citrullus*). *Biological Agriculture and Horticulture* 6: 221-227.
- [21] Murwira, H. K. and Kirchmenn, H. (1993). Soil organic matter dynamics and sustainability of tropical Agriculture. Pp 189-198.
- [22] Obigbesan, G. O. (1976). Effect of potassium on tuber yield and nutrient uptake yam varieties. Proceedings of the 4<sup>th</sup> symposium of the International Society for Root Crops. IDRC/CIAT, Columbia. Ed. Cook, Macintyre and Graham. 1976. Pp 104-107.
- [23] Ogbonna, P. E. (2008). "Effect of combined application of organic and inorganic fertilizers on fruit yield of eggplant (*Solanum melongena*)". Proceeding 42nd Annual conference Agricultural Society of Nigeria (ASN) October 19-23 p. 236-250.
- [24] Ohiri, A. C., Ogbonaya, J. C., Enyineya, A. M., Ojinaka, T. L. and Chukwu, G. O. (1988). Annual Report, NRCRI, Umudike, pp 75-77.
- [25] Ojeniyi, S. O. (2000). Effect of goat manure on soil nutrients and Okra yield in a rain forest area of Nigeria. *Applied Tropical Agriculture*. 5: 20-23.
- [26] Onwueme, I. C. and Sinha, T. D. (1991). Field crop production in Tropical Africa. Pp 276-287.
- [27] Slus, A. K. (1989). "Physical Background, soil, land use and ecological Problems". Technical Report of the Task Force on Soil and land use survey. Akwa Ibom State. The Government Printer, Uyo. Nigeria.
- [28] Smil, V. (2000). Phosphorus in the environment. National Flaws and Human Inferences. Annual Review of Energy and Environment 28: 609-620.
- [29] Synge, P. M. (1974). "Dictionary of Gardening" Royal Horticulture Society Vol. IV: PT-2YOxford Press. London. Pp. 2087.
- [30] Taylor, O. O. A., Futuga, B. A., Futuga, B. L. and Oyenuga, V. A. (1983). "Accumulation of Mineral elements in five tropical leafy vegetables as influenced by Nitrogen fertilization and age" *Scientia Horticulture*, 18: 313-322.
- [31] Tayo, O. T. (1982). Growth, yield and development of pigeon pea (*Cajanus cajan*) in lowland tropics. In: Effect of early loss of apical dominances. *Journal of Agricultural Science* 98: 79-84.
- [32] Udoh, D. J., Ndon, B. A., Asuquo, P. E. and Ndaeyo, N. U. (2005). "Crop Production Techniques for the Tropics Concept publication Lagos". Nigeria". FAO Rome. 446pp.
- [33] Udounang, P. I. (2015), Response of cocoyam-based intercropping systems to tillage and fertilization in Uyo, South eastern Nigeria. Ph.D. Thesis. University of Uyo, Uyo Akwa Ibom State, Nigeria.
- [34] Uwah, D. F., Udoh, A. H and Iwo, G. A. (2011). Effect of organic and mineral fertilizers on growth and yield of cocoyam (*colocacia esculenta*). *International Journal of Agricultural Sciences* Vol. 3 Issue 1, 2011, 33-38.
- [35] Vanlauwe, B., Wendt, J. W. and Diels, J. (2001). Combined application of organic matter and fertilizer. *Journal of American Society of Agronomy* 50: 247-279.
- [36] Wanas, S. A. and Omran, W. M. (2006) Advantages of the applying various composal types to different layers of sandy soils: Hydro Physical properties. *Journal of Applied Science Research* 2: 1298-1303.