African Journal of Agricultural Research Vol. 7(49), pp. 6553-6561, 27 December , 2012
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR12.553
ISSN 1991-637X ©2012 Academic Journals

Full Length Research Paper

Evaluation of growth and yield responses of cocoyam (*Colocasia esculenta*) cultivars to rates of NPK 15:15:15 fertilizer

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Accepted 28 November, 2012

This study was carried out in two locations in south eastern Nigeria in the year 2008 and 2009, to evaluate growth and yield responses of cocoyam cultivars to rates of NPK 15:15:15 fertilizer. This was aimed at identifying high yielding cocoyam cultivars and optimum rates of the fertilizer for optimum cocoyam production. Two locations: Nsukka (Enugu state) and Umudike (Abia state) were used for this study. The experiment was done in Nsukka location in 2008 and repeated in Umudike in 2009. Five *Colocasia esculenta* cultivars (Cocoindia, Nworoko, Odogolo, Nadu and Nkpong) and five rates of NPK 15:15:15 (100, 150, 200, 250 and 300 kg/ha) were tested. The result showed that application of NPK 15:15:15 fertilizer increased growth in cocoyam. However, the highest tuber yield/ha of 37.85 tons/ha at Nsukka and 20.845 tons/ha at Umudike were realized in response to the application of 200 and 250 kg/ha, respectively. Further increases above these rates in the locations caused non-significant decline in tuber yield. The Cocoindia cultivar also produced the highest tuber yield/ha among the five cultivars in both Nsukka (30.10 tons/ha) and Umudike (19.068 tons/ha). It was also observed that higher tuber yield was obtained in Nsukka location than in Umudike location. This study has shown that the application of NPK 15:15:15 fertilizer increased tuber yield in cocoyam grown in the south eastern Nigeria.

Key words: *Colocasia esculenta*, cultivars, fertilizer and tuber yield.

INTRODUCTION

Cocoyam is the common name for two tuber crops *Colocasisa esculenta* and *Xanthosomona sagitifolum*. Cocoyam is found throughout the tropics and is of economic interest in these areas. Together with yam and cassava, cocoyam forms the major source of carbohydrates in Nigeria. A crop initially referred to as a minor crop in the traditional intercropping system and often regarded by the locals as a "woman crop" has presently assumed significant economic importance due to the discovery of its nutritional qualities and industrial uses (Olatunji and Akinrela, 1978). Nigeria is presently the World's highest producer of cocoyam, producing about 1800000 tons of cocoyam per annum, accounting for about 30% of the World's total and 48% of Africa's total production (Onwueme and Sinha, 1991). This is produced in an estimated land area of 350000 ha. Yield is still very low in Nigeria (5143 kg/ha) compared with yields in Japan (13493 kg/ha) and China (13333 kg/ha) (Onwueme and Sinha, 1991). The very low yield may be attributed to poor production practices such as insufficient use of agrochemicals like fertilizers and pesticides. In addition, the use of low-yielding cultivars may constrain cocoyam production in the country. In Nigeria, cocoyam production, like production of other crops, is still carried out by poor rural farmers. These resource poor farmers account for over 90% of Nigeria's agricultural output through the use of the indigenous farming practices (Fadina and Ogunyemi, 2002; Apantaku, 2000).

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However, this system of production, although characterized by small farm units, fragile soil, rain dependence and minimum inputs, have continued to sustain the nation's food supply for centuries (Adedipe et al., 2004; Fasuwon and Mabawonku, 2002). Most rural farmers still rely on the natural fertility of the soil whereas in advanced countries such as Japan and China where fertilizers are used in cocoyam production, high yields per unit area are being recorded. Cocoyam like most crops has been shown to responds well to fertilization (De La Pena and Plucknet, 1972; Mare and Modi, 2009). Studies elsewhere have revealed that application of NPK fertilizers increased growth and corm yield in cocoyam (Udoh et al., 2005; Shiyam et al., 2007). Mare and Modi (2009) have also noted varying responses of cocoyam cultivars to fertilization. There is therefore the need to assess the production potentials of available cultivars and their responses to production input such as fertilizer.

Against the above background, this study was carried out to: (1) Identify high yielding cocoyam cultivars with stable performance across locations, and (2) Determine the optimum NPK 15:15:15 fertilizer rate for maximum cocoyam yield.

METHODOLOGY

To address the objectives of the study, field experiments were conducted in two locations in southeastern Nigeria namely; University of Nigeria, Nsukka in Enugu state (latitude 06°52^{l} N longitude 07°24^{l} E and altitude 442 m above sea level), National Root Crop Research Institute (NRCRI), Umudike in Abia State (latitude 05°29^{l} E longitude 07° 33^{l} E and altitude 122 m above sea level. This study lasted for two years. The experiments were carried out in the growing season of 2008 at Nsukka location and 2009 at Umudike location.

Material

Three local cultivars of cocoyam (*C. esculenta)* were sourced from these study areas. Two cocoyam varieties were also obtained from NRCRI Umudike, bringing the number of cultivars to five. Fertilizer was purchased from Enugu State Agricultural Development Project station at Nsukka.

Meteorological and soil data

Meteorological records were collected from the University of Nigeria Nsukka and NRCRI meteorological stations for 2008 and 2009 experiments, respectively. Before planting, soil samples were taken at different representative locations in each experimental site at the depth of 0 to 20 cm. The samples were thoroughly mixed to obtain a composite sample for each location from which a sub- sample was used for laboratory analysis to determine the physical and chemical properties of the soil. Particle size distribution was performed to determine the soil textural class using hydrometer method as described by Gee and Bauder (1986). Soil pH was determined in distilled water and potassium chloride solution using pH meter (Mclean, 1982). Organic carbon was obtained by acid dichromate oxidation method (Nelson and Sommer, 1982). Percentage organic matter was obtained by multiplying organic carbon by 1.724. Soil nitrogen was determined by Macro-Kjeldahl digestion method (Bremner and Mulvaney, 1982). Exchangeable Ca and Mg were obtained by the complexometric titration method of Chapman (1982), and exchangeable Na and K were determined by flame photometer, while exchangeable H and Al were determined by the method described by Mclean (1965). Cation Exchange Capacity (CEC) was determined by modified ammonium acetate method of Chapman (1982) while available P determined by Bray II method (Bray and Kurtz, 1945).

Methods

This experiment was a factorial experiment in randomized complete block design (RCBD). The treatments consisted of five cocoyam cultivars (Nkpong, Cocoindia, Nworoko, Odogolo and Nadu) and five fertilizer rates (100, 150, 200, 250 and 300 kg/ha). There were 25 treatment combinations which were replicated four times. The land was ploughed, harrowed and ridged before marking out into blocks and plots according to the experimental design. Planting was done immediately after land preparation in June in both locations at the depth of 10 cm and at the spacing of 40 × 100 cm. Four weeks after planting the fertilizer treatments were applied according to treatment allocation. Two weeding regimes were done before maturity. At maturity, expert women harvesters were engaged to harvest the cocoyam. The harvesting was done in the month of December in both locations.

Data collection and analysis

Records were taken on number of leaves/plant four weeks after planting (WAP) (NL1), number of leaves/plant eight WAP (NL2), number of suckers/stand four WAP (NS1), number of suckers/stand eight WAP (NS2), number of cormels/stand (NCLS), weight of cormels/stand (kg) (WCLS), average cormel weight (kg) (ACLW), weight of corm/stand (kg) (WCP), total tuber yield/stand (kg) (TTYS), cormel yield (kg/ha) (CLYH) and total tuber yield (kg/ha) (TTYH). These data were subjected to analysis of variance (ANOVA). This was carried out using the method outlined by Steel and Torrie (1980) for factorial experiments. Separation of means for statistical significance was done by the F-LSD procedure as described by Obi (2001).

RESULTS

The results of the soil analysis of the experimental sites presented in Table 1 showed that the Nsukka soil is texturally sandy loam while Umudike is loamy sand. Both soils were slightly acidic and contained low levels of organic matter and nutrient elements. The Umudike soil however contained more of the nutrient elements than the Nsukka soil. The weather records collected in the two locations shown in Table 2 indicated that rain started later in 2008 in Nsukka than in Umudike in 2009. The number of rain days and amount of rainfall recorded in 2009 were higher than in 2008. Temperature and relative humidity were also slightly higher in 2009 than in 2008.

Nsukka location

The results presented in Table 3 indicated significant

Table 1. Physical and chemical properties of the soil of the experimental sites before planting.

Parameter	Nsukka	Umudike
Physical properties (%)		
Coarse sand	10.00	44.00
Fine sand	60.00	40.00
Silt	20.00	9.00
Clay	10.00	7.00
Textural class	Sandy loam	Loamy sand
Chemical properties		
pH in Water	5.00	5.20
pH in KCl	4.60	4.10
Organic matter (%)	1.03	1.38
Total Nitrogen (%)	0.05	0.11
Total Carbon (%)	0.60	0.79
Available P (ppm)	2.60	10.30
Exchangeable Na (cmol/kg)	0.10	1.73
Exchangeable K (cmol/kg)	0.09	2.72
Exchangeable Ca (cmol/kg)	1.00	3.80
Exchangeable Mg (cmol/kg)	0.80	1.80
Exchangeable Al (cmol/kg)	1.00	Nil
Exchangeable H (cmol/kg)	0.40	1.40
Cation exchange capacity (cmol/kg)	6.00	6.00

differences between the effects of the NPK 15:15:15 rate on the growth attributes eight WAP. Number of leaves/plant was highest at the application of 250 kg/ha fertilizer but did not differ significantly from values obtained from 200 and 300 kg/ha rates, while number of suckers recorded highest performance at 200 kg/ha. The yield attributes were similarly affected as corm and cormel yields peaked at 200 kg/ha fertilizer and declined significantly as further increases in fertilizer were made.

Significant differences were recorded among the cultivars in both growth and yield attributes (Table 4). However, the rate of growth differed among these cultivars as the cultivar that had the highest growth four WAP failed to maintain the lead eight WAP. For instance, Odogolo and Cocoindia had the highest number of leaves/plant four WAP but eight WAP Odogolo maintained the lead while Cocoindia dropped to the third position. Similarly, on the number of suckers/stand, Odogolo had the highest number four WAP but was surpassed by Nadu and Nworoko eight WAP. On the yield attributes, Cocoindia ranked highest in total tuber yield/ha among the cultivars, but differed significantly only from Odogolo which has the lowest yield.

The interaction effects of fertilizer and cultivar on growth and yield attributes are shown in Table 5. The result showed that the application of 200 kg/ha fertilizer to Cocoindia resulted in the highest total tuber yield among all the combinations. The highest value was however statistically the same as the value obtained when the same 200 kg/ha fertilizer was applied to the other cultivars. Other yield attributes were similarly affected.

Umudike location

The results of the effect of fertilizer rates on growth and yield attributes of cocoyam grown in Umudike are presented in Table 6. The variation in number of leaves as affected by the rates of fertilizer was non-significant. Number of suckers was only affected significantly eight WAP where the application of 250 kg/ha rate produced the highest value and differed significantly from the effects of the other rates with the exception of 200 kg/ha rate. The 250 kg/ha rate also produced the best performance in the yield attributes with the exception of average cormel weight where application of 300 kg/ha produced the highest value. It was however noted that the effect of the 250 kg/ha rate differed significantly only from the effects of the other rates in number of cormels/stand, weight of cormels/stand, weight of corm/stand, total tuber yield/stand and total tuber yield/ha.

The mean performance of cultivar shown in Table 7 indicated significant differences among the cultivars. Odogolo had the highest number of leaves/plant four WAP and eight WAP and the highest number of sucker four WAP. However, eight WAP Cocoindia produced the highest number of suckers but was not significantly

Table 2. Weather records of the areas during the periods of the experiment.

Parameter												
						Nsukka						
Year							2008					
Months	January	February	March	April	May	June	July	August	September	October	November	December
Rainfall amount (mm)	0.00	0.00	61.23	143.3	254.01	186.43	246.10	203.20	326.02	198.63	8.38	
Number of rain days	0.00	0.0	4	11	12	15	14	19	22	11	2	
Maximum temperature (°C)	31.39	34.14	33.77	31.73	31.16	29.83	28.94	27.81	27.60	29.48	31.10	
Minimum temperature (°C)	20.32	21.97	22.87	22.00	20.81	31.43	20.84	20.68	20.80	20.87	22.00	
Relative humidity (0900)	56.03	56.17	74.13	74.83	75.00	76.93	78.16	79.55	78.67	76.35	74.80	
Relative humidity (1500)												
						Umudike						
Year							2009					
Months	January	February	March	April	May	June	July	August	September	October	November	December
Rainfall amount (mm)	62.80	62.80	47.80	100.50	416.20	236.70	306.30	287.40	203.50	311.10	23.70	0.00
Number of rain days	2	4	4	12	15	14	18	19	18	14	7	0
Maximum temperature (°C)	33.00	35.0	34.	33	33	31	30	29	30	31	32	34
Minimum temperature (°C)	23	24	24	23	23	23	22	23	22	23	22	23
Relative humidity (0900)	75	79	78	78	81	83	87	88	86	82	74	78
Relative humidity (1500)	50	56	57	63	70	72	78	78	72	72	58	43

Table 3. Mean effect of NPK 15:15:15 fertilizer rates on growth and yield attributes cocoyam in Nsukka location in 2008.

NPK rates (kg/ha)	NL1	NL2	NS1	NS2	NCLS	WCLS (kg)	WCP (kg)	ACLW (kg)	TTYS (kg)	CLYH (tons/ha)	TTYH (tons/ha)
100	4.400	7.050	3.830	4.730	11.090	0.572	0.187	0.054	0.759	14.300	18.983
150	4.670	7.900	3.750	5.700	14.480	0.795	0.281	0.057	1.076	17.952	26.898
200	4.670	10.230	3.800	6.670	18.040	1.159	0.355	0.063	1.514	28.967	37.850
250	4.400	11.380	4.000	6.020	16.550	0.979	0.287	0.058	1.266	24.483	31.667
300	4.430	9.370	4.130	4.970	11.570	0.703	0.209	0.089	0.912	17.583	22.808
LSD(P<0.05)	ns	2.230	ns	0.664	1.835	0.134	0.056	0.038	0.175	3.483	3.882

NL1=Number of leaves/plant at 4 wap, NL2=number of leaves/plant at 8 wap, NS1=number of suckers/stand at 4 wap, NCLS=number of cormels/stand, WCLS= weight of cormels/stand, WCP=weight of corm/plant, ACLW=average cormel weight, TTYS=total tuber yield/stand, CLYH=cormel yield/ha, TTYH=total tuber yield/ha; ns=non-significant.

different from what Odogolo produced. Considering the yield attributes, Nworoko produced the highest number of cormels/stand, and average cormel weight, while the least was obtained from Nkpong. Cocoindia was however, the best in weight of corm/stand, cormel yield/ha and total tuber yield/ha, and was followed by Nworoko in these attributes. Nadu produced the lowest total tuber yield/ha which was statistically

Table 4. Mean effect of cultivars on growth and yield attributes of cocoyam in Nsukka location in 2008.

Cultivars	NL1	NL2	NS1	NS2	NCLS	WCLS (kg/ha)	WCP (kg/ha)	ACLW (kg/ha)	TTYS (kg/ha)	CLYH (tons/ha)	TTYH (tons/ha)
NKPONG	3.733	7.910	3.150	4.280	12.170	0.757	0.315	0.060	1.070	18.917	26.750
NWOROKO	4.800	7.970	3.670	5.020	14.570	0.909	0.247	0.062	1.156	20.819	28.900
COCOINDIA	4.467	9.180	4.330	6.300	15.860	0.949	0.274	0.060	1.204	23.733	30.100
ODOGOLO	4.800	10.650	4.400	5.820	14.060	0.759	0.239	0.083	0.998	18.983	24.950
NADU	4.467	10.210	4.070	6.680	15.080	0.833	0.245	0.055	1.078	20.833	26.967
LSD(P<0.05)	0.457	2.233	0.427	0.644	1.835	0.1340	0.056	0.038	0.175	3.483	3.882

NL1=Number of leaves/plant at 4 wap, NL2=number of leaves/plant at 8 wap, NS1=number of suckers/stand at 4 wap, NCLS=number of cormels/stand, WCLS=weight of cormels/stand, WCP=weight of corm/plant, ACLW=average cormel weight, TTYS=total tuber yield/stand, CLYH=cormel yield/ha, TTYH=total tuber yield/ha.

Table 5. Mean effect of NPK 15:15:15 fertilizer by cultivar interaction on growth and yield attributes of cocoyam in Nsukka location in 2008.

Cultivars	NPK rates (kg/ha)	NL1	NL2	NS1	NS2	NCLS	WCLS (kg/ha)	WCP (kg/ha)	ACLW (kg/ha)	TTYS (kg/ha)	CLYH (tons/ha)	TTYH (tons/ha)
	100	3.667	5.250	3.167	3.750	8.250	0.410	0.253	0.049	0.663	10.250	16.583
	150	4.000	7.000	3.083	4.170	11.330	0.660	0.293	0.058	0.943	16.500	23.583
Nkpong	200	4.000	9.920	3.000	4.830	16.080	1.133	0.443	0.070	1.577	28.333	39.417
	250	3.667	9.970	3.667	5.000	14.750	0.913	0.333	0.062	1.247	22.833	31.167
	300	3.333	7.420	2.833	3.670	10.420	0.667	0.253	0.063	0.920	16.667	23.000
	100	4.667	7.170	3.667	4.080	10.670	0.613	0.163	0.057	0.777	15.333	19.417
	150	5.667	7.000	3.667	4.670	13.750	0.793	0.227	0.057	1.020	10.260	25.500
Cocoindia	200	5.333	7.920	3.333	6.500	19.680	1.290	0.337	.0667	1.627	32.250	40.667
	250	4.000	9.830	4.000	5.580	17.500	1.113	0.307	0.064	1.420	27.833	35.500
	300	4.333	7.930	3.667	4.250	11.250	0.737	0.200	0.066	0.937	18.417	23.417
	100	4.333	7.080	3.667	5.250	12.060	0.697	0.220	0.058	0.917	17.417	22.917
Nworoko	150	4.667	7.500	3.667	6.500	15.170	0.923	0.355	0.061	1.180	23.083	29.500
	200	4.667	9.830	4.667	7.370	19.250	1.197	0.330	0.062	1.527	29.917	38.167
	250	4.667	11.330	4.333	6.800	19.580	1.083	0.280	0.055	1.363	27.083	34.083
	100	5.000	9.250	4.000	4.920	10.830	0.573	0.163	0.054	0.737	14.333	18.417
	150	4.333	8.500	4.667	6.080	13.670	0.660	0.237	0.051	0.897	16.500	22.417
Odogolo	200	4.667	11.500	4.333	6.750	17.500	0.960	0.320	0.055	1.280	24.000	32.000
	250	5.000	12.750	4.000	5.750	16.670	0.930	0.260	0.054	1.203	23.250	29.750
	300	5.000	11.250	5.000	5.580	11.620	0.673	0.213	0.053	0.960	16.833	22.167

Table 5. Contd.

Nadu	100	4.333	6.500	4.667	5.670	13.670	0.567	0.137	0.049	0.927	14.167	17.583
	150	4.667	9.500	3.667	7.080	18.500	0.937	0.293	0.057	0.970	23.417	30.750
	200	4.667	11.980	3.667	7.920	17.670	1.213	0.347	0.059	1.473	30.333	39.000
	250	4.667	13.000	4.000	6.970	14.250	0.857	0.257	0.055	1.113	21.417	27.833
	300	4.000	10.070	4.333	5.750	11.330	0.593	0.193	0.052	0.787	14.833	19.667
LSD(P<0.05)		ns	ns	ns	ns	Ns	0.299	0.125	0.035	0.390	7.787	8.681

NL1=Number of leaves/plant at 4 wap, NL2=number of leaves/plant at 8 wap, NS1=number of suckers/stand at 4 wap, NCLS=number of cormels/stand, WCLS=weight of cormels/stand, WCP=weght of corm/plant, ACLW=average cormel weight, TTYS=total tuber yield/stand, CLYH=cormel yield/ha, TTYH=total tuber yield/ha; ns=non-significant.

Table 6. Mean effect of NPK 15:15:15 fertilizer rates on growth and yield attributes of cocoyam in Umudike location in 2009.

NPK rates (kg/ha)	NL1	NL2	NS1	NS2	NCLS	WCLS (kg/ha)	WCP (kg/ha)	ACLW (kg/ha)	TTYS (kg/ha)	CLYH (tons/ha)	TTYH (tons/ha)
100	4.600	5.100	2.330	4.100	9.110	0.308	0.066	0.036	0.374	9.128	9.347
150	4.533	5.401	2.470	5.230	12.550	0.437	0.098	0.038	0.528	11.465	13.188
200	4.267	5.650	2.670	6.520	14.730	0.523	0.127	0.038	0.651	13.867	16.247
250	4.333	5.867	2.330	7.330	17.100	0.648	0.230	0.038	0.752	15.587	20.845
300	4.600	5.417	1.930	5.450	13.250	0.529	0.167	0.059	0.645	11.490	16.117
LSD(P<0.05)	0.419	0.458	0.683	1.060	1.767	0.090	0.091	0.026	0.093	2.402	1.716

NL1=Number of leaves/plant at 4 wap, NL2=number of leaves/plant at 8 wap, NS1=number of suckers/stand at 4 wap, NCLS=number of cormels/stand, WCLS=weight of cormels/stand, WCP=weght of corm/plant, ACLW=average cormel weight, TTYS=total tuber yield/stand, CLYH=cormel yield/ha, TTYH=total tuber yield/ha.

Table 7. Mean effect of cultivars on growth and yield attributes of cocoyam in Umudike Location in 2009.

Cultivars	NL1	NL2	NS1	NS2	NCLS	WCLS (kg/ha)	WCP (kg/ha)	ACLW (kg/ha)	TTYS (kg/ha)	CLYH (tons/ha)	TTYH (tons/ha)
NKPONG	4.200	5.267	1.130	5.130	8.810	0.370	0.113	0.043	0.482	9.250	12.063
COCOINDIA	4.067	5.133	2.670	6.500	17.110	0.636	0.127	0.037	0.763	16.165	19.068
NWOROKO	4.333	5.601	2.000	5.470	17.680	0.585	0.147	0.052	0.731	14.563	18.278
ODOGOLO	5.267	6.067	3.670	6.050	12.080	0.468	0.098	0.041	0.559	11.480	13.975
NADU	4.467	5.367	2.270	5.480	11.060	0.386	0.204	0.036	0.481	10.078	12.033
LSD(P<0.05)	0.419	0.458	0.683	1.060	1.767	0.061	0.091	0.025	0.093	2.402	1.716

NL1=Number of leaves/plant at 4 wap, NL2=number of leaves/plant at 8 wap, NS1=number of suckers/stand at 4 wap, NCLS=number of cormels/stand, WCLS=weight of cormels/stand, WCP=weght of corm/plant, ACLW=average cormel weight, TTYS=total tuber yield/stand, CLYH=cormel yield/ha, TTYH=total tuber yield/ha.

Table 8. Mean effect of NPK 15:15:15 fertilizer by cultivar interaction on growth and yield of cocoyam in Umudike location in 2009.

Cultivars	NPK rates (kg/ha)	NL1	NL2	NS1	NS2	NCLS	WCLS (kg/ha)	WCP (kg/ha)	ACLW (kg/ha)	TTYS (kg/ha)	CLYH (tons/ha)	TTYH (tons/ha)
	100	4.333	4.833	1.000	3.670	6.200	0.2897	0.064	0.047	0.353	7.242	8.833
	150	4.000	5.167	1.000	4.580	7.650	0.3190	0.074	0.042	0.393	7.975	9.833
Nkpong	200	4.000	5.250	1.670	5.830	9.300	0.3903	0.114	0.042	0.504	9.758	12.600
	250	4.000	5.583	1.000	6.920	11.530	0.4540	0.179	0.040	0.633	11.350	15.833
	300	4.667	5.500	1.000	4.670	9.360	0.3970	0.132	0.043	0.529	9.925	13.217
	100	4.000	4.750	2.670	4.000	12.530	0.3787	0.081	0.030	0.460	11833	11.492
	150	4.333	5.000	2.670	6.080	16.220	0.5567	0.120	0.035	0.676	14.833	16.908
Cocoindia	200	4.000	5.417	2.330	7.170	17.860	0.6447	0.133	0.036	0.777	19.450	19.433
	250	4.000	5.833	2.670	8.580	21.230	0.8517	0.193	0.043	0.701	20.458	27.792
	300	4.000	4.667	3.000	6.670	17.710	0.7467	0.111	0.042	0.857	14.250	21.433
	100	4.667	5.250	1.670	3.670	11.150	0.3187	0.075	0.029	0.394	10.383	9.842
	150	4.333	5.257	3.000	5.170	17.740	0.5500	0.124	0.033	0.671	14.333	16.775
Nworoko	200	4.000	5.833	2.000	5.920	22.010	0.6800	0.170	0.035	0.850	17.333	21.250
	250	4.333	5.833	1.330	6.920	23.010	0.7440	0.225	0.028	0.969	17.100	24.225
	300	4.333	5.833	2.000	5.670	14.500	0.6333	0.139	0.033	0.772	13.667	19.300
	100	5.667	5.667	3.670	4.830	8.800	0.3373	0.063	0.043	0.401	9.350	10.017
	150	5.000	6.000	3.330	5.330	11.640	0.4207	0.093	0.041	0.480	11.017	12.008
Odogolo	200	5.000	6.167	4.330	6.750	13.140	0.4817	0.110	0.039	0.591	12.292	14.700
	250	5.000	6.417	4.330	7.250	15.890	0.6467	0.134	0.040	0.781	15.500	19.517
	300	5.667	6.083	2.670	6.080	10.920	0.4530	0.089	0.041	0.542	9.242	13.542
	100	4.333	5000	2.670	4.330	6.870	0.2133	0.049	0.031	0.262	6.833	6.550
	150	5.000	5.583	2.330	5.000	9.510	0.3400	0.077	0.036	0.417	9.167	10.417
Nadu	200	4.333	5.583	3.000	6.920	11.330	0.4200	6.110	0.038	0.530	10.500	13.250
	250	4.333	5.667	2.330	7.000	13.830	0.5410	0.418	0.040	0.674	13.525	16.858
	300	4.333	5.000	1.000	4.170	13.780	0.4143	0.364	0.036	0.524	10.367	13.092
LSD(P<0.05)		0.938	1.025	1.528	2.370	3.952	0.136	0.204	0.057	0.208	5.372	3.837

NL1=Number of leaves/plant at 4 wap, NL2=number of leaves/plant at 8 wap, NS1=number of suckers/stand at 4 wap, NCLS=number of cormels/stand, WCLS=weight of cormels/stand, WCP=weght of corm/plant, ACLW=average cormel weight, TTYS=total tuber yield/stand, CLYH=cormel yield/ha, TTYH=total tuber yield/ha.

the same with Nkpong. The fertilizer by cultivar interaction effects on growth and yield attributes are shown in Table 8. The 250 kg/ha rate produced the highest performance in the growth attributes in all the cultivars especially eight WAP. Also the application of 250 kg/ha of fertilizer to

Cocoindia produced the highest total tuber yield/ha among the combinations. It was also observed that the application of 250 kg/ha fertilizer rate produced the best tuber yield in all the cultivars.

DISCUSSION AND CONCLUSION

Application of NPK fertilizer increased both growth and tuber yield of cocoyam. This agreed with the finding of other researchers elsewhere (Kader and Rolle, 2004; Mondal and Sen, 2005; Shiyam et al., 2007; Mare and Modi, 2009). The significant effect caused by application of NPK 15:15:15 fertilizer to the cocoyam plots showed that soil in these areas lacked essential nutrients, especially those that enhance growth and development in cocoyam. This is supported by the result of the physicochemical properties of the soils of the sites prior to the establishment of the experiments. The result indicated low content of organic matter and major nutrient elements (Ibedu et al., 1988). Further increases in growth and yield observed as fertilizer rate was increased indicated that the initial rates failed to meet the optimum requirement. Above the optimum rate of 250 kg/ha a decrease was observed which implies that nutrient supply was at the luxury level and contributed less to yield. Tisdale and Nelson (1975) had noted that plant response to fertilizer is higher in soil with low nutrient contents than soil with high nutrient reserve. Consequentially, when the soil nutrient level has been raised to high level, further increase in rate will bring about low or no responses. It has also been reported that excess N depressed yield in cocoyam (Onwueme and Sinha, 1991; Igbokwe and Ogbonnaya, 1980). High levels of some nutrient elements have been reported to inhibit the availability of others especially micro nutrient elements (Harper, 1983).The cultivars also responded differently to the applied NPK fertilizer rates which is an indication of their varying efficiency in utilizing applied nutrients. This also agreed with the findings of Mare and Modi (2009) who reported similar cultivars reaction to fertilizer rates. It was observed that highest yields were not recorded at the same NPK rate at the two locations. For instance, at Nsukka location, 200 kg/ha of fertilizer application gave the highest tuber yield while at Umudike, the 250 kg/ha rates gave the highest tuber yield. This may be attributed to the fact that soil conditions and fertility levels as well as weather conditions at these locations were not the same. Despite the fact that soil with low nutrient content will require more nutrient application to induce high yield in crops, the soil physical condition and other chemical characteristics play important role in the availability of applied nutrients to crops. Other environ-mental factors such as moisture availability may also cause reduced availability of applied nutrients to crops. For instance, the results of soil analysis showed that the Umudike soil had higher levels of most nutrient elements; yet high tuber yield was realized from Nsukka location. It will be important to point out that the low yield recorded in Umudike in 2009 may be attributed to an outbreak of a disease suspected to be Taro leaf blight caused by *Phytophthora colocasiae* in this study area. Ogbonna (2009) had reported a similar observation in egusi melon, where 300 kg/ha NPK 15:1515 gave highest seed yield in 2007 and in the following year 2008 in the same area highest seed yield was obtained at 350 kg/ha rate of the same fertilizer formulation. However, this study has shown that at Nsukka location, application of 200 kg/ha NPK 15:15 15 rates should be recommended for maximum tuber yield while at Umudike 250 kg/ha rate is recommended.

The Cocoindia cultivar maintained the highest tuber yield/ha across both locations. Nworoko was also good in terms of tuber yield while Nkpong produced the lowest yield in both locations. Cocoindia produced the highest tuber yield in all locations which implied that it is also stable in performance and is therefore recommended for farmers in both areas. This study has shown that with adequate production technology, tuber yield comparable to that obtained in advanced countries such as China and Japan can be realized by farmers in these study areas.

This study also revealed that cocoyam production was the better at the Nsukka location. This suggests that the Nsukka environment provides adequate conditions for *Colocasia* production between the two locations. This explains why cocoyam production is predominant in the Nsukka area.

ACKNOWLEDGEMENTS

We acknowledge the financial and material aids from the CODESRIA – IFS Sustainable Agriculture Initiative, Grant No. T/4434-1, under which this work was carried out. We also acknowledge the support of the National Root Crop Research Institute (NRCRI), Umudike, Nigeria, for granting us the use of their experimental facilities and technical assistance.

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