Growth and Yield Attributes of Cassava, Maize and Cowpea in Intercrop as Influenced by Cropping System and NPK Fertilizer Rates

[1]Arubalueze, C.U., [2]Mouneke, C.O., [2]Remison, S.U., [1]Achebe, U. A. and [1]Udeorah, S. N.

[1]Department of Agricultural Education, Nwafor Orizu College of Education, Nsugbe, P.M.B. 1734, Onitsha, Anambra State, Nigeria

[2]Department of Agronomy, Michael Okpara University of Agriculture, Umudike, P.M.B. 7267, Umuahia, Nigeria

[1]Corresponding author: arubaluezechidi@gmail.com; +2347034876816

Abstract

A field experiment was carried out in the 2013/2014 and 2014/2015 cropping seasons to determine the influence of cropping system and NPK-15-15-15 fertilizer rates (0, 150, 300 and 450kg per hectare) on the growth and yield of cassava, maize and cowpea at Igbariam sub-station of the National Root Crops Research Institute, Umudike, Nigeria. The experiment was a randomized complete block design (RCBD) consisting of twenty-eight treatment combinations replicated three times. Growth and yield attributes of the component crops performed better in their sole crops than when intercropped. Fertilizer application significantly (<0.05) increased growth and yield components of cassava (leaf area index, plant height, number of marketable roots/plant and fresh root yield/ha), maize (leaf area index, plant height, number of grains/cob, cob length and grain yield/ha) and vegetable cowpea (leaf area index, vine length, number of seeds/pod, pod length and fresh pod yield/ha). In both cropping seasons, incremental application of fertilizer rate up to 480kg/ha increased these parameters. There were yield advantages in all the intercrop treatments, with the highest yield advantage of 2.71 and 2.72 in the 2013/2014 and 2014/2015 seasons respectively at a rate of 450kg/ha in cassava/maize/cowpea. Also the greatest monetary returns,₦3,294,700.00/ha and ₦3,306,300.00/ha were achieved at 450kg/ha N.P.K.in cassava/maize/cowpea intercrop in 2013/2014 and 2014/2015 respectively. It is therefore recommended that application of 450 kg/ha NPK fertilizer be used if cassava, maize and vegetable, cowpea are intercropped.

Keywords: cassava, maize, vegetable, cowpea, fertilizer rate, productivity.

Introduction

Intercropping is the growing of two or more crops simultaneously on the same field in different but proximate stands. It is a suitable and sustainable agro-ecosystem in the tropics.

In tropical agriculture, it is used extensively as a means of survival (Ayoola *et al*., 2011). Intercropping is generally preferred by peasant farmers because it produces better total crop

yield, insures against total crop failure, ensures better utilization of growth resources, helps to suppress weeds, erosion, insects and disease infestation, brings about a more even distribution of farm labour (Muoneke *et al*., 2002; Hector, 2010; Lyocks *et al*., 2013), and gives better yield advantage over sole cropping through yield stability (Bhatti *et al*., 2006).

A major disadvantage of intercropping is difficulty in management of component crops as they have different requirements for fertilizers, pesticides and herbicides; (Olowe and Adeyemo, 2009).

In mixed intercropping system, fertilizer application has been a matter of conjecture. Some workers suggest that fertilizer requirements of the dominant component (e.g. maize) be applied (Ekwere *et al*., 2013) while others recommend that the sum of the sole crop requirements be applied (Haizel, 1994). But Teriah (1990) stated that both practices had proved either wasteful or inadequate.

The objectives of this research therefore was to establish the optimum N.P.K. 15:15:15 fertilizer application rate for cassava, maize and cowpea as sole and in intercrops, and to assess their productivity and economics.

Materials and Methods

The Experimental Location

The research was conducted at Igbariam sub-station of the National Root Crops Research Institute (NRCRI), Umudike, Nigeria in the 2013/2014 and 2014/2015 cropping seasons. Igbariam is situated in the derived savanna zone of Nigeria. It lies on latitude 06^0 15'N, longitude 06^0 52'E, and at an altitude of 81m above sea level. The soil physical and chemical characteristics for both planting seasons are shown in Table 1.

Table 1: Some Physical and Chemical Properties of the Experiment Site at Igbariam sub-station of National Root Crops Research Institute (NRCRI), in 2013/2014 and 2014/2015

	Planting Seasons	
Soil Properties	**2013/2014**	**2014/2015**
Physical Properties		
Sand (%)	75.80	72.40
Silt (%)	11.40	11.40
Clay (%)	12.80	16.20
Texture	Sandy loam	Sandy loam
Chemical Properties		
pH (H_20)	4.80	5.10
Organic Carbon (%)	0.24	0.89
Organic Matter (%)	0.41	1.53
Total N (%)	0.04	0.08
Available P (mg/kg)	25.40	24.22
Ca (Cmol/kg)	4.80	2.40
Mg (Cmol/kg)	1.60	1.60
K (Cmol/kg)	0.22	0.20
Na (Cmol/kg)	0.29	0.35
Echange Acidity(Cmol/kg)	0.64	0.88
ECEC (Cmol/kg)	7.55	5.67
Base Saturation (%)	91.52	84.48

Land Preparation and Crop Varieties

The experimental site was slashed, ploughed and harrowed. Three (3) metre wide ridges of 6m length were prepared. The plot size was therefore 3.0m x 6.0m (18.0m^2).

Seeds of Oba super 2, an early-maturing hybrid maize cultivar was collected from the National Seed Council, Umudike, Nigeria. Brown-seeded vegetable cowpea (Akidi ani), an early maturing and spreading variety, was sourced from a local market, while an improved cassava variety (TME 419) with erect stems was obtained from Igbariam sub-station, National Root Crops Research Institute (NRCRI).

Experimental Design

A Randomized Complete Block Design (RCBD) replicated three times was used for the experiment.

The treatments comprised of sole cassava, maize and cowpea, and cassava/maize, cassava/cowpea, maize/cowpea and cassava/maize/cowpea intercrop each of which received 0, 450, 300 and 450kg/ha NPK 15-15-15 fertilizer rates. Maize and cowpea were sown the same day at two seeds per hole on 6th May, 2013 and 2014, and later thinned to one per stand two weeks after planting (WAP) to achieve 40,000 plants/ha (0.25m x 1m) and 33,333 plants/ha (0.30m x 1m) respectively.

Cassava stem cuttings (20cm), obtained from 12 month-old cuttings of uniform size, were planted on 6th May on the crest of the ridges, one meter apart (1m x 1m) to achieve plant density of 10,000 plants/ha. The fertilizer was applied 2 weeks after planting to maize and cowpea and at 6 weeks after planting to cassava.

Weeding was manually done at 3, 6, 12 and 28 weeks after planting. Vegetable cowpea was sprayed with *cypermethrin* at a rate of 80g/15L of water to ward off all types of insect pests.

Data Collection and Analysis

Four plants each of cassava, maize and vegetable cowpea from the inner rows were randomly selected and tagged for the purpose of data collection.

Data were taken on plant height, leaf area index, number of marketable roots, weight of marketable roots and fresh root yield (for cassava), plant height, leaf area index, cob length, number of grains per cob and grain yield (for maize) and vine length, leaf area index, fresh pod length, number of seeds per pod and fresh pod yield (for vegetable cowpea).

Data collected were subjected to analysis of variance and treatment means were compared with Fisher's Least Significant Differences (FLSD) at 0.05 level of significance. Land equivalent ratio LER was calculated to ascertain the productivity of the mixture as:

$$\text{LER} = \frac{Intercrop\ yield\ of\ Cassava}{Sole\ crop\ yield\ of\ Cassava} + \frac{Intercrop\ yield\ of\ Maize}{Sole\ crop\ yield\ of\ Maize} + \frac{Intercrop\ yield\ of\ Cowpea}{Sole\ crop\ yield\ of\ Cowpea}$$

Sole crop yield of cassava, maize and cowpea as well as gross monetary returns (₦/ton) of the component crops were determined by the prevailing market prices of cassava, maize and vegetable cowpea in Igbariam market.

Results and Discussion

Growth and Yield of Cassava

Cropping system significantly ($p < 0.05$) influenced all the growth and yield attributes of cassava in both cropping seasons. Plant height, leaf area index, number of marketable roots/plant, weight of marketable roots/plant and fresh root yield were all significantly higher in sole cassava plots than in intercropped plots (Table 2). This could be ascribed to interspecific competition for growth resources.

Fertilizer application up to 450kg/ha significantly ($p < 0.05$) increased plant height, leaf area index, number of marketable roots/plant, weight of marketable roots/plant and fresh root yield. This could be as a result to nutrient release, especially nitrogen and potassium which are critical for photosynthetic efficiency, and which influence crop development by increasing the expansion of leaves, affecting the total amount of solar radiation utilization when intercropped, and partitioning of dry matter within plants. This result is similar with that of Aderi *et al*. (2010) who reported significant linear increases in growth and yield of cassava with increased NPK fertilizer rates from 0 to 400 kg/ha.

There was significant interaction ($p < 0.05$) in cropping system x NPK fertilizer rates on plant height, leaf area index, number of marketable roots/plant, weight of marketable roots/plant and fresh root yield of cassava.

Sole cassava x NPK 450 kg/ha fertilizer rates performed better in all the growth and yield parameters than cassava while intercropped. Cassava with maize and cowpea x NPK 0 kg/ha fertilizer rate had the least value in all the growth and yield parameters of cassava. This is probably because the untreated plots were almost stunted in growth as they had to rely on the inherent soil fertility which from the results of chemical analysis were deficient in these nutrients.

Growth and Yield of Maize

Intercropping significantly ($p < 0.05$) reduced all the growth and yield parameters (plant height, leaf area index, cob length, number of grains per cob and grain yield) of maize in both cropping seasons (Table 3). This was perhaps as a result of interspecific competition for growth resources. Fertilizer application up to 450 kg/ha significantly ($p < 0.05$) increased all the growth and yield parameters of maize. This may probably be ascribed to NPK being part of essential nutrients required for the promotion of the meristematic and physiological activities such as plant leaf spread, root development, plant dry matter production etc., leading to an efficient absorption and translocation of water and nutrients, interception of solar radiation and assimilation of carbon dioxide. These activities promote higher photosynthetic activities leading to the production of sufficient assimilates for subsequent translocation to various sinks and hence the production of higher growth and yield attributes of maize (Jaliya *et al*., 2008). This result agreed with that of Kolawole and Ekunwe (2011), who reported a significant linear increase in growth and economic yield of maize and melon with NPK application from 0 to 450 kg/ha. There was significant ($p < 0.05$) interaction of cropping system and NPK fertilizer rates on plant height, leaf area index, cob length, number of grains per cob and grain yield. Sole maize x NPK 450 kg/ha fertilizer rate performed best in all the growth and yield parameters of

Table 2: Effects of cropping system and NPK fertilizer rates on growth and yield of cassava in cassava/maize/cowpea intercropping system in 2013/2014 and 2014/2015 cropping seasons

Cropping Season	2013/2014					2014/2015				
Cropping System	Plant Height (cm) IOMAP	Leaf area index IOMAP	No. of marketable roots/plant	Wt. of marketable roots kg/plot	Fresh root yield (tons/ha)	Plant height (cm) IOMAP	Leaf area index IOMAP	No. of marketable roots/plant	Wt. of marketable roots kg/plot	Fresh root yield (tons/ha)
Sole Cassava	184.00	8.91	5.45	1.91	24.02	188.00	8.01	5.42	1.89	23.68
Cassava + maize	145.00	6.79	5.17	1.40	19.46	146.00	6.51	4.17	1.51	18.62
Cassava + cowpea	174.00	8.00	6.31	1.80	22.19	175.00	7.44	5.00	1.81	22.24
Cassava + maize + cowpea	135.00	5.04	4.47	1.23	14.82	135.00	5.90	3.17	1.24	15.54
LSD 0.05	0.13	0.04	0.63	0.17	1.87	1.55	0.08	0.51	0.17	1.66
NPK Fertilizer rates (kg/ha)										
0.00	95.00	1.44	1.01	0.96	13.43	91.00	1.55	0.75	0.84	13.08
150.00	133.00	3.40	3.97	1.48	19.09	149.00	3.48	2.75	1.47	19.07
300.00	192.00	8.32	6.94	1.92	20.23	193.00	8.31	5.17	1.92	20.34
450.00	220.00	14.39	9.42	2.53	27.53	222.00	14.44	8.08	2.53	27.59
LSD 0.05	0.13	0.04	0.63	0.17	1.87	1.55	0.08	0.51	0.17	1.66
Cropping system x NPK fertilizer rates										
Sole Cassava 0.00	110.00	2.05	1.67	1.49	20.47	104.00	1.88	1.33	1.50	20.37
Sole Cassava 150.00	184.00	5.05	4.67	1.63	21.95	188.00	4.94	3.33	1.59	21.13
Sole Cassava 300.00	204.00	9.22	7.23	1.73	24.00	208.00	9.23	6.00	1.74	23.75
Sole Cassava 450.00	238.00	19.54	10.62	2.77	29.47	240.00	14.19	10.00	2.74	29.40
Cassava + maize 0.00	87.00	1.50	0.47	0.91	13.43	85.00	1.41	0.33	0.48	9.42
Cassava + maize 150.00	92.00	3.34	3.47	1.43	18.23	102.00	3.28	2.47	1.47	18.17
Cassava + maize 300.00	190.00	8.13	7.00	1.59	19.23	192.00	8.11	5.00	1.61	19.13
Cassava + maize 450.00	214.00	15.23	9.53	2.41	24.80	214.00	14.23	7.67	2.44	24.83
Cassava + cowpea 0.00	100.00	1.77	1.89	1.39	19.37	102.00	1.74	1.33	1.39	19.43
Cassava + cowpea 150.00	172.00	4.49	4.67	1.54	20.03	171.00	4.38	3.33	1.54	20.10
Cassava + cowpea 300.00	198.00	8.68	7.95	1.69	20.47	200.00	8.64	6.00	1.69	20.70
Cassava + cowpea 450.00	224.00	17.09	10.33	2.59	28.70	228.00	14.98	8.33	2.00	28.80
Cassava + maize + cowpea 0.00	74.00	1.24	0.00	0.00	0.00	75.00	1.18	0.00	0.00	3.07
Cassava + maize + cowpea 150.00	84.00	3.33	2.87	1.29	14.17	145.00	4.94	1.67	1.29	14.40
Cassava + maize + cowpea 300.00	174.00	7.24	5.47	1.42	17.00	175.00	9.22	3.47	1.44	17.37
Cassava + maize + cowpea 450.00	204.00	13.49	8.33	2.29	24.97	205.00	13.00	6.33	2.31	25.33
LSD 0.05	0.26	0.08	1.26	0.35	3.74	3.11	0.15	1.02	0.33	3.32

Table 3: Effect of cropping system and NPK fertilizer rates on growth and yield of maize in cassava/maize intercropping system in 2013/2014 and 2014/2015 cropping seasons

Cropping Season	2013/2014					2014/2015				
Cropping system	Maize height (cm) 10WAP	Leaf area index. 10WAP	Cob length (cm)	Number of grains/ cob	Grain yield (tons/ ha)	Maize height (cm) 10WAP	Leaf area index. 10WAP	Cob length (cm)	Number of grains/ cob	Grain yield (tons/ ha)
Sole Maize	155.00	2.08	21.00	535.00	4.25	157.00	2.41	22.00	540.00	4.30
Maize + Cassava	142.00	2.24	19.00	305.00	3.72	144.00	2.63	20.00	324.00	3.77
Maize + cowpea	147.00	2.40	20.00	334.00	3.88	148.00	3.08	21.00	336.00	3.93
Maize + Cassava + cowpea	84.00	1.96	17.00	320.00	3.08	135.00	2.63	18.00	322.00	3.13
LSD 0.05	0.96	0.11	0.12	12.20	0.02	0.34	0.13	0.13	11.55	0.01
NPK Fertilizer rate (kg/ha)										
0.00	107.00	1.06	14.00	132.00	1.62	108.00	1.45	15.00	144.00	1.67
150.00	141.00	2.17	15.00	224.00	2.65	142.00	2.62	16.00	228.00	2.70
300.00	153.00	2.54	120.00	362.00	3.47	155.00	3.22	21.00	383.00	3.52
450.00	126.00	3.36	28.00	504.00	4.48	128.00	4.44	29.00	512.00	4.53
LSD 0.05	0.96	0.11	0.12	12.20	0.02	0.34	0.13	0.13	11.35	0.01
Cropping system x NPK fertilizer rate										
Sole Maize 0.00	115.00	1.19	15.00	135.00	1.24	118.00	1.61	14.00	135.00	1.28
Sole Maize 150.00	155.00	2.52	17.00	226.00	2.62	157.00	2.17	16.00	233.00	2.68
Sole Maize 300.00	163.00	2.94	22.00	390.00	3.92	164.00	3.28	21.00	394.00	3.98
Sole Maize 450.00	185.00	4.20	29.00	590.00	4.66	188.00	5.33	28.00	593.00	4.70
Maize + Cassava 0.00	103.00	1.04	13.00	131.00	1.04	106.00	1.37	12.00	134.00	1.09
Maize + Cassava 150.00	137.00	2.08	15.00	222.00	2.12	138.00	2.30	14.00	226.00	2.17
Maize + Cassava 300.00	151.00	2.54	20.00	362.00	3.33	153.00	2.99	18.00	373.00	3.38
Maize + Cassava 450.00	125.00	3.32	27.00	501.00	4.46	128.00	3.96	26.00	504.00	4.56
Maize + cowpea 0.00	108.00	1.16	14.00	134.00	1.20	108.00	1.54	13.00	136.00	1.25
Maize + cowpea 150.00	145.00	2.25	16.00	225.00	2.28	146.00	2.85	15.00	228.00	2.92
Maize + cowpea 300.00	157.00	2.60	21.00	389.00	3.56	158.00	3.37	20.00	392.00	3.70
Maize + cowpea 450.00	129.00	3.40	28.00	587.00	4.52	132.00	4.57	27.00	590.00	4.57
Maize + Cassava + cowpea 0.00	101.00	0.89	12.00	129.00	0.90	102.00	1.22	11.00	132.00	0.95
Maize + Cassava + cowpea 150.00	126.00	1.80	13.00	222.00	1.98	128.00	2.25	12.00	225.00	2.02
Maize + Cassava + cowpea 300.00	143.00	2.23	17.00	389.00	2.44	145.00	2.71	16.00	392.00	2.49
Maize + Cassava + cowpea 450.00	104.00	3.07	26.00	590.00	3.66	106.00	3.89	25.00	592.00	3.71
LSD 0.05	1.92	0.22	0.23	24.41	0.04	1.09	0.25	0.26	23.09	0.03

maize while intercropped maize with cassava and cowpea x NPK 0 kg/ha fertilizer rate had the least value in all the growth and yield components of maize. This was probably as a result of the low fertility status of the soil which hindered maize growth and, subsequently, yield parameters, as maize has a strong exhausting effect on the soil.

Growth and Yield of Cowpea

Table 4 shows the effects of cropping system and NPK fertilizer rates on growth and yield of cowpea in cassava/maize/cowpea intercropping system in 2013/2014 and 2014/2015 cropping seasons. Cropping system significantly ($p < 0.05$) influenced all the growth and yield parameters of cowpea in both cropping seasons. Vine length, leaf area index, pod length, number of seeds per pod and fresh pod yield were all significantly ($p < 0.05$) higher in sole cowpea plots than in intercrops probably because of the shading effect by the cassava component as well as competition for nutrient and space between the component crops.

Vine length, leaf area index, pod length, number of seeds per pod and fresh pod yield significantly increased with NPK fertilizer rates up to 450 kg/ha. The positive response recorded could be due to mineralization of nutrients; as a result of which better growth was achieved. Higher vegetative production in crop means higher interception of light and, therefore, more assimilate production that increased yield (Babaji *et al*., 2011).

There was significant ($p < 0.05$) interaction in cropping system x NPK fertilizer rates. Sole cowpea x NPK 450 kg/ha fertilizer rate performed best in all the growth and yield components of cowpea while intercropped cowpea with maize and with cassava x NPK 0 kg/ha fertilizer rate had the least values in all the growth and yield components of cowpea. This could be ascribed to the fact that the untreated plants were almost stunted in growth as they had to rely on the inherent fertility of the soil fertility which, from the result of chemical analysis, was low in the vital nutrients.

Productivity and Economies of the Intercrop System

The total land equivalent ratio (LER) of the cassava with maize and cowpea intercrop were all above 1.00 in the two cropping seasons, indicating that a higher productivity per unit area was achieved by intercropping cassava with maize and cowpea rather than by growing the three crops separately (Table 5). This indicated that land resources were efficiently utilized. The highest yield advantage of 2.71 and 2.72 for the 2013/2014 and 2014/2015 cropping seasons respectively were obtained when cassava was intercropped with maize and cowpea at 450 kg NPK/ha fertilizer rate, while the least yield advantage (1.55 for 2013/2014 and 1.34 for 2014/2015 cropping seasons) were obtained when cassava was intercropped with maize at 0 kg NPK/ha fertilizer rate.

The partial LER of the component crops showed that cowpea always contributed more to the total LER than cassava and maize in both cropping seasons. The gross monetary returns of the intercrop system are shown in Table 6. The total monetary returns were all higher for the intercrops than the sole crops in both cropping seasons. The highest returns of ₦3,338,000 and ₦3,346,000 for the 2013/2014 and 2014/2015 cropping seasons respectively were when cassava was intercropped with maize and cowpea at 450 kg NPK/ha fertilizer rate while the respective seasonal least returns of ₦204,700 and ₦203,700 were observed in sole cassava at

Table 4: Effects of cropping system and NPK fertilizer rates on growth and yield of cowpea in cassava/maize/cowpea intercropping System in 2013/2014 and 2014/2015 cropping seasons

Cropping Season	2013/2014					2014/2015				
Cropping Type	Vine length (cm) 10 WAP	Leaf area index 10 WAP	Pod length (cm)	Number of seeds/ pod	Fresh pod yield (tons/ha)	Vine length (cm) 10 WAP	Leaf area index 10 WAP	Pod length (cm)	Number of seeds/ pod	Fresh pod yield (tons/ha)
Sole Cowpea	141.00	1.98	15.00	13.00	3.31	112.00	1.81	14.00	14.00	3.38
Cowpea + Cassava	133.00	1.29	12.00	10.00	3.24	134.00	1.31	14.00	12.00	3.24
Cowpea + Maize	145.00	1.51	13.00	12.00	3.29	147.00	1.54	15.00	13.00	3.32
Cowpea + Cassava + Maize	121.00	1.11	11.00	9.00	3.15	123.00	1.14	13.00	11.00	3.17
LSD 0.05	0.77	0.02	0.26	0.07	0.03	0.92	0.02	0.14	0.20	0.05
NPK Fertilizer rates (kg/ha)										
0.00	95.00	0.55	1.00	8.00	1.21	94.00	0.56	12.00	10.00	1.23
150.00	123.00	0.88	12.00	9.00	2.14	124.00	0.91	13.00	11.00	2.17
300.00	139.00	1.31	13.00	12.00	2.90	141.00	1.34	14.00	13.00	2.82
450.00	204.00	2.94	14.00	14.00	3.48	204.00	3.00	17.00	15.00	3.32
LSD 0.05	0.77	0.02	0.26	0.07	0.03	0.92	0.02	0.14	0.20	0.05
Cropping system x NPK fertilizer rates										
Sole Cowpea 0.00	109.00	0.75	13.00	10.00	1.24	108.00	0.77	14.00	12.00	1.26
Sole Cowpea 150.00	135.00	1.10	13.00	11.00	2.20	134.00	1.12	15.00	13.00	2.23
Sole Cowpea 300.00	156.00	1.62	15.00	14.00	2.92	157.00	1.64	17.00	16.00	2.96
Sole Cowpea 450.00	245.00	3.63	18.00	16.00	3.50	248.00	3.70	20.00	18.00	3.54
Cowpea + Cassava 0.00	88.00	0.48	10.00	8.00	1.14	86.00	0.49	12.00	10.00	1.15
Cowpea + Cassava 150.00	121.00	0.79	11.00	9.00	2.02	123.00	0.81	13.00	11.00	2.04
Cowpea + Cassava 300.00	133.00	1.18	12.00	11.00	2.42	135.00	1.20	14.00	12.00	2.45
Cowpea + Cassava 450.00	189.00	2.71	15.00	13.00	3.02	191.00	2.75	17.00	15.00	3.06
Cowpea + Maize 0.00	98.00	0.60	11.00	9.00	1.16	99.00	0.61	13.00	11.00	1.17
Cowpea + Maize 150.00	129.00	0.98	13.00	10.00	2.08	131.00	1.01	14.00	12.00	2.10
Cowpea + Maize 300.00	144.00	1.39	13.00	12.00	2.41	147.00	1.42	15.00	14.00	2.49
Cowpea + Maize 450.00	210.00	3.06	16.00	14.00	3.14	212.00	3.13	18.00	16.00	3.18
Cowpea + Cassava + maize 0.00	77.00	0.34	9.00	7.00	1.04	78.00	0.34	11.00	9.00	1.05
Cowpea + Cassava + maize 150.00	113.00	0.67	10.00	8.00	1.92	114.00	0.69	12.00	10.00	1.94
Cowpea + Cassava + maize 300.00	123.00	1.06	11.00	10.00	2.42	125.00	1.09	13.00	12.00	2.44
Cowpea + Cassava + maize 450.00	171.00	2.34	4.00	12.00	2.98	174.00	2.42	14.00	14.00	3.00
LSD 0.05	1.55	0.03	0.52	0.13	0.06	1.84	0.03	0.28	0.41	0.10

Table 5: Land equivalent ratio of cassava, maize and cowpea intercropping systems in the 2013/2014 and 2014/2015 cropping season as affected by cropping systems and NPK fertilizer rates

	Land equivalent ratio (LER)							
	2013/2014 Partial				2014/2015 Partial			
			Cowpea				Cowpea	
Cropping system x NPK fertilizer rates	Cassava	Maize	(fresh pod yield)	Total	Cassava	Maize	(fresh pod yield)	Total
Sole Cassava 0.00	1.00	-	-	1.00	1.00	-	-	1.00
Sole Cassava 150.00	1.00	-	-	1.00	1.00	-	-	1.00
Sole Cassava 300.00	1.00	-	-	1.00	1.00	-	-	1.00
Sole Cassava 450.00	1.00	-	-	1.00	1.00	-	-	1.00
Sole Maize 0.00	-	1.00	-	1.00	-	1.00	-	1.00
Sole Maize 150.00	-	1.00	-	1.00	-	1.00	-	1.00
Sole Maize 300.00	-	1.00	-	1.00	-	1.00	-	1.00
Sole Maize 450.00	-	1.00	-	1.00	-	1.00	-	1.00
Sole Cowpea 0.00	-	-	1.00	1.00	-	-	1.00	1.00
Sole Cowpea 150.00	-	-	1.00	1.00	-	-	1.00	1.00
Sole Cowpea 300.00	-	-	1.00	1.00	-	-	1.00	1.00
Sole Cowpea 450.00	-	-	1.00	1.00	-	-	1.00	1.00
Cassava + Maize 0.00	0.44	0.89	-	1.33	0.44	0.88	-	1.34
Cassava + Maize 150.00	0.80	0.94	-	1.74	0.83	0.94	-	1.77
Cassava + Maize 300.00	0.83	0.94	-	1.77	0.87	0.94	-	1.81
Cassava + Maize 450.00	0.90	0.91	-	1.81	0.91	0.91	-	1.87
Cassava + Cowpea 0.00	0.84	-	0.95	1.81	0.87	-	0.94	1.80
Cassava + Cowpea 150.00	0.91	-	0.97	1.88	0.93	-	0.94	1.91
Cassava + Cowpea 300.00	0.93	-	0.98	1.93	0.93	-	0.97	1.91
Cassava + Cowpea 450.00	0.97	-	0.99	1.91	0.98	-	0.98	1.91
Maize + Cowpea 0.00	-	0.91	0.97	1.88	-	0.91	0.98	1.89
Maize + Cowpea 150.00	-	0.94	0.98	1.91	-	0.95	0.98	1.93
Maize + Cowpea 300.00	-	0.94	0.98	1.94	-	0.95	0.99	1.94
Maize + Cowpea 450.00	-	0.89	0.99	1.98	-	0.99	1.00	1.99
Cassava + Maize + Cowpea 0.00	0.00	0.80	0.92	1.72	0.13	0.80	0.92	1.87
Cassava + Maize + Cowpea 150.00	0.71	0.84	0.95	2.50	0.73	0.84	0.93	2.53
Cassava + Maize + Cowpea 300.00	0.74	0.87	0.96	2.57	0.77	0.87	0.96	2.60
Cassava + Maize + Cowpea 450.00	0.84	0.89	0.98	2.71	0.81	0.89	0.97	2.72

Table 5: Land equivalent ratio of cassava, maize and cowpea intercropping systems in the 2013/2014 and 2014/2015 cropping season as affected by cropping systems and NPK fertilizer rates

	Land equivalent ratio (LER)							
	2013/2014 Partial				2014/2015 Partial			
			Cowpea				Cowpea	
Cropping system x NPK fertilizer rates	Cassava	Maize	(fresh pod yield)	Total	Cassava	Maize	(fresh pod yield)	Total
Sole Cassava 0.00	1.00	-	-	1.00	1.00	-	-	1.00
Sole Cassava 150.00	1.00	-	-	1.00	1.00	-	-	1.00
Sole Cassava 300.00	1.00	-	-	1.00	1.00	-	-	1.00
Sole Cassava 450.00	1.00	-	-	1.00	1.00	-	-	1.00
Sole Maize 0.00	-	1.00	-	1.00	-	1.00	-	1.00
Sole Maize 150.00	-	1.00	-	1.00	-	1.00	-	1.00
Sole Maize 300.00	-	1.00	-	1.00	-	1.00	-	1.00
Sole Maize 450.00	-	1.00	-	1.00	-	1.00	-	1.00
Sole Cowpea 0.00	-	-	1.00	1.00	-	-	1.00	1.00
Sole Cowpea 150.00	-	-	1.00	1.00	-	-	1.00	1.00
Sole Cowpea 300.00	-	-	1.00	1.00	-	-	1.00	1.00
Sole Cowpea 450.00	-	-	1.00	1.00	-	-	1.00	1.00
Cassava + Maize 0.00	0.44	0.89	-	1.33	0.44	0.88	-	1.34
Cassava + Maize 150.00	0.80	0.94	-	1.74	0.83	0.94	-	1.77
Cassava + Maize 300.00	0.83	0.94	-	1.77	0.87	0.94	-	1.81
Cassava + Maize 450.00	0.90	0.96	-	1.86	0.91	0.96	-	1.87
Cassava + Cowpea 0.00	0.84	-	0.95	1.81	0.87	-	0.96	1.83
Cassava + Cowpea 150.00	0.91	-	0.97	1.88	0.95	-	0.96	1.91
Cassava + Cowpea 300.00	0.95	-	0.98	1.93	0.95	-	0.97	1.92
Cassava + Cowpea 450.00	0.97	-	0.99	1.96	0.98	-	0.98	1.96
Maize + Cowpea 0.00	-	0.91	0.97	1.88	-	0.91	0.98	1.89
Maize + Cowpea 150.00	-	0.94	0.98	1.92	-	0.95	0.98	1.93
Maize + Cowpea 300.00	-	0.96	0.98	1.94	-	0.95	0.99	1.94
Maize + Cowpea 450.00	-	0.99	0.99	1.98	-	0.99	1.00	1.99
Cassava + Maize + Cowpea 0.00	0.00	0.80	0.92	1.72	0.13	0.80	0.92	1.87
Cassava + Maize + Cowpea 150.00	0.71	0.84	0.95	2.50	0.75	0.84	0.95	2.53
Cassava + Maize + Cowpea 300.00	0.74	0.87	0.96	2.57	0.77	0.87	0.96	2.60
Cassava + Maize + Cowpea 450.00	0.84	0.89	0.98	2.71	0.84	0.89	0.97	2.72

Table 6: Gross monetary return (GMR) of cassava, maize and cowpea intercropping systems in 2013/2014 and 2014/2015 cropping seasons as affected by cropping systems and NPK fertilizer rates

	Gross Monetary Return (GMR)							
	2013/2014 Partial				2014/2015 Partial			(Naira)
Cropping system x NPK fertilizer rate	Cassava	Maize	Cowpea (fresh pod yield)	Total	Cassava	Maize	Cowpea (fresh pod yield)	Total
Sole Cassava 0.00	204700			204700	203700			203700
Sole Cassava 150.00	219300			219300	212300			212300
Sole Cassava 300.00	240000			240000	237300			237300
Sole Cassava 450.00	296700			296700	294000			294000
Sole Maize 0.00		1348000		1348000		1332000		1252000
Sole Maize 150.00		1386000		1386000		1386000		1386000
Sole Maize 300.00		1586000		1586000		1586000		1586000
Sole Maize 450.00		2378000		2378000		2382000		2382000
Sole Cowpea 0.00			945000	945000			954000	954000
Sole Cowpea 150.00			960000	960000			973000	973000
Sole Cowpea 300.00			1038000	1038000			1044000	1044000
Sole Cowpea 450.00			1083000	1083000			1095000	1095000
Cassava + Maize 0.00	136300	1108000		1244300	94700	1106000		1200700
Cassava + Maize 150.00	182300	1328000		1510300	187700	1332000		15177000
Cassava + Maize 300.00	192300	1494000		1686300	196300	1490000		1686300
Cassava + Maize 450.00	268000	2242000		2510000	268300	2240000		2508300
Cassava + Cowpea 0.00	193700		921000	1114700	194300		933000	1127300
Cassava + Cowpea 150.00	200300		942000	1142300	201000		942000	1143000
Cassava + Cowpea 300.00	206700		984000	1190700	207000		999000	1206000
Cassava + Cowpea 450.00	287000		1041000	1328000	288000		1053000	1341000
Maize + Cowpea 0.00		1140000	930000	2070000		1140000	931000	2071000
Maize + Cowpea 150.00		1370000	951000	2321000		1364000	966000	2330000
Maize + Cowpea 300.00		1514000	1011000	2525000		1514000	1023000	2537000
Maize + Cowpea 450.00		2274000	1001000	3275000		2272000	1004000	3276000
Cassava + Maize + Cowpea 0.00	0	1004000	903000	1907000	30700	1000000	915000	1947700
Cassava + Maize + Cowpea 150.00	161700	1234000	921000	2316700	164000	1234000	926000	2334000
Cassava + Maize + Cowpea 300.00	170000	1378000	963000	2511000	173700	1374000	975000	2524700
Cassava + Maize + Cowpea 450.00	249700	2032000	993000	3274700	253300	2048000	1005000	3306300

0 kg NPK/ha fertilizer rate.

The partial GMR of the component crops (Table 6) showed that maize always contributed more to the total GMR than cassava and cowpea. This indicated that farmers will get their highest monetary returns by intercropping cassava with maize and cowpea at 450 kg NPK/ha fertilizer rate.

Conclusion

The result of the experiment indicated that cassava, maize and cowpea could be intercropped for optimum productivity if the correct regimes of NPK 15:15:15 fertilizer is applied.

Results also indicated that NPK fertilizer application rate of 450 kg/ha gave the optimum growth and yield for the component crops and therefore it is recommended for use in the study area.

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