Organic And Non-Organic Fertilization Of Cassava-Based Crops In Nigeria

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Cassava is a staple crop in Nigeria, crucial for food security and economic stability. However, its productivity is often limited by soil fertility issues. This study aims to compare the effects of organic and non-organic fertilization on the growth and yield of cassava-based crops in Nigeria. A field experiment was conducted in Rivers State, Nigeria. The study involved 120 plots, each measuring 10m x 10m, divided into three groups: organic fertilisation (compost and manure), inorganic fertilisation (NPK 15-15-15), and a control group with no fertilisation. Data on soil chemical properties, plant growth parameters, and crop yield were collected and analyzed using ANOVA and post-hoc tests. The results showed that organic fertilisation significantly improved soil pH, organic carbon, and total nitrogen levels compared to non-organic fertilization and the control group. Cassava plants in the organic fertilization group exhibited higher growth rates and yields, with an average yield increase of 25% compared to the non-organic group and 40% compared to the control group. Inorganic fertilisation also improved yield but had a lesser impact on soil health, with a notable decrease in soil pH and organic carbon content over time. The study demonstrates that organic fertilization is more beneficial for both soil health and cassava yield compared to inorganic fertilisation. The findings suggest that adopting organic fertilisation practices can enhance sustainable cassava production in Nigeria. Policymakers and farmers should consider integrating organic fertilizers into their farming practices to improve crop productivity and soil health.

Keywords: Cassava, organic fertilization, non-organic fertilization, soil fertility, crop yield, Nigeria

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INTRODUCTION

Shifting cultivation, as practiced by the traditional farmers to restore soil fertility in sustaining cropping can no longer meet up with the increased need for food supply due to high population pressure. The length of fallow period required to replenish the soil to maintain soil productivity has to be shortened. The primary function of soil productivity and fertility restoration through fallow is less effective since intensive cropping is now more common. The use of inorganic fertilizers alone has not been helpful under intensive agriculture because it aggravates soil degradation (Sharma and Mittra, 1991). The degradation is brought about by loss of organic matter which consequently results in soil acidity, nutrient imbalance and low crop yields. Response of crops to applied fertilizer depends on soil organic matter. The quantity of soil organic matter depends on the quantity of organic material which can be introduced into the soil either by natural returns through roots, stubbles, sloughed-off root nodules and root exudates or by artificial application in the form of organic manure which can otherwise be called organic fertilizer (Agboola and Omueti, 1982).The need to use renewable forms of energy has revived the use of organic fertilizers worldwide. Nutrients contained in organic manures are released more slowly and are stored for a longer time in the soil, thereby ensuring a long residual effect (Sharma and Mittra, 1991). Improvement of environmental conditions and public health as well as the need to reduce costs of fertilizing crops are also important reasons for advocating increased use of organic materials (Seifritz, 1982). Application of organic manures also improves the soil microbial properties (Belay et. al., 2001) The benefits derivable from the use of organic materials have however not been fully utilized in the humid tropics due to the huge quantities required to satisfy the nutritional needs of crops as well as transportation and handling costs which constitute major constraints. They are rarely available to the small-scale farmers in the required large quantities (Nyathi and Campbell, 1995) Complementary use of organic manure and mineral fertilizers has been proved to be a sound soil fertility management strategy in many countries of the world (Lombin *et al.*, 1991). High and sustained crop yield could be obtained with judicious and balanced NPK fertilization combined with organic matter amendments (Kang and Balasubramanian, 1990; Palm et. al., 1997; Makinde *et al*., 2001; Bayu et. al., 2006).

A system that integrates different practices of soil fertility maintenance is required. This will include the use of mineral fertilizers, organic manures and intercropping.

Intercropping provides a fast and good ground cover and also allows the roots to exploit soil nutrients at various depths (Steiner, 1991). The traditional farmers seem to have unconsciously designed their cropping system with a view of maintaining the soil fertility because intercropping produces a stable and sustainable agro ecosystem.

Farmers in the South western part of Nigeria practice intercropping with a wide range of crops, consisting usually of a major crop and other minor crops. Crops like cassava, maize, yam and plantain are planted as major crops while melon, cowpea and vegetables are some of the minor crops planted in various parts of the zone.

Cassava is an important food crop in the tropics and it is well suited to intercropping with short duration crops such as maize, melon, cowpea, okra and several leafy vegetables because the crops are selected on the basis of differences in growth habits and can be combined in either simple or complex mixtures. Yield depressions have been reported in many cases under cassava-based cropping systems. (Ikeorgu, 1984; Ambe, et. al., 1988).Decline in soil fertility is especially serious in tropical regions where the soil lacks adequate plant nutrients and organic matter due to leaching and erosion of topsoil by intense rainfall (Gutteridge and Shelton, 1994).

This study was therefore initiated to compare the effects of complementary and sole applications of organic and inorganic fertilizers on the growth and yield of cassava/maize/melon intercrop with a relayed cowpea.

MATERIALS AND METHODS

The experiment was conducted at Ibadan on latitude $7^0$22½'N and longitude $3^0$50½'E in the degraded rainforest vegetation zone of Nigeria between April, 1995 and March, 1997. The town is characterized by a bimodal rainfall pattern with a long rainy season which usually starts in late March while the short rainy season extends from September to early November after a short dry spell in August. Top soil samples (0-15cm depth) were taken and the initial soil nutrient status determined (Table 1). The Organic fertilizer had a pH of 7.6; 1.65% N: 0.52% P and 0.91% K (Table 2).

Table 1: Initial chemical and physical characteristics of soil at the Experimental site.

pH (H_20)	5.70
Total N (gkg^{-1})	1.44
Organic C ($g\ kg^{-1}$)	14.24
Available P ($mgkg^{-1}$)	4.30
Exchangeable K ($cmolkg^{-1}$)	0.36
Exchangeable Ca ($cmolkg^{-1}$)	3.63
Exchangeable Mg ($cmolkg^{-1}$)	2.21
Exchangeable Na ($cmolkg^{-1}$)	0.58
Exchangeable Acidity (H^+)($cmolkg^{-1}$)	0.12
ECEC ($cmolkg^{-1}$)	6.90
Base saturation (gkg^{-1})	983.40
Sand ($g\ kg^{-1}$)	850.00
Silt ($g\ kg^{-1}$)	74.00
Clay ($g\ kg^{-1}$)	76.00

Table 2: Chemical Composition of the Organic Fertilizer

pH (H_20)	7.6
Total N (%)	1.65
Organic C (%)	34.5
Available P (%)	0.52
Exchangeable K (%)	0.91
Exchangeable Ca (%)	0.26
Exchangeable Mg (%)	0.25
Mn ($Mgkg^{-1}$)	0.32
Fe ($Mgkg^{-1}$)	2.36

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replicates. Plot size was 4 x 6m with a 2m margin round each plot. The treatments were:

Inorganic Fertilizer (400 Kg/ha NPK 15-15-15) - (F.M.A.L.R, 1980; FPDD, 1989; Fondufe, 1995); Organic Fertilizer (1: 1 by weight, Poultry Manure + Decomposed Urban Refuse - 5t/ha (Titiloye, 1982; FPDD, 1989); Inorganic + Organic Fertilizer (200 kg/ha NPK 15-15-15 + 2.5 t/ha of organic fertilizer); and. No Fertilizer. DMR-LSR-W maize seeds were intercropped with Western Local melon seeds and TMS 30572 cassava cuttings. The Cowpea variety planted was Ife brown. The site for the study was slashed, ploughed and harrowed.

Organic fertilizer was applied a week before planting. It was uniformly spread on the plots and lightly worked into the soil with hoe. Inorganic fertilizer was applied 3 Weeks After Planting (WAP) by ringing around maize plant. Planting was done on the flat. Cassava, maize and melon were planted at the same time. Planting was done as soon as the rains were steady in April. Cowpea was relayed into cassava at 18 WAP, after maize and melon were harvested. Maize and melon were planted on a row at spacing of 1m x 1m; 2 plants/stand, giving a plant population of 20,000 plants ha^{-1} for each of the crops. Cassava was planted in-between the maize/melon rows at a spacing of 1m x 1m; 1 plant/stand to give a population of 10,000 plants ha^{-1}. Cowpea population was 55,555 plants ha^{-1} at 0.6m x 0.6m; 2 plants/stand. The plots were weeded manually whenever necessary while cowpea pests were controlled with Karate (Lambdacyhalothrin) at 800ml/ha from the 5th week.

Maize was harvested fresh at 12 WAP. It was sun dried to 14% moisture content. Melon was harvested at 18WAP. Cowpea harvesting commenced from the 10^{th} week to avoid pod shattering and weevil infestation while cassava was harvested at 12 months after planting (MAP).

Data Collection:

Growth and yield parameters measured for maize were: plant height (m), leaf area per plant at tasselling (m^2), dry matter yield (t/ha) and grain yield (t/ha). For melon; vine length (m); leaf area (m^2/plant) -- Wahua, 1985; and seed yield were measured while cassava root yield and cowpea grain yield were also recorded at harvest.

Data Analysis:

The Analysis of Variance (ANOVA) procedure was carried out to determine the difference in parameters. Mean values were compared using the Least Significant Difference (LSD) at 0.05 level of probability.

RESULTS AND DISCUSSIONS

Results:

Crop Growth:

Fertilizer application had no consistent significant effects on maize plant height at 2 and 4 weeks of growth. Consistent significant differences were however observed as from 6 weeks of growth under the various fertilizer treatments (Table 3). Over the two years average, at 8 weeks of growth, complementary application of inorganic and organic fertilizers had taller plants than either sole inorganic or organic fertilizer. The highest maize leaf area of 0.89 m^2 $plant^{-1}$, at tasselling, was recorded under complementary inorganic + organic fertilizer treatment in the first year. This was significantly higher than 0.79 and 0.73 m^2 $plant^{-1}$ got from inorganic and organic fertilizations, respectively. In the second year, plant leaf areas from complementary application and from sole inorganic fertilizer were similar but were both significantly higher than from organic fertilizer application (Table 4).

Melon leaf area expansion with the different fertilizer treatments followed the same trend in both years of cropping. The trend was inorganic + organic fertilizer > inorganic fertilizer > organic fertilizer in both years (Table 4). Leaf areas from the unfertilized plots were the least. It had 1.32 and 1.58 $m^2 plant^{-1}$ leaf coverage in the first and second years, respectively. The longest melon vines were given by application of sole inorganic fertilizer. At 8 weeks after planting, they were significantly longer than from those treated with complementary inorganic and organic fertilizers (Table 5).

In the first year, inorganic fertilizer application had cassava plants 1.6m tall which were not significantly shorter than 1.7m tall plants given by complementary application of inorganic and organic fertilizers. By the second year, plants from all the fertilized plots were all comparable and were all significantly taller than plants from the unfertilized plot. (Table 4). Cassava stem girth of 74mm with inorganic fertilizer application, in the

Table 3: Effect of Fertilizer Type on Maize Plant Height (m) in a Cassava/Maize/Melon/ Intercrop.

	2WAP		4WAP		6WAP		8WAP	
	Year 1	Year 2	Year 1	Year 2	Year1	Year 2	Year 1	Year 2
No Fertilizer	0.33	0.33	0.43	0.50	0.96	1.00	1.24	1.22
Inorganic	0.33	0.34	0.53	0.54	1.09	1.28	1.91	2.03
Organic	0.32	0.34	0.45	0.51	0.89	1.22	1.59	2.06
Inorganic+Organic	0.33	0.36	0.52	0.53	1.13	1.35	2.05	2.06
LSD	0.16	0.015	0.070	0.041	0.072	0.142	0.302	0.170

Table 4: Effect of Fertilizer Type on Growth Performance of Cassava/Maize/Melon/Intercrop.

	Maize Leaf Area (m^2 $plant^{-1}$)		Melon Leaf Area (m^2 $plant^{-1}$)		Cassava Plant Height (m)		Cassava Stem Girth (mm)	
	Year 1	Year 2	Year 1	Year 2	Year1	Year 2	Year 1	Year 2
No Fertilizer	0.63	0.63	1.32	1.58	1.40	1.50	62.00	69.00
Inorganic	0.79	0.87	1.69	2.01	1.60	1.70	74.00	85.00
Organic	0.73	0.72	1.59	1.71	1.50	1.60	66.00	87.00
Inorganic+Organic	0.89	0.93	1.83	2.29	1.70	1.70	79.00	88.00
LSD	0.048	0.077	0.081	0.073	0.14	0.15	9.20	11.30

Table 5: Effect of Fertilizer Type on Melon Vine Length (cm) in a Cassava/Maize/Melon/ Intercrop.

	2WAP		4WAP		6WAP		8WAP	
	Year 1	Year 2	Year 1	Year 2	Year1	Year 2	Year 1	Year 2
No Fertilizer	25.0	24.0	92.0	96.0	13 1.0	140.0	150.0	156.0
Inorganic	35.0	36.0	152.0	164.0	205.0	219.0	232.0	242.0
Organic	34.0	34.0	128.0	130.0	159.0	162.0	172.0	185.0
Inorganic+ Organic	3 1.0	34.0	167.0	170.0	197.0	204.0	221.0	225.0
LSD	2.770	2.740	8.920	6..550	8.120	7.020	6.640	1.470

Table 6: Effect of Fertilizer Type on Yield of Cassava/Maize/Melon/ Intercrop with Relayed Cowpea (t ha^{-1}).

	Maize Dry Matter Yield		Maize Grain Yield		Melon Seed Yield		Cassava Root Yield		Cowpea Seed Yield	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year1	Year 2	Year 1	Year 2
No Fertilizer	3.27	3.60	1.21	1.08	0.12	0.18	6.26	7.90	0.26	0.28
Inorganic	6.13	7.87	1.98	1.93	0.23	0.29	10.34	12.43	0.26	0.27
Organic	4.53	6.10	1.54	1.54	0.22	0.30	8.83	12.40	0.21	0.22
Inorganic+ Organic	7.20	7.90	2.12	2.61	0.24	0.30	10.01	11.48	0.34	0.37
LSD	1.281	1.835	0.160	0.371	0.072	0.103	0.603	1.867	0.028	0.052

first year, was comparable to 79mm thick stems given by complementary application. They were also both significantly thicker than stems from either organic fertilizer application or from the unfertilized plots. By the second year however, stem girth from all the fertilizer types were similar (Table 4).

Crop Yield:

The control plots that had no fertilizers gave the lowest maize dry matter yield values of 3.27 and 3.60 t ha^{-1} in the first and the second years, respectively while the highest values of 7.20 and 7.90 t ha^{-1} were obtained from plots treated with complementary inorganic and organic fertilizers. They were however not significantly higher than realized from sole inorganic fertilizer application (Table.6).Maize grain yield of 2.12 t ha^{-1} was highest with complementary application in the first year, when sole inorganic fertilizer application also had a comparable yield of 1.98 t ha^{-1}. However, by the second year, complementary application gave a significantly higher yield (2.61 t ha^{-1}.) than inorganic fertilizer application that had a yield of 1.93 t ha^{-1}. (Table 6). The yield was about 7% higher in the first year and was about 35% higher, in the second year.

Melon seed yield was significantly affected by fertilizer application but was not significantly affected by the fertilizer type. The yields were generally lower in the first year, relative to the second year. Complementary application gave the highest melon seed yields in the two years of cropping (Table 6)

Cowpea seed yield was only significantly higher with complementary application of inorganic and organic fertilizers. Yields obtained from all the other treatments, including the control were statistically similar, by the second year's cropping (Table 6).

Cassava root yield was significantly affected by fertilizer application. In the first year of cropping, inorganic fertilizer application and complementary application of inorganic and organic fertilizers had similar yields of 10.34 and 10.01 t ha^{-1}, respectively that were both significantly higher than 8.83 t ha^{-1} got from sole organic fertilizer. By the second year, both the sole inorganic and the sole organic fertilizers gave comparable yields with complementary application. Yields from the control plots were significantly lower in both years (Table 6).

Discussion:

Maize performed best in terms of growth and yield with complementary application of inorganic + organic fertilizers. This is in agreement with the findings of Titiloye (1982) who reported that the most satisfactory method of increasing maize yield was by judicious combination of organic wastes and inorganic fertilizers. Kang and Balasubramanian (1990) also found that high and sustained crop yields could be obtained with judicious and balanced NPK fertilization combined with organic matter amendments. Makinde *et al.* (2001a), has earlier reported that maize yields from sole inorganic fertilizer and a mixture of organic and inorganic fertilizer applications were similar and were significantly higher than yields from organic fertilizer application. They also found that organic fertilizer application did not benefit the yield of maize significantly. Adeniyan and Ojeniyi (2005) have also reported a higher yield of maize from a combined use of NPK fertilizer and poultry manure than from sole applications. Murwira and Kirchmann (1993) have observed that the nutrient use efficiency of a crop is increased through a combined application of organic manure and mineral fertilizer. Maize yields with complementary inorganic + organic fertilizers and with sole inorganic fertilizer treatment were comparable because nutrients were readily released from the inorganic fertilizer and maize, being an aggressive feeder, was able to utilize it for its growth and yield. Maize did not seem to benefit much from organic fertilizer probably because of low mineralization of nutrients from that source. Titiloye (1982) has reported that organic waste/fertilizer alone could hardly be depended upon as the sole source of nutrients for maize crop.

The yield of maize was least in the control plots and there was yield reduction in these plots in 1997. This could be attributed to removal of nutrients in the harvested crops without replacement. Padwick (1983) has observed that many tropical soils show nutrient deficiency problems and a decrease in crop yields after only a short period of cultivation.

Melon responded to fertilization and it appears that nutrients from inorganic source were utilized for vine formation while organic fertilizer contributed to seed production. This is because the longest vines were from inorganic fertilizer treatment but seed yields from other fertilizer treatments were similar and were much higher than realized form the control. Melon did not benefit significantly from organic fertilization because of low mineralization of nutrients from this source. Makinde *et.al* (2001b), have reported that melon yields were statistically similar with the different fertilizer types. Adeyemi (1991) reported that melon's performance got better with increasing rate of chemical fertilizer.

The highest cowpea yield, realized from inorganic + organic fertilizer treatment, showed that cowpea benefited more from this combination than from other fertilizer treatments. Cowpea yield under inorganic fertilizer treatment that was about same as obtained from the control plot showed that the residual nutrients from this source were not available to the late season crop.

Conclusion:

Application of 5 tons ha^{-1} of manure is not adequate to sustain the cultivation of cassava / maize / melon mixture, with a relayed cowpea but application of 400 kg of NPK 15- 15- 15 fertilizer/ ha, to supply 60 kg N, 60 kg P_20_5 and 60 kg K_20 is adequate. It supports the growth and the yields of the early season crops as well as the yield of cassava. It however, does not supply enough nutrients to give optimum yields for a relayed cowpea. However, a complementary application of reduced rates of 2.5 tons ha^{-1} of manure with 400 kg of NPK 15- 15- 15 fertilizer/ ha, gives comparable yields as sole inorganic fertilizer application for the early-season maize, melon and cassava. It also gives a higher yield for a relayed cowpea.

This complementary application reduces the dependence of the farmer on inorganic fertilizer use. It also reduces the exposure of the soil to the consequences of inorganic fertilizer application.

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