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Residual effects of fertilizer application on growth and yield of two cassava varieties in Ibadan, south-western Nigeria.

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Abstract
Field experiments were conducted to investigate the effects of application and residues of organomineral and NPK fertilizers on two cassava varieties in a tropical alfisol in Ibadan, south-western Nigeria in 2007, 2008 and 2009. Five Organomineral Fertilizer (OF) rates (1.5, 2.5, 3.5, 4.5 and 6.0 t/ha), NPK 15-15-15 at 600 kg/ha and no fertilizer (control) treatments as subplots were evaluated on the performance of TMS 30572 and TMS 92/0326 planted at 10,000 plants per hectare as main plots. Fertilizer was applied at planting using a split plot arrangement in a Randomized Complete Block Design (RCBD) with three replicates. After harvest at 12 Months After Planting (MAP), cassava was replanted in-situ with minimum soil disturbance, without fertilizer application to assess the residual effects of previously applied treatments. Fertilizer application significantly increased cassava root yield but had no significant influence on plant growth parameters and number of storage roots per plant. Yield obtained with NPK application was similar to those obtained with various OF rates. Residues of OF applied at 2.5 to 6.0 t/ha produced yields similar to those of previous application. Fresh and dry root yields of NPK and control treatments were significantly low. The optimum OF rate (2.5 t/ha) is capable of producing optimum cassava root yields in two consecutive cropping seasons.

Keywords : Organomineral fertilizer, residual effects, root yield

Introduction
Cassava is one of the most important food crops widely consumed in Nigeria. It plays a key role in the nation's food security as majority of Nigerians eat cassava at least once a day (Sanni *et al*., 2007). Increase in production by increasing hectarage under cultivation is no longer possible due to shortage of land, therefore intensification of production by the use of chemical fertilizers and manures is imperative in achieving sustainable increase in cassava production (Ojeniyi, 2009). However, the cost of frequently used chemical fertilizer, lack of awareness in most rural settings as well as scarcity at peak periods of need have been major sources of discouragement to rural farmers. Furthermore, the use of chemical fertilizers in sustaining cropping systems in the long run has not been effective due to the nature of Nigerian soils (Rodale, 1995; Ogunwale *et al*., 2003). Eneji *et al*. (1997) obtained yield advantage from the combination of organic and inorganic fertilizers over the use of each alone. Application of this combination (Organomineral fertilizer, OF) will give the advantage of applying both organic and inorganic fertilizers. While the inorganic components releases nutrient faster for initial growth and establishment of the crop, the organic portion supplies nutrients both (macro and micro nutrients) slowly over a longer period resulting in improved soil structure, enhanced soil micro organism activity, soil water content and nutrient holding capacity (Ayuso *et al*., 1996; Makinde, 2007; Ayeni, 2010).The fertilizer combination is capable of sustaining long term cropping in the tropics due to the residual effects typical of the organic components (Palm *et al*., 1997; Ipinmoroti *et al*., 2002). High and sustained crop yields have been obtained with appropriate and balanced combination of NPK fertilizer and organic matter amendment (Kang and Balashrubmania, 1990; Makinde *et al*., 2001).

The optimal rate of application of OF to sustain optimum cassava root yield beyond a single season of production however, needs to be investigated. This study was conducted to assess the residual effect of OF application on yield of cassava.

Materials and Methods
Field experiments were conducted in 2008 and 2009 at the University of Ibadan Teaching and Research Farm, Ajibode, Ibadan. Ajibode lies within the

derived savanna zone of south-western Nigeria on latitude 7°30'N and longitude 3°54'E with alfisol soil type (Ogunkunle, 1989). Rainfall pattern is bimodal beginning in late March to early November with peaks in June/July and September/October. The site was under continuous cultivation with arable crops such as maize, cassava and fluted pumpkin for about four years, fallowed for five years prior to the establishment of the experiment.

The experiment consisted of seven fertilizer treatments: 1.5, 2.5, 3.5, 4.5 and 6.0 t OF/ha, 600 kg/ha NPK and no fertilizer (control) as subplots; two cassava varieties (TMS 30572 and TMS 92/0326) as main plots. The experiment was laid out in a split plot arrangement in RCBD with three replicates. Cassava was planted at 10,000 plants per hectare on plots measuring 8 x 5 m with 2 m margin round each plot and fertilizer was applied at planting by ring method. The OF was a commercial type made up of 92% livestock dung and market waste fortified with 2% SSP and 6% Urea. It had a pH (H_20) of 6.2;56.3g/kg^{-1} organic matter; 34.6g/kg^{-1} organic carbon; 31.7g/ kg^{-1}nitrogen, 68.5g/ kg^{-1}available phosphorus (Bray's P1) and 13.9 cmol/ kg^{-1} exchangeable potassium.

Plots were weeded manually at 3, 7, and 12 MAP. Cassava plant height, number of functional leaves and leaf area which was used in calculating the LAI (ratio of total leaf area to land area) were assessed monthly up to 6 MAP. At harvest (12 MAP), fresh root weight and number of roots per plant were assessed, while root tuber dry weight was determined by oven-drying 250g samples of shredded cassava tubers at 65°C for 72 hours and dry weight converted to ton/ha. In the second season, cassava was replanted in the same plots, with minimum soil disturbance to assess the residual effect of previous fertilizer treatments.Data were analyzed using the analysis of variance (ANOVA) and treatment means compared using Duncan's multiple range test at 5% level of probability.

Results

The soils of the experimental site in 2007 and 2008 were texturally classified as sandy loamy, with moderate acidic pH of 6.0 and 6.2 respectively, high in organic carbon and exchangeable potassium, medium in nitrogen and moderate in phosphorus content (FFD, 2012). Total rainfall was 1336.9, 1393.0 and 1115.5 mm in 2007, 2008 and 2009, respectively.

Plant height differed significantly between the two cassava varieties with TMS 30572 having taller plants than TMS 92/0326 at 2, 4 and 6 MAP in 2007 (Table 3). Application of NPK 15-15-15 at 600kg/ha, OF at 4.5 and 6.0 t/ha all resulted in taller plants than control and lowest rate of OF (1.5 t/ha). Leaf production with the application of 3.5 t OF/ha was higher than control by 41.7% in 2008. The leaf area index (LAI) of TMS 92/0326 was higher than that of TMS 30572 at 2, 4 and 6 MAP , while application of 2.5 t OF/ha produced highest LAI (2.74) comparable with 2.68 obtained in NPK treatment in 2007. Furthermore, residue of fertilizer in 2.5 to 6.0 t OF/ha resulted in significantly taller plants than NPK and no fertilizer treatments at 2 and 6 MAP in 2008, and only 6 MAP in 2009. Residues of 3.5 and 4.5 t OF/ha in 2008 and 2009, respectively resulted in maximum number of leaves at 6 MAP in both years (Table 4). Generally, residues of OF gave significantly higher LAI than those of NPK and no fertilizer treatments in both years.

With fertilizer application, fresh and dry root yields were higher in TMS 92/0326 compared with TMS 30572; respective fresh – dry root yields of 30.8 – 11.1, 33.6 – 12.6 t/ha were obtained for TMS 92/0326, while the corresponding values for TMS 30572 were 23.8 – 8.0 and 29.4 – 10.1 t/ha in 2007 and 2008 respectively. Application of NPK and OF at 2.5 to 6.0 t/ha caused significant increase in cassava root yield than without fertilizer. Number of roots per plant was neither significantly influenced by variety nor fertilizer application (Table 5). The residue of 2.5 to 6.0 t/ha resulted in higher fresh and dry root yields of cassava than those of NPK and no fertilizer treatments in 2008 and 2009. Maximum root dry yield obtained with highest OF rate in this trial, was higher than those of no fertilizer and NPK by 51.0, 44.2%, and 53.1, 46.9% in 2008 and 2009 respectively. Interaction of fertilizer and variety was not significant on root yield (Table 6).

Discussion

The total annual rainfall of 1115.5 to 1393.0 mm recorded during the period of the experiment in the derived savanna agro-ecology as well as the soil pH range of between 6.0 and 6.2 at the sites, were within the range considered suitable for growing cassava (Howeler, 2002; Agbaje and Akinlosotu, 2004).

The responses of cassava growth parameters to fertilizer application varied but consistently enhanced in fertilizer treatments than control. Increases in plant height, leaf production per plant and LAI obtained with application of NPK 15-15-15 at 600kg/ha, OF at 2.5 – 6.0 t/ha than without fertilizer indicated a positive response of cassava to both mineral and organomineral fertilizers. Similar findings on

response of cassava growth parameters due to fertilizer application have been severally reported (Obigbesan, 1977; IITA, 2005; Okpara *et al*., 2010). Evidently, the residual effect of applying 2.5 – 6.0 t/ha OF in the first season caused significant increases in plant height, leaf production and LAI than NPK and no fertilizer in 2008 and 2009. This could have been as a result of the slow and continuous release of plant nutrient in soil which sustained the crop growth up to the second season. Higher shoot weight in soils previously treated with OF has been reported in amaranthus (Makinde *et al*., 2010).

Fertilizer caused significant increase in cassava root yield in both years of study probably due to the additional nutrient supplied by fertilizer application to boost the quantity in soil (Obigbesan, 1999). Application of NPK resulted in 40.6% and 42.7% increase while 2.5 t OF/ha caused 39.6% and 42.1% increase in root yield compared with no fertilizer treatment in 2007 and 2008, respectively. This result was an indication of the efficacy of 2.5 t OF/ha as a substitute for the frequently used mineral fertilizer in cassava production.

Residues of previously applied OF at 2.5 – 6.0 t OF/ha produced cassava root yield similar to those obtained at fresh application in the first season of planting thus confirming the efficacy of OF at 2.5 t/ha in supporting optimum cassava root yields in two cropping seasons. This could be attributed to the slow release of nutrients into the soil system which sustained the growth and optimum yield of cassava in the two cropping seasons. In contrast, nutrients in residues of NPK and no fertilizer may have been depleted during the first cropping season and inadequate to support optimum yield for two consecutive cropping seasons. This corroborates the findings of Titiloye (1982), Makinde (2007), Makinde et al. (2009), Olowokere (2009) and Ayeni, (2010) on residual effects of organic and organomineral fertilizers on various crops. Obigbesan (1999) and Adeoye *et al*. (2008) also reported the short term effects of mineral fertilizers.

Conclusion

The performance and productivity of cassava is influenced by the fertility status of the soil. Chemical fertilizers are detrimental to soil health, effects do not last in soil and may not be readily available at peak periods of needs, therefore the need to explore cheaper, sustainable and available nutrient sources.

This study showed that organomineral fertilizer was effective in supporting optimum cassava growth and yield. Application of 2.5 t OF/ha was optimum in producing cassava root yield similar to application of NPK 15-15-15 at 600 kg/ha. One application at this rate was effective in producing optimum yield of cassava in two consecutive cropping seasons.

Table 1: Soil and Fertilizer analysis

Parameters	Soil sample		Organomineral fertilizer
	2007	2008	
pH (H_2O)	6	6.2	6.2
Total nitrogen (g/kg)	1.7	1.9	41.7
Organic carbon (g/kg)	16.8	14.3	34.4
Organic matter (g/kg)	25.7	28.2	56.3
Available P (Bray's P1) (mg/kg)	8.3	6.8	68.5
Exchangeable K (cmol/kg)	0.6	0.7	13.9
Textural class	Sandy loam	Sandy loam	N/a

Table 2: Rainfall (mm) data during the experimental period

	Jan	Feb	Mar	Apr	May	June	July	August	Sept	Oct	Nov	Dec
2007	0	0.1	15.9	70.7	201.3	308.3	139.8	121.6	264.8	204.1	9.9	0.1
2008	0	0	99.9	133.1	164.1	208.6	248.9	122.9	292.4	115.8	0.1	7.9
2009	10.1	33.7	24.6	174.9	186.2	181.6	160	41.3	154.8	115.9	32.5	0

Source : International Institute of Tropical Agriculture (IITA) Ibadan

Table 3 : Effects of fertilizer application on plant height (cm), number of leaves and leaf area index at Ajibode in 2007 and 2008

Treatments	Plant height			Number of leaves			Leaf area index		
	2 MAP	4 MAP	6 MAP	2 MAP	4 MAP	6 MAP	2 MAP	4 MAP	6 MAP
Cassava Varieties (V)									
2007									
TMS 30572	25.2a	95.3a	132.8a	19.7	64.1	109.2a	0.25b	1.11b	2.21b
TMS92/0326	19.6b	69.5b	102.7b	21.5	59.3	90.6b	0.35a	1.47a	2.86a
SE ±	0.71*	2.42*	2.11*	0.72	2.93	3.14*	0.01*	0.07*	0.81*
Fertilizer (F)									
No fertilzer	22.2	77.2b	104.5	22.7	53.2	83.6	0.29	0.94b	1.96b
NPK at 600kg/ha	28.1	97.3a	126.4	24.3	72.3	103.2	0.35	1.61a	2.68a
OF at 1.5 t/ha	21.3	75.8b	118.3	18.2	59.6	101.1	0.24	1.21ab	2.48ab
OF at 2.5 t/ha	23.7	84.9ab	117.3	22.1	61.4	108.4	0.32	1.34ab	2.74a
OF at 3.5 t/ha	23.2	90.1ab	123.1	24.3	68.6	103.6	0.32	1.35ab	2.63ab
OF at 4.5 t/ha	22.3	95.2a	114.7	20.2	62.6	105.2	0.29	1.29ab	2.62ab
OF at 6.0 t/ha	23.8	96.6a	119.8	19.6	65.5	107.4	0.31	1.30ab	2.61ab
SE ±	3.06	5.98	7.37	2.56	6.87	5.17	0.035	0.201	0. 241*
SE ± F x V	4.64ns	7.59ns	8.57ns	2.90ns	8.79ns	6.50ns	0.091ns	0.924ns	1.683ns
2008									
Cassava Varieties (V)									
TMS 30572	24.9	97.9	132.1	27.7	58.3	65.5	0.38	1.27	1.86
TMS92/0326	26.6	92.2	129.3	29.8	56.9	65.4	0.51	1.46	1.99
SE ±	1.22	2.48	3.42	5.95	2.47	3.26	0.062	0.064	0.088
Fertilizer (F)									
No fertilizer	26.7	92.4	113.2	21.1	60.3	47.1c	0.33	1.23	1.17b
NPK at 600kg/ha	26.8	97.7	129.5	34.8	60.5	62.2abc	0.38	1.41	1.81ab
OF at 1.5 t/ha	25.8	105.1	137.8	22.8	62.3	54.9bc	0.34	1.23	1.57ab
OF at 2.5 t/ha	26.3	103.5	131.3	25.4	61.2	71.2ab	0.41	1.46	2.14a
OF at 3.5 t/ha	26.9	100.9	137.9	26.9	63.3	80.8a	0.47	1.66	2.46a
OF at 4.5 t/ha	26.7	104.7	131.3	26	60.6	76.2ab	0.45	1.68	2.3 4a
OF at 6.0 t/ha	27.2	103.8	133.9	25.1	61.9	66.5abc	0.41	1.64	2.47a
SE ±	1.77	4.73	6.41	4.83	3.75	7.10*	0.063	0.161	0.260*
SE ± F x V	2.84ns	6.83ns	9.08ns	15.64ns	5.81ns	9.37ns	0.121ns	0.446ns	0.932ns

Means followed by the same letters within the same column are not significantly different at 5% level of probability using Duncan's Multiple Range Test

* = Significant at 5%
ns = Not significant
MAP= Months after planting

Table 4 :Residual effects of fertilizer application on plant height (cm), number of leaves

Treatments	Plant height			Number of leaves			Leaf area index		
	2 MAP	4 MAP	6 MAP	2 MAP	4 MAP	6 MAP	2 MAP	4 MAP	6 MAP
2008									
Cassava Varieties (V)									
TMS 30572	24.1	75.8	113.2	17.1a	55.6	95.6	0.33	1.14b	2.82b
TMS 92/0326	24.7	75.7	114.7	13.8b	57.4	96.3	0.31	1.61 a	3.12a
SE ±	0.43	1.54	1.75	0.41*	1.82	2.93	0.006	0.061*	0.080*
Fertilizer (F)									
No fertilizer	21.5b	70.1cd	99.9b	13.5	43.4	76.0c	0.26	1.07b	2.33
NPK at 600kg/ha	21.5b	68.2d	98.6b	14.1	42.1	91.4b	0.33	1.32ab	2.52
OF at 1.5 t /ha	21.1b	67.6d	103.4b	14.4	45.8	96.5b	0.29	1.30ab	3.15
OF at 2.5 t/ha	24.8a	78.2bc	124.9a	15.9	58.2	106.5ab	0.33	1.59a	3.27
OF at 3.5 t/ha	26.9a	77.0bcd	121.3a	15.7	56.4	111.0a	0.34	1.59a	3.49
OF at 4.5 t/ha	26.0a	80.0ab	116.9a	15.9	58.5	98.4ab	0 .31	1.54a	3.36
OF at 6.0 t/ha	26.3a	88.3a	122.3a	15.6	59.7	100.6ab	0.31	1.58a	3.39
SE ±	0.82*	2.28*	4.21*	1.07	5.94	4.62*	0.034	0.101*	0.417
SE ± F x V	1.15ns	3.67ns	5.39ns	1.22ns	5.41ns	6.34ns	0.083ns	0.482ns	0.993ns
2009									
Cassava Varieties (V)									
TMS 30572	32.4	82.1a	114.6a	26.4	67.1a	89.8a	0.47	1.71	2.63
TMS92/0326	31.2	72.4b	106.2b	23.7	62.2b	80.4b	0.42	1.61	2.52
SE ±	1.05	1.81*	1.72*	1.24	1.34*	1.84*	0.023	0.063	0.072
Fertilizer (F)									
No fertilizer	32.3	67.5	88.8b	25.8ab	50.1d	72.3c	0.43	1.20c	2.11
NPK at 600kg/ha	31.6	70.1	90.1b	27.5a	55.5cd	76.2c	0.44	1.40bc	2.32
OF at 1.5 t/ha	31.5	82.1	101.4b	23.6ab	64.8bc	85.3bc	0.45	1.70ab	2.71
OF at 2.5 t/ha	30.1	78.5	111.6a	21.6b	63.1bc	85.8bc	0.48	1.74ab	2.83
OF at 3.5 t/ha	31.2	83.5	120.8a	27.5ab	63.5bc	87.3abc	0.48	1.78ab	2.79
OF at 4.5 t/ha	31.5	79.4	118.9a	23.9ab	77.8a	95.7a	0.51	1.93a	2.87
OF at 6.0 t/ha	35.8	83.6	119.3a	27.5a	74.3ab	94.3ab	0.53	1.91a	2.89
SE ±	2.05	5.61	5.82*	1.50*	3.91*	3.20*	0.038	0.150*	0.351
SE ± F x V	2.84ns	6.63ns	7.71ns	2.77ns	4.74ns	4.73ns	0.052ns	0.261ns	0.427ns

Means followed by the same letters within the same column are not significantly different at 5% level of probability using Duncan's Multiple Range Test

* = Significant at 5%
ns = Not significant
MAP= Months after planting

Table 5: Effect of fertilizer application on yield of cassava varieties in 2007 and 2008

Treatments	Fresh root (t/ha)	Dry matter (t/ha)	Number of roots/plant
2007			
Cassava Varieties (V)			
TMS 30572	23.8b	8.0b	6.2
TMS 92/0326	30.8a	11.1a	5.9
SE ±	1.51*	0.61*	0.46
Fertilizer (F)			
No fertilizer	18.1b	6.5b	5.2
N PK at 600kg/ha	30.5a	9.7a	6.6
OF at 1.5 t/ha	26.4a	8.6ab	6.1
OF at 2.5 t/ha	30.2a	10.5a	5.9
OF at 3.5 t/ha	27.7a	9.0ab	6.4
OF at 4.5 t/ha	29.3a	10.4a	6.2
OF at 6.0 t/ha	30.9a	10.8a	6.1
SE ±	2.02*	0.90*	0.55
SE ± F x V	3.56ns	1.44ns	1.04ns
2008			
Cassava Varieties (V)			
TMS 30572	29.4b	10.1b	8.1
TMS92/0326	33.6a	12.6a	7.5
SE ±	1.20*	0.42*	0.35
Fertilizer (F)			
No fertilizer	20.4b	7.7b	6.3
NPK at 600kg/ha	35.6ab	12.8a	8.2
OF at 1.5 t/ha	25.9b	9.8ab	8.4
OF at 2.5 t/ha	35.4ab	12.1ab	7.5
OF at 3.5 t/ha	34.6ab	12.0ab	7.7
OF at 4.5 t/ha	35.8ab	12.5a	8.2
OF at 6.0 t/ha	39.7a	13.6a	7.8
SE ±	4.22*	1.80*	0.85
SE ± F x V	7.45ns	2.43ns	1.69ns

Means followed by the same letters within the same column are not significantly different at 5% level of probability using Duncan's Multiple Range Test

* = Significant at 5%
ns = Not significant

Table 6: Residual effect of fertilizer application on yield of cassava varieties in 2008 and 2009

Treatments	Fresh root (t/ha)	Dry matter (t/ha)	Number of roots/plant
2008			
Cassav a Varieties (V)			
TMS 30572	26.2	9.2	5.8
TMS 92/0326	27.8	10.2	5.3
SE ±	1.48	0.56	0.24
Fertilizer (F)			
No fertilizer	15.7c	5.9b	4.6
NPK at 600kg/ha	16.1c	5.7b	5.1
OF at 1.5 t/ha	24.8b	8.6b	5.6
OF at 2.5 t/ha	31.6ab	11.0a	6.8
OF at 3.5 t/ha	34.9a	11.9a	5.1
OF at 4.5 t/ha	35.2a	11.7a	5.5
OF at 6.0 t/ha	36.8a	12.0a	6.8
SE ±	2.82*	1.08*	0.91
SE ± F x V	3.95ns	1.51ns	1.54ns
2009			
Cassava Varieties (V)			
TMS 30572	24.7b	8.7	8.1
TMS 92/0326	26.5a	9.4	7.2
SE ±	0.50*	0.32	0.5
Fertilizer (F)			
No fertilizer	19.0c	6.3c	6.1
NPK at 600kg/ha	18.2c	6.0c	6.9
OF at 1.5 t/ha	24.5b	8.6b	6.3
OF at 2.5 t/ha	26.6ab	9.9ab	7.5
OF at 3.5 t/ha	27.4ab	10.0ab	7.7
OF at 4.5 t/ha	30.8ab	10.4ab	7.4
OF at 6.0 t/ha	32.3a	11.3a	7.8
SE ±	1.52*	0.63*	0.83
SE ± F xV	1.86ns	0.83ns	2.41ns

Means followed by the same letters within the same column are not significantly different at 5% level of probability using Duncan's Multiple Range Test

* = Significant at 5%
ns = Not significant

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