

Cassava/Maize Intercrop Performance and Soil Nutrient Changes with Fertilizers

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Abstract

Field trials were conducted in the forest vegetation (Ibadan) and the derived savannah (Ilora) zones of south west Nigeria to assess the yield performance of cassava/maize intercrop and soil nutrient changes with sole and some combined ratios of organic-based fertilizer (OBF) and inorganic fertilizer. Sole OBF was assessed at 2.5; 5.0 and 10.0 t ha⁻¹ while 400 kg ha⁻¹ NPK 15-15-15 served as the sole inorganic fertilizer treatment. The combined treatments were: 2.5 t ha⁻¹ OBF + 100 kg ha⁻¹ NPK 15-15-15 and 5 t ha⁻¹ OBF + 100 kg ha⁻¹ NPK 15-15-15. An unfertilized treatment served as the control treatment. Maize grain yield was highest with application of 5 t ha⁻¹ OBF + 100 kg ha⁻¹ NPK. It gave a mean yield of 2.45 t ha⁻¹ at Ibadan and 2.49 t ha⁻¹ at Ilora. Cassava root yield was however highest with 10 t ha⁻¹ OBF. It gave a mean yield of 14.55 t ha⁻¹ at Ibadan and 12.52 t ha⁻¹ at Ilora. Soil N, P, K and Organic C was most increased with 10 t ha⁻¹ OBF and 5 t ha⁻¹ OBF+NPK. Crop yields and soil nutrient status decreased with no fertilizer application. Cassava –maize intercrop gives optimum yields and highest soil N, P, K increase with 10 t ha⁻¹ OBF.

Keywords: Organic-based fertilizer, NPK, Cassava, Maize

1. Introduction

Intercropping produces a stable and sustainable agro-ecosystem in the humid tropics. Farmers in the south western part of Nigeria practice intercropping with a wide range of crops. Cassava - based cropping system is particularly favoured because it is a major staple consumed by many households. Cassava is suited to intercropping because of its initial slow growth rate with its field maturity period of 12 to 18 months and the establishment at a wide spacing of 1m. It is usually intercropped with short duration crops like maize. Cassava / maize intercrop is a popular intercrop combination in many areas of the southern part of Nigeria. Various intercropping systems practiced in Africa and Asia involving cassava have been reported (Ofori and Stern, 1987; Amanullah *et al.*, 2006). Competition however exists for available resources among crops planted in mixtures which could lead to yield depression (Ikeorgu, 1984; Ambe *et al.*, 1988). There is therefore need for adequate replenishment of soil nutrients when crops are planted in mixtures. Inorganic fertilizer use has been the standard nutrient supply means for a long time but its intensive use has been associated with reduced crop yield due to soil acidity and nutrient imbalance (Kang and Juo, 1980; Agboola and Omueti, 1982, Adediran *et al.*, 2004). The huge quantities required to satisfy the nutritional needs of crops; the burden of transportation as well as handling cost have not allowed farmers to utilize the full benefits of organic materials. Several research workers have supported the use of organic materials mixed with mineral fertilizers or complementary use of both for achieving high and sustainable high crop yields (Adediran *et al.*, 2004; Abou El-Magd *et al.*, 2006). This study was therefore conducted to assess the yields of cassava/maize intercropped with different rates of organic-based

fertilizer prepared by researchers in the Institute of Agricultural Research and Training, Ibadan as well as its combination with a quarter of the recommended rates of inorganic fertilizer and soil nutrient changes after cropping for two years.

2. Materials and Methods

Field trials were conducted at the Institute of Agricultural Research and Training (IAR&T) at Ibadan (latitude 7° 22.5'N; longitude 3° 55'E) in the rain forest vegetation zone and at Ilora (latitude 7° 45'N; longitude 3° 55' E) in the derived savannah agro ecology both in south west Nigeria. It was conducted during the 2006 and 2007 cropping seasons. Total annual rainfall for Ibadan was 1528 mm and 1224 mm in 2006 and 2007, respectively. It was 1111mm in 2006 and 1363 mm in 2007 at Ilora. Samples of top soil (0 – 20 cm) were taken from the trial sites prior planting while samples were taken per plot after cropping for two years. The samples were air dried, crushed and passed through a 2mm sieve; afterwards, routine analyses were carried out following IITA procedures (1979). Soil pH was determined in distilled water at 1:1 soil to water ratio. The Total N was determined by the micro-Kjeldahl method. Percentage Organic Matter was derived by multiplying % organic carbon by Broadbent's factor of 1.72 (Broadbent, 1953). Available P was determined by the Bray's P1 test, using 0.03 NH₄F in 0.02N HCl as extractant and measuring the extracted P colorimetrically by the molybdenum blue method. Exchangeable bases were determined by extraction with neutral normal NH₄OAC at soil: solution ratio, 1:10. The results of the pre-cropping analysis are presented in Table 1. The experiments were laid out in a randomized complete block design with three replications. There were seven treatments which consisted of (i) 2.5 t ha⁻¹ Organic –based fertilizer (OBF) (ii) 5 t ha⁻¹ OBF (iii) 10 t ha⁻¹ OBF (iv) 2.5 t ha⁻¹ OBF + 100 kg ha⁻¹ NPK 15-15-15 (v) 5 t ha⁻¹ OBF+ 100 kg ha⁻¹ NPK 15-15-15 (vi) 400 kg ha⁻¹ NPK 15-15-15 and (vii) control (no fertilizer). The organic – based fertilizer was prepared from shredded maize straw, cobs and sheaths composted with poultry manure and mixed with 25 kg ha⁻¹ NPK 20-10-10. The organic – based fertilizer had a pH of 7.3 with 1.92%, 0.10%, 1.07%, 6.42% and 15.6% of total N, available P, exchangeable K, exchangeable Ca and Organic Carbon contents, respectively. It was worked into the soil before planting while the inorganic fertilizer was applied by side dressing about 5 cm beside maize plant 3 weeks after planting. Cassava variety: TMS 30572 (IITA, Nigeria1994) was planted with maize variety: TZPBR-W (IITA, Nigeria1994). Planting was done on the flat after ploughing and harrowing. Cassava was planted at 90 cm x 90 cm spacing while maize was planted at 90 cm x 45 cm (2 plants / stand). Plot size was 5 m x 4 m. The plots were hand weeded twice before maize harvesting (3 and 6 weeks after planting) and at 7 days after maize harvesting. Maize was harvested at 14 weeks after planting and dried to 14% moisture content to obtain the dry grain weight. Cassava was harvested 12 months after planting for the root yield record. Data analysis was done using analysis of variance (ANOVA) procedure and means separated by New Duncan's Multiple Range Tests at 0.05 level of probability when the F-ratio was significant.

3. Results

Maize grain yields followed the same pattern in both cropping years at both locations. In Ibadan, highest maize grain yields of 2.42 t ha⁻¹ in 2006 and 2.48 t ha⁻¹ in 2007 were got from application of 5 t ha⁻¹ OBF+ NPK. It also gave the highest yields of 2.46 t ha⁻¹ in 2006 and 2.52 t ha⁻¹ in 2007 respectively, at Ilora. These yields were not significantly higher than obtained from 10 t ha⁻¹ OBF and from sole NPK in both years at both locations (Table 2). The unfertilized plants gave significantly lower grain yields of 0.98 and 0.88 t ha⁻¹, respectively in 2006 and 2007 at Ibadan while it gave 0.97 and 0.82 t ha⁻¹ in 2006 and 2007, respectively at Ilora. Maize grain yields were generally higher for the various fertilizer treatments in Ilora than Ibadan. Highest cassava root yields of 14.3 and 14.8 t ha⁻¹ in 2006 and 2007, respectively at Ibadan with 12.3 and 12.7 t ha⁻¹ at Ilora were from application of 10 t ha⁻¹ OBF. Yields from 5 t ha⁻¹ OBF were not significantly higher than from application of 10 t ha⁻¹ OBF + NPK for both locations but were significantly higher than from sole NPK fertilizer application, only in Ibadan. In Ilora however, the yields were similar. The lowest cassava root yields were from the control (no fertilizer). Cassava yields were generally lower in Ilora than Ibadan. Soil Nitrogen was reduced with cropping, where no fertilizer was applied. It reduced from an initial 1.20 g kg⁻¹ to 0.90 g kg⁻¹ in Ibadan and from 0.89 g kg⁻¹ to 0.64 g kg⁻¹ in Ilora. Total N content increased by 22% where 5 t ha⁻¹ OBF + NPK was applied and by 20% where 10 t ha⁻¹ OBF was applied but increased by 3% where NPK fertilizer was applied in Ibadan. The same trend was also observed in Ilora. Highest P increase was from application of 5 t ha⁻¹ OBF+NPK in Ibadan but the highest value was obtained with 10 t ha⁻¹ OBF in Ilora. Available P content was slightly reduced with NPK fertilization in both locations, with the lowest value from the control, unfertilized plants. Exchangeable K increased by 21% with application of 10 t ha⁻¹ OBF in Ibadan and by 25% at Ilora. It was however reduced by 36% and 37.5% in the control, unfertilized plants and by 14% and 16.7% with NPK fertilization in Ibadan and Ilora respectively (Table 4). Exchangeable K contents increased from between 4 and 8% with other OBF treatments with or without addition of NPK in both locations except with 2.5 t ha⁻¹ OBF where it decreased by 14% and 12.5% in Ibadan

and Ilora respectively. Organic C increased from 10.20 g kg⁻¹ to 12.85 g kg⁻¹ in Ibadan and from 7.10 g kg⁻¹ to 8.55 g kg⁻¹ in Ilora. It increased by a range of 3% to 9% for all other OBF treatments with or without NPK addition at both locations except with 2.5 t ha⁻¹ OBF treatments where there were slight decreases. Organic C decreased by 19% with NPK fertilizer alone and by 21% without fertilization in Ibadan. In Ilora, it reduced from an initial value of 7.10 g kg⁻¹ to 6.13 g kg⁻¹ with NPK fertilizer and 5.66 g kg⁻¹ with no fertilizer.

4. Discussion

Maize intercropped with cassava was able to exploit the micro environment early in the growing season from the results of this trial. Maize yields were highest with complementary inorganic fertilizer (NPK) and the Organic-based fertilizer (OBF). Nutrients released early from inorganic source were utilized by maize, which is an aggressive feeder to give better yields than OBF alone. This is an indication that the nutrient use efficiency increased with addition of NPK to organic fertilizer. Similar observations have been earlier made (Makinde and Agboola, 2002; Adeniyani and Ojeniyi, 2005; Ayoola and Makinde, 2009). Early release of nutrients from NPK fertilizer also favoured maize grain yield in both years at both locations. Maize grain yields with application of 10 t ha⁻¹ OBF was comparable to yields with OBF + NPK and NPK alone probably because of the high rate of application that is likely to have released enough nutrients to compare with either complemented application or sole inorganic application. Nutrient release from organic sources applied at low rates has been found to be usually low for a crop like maize. It has earlier been observed that organic wastes/fertilizers could hardly be depended upon as the sole source of nutrientS for corn (Chung *et al.*, 2000). The observed significantly lower maize yields with 2.5 and 5.0 t ha⁻¹ OBF relative to complemented applications is an indication of the need for further fortification of the OBF. Similar observation has been made by Adediran *et al.* (2004). Fertilization generally increased maize yields due to nutrient release. The observed similar cassava root yields with applications of 10 t ha⁻¹ OBF and 5 t ha⁻¹ OBF+NPK is an indication that cassava was able to utilize nutrients applied in the early season throughout its growing period. It further showed the ability of OBF to release nutrients gradually to crops through the growing season (Patel and Meisheri, 1997; Adediran *et al.*, 1999 ;). Application of NPK alone and 2.5 t ha⁻¹ OBF showed the least residual effect on cassava root yield. Generally, there were improvements in the soil nutrients status where OBF was applied at 5 t ha⁻¹ and with the two OBF+NPK treatments due to release of nutrients. Soil N, P, K and Organic C were increased higher with addition of 10 t ha⁻¹ OBF and 5 t ha⁻¹ OBF+NPK than with application of 5 t ha⁻¹ OBF due to the high rate of application and early release, respectively. Soil N, K and organic C decreased with application of NPK alone due to early release of nutrients for utilization by maize, leading to depletion of the inherent status by the longer – maturing cassava. Application of 2.5 t ha⁻¹ OBF could not adequately compensate for nutrients uptake by crops and possible loss by leaching and erosion. It has been reported that cassava extracts large quantity of K from the soil and N, P and K accumulate in its roots (Howeler, 1981; Howeler and Cadavid, 1983). Soil N, P, K and organic C decreased with no fertilizer application which corroborates earlier observations that tropical soils naturally show nutrient deficiency before cultivation or after short periods of crop growing (Makinde and Agboola, 2002; Ayoola, 2006).

This study has shown that application of organic-based fertilizer (OBF) at 5 t ha⁻¹ complemented with 100 kg ha⁻¹ NPK and application of 10 t ha⁻¹ OBF gave maize grain and cassava root yields comparable to yields with 400 kg ha⁻¹ NPK and significantly increased soil nutrients after cropping for two years.

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Table 1. Pre cropping soil characteristics of the soils in Ibadan and Ilora

Soil properties	Values	
	Ibadan	Ilora
pH	6.00	6.40
Total N (g kg ⁻¹)	1.20	0.89
Available P (mg kg ⁻¹)	1.60	3.60
Exchangeable K (c mol kg ⁻¹)	0.28	0.24
Ca	3.50	1.80
Mg	0.18	1.13
Na	0.78	0.40
Acidity H	0.08	0.10
CEC	4.82	3.67
Organic C (mg kg ⁻¹)	10.20	7.10
Sand (g kg ⁻¹)	850.00	880.00
Clay	100.00	80.00
Silt	50.00	40.00
Textural class	Sandy loam	Sandy loam

Table 2. Maize grain yield ($t\ ha^{-1}$) as affected by different Organic – Based Fertilizer (OBF) rates and combination with NPK in Ibadan and Ilora

Treatments	Ibadan		Ilora	
	2006	2007	2006	2007
2.5 $t\ ha^{-1}$ OBF	1.64c	1.73c	1.62b	1.69b
5.0 $t\ ha^{-1}$ OBF	2.07b	2.14b	2.26a	2.23a
10.0 $t\ ha^{-1}$ OBF	2.20ab	2.29ab	2.32a	2.36a
2.5 $t\ ha^{-1}$ OBF +100 $kg\ ha^{-1}$ NPK	2.10b	2.25ab	2.30a	2.25a
5.0 $t\ ha^{-1}$ OBF+100 $kg\ ha^{-1}$ NPK	2.42a	2.48a	2.46a	2.52a
400 $kg\ ha^{-1}$ NPK	2.38a	2.35ab	2.21a	2.24a
No fertilizer	0.98d	0.88d	0.97c	0.82c

Values followed by same letter(s) in the same column are not significantly different at $P \leq 0.05$

Table 3. Cassava root yield ($t\ ha^{-1}$) as affected by different Organic – Based Fertilizer (OBF) rates and combination with NPK in Ibadan and Ilora

Treatments	Ibadan		Ilora	
	2006	2007	2006	2007
2.5 $t\ ha^{-1}$ OBF	9.81c	10.75c	9.49c	9.99c
5.0 $t\ ha^{-1}$ OBF	12.10b	12.80b	10.52b	11.12bc
10 $t\ ha^{-1}$ OBF	14.34a	14.76a	12.31a	12.72a
2.5 $t\ ha^{-1}$ OBF +100 $kg\ ha^{-1}$ NPK	10.64c	11.42c	10.02b	10.78c
5.0 $t\ ha^{-1}$ OBF +100 $kg\ ha^{-1}$ NPK	13.17a	13.90ab	11.75a	11.97ab
400 $kg\ ha^{-1}$ NPK	10.03c	10.99c	10.04bc	9.74c
No fertilizer	7.59d	7.11d	6.94d	6.41d

Values followed by same letter(s) in the same column are not significantly different at $P \leq 0.05$

Table 4. Changes in soil N, P, K and Organic C contents with different Organic – Based Fertilizer (OBF) rates and combination with NPK after cropping for two years

	N	P	K	Org C	N	P	K	Org C
	($g\ kg^{-1}$)	($mg\ kg^{-1}$)	($cmol\ kg^{-1}$)	($g\ kg^{-1}$)	($g\ kg^{-1}$)	($mg\ kg^{-1}$)	($cmol\ kg^{-1}$)	($g\ kg^{-1}$)
	Ibadan				Ilora			
Pre cropping	1.20	1.60	0.28	10.20	0.89	3.60	0.24	7.10
2.5 $t\ ha^{-1}$ OBF	1.29d	1.90c	0.24c	10.22c	1.01c	3.53cd	0.21c	7.15c
5 $t\ ha^{-1}$ OBF	1.36c	2.00c	0.29b	10.55bc	1.18b	3.81bc	0.25bc	7.50bc
10 $t\ ha^{-1}$ OBF	1.50a	2.65a	0.34a	12.83a	1.26a	4.45a	0.30a	8.55a
2.5 $t\ ha^{-1}$ OBF +100 $kg\ ha^{-1}$ NPK	1.38c	2.13bc	0.28b	10.85b	1.07b	3.67c	0.23c	7.31c
5.0 $t\ ha^{-1}$ OBF +100 $kg\ ha^{-1}$ NPK	1.47b	2.29b	0.30b	11.01b	1.22ab	4.04b	0.26b	7.73b
400 $kg\ ha^{-1}$ NPK	1.04e	1.66d	0.24c	8.25d	0.84c	3.48cd	0.20c	6.13d
No fertilizer	0.90f	1.51d	0.18	8.10	0.64d	3.34d	0.15d	5.66e

Values followed by same letter(s) in the same column are not significantly different at $P \leq 0.05$