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Response of cassava, maize and egusi melon in a three crop intercropping system at Makurdi, Nigeria

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Abstract

Field experiments were conducted from April to December, during the 2010 and 2011 cropping seasons, at the Research Farm, University of Agriculture, Makurdi, Nigeria to evaluate the yield response of cassava, maize and egusi melon in a three crop intercropping system and to assess the advantage of the intercropping system. Sole cassava, sole maize, sole egusi melon and the intercrop of cassava, maize and egusi melon constituted the treatments. The four treatments were replicated four times in a randomized complete block design. The results obtained showed that in a cassava, maize and egusi melon mixture, intercropping did not significantly ($P \leq 0.05$) affect maize yield, however, intercrop yield of cassava was significantly ($P \leq 0.05$) depressed by 23.2 % and 31.0 % respectively, in 2010 and 2011, compared to that obtained from monocropped cassava. In addition, intercrop yield of egusi melon was significantly ($P \leq 0.05$) depressed by 34.8 % and 31.6 % respectively, in 2010 and 2011, compared to that produced from monocropped egusi melon. Total intercrop yield was greater than the component crop yields. Intercropping cassava, maize and egusi melon gave land equivalent ratio (LER) values of 2.51 and 2.47 respectively, in years 2010 and 2011, indicating that higher productivity per unit area was achieved by growing the three crops together than by growing them separately. With these LER values, 60.2 % and 59.5 % of lands were saved respectively, in 2010 and 2011, which could be used for other agricultural purposes.

Keywords: Intercropping, Cropping system, Cassava, Maize, Egusi melon, Nigeria

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1. Introduction

Cassava (*Manihot esculenta* L. Crantz) originated from Central and Southern America and has since then spread to various parts of the world (FAO Report, 2001). Its systemic cultivation became generally accepted and integrated into the farming system in Nigeria and based on the area cropped and quantity produced, cassava was the country's most important root crop (Akparaobi et al., 2007). The tuber flesh is composed of about 62 % water, 35 % carbohydrate, 1-2 % protein, 0.3 % fat, 1-2 % fibre and 1 % mineral matter (Cock, 2001). The leaves have also been found to contain about 17 % protein and therefore a good source of protein in the diet of man and most ruminant animals (Elfick, 1998).

Maize (*Zea mays* L.) is an annual cereal plant of the gramineae family and native of Mexico (Hugar and Palled, 2008). It was introduced into Nigeria in the 16th century and based on the area cropped and quantity produced, maize was the country's third most important cereal crop following sorghum and millet (Uzozie, 2001). It is grown for its grain which contains 65 % carbohydrate, 10-12 % protein and 4-8 % fat (Iken and Amusa, 2004). The crop also contains the vitamins A,B,C and E, including mineral salts and essential trace elements such as carotene, thiamine, ascorbic acid and tocopherol (Groote, 2002). Maize is used mainly for human food and livestock feed while in the industry, it is used in the production of starch, oil and alcohol (Kling and Edmeades, 1997).

Egusi melon (*Citrullus lunatus* Thunb.) is a member of the family Cucurbitaceae (Badifu and Ogunsa, 1991). It originated from Africa, later introduced to Europe and Asia during the last 2000 years (Tindal, 1986). The edible seed/kernel of melon contains approximate 46 % oil and 36 % protein (Ogbona and Obi, 2010). Only the melon seed is used. The oil from seed is extracted and used for cooking and other industrial purposes, while the residue is used as soup thickener (Oyolu and Macfarlance, 1982). About 70 % of cassava, 73 % of maize and 55 % of egusi melon grown in Nigeria are produced under intercropping system (Iken and Amusa, 2004; Ogbona and Obi, 2010; Ijoyah et al., 2012a). Poggio (2005) reported that farmers intercropped for varied reasons, including insurance against crop pests, yield increment, weed control and high monetary returns.

In Makurdi, a location in the Guinea savanna agroecological zone of Nigeria, yield response of crops in a two crop intercropping system have been conducted. In an okra-maize mixture, Ijoyah and Jimba (2012) reported that though the yield of intercropped okra was significantly depressed by 24.5 % and 25.9 % respectively, in 2009 and 2010 compared to that obtained from monocropped okra, maize yield was not significantly affected by intercropping with okra. They also reported that intercropping okra and maize gave land equivalent ratio (LER) values of 1.84 and 1.80 respectively, for years 2009 and 2010.

Although a number of studies in a two crop intercropping system as influenced by various factors such as time of planting, plant densities and cropping system have been evaluated (Ijoyah and Jimba, 2011; Ijoyah and Dzer, 2012; Ijoyah et al., 2012b), however, there is a dearth of information on yield response, particularly in a three crop intercropping system, as well as assessing its advantage. This study was therefore designed to augment the currently available information.

2. Materials and Methods

2.1. Site description and variety of crops

The experiments were conducted from April to December, 2010 and 2011 cropping seasons at the Research Farm of the University of Agriculture, Makurdi, Nigeria, to evaluate the yield response of cassava, maize and egusi melon in a three crop intercropping system. The study location (7^0 48/N, 8^0 44/E) and at an altitude of 228 m above sea level, falls within the Southern Guinea savanna agroecological zone of Nigeria. The variety of cassava used was 'TMS 14(2)1425', that of maize was 'Oba 98' (an open pollinated variety), while that of egusi melon was 'Itcheghir Dam' (a local variety). The varieties of crops are popularly grown by farmers and shows good adaptation to the local environment.

2.2. Experimental area, design and treatments

The experimental area (344.0 m^2), which consisted of sandy-loam soil was ploughed, harrowed, ridged and divided into 12 plots. Each plot had an area of 25 m^2. The plot consisted of 5 ridges spaced 1 m apart. Sole cassava, sole maize, sole egusi melon and the intercrop of cassava, maize and egusi melon constituted the treatments. The four treatments were arranged in a randomized complete block design (RCBD) with four replications.

2.3. Planting

In the sole cassava plot, cassava was planted in a single row on top of the ridge, at an intra-row spacing of 1 m. Each ridge had five cassava stands, giving a total of 25 cassava plants per plot (10,000 plants per hectare equivalent). In the sole maize plot, seeds were planted on top of ridge, at a depth of 2 cm using 30 cm intra-row spacing. The maize seeds were sown per position and later thinned to one plant per position at 2 weeks after planting (WAP), giving a plant population of 100 maize stands per plot (40,000 plants per hectare equivalent). In the sole egusi melon plots, seeds were planted about 2-3 cm deep in a single row by the side of the ridge, at the intra-row spacing of 35 cm (Okaka and Remison, 1999), giving a plant population of 71 egusi melon stands per plot (28,560 plants per hectare equivalent). The fourth treatment consisted of the intercrop of cassava, maize and egusi melon, planted at their individual optimal populations as in soles. Maize was planted in between cassava stands, both on top of the ridge, while egusi melon was planted by the side of the ridge. Cassava, maize and egusi melon were planted at the same time in late April in each year.

2.4. Cultural practices

Weeding was done using the native hoe as the need arose. The use of the native hoe is a typical practice by farmers in the area. Mixed fertilizer (NPK 20-10-10) for sole cassava was applied at the rate of 100 kg ha^{-1}; sole maize: 100 kg N ha^{-1}, 40 kg P ha^{-1} and 60 kg K ha^{-1}; sole egusi melon: mixed fertilizer NPK (20-10-10) at the rate of 120 kg ha-1 and for cassava, maize and egusi melon mixture: 120 kg N ha^{-1}, 120 kg P ha^{-1} and 120

kg K ha^{-1} were applied (Enwezor et al., 1989). The band method of fertilizer application was employed. The fertilizer was applied twice to each plot at 3 and 6 WAP for the sole crops and the intercrop.

Harvesting of cassava was done 32 WAP, when the leaves were observed to dry, turn yellowish and fallen off, which were signs of senescence and tuber maturity (Ijoyah et al., 2012a). Harvesting of maize and egusi melon were respectively done at 12 and 16 WAP (Ijoyah et al., 2012b).

2.5. Data collection

Data taken for cassava include days to 50 % sprouting and establishment, plant height at 16 WAP, number of branches per plant, number of leaves per plant, number of tubers per plant, tuber weight (Kg) and yield (t ha^{-1}). Data taken for maize include days to 50 % flowering, plant height (cm) at 50 % flowering, number of cobs per plant, cob length (cm), cob diameter(cm), cob weight (g) and yield (t ha^{-1}).

Data taken for egusi melon include days to 50 % flowering, number of branches per plant, number of leaves per plant, leaf area (cm^2), number of fruits per plant, fruit weight (Kg), number of seeds per fruit, weight of seeds per fruit (Kg) and yield (t ha^{-1}).

2.6. Statistical analysis

All data were statistically treated using the Analysis of variance (ANOVA) for randomized complete block design and the Least Significant Difference (LSD) was used for mean separation ($P \leq 0.05$) following the procedure of Steel and Torrie (1980).

The land equivalent ratio (LER) and percentage land saved as described by Willey (1985) and Willey and Rao (1980) were used to assess the advantage of the intercropping system.

3. Results and Discussion

3.1. Response of cassava

Days to 50 % sprouting and establishment for cassava were not significantly ($P \leq 0.05$) affected by intercropping with maize and egusi melon (Table 1).

Plant height of cassava at 16 WAP, number of branches per plant and number of leaves per plant were significantly ($P \leq 0.05$) greater when cassava was planted as sole than in intercrop with maize and egusi melon. The competition for growth resources such as light could have contributed to the decrease in plant height, number of branches and number of leaves per plant.

Number of tubers per plant produced from the intercropped cassava was lower than that obtained from cassava planted as sole (Table 1). This view agreed with Madu and Nwosu (2001) who reported that yams planted sole, generally have greater efficiency in utilizing the growth environment, thus promoting a greater number of tubers compared to that obtained in intercrop.

Table 1. Yield and yield components of cassava as affected by intercropping with maize and egusi melon at Makurdi, Nigeria in 2010 and 2011 cropping seasons.

Treatments	Days to 50% sprouting		Days to 50% establishment		Plant height at 16 WAP (cm)		Number of branches per plant		Number of leaves per plant		Number of tubers per plant		Tuber weight (kg)		Cassava yield (t ha^{-1})	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Sole Cassava	12.6	12.0	18.3	18.6	120.2	132.3	17.6	17.7	172.1	177.3	5.2	4.8	0.78	0.82	5.6	5.8
Intercrop cassava	13.4	13.2	19.2	19.4	100.4	110.6	12.4	11	164.0	160.2	4.0	4.2	0.47	0.40	4.3	4.0
Means	13.0	13.6	18.8	19.0	110.3	121.5	15.0	14.4	168.1	168.8	4.6	4.5	0.63	0.61	5.0	4.9
LSD (P ≤ 0.05)	4.0	5.1	3.2	5.6	6.3	10.4	5.3	2.5	5.3	8.5	2.4	3.2	0.21	0.30	0.4	0.7
Cv (%)	15.2	10.4	14.3	9.2	17.5	10.2	12.4	10.0	15.2	20.3	9.6	10.3	6.4	8.5	12.3	15.6

WAP: weeks after planting

Intercropping cassava with maize and egusi melon significantly (P≤0.05) depressed tuber weight and yield of cassava (Table 1). The intercrop yield of cassava was significantly (P≤0,05) depressed by 23.2 % and 31.0 % respectively, in 2010 and 2011 compared to when cassava was planted sole. The competition for growth resources and shading by maize plant could be contributory factors.

3.2. Response of maize

Maize plant height at 50 % flowering, days to 50 % flowering, number of cobs per plant, cob length, cob diameter, cob weight and maize yield were not significantly (P≤0.05) affected by intercropping with cassava and egusi melon (Table 2), but maize yield in a cassava, maize and egusi melon intercrop was greater in both years compared to the yield obtained from monocropped maize. This view agreed with Ijoyah (2011) who reported that maize yield in a yam-minisett and maize intercrop was greater by 11.7 % and 10.0 % respectively, in 2003 and 2004 compared to the yield obtained from sole maize at equivalent population density. The greater soil moisture conservation under intercropping could have promoted a greater absorption of soil nutrients. This view agreed with Ogindo and Walker (2005) who reported that intercrops have been identified to conserve water.

3.3. Response of egusi melon

Days to attain 50 % flowering for egusi melon was greater under intercropping with cassava and maize compared to that recorded for monocropped egusi melon (Table 3). This might be linked to the greater competition for growth resources as a result of the increase in total plant population.

The number of branches per plant, number of leaves per plant and leaf area of egusi melon significantly (P≤0.05) reduced when intercropped with cassava and maize compared to those produced under monocropped egusi melon (Table 3). This view agreed with Silwana and Lucas (2002) who reported that intercropping reduced vegetative growth of component crops.

Table 2. Yield and yield components of maize as affected by intercropping with cassava and egusi melon at Makurdi, Nigeria in 2010 and 2011 cropping seasons.

Treatments	Plant height at 50% flowering (cm)		Days to 50% flowering		Number of cobs per plant		Cob length (cm)		Cob diameter (cm)		Cob weight (g)		Yield (t ha^{-1})	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Sole maize	135.6	140.3	68.4	69.2	1.6	1.5	18.4	17.2	15.3	15.6	220.4	235.2	4.4	4.2
Intercrop maize	144.5	152.0	67.2	69.0	1.4	1.3	16.0	15.1	14.8	15.3	238.0	243.1	4.8	4.6
Means	140.1	146.2	67.8	69.1	1.5	1.4	17.2	16.2	15.1	15.5	229.2	239.2	4.6	4.4
LSD (P ≤ 0.05)	12.6	17.4	4.3	6.7	3.5	3.2	5.3	7.0	4.2	5.6	7.2	3.3	3.3	2.0
Cv (%)	14.3	10.2	12.3	14.0	8.3	5.4	6.5	8.2	10.7	8.4	12.6	15.3	10.6	9.8

Table 3: Yield of egusi melon as affected by intercropping with cassava and maize at Makurdi, Nigeria in 2010 and 2011 cropping seasons.

Treatments	Days to 50% flowering		Number of branches per plant		Number of leaves per plant		Leaf area (cm^2)		Number of fruits per plant		Fruit weight (kg)		Number of seeds per fruit		Weight of seeds per fruit (kg)		Melon yield (t ha^{-1})	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Sole egusi melon	42.3	43.4	4.4	4.6	45.3	44.0	148.2	145.3	13.9	13.2	1.3	1.1	26.4	24.6	1.6	1.4	2.3	1.9
Intercrop egusi melon	45.5	45.3	3.3	3.6	30.2	32.4	135.0	138.1	11.3	10.1	0.8	0.7	20.3	18.5	0.8	0.6	1.5	1.3
Means	43.9	44.4	3.9	4.1	37.8	38.2	141.6	141.7	12.6	11.7	1.1	0.9	23.4	21.6	1.2	1.0	1.9	1.6
LSD (P ≤ 0.05)	2.2	1.5	0.3	0.5	10.1	8.4	10.1	4.3	1.6	1.4	0.3	0.2	4.3	3.5	0.4	0.6	0.3	0.5
Cv (%)	10.5	9.4	12.2	15.3	9.0	5.2	18.2	14.0	5.3	6.0	12.1	15.3	6.5	8.2	9.7	10.2	14.1	9.0

The number of fruits per plant, fruit weight, number of seeds per fruit, weight of seeds per fruit and yield of egusi melon significantly (P≤0.05) reduced when intercropped with cassava and maize compared to those obtained from monocropped egusi melon (Table 3). Shading by taller maize plants could have reduced the photosynthetic absorption rate of egusi melon (a lower growing plant), thereby reducing number of fruits, fruit weight and yield. Higher yield in sole over intercropped plants have been reported by Olufajo (1992) and Muneer et al. (2004). The yield of egusi melon under intercropping with cassava and maize was significantly (P≤0.05) depressed by 34.8 % and 31.6 % respectively, in 2010 and 2011, compared to that obtained from monocropped egusi melon (Table 3).

3.4. Assessing intercropping advantages

The total intercrop yield was greater than the component crop yields (Table 4). Intercropping cassava, maize and egusi melon gave land equivalent ratio (LER) values of 2.51 and 2.47 respectively, in years 2010 and 2011, indicating that higher productivity per unit area was achieved by growing the three crops together than by growing them separately (Table 4). With these LER values, 60.2 % and 59.5 % of lands were saved respectively, in 2010 and 2011, which could be used for other agricultural purposes.

Table 4: Yields of cassava, maize and egusi melon, total intercrop yield, land equivalent ratio (LER), percentage (%) land saved of component crops in a three crop intercropping system in Makurdi, in years 2010 and 2011.

Treatments	***Cassava yield (t ha^{-1})***		***Maize yield (t ha^{-1})***		***Egusi melon yield (t ha^{-1})***		***Total Intercrop yield (t ha^{-1})***		***LER***		***% Land Saved***	
	2010	**2011**	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**
Sole Cassava	5.6	5.8	-	-	-	-	-			-	-	-
Sole Maize	-	-	4.4	4.2	-	-	-	- -		-	-	-
Sole egusi melon	-	-	-	-	2.3	1.9	-	-	-	-	-	-
Intercrop	4.3	4.0	4.8	4.6	1.5	1.3	10.6	9.9	60.2	59.5	2.51	2.47

$$LER = \frac{\text{Intercropped yield of Cassava}}{\text{Sole crop yield of Cassava}} + \frac{\text{Intercropped of yield Maize}}{\text{Sole crop yield of Maize}} + \frac{\text{Intercropped yield of Egusi melon}}{\text{Sole crop yield of Egusi melon}}$$

$$\% \text{ Land saved} = 100 - 1/LER \times 100$$

4. Conclusion

From the results obtained, it can be concluded that it is advantageous to intercrop cassava, maize and egusi melon. This is associated with a greater total intercrop yield, high land equivalent ratio greater than 1.0 and a

greater percentage of land saved. It is however recommended that further investigation be done to evaluate a wider range of cassava, maize and egusi melon varieties and across different locations within the Guinea savanna agroecological zone of Nigeria.

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