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Potentials of Intercropping Rice (*Orysa sativa* L.) and Cassava (*Manihot esculenta* Crantz) of Different Morphotypes in the Transition Zone of South West Nigeria

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Abstract: A field trial was conducted at the Teaching and Research Farm of the University of Agriculture, Abeokuta (latitude 7°15 N and longitude 3°25 E') located in the forest-savanna transition zone of south west Nigeria in 2002 and 2003 to assess the yield and economic potentials of intercropping two cassava morphotypes (TMS 30572, branching and TME 1, non-branching) and rice varieties (WAB 189-B-B-B-6-HB, ITA 150 and ITA 321). Significant differences was observed among the rice varieties as ITA 321 produced the highest grain yield (3.50 and 3.56 t ha^{-1}) under sole in 2002 and 2003, respectively. Similarly under intercropping with both cassava cultivars it recorded the highest grain yield in 2002 and 2003. On the average intercropping significantly reduced the grain yield of rice intercropped with TMS 30572 and TME 1 in 2002 and 2003. In 2002, tuber yields of the two cassava cultivars in mixtures were similar to the yields of their corresponding sole. However, in 2003, sole cassava TMS 30572 and TME 1 produced significantly higher tuber yield than their corresponding intercrops. Rice/cassava intercrop on the average resulted in land equivalent ratio (LER) of 1.88 and 1.79 in 2002 and 2003, respectively indicating an advantage of intercropping rice with cassava. Also a high level of compatibility was observed as the land equivalent co-efficient in 2002 and 2003 was high especially in 2002 (0.52 and 0.88). The intercropping of rice with cassava gave a higher total net income of intercropping than sole crop as TMS 30572 intercropped with ITA 321 gave a higher total net income (₦ 377,100.00) than TME 1 intercropped with ITA 321 (₦ 355,800.00).

Key words: Intercropping, land equivalent ratio, land equivalent coefficient and Cost benefit ratio

INTRODUCTION

Multiple cropping (mixed or intercropping) is an important crop production technique advocated for subsistence agriculture and it offers considerable yield advantage over sole cropping due to efficient utilization of growth resources (Willey, 1979). In the event of an unforeseen environmental hazard affecting the yield of one crop it offers an alternative so providing a more stable food source overall from the same field (Baker, 1980). The pattern of mixed cropping varies considerably from one area to another and even differ among farmers within a location. The common feature is that each system tends to reflect the farmers needs, management ability and resources, economic considerations and convenience (Ntare, 1990; Osiru and Willey, 1972; Willey and Osiru, 1972).

It is the worlds most important staple food crop and more than four-fifths of the world's rice is produced and consumed by small-scale farmers in low-income and developing countries (FAO, 2003). Upland rice is commonly intercropped with pigeon pea (Mahapatra and Satpathy, 1988), cowpea and

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lablab (Aggarwal and Garrity, 1987), yam and cassava (Ugwu, 1996). Despite the fact that small scale farmers have failed to accept the recommendation of sole cropping system, most researchers have centred on sole crop, this could be as a result of trying to improve on sole cropping system (FAO, 1999).

Cassava (*Manihot esculenta*) is an important root crop widely cultivated in sub-saharan Africa. As a major source of energy, it is now gradually replacing maize in livestock feed industries (Omole, 1977; Tewe and Egbunike, 1992; Eruvbetine and Afolami, 1992; Eruvbetine and Oguntona, 1999). Special attributes of the crop include tolerance to low pH, low soil fertility and drought. These features single it out as an ideal crop for the tropics (Wilson and Adeniran, 1976). Cassava is characterized by slow initial growth and longevity hence, it is often found in mixture with short season crops that are harvested before it develops full canopy (Olasantan *et al*., 1996). Intercrops associated with cassava are highly variable and location specific. It is often intercropped with shorter duration crops such as maize, yam, cowpea, melon and vegetables (Njoku and Odurukwu, 1986; Olasantan, 2001; Olasantan and Bello, 2004). Given the high yield potentials of these new rice varieties (ITA 150, ITA 321 and WAB 189-B-B-B-6-HB) and the cassava TMS 30572, information on their compatibility in intercropping system is lacking.

Several concepts have been developed to evaluate the productivity and efficiency of different intercropping systems. Such concepts include relative crowding effect, RCE (Dewit, 1960), crop equivalent factor, CEF (Donald, 1963), coefficient of agressivity, CA (Mc Gilchrist and Trenbath, 1971), land equivalent ratio, LER (Willey, 1979), competitive ratio, CR (Willey and Rao, 1980), land equivalent coefficient, LEC (Adetiloye *et al*., 1983), staple land equivalent ratio, SLER (Reddy and Chetty, 1984), area time equivalent ratio, ATER (Hiebsch and Mc Collum, 1987). These concepts measure the productivity of the systems by comparing yields or monetary returns in intercropping with that of sole crop. However, each of the indices has its limitations. Hidlebrand (1976) advised that whichever concept is going to be adopted must be well understood by the farmer such that it can guide him in allocating his limited resources between competing demands. This study was therefore, carried out to evaluate the yield and economic advantages of cassava/rice using LER and LEC and total net income respectively in the forest-savanna transition zone of Nigeria.

MATERIALS AND METHODS

Site Description

The experiment was conducted at the Teaching and Research Farm of the University of Agriculture, Abeokuta (latitude 7°15 N and longitude 3°25 E'). The rice experiment was between July and November in 2002 and May and September in 2003 while the cassava experiment was between July 2002 to June 2003 and June 2003 to May 2004. Weather data during the period of experimentation are presented in Table 3. The soil analysis for 2002 showed that pH was 5.22, organic carbon 1.24% organic matter content 2.14%, total N 0.31%, P 0.601 (ppm) and K 1.71 (mol kg^{-1}). While in 2003 soil pH was 5.67, organic carbon 1.01%, organic matter 1.70%, total N 0.61%, P 0.466 (ppm) and K 1.33 (mol kg^{-1}).

Varieties of Cassava and Rice Used

The cassava varieties used in this study were of two different morphotypes. TMS 30572, a profusely, branching morphotype and TME 1 the non-branching type. The rice varieties used were WAB 189-B-B-B-6-HB (an early maturing interspecific rice hybrid of *Oryza glabberima*×*Oryza sativa* cross), ITA 150 (an early maturing *Oryza sativa* cross) and ITA 321 (a late maturing *Oryza sativa* cross).

Experimental Design and Treatments

The trial was laid out in a factorial arrangement in a randomized complete block design and replicated three times in each year. The treatments consisted of three sole rice varieties (ITA 321, ITA 150 and WAB 189-B-B-B-6-HB), two sole cassava varieties (TMS 30572 and TME 1) and six intercrop combinations of the two component crops.

Crop Husbandry

The field was ploughed and harrowed fourteen days later in both years. Each plot size was 9×6.4 m and separated by an alley of 0.5 m. The rice was sown by dibbling on 13th July, 2002 and 23rd May, 2003 at a spacing of 30×30 cm resulting in 31 rows of rice per plot while in mixed stands a constant arrangement of one row of cassava bordering two rows of rice with rows 30 cm apart was used. Cassava was planted at 90×90 cm. Weeding was done three times before harvesting rice at 3, 6 and 9 Weeks After Planting (WAP). After the harvesting of rice, the plots of cassava were weeded 3 times before harvest.

Determination of LER, LEC and Cost Benefit Ratio

In this study, LER and LEC were used to evaluate the agronomic advantage and economic advantage was determined using Cost benefit ratio. LER was determined by dividing yields for cassava (TMS 30572 and TME 1) by their respective sole crop yields and the resulting ratios (relative yields) for the two crops were added to obtain the LER values (Willey, 1979). LEC was determined as a product of the relative yield for cassava and rice (Adetiloye *et al*., 1983).

Statistical Analysis

The data collected were subjected to analysis of variance using the MSTATC package based on the experimental design adopted on the field. Treatments that showed significant effect on parameters measured were further separated using the Least Significant Difference method (LSD) (Steel and Torrie, 1980).

RESULTS

Weather Condition

Table 1 shows the monthly rainfall and average temperature for 2002 to 2004. In the cropping season of 2002, the wettest months were July (325.5 mm) and October (297 mm), while in 2003 the wettest months for rice were June (293 mm) and September (286 mm).

Cassava

In 2002 cropping system had no significant effect on the tuber yield of cassava cultivars (Table 2). While in 2003 cropping system had significant effect on the tuber yield of cassava, as sole cassava cultivars TMS 30572 and TME 1 produced significantly higher tuber yield (34 and 22 t ha^{-1}) than their corresponding intercrops (Table 3).

Rice

Intercropping significantly reduced the grain yield of rice as sole cropped rice significantly yielded higher than those intercropped with cassava in both 2002 and 2003 (Table 2 and 3). Among rice varieties ITA 321 had significantly higher grain yield (3.50 and 3.56 t ha^{-1}) in 2002 and 2003, respectively in sole crop, while in intercrop ITA 321 intercropped had significantly higher grain yield than other rice varieties (Table 1 and 2).

Table 1: Weather observation for Abeokuta, 2002/2003 and 2003/2004

Month	Maximum temp (°C)	Minimum temp (°C)	Mean temp (°C)	Total rainfall (mm)	Rel. humidity (%)
2002					
July	30.5	11.5	21.0	325.5	88.1
August	29.6	8.4	19.0	110.1	81.2
September	30.6	8.4	19.5	148.3	77.7
October	31.5	8.3	19.9	297.0	81.3
November	34.7	10.9	22.8	54.5	82.5
December	35.4	9.9	22.7	NA	90.7
2003					
January	35.1	11.5	23.3	12.3	60.0
February	36.9	12.0	24.5	25.7	64.0
March	36.3	15.8	26.1	NA	64.3
April	45.3	9.3	27.3	161.5	76.7
May	34.3	10.4	22.4	40.6	77.0
June	31.3	13.2	22.3	293.1	85.2
July	30.0	12.4	21.2	191.7	95.2
August	29.6	12.7	21.2	76.5	90.5
September	30.7	12.8	21.8	286.7	96.6
October	32.7	12.7	22.7	91.6	92.4
November	34.1	20.1	27.1	27.0	73.6
December	35.1	11.1	23.1	NA	63.4
2004					
January	34.8	13.5	24.1	15.3	82.0
February	35.6	15.0	25.3	20.4	86.2
March	35.8	15.1	25.4	75.2	95.6
April	33.3	14.4	23.8	83.2	78.0

NA = Not Available

Table 2: Grain yield, land equivalent ratio, land equivalent coefficient of cassava and rice in sole and intercrop in 2002

Treatments	Yield (t ha^{-1})	Relative yield		LER Sole or total of intercrop	LEC
		Cassava	Rice		
Sole rice					
WAB 189-B-B-B-6-HB	2.10	-	1.00	1.00	-
ITA 150	1.96	-	1.00	1.00	-
ITA 321	3.50	-	1.00	1.00	-
Sole cassava					
TMS 30572	38.21	1.00	-	1.00	-
TME 1	29.08	1.00	-	1.00	-
Intercropping					
TMS 30572/WAB 189	34.94+2.03	0.91	0.97	1.88	0.88
TMS 30572/ITA 150	36.93+1.66	0.97	0.85	1.82	0.83
TMS 30572/ITA 321	32.23+2.18	0.84	0.62	1.46	0.52
TME 1/WAB 189	26.32+1.87	0.91	0.89	1.80	0.81
TME 1/ITA150	26.36+1.72	0.91	0.88	1.79	0.80
TME 1/ITA 321	28.44+2.26	0.98	0.65	1.63	0.64

Intercropping Advantagel

Land Equivalent Ratio (LER)

TMS 30572 had a higher LER (1.88-1.46) when intercropped with rice varieties than TME 1 (1.80-1.63) in 2002, while TME 1 had higher LER (1.78-1.61) than TMS 30572 (1.59-1.42) in 2003 (Table 2 and 3).

Land Equivalent Coefficient (LEC)

In respect to intercrop compatibility, rice intercropped with cassava of different morphotypes in both years recorded LEC values greater than 0.25. In 2002, WAB 189-B-B-B-6-HB had the highest LEC values (0.88 and 0.81) in intercrop (Table 2 and 3).

Table 3: grain yield, land equivalent ratio, land equivalent coefficient of cassava and rice in sole and intercrop in 2003

Treatments	Yield (t ha^{-1})	Relative yield		LER	
		Cassava	Rice	Sole or total of intercrop	LEC
Sole rice					
WAB 189-B-B-B-6-HB	2.62	-	1.00	1.00	-
ITA 150	1.75	-	1.00	1.00	-
ITA 321	3.56	-	1.00	1.00	-
Sole cassava					
TMS 30572	33.68	1.00	-	1.00	-
TME 1	22.28	1.00	-	1.00	-
Intercropping					
TMS 30572/WAB 189	27.34+1.61	0.81	0.62	1.43	0.50
TMS 30572/ITA 150	23.58+1.55	0.70	0.89	1.59	0.62
TMS 30572/ITA 321	24.82+2.41	0.74	0.68	1.42	0.50
TME 1/WAB 189	14.75+1.90	0.66	0.73	1.39	0.48
TME 1/ITA150	19.62+1.58	0.88	0.90	1.78	0.79
TME 1/ITA 321	16.55+3.11	0.74	0.87	1.61	0.64

Table 4: Cost/benefit analysis of rice/cassava intercrop

Cropping system	Cost of production ₦ (kg ha^{-1})	Gross income ₦ (kg ha^{-1})	Cost benefit ratio	Net income ₦ (kg ha^{-1})	Total net income ₦ (kg ha^{-1})
Rice-cassava					
WAB 189-B-B-B-6-HB/ TMS 30572					
WAB 189-B-B-B-6-HB	65,300.00	136,500.00	1.91	71,200.00	310,800.00
TMS 30572	71,800.00	311,400.00	1.29	239,600.00	
ITA 150/ TMS 30572					
ITA 150	65,300.00	120,000.00	2.19	54,700.00	285,500.00
TMS 30572	71,800.00	302,600.00	1.31	230,800.00	
ITA 321/TMS 30572					
ITA 321	65,300.00	229,000.00	1.39	163,700.00	377,100.00
TMS 30572	71,800.00	285,200.00	1.33	213,400.00	
WAB 189-B-B-B-6-HB/ TME 1					
WAB 189-B-B-B-6-HB	65,300.00	141,750.00	1.85	76,450.00	209,950.00
TME 1	71,800.00	205,300.00	1.53	133,500.00	
ITA 150/TME 1					
ITA 150	65,300.00	123,750.00	2.11	58,450.00	216,550.00
TME 1	71,800.00	229,900.00	1.45	158,100.00	
ITA 321/TME 1					
ITA 321	65,300.00	268,000.00	1.32	202,700.00	355,800.00
TME 1	71,800.00	224,900.00	1.46	153,100.00	
Sole rice varieties					
WAB 189-B-B-B-6-HB	65,300.00	177,000.00	1.58	111,700.00	111,700.00
ITA 150	65,300.00	139,500.00	1.88	74,200.00	74,200.00
ITA 321	65,300.00	351,000.00	1.22	285,700.00	285,700.00
Sole cassava varieties					
TMS 30572	71,800.00	359,500.00	1.24	287,700.00	287,700.00
TME 1	71,800.00	256,800.00	1.38	185,000.00	185,000.00

Price Levels-Rice = WAB 189-B-B-B-6-HB ₦75/kg, ITA 150 at ₦75/kg, ITA 321 at ₦100/kg, Cassava = TMS 30572 and TME 1 at ₦10/kg, Source: OGADEP extension agent

However, among the rice varieties intercropped with cassava, ITA 150 recorded the highest LEC values (0.62 and 0.79) in 2003.

Cost Benefit Ratio

Results from Table 4 shows the cost/benefit analysis of rice/cassava intercrop in sole and intercrop, in which the reduction in the yield of rice was compensated for by the tuber yield of TMS 30572 than the tuber yield of TME 1 as greater yield obtained from TMS 30572 resulted in a higher total net income of ₦ 377,100 than TME 1 with a total net income of ₦ 355,800.

DISCUSSION

The success of any intercropping system depends on crop compatibility. It is important to select the intercrop carefully on the basis of their mutual competition and the benefit of association (Singh and Joshi, 1980). The reduction in the grain yield of rice in intercrop when compared with the grain yield of rice planted sole was due to the higher population of rice in sole than in intercrop. Nevertheless the reduction in the grain yield of rice was compensated for by the tuber yield of TMS 30572 than that of TME 1 as greater tuber yield obtained from TMS 30572 resulted to a higher total net income of ₦ 377,100.00 ha^{-1} than TME 1 with a total net income of ₦ 355,800.00 ha^{-} .[1] Intercropping has then proved to be of higher profit than sole cropping. Also the land equivalent ratio indicated higher relative yield advantage of intercropping over sole cropping in 2002 and 2003.

The land use advantage (LER>1.00) ranged between 1.46-1.88 and 1.63-1.80 among TMS 30572/Rice and TME 1/Rice respectively, of which rice variety WAB 189-B-B-B- 6- HB intercropped with cassava had a higher LER than other rice in 2002. The relative yield of cassava and rice was low in 2003. The relative yield of cassava and rice was low in 2003. Nevertheless, their was a relative yield advantage of intercropping over sole, as the LER ranged from 1.42-1.59 and 1.39-1.78 among TMS 30572 intercropped with rice and TME intercropped with rice respectively in which ITA 150 intercropped with cassava had a higher LER. The intercropping system of rice/cassava exhibited high level of intercrop compatibility as their LEC exceeded 0.25 (Adetiloye *et al*., 1983). This shows that rice can be grown in mixture with cassava of different morphotypes.

CONCLUSIONS

Cropping system significantly reduced the grain yield of rice in both years. Thus, the reduction in the grain yield of rice in mixture was more compensated for by the tuber yield of associated TMS 30572 than TME 1. Considering the economic implication, TMS 30572 intercropped with ITA 321 gave a higher total net income (₦ 377,100.00 ha^{-1}) than TME 1 intercropped with ITA 321 (₦355,800.00 ha^{-1}). Rice/cassava intercrop on the average resulted in land equivalent ratio of 1.88 and 1.39 in 2002 and 2003, Land equivalent co-efficient of 0.48 and 0.88 in 2002 and 2003 respectively, indicating an advantage of intercropping rice with cassava. Intercropping therefore proves to be profitable.

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