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2. CASSAVA ROOT YIELD, ENERGY, MONETARY AND PROTEIN RETURNS OF SYSTEM

by

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ABSTRACT

Cassava-dependent populations require additional protein to augment their cassava diets. This can be accomplished by using a farming system which includes a legume. It was desired to assess the effect of using cowpea [*Vigna unguiculata*] as an intercrop with cassava on the yield of cassava [*Manihot esculenta* Crantz]. Results were obtained from an experiment with 12 cowpea varieties evaluated for two years, with and without chemical insect protection, in sole and intercropped systems in a humid tropical zone of Nigeria. Cassava characteristics reported herein are root yield, shoot yield, plants per hectare, and root number per hectare. In addition, linear combinations of root yield of cassava and grain yield of cowpea were calculated to obtain relative monetary value, calorie (energy) yield, and protein yield for both sole and intercropped systems.

Since ratios are more stable than actual prices, a relative monetary value using a ratio of prices, was used for comparing the different treatments in an experiment. This study demonstrated that the 12 cowpea varieties intercropped with cassava had little or no effect on the root yield of cassava. Hence, any yield from cowpea represents a bonus over sole cropped cassava. The increased protein yield was 82 kilograms per hectare. Monetary values and calorie yield were also increased in the intercropping system. Thus, intercropping cassava with cowpea is a viable means of enriching the diet as well as increasing total energy and monetary value.

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Key Words and Phrases: Cassava-cowpea intercrop, Energy, Linear combination, Total revenue, Price ratios, Relative Economic value, Relative land equivalent ratio.

INTRODUCTION

In the humid tropical zone of West and Central Africa, cassava is a major food crop often intercropped with annuals which mature earlier. The annual crops may be cereals (Okigbo, 1977; Ezumah and Okigbo, 1980); grain legumes (Mba, 1985; Lutaladio, 1986; Balasubramanian and Sekayange, 1990) or vegetables (Ikeorgu *et al.*, 1989). Among the grain legumes commonly intercropped with cassava are peanuts (*Arachis hypogea*) (Lutaladio, 1986), beans (*Phaseolus vulgaris*) (Balasubramanian and Sekayange, 1990), pigeon peas (*Cajanus cajan*) (Okigbo, 1977), and cowpeas (*Vigna unguiculata*) (Mba, 1985; Juo and Ezumah, 1991). In his study of cassava + cowpea intercrops, Mba (1985) obtained yield advantage of the system in a transitional rainfall zone of Southern Nigeria only when grown on alternate rows during the first season (with a longer rain period) in the biomodal rainfall zone. He, however, used only two cowpea varieties. Using the TVX 2336 variety developed by IITA, Agboh-Noameshe (1990) obtained yield advantage in cassava + cowpea intercrop system, irrespective of whether spatial arrangements were double cowpea rows, interrow or mixed irregularly, provided the total of each crop population remained unchanged. Again, only one cowpea variety was used in this study.

The objective of the present work was to evaluate the performance of a wider range of cowpea varieties (12) intercropped with cassava under two insect protection regimes in a humid, high rainfall zone of West Africa. The cowpea yield has been reported elsewhere (Ezumah and Federer, 1991). This report deals with the returns from the cassava-cowpea intercrop system. The statistical method of intercrop analysis devised by Federer (1987, 1993) for the determination of monetary returns using price ratios, protein and energy values is used in this report. An important rationale for this study was that if cowpea and other protein-rich legumes, e.g. soybeans, can be grown successfully in the humid zone, their potential contribution to the protein requirements of the cassava-consuming population of the subsistence farmers in the humid African tropics can be estimated for policy considerations.

MATERIALS AND METHODS

The environment and the experiment design have been described in the first paper on cowpea yields (Ezumah and Federer, 1991). Only one cassava variety, TMS 30572, an improved, highly popular variety developed by the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, was used. It was intercropped with 12 cowpea varieties in a split-split plot design with spraying for insect protection as the main plot, cropping system (intercropped with cowpea or sole cowpea) as the subplot and cowpea variety as the sub-sub plot (Ezumah and Federer, 1991). Since only one cassava variety was used, its yield was analysed as a split plot with spraying as the whole plot and cowpea variety as the sub-plot. The two treatment factors (spray and cowpea variety) and their mode of application, were as discussed in the first paper. For each year, cassava yield and yield components were measured at 12 months. Root and shoot (stem and leaves) yields per plot were weighed at time of harvest. Number of plants and number of roots were counted. Sole cassava yield was obtained from additional unsprayed plots established near the experimental area for this purpose.

Energy (calories) and protein produced by the system were determined using standard values available in the literature (Onyenuga, 1968; Pratt, 1980), see Table 1. Total monetary return, which was a summation of the income from cassava (150 Naira/ton) and cowpea grain (3,000 Naira/ton) at time of harvest, were calculated and used to compare the systems. Income ratio based on the relative values of the visible economic output from the systems was also computed (Table 2; Federer 1987, 1993).

CONVERSION OF CROP MIXTURE DATA

To convert the yields of complex crop mixtures in an intercrop system to single values, Federer (1987, 1993) suggested several analyses based on users' goals. He advocates that intercrop analyses should be such as to provide a range of information from which different users can identify options which satisfy their specific goals. In our cassava + cowpea trail, for example, users' goals may be (a) high total income, (b) high total energy, (c) some balance between energy (calories) and protein, or (d) high land-use efficiency. Obviously, different conversions and analysis will be required to furnish information upon which interpretations and decisions will be based.

In our analysis of the cassava + cowpea mixture, some linear combination of data describing the response of each of the crops in the mixture is required. The generalized equations used for total revenue, energy and protein realized from the system are given in Table 2. Note that a single set of values (V^*, E^*, and P^*) can be used for estimating each of the system's monetary value, energy and protein (Federer, 1993). Any number of crops, say n, grown in complex mixture can thus be converted into simple, analyzable values for use in the comparison and evaluation of systems.

PRICE RATIOS

An extension of the monetary returns, V^*, is derived from price ratios of the crops given in Table 2. It is likely that the ratio of prices is more stable than absolute price values. This is based on a price increase of one crop component in intercrops being associated with some corresponding increase of the other crops. Figure 1 shows the relationship between absolute price of cassava + cowpea in Southern Nigeria from 1986 (prior to a devaluation of Naira) to June 1990. As the price of cowpea increased, that of cassava also increased but the ratio remained almost constant. Returns based on the 1990 prices will overestimate the total revenues from the cassava + cowpea system, while that based upon the 1986 to 1987 data may underestimate the returns. More stable and reliable information upon which plans and projections may be based is more likely to come from the price ratios (Fig. 1).

RESULTS AND DISCUSSION

Cassava Root Yield and Number Analyses of variance on the weight and number of cassava roots per hectare are given in Table 3 under 'Root yld' and 'Root#', respectively. There appeared to be no effect of cowpea variety differences or interactions with spraying for insect protection. Although the varieties appeared to respond differently for cassava root yield and number (Figures 2a-2d), this was within the experimental variation in the experiment. The coefficients of variation were large, ranging from 30-38%, where these were computed from the error(b) line in the split plot analysis.

The contrast of spraying for insect protection versus no spraying was not significant when tested against the Residual = error(a) mean square with two degrees of freedom. However, to see the effect of spraying cowpea plants on cassava root yield and number, Figures 2a – 2d were prepared. In Figures 2a and 2b, the symbols V1 to V12 were used for designating cowpea varieties. Here we see that the cassava root yields for sprayed plots were lower than unsprayed plots for nine of the 12 cowpea varieties in each of the two years (see Figures 2a – 2b). These responses for varieties varied from year to year. Note that based on the null hypothesis of no difference due to spraying treatments, a somewhat large value for chi-square is obtained, i.e., $[(9-6)^2 + (3-6)^2]/6 = 3$ with one degree of freedom. The sum of the chi-squares for both years is six with two degrees of freedom. The probability of obtaining a larger chi-square than six with two degrees of freedom given there is no spray effect, is 0.05. Hence, there appears to be evidence that spraying cowpea varieties for insect protection lowers the root yield of cassava in the intercrop system.

With respect to root number, the effect of spraying is even more pronounced in that 11 of the 12 cowpea variety intercrops resulted in fewer roots from sprayed plots than from the unsprayed plots in 1987/88. For 1988/89, the ratio of lower yields was 10 to 2 (see Figures 2c – 2d). The resulting chi-square value with two degrees of freedom is $[(11-6)^2 + (1-6)^2]/6 + [(10-6)^2 + (2-6)^2]/6 = 13.7$, with a p-value of less than 0.005. In Figures 2c and 2d, the varieties were ordered a to l, lowest root number to highest root number, for the 1987/88 sprayed means. The same order was maintained for unsprayed and for the 1988/89 means.

Since this is a split plot design for the data discussed herein, it is noted that in order to make comparisons among the 24 cowpea variety by spraying treatment means, two different standard errors are required. Let E_a be the whole plot or error(a) mean square which is the Residual with two degrees of freedom in Table 3, and let E_b be the split plot or error(b) mean square. Then, the standard error for comparing differences of two cowpea variety treatments within either the sprayed or unsprayed treatments is $(2E_b/r)^{1/2}$ where r is the number of replicates The standard error of the difference between two spraying treatment means for the same or different cowpea variety is $\{2[(q-1)E_b + E_a]/rq\}^{1/2}$, where q is the number of split plot treatments (12 here). The degrees of freedom associated with this second standard error need to be approximated.

In comparing the unsprayed treatment means with sole crop cassava means (Table 3), it would appear that the addition of a cowpea variety as an intercrop did nto essentially alter root yield, shoot yield, plants/ha, or root number/ha over that obtained from sole cropping cassava. This means that any produce obtained from the cowpea was an additional benefit. This illustrates the advantage of intercropping cassava with a legume such as cowpea.

Cassava Top Weight The top weight of cassava plants, denoted as 'Shoot yld' in Table 3, appeared to be unaffected by the cowpea variety used as an intercrop. Also, there was little statistical evidence of a spraying treatment by cowpea variety interaction. From Figures 3a and 3b, it would appear that there was considerable variation in response. Treatments V1 and V4 from unsprayed plots resulted in the highest shoot yield in 1987/88 and V6 and V9 in 1988/89. V1 and V9, unsprayed, performed relatively well in both years.

With respect to spraying treatment, seven out of the 12 unsprayed treatments exceeded the sprayed, almost at the expected value of six (Figure 3a). However in 1988/89 this was not the same. Ten of the unsprayed plot means were larger than the corresponding sprayed plots, one was the same, and one was the reverse. This results in a chi-square value of $[(10.5 - 6)^2 + (1.5 - 6)^2]/6 = 6.75$ with a p-value of 0.01. Note that since one pair was even, one-half was allocated to one group and one-half to the other group. This indicates that spraying was detrimental to shoot yield in 1988/89 but not in 1987/88.

Shoot yield was higher than root yield in both years. In 1987/88, the ratio of root weight to shoot weight was $41.1/36.2 = 1.14$ or a 14% difference. In 1988/89, the ratio of root to top weight was $22.5/15.2 = 1.48$, or a 48% difference. Also shoot yield of the intercropped plots was similar to that from sole-cropped cassava, indicating little or no effect of an intercropped cowpea variety on the yield of cassava.

Plant Population Although spraying for insect protection on cowpeas reduced the number of plants per hectare by 21% in 1987/88 and 14% in 1988/89, the difference was not large enough to show statistical significance at the 5% level. The addition of an unsprayed cowpea variety as an intercrop with cassava did not change the plot population of cassava (see Table 3) over that obtained from sole-cropped cassava.

It did not appear that a logarithmic transformation of the data was necessary. An anomaly that occurred in this experiment was that the residual for whole plots was sometimes smaller than the residual for split plots. This may have resulted from the sampling variation encountered when there are such few degrees of freedom, two here, in the residual for whole plot mean squares.

TOTAL REVENUE AND PRICE RATIOS

The total revenue from the cassava + cowpea intercrop system was very low in

1988/89 compared with 1987/88 because of the low yields of both the cassava and the cowpea in 1988/89 (Table 4). An increase of cowpea price to six Naira/kg, i.e., 1:40 as cassava:cowpea, increased the total revenue significantly only in 1987/78, when the cowpea yield averaged 716 kg/ha compared with 338 kg/ha in 1988/89 (Ezumah and Federer, 1991). If the goal of a farmer is high returns from cassava, any of the cowpea varieties could be used in the intercrop system because cowpea variety had little effect on cassava (TMS 30572) revenue. However, higher cassava revenue ranging from 4813 (V4) to 6059 (V11) per hectare in 1987/88 was obtained depending upon the cowpea variety intercropped with the TMS 30572 cassava (Table 5a). The 1988/89 revenue from cassava alone varied from 1709 (V7) to 2850 (V5) Naira (Table 5b). Addition of returns from cowpea may increase the total system (cassava + cowpea) revenue by 50% or four times, depending upon price ratios used. A more realistic value is the 1:20 price ratio which is normal (Fig. 1); but during off-season periods, cowpea grain may cost 4.5 Naira/kg, i.e., 1:30 ratio or in extreme cases, 6.0 Naira per kg (1:40); see Table 5. For all 12 cowpea varieties and all price ratios used, the revenue exceeded that for sole crop cassava. However, the low yielding cowpea varieties such as V9, V1, and V5 contributed much less to the system's total returns. In 1988/89, cowpea yields were so low that even at the high 6 Naira/kg price, the revenue contributed did not significantly change the overall returns (Table 5b). The reduction in cassava root yield due to spraying cowpeas for insect protection becomes more noticeable as the price ratio increases and is noted from the increasing F-values.

ENERGY

Neither spraying nor cowpea variety intercropped with TMS 30572 cassava significantly changed the total energy produced (Table 6). In 1987/88, the value averaged 44.22 million calories per hectare or 121,152 calories per hectare per day. The corresponding values in 1988/89 were 24.15 million calories per hectare, i.e., 66,164 calories per ha/day

(Table 6). Although the calories from sole cassava may be higher compared with the average from cowpea (Table 6), some specific cowpea varieties intercropped with cassava resulted in high cassava roots and produced more calories than sole cassava (Fig. 2). Cassava intercropped with V12 in 1987/88, for example, gave 42 tons per hectare root yield, which converts to 64.26 million calories compared with 57.68 million calories during the same year in sole cassava (Table 6).

Protein The data in Figure 4b show significant protein yield differences of the cowpea varieties under intercropping with cassava in 1987/88. The non-significant 1988/89 effects reflect low cowpea yields during that year (Figure 2b). Protecting the cowpeas with insecticides tended to increase intercropped cowpea protein, apparently because of higher grain yields (Ezumah and Federer, 1991). The highest total protein during the two years were from system with V3, V6, and V12, the three cowpea varieties which were suggested for further on-farm testing (Fig. 4; Ezumah and Federer, 1991). Note that supplementary protein averaging over 250 kg/ha can be produced from the cassava-based intercrop system simply by adding cowpea as a companion crop (Fig. 4b).

Cassava root yields were not affected by intercropping with cowpea in alternate row arrangements. The issue of spatial arrangement and population of cassava in the intercrop system with cowpea and some other annuals remain uncertain. Mba (1985) reported a reduced cassava root yield only in replacement arrangments. Agboh-Noameshe (1990) and Balasubramanian and Sekayange (1990) also reported such a reduction of cassava yield only at reduced cassava population. No yield reductions were observed in additive intercrop system with cassava by Mason *et al.* (1986) in Columbia or by Ikeorgu *et al.* (1989) in Nigeria. Since cassava yield is not reduced by cowpea, and since their periods of active growth resource demands do not overlap (Mason *et al.*, 1986; Juo and Ezumah, 1991), it may not be necessary to reduce cassava population below the optimum for highest root yield in its intercrop system with early-maturing annuals. Evidently the non-synchronization of resourcedemand periods of the component crops give yield advantages to the system. The processes involved need to be better understood since our knowledge of these remains scanty. Perhaps higher yield advantages than we now obtain from a cassava and annual crops intercrop system may be realized.

Cassava (TMS 30572), intercropped with twelve varieties of cowpeas, produced root yields which did not differ significantly from root yield of cassava grown in association with cowpea. Cowpea may be a good source of cheap protein for cassava-dependent subsistence farmer populations if stable yields can be obtained. High yield variability within years, between varieties and between years were observed and these similarly affected income, energy, and protein returns. The specific processes involved in the compatibility of a cassava + cowpea intercrop system are not well understood and documented.

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Table 1. Estimated values of crops used in system analysis and comparisons

	Intercrop combinations		
Crop factors	Cassava	Cowpea	Source
Naira† Value/ton	150	3000	Market Survey‡
Calorie/100 g.	153	340	Pratt (1980)
Protein/100 g.	0.7	22	Pratt (1980)
Price Ratio	1.0	20.0	——

† Naira, N, is Nigerian currency. US $ was equivalent to 8.78N at time of trial.

‡ IITA Weekly Bulletin, Agric. Econ. IITA.

Table 2. Linear combinations of yields from a cassava-cowpea intercrop[†]

$$\text{Total value} = V_{ca}Y_{ca} + V_{co}Y_{co} = V$$
$$\text{Relative value} = Y_{ca} + (V_{co}/V_{ca})Y_{co} = V^*$$

$$\text{Total calories} = C_{ca}Y_{ca} + C_{co}Y_{co} = E$$
$$\text{Relative calories} = Y_{ca} + (C_{co}/C_{ca})Y_{co} = E^*$$

$$\text{Total protein} = P_{ca}Y_{ca} + P_{co}Y_{co} = P$$
$$\text{Relative protein} = Y_{ca} + (P_{co}/P_{ca})Y_{co} = P^*$$

$$\text{Land equivalent ratio} = \frac{Y_{ca}}{S_{ca}} + \frac{Y_{co}}{S_{co}} = L\ (\text{LER})$$

$$\text{Relative LER} = Y_{ca} + (S_{ca}/S_{co})Y_{co} = L^*$$

where

Y_{ca} = yield of cassava from intercrop
Y_{co} = yield of cowpea from intercrop
S_{ca} = yield of cassava from sole crop
S_{co} = yield of cowpea from sole crop
V_{ca} = value of cassava
V_{co} = value of cowpea
C_{ca} = conversion factor for calories from cassava
C_{co} = conversion factor for calories from cowpea
P_{ca} = conversion factor for protein from cassava
P_{co} = conversion factor for protein from cowpea

[†] Comparisons among treatments may be made with either form of the linear combination, but it is simpler to use the relative values for analyses.

Table 3. Analysis of variance for cassava yield and components of cassava + cowpea intercropping trial in a humid zone of Nigeria, 1987/88 and 1988/89[†]

		Mean square							
		1987/88				1988/89			
Source of Variation	df	Root yld	Shoot yld	Plant#	Root#	Root yld	Shoot yld	Plant#	Root#
Cf Mean	1			$\times 10^6$	$\times 10^8$			$\times 10^6$	$\times 10^8$
Replication	2	617.9	1007.2	4.753	4.369	117.78	330.0	3.190	0.137
Spray	1	776.8	562.5	0.543	4.050	124.69	1180.2*	12.500	6.799
Residual (whole)	2	983.7	751.0	1.714	3.996	57.34	64.2	3.190	2.283
Cowpea Var (V)	11	42.3	80.3	2.184	3.181	34.53	45.3	5.232	1.561
Spray × V	11	107.0	390.0	2.294	1.638	29.09	145.2	2.746	0.8722
Residual (split)	44	120.0	203.9	1.979	3.458	32.80	114.2	4.232	1.983

* Significant at 0.05 level .

	Root yld	Shoot yld	Plant#	Root#	Root yld	Shoot yld	Plant#	Root#
CV%	30.3	34.7	16.4	29.8	37.7	47.6	29.5	35.4
Mean: Spray	32.9	38.3	8,507	54,965	13.9	18.4	6,563	36,667
No spray	39.5	43.9	8,681	69,965	16.5	26.5	7,396	42,813
Mean: Sole Cassava	38.2	44.5	9,735	70,053	19.9	28.4	7,111	38,960

[†] Plant population/ha = Plant#

Cassava root wt (tons/ha) = Root yld

Cassava root no./ha = Root#

Cassava top wt. (tons/ha) = Shoot yld

Table 4a. Analysis of variance of cassava + cowpea intercrop system in 1987/88

Source of Variation	df	Mean Squares Naira† per hectare							
		cassava		cassava + cowpea system					
		Alone	F	Price Ratio 1:20	F	Price Ratio 1:30	F	Price Ratio 1:40	F
Replication	2	13,926,751		10,726,308		6,134,982		7,335,948	
Spray	1	17,449,278	0.79	894,453	0.037	10,742,115	0.343	231,393,828	6.60
Residual (a)	2	22,099,149		23,870,468		31,302,002		35,073,573	
Cowpea variety	11	953,946	0.35	27,403,320	7.20*	49,275,863	2.42*	88,402,159	2.64*
Spr × Cowpea var.	11	2,404,075	0.89	3,791,090	0.99	27,166,261	1.34	46,003,534	1.38
Residual (b)	44	2,699,174		3,819,115		20,347,928		33,435,999	
Mean (N†/Ha)		5,425		7,491		14,721		17,820	
N†/Ha Sole		5,730		5,730		5,730		5,730	

* $F_{.05}(11,44) = 2.01$; $F_{.01}(11,44) = 2.68$.

† Naira(N) is Nigerian currency; one US dollar was equivalent to 8.78N at time of trial.

Table 4b. Analysis of variance of cassava + cowpea intercrop system in 1988/89

Source of Variation	df	Mean Squares Naira† per hectare							
		cassava		cassava + cowpea system					
		Alone	F‡	Price Ratio 1:20	F‡	Price Ratio 1:30	F‡	Price Ratio 1:40	F‡
Replication	2	2,181,682	2.45	4,727,623	2.85	6,372,976	2.87	8,266,588	2.86
Spray	1	3,865,388	4.33	562,783	0.34	20,236	0.009	216,859	0.75
Residual (a)	2	890,706		1,657,433		2,216,874		289,370	
Cowpea variety	11	774,241	1.02	948,699	1.42	1,218,029	1.62	1,608,759	1.74
Spr × Cowpea var.	11	641,707	0.85	622,094	0.93	761,029	1.01	999,125	1.08
Residual (b)	44	752,026		669,333		753,919		922,460	
Mean (N†/Ha)		2,278		3,085		3,489		3,893	
N†/Ha Sole		2,935		2,935		2,935		2,935	

† Naira is as in Table 1.

‡ Note that F values for cowpea variety and cowpea variety by spray increase with price of cowpea even though nonsignificant.

Table 5a. Revenue, Naira[†], per hectare from cassava + cowpea system in Southern Nigeria, 1987/88

Cowpea Variety		Cassava	Cassava Systems: Cassava + Cowpea at:		
		Cassava in Cassava + Cowpea System	Price ratios 1:20	1:30	1:40
			Cash Values (Naira)		
V1	IT84E-124	5263	6,957	12,887	15,429
V2	IT84E-108	5731	7,494	13,663	16,306
V3	IT83D-442	4906	7,556	16,831	20,806
V4	IT84S-2163	4813	6,905	14,232	17,371
V5	IT85F-1517	5544	7,167	12,848	15,283
V6	IT83D-442	5038	7,827	17,590	21,774
V7	IT84S-2246-4	5053	7,078	14,166	17,203
V8	IT82D-889	5563	7,789	15,581	18,920
V9	AKIDI	5806	6,232	7,722	8,360
V10	IT84D-666	5663	7,900	15,731	19,088
V11	IT84D-449	6059	8,767	18,243	22,304
V12	IT83D-340-5	5668	8,222	17,162	20,994
S	–	5730	5,730	5,730	5,730
	Means (± SE)	5,425(533)	7,491(1615)	14,721(2380)	17,820(2531)

[†] For the value of Naira, see Table 1.

S = Sole cassava.

Table 5b. Revenue, Naira[†], per hectare from cassava + cowpea system in Southern Nigeria, 1988/89

Cowpea Variety		Cassava	Cassava Systems: Cassava + Cowpea at:		
		Cassava in Cassava + Cowpea System	Price Ratios 1:20	1:30	1:40
			Cash values (Naira)		
V1	IT84E-124	2459	3,398	3,868	4,338
V2	IT84E-108	2488	2,888	3,088	3,288
V3	IT83D-442	2775	3,870	4,418	4,965
V4	IT84S-2163	2147	2,690	2,962	3,234
V5	IT85F-1517	2850	3,744	4,190	4,637
V6	IT83D-442	2197	3,412	4,019	4,627
V7	IT84S-2246-4	1709	2,347	2,665	2,984
V8	IT82D-889	1931	3,010	3,549	4,088
V9	AKIDI	1859	2,176	2,335	2,493
V10	IT84D-666	2372	3,165	3,562	3,959
V11	IT84D-449	2025	2,642	2,950	3,258
V12	IT83D-340-5	2519	3,682	4,264	4,846
Sole cassava		2985	2,985	2,985	2,985
	Means (± SE)	2,278(279)	3,085(805)	3,489(1052)	3,893(1338)

† For the value of Naira, see Table 1.

Table 6. Analysis of variance of energy† and calories per hectare from a cassava + cowpea system in Southern Nigeria

Source of Variation	df	Mean Squares 1987/88	F	1988/89	F
Replication	2	1407.6		251.3	
Spray	1	1516.7	0.65	348.8	3.50
Residual (a)	2	2318.8		99.6	
Cowpea Variety	11	93.6	0.33	80.1	1.06
Spray × Cowpea Var.	11	254.0	0.89	64.5	0.85
Residual (b)	44	285.5		75.56	
Means · g–Cal/ha.		44.22×10^6		24.15×10^6	
Sole Cassava		57.68×10^6		30.45×10^6	

† See Table 1.

Table 7. Analysis of variance of proteins† in the cassava + cowpea system

Source of Variation	df	Mean Squares Cassava	F	Cowpea	F	Total	F
				1987/88			
Replication	2	30,329		2261		20,149	
Spray	1	38,001	0.80	56,157	133.5**	1,767	0.03
Residual (a)	2	48,127		421		54,342	
Cowpea Variety	11	2077	0.35	13,755	3.19**	13,193	1.30
Spr × Cowpea Var.	11	5236	0.89	6324	1.47	12,282	1.21
Residual (b)	44	5878		4305		11,276	
Means (kg/ha)		253		151		404	
Sole Cassava (kg/ha)		267		–		267	
				1988/89			
Replication	2	4751		2670		14,435	
Spray	1	8418	4.34	7950	6.29	6.9	0.0013
Residual (a)	2	1940		1263		2009	
Cowpea Variety	11	1686	0.047	1306	1.45	2758	1.64
Spr × Cowpea Var.	11	1397	0.039	1067	1.18	1718	1.02
Residual (b)	44	35,729		903		1683	
Means (kg/ha)		106		59		166	
Sole Cassava (kg/ha)		139		–		139	

† See Table 1.

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