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INTRODUCTION

Problem Definition and Justification of Study

The current agricultural policy of the government of Zaire (GOZ) is directed towards increasing food crop production in order to satisfy national demand and to improve the farmer's income levels and thus their quality of life. Over 78% of the national foodcrop is produced by traditional methods mostly under mixed cropping system. This is especially the case during the first part of the year's crop rotation. In the Kwilu Sub-region about 58% of the area cultivated per household was devoted to mixed crops during the 1979-1980 crop season [PNUD/FAO, 1].

Several studies have been done to evaluate the performance of such a system in achieving the objective of food self-sufficiency in several developing countries. The results of most of these studies indicated an advantage of mixed cropping over sole cropping system in terms in greater gross and net outputs and in reducing the variability of food crop production [Hart, 2, 3; Webster and Wilson, 4 ; Gomez 5]. Apart from the location specific nature of agricultural problems, almost all of these studies are based on an analysis of the two systems by comparing the production of the different crops of a mixture with that of one planted alone. However in the Kwilu Sub-region, food crops (basically cassava, corn and peanuts) may be produced under both mixed cropping and sole cropping systems by the same farmer despite the predominance of the former system. Under these conditions, comparisons between the two systems need consider outputs from all crops of a mixture on one hand and those from pure stands of the different crops of this mixture put together on the other hand.

Purpose of Study

The overall goal of the study is to compare the two systems of cropping to gain an understanding of the

rationale behind the farmers' behavior with respect to choices made. Such an understanding is a prerequisite for introducing suitable changes in traditional agriculture with the aim of enhancing its productivity.

Specific objectives include:

a) to compare intercropping of cassava, corn and peanuts with pure stands of the three crops in terms of efficiency of input use in the aggregate;

b) to evaluate the relative variability in crop productivity (yields/ha) and returns between the two systems.

Previous Work

Several studies have been done in the area of mixed cropping versus sole cropping system. Caldwell [6] indicated that because family farms use their limited resources to produce for both home consumption and sale, they use different production strategies than do agribusiness farms. One such strategy is diversification to reduce risk associated with dependence on one or few types of enterprises. Gomez and Gomez [5] compared various intercrops with pure stands of the same crops using the Land Equivalent Ratio (LER) approach. Over 97 percent of the LER values exceeded 1.0 indicating that intercropping was almost always more production than monocropping despite competition among species. Further, they argue that intercropping offers two important advantages to subsistence oriented farm households. First it enhances the diversity of farm products, a very desirable feature for households of this type. Secondly intercropping increases the stability of farm productivity so that the yield level, even during bad years, is sufficient to satisfy the minimum food requirement of the family.

Similarly, Webster and Wilson [4] pointed out that under traditional subsistence farming conditions, crop mixtures have advantages in checking weed growth, reducing and spreading labor demand and, perhaps, in providing greater assurance of food supply since some crops are likely to give a fair yield even if bad weather, pest or diseases cause partial or total failure of others. Agbola and Fayemi [7] found that interplanting with legumes could supply the nitrogen requirement of corn for at least two or three seasons after cleaning from bush fallow.

In the Kwilu Sub-region of Zaire, Fresco [8] noted the effects of mixed cropping on pest incidence. She concluded that cassava intercropped with legumes on soils in the forest and valleys seemed to be in much better phytosanitary condition whereas large monoculture fields enable diseases and pest to spread.

Norman [9] considered the gross and nat returns per acre, gross returns per person-hour, the variability of return (coefficient of variation) from sole and mixed crops. He also used the Cobb-Douglas production function to analyze the rationality of mixed cropping in northern Nigeria. He concluded that, although the yields of individual crops were lower when grown in mixtures, the decrease was more than offset by the yields of other crops in the mixtures. He further found that the practice of mixed cropping under indigenous technological and economic conditions is consistent with the goals of security and profit maximization. In a similar study, Raul and Hart [10] observed that intercropping combinations in Central America are associated with greater gross and net returns and economic efficiency (income to cost ratio than those resulting from pure stand crops. Also the stability of the different cropping systems, as measured by the coefficient of variability of total biomass produced by a cropping system, is greatly increased by changing from one to two crops but does not seem to be affected by increasing this to three crops. In addition, the Land Equivalent Ratio (LER) has a positive linear relationship with the number of crops up to three crops in a cropping system. Adding the fourth did not increase LER.

Flinn [11] discussed various agroeconomic considerations in cassava intercropping research. He pointed out that the most usual and practical way of evaluating the relevance of cropping patterns and cultural techniques is through budget analysis focusing on the return to the farmer's most limiting resources, and the variability of these returns. Variable returns result from differences in weather over time, differences in response over space or sites, and differences due to farmer's management. On this basis, if the farmer is risk adverse, he may prefer pattern A with a lower coefficient of variation (variability) to pattern B with a higher variability, even if pattern A yields a lower expected net benefit. Dillon [12, page

103] and Anderson, et.al. [13] indicated that although the approach discussed above has intuitive appeal for appraising risky outcome and alternatives, it is somewhat arbitrary. The decision based on the maximization of expected utility provides the most rigorous basis for risk choice. However,, according to Flinn [11], this maximization of expected utility approach has not been widely applied to the evaluation of cropping innovations in developing countries partly because of difficulty and instability in estimation and lack of understanding of the utility functions of low resource, traditional farmers.

Lee, Brown, and Lovejoy [14] described how alternative criteria and alternative income distributions predicted adoption of a reduced tillage practice in the watersheds in the Central Indiana. They found that the mean expected income criterion did as well or better than both mean-variance and Stochastic Dominance for both objective and subjective income distributions. In addition they concluded that if these results are not specific to this one experiment, the study implies that the mean or the mean-variance criterion may be preferable to stochastic efficiency criteria where the researcher has only objective income distributions with which to work.

PROCEDURE

Theoretical Framework/Method of Analysis

Different procedures are used to test the objectives, hence the theoretical framework and method of analysis are presented together.

First Objective: To compare intercropping of cassava, corn, and peanuts with pure stands of the three crops in terms of efficiency in aggregate input use.

The concept of income equivalent ratio (IER) and Income Cost Ratio (ICR)[1] are employed here. IER represents the area needed under sole cropping to yield the same income as is obtained from 1 ha of intercropping at the same management level. Specifically the net income equivalent ratio (NIER) is used. A NIER greater than one implies that land is more efficiently utilized under intercropping than under sole cropping system.

The efficiency of use of inputs other than land (labor, seed, tools) is evaluated on aggregate basis employing the ICR procedure. The greater the ICR, the more efficient is the system in the use of these inputs. Both ratios utilize information on total yields of the various crops in each system, farm gate prices, opportunity cost of labor and seeds and the cost of tools and land.

For an individual farmer, the price of a given quantity of a crop varies between a minimum and maximum and also with time and kind of buyer. It's necessary to consider these various prices in evaluating the marketed portion of each crop. Unsold quantities of the different crops (home consumption, gifts, stock) are also evaluated at these prices. The effects of price variation on the farm decision are analyzed at three levels: minimum, average and maximum. Thus with the three crops under consideration the farmer is faced with 27 different price combinations. With any one of these price combinations, one finds that it is possible

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[1] Income includes value of sales and estimated value of home use.

to evaluate the production of each farmer relative to system 1 (mixed cropping system) or system 2 (sole cropping system) as

$$V_{iz} = \sum_{e=1}^{3} B_{ie} P_{ej} \text{ , where:}$$

V_{iz} = value of the production of the Zth farm in the ith system;

B_{ie} = total yield of the eth crop in the ith system;

P_{ej} = price of the eth crop, given the jth price level

i = 1, 2

e = 1, 2, 3 (cassava, corn and peanuts)

j = 1, 2, 3 price levels

The net value of a given farm's production is obtained as the difference between Viz and the opportunity costs of labor and seeds for each farm in each system and the depreciated cost of tools for each farmer. The average net value of the crop production per hectare in the system (NV_i) for a given price combination is obtained as the ratio of the sum of individual net values in each system to the total hectarage in the system. Thus, the NIER is computed as:

$$NIER_j = \frac{NV_{1j}}{NV_{2j}} \text{ , where:}$$

$NIER_j$ = net income equivalent ratio given the jth price combination, and

NV_{ij} = average net value of the crop production in the ith system, given the jth price combination (net value/ha).

The ICR is obtained as the ratio of the sum of individual values of production under each system, at a given price combination, to the sum of the total costs in the system.

$$ICR_{ij} = \frac{\sum_{z=1}^{ni} V_{iz}}{\sum_{z=1}^{n_i} C_{iz}}, \text{ where}$$

ICR_{ij} = Income-Cost Ratio for the ith system, given the jth price combination;

V_{iz} = Value of production of the zth farm in the ith price combination

C_{iz} = total cost on zth farm in the ith system given the jth price combination and

n_i = number of farms under the ith system.

The opportunity cost of labor is estimated as

$L_{iz} = Wl_{iz}$, where:

L_{iz} = labor opportunity cost on the zth farm in the ith system;

L_{iz} = number of person-days allocated to the ith system by the zth farm and

W = opportunity cost per person-day.

The opportunity costs of seeds for corn and peanuts are also estimated as follows:

$Q_{iez} = q_{iez} P_{ej}$ where:

Q_{iez} = opportunity costs of seeds of the eth crop (corn and peanuts only since cassava cutting are not purchased and have no alternative use) on the zth farm in the ith system,

q_{iez} = quantity of seeds of the eth crop (corn and peanut) used on the zth farm in the ith system, and

p_{ej} = price of the eth crop at the jth price combination.

It is supposed that these quantities of seeds could either have been marketed or consumed by the producer[2]. Cost of tools is estimated as a linear depreciation of the values of tools used, i.e.,

$K_z = XT_z$, where

K_z = depreciated value of tools used by the zth farmer,

X = rate of depreciation, and

T_z = value of tools used by the zth farmer.

K_z is allocated to the two systems

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[2] In general, farmers in Kwilu Sub-region get the necessary seeds from stocks.

proportionately to the number of hectares farmed in each system, i.e.,

$$K_{iz} = \frac{A}{B}$$, where

K_{iz} = depreciated value of tools used by the zth farmer under the ith system.

A = K_z times the number of ha cultivated by the zth farmer in the ith system, and

B = Total ha cultivated by the zth farmer in both systems.

NIER and ICR procedures have the advantage of being able to capture the influence of all variables even for those which pose measurement problems. However, their major shortfall is their inability to explicitly evaluate the efficiency in the use of the different factors under each system. Analysis of value of marginal products of these inputs through production function estimation can provide a solution to this problem. This aspect, however, will be undertaken in a separate study.

Second Objective: To evaluate the relative variability in crop productivity (yields/ha) and returns between the two systems.

The relative variability in yields and returns between the two systems are also compared. However, since three different crops are being considered, monetary values (Zaires) are used instead of actual yield values. Gross benefit per ha at a given price combination is a good reflection of the yield per hectare. Hence the gross benefits per ha of each individual farm under each system is estimated. The average gross benefit per ha and the coefficient of variation of the above individual values are then compared under the two systems. The preferred system might be the one with a higher average gross benefit per ha and a lower coefficient of variation (C.V.). However, an extremely risk averse farmer may even prefer a system with a lower expected gross benefit per ha and a lower coefficient of variation. This procedure is repeated for the analysis of net returns.

SURVEY DESIGN AND INFORMATION OVERVIEW

Survey Sampling Procedure

Zaire is divided into nine regions which are subdivided into a number of sub-regions. Each sub-region is then divided into zones which are made of collectivities consisting of several villages.

The primary data for the study were obtained from a survey conducted in October and November 1985 on the 1984-1985 crop season. It covered five zones of the Kwilu Subregion; Gungu, Bulungu, Idiofa, Masi-Manimba and Bagata. A collectivity was selected at random from each zone and 3 to 5 villages were surveyed covering an average of six farm-households per village. Over 90% of the rural population of this Sub-region are farmers.

The number of farmers to be interviewed were assigned to these five collectivities according to the ratio of population in the zone to the population of the region. A total of 108 farmers were selected for the sample. The number was limited to 108 primarily because of time and transportation constraints. The sample size in each zone was determined as

$$\Omega = \frac{\Gamma(108)}{\theta} \text{ where}$$

Ω = number of farmers to be interviewed in a given collectivity;

Γ = total population of the zone of the considered collectivity;

θ = total population of the Kwilu Sub-region of Zaire,

The results were 27 interviews in Bulungu zone (Luniungu Collectivity), 17 in Gungu (Gungu Collectivity), 30 in Idiofa (Mateko Collectivity) and 24 and 10 interviews respectively in Masi-Manimba (Masi-Manimba Collectivity) and Bagata (Wamba Collectivity).

Sample Characteristics

Mixed Cropping Versus Sole Cropping

Over 60% of interviewed farmers reported cassava, corn and peanuts in mixed stands. Of these mixed stands, 40.5% had all three crops, 25.4% had cassava and corn, 14.7% cassava and peanuts and only 8.6% were of corn and peanuts mixture. It's worth noting that cassava usually follows corn and peanuts in pure or mixed stands after these crops have been harvested in the double cropping system. Our study considers only the first part of this rotation. In the case of farmers with crops in pure stands, 33.5% had all three crops, 29.7% had two and 31.1% had only one crop in pure stands.

Farmers advanced several reasons for their preference for mixed crops over sole crops. These included traditional values, less labor requirement and better or more intensive use of fertile soils. Risk was never given as a reason or rationale for their choice. However, the risky nature of farming might be captured in the word "tradition", i.e., farmers are using cropping techniques that their parents and grand-parents taught them. Quite probably, these ancestors had considered this risk aspect in introducing and accepting mixed cropping over sole crops. On the contrary, however, the extension service personnel visited in each collectivity cited risk-management as a reason for the farmers' choice, particularly the risk of harvest losses due to pest or disease incidence. In this case, it's advantageous for farmers to mix peanuts with cassava and/or corn since this association provides an implicit rotation within each year [Norman, 9] which (as a year-to-date rotation) reduces pest and disease incidence. In fact, given the crop specific nature of insect pests and of some diseases [Leihner,15] any crop mixture constitutes a mechanical barrier to specific insects or diseases. The pest control mechanism is of tremendous importance to the small farmer who cannot use purchased inputs to control diseases and pests [Thung, Cock, 16]. Further-

more, the quick groundcover of peanuts reduces weed growth, hence, the quantity of labor needed for weeding. Citing "less-work" as a reason for choosing mixed cropping, farmers are referring to this reduction in the needed weeding. In addition, multiple cropping system in general allowed for the maximum use of past labor. For example, planting cassava in fields previously under corn and/or peanuts requires almost no additional work for land preparation. Farmers also revealed that the number of crops grown simultaneously in a given field depends on the soil's fertility level. Three to five crops are grown on newly cleared forest land while only 2-3 are grown on less fertile land such as soil in savanna areas. Hence most of the pure stands are found in the Gungu Collectivity where soils are generally of poor quality. Maximizing the use of available soil nutrients is implied by this practice. Species of different growth habits and root systems can be intercropped in such a manner that they don't compete for soil nutrients, but utilize the nutrients not absorbed by the companion crops.

Primary Causes of Production Variability

Several factors contribute to the variation in productivity among which are declining soil fertility and incidence of pests and diseases. According to farmers and extension service personnel, soil fertility has declined considerably due to repeated fires on lands for cropping and hunting purposes, shortened fallow periods and cropping along slopes susceptible to erosion mechanisms. In the Bulungu Zone, yield of cassava has dropped from 5-7 harvestable roots some 8 years ago to only 2-3 roots. Cassava and peanut growers in Gungu Collectivity often realize total crop failures partly because of poor fertility of soils.

Pest and disease infestation are frequent, particularly attacks on cassava by Bacterial Blight, Mosaic Disease, Anthracnosis, and Mealy Bugs. Peanut fields experience less frequent infestation than those of cassava. Corn seems to be the least susceptible in the study area.

Other major problems faced by these farmers are the shortage of rainfall immediately after planting and the destruction of crops by domestic animals such as cattle goats and sheep.

Primary Causes of Variability in Farmgate Prices

Farmers received different prices for a given quantity of a crop during the same cropping year. Causes of this variability included the number of available buyers, a general shift in the demand for the commodity and price discrimination on the part of the farmers themselves.

As an illustration, a sole buyer of corn in Mateko Collectivity during the 1985 marketing period offered 300 Z per 60 kg-sack at the beginning of the season and 250 Z further into the season.

This price variation appeared to be due to the increase in supply as the marketing season advances. In the Gungu, Bilungu and Masi-Manimba zones, the three crops were in high demand by local consumers, local merchants and merchants from the market center of Kinshasa. In addition farmers in these zones charged different prices for a unit of the commodity depending on the buyer - lower prices to locals and higher prices to outsiders (Table 1). Further prices received by farmers for sacks of cassava, corn or peanuts in Kinshasa were higher than those obtained in local markets (Table 2).

Table 1 Prices received in the Kwilu Sub-Region of Zaire (1984-85).

Collectivity	Zaires/sack of cassava cossettes	Zaires/sack of corn (grains)	Zaires/sack of peanuts (husks)
Luniungu			
local buyers	200; 250; 300*	240; 300*	450; 500*
outsiders	250; 350	330; 400	500; 550
Masi-Manimba			
local buyers	250; 300		
outsiders	300; 350		
Gungu			
local buyers	200; 260	400; 450	
outsiders	250; 280		

*Different prices received from different buyers and/or at different times.

Table 2. Prices received by Kwilu Farmers, by market and collectivity (1984-1985).

Collectivity	Zaires/sack of cassava cossettes		Zaires/sack of corn (grains)		Zaires/sack of peanuts (husks)	
	Kinshasa[a]	local	Kinshasa[a]	local	Kinshasa[a]	local
Masi-Manimba	600	350	600	300		
Wamba	500	300				
Mateko	450	300			550	400

[a]Consumer price at Kinshasa less the transportation and other transaction costs (i.e. price received by farmer for crops sold at Kinshasa market).

DATA EVALUATION AND RELATED TRANSFORMATIONS

Size of Farms

Sizes of individual holdings were obtained from extension agents and farmers' actual measurements. Figures on the farm sizes in hectares under each system were thus obtained. The average farm size per household was obtained as the sum of all the individual farm sizes divided by 108. Table 3 gives this average as well as that obtained from a survey by FAO. These figures demonstrate a stagnation of the average farm size in either system.

Table 3: Average Farm Size and Crop Yields under Mixed and Sole Cropping Systems in the Kwilu Sub-Region of Zaire (1979-1985).

Crop System	1980[1]		1985	
	ha	yield (tons/ha)	ha	yield (tons/ha)
Mixed crops	0.78		0.82	
Cassava[2]	0.68	1.70		
Corn (grain)	0.56	0.45		
Peanuts (husk)	0.42	0.15		
Pumpkin	0.28	0.08		
Millet	-	-		
Others	0.10	-		
Sole Crops	0.56		0.51	
Cassava[2]	0.18	5.00	0.15	2.35
Corn (grain)	0.11	0.80	0.15	0.68
Peanuts (husk)	0.16	0.70	0.13	0.57
Pumpkin	0.13	0.50	-	-
Millet	-	-	0.06	-
Others	0.08	-	0.03	-
Total	1.34		1.3299	

[1] Source: PNDU/FAO (26).
[2] Cossette

Crop Yields

Units of measurement of crop yields varied. Some were given as number of sacks, basins or baskets of the commodity. The number of basins or baskets making a sack of the commodity also varied, two in some collectivities and three in others. It was also estimated that a sack of corn grain on the average weighed 60 kg while a sack of cassava cossettes and that of peanuts (husks) weighed 50 and 38 kg respectively. These figures were used to obtain individual crop yields (Tables 3, 4, 5).

Peanuts and corn yields per hectare show a decrease of 18.6 and 15 percent respectively in the pure cropping system. This decline can be attributed to the loss in soil fertility over the years in the Sub-region. For cassava an average yield of 4 tons of fresh tubers/ha or 1.40 tons[1] of cassava cossetes/ha has been noted by Fresco L. [8].

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[1] 100 kg of fresh tubers yielding approximately 35 kg of cassava cossettes (see Fresco [8, p.5].

Table 4. Summary of the First Survey Data from the Five Collectivities Visited (averages) - 1984-1985.

ITEM/SYSTEM	AVERAGE (yield, guantity or value of input
Mixed crops	
(1) Cassava - Yield (total yield in kg)	1,062.3
(2) Corn	
- Yield (total yield in kg)	333.0
- kg of seeds	19.0
(3) Peanuts	
- Yield (total yield in kg)	223.1
- kg of seeds	66.1
(4) Labor allocated to S_1 (person-days)	198.4
(5) Value of tools assigned to S_1 (2)	138.3
Sole crops	
(1) Cassava	
- Yield (total yield)	761.3
(2) Corn	
- Yield (total yield in kg)	212.6
- kg of seeds	8.6
(3) Peanuts	
- Yield (total yield in kg)	158.3
- kg of seeds	21.8
(4) Total labor allocated to S_2 (person-days)	166.9
(5) Value of tools assigned to S2 (Z)	153.2

Table 5. Yield, Seeds: Labor and Tool Value Average (per household) from the 1985 and 1986 surveys.

Item	Cassava yield (kg)	Corn yield (kg)	Peanuts yield (kg)	Corn seeds (kg)	Peanuts seeds (kg)	Labor used (person-days)	Total tool-value (Z)
A. First round survey [a]							
- Total	130,739.1	38,270.2	26,434.23	2,008.37	6,641.78	25,126	79,657
- Average	1,210.55	354.35	244.76	18.6	61.5	232.55	737.56
B. Second round survey [b]							
- Total	64,137.5	17,665	12,110	912.6	4,120	13,627	62,625
- Average	1,068.96	294.42	201.83	15.21	68.67	227.12	1,043.75

(a) First survey undertaken in October-November 1985 (and corresponds to the crop year 1984-1985).

(b) Second survey undertaken in June-July 1986 (and refers to the crop year 1985-1986)..

Furthermore experiments conducted by PRONAM ("Programme National Manioc") in peasants' fields (in pure stands), yielded an average of 7 tons of fresh tubers/ha or 2.45 tons of cossettes/ha [Fresco L.; 8]. Thus, an average yield of 5 tons of cassava cossettes/ha or 15.15 tons of fresh tubers/ha as reported in the 1980 survey appears to be an exaggeration. The average production per household in current survey is 1,210.55 kg of cassava cossettes, 354.35 kg of corn and 244.76 kg of peanuts. These figures are comparable with those advanced by the "Division Régionale de l'Agriculture - Bandundu [17] and the Département de l'Agriculture et du Développement Rural [18] which reported 1,717.78 kg of cassava cossettes, 310 kg of corn (grains) and 330 kg of peanuts per farm-household in 1980. The large difference in the case of cassava yield per household is basically because the current estimation does not include the production of cassava planted after corn and peanuts associations and/or pure stands.[2]

Input of Seeds

Various units of measurements were used by farmers - Kg of corn grains, portions of a sack of corn ears, sacks, basins or baskets of peanut husks and kg of hulled peanuts. Conversion rate of 26.3 kg of corn grains per sack of corn ears, 70 kg of hulled peanuts per 100 kg of husks were used [Ministère de la Cooperation, 19 p. 737] to estimate seed quantities.

Quantities of seeds of corn and peanuts average 27.3 kg/ha of corn and 78.3 kg/ha of peanuts in the case of single cropping system. These figures lie within the limits indicated in most agronomic literature: 14 - 40 kg of corn (grains) and 40 - 200 kg of

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[2]Only the production of the first part of the rotation is considered in this analysis. Otherwise, all farms are cases of multiple cropping system.

peanut husks per ha, depending on the crop density, the germination power and on the plant variety.[3]

Labor Requirements

Labor usage for the various cropping activities is obtained in man-days based on a 5-day workweek. These are 5-hour workdays. The number of workers varies with the type of activity involved. Land preparation involves both men and women. However, the latter spend an average of 5 days per month on this activity. Contrarily, other activities such as seeding or planting, crop maintenance and harvesting are virtually done solely by women.

Cassava is harvested over a period longer than one year hence labor requirement for this activity is difficult to estimate. Our estimation is based on procedure used by Ministère de la Cooperation [19]. Here a hectare of pure stand of about 10,000 cassava plants requires about 30 person-days of 8 working hours per day. This corresponds to 48 person-days on the basis of 5 work-hours per day utilized in our study. Thus for our average of 4,000 cassava plants per ha in the mixed cropping system, 19.2 person-days will be required to accomplish the task. The total quantity of labor required for harvesting per farmer is obtained on this basis (Tables 4 and 5). The average quantities of person-days is 232.6 person-days per household for both systems. Fresco L [8] noted that the time input into agricultural production can be estimated at 1562 hours or 313 person-days per household per year in the Kwilu

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[3] Ministère de la Cooperation [19] proposes 15-25 kg of corn grains per ha and 100-150 kg of peanuts husks per ha; Vandenput [20] suggests 30 kg of corn grains per ha (1 X 0.5 m) and 100 kg of peanuts husks per ha (20 X 20 cm); Département de l'Agriculture et du Développement Rural [18] mentions 200 kg of peanuts per ha; Fresco L. [8] advises 30-40 kg of corn grains/ha, and 80 kg of peanuts husks/ha.

Sub-region. However, it should be noted that our figures are for only the three major crops, whereas the latter refers to all agricultural production of the farm-household.

For the sole cropping system, the quantities of person-days per ha averaged 182.7 for cassava, 150.1 for corn and 216.8 for peanuts.

Estimates by Ministère de la Cooperation [19] and Vandenput [20] are 98-120 person-days/ha for cassava, 157 for peanuts and 124.3 for corn on the basis of 8-hour days. Converted to 5-hour day basis, these figures yield 156.8 - 192 for cassava, 198.9 for corn and 251.2 for peanuts. These estimates do not deviate much from ours.

Labor Opportunity Costs

Labor opportunity cost was estimated on the basis of gains from available non-farm activities. The estimate averaged 364.5 zaires per month or 14.02 zaires per day or 1.75 zaires per hour. In addition, the estimates of hours spent on farming activities were obtained. The average labor opportunity costs per person-day (zaires/day of 5 work hours) for each collectivity was used to evaluate the quantity of labor utilized by each farmer under each system. Some of the non-farm activities included hunting, fishing, collecting palm oil fruits in the wild, and basket weaving yielding 8.75 zaires per day of 5 work-hours. This is comparable with the wage rate earned by the lowest paid public administration worker until June 1985 (roughly 274 Zaires per month, 10.54 zaires per day or 1.32 zaires per hour (Table 6).

Value of Tools Used

The total values of the different farm implements were obtained for each farmer. In addition, an average depreciation rate was computed for each collectivity. The value of the tools for the 1984-85 crop season was then computed as the product of the depreciation rate and the total value of tools for the farmer (Tables 4 and 5).

Table 6: Estimates of Hours of Work per Day and Wage Rates in the Kwilu Sub-Region of Zaire (1984-1985)

ITEM	COLLECTIVITY					AVERAGE
	GUNGU	LUNTUNGU	MATEKO	MASI-MANIMBA	WAMBA	
A. Hours of work per day (hours)*						
- Males	5.375	4.800	3.720	3.357	4.000	4.100
- Females	6.400	7.200	7.958	6.456	6.200	6.978
- Total	6.043	6.171	5.796	5.250	5.222	5.727
B. Wage rates						
- Zaires per month	377.000	443.250	311.000	322.929	355.000	361.507
- Zaires per day (of 8 working hours)	14.500	17.048	11.962	12.420	13.654	14.019
- Zaires per hour	1.812	2.131	1.495	1.553	1.706	1.750
- Zaires per day of 5 working hours	9.06	10.66	7.48	7.76	8.53	8.75

* Hours allocated to farming activities (including break time and time for walking to and from fields).

Farmgate Prices

Prices were obtained in Zaires per sack, basin or basket of the commodities then converted to Zaires per kg using the conversion rates described earlier (Table 7).

Table 7: Average of Prices Received by Farmers in the Kwilu Sub-Region of Zaire in 1984-1985 (zaires/kg).

CROP	LOWEST PRICE (Po)	AVERAGE PRICE (P_1)	HIGHEST PRICE (P_2)
1. Cassava (cossette)	4	6.3	12
2. Corn (grains)	3.5	5.4	10
3. Peanuts (husks)	6.5	10.6	16.5

RESULTS AND ANALYSES

Efficiency of Input Use

Estimates of NIER and ICR at the various price combinations are presented in Table 8. NIER estimated is above 1 at any given price combination (1.16 to 1.27 with an average of 1.21). This implies that mixed crops yield more net income per hectare (16.62 to 20.86 percent or an average of 20.7 percent) than a hectare of crops in pure stand. Mixed cropping is thus more profitable than sole cropping system in terms of land use. Given, then, that amount of land that can be prepared and cultivated manually is limited, traditional farmers would be better off under mixed cropping rather than under sole cropping system. The figures also exhibit very little variation over the price range meaning that changes in prices do not yield substantial relative variation on net outputs between the two systems.

The ICR from each of the two systems is greater than 1 at any price combination again implying efficient use of resources in both systems.

Thus the NIER and ICR indicate the resources (except land) are efficiently used in both systems. However, these two procedures do not allow the evaluation of the efficiency in the use of individual inputs. An analysis of the value of marginal products of these inputs is one way of solving this problem. However, this is not handled in the current study.

Variability in Gross and Net Returns

The ratio of the coefficient of variation for sole cropping to that of mixed cropping is a measure of relative variability between the two systems. A ratio greater than 1 indicates that the characteristic under investigation is more variable under sole cropping than under mixed cropping system.

Variability in gross benefits per hectare is, therefore, greater under sole cropping than under mixed cropping irrespective of prevailing price combination implying a far greater risk under the former than under the latter system of farming (Table 9). Similar conclusion can be reached in terms of variability in net returns.

Table 8. Estimates of NIER and ICR given the Different Price Combinations

CROP SYSTEM

	P_1	P_2	P_3	P_4	P_5	P_6	P_7
S_1							
(1) Gross income/ha (naires)	6380.0	7241.8	8481.9	6976.1	7837.9	9078.0	8419.3
(2) ICR -	2.8	2.9	2.984324	3.09	3.12	3.15	3.60
(3) Net income/ha (naires)	4161.4	4767.3	5639.7	4723.1	5329.3	6201.8	6083.8
S_2							
(1) Gross income/ha (naires)	5252.598	5960.261	6978.603	5692.926	6400.589	7418.931	6758.984
(2) ICR	2.761142	2.978834	3.256959	2.964856	3.170684	3.433924	3.442754
(3) Net income/ha (naires)	3350.270	3959.190	4835.929	3772.790	4381.911	5258.449	4795.735
NIER	1.242115	1.204045	1.166213	1.251877	1.216214	1.179393	1.268593

	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}
S_1							
(1) Gross income/ha (naires)	9281.053	10521.15	8631.562	9493.321	10733.41	9227.659	10089.42
(2) ICR	3.582109	3.556125	3.889842	3.836479	3.776526	4.095643	4.022045
(3) Net income/ha (naires)	6690.107	7562.547	6412.562	7018.833	7891.273	6974.617	7580.088
S_2							
(1) Gross income/ha (naires)	7466.646	8484.989	7161.348	7869.011	8887.353	7601.676	8309.339
(2) ICR	3.621437	3.8850521	3.764518	3.932794	4.147786	3.958926	4.116228
(3) Net income/ha (naires)	5404.855	6281.394	5259.020	5868.140	6744.679	5681.540	6290.611
NIER	1.237796	1.203960	1.219345	1.196092	1.17000	1.227593	1.205102

	P_{15}	P_{16}	P_{17}	P_{18}	P_{19}	P_{20}	P_{21}
S_1							
(1) Gross income/ha (naires)	11329.51	10670.84	11532.60	12772.69	14211.49	15073.24	16313.34
(2) ICR	3.939081	4.569054	4.451115	4.317143	6.404452	6.091461	5.739808
(3) Net income/ha (naires)	8453.328	8335.383	8941.655	9814.095	11992.48	12598.76	13471.20
S_2							
(1) Gross income/ha (naires)	9327.681	8667.734	9375.396	10393.74	11891.73	12599.39	13617.73
(2) ICR	4.317408	4.414994	4.547210	4.716719	6.251143	6.296954	6.355483
(3) Net income/ha (naires)	7167.199	6704.485	7313.605	8190.144	9989.397	10598.52	11475.06
NIER	1.179447	1.2432547	1.222606	1.198281	1.200521	1.188728	1.173955

Table 8 (continued)

	P_{22}	P_{23}	P_{24}	P_{25}	P_{26}	P_{27}
S_1						
(1) Gross income/ha (zaires)	14807.58	15669.34	16909.43	16250.77	17112.52	18352.0
(2) ICR	6.572260	6.246425	5.879126	6.958272	6.604738	6.203145
(3) Net income/ha (zaires)	12554.54	13160.81	14033.25	13915.31	14521.58	15394.02
S_2						
(1) Gross income/ha (zaires)	12332.05	13039.72	14058.06	13398.11	14105.77	15124.12
(2) ICR	6.422490	6.459533	6.506909	6.824458	6.841515	6.863382
(3) Net income (zaires)	10411.92	11021.04	11897.55	11434.86	12043.98	12920.52
NIER	1.205786	1.194153	1.179505	1.216919	1.205712	1.191439

Table 9: Mean and Variability of Gross and Net Returns per Hectare at Various Price Combinations.

Price	Statistic	Relative Variability in Gross Returns			Relative Variability in Net Returns		
		Mixed Crops$_1$	Sole Crops$_2$	$C.V_2/CV_1$	Mixed Crops$_1$	Sole Crops$_2$	$C.V_2C.V_1$
P_1	Mean	6,436.2	4,996.5		4,043.1	2,765.2	
	Std Dev.	2.164.6	2,856.4		2,273.3	3,265.1	
	C.V.	33.6	57.2	1.70	56.2	118.1	2.10
P_2	Mean	7,127.4	5,742.0		4,522.9	3,277.5	
	Std Dev.	2,501.6	3,144.1		2,540.8	2,929.0	
	C.V.	35.1	54.8	1.56	56.2	89.4	1.59
P_3	Mean	8,411.2	7,125.8		5,414.0	4,499.5	
	Std Dev.	3,313.2	4,125.5		3,181.2	3,751.3	
	C.V.	39.4	57.9	1.50	58.8	83.4	1.42
P_4	Mean	8,207.4	6,625.9		5,443.8	4,093.5	
	Std Dev.	2,942.1	3,259.3		2,974.7	3,023.6	
	C.V.	35.8	49.2	1.37	54.6	73.9	1.35
P_5	Mean	7,812.4	6,200.1		5,169.7	3,717.6	
	Std Dev.	2,739.1	3,027.9		2,815.1	2,848.4	
	C.V.	35.1	48.8	1.39	54.4	76.6	1.41
P_6	Mean	9,096.2	7,583.9		6,060.7	4,939.5	
	Std Dev.	3,472.9	3,957.8		3,391.3	3,613.9	
	C.V.	38.2	52.2	1.37	56.0	73.1	1.31
P_7	Mean	9,865.8	7,735.1		7,009.7	5,158.9	
	Std Dev.	3,801.2	3,317.1		3,896.7	3,171.1	
	C.V.	38.5	42.9	1.11	55.6	61.5	1.11
P_8	Mean	9,470.7	7,309.3		6,735.5	4,782.9	
	Std Dev.	3,662.8	3,166.0		3,784.9	3,072.4	
	C.V.	38.7	43.3	1.12	56.2	64.2	1.14

Table 9: Continued

Price	Statistic	Relative Variability in Gross Returns			Relative Variability in Net Returns		
		Mixed Crops$_1$	Sole Crops$_2$	$C.V_2/CV_1$	Mixed Crops$_1$	Sole Crops$_2$	$C.V_2C.V_1$
P_9	Mean	10,759.5	8,693.1		7,626.6	6,004.8	
	Std Dev.	4,193.1	3,869.8		4,205.8	3,611.0	
	C.V.	39.0	44.5	1.14	55.2	60.1	1.09
P_{10}	Mean	9,759.5	7,759.9		7,034.1	5,245.7	
	Std Dev.	3,389.4	4,784.3		3,375.3	3,623.3	
	C.V.	34.7	61.7	1.78	48.0	69.1	1.44
P_{11}	Mean	9,364.5	7,334.2		6,759.9	4,869.7	
	Std Dev.	3,200.1	4,648.6		3,221.7	4,040.7	
	C.V.	34.2	63.4	1.85	47.6	83.0	1.74
P_{12}	Mean	10,648.3	8,718.0		7,651.0	6,091.7	
	Std Dev.	3,886.3	5,247.5		3,774.3	4,530.7	
	C.V.	36.5	60.2	1.65	49.3	74.4	1.51
P_{13}	Mean	10,444.4	8,218.1		7,680.9	5,685.7	
	Std Dev.	3,549.6	4,613.6		3,571.6	3,977.8	
	C.V.	34.0	56.1	1.65	46.5	70.0	1.50
P_{14}	Mean	10,167.9	7,920.0		7,489.0	5,568.7	
	Std Dev.	3,426.1	4,525.0		3,471.3	4,695.8	
	C.V.	33.7	57.1	1.70	46.4	84.3	1.82
P_{15}	Mean	11,333.2	9,176.1		8,297.8	6,531.7	
	Std Dev.	4,012.9	5,048.8		3,943.2	4,340.4	
	C.V.	35.4	55.0	1.55	47.5	66.4	1.40
P_{16}	Mean	12,102.8	9,327.3		9,246.8	6,751.1	
	Std Dev.	4,264.9	4,471.2		4,347.8	3,887.9	
	C.V.	35.2	47.9	1.36	47.0	57.6	1.22
P_{17}	Mean	11,707.8	8,901.5		8,972.6	6,375.1	
	Std Dev.	4,136.7	4,402.7		4,240.6	3,859.7	
	C.V.	35.3	49.5	1.40	47.3	60.5	1.28

Table 91. Continued

Price	Statistic	Relative Variability in Gross Returns			Relative Variability in Net Returns		
		Mixed Crops$_1$	Sole Crops$_2$	$C.V_2/CV_1$	Mixed Crops$_1$	Sole Crops$_2$	$C.V_2C.V_1$
P_{18}	Mean	12,991.6	10,285.3		9,863.7	7,597.0	
	Std Dev.	4,628.4	4,809.2		4,641.9	4,147.7	
	C.V.	35.6	46.8	1.31	47.1	54.6	1.16
P_{19}	Mean	15,303.5	11,705.8		12,578.1	9,191.6	
	Std Dev.	5,385.9	8,922.7		5,367.5	7,996.0	
	C.V.	35.2	76.2	2.17	42.7	87.0	2.04
P_{20}	Mean	14,908.5	11,280.0		12,304.0	8,815.6	
	Std Dev.	5,258.5	8,902.6		5,257.6	8,007.6	
	C.V.	35.3	78.9	2.24	42.7	90.8	2.13
P_{21}	Mean	16,192.3	12,663.9		13,195.0	10,037.5	
	Std Dev.	5,733.2	9,065.9		5,657.7	8,069.5	
	C.V.	35.4	71.6	2.02	42.9	80.4	1.87
P_{22}	Mean	15,988.5	12,164.0		13,224.9	9,631.6	
	Std Dev.	5,469.2	8,734.9		5,475.5	7,808.5	
	C.V.	34.2	71.8	2.10	41.4	81.1	1.96
P_{23}	Mean	15,593.4	11,738.2		12,950.7	9,255.6	
	Std Dev.	5,348.4	8,725.5		5,370.3	7,831.2	
	C.V.	34.2	74.3	2.17	41.5	84.6	2.04
P_{24}	Mean	16,877.2	13,122.6		13,841.8	10,477.6	
	Std Dev.	5,801.8	8,856.2		5,754.0	7,859.3	
	C.V.	34.4	67.5	1.96	41.6	75.0	1.80
P_{25}	Mean	17,646.8	13,273.2		14,790.8	10,696.9	
	Std Dev.	5,916.0	8,417.8		5,971.6	7,499.8	
	C.V.	33.5	63.4	1.89	40.4	70.1	1.74
P_{26}	Mean	17,251.8	12,847.4		14,516.6	10,321.0	
	Std Dev.	5,814.9	8,436.3		5,880.9	7,550.8	
	C.V.	33.7	65.7	1.95	40.5	73.2	1.81
P_{27}	Mean	18,535.[illegible]	14,453.1		15,407.7	11,690.3	
	Std Dev.	6,202.5	8,294.8		6,217.0	8,474.0	
	C.V.	[illegible]	[illegible]	1.71	40.4	72.5	1.80

There is a substantial variability in the gross and net returns from both systems across price level (C_0V_2/CV_1 ranges from 1.11 to 2.24 in terms of gross returns and 1.1. to 2.13 for the net), again with the variability under sole cropping (0.43 to 0.76 for gross and 0.54 to 1.18 for net returns being wider than that under mixed cropping system (0.33 to 0.39 for gross and 0.40 to 0.59 for net returns). This suggests that price instability yields a larger return instability (risk) under sole crops than under mixed crops. Such a situation is easily understandable under the classical analysis of mixed versus sole cropping system where a pure stand of say cassava crop is compared with a mixed stand of cassava, corn and peanuts. In this case, an increase (decrease) in cassava price lead to a wider change in returns under sole cropping than under mixed cropping where this price change may be offset by opposite changes in the price of corn and/or peanuts. In the present study, the variability in returns with respect to price levels might be due to the fact that not all farmers practicing mixed cropping planted all three crops. In fact, the majority of these farmers had only two of the crops. Furthermore, about 31.1% of the farmers practicing sole cropping had only one type of crop in pure stands making variability in returns from the system more sensitive to price changes. The analysis of NIER and ICR failed to indicate this situation because of the high degree of averaging to which the figures were subjected.

One reason given by some farmers for practicing sole cropping was soil fertility. The soils in some parts of the region are not fertile enough to sustain more densely cropping pattern that mixed cropping tends to impose. The farmers are thus, obliged to reduce the number of crops in mixtures and even to resort sole cropping system. In addition, farmers who are aware of competition among plants for environmental elements like light and water tend to practice sole cropping irrespective of soil condition. However, soil fertility can be improved by other farming practices such as manuring, mulching and frequent weed control. It is also possible to reduce substantially, competitive effects of intercropping by adequate spacing, proper

choice of crop mixtures (relation to their growth habit) etc. Hence, mixed cropping remains the recommended system, for achieving greater farm-outputs with less risk.

CONCLUSION AND IMPLICATIONS

Intercropping combinations of cassava, corn and peanuts are compared with pure stands of the same crops to determine the more economically advantageous system to traditional farmers of the Kwilu sub-region of Zaire. The Net Income Equivalent (NIER) and Income-Cost Ratio (ICR) are employed to evaluate the efficiency of each system in terms of the use of land, labor, tools and seeds.

The possibility of risk consideration on the part of farmers in choosing between the two systems in analyzed under the variability in the productivity of different crops. This is done by comparing the two systems in terms of the average gross and net returns per ha and associated coefficients of variation.

The NIER has an average value of 1.2. This means that land is more efficiently utilized under mixed crops than under sole crops (a ha of mixed crops yielding 20.7% higher returns than a ha of crops in pure stands). The ICR, with an average of 4.5 for mixed crops and 4.67 for sole crops, shows that these farmers are making an efficient use of the different inputs as a whole under either system.

In all cases, average returns for mixed stands remain substantially higher than that from pure stands. The difference in the variability in crop yields under sole cropping and that under mixed cropping system is high enough to support the belief that the former system remains riskier than the latter even when these are pure stands of all the different crops in mixtures. Due to the fact that not all farmers have all three crops, price variability yields considerable return instability. Again this is found to be greater under sole cropping than under mixed cropping system. Under these conditions, the farmer's choice should clearly fall on the mixed cropping system. Hence farmers in the region under study are making the right decisions given the available resources, technology and economic circumstances.

Implications

When introducing new technologies in the Kwilu traditional agriculture, effects should be undertaken in adapting and combining them with crop mixtures which appear to be well adopted cropping practice in this area. So often in the past, new technologies favor crops in pure stands which then go contrary to the reasonings for choosing a mixed system. Farmers under sole cropping system could move to mixed cropping system in order to increase food production in the sub-region and in Zaire as a whole. However, some corrective measures should be taken to make the move easier. These include improving soil fertility by the use of green or animal manure, mulching and control of bushfire used in land clearing and hunting purpose. Finally there is a severe discrepancy in terms of prices received by farmers at different locations in the region. Pernaps a government instituted price subsidy program can be used to offset the differential.

REFERENCES

PNUD/FAO Rapport Terminal. Dévelopment Rural Integre du Kwilu - Conclusion et Recommandations du Projet, Projet AG: DP/ZAI/78/001, Rome 1982.

Hart, R "A bean, corn and manioc polyculture cropping system. I. The effect of inter-specific competition on crop yield". Annual Crops Program CATIE, 25, Turrialba (Costa Rica) 1975 - pp. 294-301.

Hart, R. "A bean, corn and manioc polyculture cropping. II. A comparison between the yield and economic return from mono-culture and polyculture cropping system. " Annual Crops Program, CATIE, 25, Turrialba (Costa Rica), 1975 - pp. 377-384.

Webster, C.C. and P.N. Wilson. Agriculture in the Tropic 1980.

Gomes, A.A. and K.A. Gomez. Multiple cropping in the Humid Tropics of Asia, 1983.

Caldwell, J.S. "An overview of Farming Systems Research and Development; Origins, Applications and Issues. "Tradition and Dynamics in Small-Farm Agriculture - Economic Studies in Asia, Africa and Latin America. Ames, Iowa State University Press, pp. 25-54.

Agbola, A.A. and A.A. Fayemi, "Preliminary Trial on Intercropping of maize with different Legumes in Western Nigeria". Journal of Agricultural Science, 77, 1971 - pp. 219-225.

Fresco, L. Women and Cassava Production - Kikwit/Zaire, 1982.

Norman, D.W. "Economic Rationality of Tradition Hausa Dryland Farmers in the North of Nigeria." Traditions and Dynamics in Small Farm Agriculture Economic Studies in Asia, Africa and Latin America. Ames, Iowa State University Press, pp. 25-54.

Raùl, A. Moreno and R.D. Hart. "Intercropping with Cassava in Central America. Intercropping with Cassava: Proceeding of an International Workshop held at Trivandrum, India, Nov. 27 - Dec. 1, 1978. Ottawa Ont. IDRC, 1979, pp 17-24.

Flinn, J.C. "Agroeconomic Considerations in Cassava in Central America. Intercropping with Cassava: Proceedings of an International Worksnop held at Trivandrum, India, Nov. 27 - Dec. 1, 1978, Ottawa, Ont. IDRC, 1979 - pp. 87-101.

Dillon, J.L. The Analysis of Response in Crop and Livestock Production: 2nd Edition. Oxford, Pergamon Press