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Productivity and income potentials of intercrop combinations among food crop farmers in Southwestern Nigeria

Jelili Olaide SAKA

Southwest Farming Systems Research and Extension Programme, Institute of Agricultural Research and Training, Moor Plantation, Ibadan, Nigeria.

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Population pressure is impressing on the need to increase productivity of arable cropland in the midst of reported decrease in fallow period. This study examined the agronomic and economic potential of cropping systems of farmers in food crop production. Data were generated through a survey of 341 food crop farmers selected through multi-stage sampling. Data were elicited with the aid of questionnaires. The fallow rotation pattern and cropping intensity index of farmers were determined while Land Equivalent Ratio (LER) and Relative Value Total (RVT) were used to compare the agronomic and economic potential of intercropping relative to monocropping across different crop combinations. The LER estimates were significantly higher for farmers who used fertilizers (1.59) than non-users (1.34). LER was also significantly higher in the Derived savanna agro ecology (1.65) than 1.37 and 1.13 in the forest and southern guinea savanna respectively. Similarly, LER was significantly higher for farmers under low (2.67) and medium (1.67) land-use intensity than for those under high (1.50) and very high (1.37) land-use intensity categories respectively. Generally, RVT of the intercrops was less than 1.0 except for Cassava/yam intercrop (1.17). The study showed that farmers may continue to gain higher yield by intercropping by but, higher productivity could be attained when farmers apply inorganic fertilizer or reduce the level of land-use intensity possibly through longer fallow. The potential under this scenario could also be higher in the derived savannah agro-ecology. Inclusion of more intensive with high market premium could however enhance the economic return from intercrops.

Key word: Crop combinations, yield, economic potential, Nigeria.

INTRODUCTION

"Global Change" refers to the complex of interlinked changes that are altering the contemporary earth at an unprecedented and accelerating rate. It includes the growing demands of the human population for food, fibre and water that have led to a dramatic transformation of the land surface, from quasi-natural cover to cultivated lands (Scholes et al., 2006). In addition to the population driven increase in demand for food, the demand for basic infrastructural facilities due to population growth and increasing pace of urbanization has increased the rate of

E-mail: saka_sakang@yahoo.com, saka_sakang@hotmail.com. Tel: +234-8055110141.

agricultural land alienation especially in Sub Sahara Africa. These factors have to a large extent, been major drivers of increased pressure on agricultural land across these countries.

In addition to the problem of land alienation, the rapid population increase estimated to be at an annual average of 2 to 4% in the midst of lower food production growth rate of 1.9% in Sub Sahara Africa is viewed as being capable of exacerbating the precarious food situation in the region if unabated (FAO, 1996; Rosegrant et al., 2001; Scholes et al., 2006; USDA, 2006; Tappan and McGahuey, 2007). In view of this, a long-standing interest has been generated on greater and more effective utilization of arable land for increased productivity at the farm level.

In Nigeria, increased pressure on arable land is evident in reduction in land-man ratio, average size of farmland (Bamire and Manyong, 2003), increased land use intensity characterized by multiple cropping and intercropping of two or more crops under shortened fallow (Oluwatosin et al., 2008; Saka et al., 2011). While intercropping of two or more crops under shortened fallow are indicative of increased land-use intensification, proponents of agricultural intensification (Sivanappan, 1995; Jabar et al., 1998; Cassman, 1999) identified commensurate use of modern inputs as essential conditions for sustainable increase in productivity, in the absence of which intensification could lead to rapid land degradation.

Intercropping is traditionally noted for its role as a risk aversion measure. Its persistence in the Nigeria food sub-sector is further justified by the increasing threat of climate variability in recent times. However, the competition among component crops for space, soil nutrients and moisture in a cropping system characterized by low level of external inputs point to the challenges of such practices on productivity. Similarly, the structure of the cropping system also goes a long way in determining the opportunity for further intensification through multiple cropping, opportunity for enhanced productivity and income. The income potential is to a large extent, influenced by the market premium attracted by each commodity. This study therefore examined the implication of the choice of crop combination for intercropping, land-use intensity and agro-ecologies on productivity and income potential of food crop farmers in Southwest Nigeria.

MATERIALS AND METHODS

Data for this study were generated through a survey of 341 farmers selected through multistage sampling technique of food crop farmers in Southwestern Nigeria. Two states (Ondo and Oyo) representative of the two broad agro ecologies in Southwest Nigeria were selected to accommodate the intended analysis of the influence of agro-ecologies and choice of crop combination on land use intensity and productivity. This method allows for strategic and diagnostic research targeted at specific recommendations domains, in this case, the forest and savannah agro ecologies of Southwest Nigeria. Two Agricultural Development Programmes (ADP) Zones were randomly selected from each of the States (Oyo State: Ibadan-Ibarapa and Saki Zone) (Ondo State: Zone 1 and 2). The third stage was the random and proportionate selection of one-third of the Local Government Areas (LGAs) listed in the village listing documents of the respective State ADPs. Consequently, 6 LGAs were randomly selected out of 18 listed in Ondo State and 10 out of 29 LGAs listed in Oyo State. Five villages were then selected from each LGA and finally, food crop farmers were randomly selected from each of the villages by probability proportionate to size of farming households in each village. Data were collected on household and landholding size, cropping cycle, production systems, crop combinations, input and output in food crop production through personal interview conducted with the aid of questionnaire.

The study made use of both descriptive and inferential statistic Land-use intensity was measured taking into consideration the frequency of land cultivation and the crop load on a piece of land. Consequently, the Fallow Rotation Index (FRI) accounts for the frequency to which a piece of land is subjected to cultivation while the Cropping Intensity Index (CII) accounts for the 'crop-load' effect of the choice of cropping system and crop combinations. Following Ruthenberg (1980) quoted in Erbaugh (1999) and Dayal (1978), FRI and CII were estimated as shown respectively:

$$FRI_i = \frac{t_i}{C_{i\ i}}$$

$$CII = \frac{1}{12}\left[\frac{\sum_{i=1}^{n} A_{ci}.d_i}{S}\right]$$

Where: t_i = Number of years for which cropland is consecutively cultivated before been allowed to fallow; C_i = Length of cropping cycle (addition of years of consecutive cultivation and period of Fallow); A_{ci} = The area under crop i (ha); D_i = The duration of crop i in the field (months) and S = The net sown area (ha).

Consequently, farmers were classified on the basis of fallow rotation index as FRI<0.33 (low), 0.33<FRI≤0.66 Medium and FRI>0.66 (high). Similarly, farmers were classified into three categories on the basis of CII as CI<0.38 (low) 0.38≤CI≤0.75 (medium) and CI>0.75 (High). These groupings were equally ranked as 1, 2, and 3 for low, medium and high respectively. The FRI and CRI ranked categories were then combined to generate a rank aggregate Land-use Intensity scores as: Aggregate Rank Score of 2=Very Low, 3=Low, 4=Medium, 5=High and 6=Very High.

The study also estimated Land Equivalent Ratio (LER) and Relative Value Total (RVT) for the appraisal of the agronomic and economic potential of the intercropping crop combinations relative to monoculture. These estimates appraised the potentials afforded food crop farmers by their choice of cropping system and crop combinations in food crop production.

The LER exhibits the extent to which the individual crops are able to explore and make use of available soil nutrient in the midst of the competition between the different crops and the ability of the level of soil fertility to adequately support and compensate for such competition. The RVT measures how the market prices as an indication of the value attached to the component crops in the intercrop is able to complement the possible yield advantage or compensate for possible yield loss for a higher total value relative to sole cropping.

Table 1. Cropping system adopted by farmers by agro-ecology.

Cropping system	Forest	Derived Savanna	Southern Guinea Savanna	Total
Sole cropping	64(42.11)	34(23.61)	14(31.11)	112(32.85)
Inter cropping	88(57.89)	110(76.39)	31(68.89)	229 (67.15)

*Values in parenthesis are percentages of farmers.

Table 2. Specific crop combination.

Specific crop combination	Frequency	Percentage
Sole maize	44	12.9
Sole cassava	08	2.3
Sole yam	35	10.3
Sole sorghum	08	2.3
Maize/cassava	137	40.2
Maize/cassava/yam	32	9.4
Maize/yam/sorghum	14	4.1
Maize/yam	09	2.6
Maize/sorghum	08	2.5
Cassava/yam	09	2.6

Source: Computed from Field Data.

The relative agronomic and economic potentials were then compared across crop combinations, fertilizer usage, agro-ecologies and land-use intensification categories using Analysis of Variance (Anova) to explore the influence of these factors on the potentials. Following Alabi and Esobhawan (2006) and Chukwuji (2008), the agronomic and economic potential indices were estimated as shown respectively:

$$LER_{ij} = \sum_{j=1}^{n} \left(\frac{Q_{pij}}{Q_{mj}} \right)$$

$$RVT_{ij} = \sum_{j=1}^{n} \left(\frac{R_{pij}}{R_{pmj}} \right)$$

Where: Q_{pij} = Average yield of crop j when grown by farmer i as intercrop (or polyculture); Q_{mj} = Average yield of crop j when grown by farmers as sole (or monoculture). R_{pij} = Values of crop j when grown by farmer i as intercrop estimated at farmgate price and R_{mj} = Average value of crop j when grown by farmers as sole crop estimated at farmgate price.

RESULTS AND DISCUSSION

Prominent cropping systems and crop combinations

The distribution of farmers by cropping system and prominent crop combination (Table 1) shows that intercropping was commonly practiced by about 67% of the farmers with prominent crop combinations as maize/cassava (40.2%), maize/cassava/yam (9.4%), maize/yam/sorghum (4.1%), maize/yam (2.6%), maize/sorghum (2.5%) and cassava/yam (2.6%) as shown in Table 2. The results also show that maize was the commonest crop grown under monoculture by 12.9% of the farmers followed by sole yam (10.3%), sole cassava (2.4%) and sole sorghum (2.4%).

The results indicate the dominance of crop combination that are usually described as soil nutrient miners (cereals and tubers) in the farming system. The need to create security against potential risk of monoculture has been identified as one of the driving forces behind intercropping as a form of diversification among smallholder farmers (Muhammad et al., 2003; Preston, 2003). However, the absence of legume crops in the combination points to the impending challenges as regards the maintenance of soil fertility and consequently, productivity of the crops. The basic challenge in such multi-cropping systems is associated with the inherent competition for space, soil nutrients, moisture, light and air among the component crops, and when the cultural practices adopted by the farmer do not cater for such competitions adequately, reduction in soil fertility, land degradation and consequently, low productivity result (Makinde et al., 2007).

Table 3. Distribution of farmers by land-use pattern across agro-ecologies.

Land-use intensity pattern		Forest (N=152)	Derived Savanna (N=144)	Southern G. Savanna (N=45)	Total
Fallow rotation					
Shifting cultivation		02(1.3)	17 (11.8)	02 (4.4)	21(6.1)
Bush fallow		31 (20.4)	16 (11.1)	16(35.6)	63(18.5)
Continuous cropping		119(78.3)	111(77.1)	27 (60.0)	257(75.4)
Cropping intensity group					
Low		15 (9.93)	07(4.86)	05 (8.88)	27(7.65)
Medium		27 (17.88)	12(8.33)	06(13.33)	45(13.24)
High		109(72.19)	125(86.81)	35(77.78)	269(79.11)
Land-use intensity group	**Intensity ranked score**				
Very low	2				
Low	3	01(0.66)	01(0.69)	3(6.67)	05(1.47)
Medium	4	14(9.21)	24 (16.67)	03(6.67)	41 (12.02)
High	5	41(26.97)	18 (12.50)	13(28.89)	72(21.11)
Very high	6	96(63.16)	101(70.14)	26(57.78)	223(65.40)

Figures in parenthesis are percentages.

Fallow rotation intensity and cropping intensity in food crop production

The classification of the farmers on the basis of the fallow rotation intensity and cropping intensity indices using the framework advanced by Ruthenberg (1980) and Dayal (1978) respectively is shown in Table 3. The distribution shows that 75.4% of the food crop farmers have engaged their land in continuous cropping while 18.5 and 6.1% engaged in bush fallow and shifting cultivation respectively. Similarly, the distribution according to the level of cropping intensity showed that 79.1% of the farmers engaged their land in high cropping intensity while about 7.7 and 13.2% had their land under low and medium cropping intensity respectively (Table 3). Consequently, land-use in food crop production in southwestern Nigeria is characterized mainly by continuous cropping under high cropping intensity and the pattern is similar across agro-ecologies.

Furthermore, the grouping of the farmers on the basis of the aggregate ranked score for the two indices shows that majority of the food crop farmers (65.4%) cultivated their farmland under very high land-use intensity while 21.1, 12.0 and 1.5% cultivated farmland under high, medium and low land-use intensities respectively. However, none of the farmers had their land under very low land-use intensity.

The distribution of food crop farmers by their use of modern inputs (fertilizer, herbicides) shows that the use of fertilizer was more prominent with cereal based cropping systems than with non-cereal based cropping systems (Table 4). Thirty percent of farmers who cultivated sole root crops used fertilizers while fertilizer was used by 50.7, 43.3 and 65.9% of farmers who cultivated cereal-root crop, cereal-root-tuber crops and sole cereal crop combinations respectively. The result also showed that fertilizer use was not common among farmers that cultivated stem tuber crops (8.8%) as sole crop.

The prominence of fertilizer usage among cereal-based cropping systems could be a pointer to the farmers' realization of the high level of

Table 4. Modern input usage by major type of crop combinations.

Usage of modern inputs	Major crop combination type (N=314)				
	Cereal/root crop	Cereal/root/tuber crop	Sole cereal	Sole root crop	Sole tuber crop
Fertilizer					
Used	69 (50.7)	13 (43.3)	27 (65.9)	03 (30.0)	03 (8.8)
Not used	67 (49.3)	17 (56.7)	14 (34.1)	07 (70.0)	31 (91.2)
Agrochemical					
Used	14 (10.3)	02 (6.7)	03 (7.3)	01 (10.0)	01 (2.9)
Not used	122 (89.7)	28 (93.3)	38 (92.7)	09 (90.0)	33 (97.1)

Figures in parenthesis are standard deviations.

Table 5. Use of modern input by land-use intensity groupings.

Land-use intensity group	Fertilizer usage		Agrochemical		Tractor	
	Used	Not used	Used	Not used	Used	Not used
Low	02(0.59)	03(0.88)	03(0.88)	02(0.59)	03(0.88)	02(0.59)
Medium	13(3.81)	28(8.21)	05(1.47)	36(10.56)	16(4.71)	25(7.35)
High	37(10.85)	35(10.26)	09(2.64)	63(18.48)	23(6.76)	49(14.41)
Very high	113(33.14)	110(32.26)	23(6.74)	200(58.65)	66(19.41)	156(45.88)
Total	165(48.39)	176(51.61)	40(11.73)	301(88.27)	108(31.76)	232(68.24)

Figures in parenthesis are percentages.

responsiveness of cereal to nutrient depletion and the intensive nature of most cereal crops notably the dominant maize. However, fertilizer use was more prominent among farmers who had their land under very high use intensity (33.2%) while about 11, 4 and 1% of the farmers who cultivated their land under high, medium and low intensities used fertilizer. Consequently, about 44% of the farmers (that is, those in high and very high categories who did not use fertilizer) could be said to be mining the soil (Table 5).

Potential of intercropping relative to monocropping systems

Although the previous sections of this study have shown the prevalence of intercrops relative to monoculture in the food crop farming systems of the study area, this section examine the inherent potential in the intercropping system relative to monoculture across crop combinations, fertilizer usage, agro-ecology and land-use intensity categories.

The average value of crop output per hectare and the estimated LER and RVT are presented in Table 6. The results show that the total value of crops estimated at the farm gate price differed by crop combination. The average values of intercrops were significantly higher than the estimated value of sole crops. However, the average value of sole yam (₦1,105,467.80) was higher than the value of all the intercrops except cassava/yam intercrop with average value of ₦1,474,154.60. The results also showed that the average value of intercrops with yam as component crop were significantly higher than the

Table 6. Relative potential of intercrops by crop combinations.

Crop combinations	Average value/ha		Land equivalent ratio (LER)	Relative value total (RVT)
	Mean (₦)	Standard Deviation		
Sole cassava	148,860.75	87,577.98	-	-
Sole maize	71,766.87	19,653.72	-	-
Sole yam	1,105,467.80	461,430.57	-	-
Sole sorghum	31,093.80	15,656.00	-	-
Maize/cassava	147,502.42	79,586.00	1.44(0.66)	0.67(0.36)
Maize/cassava/yam	840,141.91	666,106.58	1.57(0.88)	0.63(0.50)
Maize/yam/sorghum	635,186.00	363,530.44	1.20(0.45)	0.53(0.30)
Maize/yam	887,946.22	811,592.60	1.22(0.83)	0.85(0.67)
Maize/sorghum	63,408.50	37,906.38	1.25(0.71)	0.62(0.37)
Cassava/yam	1,474,154.60	935,343.52	2.14(0.90)	1.17(0.74)
F-Statistics	44.81*		1.90	2.48**

*Significant at P≤0.01**Significant at P≤0.05. † LER and RVT of each combination determined relative to the average yield and value of the component crops under monocropping. Figures in parenthesis are standard deviations. Source: Computed from Field Data (2008).

average values of other intercrop combinations thereby underscoring the high economic potential of yam in the farming system.

The LER estimates showed that generally, more than 1 ha of land would be required by the farmers to produce from sole cropping, yield that are equivalent to the aggregate yield from the component crop in the intercrops. However, the RVT values showed that more than 1 ha of land would be needed for intercrops to obtain revenue equivalent to the aggregate revenue from crops cultivated as sole except for cassava/yam intercrop which has RVT value of 1.17.

The results have shown that despite the fact that intercropping has greater agronomic potentials relative to monocropping in terms of yield obtained by farmers, the choice of the crop combinations did not generate enough economic returns to compensate for the possible loss of yield from intercropping. This is attributable to the prominence of cassava in the intercropping systems as a less intensive crop compared to maize, and yam which command greater market premium in the study area.

The comparism of the estimate of the relative potentials across usage of inorganic fertilizer, agro-ecology and land-use intensity class (Table 7) indicated that there were significant differences in the LER of the intercrops by fertilizer usage, agro-ecology and land-use intensity classes. The LER of farmers who applied fertilizer in their intercrops (1.59) was significantly higher than the estimate for farmers who did not apply inorganic fertilizer. Similarly, the LER of intercrops in the derived savannah (1.65) was significantly higher than the ratio in the forest (1.37) and southern guinea savannah (1.13) agro-ecologies respectively while LER values of 2.67 and 1.57 under low and medium land-use intensity were significantly higher than the estimates of 1.50 and 1.37 for high and very high land-use intensity respectively. However, there were no significant difference in the RVT estimate by usage of inorganic fertilizer and land-use intensity group. The RVT however differed across agro-ecologies with the RVT value of 0.77 for the derived savannah been significantly higher than the values of 0.66 and 0.41 estimated for forest and southern guinea savannah respectively.

These results have shown that farmers may continue to gain by intercropping and this gain is higher for farmers in the derived savannah agro-ecology and might further be enhanced when they apply inorganic fertilizer and/or reduce the level of land-use intensity possibly through longer fallow. However, situating the production system within the objective of maximizing income, the results show that the farmers would need to incorporate more intensive crops (crops that command higher market premium) for their income to be enhanced. The relative potential of yam in this regards is shown in the greater RVT generated.

The low economic potential of the intercrops is

Table 7. Land equivalent ratio and relative value total of intercrops by fertilizer usage, agro-ecology and land-use intensity categories.

Category	N	LER	RVT
Fertilizer usage			
Used	97	1.59(0.68)	0.65(0.44)
Not used	102	1.34(0.99)	0.72(0.41)
F. Statistics		5.88**	1.20
Agro-ecology			
Forest	103	1.37(0.71)	0.66(0.42)
Derived Savannah	81	1.65(0.79)	0.77(0.43)
Southern Guinea Savannah	16	1.13(0.81)	0.41(0.38)
F. Statistics		5.61*	5.37*
Land-use intensity group			
Low	03	2.67(0.58)	1.11(0.22)
Medium	30	1.67(0.71)	0.73(0.36)
High	48	1.50(0.72)	0.68(0.36)
Very High	118	1.37(0.71)	0.66(0.47)
F. Statistics		4.41*	1.24

*Significant at P≤0.01**Significant at P≤0.05, Land Equivalent Ratio (LER), Relative Value Total (RVT). Figures in parenthesis are standard deviations. Source: Computed from Field Data (2008).

largely due to the prominence of cassava which is bedeviled with frequent market price fluctuation arising from market glut at the peak of the season. However, yam production is a very lucrative but at the same time requires high investment in its production. The high economic premium placed on it by famers is evident in the greater priority accorded the crop in land allocation by farmers who engages in its production. The usual practice among farmers in the zone is to allocate the most fertile (usually fallow land) to yam production although fertilizer application is very uncommon in its application. Although cassava attracts lower premium compared to yam, the crop is very strategic in food security of the farming households while it is less sensitive to environmental stress compared to other crops such as maize and yam. Hence, it is widely grown and therefore prominent in most cropping systems in the zone.

The desire to balance household need with economic returns therefore requires combinations of crops that attract greater market premium (e.g. yam and maize) with those that are strategic to household food security (e.g. cassava). Engaging in sustainable production of these crops however requires adequate consideration to soil fertility maintenance more so when there are indications than land-use intensification would continue to increase due to scarcity of fertile land as also pointed out by Oyekale (2007).

Conclusion

The results of this study have shown that farmers may continue to gain higher yield by intercropping but higher productivity could be attained when farmers apply inorganic fertilizer and/or reduce the level of land-use intensity possibly through longer fallow. The potential under this scenario could also be higher in the derived savannah agro-ecology. The farmers' choice of crop combination is largely devoid of leguminous crops thereby indicating the inability of the farmers to take advantage of soil fertility replenishing potential of legume through natural nitrogen fixation in the intercrop.

The RVT however points to the low economic potential of the choice of crop combinations relative to monocropping. Largely, the composite value of the component crops in the intercrops, are not enough to compensate adequately for income loss traceable to yield loss arising from competition and low market premium of the component crops when compared to their respective values under monocropping.

Although the inclusion of more intensive crops like yam displays some potential, such combination should be combined with soil fertility maintaining practices such as fertilizer application and legume rotation or fallow. The possibility of farmers engaging in long fallow as an alternative strategy is constrained by land unavailability in the midst of increasing population and the evident high land-use intensity characterizing food production in the region.

Conflict of Interests

The authors have not declared any conflict of interests.

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