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Economic Analysis of Land Improvement Techniques in Smallholder Yam-Based Production Systems in the Agro-ecological Zones of Southwestern Nigeria

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ABSTRACT For increased crop productivity and sustainable resource management within the practical scope of small-scale farming systems, there is need for a clear understanding of the problems associated with land use and management practices employed by farm operators. This paper examines smallholder yam-based production systems in the rain forest and savannah agro-ecologies of Southwestern Nigeria to determine the net returns to the use of land improvement techniques, their effect and that of farmers socioeconomic characteristics on net returns, and to identify major constraints and requirements for enhanced yam production and sustainable use of the land resource. With the aid of multi-stage sampling technique, primary data were collected from 200 yam farmers using structured questionnaire. Focus group discussions were also conducted. Data were analysed with descriptive statistics, costs and returns analysis as well as multiple regression techniques. Major land improvement techniques used by respondents in the study area include mulching, bush fallow, inorganic fertilizer, organic manure and crop rotation. Costs of yam setts constituted more than 60% of the total variable cost, while labour was about 30% for all land improvement techniques in the two agro-ecologies. However, per hectare yield and profitability of inorganic fertilizer in yam production were significantly higher in the savannah zone. Regression results revealed that the effect of land improvement techniques on net returns to yam production, as well as the profitability of each technique varied by agro-ecology. Thus, designing strategies for improved yam production have to be location-specific, while use of inorganic fertilizer and its combination is more profitable in the savannah zone. Research studies and extension services should therefore consider ecological differences in providing relevant information to farmers on the use of appropriate land improvement techniques for sustainable food production.

INTRODUCTION

Yam and cassava are the two most important root and tuber crops grown for food in West and central Africa. Yam is especially important throughout coastal West Africa, where over 60 million people obtain dietary calories per day from it (Nweke et al., 1992). The overall objective of Nigeria's food security programme is to increase agricultural production for food self-sufficiency. Smallholder farmers in Southwestern Nigeria depend upon root and tuber crops, especially cassava and yam, as a dietary supplement and a major source of energy and nutritional requirements, and as food security is achieved when a country can assure all its citizen of both physical and economic access to food of an appropriate nutritional quality, root crops are therefore regarded as essential for improving food security (SARRNET, 1993).

Statistical evidence shows that the food self-sufficiency ratio of Nigeria has for sometime now (1981-1994) been less than one (Rahji, 1999). This implies that the food situation in Nigeria is inadequate to meet with the increasing rate of population growth. Rahji further noted that the actual yields of major food crops in Nigeria are far lower than the potential yields. The productive yield efficiency for such crops as yam (54.10%), cassava (41.00%) and maize (56.07%) still fall below 60% in 1991 (FOS, 1997). However, in terms of land use, the amount of land devoted to the cultivation of root and tuber crops is not as significant, as land area grown to root crops only constitute about 10% of total land for major arable crops (FOS, 1999).

Yam and the Nigerian Economy

One of the principal root crops of the Nigerian economy, both in terms of land under cultivation and in the volume and value of production is yam.

It is a preferred staple food, appreciated for its taste and cultural role. This implies that root crops such as yam have high relative value per unit of land used in their cultivation when compared with other crops, particularly the cereals. CBN (1998) reported that root crops including yam contributed 64.6% of the total staple food in the country between 1990 and 1998 while cereals contributed only 28.9%. This shows that yam plays a prominent role in the supply of staple foods in the nations agricultural production economy.

Agboola (1999) and Asadu et al. (1996) asserted that the best location for yam production is the sub-humid Guinea savannah, followed by the humid forest region and then the transitional forest savanna zone. Though yam production has been enjoying prime position in allocated land for production throughout the country, the yield per hectare is highest in the eastern part of Nigeria, followed by the west and north respectively (Oluwasola, 1999). While yam is considered a man's crop and has ritual and socio-cultural significance, it is also the food of choice for many ceremonies and festivals, and an indispensable part of pride price. Additionally, CBN (1998) showed that yams constituted an average of 32% of farmers' gross income derived from arable crops. Yam is an important source of carbohydrate and protein in the diet of the people. Bradbury and Holloway (1998) and USDA (1975) claimed that yams also supply vitamins (A, B, C and D) and minerals (Calcium, Iron and Phosphorus) in relatively small quantities. Some species contain some quantities of crude protein, for example *D. dumetorum*, but according to Hahn et al. (1987), this particular species is also high in alkaloids and has to be washed in salt water and boiled for a long time before consumption. *D. alata*, which has large starch grains, is eaten as mashed yam in Barbados as well as in Trinidad and Tobago. In Cross River and Akwa Ibom States of south-eastern Nigeria, however, it is eaten in boiled or roasted form, or in a special mashed preparation, *ikpankwukwo*. Among the Ijebus of south-western Nigeria, a similar preparation, *ikokore*, is common. In Nigeria, yams are processed into different food forms, including pounded yam (from *D. rotundata*, and sometimes, *D. cayenensis*), boiled yam, roasted or grilled yam, fried yam slices and yam balls, mashed yam, yam chips and flakes. Fresh yam tubers are also peeled, chipped, dried and milled into a flour, which is then cooked in boiling water and turned into a thick paste called *amala* in Western Nigeria and *akwuna ji* in the east of the Niger. It is eaten with soup.

There is an increasing gap between the levels of supply and demand for yam. This arises from the subsistence system of its production, high production costs, and the need for appropriate land improvement techniques for restoring, replenishing, conserving and maintaining the quality of agricultural land in order to increase farmers yield and income levels under the prevailing rate of population growth (Lal, 1975; Okorji, 1992; Rosegrant et al., 2001). According to Grandstaff (1981), shifting cultivation is the most widespread farming system in the humid tropics, though often labeled the most serious land use problem. Christanty (1986) however noted that shifting cultivation can only be ecologically sound and can efficiently respond to human food needs if the human population is not too high and fallow periods long enough to restore farm productivity. Bostid (1993), reported that shifting cultivation systems are especially well suited for producing basic foodstuffs and meeting subsistence and local market needs. Nonetheless, in many areas where shifting cultivation had been practiced successfully for centuries, population pressures have forced the shortening of the fallow period and field rotation cycle resulting in the loss of productivity. In effect, soil fertility depletion coupled with the adoption of shorter fallows has become pronounced with a consequent reduction in farm output and returns. Thus, unless there are substantial social and economic changes, short-term cycles will continue and more land will be cleared.

Coursey (1967) posited that the generally low nutrient status of Nigeria soils requires the need to supplement it with inorganic fertilizers. Rouyanet (1976) found that 500kg/ha of 10:10:10 fertilizer mixtures on staked D. trifida produced a significant yield increase of 3.8 tonnes and 3 tonnes per hectare in the presence and absence of organic manures respectively. However, most farmers do not use fertilizers and manures to any appreciable extent on yams. This was attributed to the first place yam occupies in the sequence of cropping after a bush fallow, in which yam has the advantage of using mineral reserves accumulated when the soil is rested or after burning of the vegetation. Additionally, the use of crop rotation sequence, rather than continuous successive planting of the same crop can play a role in reducing soil erosions as well as restore soil structure, break pest and disease cycle, and help maintain soil fertility (Hudson, 1991). Soils are only considered 'productive' if the nutrients in the soil are accessible to the crops. Hence, owing to the interrelationship of these characteristics, appropriate land management techniques are required to maintain optimal yam production systems. There is therefore a need to assess the ecological variation in the economic benefits of land improvement techniques employed by smallholder yam farmers, with the aim of suggesting measures to enhance their productivity, enhance farm income levels, as well as meet the food needs of the nation. Specifically, this paper examines the socioeconomic characteristics of smallholder yam farmers in the Southwestern part of Nigeria, in order to determine the net returns to the use of land improvement techniques, the effect of these techniques and farmers socio-economic characteristics on net returns, as well as to identify major constraints and requirements for enhanced yam production and sustainable use of the land resource.

METHODOLOGY

The Study Area: The study was conducted in Ekiti and Osun states, representing two ecological zones (savannah and rain forest respectively) in Southwestern Nigeria. Osun State lies within the forest regrowth vegetation while Ekiti State is a mix of the derived and Southern Guinea savannah. The vegetation types affect agricultural production systems through their influences on fallow and soil fertility, the establishment of natural ecosystems, as well as impact on the cropping patterns and livestock management techniques. The farming systems of the forest zone are considered to be ecologically more balanced than those of the savannah, especially for the food production systems, as the mixed vegeculture farming system, which is predominant, is characterized by root crop dominance, with cereals playing a secondary role in cultivation. On the other hand, the seed culture cultivation that characterizes savannah farming is based on a highly productive combination of cereals, leguminous grains, rice and maize. However, the ability of yam to thrive under a variety of environmental conditions owing to differences in the ecological requirements of the various species enables the production of the crop to be undertaken in the forest, derived savanna and southern Guinea savannah environments. Additionally, the place of yam in the sociocultural life of the people and in the food economy makes the crop the staple food, which almost all farmers grow. Land improvement techniques generally used for agricultural production include among others mulching, organic manure, crop rotation and planting of cover crops.

Data Collection and Sampling Procedure: Primary data were collected from 200 respondents using a questionnaire. Data collected include respondents' socio economic characteristics such as age, household size, and literacy level; land use patterns, land improvement techniques, levels of production, and costs and returns to resource use, as well as problems constraining yam production activities. Secondary data were collected from the Local Government Areas (LGAs), the Agricultural Development Projects, and the States' Ministries of Agriculture. Focus group discussion (FGD) was also undertaken to gain better understanding of the study focus.

The field survey was carried out between April and August 2001. Multi-stage sampling technique was employed to select the sample points. In the first stage, two states having different agroecological characteristics were selected. In order to ensure some distinct variation in the ecology of the survey locations, 5 LGAs identified as major yam-producing areas, were purposively selected respectively in the northern fringes of Ekiti State, and the southern end of Osun State. Three rural communities were then randomly selected in each LGA. From the list of yam growers obtained in each community, between 5 and 10 respondents were then chosen using simple random sampling technique and in proportion to the total number of yam farmers in the communities. A total of 200 respondents were interviewed.

Data Analysis: Ninety-five percent (95%) of the questionnaire, representing 190 respondents (104 in the forest and 86 in the savannah zones), was found suitable for data analysis. Descriptive statistics, regression analysis and cost and returns techniques were employed for data analysis. Descriptive statistics involved the use of tables, means, mode and percentages to describe the distribution of variables in the study. Ordinary Least Square (OLS) regression analysis was employed to determine the effect of yam farmers' socioeconomic characteristics on the net returns from use of land improvement techniques, while costs and returns analysis was used to evaluate the net returns to use of land improvement techniques in the study area. Tests of differences between means and proportions were used to compare variables in the two agroecological zones.

Model Specification

(a) Costs and Returns: The formula employed is expressed as:

Net Returns (NR) = Total Revenue (TR) – Total Cost (TC)

Where TR = Quantity x Price

TC = TFC + TVC

(b) Regression Analysis: Three functional forms of the model fitted to the data are Linear, Semi Logarithm and Cobb-Douglas. These are expressed as:

Linear: $Y = f(X_i, m_i)$

$$Y = b_0 + b_1X_1 + b_2X_2 + Sb_{3i}X_{3i} + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + m_i$$

SemiLog: $Y = f(InX_i, m_i)$

$$Y = Inb_0 + b_1InX_1\ b_2InX_2 + Sb_{3i}InX_3i + b_4InX_4 + b_5InX_5 + b_6InX_6 + b_7InX_7 + m_i$$

Cobb-Douglas: $InY = f(InX_i, m_i)$

$$InY = Inb_0 + b_1InX_1\ b_2InX_2 + Sb_{3i}InX_3i + b_4InX_4 + b_5InX_5 + b_6InX_6 + b_7InX_7 + m_i$$

Where,

Y = Net returns in ₦/kg in the growing season
X_1 = Farmers' age (years)
X_2 = Farming experience in yam production (years)
Sb_{3i} = Use of specific land improvement technique (dummy: 1-Use, 0-Non-use); (i^+ = 1,2,….,7)
X_4 = Size of farmland cropped to yam (ha)
X_5 = Level of education (years)
X_6 = Average labour expenses on yam production (N)
X_7 = Extension advice (measured by the percentage of extension visit: ^{3}50%– 1, <50% – 0)
b_0 = Regression constant or intercept
b_i = Regression coefficients to be estimated
In = Natural logarithm
b_i = stochastic (error) term

The 'a priori' expectation of the parameters can be expressed as:

$$\frac{¶g}{¶xi} < 0 \text{ where } i=1,6; \quad \frac{¶g}{¶xi} > 0 \text{ Where } i = 2,3,4,5,7$$

Note: $_i^+$, shows the 7 land improvement techniques employed in the study area as estimated in the regression model. Mulching (X_{31}), Mulching/Inorganic fertilizer (X_{32}), Mulching/Organic manure (X_{33}), Mulching/Bush fallow (X_{34}), Mulching/Crop Rotation (X_{35}), Mulching/Inorganic fertilizer/Crop rotation (X_{36}), Mulching/Inorganic fertilizer/Bush fallow (X_{37}).

RESULTS AND DISCUSSION

Socioeconomic Characteristics of Yam Producers in the Study Area: The socio-economic characteristics of respondents showed that respondents in the forest and savannah

Table 1: Selected socioeconomic characteristics of yam growing farmers in the study area.

Characteristics	*Savannah zone (n = 86)*	*Forest zone (n = 104)*	*t- value*
Age (Years)	55	59	0.98
Family size (Number)	3	4	0.21
Primary Occupation (%):			
Farming (Full-time)	73	81	
Trading	22	13	
Others	05	06	
Labour (%):			
Family	17	29	
Hired	52	43	
Mixed (Hired/ Family)	26	20	
Exchange	05	08	
Literacy level (Years)	7	3	2.68*
Total farm size (hectare)	0.56	0.35	2.04**
% Total farm devoted to yam production	68.0	51.0	1.97**
Experience in farming (Years)	55	58	1.62
Experience in yam farming (Years)	55	58	1.62
Average investment in land improvement techniques (₦)	16,350.00	11,890.00	2.11**
% Users of inorganic fertilizers only	49.0	23.0	2.97*
Quantity of fertilizer used (kg/ha) (NPK 15-15-15)	18.4	19.6	1.02
Mode of Land Acquisition (%)			
Inheritance	51.0	64.0	
Lease	-	2.0	
Tenancy	13.0	5.0	
Purchase	21.0	8.0	
Communal	5.0	1.0	
Land Use Pattern (%)			
Sole cropping	33.0	29.0	
Intercropping	57.0	61.0	
Length of growing period (months)	9 – 11	10 – 12	
Duration of fallow (Years)	3	2	0.90
Extension advice (%)	26.0	31.0	

*, **, ***Significant at 1%, 5%, and 10% respectively

ecologies engaged in full-time farming as their primary occupation, and with a mean age that indicate active and vigorous capability for farm operations (Table 1).

A low percentage of respondents employed hired labour for their farm operations. FGDs revealed that this is due to the small family sizes, though borne out of their search for better oppo-rtunities in the urban centers. However, this is capable of reducing consumption expenditure and provides some savings for possible investment in land improvement techniques. The average year of formal education attained by respondents in the savannah zone was significantly higher than in the forest zone. This may have implications in farmers better understanding of use of modern land improvement techniques in this zone than in the rain forest. For instance, a larger percentage (49%) of respondents used inorganic fertilizer in the savannah zone. Though total farm size was significantly different between the two agroeco-logies at 5% level of probability, respondents were generally found to be smallholders. However, the percentage of land area cultivated to yam was significantly higher in the savannah zone at the 5% level of significance. This, in addition to the high literacy level, may have accounted for the significantly higher amount of investment in land improvement techniques by farmers in the savannah ecology (Table 1). Respondents in the two ecologies had been involved in yam production since they started farming. This may further indicate the importance of yams as staple foods in these areas. A larger proportion of the respondents in the two ecologies acquired their farmland through inheritance, followed by purchase and tenancy, while intercropping dominated their cropping pattern. Intercropping with maize, cassava, cocoyam, and melon is widely practiced. FGDs revealed that this accounts for about two-thirds of the area under the crop. A small proportion of farmers in both ecological zones cultivate yam as a sole crop. On the average, the growing periods for yam in the two zones fall within one calendar year. This implies that yam production is an annual event, and as an important crop with ritual and socio-cultural significance, result in the celebration of annual yam festivals in the study areas. Less than 32% of the respondents in the two ecologies claimed to have had extension advice within the period (Table 1). According to the respondents, extension agents are not as interested in tubers as in cereals. This has negative implications on the appropriate delivery of research results and hence on farmers outputs, yields and income levels.

Land Improvement Techniques Employed by Respondents: Major land improvement techniques used by respondents in the study area include: mulching, bush fallow, inorganic fertilizer, organic manure and crop rotation (Table 2).

Table 2: Land improvement techniques employed by respondents in the study area

Land improvement technique	*Savannah (n = 86)*		*Rain forest (n = 104)*	
	*Fre-quency**	*%*	*Fre-quency**	*Percen-tage*
Mulching	86	100.0	104	100.0
Mulching/Inorganic fertilizer	26	30.2	31	29.8
Mulching/Organic manure	12	14.0	23	22.1
Mulching/Bush fallow	65	75.6	87	83.7
Mulching /Crop rotation	09	10.5	14	13.5
Mulching/ Inorganic fertilizer/Crop rotation	42	48.8	24	23.1
Mulching/Inorganic fertilizer/Bush fallow	27	31.4	32	30.8

*Multiple responses

All the respondents in the two agroecologies employed mulching, while more than ¾ combined the use of mulching and bush fallow. However, less than 32% of the respondents combined either mulching/inorganic fertilizer or mulching/ inorganic fertilizer/bush fallow, while about 49% and 23% respectively used mulching/inorganic fertilizer/crop rotation in the savannah and forest ecologies. FGDs revealed that apart from the high cost and scarcity of inorganic fertilizers, respondents claimed that the use of inorganic fertilizer destroys the quality of 'pounded yam', a highly preferred food of the people, prepared by pounding boiled tuber pieces into dough. However, most of the respondents desire to use mineral fertilizers in yam production because it enhances yield levels. In addition, inorganic fertilizers were not adequa-tely available for use and most farmers did not apply the required dosage per unit land area. All respondents in the study area used only NPK 15-15-15 which are usually not uniformly applied across the farms, while the rates of application fall short of recommended dosage (Table 1). Yayock (1980) recommended 300 kg/ha NPK 12:12:17 + Mg on acid soils and 50 kg/ha N + 60 kg/ha K_2O on other soils in Southwestern Nigeria. The frequency of use is higher in the forest than in the savannah ecology. Mulching was most commonly used to improve the performance of yams, as respondents agreed that it helps in soil temperature control thereby preventing the tuber from rotting before germination and the young vines from being scorched by heat. Mulching also allows for gradual seeping of water into the soil and aid weed suppression. Bush fallowing ranks second with the duration of fallow being between 2-3 years in the two zones (Table 2). This corroborates FGD findings that population pressure has rendered shifting cultivation impracticable in the study area, as the maximum period of fallow within the same farmland was 4 years, while continuous cropping on the same piece of land cannot be effected for more than 3 years before decline in yields are observed. Respondents claimed that yams were the first crops grown immediately after fallow. The use of organic manure is limited to non-distant farms and it is obtained mainly from farm yard/ poultry manure. According to FGDs, the use of crop rotation and mulching was aimed at controlling the population of pests on the yam fields.

Costs and Returns to Land Improvement Techniques: Costs and returns estimates showed that per hectare yield and profitability of yams when inorganic fertilizer and its combinations are used was significantly higher in the savannah zone (Tables 3-9). However, the total costs incurred by the yam farmers were found to be higher for the use of this technique than for other combinations (Table 10). Statistically significant differences were recorded in the net returns to use of mulching/bush fallow and mulching/crop rotation in the forest ecology. Costs of yam setts constituted more than 60% of the total variable cost, while labour was about 30% for all land improvement techniques in the two agroecologies. This consequently affects the output and income accruing to the farm operators. More than 60% of the respondents earned below the average net returns to particular land improvement techniques in the two ecologies. According to (Waitt, 1981), the rate of application of inorganic fertilizer

Table 3: Average costs and returns (₦/ha) to mulching/inorganic fertilizer use

Item	*Savannah*	*Rain Forest*	*t-value*
Yam yield (kg/ha)	19,436.70	14,620.45	2.86*
Price (₦/kg)	7.96	9.52	1.98**
Total Revenue (₦)	154,716.13	139,186.68	2.01**
Variable Costs			
No. of yam setts (N/ha)	6,870	5,988	0.71
Unit cost of yam setts (₦/ha)	8.69	9.15	1.96**
Costs of yam setts (₦/ha)	59,700.30	54,790.20	1.99**
Cost of fertilizer material	1,980.00	1,950.40	
Labour Costs (man-days/ha)			
Land preparation	8,703.56	7,754.62	1.53
Weeding	5,369.10	6,398.20	1.07
Planting	4,718.13	2,987.30	2.04**
Fertilizer application (₦/ha)	1,048.50	886.47	2.82*
Mulching	618.20	540.00	
Staking	2,368.45	1,982.52	2.01**
Harvesting	5,496.91	5,832.30	1.41
Transportation costs (₦/km)	812.11	764.90	1.03
Total labour costs (N)	29,134.96	27,146.31	0.75
Total variable costs (N/ha)	90,815.26	83,886.91	1.98**
Gross margin (GM) (N/ha)	63,900.87	55,299.77	2.91*
Percent of respondents earning below GM (%)	59.0	68.5	

*, **, ***Significant at 1%, 5%, and 10% respectively

Table 4: Average costs and returns (₦/ha) to use of mulching

Item	*Savannah*	*Rain Forest*	*t-value*
Yam yield (kg/ha)	12,055.14	11,088.63	1.47
Price (₦/kg)	7.96	9.52	1.79***
Total Revenue (₦)	95,958.91	105,563.76	2.15**
Variable Costs:			
No. of yam setts (₦/ha)	5,547	5,850	
Unit cost of yam setts (₦/ha)	8.69	9.15	
Costs of yam setts (₦/ha)	48,203.43	53,527.50	1.96**
Labour Costs (man-days/ha):			
Land preparation	7,081.75	6,472.50	
Weeding	4,970.26	4,850.20	
Planting	4,320.60	3,704.40	
Mulching (₦/ha)	796.75	748.50	
Staking	1,758.50	1,708.60	
Harvesting	4,140.30	3,780.55	
Transportation costs (₦/km)	385.70	645.40	
Total labour costs (₦)	23068.16	21,264.75	1.83***
Total variable costs (₦/ha)	71,657.29	75,437.65	2.02**
Gross margin (GM) (₦/ha)	24,301.62	30,126.11	1.89***
Percent of respondents earning below GM (%)	33.8	42.6	

*, **, ***Significant at 1%, 5%, and 10% respectively

Table 5: Average costs and returns (₦/ha) to use of mulching/organic manure

Item	*Savannah*	*Rain Forest*	*t-value*
Yam yield (kg/ha)	13,809.85	13,270.60	1.10
Price (₦/kg)	7.96	9.52	
Total Revenue (₦)	109,926.41	126,336.11	1.98**
Variable Costs:			
No. of yam setts (₦/ha)	5,865	6,020	
Unit cost of yam setts (₦/ha)	8.69	9.15	
Costs of yam setts (₦/ha)	50,966.85	55,083.00	.75***
Cost of organic manure material (₦/ha)	786.20	840.50	
Transportation costs (₦/km)	586.30	405.35	
Labour Costs (man-days/ha):			
Land preparation	7,790.60	7,814.20	
Weeding	5175.44	5,320.18	
Planting	4,266.80	4,347.20	
Manure application (₦/ha)	1,240.25	1,455.65	
Mulching	592.60	462.30	
Staking	2,160.40	2,008.75	
Harvesting	5,275.20	5,612.40	
Total labour costs (₦)	26,501.29	27,020.68	1.07
Total variable costs (₦/ha)	78,840.64	83,349.53	2.10**
Gross margin (GM) (₦/ha)	31,085.77	42,986.58	2.94*
Percent of respondents earning below GM (%)	71.4	65.0	

*, **, ***Significant at 1%, 5%, and 10% respectively

is between 224.2 – 448.4 kg/ha depending on soil quality. However, findings indicate that the use of inorganic fertilizers in yam production is on a limited scale in the study area, with a very low mean rate of application of about 18.4 kg/ha and 19.6 kg/ha in the savannah and rain forest ecologies respectively. According to FGDs, inorganic fertilizers are not readily available and are not appropriately applied by farm operators. This is coupled with the perception of most yam farmers that inorganic fertilizer affects the taste of 'pounded yam'. This implies that the economic benefit of this land improvement technique has not been fully realized in the ecologies.

Regression Results of the Effect of Socio-economic Factors on Net Returns (₦/ha) to Respondents' Land Improv-ement Techniques : Based on the values of the R^2, F, the significance of the regression parameters at different levels of probability, as well as the conformity of the parameters to *a priori* expectations, the Cobb-Douglas function was chosen as the lead

Table 6: Average costs and returns (₦/ha) to mulching/bush fallow practices

Item	*Savannah*	*Rain Forest*	*t-value*
Yam yield (kg/ha)	13,435.18	12,488.25	1.33
Price (₦/kg)	7.96	9.52	
Total Revenue (₦)	106,944.03	118,888.14	3.09*
Variable Costs:			
No. of yam setts (₦/ha)	5,780	5,927	
Unit cost of yam setts (₦/ha)	8.69	9.15	
Costs of yam setts (₦/ha)	50,228.20	54,232.05	1.87***
Transportation costs (₦/km)	484.60	461.85	
Labour Costs(man-days/ha):			
Land preparation	8,016.30	8,174.20	
Weeding	5,224.60	5,400.00	
Planting	4,275.15	4,386.40	
Mulching	589.62	655.30	
Staking	2,095.16	2,214.50	
Harvesting	5,160.70	5,280.60	
Total labour costs (₦)	25,846.13	26,111.00	1.29
Total variable costs (₦/ha)	76,074.33	80,804.90	160
Gross margin (GM) (₦/ha)	30,869.70	38,083.24	2.11**
Percent of respondents earning below GM (%)	57.9	69.3	

*, **, ***Significant at 1%, 5%, and 10% respectively

Table 7: Average costs and returns (₦/ha) to mulching/crop rotation

Item	*Savannah*	*Rain Forest*	*t-value*
Yam yield (kg/ha)	14,229.14	13,296.88	1.35
Price (N/kg)	7.96	9.52	
Total Revenue (N)	113,263.95	126,586.30	2.94**
Variable Costs:			
No. of yam setts (N/ha)	6,250	5,520	
Unit cost of yam setts (N/ha)	8.69	9.15	
Costs of yam setts (₦/ha)	54,312.50	50,508.00	2.01**
Transportation costs (₦/km)	525.60	418.45	
Labour Costs (man-days/ha):			
Land preparation	7,836.20	7,962.18	
Weeding	5,245.60	5,787.40	
Planting	4,690.75	4,576.00	
Mulching	585.90	510.60	
Staking	2,276.40	2,088.75	
Harvesting	5,345.80	5,662.80	
Total labour costs (N)	26,506.25	27,006.18	1.48
Total variable costs (₦/ha)	80,818.75	77,514.18	1.95**
Gross margin (GM) (N/ha)	32,445.20	49,072.12	2.18**
Percent of respondents earning below GM (%)	61.4	47.2	

*, **, ***Significant at 1%, 5%, and 10% respectively

Table 8: Average costs and returns (₦/ha) to mulching/Inorganic fertilizer/bush fallow

Item	*Savannah*	*Rain forest*	*T-value*
Yam yield (kg/ha)	21,063.00	15,268.46	2.65*
Price (₦/kg)	7.96	9.52	
Total Revenue (₦)	167,661.48	145,355.74	2.06**
Variable Costs:			
No. of yam setts (₦/ha)	7,430	6,274	
Unit cost of yam setts (₦/ha)	8.69	9.15	
Costs of yam setts (₦/ha)	64,566.70	57,407.10	1.97**
Cost of fertilizer material	1,998.00	1987.60	
Transportation costs (₦/km)	788.81	681.34	
Labour Costs (man-days/ha):			
Land preparation	11,869.50	8,304.40	
Weeding	7,245.50	6,105.50	
Planting	4,875.20	3,520.90	
Fertilizer application (₦/ha)	1,520.60	994.20	
Mulching	865.30	617.55	
Staking	2,195.40	1,935.70	
Harvesting	6,880.15	5,966.25	
Total labour costs (₦)	35,451.65	27,444.50	1.93**
Total variable costs (₦/ha)	102,805.16	87,520.54	3.24*
Gross margin (GM) (₦/ha)	64,856.32	57,835.20	2.78*
Percent of respondents earning below GM (%)	40.3	31.9	

*, **, ***Significant at 1%, 5%, and 10% respectively

Table 9: Average costs and returns (₦/ha) to mulching/Inorganic fertilizer/crop rotation

Item	*Savannah*	*Rain Forest*	*t-value*
Yam yield (kg/ha)	22,015.55	16,543.89	3.01*
Price (₦/kg)	7.96	9.52	
Total Revenue (₦)	175,243.78	157,497.83	2.90*
Variable Costs:			
No. of yam setts (₦/ha)	7,450	6,680	
Unit cost of yam setts (₦/ha)	8.69	9.15	
Costs of yam setts (₦/ha)	64,740.50	61,122.00	1.88***
Cost of fertilizer material	2,220.00	1985.60	
Labour Costs (man-days/ha):			
Land preparation	11,215.30	10,188.50	
Weeding	6,470.45	6,572.92	
Planting	4,966.44	5,209.80	
Fertilizer application (₦/ha)	1,650.30	1,076.65	
Mulching	895.60	651.45	
Staking	2,272.80	2,017.91	
Harvesting	6,920.60	6,043.80	
Transportation costs (₦/km)	950.00	770.10	
Total labour costs (₦)	34,391.49	32,531.13	1.76***
Total variable costs (₦/ha)	102,301.99	95,638.73	2.11**
Net returns/Gross margin (GM) (₦/ha)	72,941.79	61,859.10	2.05**
Percent of respondents earning below GM (%)	46.8	32.2	

*, **, ***Significant at 1%, 5%, and 10% respectively

Table 10: Summary of costs and returns (₦/ha) on yam production according to agroecological zones and land improvement techniques employed

Land Improvement Technique	*Savannah zone*			*Rain forest zone*			*t-value*
	Total returnes (₦/ha)	*Total variable Costs (₦/ha)*	*Gross margin (₦/ha)*	*Total returns (₦/ha)*	*Total variable costs (₦/ha)*	*Gross margin (₦/ha)*	*for GM in the Two ecologies*
Mulching	95958.91	71657.29	24301.62	105563.76	75437.65	30126.11	124
Mulching/Inorganic fertilizer	154716.13	90815.26	63900.87	139186.68	83886.91	55299.77	1.96**
Mulching/Organic manure	109926.41	78840.64	31085.77	126336.11	83349.53	42986.58	1.55
Mulching/Bush fallow	106944.03	76074.33	30869.70	118888.14	80804.90	38083.24	1.88***
Mulching/Crop rotation	113263.95	80818.75	32445.20	126586.30	77514.18	49072.12	2.11**
Mulching/Inorganic fertilizer/Bush fallow	167661.48	102805.16	64856.32	145355.74	87520.54	57835.20	2.92*
Mulching/Inorganic fertilizer/Crop rotation	175243.78	102301.99	72941.79	157497.83	95638.73	61859.10	2.01**

1.551.88*2.11**2.92*2.01**
*, **, ***Significant at 1%, 5%, and 10% respectively
1 US Dollar ($) = 120 Nigerian Naira (₦)

equation for the two ecologies (Table 11).

Regression results revealed that respondents age, farm size, use of land improvement techniques such as mulching/bush fallow, mulching/ inorganic fertilizer /crop rotation, mulching/inorganic fertilizer/bush fallow, and extension advice are statistically significant in the determination of net returns to farmers in the forest zone (Table 11). While respondents' age, farm size and use of mulching/bush fallow were significant at the 1% level of probability; mulching/inorganic fertilizer/crop rotation was significant at 5% level, while extension advice and mulching/inorganic fertilizer/bush fallow were significant at the 10% level. These variables should therefore be taken into consideration in designing programmes directed towards improving yam production in the forest zone. Farm size, mulching/bush fallow, and mulching/inorganic fertilizer/bush fallow positively influenced farmers' net returns. This implies that as these variables increase by one unit, net returns to yam production increases by 0.088, 0.065, and 0.092 naira respectively. However, age, extension advice and mulching/inorganic fertilizer/crop rotation negatively influence net returns to yam production, such that for any one-unit increase in these variables, net return decreases by 0.169, 0.013 and 0.036 respectively. According to FGDs, the negative relationship recorded for mulching/ inorganic fertilizer/crop rotation as a land improvement technique is due to the inadequate use of the fertilizer on yam fields, while farmers tend to desist from active farm work as they grow old.

Table 11: Regression estimates of the effect of land improvement techniques on net income to yam production according to agroecological zones

Variable	*Rain forest (n = 104)*	*Savannah (n = 86)*
Farmers' age (years) (X1)	- 0.169*	- 0.382
Farming experience in yam production (years) (X2)	+ 0.102	+0.011
Use of Mulching	+ 0.113	+ 0.015
Mulching/Inorganic fertilizer	+ 0.154	+ 1.007*
Mulching/Organic manure	+ 0.072	+ 0.068
Mulching/Bush fallow	+ 0.065*	+ 0.025
Mulching/Inorganic fertilizer/Crop rotation	- 0.036***	+ 0.112*
Mulching/Crop rotation	+ 0.075	+ 0.087
Mulching/Inorganic fertilizer/Bush fallow	+ 0.092**	+ 0.066**
Size of farmland cropped to yam (ha) (X4)	+ 0.088*	+ 0.523
Level of education (years) (X5)	+ 0.143	- 0.174***
Average labour expenses on yam production (₦) (X6)	- 0.097	- 0.091**
Extension advice (X7)	- 0.013***	- 0.008**
Constant	2.728	2.809
R^2	0.814	0.760
$\bar{R}^2$	0.795	0.735
F	13.37	13.96

Figures in parentheses ( ) are t-values
*, **, ***Significant at 1%, 5%, and 10% respectively

In the savannah zone, mulching/inorganic fertilizer, mulching/inorganic fertilizer/crop rotation, and mulching/inorganic fertilizer/bush fallow have positive and statistically significant effect on net returns at different levels of probability, while literacy level, extension advice, labour and age have negative but significant effects on net return to yam production (Table 11). The negative sign on literacy level may be due to the insufficient level of commitment on the part of the more educated farmers who are largely part time farmers. Thus, as literacy level increases, the level of participation in farm work decreases. FGDs ascribed the high proportion of investment expended on labour as negatively influencing net returns to yam production. The negative influence of extension advice to net

Table 12: Constraints to yam production in the study area

Improvement technique	*Constraints*	*Derived Savanna zone (n=86)% of n*	*Rain forest zone (n=104)% of n*
Bush fallow	-Does not allow for optimal use of available land	10.0	4.0
	-High cost of labour for clearing after fallow	88.0	96.0
	-Decreasing availability of good quality land (only marginal land available)	32.0	45.0
Inorganic fertilizer	-High cost of fertilizer procurement and transportation	61.0	52.0
	-After effects of fertilizer usage on tubers	59.0	67.0
	-Increases in production cost	37.0	43.0
	-Difficulty in transportation of fertilizer	9.0	21.0
	-High rate of weed emergence	22.0	39.0
Manure	-Non availability of quality manure	10.0	2.0
	-Transportation of manure	63.0	17.0
	-Labour requirements for manure application	29.0	6.0
Crop rotation	-High cost of labour for successive land preparation	14.0	23.0
Mulching	-Non availability of mulching materials	46.0	51.0
	-Labour and time requirements for the application	16.0	25.0

Multiple responses taken

returns in the two ecologies could be attributed to the very low percentage of farmers who receive extension contact as shown in Table 1.

The constraints confronting yam production in the study area vary according to the type of land improvement technique employed, with high labour costs being the most common to all the techniques (Table 12).

CONCLUSION AND POLICY IMPLICATIONS

The type of land management technique employed by farm operators affect their output and income levels, as well as the sustainable use of the land resource base, while differences in ecology contribute significantly to the food production system.

Variations exist in the net income levels (₦/ha) accruing to land management practices employed in yam for the two ecologies (rain forest and savannah). This implies there is need for location-specific research studies on yams. Extension service /advice should therefore consider ecological differences in providing relevant information to farmers, and not be bias towards specific crops.

Land management practices are mainly traditional (bush fallow and mulching) as respondents' claimed that inorganic fertilizer use associated with tubers are not good for pounding yam, while its scarcity and high costs of purchase limit its use by the farmers. This suggests the need for research on the cause of problem and on how this could be solved to further enhance yam production to meet household consumption needs. Additionally, a combination of different land management practices involving traditional and modern techniques may suffice to enhancing sustainable yam productivity in order to meet the food needs of the growing population. Majority of the farmers are not aware of any hybrid/improved variety of yams in the study area, as local varieties are used by all of them. There is need for selection, breeding and introduction of high yielding improved yam varieties to farmers in the study location in order to enhance the production of this important crop, yam for sustainable food production. This is an area for research focus and consequent delivery of research results to the farmers through extension service. Paradoxically, extension agents, according to FGDs, are not particularly interested in root crops but on cereals, thereby suggesting that extension service in the study areas should be oriented in such a way as not to be bias on specific crops.

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