Original Research Article

Orange fleshed sweet potatoes (OFSP) and productivity: the case of smallholders in Kwara State, Nigeria

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Abstract

In rural Nigeria, most households cannot afford food products rich in vitamin A which gave rise to the introduction of bio-fortified agricultural produces. One of these is the Orange Fleshed Sweet Potatoes (OFSP). Although introduced about six years ago, empirical evidence as regards the actual level of adoption as well as its effect on their productivity remains relatively scarce. The analysis was built on a field survey of 183 smallholders in Kwara State, Nigeria conducted in the year 2016. Tobit model and the Heckman's two stage models were used to model the determinants the intensity of cultivation and the effect of OFSP's cultivation on the income of the smallholders. Results indicate that almost 87% of the smallholders sampled were into the cultivation of OFSP with 56% of them cultivating it solely for family consumption and its nutritional value. Also, 44% of them put less than half a hectare of their farmland to the cultivation of OFSP. The result showed that aged smallholders, members of cooperative groups and those who cultivate OFSP solely have a smaller proportion of their farmland cultivated to OFSP. Similarly, the age of the smallholders, household size, years of schooling, cost of production were the factors that significantly influence the cultivation OFSP on the income of the smallholders. The policy implication of this is that the potentials of OFSP have to be promoted particularly among the rural smallholders most especially through the existing cooperative groups. This can either be through organized seminars or specifically through demonstration plots.

Keywords: awareness; income; Tobit model; Heckman Two-Stage Model; intensity, cultivation; (*Ipomoea batatas* L.)

INTRODUCTION

Sweet potato (*Ipomoea batatas*) is a food crop that has been recognized as having an important role to play in improving household and national food security, health and livelihoods of poor families in sub-Saharan Africa (SASHA/CIP, 2010). Sweet potato as a crop has many good attributes such as high yield, wide ecological adaptability, low input requirements, and shorter growing period than other root crops. The roots are rich in carbohydrates and are among the world's major food crops which produce the highest amount of edible energy per hectare per day while the leaves are used as vegetables rich in essential minerals, vitamins and other compounds (Bradbury et al., 2013). It is traditionally regarded as a poor man's crop as it is typically grown and consumed by resource-constraint households. It also gives satisfactory yields under adverse climatic and soil conditions as well as under low or non-use of external inputs (Githunguri and Migwa, 2004).

Sweet potato roots vary in colour, with the Orange-fleshed sweet potatoes (*Ipomoea batatas L.)* being particularly rich in β-carotene, the most important pro-vitamin A carotenoid. The OFSP is one of the bio-fortified crops being developed as part of the global effort to control vitamin A deficiency (HarvestPlus, 2009). It is one of the starchy staple crops which contain ascorbic acid and the amino acid lysine that is deficient in cereal-based diets like rice in addition to appreciable amounts of β-carotene. It also contains soluble fibre which helps in reducing cholesterol concentration and anti-oxidant nutrients which can inhibit the development of coronary heart disease (Kays and Kays, 1997).

According to Williams et al. (2013) the leaves of OFSP contain chlorogenic acids, a phenolic compound responsible for suppressing obesity in humans. They also contain considerably higher amounts of minerals such as phosphorus, nitrogen, potassium, magnesium, copper, iron and zinc than what is contained in commonly cultivated vegetables (Shi et al., 2008). Recently, OFSP varieties are gaining great attention as a means of reducing common health-related problems

associated with vitamin A deficiency in low-income communities. This variety is believed to be the least expensive source of dietary vitamin A available to poor families (Stathers, 2005; Laurie et al., 2013).

Deficiency in vitamin A is one of the most prevalent problems, particularly in Sub-Saharan Africa. The functional consequences of vitamin A deficiency have been associated with a 23% increase in pre-schooler mortality in areas with endemic Vitamin A deficiency (McGuire, 1993). According to West (2002), Vitamin A deficiency is also widespread among young children in the developing world with approximately 127 million children under-six years of age estimated to be affected. Vitamin A deficiency can limit growth, weaken immunity, cause xeropthalmia leading to blindness, and increase mortality (McLaren and Frigg, 2001). Poor households typically cannot afford to consume the highly bioavailable animal foods on a regular basis and so they prefer to go for the plant sources one of which is OFSP.

The potential of OFSP's contribution to food security, increased incomes and reduction of nutritional deficit is enormous. However, this is yet to be fully exploited in developing countries including Nigeria. Prominent among the limiting factors include high perishability of sweet potato, limited availability of the orange-fleshed variety and non-availability of its nutritious processed forms equivalent to local dietary preferences. According to Njoku and Umoh (2013), the first variety of OFSP was released in December 2012, and the second variety was released in June 2013 in Nigeria, particularly Kwara State, by "reaching agents of change organization". And over 20,000 farmers have since received at least one bundle of OFSP vines to plant and access its roots for either consumption or commercialization (Olapeju, 2015).

Several articles such as those by Okello et al. (2014) and Omoare et al. (2014) have considered the potentials and consumption of OFSP, however, little or none have considered the intensity of its cultivation by farmers and its effect on their income specifically in Nigeria. This paper therefore aims to fill that gap in literature.

Hypothesis

H_o = The cultivation of OFSP does not affect the productivity of smallholders in Kwara state, Nigeria.

Aims of the study

i) to examine the factors that determine the intensity of cultivation of Orange Fleshed Sweet Potatoes
ii) to identify the determinants of OFSP's cultivation and how it affects the smallholder farmers' income

MATERIALS AND METHODS

The study was conducted in Kwara State, Nigeria. The state is located between latitude 7°45 North and 9°37 North and longitude 2°30 East and 6°25 East and a total land area of 3,682,500 hectares and 247,975 farm families with majority living in rural areas. The estimated population of the state is about 2.37 million people (NPC, 2008) out of which farmers account for about 70%. The State is made up of 16 local government areas (LGA) namely, Asa, Baruten, Edu, Ekiti, Ifelodun, Ilorin East, Ilorin West, Ilorin South, Irepodun, Isin, Kaiama, Moro, Offa, Oke–Ero, Oyun and Pategi (NPC, 2008). Based on agro–ecological and cultural characteristics, the state is divided in to four agricultural zones: – Zones A, B, C and D, by the Kwara State Agricultural Development Project (KWADP). The occupation of the people is primarily farming. They produce food crop as well as cash crops. The annual rainfall ranges from 800 mm to 1500 mm *per annum*. The vegetation in the state consist largely with a great expanse of arable land and fertile soil with crops like rice, yam, sweet potatoes, maize, cassava and vegetable grown.

This study employed a four (4) stage sampling technique to select 217 smallholders from three (3) out of the four (4) agricultural zones present in the study area. This is because of the prevalence of orange fleshed sweet potatoes in those zones. The number of smallholders sampled per zone was proportionate to the number of registered OFSP farmers found in the zone. However, only 183 were found useful for the purpose of data analysis. The data were collected through the use of a well-structured questionnaire. Focus Group Discussion (FGD) was also held with the farmers and the major problems highlighted include inadequate market for the sale of OFSP which was driven by lack of awareness of the crop and problems of Fulani Herdsmen on their farmland. This paper employed the descriptive statistic, Tobit model and the Heckman Two-stage model in analysing the data that were collected. STATA 13 was the statistical package used for data analysis.

The descriptive statistics was used to analyse the socio-economic characteristics of the farmers. This includes measures of mean, standard deviation and frequency distribution. The Tobit model was used to examine the factors that determine the intensity of cultivation of Orange Fleshed Sweet Potatoes. The model describes the relationship between a non-negative dependent variable y_i and an independent variable x_i. In addition, there is a normally distributed error term μ_i to capture random influences on this relationship.

$$y_i = \begin{cases} y_i^* \text{ if } y_i^* > 0 \\ 0 \text{ if } y_i^* \le 0 \end{cases} \quad (1)$$

It is given as

$$y_i^* = \beta x_i + \mu_i, \mu_i \sim N\left(0, \sigma^2\right) \quad (2)$$

Where:

$$Y = \frac{Cultivated\ land\ with\ orange\ fleshed\ sweet\ pototaes}{Total\ farmland\ cultivated}$$

X_1 = Age of the farmer (years)
X_2 = Gender of the farmer (Male = 1, 0 otherwise)
X_3 = Years of schooling
X_4 = Members of cooperative societies (Yes = 1, 0 otherwise)
X_5 = Method of planting (intercropping =1, 0 otherwise)
X_6 = Access to extension contact (Yes = 1, 0 otherwise)
X_7 = Cost of Production (₦/planting season)

Heckman Two-Stage Model was used to identify the determinants of OFSP's cultivation and how it affects the smallholder farmers' income, the relationship of the effect X_i of OFSP's cultivation on the income can be stated as a linear function of vector of explanatory variables (X_i) and OFSP's dummy variable (D_i). The linear regression can be specified as:

$$G_i = X_i\lambda + \gamma D_i + \varepsilon_i \quad (3)$$

Where:
G_i = is the farmer's income
ε_i = is a normal random distribution term
D_i = is a dummy variable representing OFSP's cultivation. It takes the value of 1 if the farmer cultivates OFSP and 0 otherwise.
X_i = is the vector of household and farm characteristics.

The Cultivation of OFSP by the smallholders is a function of farmer and farm characteristics. By deciding to cultivate OFSP, the farmer is self-selected instead of a random assignment. Therefore, following Becerril and Abdulai (2009), we assume that the farmer is risk-neutral. The index function used to estimate cultivation of OFSP by the farmers is thus expressed as:

$$D_i^* = X_i\alpha + v_i \quad (4)$$

Where:
D_i^* = is a latent variable denoting the difference between utility from OFSP's cultivation U_{iA} and the utility from not cultivating OFSP U_{iN}. The farmer will cultivate OFSP if

$$D_i^* = U_{IA} - U_{IN} > 0$$

whereas the $X_i^*\alpha$ .provides an estimate of the difference in utility from OFSP's cultivation. ($U_{IA} - U_{IN}$) using the household and farm-level characteristics as explanatory variables, while v_i is an error term.

In estimating equations (3) and (4), it needs to be noted that the relationship between the OFSP's cultivation and income could be interdependent. Specifically, the selection bias occurs if unobservable factors influence both error terms of the income equation (ε_i) .and the choice whether to cultivate OFSP or not equation (v_i) thus resulting in the correlation of error terms of the income and OFSP's cultivation specifications. Thus, estimating equation (3) using the ordinary least squares (OLS) will lead to biased estimates. To address this problem, a two-step Heckman's procedure was used to analyse factors affecting the probability of cultivating OFSP. The model is appropriate because it addresses simultaneity problems. The Heckman two stage procedure has been used to address selection bias when the correlation between the two error terms is greater than zero (Adeoti, 2009; Tobi et al., 2010; Siziba et al., 2010). This depends on the restrictive assumption of normally distributed errors (Wooldridge, 2002). Thus the procedure involves, first, the estimation of the selection equation using a probit model (OFSP's cultivation equation (4)) and second, the estimation of the income equation (3). The OFSP's cultivation is estimated as in equation (4). Where D_i^* is a latent variable representing the propensity of OFSP's cultivation by smallholder. X_i is the vector of smallholder's characteristics that influence a farmer's decision to cultivate OFSP. The probit model predicts the probability of cultivating OFSP and also obtains the inverse Mill's ratio (IMR). The inverse of the mill's ratio (λ), which is the ratio of the ordinate of a standard normal to the tail area of the distribution, can be computed as shown below:

$$\lambda_i = \frac{\varnothing(\rho + X_i)}{\Phi(\rho + X_i)} \quad (5)$$

φ where and Φ are, respectively the standard normal density function and standard normal distribution functions. λ_I is the calculated IMR term to provide OLS selection corrected estimates (Greene, 2003).

Where:
X_1 = Age of the farmer (years)
X_2 = Gender of the farmer (Male = 1, 0 otherwise)
X_3 = Years of schooling
X_4 = Members of cooperative societies (Yes = 1, 0 otherwise)
X_5 = Access to extension contact (Yes =1, 0 otherwise)
X_6 = Cost of production (₦/planting season)
X_7 = Farm size (hectares)
X_8 = Household Size (Adult Equivalent)

The predictors X_1 to X_8 were chosen through a stepwise selection process. This involves analysis at each step to determine the contribution of a predictor entered previously into the equation. It helps to understand the contribution of previous variables as another variable is added. Thus variables are retained based on their statistical contribution.

RESULTS AND DISCUSSION

Socioeconomic characteristics of smallholders

The summary statistics is presented in Table 1. The average age of the smallholder farmers was 46 years and the gender was measured such that male of

Table 1. Summary statistics of smallholders

Variable	Mean	Standard deviation
Age (years)	46	12.81
Gender (male =1)	0.64	0.42
Years of schooling	3	2.62
Farming experience (years)	19	12.31
Farm size (hectares)	2.75	4.24
Off-farm income (₦/month)	22,431.69	45,645.34
Frequency of extension contact (number/year)	2	1.35
Sweet potatoes farming experience (years)	10	8.84
OFSP farming experience (years)	2	1.06
OFSP farm size (hectares)	0.47	0.58
Household size (AE)	4	1.77
Farm income (₦/month)	2,785.09	7,186.75

Source: Survey Data, 2016; Number of observations = 183; AE = Adult Equivalent

Table 2. Factors that determine the intensity of cultivation of OFSP

Variables	Estimates	t-Value
Age (years)	–0.01***	–2.62
Gender (male)	–0.02	–0.27
Years of schooling	0.01	0.74
Members of cooperative societies(yes = 1)	–0.23***	–2.64
Method of planting (Intercropping = 1)	0.38***	4.13
Access to extension (yes = 1)	0.03	0.77
Cost of production (₦/production cycle)	1.44e–06	0.44
Constant	0.54***	3.60
LR Chi²(7)	34.84***	
Log – Likelihood	–149.83	

Source: Survey Data, 2016; Number of observations = 183; *** = significant at 1%

the smallholders were scored 1. The mean of the gender (0.64) indicate that about 64% of the smallholders are male. Also, the average education of the smallholders was found to be approximately three years of schooling. This shows that the smallholders are averagely literate. The average farming experience of the smallholders was about 19 years while the mean farm size cultivated to OFSP by the smallholders was 0.47 hectare. The average frequency of extension contact received by the smallholders was two extension contacts per planting season. Table 1 also shows that the off-farm income of the smallholders was estimated to be ₦22,431.66 per month while the average farm income of the smallholders was estimated to be ₦2,785.09.

Determinants of the intensity of cultivation of OFSP

The determinants of the intensity of cultivation of OFSP were assessed using the Tobit model. The dependent variable is the proportion of farmland cultivated to OFSP. The result of the analysis is presented in Table 2. The result in the Table shows that the estimated model has explanatory power as shown by the likelihood ratio which was significant at the 1% level. The result also shows that three out of the seven variables included in the model were statistically significant (positive and negative).

The variable that positively influence the proportion of farmland cultivated to OFSP is the method of planting (intercropping). Those that negatively influence the proportion of farmland cultivated to OFSP are the age of the smallholders and membership of cooperative societies. The positive coefficient of the method of planting of OFSP implies that the smallholders that intercrop OFSP with other crops have a larger proportion of their farmland cultivated to OFSP than the smallholders who do not intercrop. Also, farmers with large farmland will be able to cultivate more of OFSP since they cultivate OFSP with other crops like yam, maize, cassava and vegetables while the OFSP serves as a leguminous crop that helps in the fixing of nitrogen to the soil.

The negative and significant coefficient of the age of the smallholders and their membership of cooperative societies implies that the older the smallholder the lesser the proportion of farmland cultivated to OFSP.

Table 3. Probit estimate of the seterminants of cultivation of OFSP

Variables	Probit Estimates	
	Coefficient	Z-Value
Age (years)	5.02e–04	0.35
Gender (male = 1)	–2.92e–03	–0.12
Household size (AE)	–0.01	–0.71
Years of schooling	–2.55e–03	0.63
Member of cooperative (yes = 1)	–9.75e–03	0.70
Cost of production (₦/production season)	7.62e–07	1.28
Access to extension contact (yes = 1)	0.03	1.12
Farm size (hectares)	–0.01***	–3.51
Constant	0.99***	14.17
Mills (lambda)	0.06	0.78
Rho	0.43	
Sigma	0.15	
Wald chi² (8)	15.03*	

Source: Survey Data, 2016; Number of observations = 183; AE = Adult Equivalent; *** = Significant at 1%

Table 4. Ordinary Least Square's estimate (OLS) of the effect of OFSP's cultivation on income

Variables	Ordinary least square estimate	
	Coefficient	Z- Value
Age (years)	0.07**	2.44
Gender (male = 1)	–0.16	–0.32
Household size (AE)	–0.43**	–2.55
Years of schooling	0.18**	2.03
Member of cooperative (yes = 1)	–0.38	–0.91
Cost of production (₦/production season)	8.89e–05***	3.30
Access to extension contact (yes = 1)	–0.60	–1.36
Farm size (hectare)	–0.04	–0.38
Constant	–0.17	–0.15
Mills (lambda)	0.06	
Rho	0.43	
Sigma	0.15	
Wald chi² (8)	15.03*	

Source: Survey Data, 2016; Number of observations = 183; AE = Adult Equivalent: ***= Significant at 1%; ** = Significant at 5%; * = Significant at 10%

This might be because the older smallholders do not have small children of about six years of age with them so they do not see the importance of cultivating more of OFSP. Also, older smallholders might not be willing to take the risks involved and as such smaller proportion of their farmland is cultivated to OFSP. For membership of cooperative societies, it implies that smallholders who are a member of cooperative societies are not likely to cultivate a large proportion of their farmland to OFSP. This might be because most cooperative societies in the rural areas are not aware of the nutritive value of the crop and as such do not encourage their members to produce it.

This finding is consistent with the findings of Kaguongo et al. (2012) where knowledge on value addition and nutritional benefit and having children not older than five years of age are said to be the major factors that influences the intensity of adoption of OFSP.

Effect of the cultivation of OFSP on the smallholder farmer's income

The effect of cultivating OFSP on the income of the smallholder was examined using two-stage Heckman model. This consists of the probit and ordinary least square (OLS) regression estimates. These results are presented in Table 3 (Stage 1) and 4 (Stage 2).

The first stage is the probit estimate of the factors influencing the cultivation of OFSP as shown in Table 3. It shows that only the farm size measured in hectares was significant. The farm size of the smallholder is found to negatively influence the cultivation of OFSP by

the smallholders. This implies that smallholders with larger farm size have a lower probability of cultivating OFSP. This might be because of the inadequate market for OFSP as discovered in the study area. This can be attributed to the fact that most people in the study area are unaware of the nutritional value of the OFSP which results in low demand for the product. This in turn affects the production by farmers as they couldn't get market for their production.

Table 4 shows the effect of cultivating OFSP on the income of the smallholders within the framework of OLS. Table 4 shows that the age ($P < 0.05$), household size, year of schooling ($P < 0.05$) and cost of production ($P < 0.01$) significantly influence the income of smallholders. It therefore implies that a year increase in age and higher level of education of smallholders contribute more advantage in the cultivation of OFSP for more profit maximization and increased income. They used their knowledge in the minimization of their cost of production to increase their income. Household size however, significantly ($P < 0.05$) reduces income of smallholder farmers, this implies that the more the household size, the more the number of children and as such the consumption of OFSP which ultimately leads to reduced income for the smallholders.

CONCLUSIONS

In this paper the intensity of cultivation of OFSP and its effect on smallholders' income in Kwara State, Nigeria was examined. The likelihood of intensity of cultivation of OFSP is significantly higher among those who practice intercropping. This indicates that those who intercropped have a larger proportion of their farmland cultivated to OFSP. More surprising is the fact that members of cooperative groups have relatively smaller proportion of their farmland cultivated to OFSP which is against *a priori* expectation, suggesting the low level of awareness of the potentials of this crop. The result from the Heckman two-stage model shows that OFSP's cultivation in the study area reduced significantly with farm size which can be due to low level of awareness and inadequate market for OFSP in the study area. This is against what obtains in other countries where the crop has become widespread. However, the age of the smallholder, household size (adult equivalence), years of schooling and the cost of production as expected were the factors that influenced the income of the smallholders.

This study therefore recommends that smallholders in rural Nigeria need to be more enlightened as to the potentials inherent in OFSP. This can be through existing cooperative groups; farm demonstration plots as well as through seminars. Also, a form of out-growers' production scheme can be put in place. This is such that smallholders are encouraged to produce in larger quantities either in groups or individually given that government agencies as well as research institutes will buy the product from them at a market competitive price. These policies will encourage smallholders to produce more, increase their income while reducing the level of vitamin A deficiency in the State as well as in the nation at large.

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