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The Effect of Bio-Fortified Orange Fleshed Sweet Potato Adoption on Farming Household Welfare in Osun State Nigeria

***[1]Adepoju, A. A. [2]Raufu M. O. [3]Sanusi, W. O and [4]Onabamiji O. A**

[1,2&3]Department of Agricultural Economics, Ladoke Akintola University of Technology, P.M.B 4000 Ogbomoso, Nigeria
[4]Osun State Agricultural Development Programme (OSSADEP),
Osogbo Zonal Office P. M. B 4312, Osogbo, Osun state Nigeria.
*correspondence: busolaadepoju@gmail.com

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The level of poverty in a household is a reflection of low welfare. There is need to develop ways of enhancing agricultural production to improve output and consequently, meet up with growing food demand and enhance farm income which further upgrade the welfare of the farming households. As a result, the study examined the effect of orange fleshed sweet potato (OFSP) adoption on farming household welfare. Primary data were collected with the aid of structured questionnaire using multistage sampling technique. Data collected were analysed using descriptive statistics, double-hurdle regression models and ordinary least square models (OLS). The results revealed that most of the OFSP farmers were male (94%), 98% of them were married with average age of 51 years. The mean years of education was 12 years, 46.42 % of them belong to farmers association and had an average farm size of 1.53 hectares. The study revealed a high level of awareness (83.77%) and adoption (74.34%) of the OFSP technology. The categories of household welfare used revealed a large difference in between them in terms of their mean per capita expenditure. Estimates of the first hurdle (Probit Model) revealed that adoption is influenced by age, household size, and education among others. The second hurdle estimates on the decision variables that influence the intensity of use of OFSP technology includes children below 5 years, farming experience, income number of extension visit etc. The OLS estimates showed that intensity of use of the OFSP significantly affect farming household welfare level. The study therefore conclude that adoption of OFSP technology directly influence household welfare. It was recommended that the youth should be encouraged to engage in farming activities.

Key words: Welfare level, OFSP adoption, double-hurdle regression models, Nigeria

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INTRODUCTION

Globally, more than two billion are known to suffer from hidden hunger that leads to adverse health consequences which may include poor physical, mental, and cognitive development. Micronutrient deficiency is a serious public health problem in many developing countries, but unlike wasting, it is often difficult to recognize and thus referred to as Hidden Hunger. Vitamin A deficiency (VAD) negatively affects child health and survival by weakening the immune system and over 350,000 children become blind yearly because of VAD (Low et al.,2017). Although it is vital to prevent disease, disability, and death among the vulnerable e.g pregnant women and children, interventions that focus on increasing the micronutrient intake through a single mechanism, such as supplementation, is weak if not paired with balanced approaches such as food fortification and dietary diversification Jenkins, Carmen and Houghtaling. (2015). Black et al (2013) reported that more than 40% of children under five suffer from VAD. Hence, several interventions are put in place to confront the VAD challenge not only through the provision of vitamin A supplement twice yearly for young children but also fortifying commonly consumed foods with vitamin A e.g. vegetable oil and sugar and breeding vitamin A into key staple crops such as sweet potato, maize and cassava.

The staple crops are biofortified with beta-carotene, a precursor of vitamin A, which has an orange color. With regard to the natural existence of high levels of beta-carotene in sweet potato varieties, the breeding development for biofortified orange fleshed sweet potato (OFSP) has been much faster than for the other vitamin A-enriched staple crops. Orange fleshed sweet potato (OFSP) roots are known to be rich in bioavailable beta-carotene and are also good sources of vitamins C, K, E, and several B vitamins as well as potassium and phosphorous. The leaves have reasonable amounts of beta-carotene after cooking and also have an excellent source of lutein, a good source of calcium, vitamin K, and several B vitamins (Haskell et al., 2004)

Production of sweet potato in SSA is mostly rain-fed. With two distinct rainy seasons, better varieties mature within 3-5-month therefore it can be produced 2-3 times yearly. However, in areas of unimodal rainfall, additional irrigation activities are required for the second crop except there are valley bottoms with sufficient residual humidity. The relative yield of SSA's sweet potato range from 5-25 tons per hectare compared to 50-60 tons per hectare in South Africa's modern agricultural sector. The negative association between area harvested and yield is common to sweet potato data in Sub-Saharan Africa. Walker et al (2011) opined that this may be due to the fact that sweet potatoes were planted on more marginal land. According to Fawole (2007), factors determining low yields include mixed cropping, with use of low quality vines, inadequate fertilizer use, insufficient rainfall, inappropriate planting density and ineffective weeding schedule. The prevailing sweet potato varieties in SSA comprise white or yellow-fleshed having no or low levels of beta-carotene respectively.

The third major producer of sweet potatoes in the world is Nigeria in relations to production quantity, it is nonetheless still regarded as a minor crop. Nigeria produced about 2.5% of the world's production of sweet potatoes in 2010 and in this same year, its production had the tenth highest production level among other single food crop in Nigeria. The gross agricultural production value for sweet potatoes was put at $954 million USD and this accounted for almost 1.73% of agricultural production value for all crops in Nigeria (Bergh et.al., 2012, Ahmad et al., 2014). Sweet potatoes are grown in all parts of the country in diverse agro ecological zones, from tropical rainforest to semi-arid and arid zones. While sweet potatoes are considered a cash crop in certain parts of Nigeria, most areas produced it as a secondary crop.

Even though Nigeria is the world's third largest sweet potato producer, report reveals that it only exports an inadequate quantity of sweet potatoes. According to Bergh et al., (2012), Nigeria ranks 33rd in world sweet potato exports. In 2011, Nigeria's sweet potato exports totaled 2,401 MT, a representation of just 0.1% of world sweet potato exports. Hence the overall export value of sweet potatoes in Nigeria is marginal. Sweet potatoes can be used for human consumption, animal feed, and diverse industrial uses. Most commonly, the fresh root is peeled and boiled, roasted, or fried into chips (fries). The leaves are often boiled and incorporated into soups, and the vines, leaves and roots are useful for animal feed. Recent studies found that animals fed on sweet potato vines produce less methane gas relative to animals fed with other types of feed. This suggests that sweet potato animal feed can help contribute to reduction in global emissions. Sweet potatoes are extremely adaptable to adverse environmental conditions; they can help increase food security in times of drought and famine.

PROBLEM STATEMENT

The agricultural sector in Nigeria is dominated by small-holder farmers which accounts for over 75% of the food production while more than half of the farmers produce mainly food crops (Amare and Shiferaw (2017). However, the sector is not growing at the same proportion with the population growth rate. Iheke and Nwaru (2013) reported that in Nigeria agricultural production increased to 12.3 percent of gross domestic product in 2009. However, 72.9 percent of the population lives on less than US$2 per day while 27.5 percent consume inadequate calories and 23.6 percent of children under five are malnourished and underweight. This therefore necessitate an enhancement of the agricultural sector to meet up with the increasing demand for food and other raw materials requirements of the agro allied companies. Most of the small holder farmers cultivate less than 5 hectares of land and reside mainly in the rural area where abject poverty is prevalent (Balogun and Yusuf 2011).

The level of poverty in a household is a reflection of low welfare. Hence, the need to develop means of enhancing agricultural productivity to improve output and consequently, meet up with growing food demand as well as enhance farm income which further upgrades the welfare of the farming households is paramount. Poverty exists when an individual or a group of individuals fails to attain a level of well-being, usually material well-being which is deemed to constitute a reasonable minimum by the standard of that society. This means that poverty is an ex-post measure of a well-being. A state of a long term deprivation of well-being is a situation considered inadequate for a decent life.

It is known that about 68 percent of the extreme poor are dependent on agriculture and most of these farming households face one type of risk situation or another which leads to fluctuations in their income. Consequently, they are impoverished and vulnerable to negative changes in environmental, socio-cultural, political and economic conditions because of their entanglement in the vicious cycle of poverty. Some of them are food insecure because they sell the best of their farm and consume low grade crops. Irrespective of this fact, they earn low incomes due to poor marketing facilities, poor storage and preservation techniques, poor health facilities, lack of technological know-how among others. Farmers are invariably the most vulnerable due to the peculiar characteristics inherent in their primary means of livelihood. However, it has been recognized that a household's sense of well-being depends largely on its average income or expenditures. In view of this improving agricultural productivity to increase output and consequently raising farm income has become an urgent necessity. One of the essential ways of improving agricultural productivity is through introduction and adoption of improved agricultural technologies (Obisesan, Amos and Akinlade 2016). The issue of increasing agricultural productivity has therefore become the main concern to governments after a considerable increase in food price over the last two years that follows decades of low food price

It is an established fact that improved agricultural technologies reduce poverty by increasing rural agricultural incomes, reducing food prices, facilitating the growth of non-farm sectors, and by motivating the switch from low productivity subsistence agriculture to highly productive agro-industrial economy. According to Tanko and Olasunkanmi (2016). Agricultural innovation can have both direct and indirect influence on poverty and consequently over all welfare. The direct influence of an agricultural innovation on poverty reduction is those productivity benefits enjoyed by the farmers who actually adopt the innovation. These benefits normally manifest themselves in form of higher farm profits while the indirect influences are productivity induced benefits passed on to others by the innovating farmers. These may include lower food prices, greater non-farm employment levels or increased consumption for the farmers. How dominant the influence is largely dependent on the speed with which farmers adopt new technologies and whether or not the affected households are net food buyers or sellers.

The impact of the adoption of a new technology can be studied from the pro-poorness of the new technology. The adoption of a new technology is pro-poor if it benefits the poor relatively more than the non-poor (Lambrecht, et al., 2014). Obviously, such a technology must be affordable by the poor. Moreover, its benefit must be substantial relative to its cost including risks involved. Iheke and Nwaru (2013) reiterates that increasing agricultural productivity can increase food availability and access in addition to improving rural incomes. Fortunately, Africa has experienced continuous agricultural growth during the last few years. However, much of the growth has emanated from area expansion rather than increases in land productivity. They noted that the principal solution to increase food production lies in raising the productivity of land given the existing new technology. (Amare and Shiferaw (2017).

Orange fleshed Sweet potatoes production can offer a particularly significant potential for increasing food production and income there by reducing poverty, improving food security level and enhancing household welfare in Nigeria (Ahmad 2014). In that wise, it is believed that improving productivity, profitability and sustainability of smallholder agriculture in Nigeria is significant to promoting inclusive economic growth and the main route to poverty and inequality reduction in addition to better household well-being.

However, level of agricultural technology adoption requires initial capital for land, equipment, etc. Acquisition of this requirement may be difficult for poor farmers to attain. Relatively, the richer households on another other hand, may often have farms with good quality soils, access to markets, and use new technology to improved productivity thus leading to increased inequality. To this point, little policy attention has been directed to understanding how the changes in agricultural productivity through technology adoption affect farming household welfare inequality. Recent studies suggest that improving agricultural productivity could play a crucial role in reducing poverty by generating greater incomes and creating employment for smallholder farmers, however, its effects on welfare inequality are not well understood. In view of these facts, the study examined the effect of OFSP adoption on farming household welfare. Specifically, it describe the socio economic characteristics of the OFSP farmers, examine the level of adoption of OFSP, categorise the farmers based on welfare level, determine the factors influencing adoption of OFSP and evaluate the influence of OFSP adoption on farming household welfare.

RESEARCH METHODOLOGY

The study area. The study was conducted in Osun state, Nigeria. The state was created in August 27, 1991 from part of the old Oyo state with its capital located in Osogbo. There are 30 local government areas in the the state. It can be found on the 7°30′N 4°30′ECoordinates, located in the south west region of Nigeria with a total population of 3,416,959 people (NPC 2006), the state occupies a total area of 9,251 km^2. The major sub-ethnic groups in Ọsun are Ife, Ijesha, Oyo, Ibolo and Igbomina of the Yoruba people, although there are also people from other parts of Nigeria.

Sampling technique and data collection. A multistage random sampling technique was used. The study area was divided into three agricultural zones namely Iwo, Osogbo and Ife/Ijesa with 10 local government areas each. The first stage involved the random selection of a local government area from each zone. These include Ede north, Obokun and Ife central local government areas. About 270 households were randomly selected for the study with at least not less than 85 households selected from each local government representing each zone. A total of 265 questionnaires were eventually used for the analysis. Primary data collected through the use of structured questionnaire was used for this study. The data include the socio-economics characteristics such as age (years), sex, educational level (years of formal education), household size (number in house of farmer), occupation, farming experience (years), marital status, etc, vine cost (naira), farm size (hectares), among others

Empirical analysis. The data collected was analyzed through the use of descriptive statistics, double hurdle model ordinary least regression (OLS) model. The descriptive tools used include frequency, percentages, mean, standard deviation, quintiles among others. Model of Adoption, the double-hurdle model was used to analyse both the determinants of incidences and the intensity of adoption of OFSP technologies. This model assumes that households make two sequential decisions with regard to technology adoption. Each hurdle is conditioned by the farmer's socio-economic characteristics and technology-specific attributes. To estimate the double-hurdle model, a probit regression (using all observations) is followed by a truncated regression on the non-zero observations (Cragg, 1971). Double-hurdle model is invented to analyse instances of an event which may or may not take place and if it takes place, takes on continuous values. The adoption of OFSP technology by a farmer involves first the decision on adopting the technology then the decision on the intensity of its use. A different latent variable was used to model each decision process, with a probit model to determine the probability that a household will adopt planting OFSP variety and a truncated regression model to determine the intensity of adoption. As used by Kaguongo et al., (2010). The specification of the generalized double-hurdle model is as follows:

$$y = \begin{cases} x'\beta + v & if \;\; x'\beta + v > 0 \; and \; z'\alpha + u > 0 \\ 0 & otherwise \end{cases} \quad \text{....1}$$

$$\begin{bmatrix} u \\ v \end{bmatrix} = N\left\{0. \begin{bmatrix} 1 & \rho\sigma \\ \rho\sigma & \sigma^2 \end{bmatrix}\right\} \qquad \text{where } v > -x'\beta,$$

where *y* is the adoption; *x* and *z* are variables determining the awareness and the intensity of use respectively; *u* and *v* are residual terms from the two processes, with a correlation coefficient ρ; α, β, ρ, and σ are parameters for estimation. Then the likelihood function can be written as

$$L = \prod_{y=0}\{1 - \varphi\,(z'\alpha, x'\beta/\,\sigma, \rho)/\Phi\,(x'\beta\,/\,\sigma)\} \quad \text{...2}$$

$$\text{x} \prod_{y>0}\left\{\frac{1}{\sigma}\,\emptyset\,[(y - x'\beta\,/\,\sigma)]\;\Phi\,\frac{z'\alpha + \rho\,(y - x'\beta\,/\,\sigma)}{(1-\rho^2)^{1/2}}\right\} \quad \text{...3}$$
$$[\Phi\,(x'\beta\,/\,\sigma)]^{-1}$$

where Φ (.) and $\emptyset$ (.) are univariate standard normal CDF and PDF respectively; ψ (·) is the bivariate standard normal CDF with three arguments, bivariate means and the errorterm correlation. When ρ = 0 , the above model reduces to Cragg's independent hurdlemodel.

Ordinary Least Square (OLS): The conventional model of household economic behaviour under constrained utility maximization was used to relate the level of household expenditure (as money - metric indicator of welfare) directly to household endowments (assets) and variables describing economic environment in which decisions are made. The household welfare is hypothesized to be influenced by the independent variables included in the model below:

$$In\ E_i = \alpha + \beta Adoption_i + \gamma SC_i + \delta OA_i + \sum_{i=1} x_i + \mu_i$$
(4)

Where E_i = *per capita* expenditure of household i
$Adoption_i$ = a measure of the household adoption and intensity of use of OFSP technology
SC_i = the household social capital; (group membership (dummy))
OA_i = represent household assets; (farm size in hectare and total income)
X_i = a vector of household characteristics: (age in years, sex (dummy), household size (actual number), children below 5years (actual number), farming enterprise

(dummy) farming experience (actual number),
μ_i = represent unobserved disturbances and potential measurement errors.

RESULTS AND DISCUSSIONS

A. The socio-economic characteristics of the respondents

The distribution of the respondents based on their socioeconomic features is as presented in Table 1. The results revealed that 3.4% of the respondents were either 30 years or less than or are between the age range of 31 and 40 years. About 42 percent of the OFSP farmers were between 41 and 50 years of age and this represent the highest percentage. The mean age of the farmers was 51.62years, an indication that the farmers were no longer in their active years. OFSP production is dominated by male farmers in the study area and this accounted for 94.72%. Majority of the sampled farmers (98.49%) were married, 39.25 percent of them are primarily engage in farming as a source of livelihood while 82.82 percent of them engage in secondary occupation to augment their household income.

Also, about 39.25 percent of the respondents have a household size that range between 4 and 6 members while those with 3 members or less accounted for only 0.2 percent. The average household size in the study area is about 8 members. This is an indication that farmers keep fairly large family members in the study area. Only 2.26 percent of the respondents had no formal education, 40.38 and 47.55 percent of them testify they had post primary and tertiary education respectively. The mean years of education for the OFSP farmers are about 12 years which according to the Nigerian education policy is for complete secondary education. This mean majority of the farmers were literate and this can enhance their decision of adoption of OFSP variety when the nutritional benefit of the root crop is put into consideration.

About 46.42% of the farmers indicated that they belong to one association or the other where they derive benefit such as information sharing about OFSP production, marketing information, sources of vine among others. In addition, majority of them (77.36%) also affirm they have access to extension services in their locality which can help boost technical knowledge about OFSP production. About average of the farmers in the study area (51.70%) cultivated between half and one hectare of land. This is followed by those had above 2 hectares of farmland. The average farm size for the farmers in the area is 1.53 hectares, an indication that agricultural production is at the subsistence level. From this, the average land cultivated for OFSP is 0.28 hectares.

About 51.32 percent of the OFSP farmers claimed they earn a total monthly income that range between ₦300,000 and ₦600,000 from their farm and off farm earnings. This is followed by respondents that earn less than ₦300,000 as their total income. The least percentage (0.75) are those who earn above ₦1.2m. the average total income is about ₦410,000.00 per faming household. This is implies that the farmers earn enough to cater for their household needs.

B. Awareness, adoption and rate of adoption of OFSP

Majority of the farmers in the study area (83.77%) are aware of the biofortified orange fleshed sweet potato specie. About 74 percent of these farmers indicated they have adopted the vitamin A rich OFSP for cultivation on their various farms. Based on sources of awareness of the specie, none of the respondents specified that they got information about the values of OFSP from neither television programmes nor billboard advertisement. However, about 60 percent of the OFSP farmers claimed they sourced the information from the extension officers of the Agricultural Development Programme. This is followed by those farmers introduced to OFSP cultivation by OFSP Jumpstarting programme (37.74%). A programme launched by the state to provide nutritive food for public school pupils in order to enhance their growth and wellbeing. Only 5.66 and 5.28 percent of the OFSP farmers declare that knew about the biofortified specie through Non-Governmental Organisations and their farmers association respectively.

Majority of the OFSP farmers (68.68%) grow a type of OFSP specie called Sologold. Other grown in the locality include mothers delight (15.47%) and King J (27.55%). Considering the intensity of adoption of OFSP specie in the study area. Twenty percent of the OFSP farmers dedicated between 0.21-0.3 hectares of their farmland to OFSP production. Farmers who dedicated above 0.4 hectares of their farm size to OFSP production accounted for only 10.57 percent. The mean farm size used for the cultivated of OFSP in the study area is 0.26 hectare. This is an indication that the rate of adoption is still very low relative to the usefulness of the root crop.

Table 1. Socio-economic characteristics of the respondents

Variables	Freq	Percent	Mean	Variables	Freq	Percent	Mean
Age				**Sex**			
<=30	9	3.4	51.62	Female	14	5.28	
31-40	9	3.4		Male	251	94.72	
41-50	112	42.26		**Pryoccup**			
51-60	96	36.23		Traders	66	24.91	
>60	39	14.72		Civil service	56	21.13	
Marital Status				Farming	104	39.25	
Married	261	98.49		Artisans	39	14.72	
Single	4	1.51		**Secoccup**			
Householdsize				No	45	17.18	
<=3	2	0.75	7.7	Yes	220	82.82	
04-06	104	39.25		**Group membership**			
07-09	94	35.47		No	142	53.58	
>9	65	24.53		Yes	123	46.42	
Education (yrs)				Extension service			
<=0	6	2.26	12.42	No	60	22.64	
01-06	26	9.81		Yes	205	77.36	
07-12	107	40.38		**OFSP famsize (ha)**			
13-17	126	47.55		0	68	25.66	0.28
Farmingexp (yrs)				<=0.2	29	10.94	
<=10	155	58.49	11.23	0.21-0.4	63	23.77	
11-20	104	39.25		0.41-0.6	77	29.06	
21-30	6	2.26		0.6	28	10.57	
Farmsizegrp (ha)				**Totalincome (₦)**			
<=0.5	4	1.51	1.53	<=300,000	79	29.81	410,121.70
0.51-1.0	137	51.70		300,001 - 600,000	136	51.32	
1.01-1.5	53	20		600,001 - 900,000	33	12.45	
1.51-2.0	12	4.53		900,001 - 1,200,000	15	5.66	
>2	59	22.26		>1,200,000	2	0.75	
Total	**265**	**100**		**Total**	**265**	**100**	

Table 2. Distribution of farmers based on awareness, adoption and rate of adoption of OFSP

***Awareness**	**Freq.**	**Percent**
Awareness of OFSP	222	83.77
Sources of awareness		
Television	0	0.00
ADP agent	158	59.62
Radio brdcast	59	22.26
OFSP Jumpstating prog	100	37.74
Billboard	0	0.00
Friends	20	7.55
Farmers	54	20.38
NGO	15	5.66
Farmers assoc	14	5.28
Adopted OFSP	197	74.34
Type of OFSP grown		
Mothers delight	41	15.47
Sologold	182	68.68
King J	73	27.55
Rate of adoption (ha)		
No adoption	68	25.66
<= 0.2	70	26.41
0.21 – 0.3	53	20.00
0.31-0.4	46	17.36
> 0.4	28	10.57
Mean 0.26 (ha)		

*Multiple choices.

Table 3. Distribution of the farmers based on their welfare categories.

Quintiles	Freq (%)	Mean PCE	Std. Dev.	Min	Max
quintile1	53 (20.00)	1,907.84	953.1547	772.2222	3,383.333
quintile2	53 (20.00)	3,896.80	259.0173	3,528.572	4,231.25
quintile3	53 (20.00)	5,074.08	709.2775	4,275	6,350
quintile4	53 (20.00)	7,106.50	664.2086	6,380	8,160
quintile5	53 (20.00)	17,212.77	13,459.39	8,308.333	57,583.33
PCE	265 (100.00)	7,039.60			

C. Welfare categories of the OFSP farmers.

Table 3 presents the welfare categories of the OFSP farmers in the study area. The households were profiled into five different groups based on their per capita expenditure. The mean per capita expenditure of the total households studied is ₦7,039.60. The households in the first quintile represent the lowest category with mean per capita expenditure (PCE)of only ₦1,907.84. The meanPCE of the second quintile doubles that of the first quintile, that is ₦3,896.80. Respondents that are in the third quintile represent the middle category from both the first and the fifth categories. The mean PCE for this category of respondents increased by almost 50% relative to the second quintiles (₦5,074.08).

The fifth quintile is the category of respondents that has the highest level of welfare. Their mean PCE is ₦17, 212.77 which is more than double MPCE in the fourth category and triple that of the third category as well. The farmers in the fourth and the fifth quintiles are the two basic categories whose MPCE is same or over the overall MPCE for the group of farmers considered for this study. Hence, they may be viewed as living in affluence whose basic welfare may be guaranteed based on their PCE.

D. Determinants of Adoption and intensity of adoption of OFSP

The factors that influence farmers' adoption status and the rate of adoption of OFSP is presented in Table 4. The result from the first hurdle, eight out of nine decision variables significantly influences farmers' adoption decision concerning cultivation of OFSP at 1 percent level of significance. The estimates indicates that sex, children below 5 years of age and age squared which capture the life cycle of the household head, education level and secondary occupation positively influence the decision to adopt growing OFSP while age, marital status and household size significantly affect it negatively.

The marginal effects of the model reveal changes in the probability of adoption of OFSP for additional unit increase in the independent variables. A unit increase in the number of male farmers as well as respondents who engage in secondary occupation will increase the probability of adopting OFSP by over 220% in both cases. The reason for this is not farfetched as male dominates agricultural production especially root crop farming and income from secondary occupation can encourage farmer to adopt the new technology. Increase in the number of children below 5 years and years of education will also increase the probability of farmers adopting OFSP technology by 88% and 14% accordingly. This is because the underaged are known to need micronutrients contained in the biofortified root crop. Also, educational exposure will aid the decision making relative to the nutritive values of the crop.

Age of the household head and its square are significant at 1 percent and are negative and positive respectively. This is an indication that as household head increases in age, there will be decrease in the probability of farmer adopting OFSP technology but this likelihood decreases at an increasing rate as the age advances. Household size also affects OFSP technology adoption but negatively associated with it. This shows that as household size increases there will be decrease in probability of adopting the technology by 36%.

The second hurdle estimates (truncated model) reveals that children below 5 years of age, marital status, farming experience, income from paid employment negatively influence the decision of optimum level of utilization of OFSP technology while householdsize, secondary occupation, farm income, vine cost and number of extension visit positively affect the utilization of OFSP technology. An increase in the number of children below 5 years of age as well as married farmers will decrease the likelihood to optimally utilize the OFSP technology. This may be due to distraction that can ensue from increase of these factors thereby affecting the technicalities involved in OFSP production. An increase in income from paid employment negatively affects optimal use of the technology. This is because more attention will be diverted to this source at the detriment of the efficiency needed to optimally use the OFSP technology.

An increase in household size and number of farmers that engaged in secondary occupation positively influence for optimal utilization of the technology. The nutritional benefit and the fact that it can be grown up to three times a year can encourage its optimal use with increase household size. Also, income from other sources may augment income from farm thereby making accessibility of the technology affordable to intensify its use. In addition, an increase in the income derived from farm activities, increase in the cost of vine and number of visit of extension worker to the farmer will further boost the optimum utilization of the technology. This is because a rational farmer will want to make more money through increasing the intensity of use of the technology.

E. OFSP technology adoption and household welfare

The result of the ordinary least square method is presented in Table 5. The OLS estimation of the effect of OFSP adoption and its intensity on household welfare indicates that age, sex, household size children below 5years, farming status, farm experience, group membership, farm size, total income and intensity of adoption make significant contribution to changes in household welfare. The R^2 is 0.476, it reveals that 47.6% of the proportion of the variance in the dependent variable is predictable from the independent variables.

Table 4. Factors influencing adoption and intensity of use of OFSP technology

Adoption	**Marginal Effect**	**Std. Err.**	**z**
Sex	2.471***	0.514	4.8
Age	-0.714***	0.252	-2.84
Agesqr	0.007***	0.002	3.15
Children below 5years	0.885***	0.216	4.09
Marital status	-1.114***	0.337	-3.3
Household size	-0.358***	0.079	-4.52
Farming experience	-0.045	0.048	-0.92
Educational level (yrs)	0.140***	0.046	3.03
Secoccup_dummy	2.238***	0.416	5.37
_cons	16.921	7.090	2.39
Intensity of use			
Sex	0.051	0.058	0.89
Age	-0.007	0.006	-1.22
Agesqr	0.000	0.000	-1.15
Children below 5years	-0.128***	0.014	-8.86
Marital status	-0.059**	0.027	-2.17
Household size	0.022***	0.005	4.48
Educational level (yrs)	0.000	0.004	0.01
Secoccup_dummy	0.088**	0.033	2.64
yrsfarexp	-0.008**	0.003	-2.54
Groupmembshp_dummy	0.017	0.016	1.07
Paidemployment income	0.000***	0.000	-8.36
Farm income	0.000***	0.000	6.49
Vine cost OFSP	0.000***	0.000	6.64
Number of extension visit	0.038***	0.007	5.43
_cons	0.931	0.171	5.46
sigma			
_cons	0.073	0.004	17.79
Log likelihood	161.2777	Number of obs	247
Prob > chi2	0.000	Wald chi2(9)	82.08

Table 5. Effect of OFSP technonolgy adoption on household welfare

Inpce	Coef.	Std. Err.	t
age	0.024**	0.009	2.69
sex	-0.364**	0.183	-1.99
hhdsize	-0.148***	0.019	-7.92
children below 5years	0.183***	0.055	3.31
Farming Status	0.266***	0.040	6.57
yrsfarexp	-0.062***	0.020	-3.06
groupmembshp_dummy	-0.210**	0.099	-2.11
Farm size (ha)	0.383***	0.065	5.86
totincome	0.000*	0.000	1.90
adoptedofsp_dummy	-0.102	0.119	-0.85
rateofadoption	1.047***	0.312	3.36
_cons	9.053	0.430	21.06
R-squared	0.476		
Adj R-squared	0.453		

An increase in age of the household head and the number of children below 5 years will increase per capita expenditures by 0.024 and 0.183 respectively. This explains an improved welfare of the household. Increased age may attract remittances from well-wishers which will supplement income from livelihood activities. Result on the gender reveals that increase in the number of female headed household will enhance household welfare while a unit increase in the number of respondents primarily engaged in farming activities will increase the household per capita expenditure. On a contrary, increase in household size and farming experience are associated with decrease in household *per capita* expenditures, whereas an increase in the farm size is associated with an increase in household *per capita* expenditures. The total income is also positively related to household welfare, this indicates that when the income earn increases per capita expenditure of the household also increases. Lastly, increase in the optimal utilization of OFSP technology as indicated by rate of adoption positive influence household welfare. This is to say that it is not enough to adopt OFSP technology, it is as well important to increase the intensity of use in order to effectively influence welfare status of the farming households

CONCLUSION

The study revealed a high level of awareness and adoption of the biofortified orange fleshed sweet potato technology in the study area. Farming is dominated by male farmers who are no longer in their active age. Most of the farmers grow Sologold, a type of the OFSP technology. The categories of farmers growing OFSP revealed a large disparity in expenditure between the first and last quintile an indication of basic household welfare anong the first category of farmers. Among the factors influencing farmers' adoption decision regarding cultivation of OFSP tech in the study area is age, educational level, and marital status among others. Also, the optimum level of utilization of the bio-fortified OFSP technology that is, the intensity of use is influenced by farm experience, income from farm and paid employment in direct directions, cost of vine, extension visit etc. the optimal utilization of the OFSP technology positive influence farming household welfare. This emphasise that intensity of use of OFSP tech is the sufficient condition for its adoption in order to enhance the level of welfare in the household. The study recommends that the youth should be enlightened and encouraged to engage in farming activities, acquire basic human resource necessary and have moderate household size.

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