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Full Length Research Paper

Factors influencing adoption and intensity of adoption of orange flesh sweet potato varieties: Evidence from an extension intervention in Nyanza and Western provinces, Kenya

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This study applied logit and transformed logit regression to examine factors affecting the adoption of orange flesh sweet potatoes, and intensity of such adoption, by a representative sample of 340 farmers in the Busia and Rachuonyo (OFSP) districts of Kenya in 2009. A double-censored Tobit model was also used to study factors affecting intensity of adoption. The study also investigated whether participation in a value chain extension intervention programme increased farmers' likelihood of adopting OFSP. The participation variable was first tested for endogeneity and "purified" before using it as a "proxy" in the adoption regression. The results suggest that the district where the farmer comes from, knowledge on value addition and nutritional benefits, and availability of vines were the key factors for adoption. The results also suggest that participation in a value chain extension programme enhanced the probability of adoption. Factors affecting intensity of adoption were site, value addition, vines availability, level of commercialization and having a child of up to five years.

Key words: Extension intervention programme, intensity of adoption, orange flesh sweet potato, Kenya.

INTRODUCTION

Sweet potato (*Ipomea batata L.*) is an important traditional crop that is grown customarily by small-scale farmers in many developing countries mainly for household consumption. It is traditionally regarded as a 'poor man's' crop as it is typically grown and consumed by resource poor households, and mainly by women, and it gives satisfactory yields under adverse climatic and soil conditions, as well as under low or non-use of external inputs (Carey et al., 1999; Kung'u, 1999; Ndolo et al., 2001; Githunguri and Migwa, 2004).

As a food security crop, it can be harvested piecemeal as needed, thus offering a flexible source of food and income to rural households that are mostly vulnerable to crop failure and consequently fluctuating cash income. In addition to being drought tolerant and having a wide ecological adaptation, it has a short maturity period of three to five months. It is also an excellent source of vitamin A, especially the orange fleshed varieties (Ndolo et al., 2001). The orange fleshed varieties are also tasty and have attractive color to children (Kaguongo et al., 2008a) hence have high potential to address caloric and vitamin A deficiency problems of children among the

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Abbreviations: AVRDC, World vegetable center; **CIP,** Centro International de la Papa (International Potato Center); **CV,** commercial village; **FCI,** farm concern international; **KARI,** Kenya Agricultural Research Institute; **OFSP,** orange flesh sweet potato; **TAVs,** Traditional African Vegetables; **UH,** urban harvest programme.

poorest communities (Stathers et al., 2005; van Jaarsveld et al., 2006; Low et al., 2007). However, most varieties in sub-Saharan Africa are white-fleshed, low yielding and lacking beta-carotene, the precursor of vitamin A (Stathers et al., 2005).

Sweet potato is produced in most parts of Kenya, being concentrated in districts of Nyanza and Western provinces. About 60% of the households in these two provinces live below the poverty line (Central Bureau of Statistics (CBS), 2003), an indication of a potentially high proportion of the population without adequate quantity and quality of food intake. The potential of sweet potato’s contribution to food security, increased incomes and reduction of nutritional deficit is, therefore, considerable and is yet to be fully exploited in developing countries (Woolfe, 1992).

Although commercialization of sweet potato is still low in most parts of Nyanza and Western provinces, its gross margin of USD 238 to 362 ha^{-1} is highly competitive when compared with that of maize (USD 55 to 244 ha^{-1}) and cassava (USD 97 to 171 ha^{-1}) which are the other important crops commonly grown in these regions (Nyoro, 2002; Stathers et al., 2005; Kaguongo et al., 2008b; Fermont et al., 2010). However, the area allocated to sweet potato is often a small fraction of area allocated to maize or cassava because sweet potato is often grown as a subsistent crop (Gakonyo, 1993; Kaguongo et al., 2008b; Fermont et al., 2010).

The Traditional Food Project was a programme in Kenya and Tanzania jointly implemented between April 2007 and September 2009 by the International Potato Center (CIP), Farm Concern International (FCI), Urban Harvest (UH), and World Vegetable Center (AVDRC-Asian Vegetable Development Center). Its aim was to increase productivity, utilization and marketing of Traditional African Vegetables (TAVs) and sweet potatoes, specifically orange flesh sweet potatoes (OFSP). The project aimed to achieve this through the delivery of improved extension services to the farmers participating in the programme. The three OFSP varieties promoted in Busia and Rachuonyo districts in Kenya were Ejumula, Vindolotamu and Vitamu-A.To promote increased adoption, commercialization and marketing of improved varieties of the targeted crops by the programme farmers, the project used a “Commercial Villages” (CV) approach. The approach uses a collective approach in interventions aimed at increasing adoption, productivity and commercialization by the rural poor. In the scheme, farmer groups are clustered together to form one large group called a “commercial village” that aims to benefit from economies of scale in extension work, input sourcing, production and marketing activities.

To evaluate the impact of interventions from this programme, the researchers plan to conduct impact analyses using baseline and adoption data generated from participants (members of the programme) and non-participants (non-members of the programme). However, before undertaking any impact assessment, it is imperative to establish whether the programme participation by farmers was instrumental in the adoption of improved technologies and innovations and control for confounding factors that affect the adoption and impacts measured in terms of any outcome variable. The objective of this study is, therefore, to analyze the adoption of OFSP among sample farmers in two provinces of Kenya by identifying key determinants of adoption and intensity of adoption of OFSP, and establishing whether programme participation enhances adoption and intensity of adoption. The review of adoption studies by Feder et al. (1985) indicated, *inter alia*, that adoption decisions are influenced by a number of socioeconomic, demographic, ecological and institutional factors and are dependent on the nature of the technology. Studies of the key determinants of technology adoption by farmers growing upland rice and soybeans in Central-West Brazil (Strauss et al., 1991) and to evaluate the role of human capital and other factors in adoption of reduced tillage technology in corn production (Rahm and Huffman, 1984) found that farmers’ education and experience play a crucial role in facilitating technology adoption. Doss (2003) reported that the major reasons for not adopting farm-level technology in East Africa were: (1) farmers’ lack of awareness of the improved technologies or a lack of information regarding potential benefits accruing from them; (2) the unavailability of improved technologies; and (3) unprofitable technologies, given the farmer’s agro-ecological conditions and the complex set of constraints faced by farmers in allocating land and labor resources across farm and off-farm activities. The mismatch between technology characteristics and farmers’ technology preferences has also been identified as the most important factor for the low level of technology adoption in Ethiopia (Wale and Yallew, 2007).

Other studies have revealed that off-farm incomes and availability of information influence technology adoption decisions through affecting risk aversion levels of smallholder farmers. Risk aversion level is likely to be negatively associated with adoption as farmers are less certain about the profitability (productivity) of new technologies when they use them for the first time. Farmers level of risk aversion (which is a function of their poverty level, lack of information on the productivity of the technology, and non-stability of the impact of the technology) is also an important factor in the adoption decision (Feder and Slade, 1984; Feder et al., 1985; Kristjanson, 1987; Kaguongo et al., 1997).To improve availability of relevant information for increasing adoption, many development agents have devised several approaches and innovations. When the innovation system is linked to farmers to promote effective communication, problem identification, problem solving and personal interactions of a formal or informal nature, higher adoption of technology is likely (Steffey, 1995).

Putler and Zilberman (1988) revealed the importance of physical capital endowment in the adoption process. Physical capital commonly associated with adoption of technologies has been identified as farm size or cultivated land, livestock and farm implements owned (Feder and O'Mara, 1981; Rahm and Huffman, 1984; Shapiro, 1990; Nkonya et al., 1997). Financial capital and credit access have also been shown to affect adoption of agricultural technologies and innovations especially when such adoption does not involve increasing diversification, which is viewed as a reducing measure (Feder and Umali, 1993; Cornejo and McBride, 2002; Simtowe and Manfred, 2006).

A Kenyan study, which evaluated the effect of women farmers' adoption of OFSP in raising Vitamin A intake, found that women farmers were likely to adopt the OFSP if the clones were sufficiently high in starch (high dry matter), low in fibre, and if they were introduced through community-level education programmes that focused on the health of young children (Hagenimana and Oyunga, 1999). A study in Mozambique revealed that some of the key factors affecting adoption of OFSP included availability of vines, intensity of extension service and number of times the respondent received vines (Mazuze, 2005). A number of studies have also revealed that most of the factors affecting adoption also affect the intensity of adoption (Alene et al., 2000; Kaliba et al., 2000).

METHODOLOGY

Study site

The study was conducted in Rachuonyo (Nyanza province) and Busia (Western province) districts of Kenya. The Rachuonyo site comprised of the most commercialized sweet potato area in the country. Nyathiodiewo, a local variety which is yellow fleshed, is the most commonly grown variety accounting for over 90% of total production in the area. Traders from major towns of the country (Nairobi, Kisumu, and Nakuru) bought sweet potatoes from the district and transported them using large trucks. Sweet potato is also regarded as a food security crop in the area and is particularly important when there is an undersupply of maize. The site is located in the lower midland tea zone (LM2), with elevation ranging from 1,300 to 1,700 m and mean annual precipitation of 1,300 to 1,700 mm. The long rains occur from February to June while short rains occur from August to November.

The Busia site comprised of an area where sweet potato is less commercialized although sweet potato is important as a food security crop and farmers produce it on a small scale mainly for home use and only sell when there is an excess or when there is a pressing demand for cash. The area falls within the marginal sugarcane zone (LM1), with elevation ranging from 1,200 to 1,300 m and annual precipitation of 1,400 to 1,550 mm. The mean annual temperature ranges from 20.4 to 22.3°C. Sweet potato is planted in the months of April through June during the long rains and September through mid-November during the short rains. Sweet potato varieties grown are mainly white fleshed such as Bungoma and Kampala, and none is predominant in the area.

Survey design, sampling and data collection

Farmers were grouped into participants if they participated in the traditional Food Program and non-participants if they did not. Baseline and adoption survey data were collected for the purpose of undertaking impact assessments by comparing both participant and non-participant farmers before and after the programme implementation. The baseline survey was conducted in September to October 2007 while the adoption survey was conducted in November to December 2009. The two surveys used structured questionnaires to gather information on socio-economic characteristics, cultivation, consumption and marketing of sweet potatoes by the households.

Each site had four CVs comprising of about seven farmer groups each and with an average of 18 participants per group. Representatives of participant farmers (beneficiaries) and non-participant farmers (non-beneficiaries) were interviewed during the baseline and adoption surveys. During the baseline survey four farmers were randomly sampled per group per CV. The same farmers in the baseline survey were targeted during the adoption survey, but due to high attrition additional participants were sampled for the adoption survey. The non-participant farmers who acted as the 'control' for the study were sampled from villages with similar characteristics as those from which participant farmers in CVs originated. Twenty non-participant farmers were randomly sampled to act as control for each CV. A total of 340 farmers were interviewed during the adoption survey, of which 205 were participants and 135 were non-participants. Due to the nature of the programme interventions, the sample selection criteria included two priorities: the first priority was targeting farmers who were members of farmer groups and the second priority involved targeting farmers with children of up to five years during the onset of programme implementation (2007). However, lack of foreseeable benefits by would-be "control" farmers resulted in non-willingness to participate in the study, hence the priority one was relaxed for "control" farmers. Relaxation of priority one and retaining priority two resulted in more "control" farmers having children of up to five years and fewer of them belonging to farmers groups compared to non-participant farmers.

Data collected were entered and "cleaned" using CSPro. The SPSS software package (Norušis, 2005) was used for data processing while the STATA package (StataCorp, 2008) was used for econometric analysis.

Data analyses

Logit regression

Modeling farmers' decision making about whether to adopt or not to adopt a technology constitutes a discrete (whether or not to take up the technology) and continuous (the intensity of use of the technology) decision (Wale and Yallew, 2007). Most adoption models are based on the assumption that farmers are faced with a choice between two alternatives and the choices they make depend on identifiable characteristics of the technologies (Pindyck and Rubinfeld, 1997).

In a logit model, the parameter estimates are linear and, assuming a normally distributed disturbance term (µ), the logit maximum likelihood (LML) estimation procedure is used to identify explanatory variables affecting the adoption of OFSPs.

According to the logit model, the likelihood of an individual farmer adopting a new technology t_2, given a well-defined set of socio-economic and physical characteristics (X), is represented as:

$$P_i = P(t_2 \mid X_i) = \exp^{(\hat{a}X_i + \mu)} / [1 + \exp^{(\hat{a}X_i + \mu)}] \quad (1)$$

Where: P_i = is likelihood of the i^{th} farmer adopting a technology, labeled as $Adoption_i$; X_i = exogenous variables; â = the coefficients. The adoption logit model was specified as:

Table 1. Summary description of the variables used in modeling adoption and intensity of adoption.

Variable name	Variable description	Mean (std)
Site	Location where the farmer comes from, 1= Rachuonyo district, 0= Busia district	0.51 (0.50)
Participatant	If a farmer participated in the programme (= 1) or not (= 0)	0.60 (0.49)
Gender	Gender of household head, 1= Female, 0=Male	0.34 (0.47)
Off-farming	If household has off-farm income source (= 1) or not (= 0)	0.67 (0.47)
Valueadd	If household has done value addition in the last 12 months (= 1) or not (= 0)	0.19 (0.39)
Knowvit_A	If respondent knows that OFSP contains vitamin A (= 1) or not (= 0)	0.31 (0.46)
Vineconst	Whether household is vine constrained (= 1) or not (= 0)	0.51 (0.50)
Haschild	Whether household has a child of up to 5 years (= 1) or not (= 0)	0.78 (0.42)
Child5yrs	Number of children of up to 5 years in 2007	1.29 (0.99)
Hheadage	Age of household head in years	47.03 (13.29)
Hheadeduc	Years of formal education for household head	7.02 (4.21)
SParea	Area under sweet potato in hectares	0.19 (0.24)
Cassava	Area under cassava in hectares	0.13 (0.24)
Labor	Labor available for farm activities (number of household members available fully or partly for farming)	3.21 (1.43)
WID	Wealth index	0 (1)
P_{OFSP}	Proportion of area under OFSP	0.10 (0.23)

$$\text{Adoption} = \beta_0 + \beta_1\text{Site} + \beta_2\text{Participant} + \beta_3\text{Valueadd} + \beta_4\text{Knowvit\_A} + \beta_5\text{Vineconst} + \beta_6\text{hheadage} + \beta_7\text{Labour} + \beta_8\text{WID} + \mu_i$$

Where: Adoption=likelihood of adoption, 1= had adopted (a farmer was growing OFSP in 2009), 0= had not adopted (a farmer was not growing OFSP in 2009); Site = Location where the farmer comes from, 1= Rachuonyo district, 0= Busia district; Participant = If a farmer participated in the programme (= 1) or not (= 0); Valueadd = If household has done value addition in last 12 months (= 1) or not (= 0); Knowvit_A = If respondent knows the OFSP contains vitamin A (= 1) or not (= 0); Vineconst = Whether household is vine constrained (= 1) or not (= 0); Hheadage = Age of the household head (in years); Labor = Labor available for farm activities (number of household members available fully or partly for farming); WID = Wealth index (WID)

The wealth index (WID) was calculated from cultivated area of land, total livestock units and number of equipment items and tools owned by the farmer using principal component analysis (PCA). Attempts to use individual assets in regression models result in an unnecessarily high number of explanatory variables and create multicollinearity. Use of PCA is convenient since it solves the problem of aggregating assets of different units and controls multicollinearity which is likely to occur when many types of asset variables are included in the regression equation (Nieuwoudt, 1977; Filmer and Pritchett, 2001; McKenzie, 2003; Vyas and Kumaranayake, 2006). Table 1 shows summary details of variables in the econometric models used in this study.

Endogeneity test

Since participation in extension programme was one of the factors evaluated for its influence on the adoption of OFSP, there was a need to test for endogeneity. Selection bias occurs because participation is rarely random and this is often correlated with the outcome variable of interest (Heckman, 1979; Goodfellow et al., 1988; York, 1998; Cuddeback et al., 2004). A Hausman specification test (Hausman, 1976) was performed to evaluate if the participation variable (P_i) was endogenous.

The exogeneity of P_i was tested using the estimated residual ($\hat{v}_i$) from the reduced form equation (participation regressed on its instruments) as explanatory variables in the structural equations (with adoption as the dependent variable).

$$\textit{Participation } (P_i) = á_0 + á_1 Y_i + v_i \quad (2)$$

$$\textit{Adoption}_i = â_0 + â_1 W_i + â_1 \hat{P}_i + â_1 \hat{v}_i + \mu_i \quad (3)$$

Where Y_i is a vector of variables postulated to affect participation and W_i is a vector of exogenous variables postulated to affect adoption of OFSP.

If the residual variable of the reduced form Equation (2) is correlated with the dependent variable in the structural Equation (3) of adoption, then it means the participation variable is endogenous (Gujarati and Sangeetha, 2009). To get rid of the correlation between the P_i and μ_i a Heckman's two- stage regression approach was used where the participation variable (P_i) was first regressed on all the predetermined variables in the whole system, involving participation Equation (2) and adoption Equation (3) (Zuehlke and Zeman, 1991; Arendt and Holm, 2006; Kacagil and Demir, 2006).The predicted $\hat{P}_i$ estimated from the instrumental equation, which is free from influence of the stochastic disturbance μ_iì, is used in the second stage regression replacing P_i.

Logit transformation regression

The intensity of adoption in this paper is defined as the proportion of area under OFSP and is estimated as a fraction of total area under sweet potatoes. The larger the proportion the more intensive is the adoption of OFSP. Wale (2010) used logit transformation regression to explain land share allocated to local coffee varieties in Ethiopia which was the response variable. In the present study, the

Table 2. Factors determining participation in the extension programme.

Variable	B	S.E.	Exp(B)
Gender of household head (Gender)	1.497**	0.531	4.468
Household belongs to a farmer group (Farmergp)	6.654**	1.067	775.618
Area under sweet potato (SParea)	1.512	1.162	4.537
Number of children of up to 5 years (Child 5 years)	-0.772**	0.212	0.462
Area under cassava (Cassava)	1.119	0.927	3.063
Constant (Constant)	-4.554**	1.137	0.011

**P-value ≥ 0.05.

proportion under OFSP varieties (P_{OFSP}) would be defined as a function of the prevailing factors in the farmers' working environment (ϖ_1) stated as Equation 4: (P_{OFSP}) = $f(\varpi_1)$ (4)

For proportion data with 0, 1 extremes and continuous values in-between, use of OLS regression is inappropriate because predictions are likely to go beyond the 0 to 1 range. Papke and Woodridge (1996) indicate that the drawbacks of linear models for fractional data are analogous to the drawbacks of the linear probability model for binary data. Logit transformation is performed on the dependent variable as shown in Equation 5 (Birkhaeuser et al., 1991; Grigoriou et al., 2005; Wale, 2010):

$$TransP_{OFSP} = \ln\left(\frac{P_{OFSP}}{1-P_{OFSP}}\right) \quad (5)$$

However, this procedure cannot be applied directly if the dependent variable takes the extreme values of 0 and 1, that is, the transformed variable cannot be evaluated. Hence, to deal with this problem the extreme values (0 and 1) are substituted with close approximations (Birkhaeuser et al., 1991; Grigoriou et al., 2005; Pryce and Mason, 2006; Wale, 2010).There were 263 (77.4%) zeros and 8 (20.4%) ones which were replaced with 0.000001 and 0.999999, respectively. After this OLS regression is conducted on the transformed dependent variable (Equation 6):

$$TransP_{OFSP} = b_0 + \sum_{i=0}^{m} \varpi_{1i} b_i + \varepsilon_i, \quad i = 1, 2, 3, \ldots\ldots, n \quad (6)$$

Where ϖ_{1i} are the explanatory variables postulated to influence the rate of intensification.

The transformed regression model is as follows:

$TransP_{OFSP} = b_0 + b_1 Site + b_2 Participant + b_3 Valueadd + b_4 Knowvit\_A + b_5 Vineconst + b_6 Sellsp + b_7 Hasschild + e_i$

Where: $TransP_{OFSP}$ = Transformed proportion of area under OFSP; Haschild = Whether household had a child of up to 5 years in 2007 (= 1) or not (= 0); Sellsp = Whether a household sells any type of sweet potato (=1) or not (=0); Site, Participation, Valueadd, Knowvit_A and Vinecost are as defined for the logit regression model; e_i = Disturbance term;

A double- censored Tobit was also estimated to check the robustness of the results of the logit transformation regression.

RESULTS AND DISCUSSION

Characteristics of adopters and non-adopters

In all sites, 38.2% of respondents had adopted growing of OFSP, with 66.1% of 168 households and 11.0% of 172 households adopting in Busia and Rachuonyo districts, respectively. The mean age of household head was 47.3 years and 34.1% of household heads were female. There was no statistically significant difference between adopters and non-adopters by age or gender. Households with off-farm income were also not statistically different between adopters (63.8%) and non-adopters (69.0%). More adopters (33.1%) than non-adopters (10.0%) were doing value addition of sweet potato and also more adopters (48.5%) than non-adopters (19.5%) knew that OFSP contain vitamin A (beta carotene).

The number of years of formal education for adopters (7.6 years) was significantly higher than that of non-adopters (6.7 years) indicating possible positive association between education and adoption of OFSP.

Endogeneity test and "purification" of endogenous participation variable

Testing of endogeneity started with a search for instrumental variables that influenced participation in the programme but with no direct effect on adoption of OFSP. This evaluation indicated that gender of the household head, belonging to a farmer group, total area allocated to all types of sweet potatoes, number of children of up to five years of age and area under cassava were good proxies for participation. Table 2 shows the details of the instrumental variables used to predict participation in the extension programme.

The programme targeted farmer groups as a way of increasing effectiveness of extension and ensuring collective action was easily achieved, and this may explain why belonging to a farmer group highly increased the odds of participating in the programme. The coefficient for gender of the household head was also significant ($p < 0.05$) indicating that female headed households were more likely to participate in the programme than male headed households (Table 2).Having children of up to five years had a negative and statistically significant coefficient. The results indicate that households with more children were less likely to participate in the intervention programme possibly

Table 3. Coefficient estimates of variables in the logit equation, adoption of OFSP, Kenya.

Variable	B	S.E.	Exp(B)
Location (Site)	3.985**	0.484	53.802
Predicted participation variable (PRE_2)	0.982**	0.503	2.670
Value addition (Valueadd)	1.491**	0.541	4.443
Knows that OFSP contains vitamin A (Knowvit_A)	1.026**	0.380	2.790
Vine constrained (Vineconst)	-2.262**	0.403	0.104
Age of household head (Hheadage)	-0.020	0.014	0.980
Labor available (Labor)	0.118	0.131	1.125
Wealth index (WID)	0.279	0.195	1.321
Constant (Constant)	-2.320**	0.767	0.098

**P-value ≥ 0.05.

because child care and attending programme trainings were competing for the available time. Although area allocated to sweet potato and cassava positively affected participation in the programme as expected and improved the model fit, their coefficients were not statistically significant at the 5% level of significance.

The endogeneity test using residuals from the participation instrumental equation yielded a *p*- value of 0.064 indicating that the Null hypothesis of exogeneity would be rejected at the 10% level of significance but accepted at the 5% level of significance. Hence, to yield efficient and consistent estimates we treated farmers' decisions to participate in the programme as endogenous in adoption decision and followed a two-stage procedure to solve the endogeneity problem. The predicted participation variable (PRE_2) obtained from the first stage regression using all predetermined variables in all the systems was used in the adoption equation as a "proxy" for participation.

Binary logit and logit transformation regression results

The value from the Hosmer and Lemeshow Chi-square test was non-significant (0.108), which indicates that the binary logit model adequately fitted the data while Omnibus tests of model coefficients indicated that all predictors jointly predicted the dependent variable well at the 5% level of significance. The classification table also showed good prediction performance of 85.1% (90.5% of ones and 78.2% of zeros correctly predicted), which compared well with the Count R^2 of 89.5%.

Some variables hypothesized earlier to explain adoption of OFSP were dropped from the model either because including them in the regression analysis reduced the goodness of fit of the model and their estimated coefficients were not statistically significant at the 5% level, or they were correlated with some of the factors that improved the goodness of fit. The variables dropped were such as the number of children in the household, number of years of formal education of the head, number of days in a week the household consumed sweet potatoes, and selling any type of sweet potato. Table 3 presents the estimated logit regression model results.

The results indicated that site, participation in the programme, skills of value addition, knowledge about vitamin A and availability of vines were crucial factors determining adoption of OFSP. The results also suggested that age of the household head and asset ownership influenced adoption although their coefficients were only significant at the 15% level of significance. However, labor availability did not affect adoption possibly because there was no difference in labor requirement between OFSP and other varieties grown by the sample farmers.

Some of the identified variables mirrored the findings from Mazuze (2005), who observed that adoption of OFSP varieties is affected by the district where the respondent resides, quality of extension and availability of vines to farmers. The study further observed that to spur adoption of OFSP, it was important to identify market opportunities for processed products and link farmers to potential processors and market outlets.

Site

According to the results, being in Busia district increased the odds of adopting OFSP than being in Rachuonyo. A farmer in Busia is 54 times more likely to adopt. This could be due to several underlying factors, which included the fact that sweet potato was more commercialized in Rachuonyo District than in Busia District and the yields of the local varieties grown in Rachuonyo were comparable to the yields of OFSP varieties being introduced. More importantly, the short time of programme implementation might not have had sufficient effect on traders' preferences that might not have been willing to trade in the less familiar OFSP in Rachuonyo Districts. Increasing promotion campaigns targeting traders and consumers might have increased the probability of farmers in Rachuonyo adopting OFSP.

Participation

The estimated coefficient for the participation variable was statistically significant at the 5% level and had a positive sign (in reference to participants), as hypothesized. The odds for the farmers who were in the programme adopting OFSP were three times higher than those who were not. This was according to the expectation of the programme implementers and researchers, who postulated that collective action resulting from aggregating farmers in commercial villages, would make it easy and cost effective for farmers to access extension services and planting materials. Although the programme was implemented for about 2.5 years, it means that farmers participating in the programme had a higher probability of adopting OFSP. This result offered justification for impact analysis, that is, researchers could conduct a more robust econometric analysis to evaluate the intensity and impact of adoption using differences in differences (DD) as earlier planned.

Value addition

As hypothesized, farmers who had the know-how of processing sweet potatoes were about four times more likely to adopt OFSP than those who did not have the know-how. Some farmers processed sweet potatoes into dried chips for long storage or made sweet potato flour and mixed this with sorghum or millet flour to make porridge, or mixed sweet potato flour with wheat flour for making baked products such as cakes, bread, scones and buns. Although a few farmers sold these products in the markets and institutions such as schools the majority used them at home to improve the nutritional value and reduce the costs of making the products. The products made using OFSP varieties are tastier, nutritious and appealing to farmers and hence farmers were more likely to prefer OFSP for further value addition. This means if dissemination of value addition techniques was included in intervention programmes, the adoption rate would have even been better.

Farmer knowledge on vitamin A

The regression results suggested that farmers who had knowledge about the nutritional content of OFSP were about three times more likely to adopt OFSP than those who did not have this knowledge. This was in conformity with *a priori* expectation as knowledge of the nutritional value of OFSP was likely to motivate adoption of OFSP, especially for home consumption. This means any programme that includes effective training on the nutritional value of OFSP is likely to enhance its adoption.

Constraint of vines (planting material)

As hypothesized, the results suggest a negative impact of constraint of vines, i.e. farmers who have limitations in accessing vines are less likely to adopt OFSP. However, the odds of not adopting due to constraints of vines were not high (0.104). This could be because most farmers who were not able to preserve planting materials or get them from neighbors were linked to the seed multipliers by the programme, and this reduced the odds of not adopting.

Age of the household head

The age of the household head had a negative sign as expected. According to the results, if age of the household head increases by one year, the odds in favor of not adopting increase by 2.0%. The main reasons given for older people being less likely to adopt new technologies was that they were said to be less receptive to new ideas and were less willing to take risks. This means there may be a need to review methods of technology dissemination used in the intervention programme to ensure that they are attractive to both young and old farmers.

Testing the results of the OLS regression of the transformed dependent variable for heteroscedasticity using the Breusch- Pagan-Godfrey test rejected the OLS model with homoscedasticity (χ^2tabulated = 14.07 and χ^2calculated = 88.99). To remedy the heteroscedasticity, a weighted least squares regression was run using White's heteroscedasticity-corrected variances (Robust standard errors) using Stata (Gujarati and Sangeetha, 2009). The HC3 estimator was used for heteroscedasticity correction following the suggestion that it is the best estimator, especially in small samples (Long and Ervin, 2000).

Results of the transformed logit model revealed that participating in the programme and nutritional knowledge of OFSP did not influence the intensity of adoption of OFSP. However, in addition to site, value addition and constraints of vines, having a child of up to five years and selling any type of sweet potato also significantly influenced the intensity of adoption (Table 4). Having a child of up to five years positively affects intensity of adoption at the 10% level of significance. However, this variable was not significant in the double-censored Tobit model. The results of the double-censored model were similar to those in the logit transformation regression for other variables (Table 5).

Site had a positive and statistically significant coefficient in the logit transformation regression results,

Table 4. Logit transformation results for intensity of adoption of OFSP.

TransPofsp	Coefficient	Robust HC3 Std. Err.	t
Location (Site)	2.26596**	0.40737	6.04
Predicted participation variable (Pre_2)	0.15773	0.48086	0.33
Value addition (Valueadd)	1.52385**	0.55630	3.29
Knows that OFSP contains vitamin A (Knowvit_A)	0.41227	0.39883	1.10
Vine constrained (Vineconst)	-1.05751**	0.34343	-3.15
Sells sweet potato (Sellsp)	1.19640**	0.46865	2.83
Had a child of up to 5 years (Haschild)	0.70806*	0.40387	1.60
Constant (_cons)	-7.7398**	0.67347	-11.38

*P-value ≥ 0.10, **P-value ≥ 0.05.

Table 5. Regression results of double-censored Tobit model for intensity of adoption.

OFSP_frac	Coefficient	Std. Err.	t
Location (Site)	0.139581**	0.021381	6.53
Predicted participation variable (Pre_2)	0.004189	0.027323	0.15
Value addition (Valueadd)	0.087476**	0.026385	3.32
Knows that OFSP contains vitamin A (Knowvit_A)	0.001075	0.021427	0.05
Vine constrained (Vineconst)	-0.05535**	0.019144	-2.89
Sells sweet potato (Sellsp)	0.067691**	0.024084	2.81
Had a child of up to 5 years (Haschild)	0.033645	0.025276	1.33
Constant (_cons)	0.05425	0.03874	1.40
/sigma	0.165742	0.006521	

**P-value ≥ 0.05.

indicating that being in Busia had a positive effect on the intensity of adoption. The same site specific reasons affecting adoption were expected to affect intensity of adoption. However, the results indicated that participation did not influence the intensity of adoption. This means once the programme influenced farmers to adopt new varieties, other non-programme factors were more important in determining the proportion of land allocated to OFSP. Similarly, although nutritional knowledge had a positive effect in intensification, it was not statistically significant.

Results suggested that having know-how of value addition had a significant positive effect on intensity of adoption. Farmers who had processing techniques were able to earn extra cash from OFSP products (chips, flour and *mandazi*), and hence they were willing to put a greater proportion of land under OFSP. This suggests that market access was crucial to adoption intensification as suggested by the coefficient of marketing variable which was positive and statistically significant. This means that once programme participation and other factors influenced farmers to grow OFSP, possibly for home consumption, the possibility of marketing the OFSP alongside other varieties increased the likelihood of intensifying adoption. Since OFSP was promoted for both home consumption and marketing, it emerged that those farmers who commercialized any type of sweet potato were more likely to increase the proportion of land under OFSP than those who were not.

Logit transformation results also indicated that constraints of vines *(planting material)* affect intensity of OFSP adoption negatively and significantly. The results from the two regressions (binary logit and logit transformation) mean an intervention programme that includes training farmers on how to preserve their vines and how to source vines is more likely to increase both adoption and intensity of adoption.Although having a child of up to five years of age did not seem to affect adoption of OFSP, its estimated coefficient in the logit transformation regression was positive and statistically significant. This suggests that once the farmer has made decision to adopt OFSP (for other reasons reported in Table 4) having a child of up to five years of age affects the rate of intensification positively. This could mean that the observation by farmers of how their children devoured the OFSP after harvest and the awareness that children benefited the most from consumption of OFSP, which was one of the messages delivered by the programme, probably affected intensification positively.

CONCLUSIONS AND RECOMMENDATIONS

This study evaluated the factors affecting adoption and intensity of adoption of OFSP in Busia and Rachuonyo Districts in Kenya using adoption data collected from 340 farmers in 2009. The main objective was to determine the adoption rate of OFSP, the key factors determining adoption of OFSP and intensity of adoption, and to investigate whether participation in an extension intervention programme significantly increased the probability of adopting OFSP.

The empirical results revealed four factors that are important in influencing both adoption of OFSP and the intensity of adoption. These factors include (1) district where the farmer resides, (2) know-how on value addition, (3) knowledge on nutritional value, and (4) availability of vines.

The study suggests that to enhance technology adoption and its intensity, the attribute preferences of farmers and site specific factors (such as annual precipitation, soil fertility and performance of local varieties) will have to be integrated into the development of improved varieties and the extension approaches should be packaged so as to build on the value systems and preferences of both experienced and young farmers.

The results suggest that yield performance of OFSP in Rachuonyo district is one of the possible areas that need to be addressed to promote adoption at the site. There is a need for intervention packages to address competitiveness of new varieties against local varieties and create awareness of the potential benefits of OFSP among the value chain players. The results also suggest that farmers who had processing (value addition) techniques and those who were linked to a OFSP processor were able to earn extra cash income; hence, had a bigger proportion of land under OFSP. This demonstrates the importance of linking agricultural technology adoption with value addition and marketing. The results underpin the importance of using a value chain intervention and a collective action approach in the framework of a commercial village, where production and marketing innovations are sought, to ensure that the adoption programme succeeds. Knowledge about the desirable features of OFSP varieties and farmers' participation in the intervention programme also boosted adoption, confirming that adoption interventions need to create awareness, train beneficiaries and engage farmers in the implementation of a programme such as the Traditional Food programme.

Availability of vines also affected both adoption and intensity of adoption of OFSP; hence an extension programme should ensure adequate access to vines either through conservation in wetland or irrigated areas or through establishment of a sustainable network of vine multipliers.

The age of the household head only affected adoption of OFSP and had no effect on intensity of adoption. The negative effect of age means the promotion campaigns and extension approach should be appropriate for both the young and the aged, and the attributes of the technology need to be adapted to all ages of farmers.

Two factors, (1) selling sweet-potato and (2) having a child, affected intensity of adoption and not adoption of OFSP. This implies that market access is very important if an adoption programme has to push adoption of any improved varieties to a higher level. Although adoption of improved varieties may be boosted by the knowledge of nutritional benefits of home consumption, commercialization of the varieties is important for intensification. Targeting households with young children, especially when the main concern is increased consumption of OFSP, is also likely to increase the intensity of use. This also implies that intervention programmes that create awareness of the nutritional benefits of improved varieties to children are more likely to increase adoption intensity.

The programme also underscores the importance of creating awareness of nutritional value and commercialization in enhancing adoption of traditional crops commonly viewed as inferior food crops. Finally, it is recommended that the benefits and costs of the programme should be comprehensively studied, considering financial, environmental, poverty and food security dimensions, and the cost effectiveness of using a commercial village approach.

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