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Analysis of the Adoption of Orange-Fleshed Sweet Potatoes in the Gihanga Commune in Burundi

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Abstract
The orange-fleshed sweet potato varieties have been adopted with the aim of increasing production, farmers' welfare, and combating chronic malnutrition (ISTEEBU, 2019). This study analyzed the factors determining the adoption of orange-fleshed sweet potato and the constraints associated with adoption in the commune of Gihanga in Burundi. A survey of 385 households was conducted. The results of the logit model showed that adoption of OFSP was positively and significantly influenced by the level of education of the head of household, family labor, access to credit, access to extension services and membership of producer organizations, while the age of the head of household and household size had a negative influence on OFSP adoption. Analysis of constraints using Kendall's Concordance Coefficient revealed that unpredictable weather and climate, lack of capital, unavailability of OFSP cuttings, insufficient arable land and high labor costs were the main constraints to adoption of orange-fleshed sweet potato. The government and other players in the agricultural sector should do their part to raise awareness, mobilize and support farmers to adopt sweet potato varieties. They should also disseminate and facilitate access to cuttings in order to improve their adoption rate.
Keywords: Orange-fleshed sweet potato, adoption, determinants, Gihanga.
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Introduction

Sweet potato (Ipomoea batatas) is cultivated in more than 100 countries. It is the seventh among all food crops worldwide from the point of view of total production, thirteenth in value of production and fifth in caloric contribution to human diet (Nwankwo *et al.,*2014). Sweet potato is a major food crop renowned for its role in food security, nutritional and health benefits and market value in sub-Saharan Africa (Andrade *et al.,* 2017). The agricultural sector is the cornerstone of the Burundian economy. The agricultural population is around 90% according to the results of ENAB 2019. Nearly 90% of the developed area is devoted to food crops, which, while contributing more than 80% to agricultural GDP, are 80% self-consumed (ISTEEBU, 2019). Sweet potato is the third most important crop after cassava and banana, with 746,048 tons produced in 2016 (ISABU, 2019). However, production of the sweet potato with white and yellow flesh roots widely cultivated in all provinces of Burundi is constantly decreasing following the multiplication of viruses in these local varieties and the increased incidence of drought and floods.

Several organizations, including the FAO and the IPC, have invested in researching and promoting new varieties, including the orange-fleshed sweet potato (OFSP), which is grown in tropical and semi-tropical regions of the world. Research into new varieties of orange-fleshed sweet potato has been developed in Burundi by ISABU since 2018, and popularized by development organizations in the provinces of Muyinga, Ruyigi, Rutana, Cibitoke and Bubanza.

Orange-fleshed sweet potato varieties are believed to have high yields and are therefore a means of increasing sweet potato production at farm level, boosting household food security and are a natural source of healthy nutrients for improving nutrition. Indeed, OFSP is extremely rich in easily bio-assimilable beta-carotene and easily in vitamins A, vitamins C, E, K and B as well as other mineral salts (ISABU, 2018). The adoption of orange-fleshed sweet potato varieties also aims to increase farmers' well-being, combat the chronic malnutrition rampant in Burundi (ISTEEBU, 2019), improve women's empowerment and create income-earning opportunities, even for poor households. Its good plant cover also helps prevent erosion, and its nutrient-rich leaves are an excellent daily feed for cattle and pigs. Despite their importance, the new orange-fleshed sweet potato varieties have not yet been adopted by all farmers, even though they could be adapted to all regions of Burundi. Few studies have looked at the effects of adopting new technologies and new varieties in Burundi. For example, no research has been conducted on the adoption of orange-fleshed sweet potato. The purpose of this study is to examine the determinants and constraints of the orange-fleshed sweet potato in the commune of Gihanga.

The literature on the adoption of new technologies or improved varieties in agriculture has attracted the attention of economists because a large part of the population in developing countries derives most of its livelihood from agricultural production (Feder *et al.* 1985). The use of improved technologies would continue to be critical

input for improved farm productivity (Ademiluyi, 2014). Utility maximization theory is used to explain farmers' adoption of agricultural innovations. Farmers are assumed to make rational decisions about whether or not to adopt innovations based on utility maximization (Nkamleu and Adesina, 2000). The decision to adopt a new improved technology or practice can also be seen as an investment decision (Caswell *et al.*, 2001). The choice of whether or not to adopt a new technology is therefore based on an assessment of a number of technical, economic and social factors. The individual seeks to learn about the new technology, its functions and its advantages.

Intensification processes have made it possible to increase land productivity while reducing the risks associated with climatic hazards. However, research has shown that farmers are true experimenters, that they innovate and that their contribution to agricultural development is of prime importance (Chambers *et al.,* 1994).

The adoption of an innovation will be influenced by exogenous factors such as age, household size, field size, education, experience and farm enterprises, or by the intrinsic characteristics of the innovation (Adams, 1983). The author states that the characteristics of a given technology are important determinants of adoption.

The results of empirical studies conducted on the adoption of new crop varieties in Africa highlight several factors influencing the adoption of improved varieties. These are demographic, socio-economic and institutional characteristics (Bouréma *et al.,* 2021). The literature shows that the variables influencing adoption are age, area, membership of a farmers' organization, number of cattle, distance from the market and contact with the agricultural agent (Nwankwo *et al.,* 2014; Ben-Chukwu *et al.,* 2021; Diallo, 2022). Some authors (Ndimanya and Ndayitwayeko, 2010) have highlighted the factors constraining the adoption of agricultural technologies, such as diseases and pests, the lack of extension services, insufficient human manpower and difficult access to agricultural credit by variety.

Research methodology

Study area

The commune of Gihanga is one situated in Bubanza province in north-west Burundi. It is bordered to the north by the communes of Bubanza and Buganda, to the east by the commune of Mpanda, to the south by the commune of Mutimbuzi and to the west by the Democratic Republic of Congo (DRC). It is subdivided into two zones: Buringa and Gihanga. With an average altitude of 824m, it has a relatively flat plain with very gentle slopes. The commune has a dry tropical climate with a marked dry season, an average temperature of 25°C and an average rainfall of 494.6 mm (PCDC Gihanga, 2013). The commune covers an area of 287.32 km2, with 4,000 ha of the Rusizi nature reserve and 1,550 ha of marshland. It stretches across the central part of the Imbo natural region located in the natural trench of Lake Tanganyika.

Figure 1-Map of the municipality of Gihanga
Source: author's compilation

Sampling and sample size

A multi-stage sampling procedure was used to select the sampled households. In the first stage, out of a total of 64 distribution sites in 3 provinces of the country by ISABU, the commune of Gihanga was selected. In the second stage, six of the eleven distribution sites in the commune of Gihanga were selected. These were Gihungwe, Rugunga, Gihanga, Bwiza bwa Ninga V6, Ninga V4 and Buringa, using a simple random sampling technique. In the third stage, farmers were stratified into two groups according to whether or not they had adopted orange-fleshed sweet potato varieties.

The total size of the sample of households was determined using a formula developed by Cochran (1977): **n** $= \frac{t^2 p(1-p)}{e^2}$.

A total sample of 385 households was surveyed.

Data collection

Qualitative and quantitative data were collected using a questionnaire. The information gathered concerned their perceptions, institutional factors affecting them and their socio-economic characteristics from 385 sweet potato-growing households in the commune of Gihanga, including 161 adopters and 224 non-adopters. General information on the socio-economic characteristics of the households and the constraints linked to the adoption of orange-fleshed sweet potato, as well as other information on orange-fleshed sweet potato varieties distributed by ISABU in the study areas were collected.

Choice of variables

The table below explains the different variables used in our study and their expected signs.

Table 1: Definition of study variables and expected signs

Variable	Definitions	Expected sign
ADOPT	Adoption of orange-fleshed sweet potatoes	N/A
AGE	Age of head of household	+/-
STAMATR	Marital status	+
EDUC	Education of the head of household	+
SEX	Sex: gender of head of household	+
TMEN	Household size	+
MACTIF	Size of active household members	-
SUPEMB	Area planted	+
ACCREDI	Access to credit	+
ORGPROD	Participation in a producer organisation	+
VULG	Extension service	+
ACINTRA	Access to seeds	+
DISMARCHE	Distance between home and market	-

Source: author's compilation

Selected demographic variables that are likely to influence adoption are age of household head, gender of household head, household size, active household members, and marital status of household head. Socio-economic factors are the area sown, distance to market and education of the household head, while institutional factors are membership of a producer organization, access to extension, access to credit and access to seed.

Data analysis methods and tools

The empirical analysis followed a methodological approach. Using the logit model, the study assessed the factors influencing orange-fleshed sweet potato adoption in the study area as well as the constraints associated with adoption. Kendall's concordance coefficient was used to determine the constraints associated with the adoption of orange-fleshed sweet potato.

Measuring constraints to sweet potato adoption

Kendall's concordance coefficient was used to assess the constraints on sweet potato production. Kendall's concordance coefficient (W) is a measure of the degree of agreement between m sets of n ranks. Kendall's W is defined as follows:

$$W = \frac{12S}{m^2(n^3-n)}$$

Intermediate values of W indicate a greater or lesser degree of unanimity between the different respondents (Mattson, 1986). The constraints were then ranked from the most restrictive to the least restrictive.

Modelling the determinants of adoption of orange-fleshed sweet potato varieties

This study adopted logistic regression to assess the factors that determine farmers' decisions to adopt orange-fleshed sweet potato varieties. The logistic regression model, or logit model as it is often called, is a special case of generalized linear model and analyses models where the outcome is a dummy variable. (Hosmer, 1989; Gujarati, 1995).

According to Pindyck and Rubinfeld (1998), the equation for the probability of adoption can be written as follows:

$$P(x) = \frac{1}{1+e^{-Zi}}$$

where P(x) is the probability of adoption and takes values between 0 and 1; Zi is the function of the explanatory variables.

The non-adoption equation therefore becomes:

$$1\text{-}P(x) = 1 - \frac{1}{1+e^{-z_i}} = \frac{1}{1+e^{zi}}$$

Using the estimated logit model, the marginal effect of each explanatory variable on adoption can be calculated as follows:

$$\frac{\partial p_i}{\partial x_i} = p_i(1-p_i)\beta_i$$

The marginal effect is used to calculate whether the probability increases or decreases with a one-unit increase in the corresponding independent variable. The equation of adoption is the following:

$Y_1=\beta_0+\beta_1X_i+\beta_2X_i+\beta_3X_i+\beta_4X_i+\beta_5X_i+\beta_6X_i+\beta_7X_i+\beta_8X_i+\beta_9X_i+\beta_{10}X_i+\beta_{11}X_i+\beta_{12}X_i+\mathcal{E}i$

Where i represents the grower, Y_i represents the adoption variables, explained by the independent X_i variables; represents the parameters to be estimated and ε_i: error term

The specific pattern of adoption of the orange-fleshed sweet potato variety:

$ADOPTION = \beta_0 + \beta_1 AGE_i + \beta_2 EDUC_i + \beta_3 XTMEN_i + \beta_4 SEX_i + \beta_5 XMACTIF_i + \beta_6 SUPEM_i + \beta_7 ACRED_i + \beta_8 ORGPROD_i + \beta_9 VULG_i + \beta_{10} ACINTRA_i + \beta_{11} STAMATR_i + \beta_{12} DISMARCHE_i + \mathcal{E}i$

The above variables were used to study the determinants of the adoption of the Orange-freshed sweet potatoes.

Results

Constraints to the adoption of orange-fleshed sweet potato varieties

The results of the study show that the adoption process was hampered by six institutional and environmental factors, as well as by the characteristics and situation of the farmers themselves.

Table 2: Ranking of constraints linked to sweet potato production

Constraints on the adoption of OFSP	Average rank	Grobal rank
Capital shortfalls	4.58	2ème
High labour costs	2.27	5ème
Small areas	3.1	4ème
Unavailability of OFSP cuttings	4.34	3ème
Farmers' perceptions	2.08	6ème
Climatic hazards	4.62	1ère
N	385	
W de Kendall[a]	0.409	
Chi-square	789.528	
Ddl	5	
Asymptotic significance	0.000	

Note : [a.] Kendall's concordance coefficient

Source: author's compilation

Climatic hazards were identified as the first constraint to the adoption of orange-fleshed sweet potato varieties. due to the period of drought and water shortages. Lack of capital was also ranked second as a constraint to sweet potato adoption. while unavailability of OFSP cuttings was identified as a third constraint to orange-fleshed sweet potato adoption. Insufficient arable land was ranked as the fourth most limiting factor to the adoption of orange-fleshed sweet potato. While the high cost of labor was also mentioned as a constraint to the adoption of orange-fleshed sweet potato. Finally. farmer perception was mentioned as a constraint to new orange-fleshed sweet potato varieties.

Determinants of orange-fleshed sweet potato adoption

The results of the factors influencing the adoption of OFSP varieties reveal six explanatory variables. The results of the logit model are shown in Table 3.

Table 3: Logit estimates of factors influencing adoption of orange-fleshed sweet potato varieties

	Coefficient	Std. err.	Z	P>z	Marginal effects
SEX	0.0041369	0.4003901	0.01	0.992	0.0008592
TAMATR	0.1075229	0.2518544	0.43	0.669	0.0223412
AGE	-0.023368	0.0130122	-1.8	0.073*	0.004855
EDUC	0.6551056	0.2195196	2.98	0.003***	0.1361182
TMEN	- 0.1241596	0.0683307	1.82	0.069*	0.025798
MACTIF	0.2490911	0.1276305	1.95	0.051*	0.0517563
ORGAPROD	0.6140449	0.3788437	1.62	0.105	0.1176431
ACREDI	1.010946	0.3046763	3.32	0.001***	0.1920742
ACINTRA	0.4406332	0.4679411	0.94	0.346	0.0974299
SUPEMB	0.00936	0.0120071	0.78	0.436	0.0019448
VULG	3.72169	0.6315624	5.89	0.000***	0.4995738
DISMARCHE	-0.047541	0.1182867	-0.4	0.688	0.009878
_cons	-4.893646	1.228487	-3.98	0.000***	
Number of obs	385				
LR chi2(12)	163.11				
Prob > chi2	0.000				
R2 username	0.3117				
Log likelihood	-180.1286				

Note: ***significant at 1%. **significant at 5% and *significant at 10%.
Source: author's compilation

Education of the household head. extension services. and access to credit have a positive and significant influence at the 1% level on adoption of orange-fleshed sweet potato varieties. An increase of one year of education would increase the probability of adopting orange-fleshed sweet potato by about 13.6% and the presence of one more extension worker would increase the probability of adopting orange-fleshed sweet potato by up to 49.95%. Marginal effects also show that increasing credit accessibility by one unit increases the probability of adopting orange-fleshed sweet potato by 19.2%. This shows that farmers who have access to credit adopt orange-fleshed sweet potato more than those who do not. In addition. family labor has a positive influence at the 10% significance level on the adoption of orange-fleshed sweet potato varieties.

However. the age of the head of household and the size of the household had a negative influence on the adoption of orange-fleshed sweet potato varieties at the 10% significance level.

Discussion

The unpredictability of weather and climate conditions was identified as the primary constraint to the adoption of orange-fleshed sweet potato varieties. due to the period of drought and insufficient water. The study area is a drought-prone region and irrigated areas are reserved for rice. despite the interest shown by farmers in growing sweet potatoes. The unavailability of OFSP cuttings was also mentioned as a constraint to orange-fleshed sweet potato production. The distribution of cuttings as the dry season approaches and competition from livestock farmers are the main causes of this shortage of cuttings.

Lack of capital was ranked as the second most important constraint to the adoption of new sweet potato varieties. Farmers in the Gihanga commune need capital to buy cuttings. rent land and provide family labor. all of which affect the adoption of new orange-fleshed sweet potato varieties.

The lack of arable land is another factor limiting the adoption of orange-fleshed sweet potatoes. Around 85% of respondents cultivate on rented land. Sweet potatoes compete with other crops. including maize and rice. Moreover. sweet potatoes are more productive in irrigated wetlands than in dry areas. However. this area is increasingly being taken over by rice cultivation. in line with the new agricultural strategy required by the local administration.

The high cost of labor was also mentioned as a constraint to the adoption of orange-fleshed sweet potatoes. Family labor continues to decline and most farmers depend on hired labor. which has also become scarcer. The Gihanga commune is also an area where labor costs are high.

The other constraint is farmers' perception. Some farmers do not appreciate the taste of orange-fleshed sweet potato compared with other sweet potato varieties. and the perceived production of orange-fleshed sweet potato

by some farmers compared with other local varieties is also a barrier to adoption.

The results on sweet potato determinants showed that education influences the adoption of sweet potato varieties. Farmers with more years of education adopt OFSP varieties. especially as they are able to compare different varieties and make more accurate choices. This study has shown that extension services increase the likelihood of adoption of orange-fleshed sweet potato. Farmers who have access to extension services are more likely to adopt the technology (Abdulai and Hufmann. 2005). This shows the importance of extension services and demonstration plots in the adoption process of orange-fleshed sweet potato varieties in the study area.

Access to credit makes it easy for farmers to adopt the orange-fleshed sweet potato. Credit is important in agriculture in the Gihanga commune because farmers need cash to rent land. buy labor and purchase agricultural inputs. Improving access to institutional support services. including credit. should therefore be an important part of efforts to promote the adoption of modern technologies (Khonje, 2015).

The results show that family labor force has a positive and significant influence on the adoption of orange-fleshed sweet potato varieties. since households with a relatively high labor force adopt improved varieties more. Household size. on the other hand. had a negative influence on the adoption of orange-fleshed sweet potato varieties. Large households adopt orange-fleshed sweet potato less than small ones. In this commune of Gihanga. members of households whose children do not provide agricultural labor and constitute a source of additional expenditure; this reduces the likelihood of adopting orange-fleshed sweet potato varieties.

Conclusion

Analysis of the results of this study revealed that unpredictable weather and climate conditions. lack of capital. unavailability of OFSP cuttings. insufficient arable land. high labor costs and farmers' perceptions were the main constraints to adoption of orange-fleshed sweet potato. The results of the logit model show that adoption of orange-fleshed sweet potato was positively influenced by. among other things. the level of education of the head of household. family size. family labor. access to credit. access to extension services and membership of farmers' organizations. Non-adoption of new varieties. on the other hand. was associated with the age of the household head. Further studies using robust empirical methods are recommended on the effects of adoption. both nationally and in other regions. in order to provide robust empirical evidence on the adoption of orange-fleshed sweet potato varieties in the study area and in the country as a whole. taking into account regional specificities.

Recommendations

It is recommended that the government strengthen and improve the policies and strategies in place to facilitate the adoption of new varieties of orange-fleshed sweet potato and the establishment of mechanisms for the conservation and processing of this crop. Development organizations are asked to raise awareness of the importance of the orange-fleshed sweet potato. its countless income-generating opportunities through the processing of by-products. and to improve and broaden dissemination strategies and extension packages for these varieties to help increase the rate of adoption across the country.

References

Abdulai. A. & Huffman. W. (2005). The Diffusion of New Agricultural Technologies: The Case of Crossbred-Cow Technology in Tanzania. *American Journal of Agricultural Economics*. *87*(3). 645-659.

Adams. M.E. (1982). Agricultural Extension in Developing Countries. Longman House. Burnt Mills. Harlow. Essex. UK.

Ademiluyi, I.O. (2014). Adoption of improved maize varieties among farmers in Bassa local government area of plateau state. *International Journal of Innovative Agriculture & Biology Research*. *2* (4). 26-33.

Andrade. M. I., Ricardo. J., Naico. A., Alvaro. A., Makunde. G. S. Low. J. & Grüneberg.W. J. (2017). Release of orange-fleshed sweet potato (Ipomoea batatas) cultivars in Mozambique through an accelerated breeding scheme. *The Journal of Agricultural Science*. *155*. 919–929.

Barry. S. (2016). Socioeconomic and institutional determinants of the adoption of improved maize varieties in the Centre-South of Burkina Faso. *Revue d'Economie Théorique et Appliquée Institut de l'Environnement et de Recherches Agricoles (INERA)*. *6*(2). 221-238.

Bouréma. K.. Bandiougou D.. Abdoulaye. N.. Moumoune. S. & Oumar. K.A. (2021). Determinants of the adoption of Improved Maize Varieties in the Sikasso Region of Mali. *European Scientific Journal. ESJ*. *17*(9). 40.

Caswell. M.. Fuglie. K.. Ingram. C.. Jans S. & Kascak C. (2001). Adoption of Agricultural production. *Journal of Biology. Agriculture and Healthcare*. *2*(3) www.iiste.org; ISSN 2224-3208 (Paper) ISSN 2225-093X (Online).

Chambers. R.. Pacey. A. & Thrupp. L. A. (1994). Les Paysans d'abord. Les innovations des paysans et la recherche agronomique. *Karthala*. Paris.

Feder. G.. Just. R.E. & Zilberman. D. (1985). Adoption of agricultural innovations in developing countries: a survey. *Economic Development and Cultural Change*; *33*(2). 255-298.

Gujarati. D.N. (1995). Basic Econometrics. 4th Edition. *United State Military Academy*. New York.

Hosmer. D.W. & Lemeshow. S. (1989). Applied Logistic Regression. John Wiley & Sons. *Inc*. New York.

ISABU. (2019). Bulletin of agricultural research in Burundi.

Khonje (2015) Adoption and welfare impacts of multiple agricultural technologies: evidence from eastern Zambia. *Agricultural Economics*. *49*(5). 599-609.

Ndimanya and Ndayitwayeko. (2010) n inquiry into the level of technological adoption in Burundi: a case study of rice in Gihanga. *Cahiers du CURDES n° 11.* pp. 137-175.

Nkamleu. G.B. & Adesina. A.A. (2000). Determinants of chemical input use in peri-urban lowland systems: bivariate probit analysis in Cameroon. *Agricultural Systems*. *63*(2). 111-121.

Nwankwo. I.I.M., Bassey. E.E. & Afuape. S.O. (2014). Yield evaluation of open pollinated sweet potato (Ipomoea batatas (L.) Lam) genotypes in humid environment of Umudike. Nigeria. Global *Journal of Biology. Agriculture and Health Sciences*. 3(1). 199-204.

Oleh. K. (2013). Determinants of the adoption of crop innovations in rural areas: illustration from the case of Soya introduced by the CNRA (Centre National de Recherche Agronomique) in the Northern Region of Côte d'Ivoire. *Rev iv hist*. *22*.140-156.

Pindyck. S.R. and Rubinfeld. L.D. (1998) Econometric Models and Economic Forecasts. Irwin/McGraw-Hill. New York.

Rogers. E. M. (1983). "Diffusion of Innovations. 3rd Edition. The Free Press. London.