THE IMPACT EVALUATION AND ADOPTION OF THE CLIMATE-NUTRITION ORANGE FLESHED SWEET-POTATO IN BURUNDI: A CASE STUDY OF THE RURAL BUJUMBURA PROVINCE

Abstract

The new orange-fleshed sweet potato varieties have been adopted with the aim of increasing production, farmers' welfare, and combating chronic malnutrition (ENSNSAB, 2019).This study analyzed the impact of orange-fleshed sweet potato adoption on production in Gihanga commune using the propensity score matching method.A survey of 385 households was carried out, including 161 orange-fleshed sweet potato adopters and 224 non-adopters. The determinants and rate of adoption of orange-fleshed sweet potato were also analyzed using the logit model and the ATE method respectively, while Kendall's Concordance Coefficient was used to determine adoption constraints. Thus, unpredictable weather and climatic conditions, lack of capital, unavailability of PDCO cuttings, insufficient arable land as well as high labor costs are the main constraints to orange-fleshed sweet-potato adoption.The adoption rate for orange-fleshed sweet potatoes is estimated at 42%. Adoption of PDCO was positively and significantly influenced by the household head's level of education, family labor, access to credit, access to extension services and membership of producer organizations, while the household head's age and household size had a negative impact on adoption.The ATT revealed that the adoption of orange-fleshed sweet potatoes increased production per adopter household by an average of 369.88 kg, although the difference was not statistically significant.The government and other players in the agricultural sector should do their part to raise awareness, disseminate, facilitate access and mobilize farmers to adopt sweet potato varieties in order to improve their productivity.

Keywords: adoption, Orange-fleshed sweet-potato, propensity score matching

Introduction

Sweet potatoes (Ipomoea batatas) are the world's seventh most important crop (Afuape, 2014). In tropical countries, it occupies second place among root and tuber crops after cassava. In Burundi, this resilient crop is the third most important crop after cassava and banana, with 746,048 tonnes produced in 2016 (ISABU, 2019). However, production is steadily declining following the multiplication of viruses in local varieties and the increasing incidence of drought and floods. Thus, for maximum gain in production, the use of improved varieties and other agricultural technologies is necessary. The development of new varieties of higher-yielding crops, or those more resistant to pests and diseases, makes it possible to improve the quality and yield of agriculture (MUGISHO.P., 2010). Production of sweet potatoes with white and yellow flesh roots, widely cultivated in all provinces of Burundi, has been steadily declining due to the multiplication of viruses in these local varieties and the increasing incidence of drought and floods. Several organizations, including the FAO and CIP, have invested in research and promotion of new varieties, including the orange-fleshed sweet potato (PDCO), which is grown in tropical and semi-tropical regions.

Orange-fleshed sweet potato varieties are believed to have high yields and therefore a means of increasing sweet potato production at farm level, boosting the food security of farming households and are a natural source of healthy nutrients for improved nutrition. Indeed, PDCO is extremely rich in easily bio-assimilable beta-carotene, which the human body readily converts into vitamin A (retinol). Vitamin A is a micronutrient that helps young children grow, develop normally and stay healthy. In addition, PDCO contributes significantly to the need for vitamin C, E, K and many B-group vitamins and other mineral salts (ISABU, 2018). The new orange-fleshed sweet potato varieties have also been adopted with the aim of increasing production, farmers' well-being, and combating the chronic malnutrition rampant in Burundi and constituting an overwhelming problem that affects 1 in 2 children under the age of 5 (ENSNSAB, 2019). Orange-fleshed sweet potato has been embraced for its importance in improving farmers' livelihoods (ISABU, 2018), empowering women and creating income-earning opportunities, even for poor households. Thanks to the high productivity of most PDCO varieties, farmers can produce more PDCO surplus and sell the tubers and other sub.Its good vegetation cover also helps in erosion prevention, and its nutrient-rich leaves are an excellent daily feed for cattle and pigs. Orange-fleshed sweet potato can partially substitute 20-60% of imported wheat flour to make economically profitable and viable PDCO breads and cookies (ISABU, 2018). Despite their importance, the new orange-fleshed sweet potato varieties have not yet been adopted by all farmers although they could be adapted in all regions in Burundi. Few studies have examined the effects of adopting new technologies and varieties in Burundi. Thus, no research has been carried out on the adoption of the orange-fleshed sweet potato, nor on its effects. The aim of the present study is to analyse the adoption of orange-fleshed sweet potatoes and its effects on production in the commune of Gihanga.

The literature on the adoption of new technologies or innovations is abundant. Diffusion and innovation theory was proposed by Rogers in 1962. It was born to explain the way in which a technological innovation evolves from the stage of invention to that of use. In the agricultural sector, innovation is understood as the introduction of a new agricultural practice, sometimes a modification of a traditional practice, more rarely the adoption of a new socio-economic behavior (Oleh, 2013). And Adams (1982) sees innovation as a new idea, practical method or technique for sustainably increasing agricultural production and income.

The adoption of improved or new technologies in agriculture has attracted the attention of economists because a large proportion of the population in developing countries derive most of their livelihood from agricultural production (Feder et al.1985). Utility maximization theory is used to explain farmers' adoption of agricultural innovations. According to this theory, farmers are assumed to make rational decisions about whether or not to adopt innovations, based on utility maximization (Nkamleu and Adesina, 2000). In the literature, the determinants of decisions to adopt or reject innovations are often analyzed using different econometric approaches.

The decision to adopt a new and 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 potential of the new technology to increase production, reduce the cost of production and generate a high profit, is also essentially important. In the case of agricultural innovations, Chambers et al (1994) show that farmers do not think in terms of adoption or rejection as researchers do. Instead, they seek to learn about the new product, its features and its advantages.The speed of diffusion and adoption of an innovation will be influenced by factors that are not linked to the innovation itself, but to the environment in which the innovation is introduced (exogenous factors) or to the intrinsic characteristics of the innovation (endogenous factors). According to Rogers (1983), diffusion is a process by which an innovation is communicated at any given time to members of a social system through certain channels. Rogers (1983) states that the characteristics of a given technology are important determinants of adoption. In addition, farmer characteristics such as age, household size, field size, education, experience and farm enterprises are also factors that can influence the adoption decision.

Research methodology

The study was carried out among sweet potato growers in the commune of Gihanga, province of Bubanza. The commune of Gihanga was chosen because it is one of the sites where orange-fleshed sweet potato cuttings have been widely distributed. The commune was also chosen because it is one of the areas with the greatest potential for sweet potato production. In addition, it has been the area for the introduction of improved sweetpotato varieties by ISABU and FAO for almost four years, with 403,000 orange-fleshed sweetpotato cuttings distributed (ISABU, 2019). Six of eleven distribution sites in the Gihanga commune were selected. These were the sites of, Gihungwe, Rugunga, Gihanga, Bwiza bwa Ninga V6, Ninga V4 and Buringa using a simple random sampling technique.

Figure 1. Map of the commune of Gihanga

Design of the study

The figure above shows the variables that were chosen to determine their relationship with orange-fleshed sweet potato adoption and that are likely to influence adoption. The demographic variables chosen are age of household head, gender of household head, household size, active household members, and marital status of household head. Socio-economic factors were sown area, distance to market and education of the household head, while institutional factors were membership of a producer organization, access to extension, access to credit and access to inputs. The study also analyzed the effect of orange-fleshed sweet potato adoption on production.

Sampling, data collection and analysis

A multi-stage sampling procedure was used to select the sampled households. Six of the eleven distribution sites in the Gihanga commune were selected. Farmers were stratified into two groups according to their adoption or non-adoption status of orange-fleshed sweet potato varieties. The total household sample size was determined using a formula developed by Cochran (1977). A total sample of 385 households was surveyed. Quantitative and qualitative primary data were collected through a survey of adopters and non-adopters of orange-fleshed sweet potato varieties in the Gihanga commune, using a questionnaire and Kobo Collect software. Data were collected from farmers in the Gihanga commune. Once the data had been collected, entered and processed in an Excel spreadsheet, they were analyzed using SPSS and STATA software. Data analysis involved both descriptive and econometric analysis.

Propensity Score Matching Approach

The study uses propensity score matching to measure the impact of orange-fleshed sweet potato varieties on production. (Rosenbaum and Rubin, 1983). Propensity score matching (PSM) is a quasi-experimental method for estimating the causal effects of treatment. It matches control groups to treatment groups on the basis of observed characteristics or propensity scores. Only variables that simultaneously influence the participation decision and the outcome variable should be included (Sianesi, 2004; Smith and Todd, 2005). In addition, the matching method focuses on the problem of common support, thus avoiding selection bias by comparing the situation before and after matching to check whether differences remain after conditioning on the propensity score.

The average treatment effect (ATE) is given by the difference between the average outcomes (sweet potato production) of adopters and matched non-adopters who receive common support conditional on propensity score. The average effect of adopting orange-fleshed sweet potato varieties is therefore given by :

$ATE = E(Y_1 \mid Di = 1) - E(Y_0 \mid Di = 0)$……………………………………….....(8)

Where: ATE is an average treatment effect, Y is the outcome (sweet potato production) and Di is a dummy variable indicating whether household i, received the treatment or not.

Following Takahashi and Barrett (2013), to know the treatment effect it is necessary to measure the average treatment effect on treated individuals (ATT), which can be defined as follows:

$ATT = E\{ Y_1 - Y_0 \mid D = 1 \} = E(Y_1 \mid D = 1) - E(Y_0 \mid D = 1)$…………...…… (9)

Where: Y1 = the result in the treated condition, Y0 = the result in the control condition; and D = dummy variable denoting the adoption of orange-fleshed sweet potato varieties.

Using the same procedure for estimating ATT, it is possible to estimate the average effect of treatment on non-treated, better known as the Average Effect of Treatment on Non-Treated (ATU).

$ATU = E\{ Y_1 - Y_0 \mid D = 0 \} = E(Y_1 \mid D = 0) E(Y_0 \mid D = 0)$……………...………...(12)

To estimate the treatment effect using the propensity score matching method, the Nearest Neighbor Matching (NNM) method was used.

Analysis and discussion of results

The propensity score matching (PSM) method was used to study the impact of orange-fleshed sweet potato adoption on production. The PSM method involves a multi-step estimation process including choice of matching algorithm, definition of overlap and common support, estimation of matching quality and estimation of impact. Matching quality can be assessed using graphs. To this end, Figure 1 shows the graphical distribution of the propensity score and common support for impact estimation.

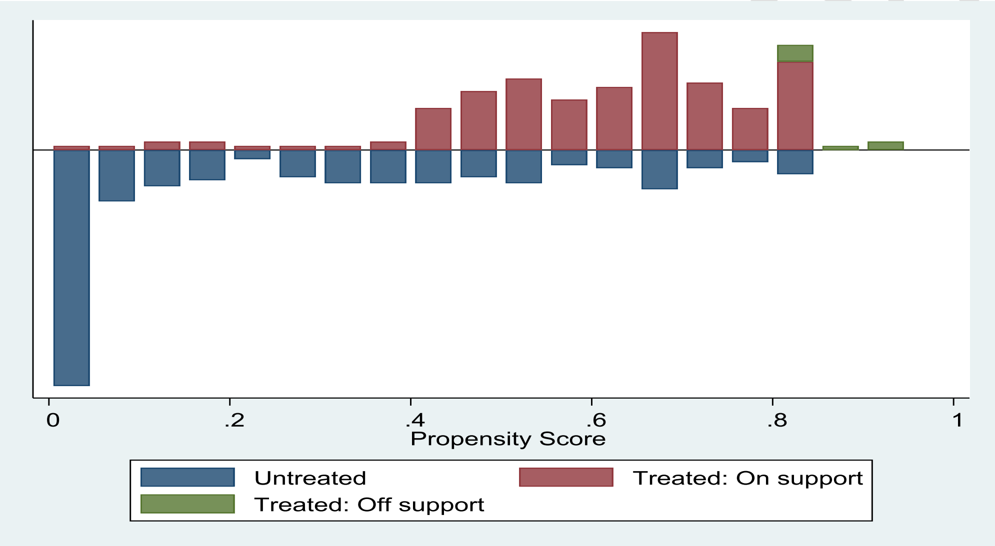
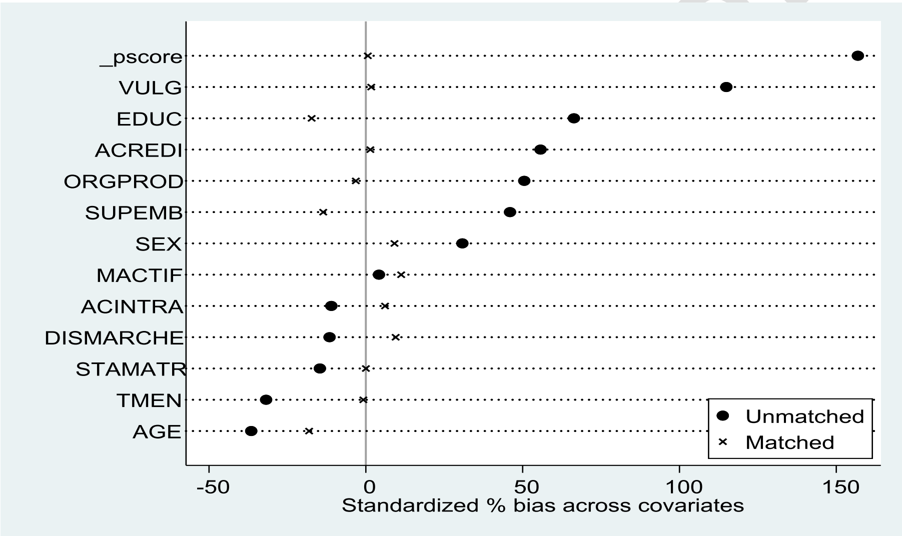


Figure 2 : Propensity score distribution and common support region

Source: author based on survey data

Common support graphically shows a significant overlap in the distribution of propensity scores of adopters and non-adopters of orange-fleshed sweet potato varieties and confirms the achievement of good balancing, although small differences still appear.Once the matching algorithm had been chosen, the mean standardized bias reduction test between matched and unmatched households was carried out. The matching process created a high degree of covariate balance between the treatment and control groups, ready for use in the estimation test.

Figure 3 :Standardised bias before and after matching



Source: author based on survey data

The results confirm a reduction in standardized bias after matching. Before matching, its value is most of the time higher than 10%, and goes up to more than 100% for variables such as access to extension services.

Results of the estimation of the effect of the adoption of orange-fleshed sweet potato on production

This section is devoted to analyzing the effect of orange-fleshed sweet potato adoption on production. The study of the effect of orange-fleshed sweet potato adoption used the nearest-neighbor matching (NNM) algorithm.

Table 1: Average treatment effect results

Variable	NNM				
	Sample	**Treated**	**Controls**	**Difference**	**T-stat**
Production of PDCO in Kg	ATT	1 651,24	1 281,37	369,88	1,82
	ATU	1 375,71	1 311,96	63,75	
	ATE			191,77	

Source: Author's compilation

From the results found, it appears that households in the treatment group had higher average production than those in the control group. Households in the treatment group averaged 1,651.24 kg, while those in the control group received 1,281.37 kg for. The difference between the two averages of the counterfactual results represents the average treatment effect on treated (ATT), which is equal to 369.88 kg. This result means that orange-fleshed sweet potato production over the last 12 months for an average household increased by around 369.88 kg for households in the treatment group compared with the control groups.

Discussions

The result shows that the adoption of sweet potatoes had a positive effect on production. Households adopting orange-fleshed sweet potato had better production than non-adopters. However, this result is statically insignificant at the 5% level, as the student t-value (1.82) is below the critical value ($t < 1.96$). The positive, non-significant result means that adoption has had a positive effect on production, but that the difference in production between adopters and non-adopters is small.

This situation can be explained by the constraints associated with adoption, including drought and lack of water. In addition, cuttings were distributed at the approach of dry salting, and cuttings, which caused their deficiency for the following seasons. In addition, although the orange-fleshed sweet potato was adopted in order to reduce the productivity and disease problems of other varieties, growers in the study area have a positive perception of the production and taste of certain other sweet potato varieties.

The results found concur with those found in Tanzania (Tebabal, 2019) where participation in the orange-fleshed sweetpotato adoption project had small effects on nutrition and in Ethiopia, Abebaw and Haile (2013) found that adoption of improved orange-fleshed sweetpotato seed had a positive but non-significant impact on farmers' incomes.

However, the results are not in agreement with a large number of authors on the significance of the results. Results from the literature show that the adoption of new improved sweetpotato varieties and other crops, as well as the adoption of new technologies, had a positive impact on production and productivity (Issoufou et al. 2017; Tilaye, 2022; Lapar et al., 2011; Chukwu et al., 2021) in Tanzania, Ethiopia, China, Niger, Nigeria and elsewhere.

Conclusion and recommendations

The aim of this study was to analyze the effects of adopting orange-fleshed sweet potatoes on production. The results of the survey of 385 sweetpotato-growing households in the commune of Gihanga, including 161 adopters and 224 non-adopters, using the SHP method, show that the adoption of orange-fleshed sweetpotato had a positive but non-significant impact on their production. The results of the ATT show that, compared with non-adopters, the increase in average production for adopters varied by around 369.88 kg. However, this increase was statistically insignificant at the 5% threshold, which means that although the effect of adoption was positive on production, the increase was small.

In view of the above key findings and conclusions, the following recommendations are made: Improve strategies and financing plans in the agricultural sector adapted to farmers' needs to enable them to adopt the orange-fleshed sweet potato; strengthen policies and strategies for the adoption of new orange-fleshed sweet potato varieties.Raise awareness of the importance of the sweet potato and its countless income-generating opportunities through the processing of by-products. Disseminate, facilitate access to and mobilize farmers to adopt sweet-potato varieties so that they can improve their production'; improve and expand dissemination strategies and extension packages to help increase adoption rates across the country Successful adoption. Adopt the new orange-fleshed sweet potato varietieshas proved more productive and also improve sweet potato cuttings multiplication strategies, taking climatic conditions into account will boost the productivity of this most wanted tuber. Use inputs such as fertilizers will increase the productivity of orange-fleshed sweet potatoes.

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