American Journal of Rural Development, 2019, Vol. 7, No. 2, 44-52
Available online at http://pubs.sciepub.com/ajrd/7/2/1
Published by Science and Education Publishing
DOI:10.12691/ajrd-7-2-1

Determinants of Adoption and Farmers' Preferences for Cassava Varieties in Kabare Territory, Eastern Democratic Republic of Congo

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Received July 15, 2018; Revised September 03, 2018; Accepted April 17, 2019

Abstract Cassava plays a major role in households' food and income security in Democratic Republic of Congo (DRC). Despite multiple efforts to overcome the problem of low productivity in cassava production through the introduction of improved technologies, the level of adoption of such technologies by farmers has remained low in eastern DRC. This study, therefore, aimed at identifying determinants of adoption and farmers' preferences for cassava varieties in Kabare Territory, eastern DRC. A participatory approach was used to collect data on 250 cassava smallholder farmers in five different zones called "groupements" including Cirunga, Kagabi, Bugorhe, Katana, and Mumosho. Results showed that improved cassava varieties are adopted by 28.8% of smallholder farmers. Membership in an agricultural cooperative, access to planting material as a credit, education level, gender, and cropping system had a positive influence on improved varieties' adoption. In contrary, field-to-house distance, location and total farm size had a negative effect on adoption decision. This study demonstrated that introduced varieties possess most of traditional desirable traits (yield potential, taste, high disease resistance and early maturity) but are lacking local (regional) farmers' preferences such as leaf production, in-soil storage, bitterness, tuber color which had limited adoption by farmers who continue relying on local landraces (88%) for those traits. Therefore, in addition to addressing negative factors that prevent adoption, specific attention should be given by cassava breeders to local specific preferences if the objective is to increase adoption of improved varieties by farmers in eastern DRC.

Keywords: *Improved varieties, landraces, dissemination strategies, smallholder farmers, South-Kivu*

Cite This Article: Jean M. Mondo, Alain B. Irenge, Rodrigue B.B. Ayagirwe, Paul M. Dontsop-Nguezet, Katcho Karume, Emmanuel Njukwe, Sylvain M. Mapatano, Patient M. Zamukulu, Géant C. Basimine, Eric M. Musungayi, Héritier K. Mbusa, Léon M. Kazamwali, René Civava, and Gustave N. Mushagalusa, "Determinants of Adoption and Farmers' Preferences for Cassava Varieties in Kabare Territory, Eastern Democratic Republic of Congo." *American Journal of Rural Development*, vol. 7, no. 2 (2019): 44-52. doi: 10.12691/ajrd-7-2-1.

1. Introduction

Cassava (*Manihot esculenta* Crantz) is the main staple and the most widely grown crop in Democratic Republic of Congo (DRC) [1]. Its production has reached about 14.7 million tons of tuberous roots in 2016, making approximately 71% of national agricultural production [2]. DRC cassava per capita consumption is about 353 kg per person per year and it is the highest in the world [3]. Its ability to produce under poor soil conditions with minimal inputs and its flexibility in harvesting dates increased its popularity among smallholder farmers and consumers in eastern DRC [4]. In addition to income generation for rural households (49.2% of production being oriented to market participation) [5], cassava provides basic dietary energy while leaves are consumed as vegetable and source of proteins, vitamins, carotenes and minerals [6]. In South-Kivu, cassava is grown for both root tubers and leaves [7]. Alongside with banana and other root and tuber crops, they are feeding more than 87% of the population [3,5].

However, there was a decrease in cassava production with low average yields of 8 to 9 t ha^{-1} [2] while the crop potential in DRC is above 50 t ha^{-1} [8], a situation exacerbated by the use of low productive varieties, which are susceptible to pests and diseases (such as

cassava mosaic disease and cassava brown streak disease), low soil fertility, climate hazards and the use of inappropriate farming practices [1,5,7,9]. This is severely threatening the food security of populations and thus increasing the risk of famine and poverty among smallholder farmers. To cope with that situation, local and international organizations had introduced new cassava varieties since the 2000s in all provinces of the country including the South-Kivu [10]. These varieties have high yields, good resistance to multiple diseases and pests and possess qualities for food, feed and industrial use [1,8,11,12]. Although the combination of these new varieties with adequate agronomic practices increased yields per unit area by at least 40%, the adoption rate by smallholder farmers still remains low (14%) [13]. According to [14], the dissemination of these varieties has often suffered from a lack of a reliable seed distribution system from national agricultural research organizations, weakness of the extension services, insufficient quality seed, as well as delays in the certified seed distribution, which led farmers to continue cultivating local landraces that are susceptible to diseases, late maturing and low yielding [15].

The success of extension programs and adoption could be improved with a greater understanding of farmers' cassava varieties preferences [16,17]. The choice of varieties to be introduced in a given environment should consider several criteria that are linked not only to specific characteristics of varieties, but also to factors related to individuals, environment (social and economic), production system and marketing constraints [13,18] that affect the decision-making process of farmers on adoption [19]. Examples of empirical studies on innovation and technology dissemination highlight important elements affecting adoption such as the agro-ecological zone, marital status, the farm size, the type of farmer, the education level, the contact with extension services, the farming experience, the cropping systems, the volume of production, processing facilities, access to credit, presence of non-farm incomes, the existence of a market for the sale of products, etc. [10,13,16,17]. In addition to those non-farm factors affecting cassava varieties adoption, there are farmers' preferences for specific varietal traits. [20] showed that early maturity, high yield potential, resistance to pests and diseases, leaf production, stem height and early branching varieties, drought tolerance, flowering varieties, etc. were the major farmers' preferences for cassava variety traits in Cameroon. In Ghana, [17] revealed that in-soil storage (longevity) and disease resistance were the most important attributes for farmers' choice over high productivity. Farmers in Nigeria were even more demanding as they preferred white fleshed roots, ability to be processed into gari or fufu, ease of peeling, good poundability and palatability when boiled, smoothness and fiber content, in addition to traits previously identified for Cameroonian and Ghanaian farmers [21]. However, as it can be realized from previously highlighted cases, most of those preferences are regional and depend on socio-economic aspects, local farming and processing practices and eating habit of each people, and therefore, farmers' preferences for variety traits may vary from one people to another, from one country to another and even from one area of a country to another. The present study aims to contribute to the identification of determinants associated with cassava varieties adoption and to determine farmers' preferences for cassava varieties grown in Kabare Territory of the eastern DRC to guide local and regional priorities of breeding programs and extension services.

2. Material and Methods

2.1. Study Site

This study was carried out in Kabare Territory in 2016. Kabare is located between 28°45' and 28°55' E (longitude), 2°30' and 2°50' S (latitude) and between 1460 and 3000 m above sea level (altitude). It covers an area of 1960 km² with a population density of 347 persons per km². It has a mountainous tropical climate, moderate temperature, increasingly depleted and eroded clay soil. The Kabare Territory experiences an average annual rainfall ranging between 1300 mm and 1800 mm under a bimodal regime. Agriculture, livestock farming and fishing are the main economic activities of the population. Cassava, banana, beans, sweet potato and maize are major crops grown by smallholder farmers while coffee, tea and sugar cane are the most common industrial crops found in Kabare Territory. Its proximity to Bukavu City presents an economic opportunity as farmers easily access the market [22,23]. The choice of Kabare for this study was motivated by the high dependence of population on cassava as staple food as well as its proximity to research centers, local (e.g. INERA) and international organizations (e.g. IITA, CIAT, etc.) that promote improved cassava varieties uptake by farmers. More specifically, this study was carried out in five out of 14 "groupements" of Kabare Territory. These included two areas in the central part (Cirunga and Kagabi), two areas in the northern part (Bugorhe and Katana) and one in the southern part (Mumosho). These areas are among the major beneficiaries of cassava variety dissemination programs carried out by several governmental and non-governmental organizations (IITA, INERA-Mulungu, Comité Anti-bwaki, HarvestPlus and others) for the last two decades.

2.2. Sampling and Data Collection

A random sample of 50 respondents per "groupement" making a total of 250 cassava smallholder farmers was involved in a survey. Individual interviews with cassava farmers were organized and information on their socio-economic/demographic characteristics, production practices as well as access to technical and financial information was collected through a well-structured questionnaire. A participatory evaluation considering major cassava varietal traits such as yield potential, taste, early maturity, resistance to diseases and pests, drought tolerance, in-soil storage, bread (fufu) quality, leaf production, etc. were conducted with farmers to determine

their preferences for each of those traits from cassava varieties grown in their farms and their area. A list of individuals cultivating improved cassava varieties per growing area was obtained from farmer associations and then person-to-person contacts with local people. That list was exclusively used to assess farmers' preferences for cassava traits as their fields provided plant materials for the participatory evaluation which involved both adopters and non-adopters of introduced varieties.

2.3. Conceptual Framework and Analytical Model

Descriptive analysis was used to assess trait preferences while logistic analysis was performed to assess factors influencing improved cassava varieties' adoption. The decision for a farmer to adopt or not a particular cassava variety can be captured as a binary choice which takes the value 1 if the farmer decides to adopt the variety and 0 if the farmer decides otherwise. In econometric literature, identification of factors affecting such decisions is modelled through a binary model such as logit or probit, with little consideration on the choice between the two models [24,25,26]. In this study, we fitted a logit model to examine factors influencing the adoption decision of cassava farmers vis-a-vis improved varieties.

The binary logistic distribution for the adoption decision can be specified as:

$$P_i = \frac{1}{1+e^{-z_i}} \quad (1)$$

Where P_i is a probability of engaging in improved variety farming for the i^{th} farmer and ranges from 0 to 1. e represents the base of natural logarithms and Z_i is the function of a vector of n explanatory variables and expressed as:

$$Z_i = \beta_0 + \sum \beta_i X_i \quad (2)$$

The explicit binary logit model can be expressed as:

$$Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + u \quad (3)$$

Where $P\ (Y_i)$ = probability for an individual i to adopt the improved variety (1 if the farmer adopt and 0 if otherwise); X_i are the explanatory variables including the characteristics of the farmer and farm attributes [27]; β_0 is the intercept and $\beta_{(1\text{-}n)}$ are the coefficients for the respective variables in the logit function and u is error term [28].

The choice of independent variables summarized in Table 1 was based on literature review, and socio-economic theory governing the adoption of agricultural innovations [13,17,29]. This study assumed that variables affecting positively the adoption of introduced cassava varieties had a negative impact on the use of local landraces by farmers and vice versa, and therefore, the expected sign for the local landraces for each variable is the opposite of the one presented in Table 1.

Table 1. List of determinant variables for the introduced cassava varieties adoption and their expected effects

Variables	Definition	Expected effect
Non-farm incomes (1/0)	1 if presence of lucrative non-farm activities; 0 otherwise	Positive
Age (years)	Age in years of the household head	Positive/Negative
Membership of cooperatives (1/0)	1 if the farmer is member; 0 otherwise	Positive
Access to financial credit (1/0)	1 if farmer has access to credit; 0 otherwise	Positive
Access to cassava planting material (1/0)	1 if farmer has access to cutting credit; 0 otherwise	Positive
Cassava as main crop (1/0)	1 if cassava is the main crop for the household; 0 otherwise	Positive
Cassava market-oriented production (1/0)	1 if more than 50% of production is for market participation; 0 otherwise	Positive
Distance to input market (km)	Distance in km between the market center and the farmer field	Negative
Field-to-house distance (km)	Distance in km between the farmer field and farmer house	Negative
Marital status	1 if the farmer is married; 0 otherwise	Positive/Negative
Cassava farming experience (years)	Number of years in cassava cultivation by the household head	Positive/Negative
Training on cassava farming (1/0)	1 if farmer trained at least once; 0 otherwise	Positive
Location or ''Groupement''	Growing area where the farmer is located	Positive/Negative
Plant disease (1/0)	1 if presence of disease in the farmer growing area; 0 otherwise	Positive
Education level	1 if at least primary education completed; 0 otherwise	Positive
Household size (number)	Number of persons in the household	Positive/Negative
Hired farm labor (1/0)	1 if the farmer uses other persons outside the household for farming; 0 otherwise	Positive/Negative
Crop rotation (1/0)	1 if the farmer practices rotation in his/her cassava farm; 0 otherwise	Positive/Negative
Gender (1/0)	1 if the household head is a man; 0 otherwise	Positive/Negative
Total farm size (ha)	Acreage owned by the household in ha	Positive/Negative
Cropping system (1/0)	1 if cassava is grown in monoculture; 0 otherwise	Positive
Contact with extension agents (1/0)	1 if at least one visit per year from extension services; 0 otherwise	Positive

3. Results and Discussion

3.1. Socio-economic Characteristics of Cassava Farmers

Socio-economic characteristics of cassava farmers in Kabare are presented in Table 2. The involvement of men and women in cassava cultivation varied from one "groupement" to another in Kabare Territory. Across the territory, the majority of producers were women (56.4%) although there was a strong involvement of men in cassava production in Cirunga and Katana "groupements" (62%). Men usually grow cash crops and, therefore, the heterogeneity in gender involvement across growing areas would depend on the final destination of the produce [30,31]. In areas where cassava is considered as a cash crop (sell of cuttings), men are likely to be most involved than women who are more attached to subsistence crops [32]. Majority of cassava producers (53.6%) in Kabare Territory were between the age of 30 and 50 years old and were almost all married (94.4%) with 88% having a household size of more than 5 members. Their level of education was very low, only about 15% has more than primary school level (42.4% of illiterates and 42.0% of primary education level). Agriculture was their main economic activity (79.6%) with a large part (50.8%) having experience of more than 20 years in the agricultural sector. Concerning the experience in cassava farming particularly, the majority of farmers (66.8%) have an experience ranging between 11 to 20 years.

3.2. Inventory of Major Cassava Varieties Grown in Kabare Territory and their Utilization Rate

The use of improved cassava varieties by farmers had increased in the last 5 years. Variety 1661 was the most recently introduced in Kabare Territory. Referring to the origin of these varieties, most of the farmers obtained them through an informal seed system either from non-governmental organizations (NGOs) (Mayombe: 71.8% and 1661: 100%) or from other farmers within the area or from neighboring zones (Liyayi and Sawasawa). [33] reported that community-based organizations (CBOs), NGOs and farmer groups are very instrumental in facilitating the delivery of improved varieties to farmers and thus facilitate their adoption. The mode of acquisition of improved varieties was mainly by donation (gift). Almost all local varieties were grown for more than 5 years and were obtained as a gift from other farmers (and farmer-saved seed) except the variety M'Shediye which was recently introduced into Mumosho zone from Rwanda (Table 3). Sawasawa and Liyayi varieties presented the highest utilization rate among improved varieties and were cultivated by 46.4% and 34.6% cassava farmers, respectively; who considered them highly productive. Varieties Mayumbe and 1661 were found in only 22.8% and 10.8% farms, respectively. Nambiyombiyo (a local variety) was the most popular (69.2%) in Kabare Territory. It was the only variety among local landraces found in all the 5 growing areas covered by this study. The other local varieties such as Nabinzoza (28.4%), M'Baila (25.6%) and Nakarasi (16.0%) were also popular but not present throughout the territory (Table 3).

Table 2. Socio-economic characteristics of cassava farmers in Kabare Territory

Characteristics	Category	Proportion (in %) per "groupement"					Total	Khi^2
		Bugorhe	Cirunga	Kagabi	Katana	Mumosho		
Gender	Women	76.0	38.0	64.0	38.0	66.0	56.4	24.6***
	Men	24.0	62.0	36.0	62.0	34.0	43.6	
Age	<30 years	18.0	18.0	22.0	18.0	20.0	19.2	6.6^{ns}
	30-50 years	42.0	56.0	56.0	54.0	60.0	53.6	
	>50 years	40.0	26.0	22.0	28.0	20.0	27.2	
Marital status	Single	6.0	0.0	2.0	8.0	0.0	3.2	19.6*
	Married	86.0	100.0	94.0	92.0	100.0	94.4	
	Widowed	8.0	0.0	4.0	0.0	0.0	2.4	
Household size	<5 members	8.0	16.0	16.0	16.0	2.0	11.6	8.0^{ns}
	>5 members	92.0	84.0	84.0	84.0	98.0	88.4	
Education level	No schooling	44.0	26.0	32.0	58.0	52.0	42.4	30.9**
	Primary	28.0	56.0	56.0	28.0	42.0	42.0	
	High school	28.0	18.0	12.0	12.0	6.0	15.2	
	University	0.0	0.0	0.0	2.0	0.0	0.4	
Main economic activity	State work	6.0	10.0	6.0	2.0	0.0	4.8	49.9**
	Farming	74.0	86.0	88.0	70.0	80.0	79.6	
	Teaching	0.0	0.0	0.0	4.0	6.0	2.0	
	Small business	12.0	4.0	6.0	18.0	14.0	10.8	
Farming experience	<5 years	6.0	14.0	28.0	6.0	8.0	12.4	41.1***
	5-10 years	16.0	26.0	26.0	8.0	12.0	17.6	
	11-20 years	20.0	6.0	6.0	32.0	32.0	19.2	
	>20 years	58.0	54.0	40.0	54.0	48.0	50.8	
Cassava farming experience	<5 years	8.0	26.0	34.0	14.0	8.0	18.0	22.8*
	5-10 years	20.0	14.0	10.0	14.0	16.0	14.8	
	11-20 years	70.0	60.0	56.0	72.0	76.0	66.8	
	>20 years	2.0	0.0	0.0	0.0	0.0	0.4	

ns: not significant; *, **, ***: significant at 10%; 5% and 1% P-value thresholds, respectively.

Table 3. Distribution of major cassava varieties in Kabare by year, origin and mode of acquisition

Type of variety	Variety local name	Year of acquisition (%)			Source of acquisition (%)			Mode of acquisition (%)		Rate of utilization (%)
		<1yr	1-5yr	>5yr	NGO	RC	Farmer	Purchase	Gift	
Improved varieties	Mayombe	14.3	85.7	0.0	71.4	28.6	0.0	0.0	100	22.8
	Liyayi	6.5	71.7	21.7	21.7	13.0	65.2	4.3	95.7	34.4
	Sawasawa	13.4	68.7	17.9	20.9	29.9	49.3	4.5	95.5	46.4
	1661	100	0.0	0.0	100	0.0	0.0	0.0	100	10.8
Local varieties	Nambiyombiyo	0.6	3.4	96.0	0.0	0.0	100	2.3	97.7	69.2
	M'Baila	0.0	3.2	96.8	0.0	0.0	100	1.6	98.4	25.6
	Nganga-na-butu	0.0	0.0	100	0.0	0.0	100	0.0	100	4.8
	Nakarasi	0.0	12.5	87.5	0.0	0.0	100	0.0	100	16.0
	M'Shediye	0.0	52.6	47.4	0.0	0.0	100	0.0	100	7.6
	Nalubanda	0.0	0.0	100	0.0	0.0	100	0.0	100	3.2
	Nabinzoza	0.0	4.3	95.7	0.0	0.0	100	0.0	100	28.4
	Kanyunyi	0.0	0.0	100	0.0	0.0	100	0.0	100	10.4
	Kamegehe	0.0	0.0	100	0.0	0.0	100	0.0	100	8.0
	Kabunga	0.0	0.0	100	0.0	0.0	100	0.0	100	4.4

Yr=year; RC=research center; NGO=non-governmental organization.

3.3. Determinants of Cassava Varieties Adoption

Table 4 presents the adoption rate of improved and local varieties of cassava across growing areas ("groupements"). The adoption rate of improved and local varieties of cassava was highly variable from one zone to another. In general, local varieties had a high adoption rate (88.0%) compared to improved varieties (28.8 %). The adoption of improved cassava varieties was higher in Cirunga (52.0%) and Bugorhe (40.0%) than Mumosho (24.0%), Kagabi (18.0%) and Katana (10.0%). This difference can be attributed to the fact that, for Cirunga and Bugorhe, non-governmental organizations (NGOs) intervene in several agricultural cooperatives in opposition to what was reported for Mumosho and Kagabi. NGOs activities are most of the time supporting extension services by forming and informing farmers on new released cassava varieties and increase farmers' access to cassava planting materials and thus influencing farmers' decision making toward new varieties [33]. In addition, NGOs provide technical support to farmers and training on adequate farming practices for increasing yield and income from farming. Compared to the adoption rate of 14% reported by [13] on data collected from a survey conducted in Kabare and Walungu Territories in 2006-2007, improved cassava varieties are increasingly adopted by smallholder farmers. The present research conducted in Kabare Territory and which is based on data collected in 2016 revealed a current adoption rate of 28.8% while a survey conducted during the same year in Walungu Territory by [10] showed an average variety adoption rate of 32.2%. This is in part due to efforts from NGOs and farmer associations. Across all the cassava growing areas, there is a coexistence of improved varieties and local landraces as farmers adopting introduced varieties are not willing to reject their landraces. This could be explained by the fact that none of the introduced varieties is combining all the farmers' preferred traits, suggesting the necessity of initiating a breeding program which will consider desirable attributes found in local landraces while developing new varieties. This would be a way of improving the adoption rate of cassava varieties in South-Kivu province, and Kabare in particular. [17] showed that most of research organizations make a mistake by focusing on yield and disease resistance during variety selection, which are not enough for farmers and other end-users. [17] revealed that Ghanaian cassava farmers value most in-soil storage over traditional breeding objectives (yield, disease resistance, etc) and are willing to pay for it. For Kabare specifically, most of improved varieties are developed and introduced from areas with different breeding objectives in terms of traits to be involved in a new variety. For example, most of crop varieties grown in South-Kivu are from eastern African countries where crop leaves (cassava, beans, pumpkin, sweet potato) are not at all used for human consumption while in South Kivu, crop leaves play a major role in nutrition and household income generation [7].

Table 4. Adoption rate of improved cassava varieties and use of local varieties in Kabare Territory

Variety type	Category	Zones (%)					Total	Khi^2
		Bugorhe	Cirunga	Kagabi	Katana	Mumosho		
Improved varieties	Non-adoption	60.0	48.0	82.0	90.0	76.0	71.2	24.4***
	Adoption	40.0	52.0	18.0	10.0	24.0	28.8	
Local varieties	Non-adoption	14.0	26.0	6.0	10.0	4.0	12.0	14.3**
	Adoption	86.0	74.0	94.0	90.0	96.0	88.0	

*, **, ***: significant at 10%; 5% and 1% P-value thresholds, respectively.

Key factors that emerged from the logit model and that motivated cassava farmers to adopt improved varieties are presented in Table 5. The LR Khi^2 of 103.29 is greater than the Khi^2-critical value at 1% significance level, suggesting that the logit model is an adequate representation of the data. Five determinants including membership in an agricultural association or cooperative, access to credit for cassava planting materials, education level, gender, and cropping system had positively and significantly influenced the adoption of improved cassava varieties. However, three determinants had negatively affected the adoption. These included the field-to-house distance, location ("groupement") and the total farm size. In fact, belonging to a farmers' association promotes access to information about innovation through other members [34]. Also, the presence of an agricultural cooperative allows the contact of a locality with support structures or extension workers, who have innovative information [35,36]. In Kabare Territory, only few farmers have access to financial credit as farmers fail to pay back the previous loan. Also when accessing financial credit, farmers are not willing to affect it directly into agricultural sector, fearing to not harvest enough to pay back. The same case was reported in Tanzania where access to financial credit had reduced the probability of adopting maize varieties by 16% as farmers were not investing the credit in agricultural activities [29]. Therefore, most of organizations supporting farmers provide credit but directly in form of planting materials. That strategy has positively stimulated cassava variety adoption in two ways. Firstly, it acts as the traditional credit by making factors of production accessible to producers and thus improving their living conditions [37,38]. [36] revealed that the impact of extension services on poverty reduction and cooperatives on technology adoption is significantly stronger when smallholders access credit. Secondly, it makes the planting material available to farmers, who consider it as the most limiting factor in improved variety farming. The distance between the house and the field is negatively correlated with the adoption of improved varieties. Farmers living far from their cassava fields adopt less improved cassava varieties because improved varieties introduced are not bitter enough and their cuttings are absent in local markets, encouraging tuber and cutting thefts as fields are far from owners. Also, as improved varieties are grown mainly for household consumption and on small plots due to limited access to planting materials, they are kept near the farmer house for easy access. The education level has had a positive influence on the adoption of improved cassava varieties. Many studies have previously shown that adoption of innovations increases with the farmer education level [13,29,39,40]. This could be explained by the fact that producers with a high education level have a propensity to get information on varieties and other new technologies that may be profitable, which translates into a higher probability of engaging in new technologies. It can as well be explained by the fact that most of educated farmers in rural areas are the most targeted by NGOs and are more involved in farmers' associations. The growing area influenced the adoption of improved cassava varieties in Kabare Territory. Indeed, the difference between areas was due to a strong NGOs presence and intervention in some areas. The farmer's gender influenced adoption and use of improved cassava varieties. Men adopted most the improved varieties than women probably because they have more access to information than women and are often more educated [16]. Estimation of logit model on factors favoring the high use rate of local landraces in Kabare Territory revealed that lack of access to planting material as a credit, experience in cassava farming, the total farm size and the lack of regular contacts between farmers and the extension service were the most determinant. Older farmers who have spent more time growing cassava were reluctant to take risks by changing their crop variety or cropping system as also indicated by [41]. Producers with larger farm size allocated to cassava cultivation had challenges in obtaining sufficient planting materials of improved cassava varieties and were, therefore, forced to use local varieties for which cuttings were available in large quantities and at a lower cost. It has been observed that regular contact between producers and the extension service significantly reduces the use of local varieties and favors improved varieties. Contact with extension agents is important in adoption as it allows access to information on the benefits of the new innovations and released varieties [36,42,43].

3.4. Varietal Traits and Farmers' Preferences

Table 6 presents preferences after assessment by farmers of improved and local cassava varieties grown in Kabare Territory. Most farmers were satisfied for yield potential (96.5%), disease resistance (82.2%), earliness (72.7%), tuber size (74.5%) and cassava bread quality (71.8%) of improved cassava varieties. The trend was the same for the taste (75.6%) and tuber color (50%), except for the variety 1661, for which farmers did not prefer the taste and the tuber color. Among local varieties, Nganga-na-butu, M'Shediye, Nabinzoza, Nambiyombiyo and Nakarasi were valued by farmers for their high yield potential, tuber size and fresh leaf production, while Nganga-na-butu and M'Shediye were also appreciated for their taste. Even if not popular, Nganga-na-butu was the best local variety as it combined most of traits preferred by cassava farmers while introduced varieties were heterogeneous for most of traits. Local varieties were less resistant to diseases and took longer to mature but were also intermediate for tuber color and drought resistance. These results demonstrated that introduced cassava varieties do not lack traditional desirable traits (yield potential, high disease resistance and early maturity). In addition to extension service weaknesses and lack of reliable seed delivery system in Kabare Territory, introduced varieties are lacking local (regional) preferences such as leaf production, in-soil storage, bitterness, tuber color which had limited adoption by farmers who continue relying on local varieties (88%), which possess most of those traits. While analyzing farmers' preferences for maize varieties in South Africa, [44] reached the same conclusion that improved varieties were lacking farmers' preferred traits which had limited their adoption and, therefore, favored high utilization rate of local landraces. Farmers were willing to adopt those high yielding hybrid varieties only if their preferred traits were incorporated. This could be possible by involving farmers directly in breeding and selection process (through participatory plant breeding approach), which will ensure that farmers' priorities and expectations are met by the new developed varieties [44].

Table 5. Estimation of logit model for determinants of adoption of improved cassava varieties

Determinants	Coefficient	Std. Error	Marginal effects	Probability
Constant	-1.309654	1.547452	-0.846329	0.3974
Presence of non-farm incomes (1/0)	-0.259947	0.193396	-1.344118	0.1789
Age of household head (years)	0.334695	0.416130	0.804304	0.4212
Membership of associations or cooperatives (1/0)	0.847531	0.288919	2.933459	0.0034**
Access to financial or cash credit (1/0)	-1.112898	0.587772	-1.893420	0.0583
Access to planting material as credit (1/0)	3.097398	1.439796	2.151276	0.0315*
Cassava as main crop (1/0)	0.435500	0.472877	0.920959	0.3571
Cassava market-oriented production (1/0)	-0.068423	0.239708	-0.285443	0.7753
Field-to-market distance (km)	-0.144400	0.283066	-0.510129	0.6100
Field-to-house distance (km)	-1.013749	0.257932	-3.930299	0.0001***
Marital status (1/0)	0.046627	0.885683	0.052645	0.9580
Cassava farming experience (years)	-0.250017	0.422519	-0.591729	0.5540
Training on cassava farming (1/0)	0.628143	0.531073	1.182781	0.2369
Location or ‘’groupement’’	-0.372151	0.103445	-3.597590	0.0003***
Plant diseases (1/0)	0.019737	0.402852	0.048993	0.9609
Education level	1.197058	0.349137	3.428625	0.0006***
Household size (number)	0.597640	0.617167	0.968359	0.3329
Hired farm labor (1/0)	0.659649	0.449368	1.467947	0.1421
Crop rotation (1/0)	-0.387755	0.583150	-0.664931	0.5061
Gender (1/0)	1.100817	0.289900	3.797232	0.0001***
Total farm size (ha)	-0.587030	0.156844	-3.742774	0.0002***
Cropping system (1/0)	2.566950	0.882783	2.907793	0.0036**
Contact with extension agents (1/0)	0.272293	0.486649	0.559526	0.5758
Number of observation	250			
LR statistic	103.29***			
Prob. > Khi^2	0.00			
Pseudo R^2	0.31			
Log likelihood	-115.31			

*, **, ***: significant at 10%; 5% and 1% P-thresholds, respectively.

Table 6. Preferences and evaluation of cassava varieties by Kabare Territory farmers

	Variety local name	Yield			Taste			Disease resistance			Earliness			Tuber color		
		Bad	*Interm	Good	Bad	Interm	Good	Bad	Interm	Good	Bad	Interm	Good	Bad	Interm	Good
Improved varieties	Mayombe	0.0	0.0	100	28.6	14.3	57.1	0.0	14.3	85.7	0.0	14.3	85.7	0.0	57.1	42.9
	Liyayi	2.3	4.5	93.2	11.4	15.9	72.7	0.0	40.9	59.1	2.3	47.7	50.0	0.0	50.0	50.0
	Sawasawa	0.0	7.2	92.8	0.0	2.9	97.1	0.0	15.9	84.1	1.4	43.5	55.1	0.0	43.5	56.5
	1661	0.0	0.0	100	100	0.0	0.0	0.0	0.0	100	0.0	0.0	100	0.0	100	0.0
Local varieties	Nambiyo	2.9	27.2	69.9	11.6	40.5	48.0	28.9	53.8	17.3	19.1	62.4	18.5	0.6	67.6	31.8
	M’Baila	4.7	59.4	35.9	21.9	62.5	15.6	37.5	42.2	20.3	17.2	73.4	9.4	12.5	64.1	23.4
	Nganga-na-butu	0.0	10.0	90.0	0.0	10.0	90.0	0.0	70.0	30.0	0.0	20.0	80.0	0.0	20.0	80.0
	Nakarasi	7.5	27.5	65.0	2.5	67.5	30.0	7.5	87.5	5.0	0.0	90.0	10.0	0.0	97.5	2.5
	M’Shediye	0.0	26.3	73.7	5.3	42.1	52.6	5.3	94.7	0.0	0.0	100	0.0	0.0	94.7	5.3
	Nalubanda	0.0	75.0	25.0	0.0	100	0.0	0.0	75.0	25.0	0.0	100	0.0	0.0	100	0.0
	Nabinzonza	0.0	47.1	52.9	7.1	51.4	41.4	34.3	54.3	11.4	37.1	54.3	8.6	0.0	91.4	8.6
	Kanyunyi	0.0	46.2	53.8	0.0	57.7	42.3	0.0	50.0	50.0	50.0	50.0	0.0	0.0	100	0.0
	Kamegere	0.0	55.0	45.0	0.0	55.0	45.0	45.0	55.0	0.0	0.0	100	0.0	0.0	100	0.0
	Kabunga	0.0	50.0	50.0	0.0	50.0	50.0	50.0	50.0	0.0	0.0	100	0.0	0.0	100	0.0
	Variety local name	Drought resistance			In-soil storage			Tuber size			Bread quality			Leaf production		
		Bad	Interm	Good	Bad	Interm	Good	Bad	Interm	Good	Bad	Interm	Good	Bad	Interm	Good
Improved varieties	Mayombe	0.0	100	0.0	0.0	85.7	14.3	42.9	0.0	57.1	0.0	42.9	57.1	0.0	100	0.0
	Liyayi	0.0	84.1	15.9	20.5	70.5	9.1	6.8	20.5	72.7	9.1	36.4	54.5	2.3	75.0	22.7
	Sawasawa	0.0	62.3	37.7	18.8	44.9	36.2	0.0	31.9	68.1	0.0	24.6	75.4	0.0	47.8	52.2
	1661	0.0	100	0.0	0.0	100	0.0	0.0	0.0	100	0.0	0.0	100	0.0	100	0.0
Local varieties	Nambiyombiyo	2.9	86.7	10.4	12.1	26.0	61.8	2.3	44.5	53.2	0.0	42.8	57.2	3.5	68.2	28.3
	M’Baila	9.4	81.3	9.4	10.9	40.6	48.4	10.9	64.1	25.0	3.1	56.3	40.6	6.3	64.1	29.7
	Nganga-na-butu	0.0	20.0	80.0	0.0	20.0	80.0	0.0	10.0	90.0	0.0	20.0	80.0	0.0	20.0	80.0
	Nakarasi	0.0	97.5	2.5	0.0	85.0	15.0	7.5	40.0	52.5	0.0	37.5	62.5	0.0	37.5	62.5
	M’Shediye	0.0	94.7	5.3	0.0	94.7	5.3	0.0	42.1	57.9	0.0	21.1	78.9	52.6	21.1	26.3
	Nalubanda	0.0	100	0.0	0.0	100	0.0	0.0	75.0	25.0	0.0	0.0	100	0.0	0.0	100
	Nabinzoza	0.0	100	0.0	8.6	20.0	71.4	0.0	85.7	14.3	0.0	55.7	44.3	0.0	100	0.0
	Kanyunyi	0.0	100	0.0	0.0	11.5	88.5	0.0	88.5	11.5	0.0	84.6	15.4	0.0	88.5	11.5
	Kamegere	45.0	55.0	0.0	0.0	100	0.0	45.0	55.0	0.0	0.0	100	0.0	45.0	55.0	0.0
	Kabunga	0.0	50.0	50.0	0.0	100	0.0	50.0	50.0	0.0	0.0	100	0.0	50.0	50.0	0.0

*Interm=intermediate.

4. Conclusion

Better understanding of farmers' preferences and factors determining the adoption of new cassava varieties would allow a better implementation of policies for variety selection and diffusion to meet farmers and other end-users' expectations. This study revealed that introduced cassava varieties possess traditional desirable traits (yield potential, disease resistance, early maturity) but are not meeting local (regional) farmers' preferences for leaf production, tuber bitterness, in-soil storage, tuber color, etc. which are, however, among the major criteria for cassava variety adoption in rural areas of South-Kivu. This study showed that to increase the adoption rate of improved cassava varieties in Kabare Territory, it would be advisable for extension services to intensify the promotion of new varieties so that their characteristics might be better known; ensure the availability of planting materials; initiate a participatory plant breeding program that consider regional farmers' preferences during variety development scheme; and to encourage actions of intervening actors in agricultural credit. The use of DNA fingerprinting, in addition to morphological descriptors, is to be encouraged in the future for improving the accuracy in the varietal identification in farmers' fields and the estimation of the adoption status in Kabare Territory.

Acknowledgments

Financial support received from Pains pour le Monde-Service protestant de développement through DIOBASS-Kivu Platform and UEA is gratefully acknowledged. Authors are thankful to farmers who provided data used in this study.

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Résumé (French) Le manioc joue un rôle majeur dans la sécurité alimentaire et financière des ménages en République Démocratique du Congo (RDC). En dépit de multiples efforts pour contrôler la baisse de rendement en culture du manioc par la promotion de bonnes technologies agricoles, leur adoption par les agriculteurs est restée faible à l'est de la RDC. Cette étude visait ainsi à identifier les déterminants de l'adoption et les préférences des agriculteurs pour les caractères variétaux de manioc dans le territoire de Kabare, à l'est de la RDC. Une approche participative a été utilisée lors de la collecte des données auprès de 250 petits exploitants cultivant le manioc dans cinq zones différentes appelées groupements. Il s'agissait de groupements de Cirunga, Kagabi, Bugorhe, Katana et Mumosho. Les résultats ont montré que les variétés améliorées de manioc sont adoptées par 28,8% des petits exploitants. L'adhésion à une coopérative agricole, l'accès aux boutures comme crédit, le niveau d'éducation, le genre et le système de culture ont eu une influence positive sur l'adoption des variétés améliorées tandis que la distance entre le champ et la maison d'habitation, la zone de production et la superficie totale détenue par le ménage ont eu un impact négatif sur l'adoption. Cette étude a démontré que les variétés introduites possèdent la plupart des caractéristiques traditionnelles (rendement élevé, bon goût, résistance aux maladies et la maturité précoce) mais manquent des caractéristiques préférées localement comme la production de feuilles, l'aptitude au stockage des tubercules dans le sol, l'amertume et la couleur des tubercules, qui par conséquent, limitent l'adoption des variétés améliorées et favorisent la dépendance des agriculteurs aux variétés locales (88%). Ainsi, en plus de contrôler les facteurs interférant négativement avec l'adoption des variétés améliorées de manioc, une attention particulière devrait être accordée par les améliorateurs aux caractéristiques variétales préférées localement à chaque fois que l'on souhaiterait accroitre le taux d'adoption des variétés par les agriculteurs à l'est de la RDC.

Mots clés: *Variétés améliorées, variétés locales, stratégies de diffusion, petits exploitants, Sud-Kivu*