African Crop Science Journal, Vol. 32, No. 3, pp. 279 - 289
© 2024, African Crop Science Society
pISSN 1021-9730/2024
eISSN 2072-6589/2024

DOI: https://dx.doi.org/10.4314/acsj.v32i3.7

FACTORS INFLUENCING FARMERS' CHOICE OF POTATO VARIETIES TO GROW IN SOUTH-WESTERN UGANDA

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(*Received 18 April 2024; accepted 30 August 2024*)

ABSTRACT

The demand for potato (*Solanum tuberosum* L.) and its products is rapidly expanding in sub-Saharan Africa (SSA), owing to the unequivocal rise in human population largely through urbanisation. This study aimed at investigating the extent to which varietal and seed-system-based attributes influence the farmers' choice of potato varieties to grow in Uganda. Data were collected from 147 purposely, potato-growing households in south-western Uganda. Varietal attributes, such as resistance to bacterial wilt, thick tuber skin texture, high dry matter content, and yield, significantly influenced the farmers' choice of potato varieties. Thick tuber skin texture influenced varietal change positively, by 18% points. For the seed system-based attributes, distance to the seed sources, and long-term cultivation of a variety, negatively influenced potato varietal choices by 1.4 and 1.2%, respectively. It is concluded that varietal and seed system-based attributes influence potato varietal choice in south-western Uganda; although for farmers to change from one variety to another, the distance to seed sources should be minimal.

Key Words: *Solanum tuberosum*, tuber skin texture

RÉSUMÉ

La demande de pomme de terre (*Solanum tuberosum* L.) et de ses produits est en pleine expansion en Afrique subsaharienne (ASS), en raison de l'augmentation sans équivoque de la population humaine, en grande partie causé par l'urbanisation. Cette étude visait à déterminer dans quelle mesure les attributs variétaux et semenciers influencent le choix des variétés de pommes de terre à cultiver en Ouganda. Les données ont été collectées auprès de 147 ménages producteurs volontaires de pommes de terre dans le Sud-Ouest de l'Ouganda. Les attributs variétaux, tels que la résistance au flétrissement bactérien, la texture épaisse de la peau du tubercule, la teneur élevée en matière sèche et le rendement, ont significativement influencé le choix des variétés de pommes de terre par les agriculteurs. La texture épaisse de la peau du tubercule a influencé positivement le changement variétal, de 18 points de

pourcentage. Pour les attributs basés sur le système semencier, la distance par rapport aux sources de semences et la culture à long terme d'une variété ont influencé négativement les choix variétaux de pommes de terre de 1,4 et 1,2 %, respectivement. Il est conclu que les attributs variétaux et semenciers influencent le choix variétal de pommes de terre dans le Sud-Ouest de l'Ouganda ; Bien que pour que les agriculteurs puissent passer d'une variété à une autre, la distance par rapport aux sources de semences doit être minimale.

Mots Clés: *Solanum tuberosum*, texture de la peau du tubercule

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a premier crop grown, especially in the highlands of south-western and eastern Uganda. Its consumption in the country and elsewhere in the region is surging, owing to the rapidly bulging human population and expanding urbanisation (Witte, 2013). In 2009, the total amount of potato produced in Uganda was 154,435 metric tonnes from a total area of 32,759 hectares; which translates into 87.6% of the tubers from 79.7% from the south-western part of the country (UBOS, 2010). This implies a productivity rate of 5.2 metric tonnes of potato per hectare, from this part of Uganda.

It is, however, apparent that the increase in potato production is almost entirely due to expansion in cultivated areas rather than increase in productivity intensification. Gildemacher *et al*. (2009) concluded that a further increase in potato production in Africa through increasing land under cultivation will become severely constrained by population pressure. Thus, the most feasible manner in which the growing demand for potatoes could be satisfied is through increased productivity; i.e., tuber yield per hectare.

Several disease-resistant, early maturing, and high-yielding potato varieties have been released by breeders in recent times in Uganda, with a reported adoption rate of 77% (Kaguongo *et al*. (2008). The other possible cause of the yield gap is inability of farmers to replace older potato varieties with new improved varieties. Past research suggests lack of a scheme to replace old materials with new superior ones, which tends to stagnate the returns of the production system to genetic improvement (Brennan and Byerlee, 1991). Simply put, the permanency of first-generation improved varieties in farmers' fields will lead to declining productivity because of the emergence and evolution of new disease and pest pressures; thus necessitating new release of varieties in crop improvement.

Most studies on the effectiveness of crop improvement research in Sub-Saharan Africa have focused more on assessing the level of adoption of improved cultivars and their impacts (Walker *et al*.,2014). However, the level of adoption tells only part of the story of crop improvements which is adoption, leaving out choice and varietal change (Walker *et al*., 2014). The objective of this study was to interrogate varietal and seed system-based attributes that influence the farmers' choice of potato varieties in south-western Uganda.

MATERIALS AND METHODS

Study area. The study was conducted in two main potato-producing districts; namely Kabale and Kisoro; located in the South-western Highland Agro-ecological Zone (SWHAEZ) of Uganda. Both sites are mostly made up of highlands, at altitudes ranging from 1867 to 1929 meters above sea level. Kisoro lies at -1.21 latitude and 29.75 longitude; while Kabale lies at -1.33 and 29.87 longitude. Kisoro lies at altitude 2150.18 meters above sea level (masl); while Kabale district is at 2156.6 masl. Prevailing temperatures are generally low,

ranging from 26 - 28 °C. Mean annual rainfall is 1171.1 and 932.9 mm for Kisoro and Kabale districts, respectively.

Regarding potato production, Kisoro district is the leading producer, with 138,000 metric tonnes from 3000 hectares. On the other hand, Kabale district produces up to 61,000 metric tonnes from a land area of 9,000 hectares (UBOS, 2010).

Respondent sample selection. A random sample of 10 households was selected from each village, making a total of 200 households. The respondents were purposefully selected from two districts because they were among the leading potato producing administrative areas in the country. Two sub-counties were also purposively selected from each district, based on the volumes of potatoes produced and farmers producing potatoes (UBOS, 2010; Mbowa and Mwesigye, 2016). From each sub-county, five villages were randomly selected, and a list of all households growing potatoes was generated by simple random sampling.

Data collection. Cross-sectional data were collected using a semi-structured questionnaire, administered to the sampled household heads. Data were collected using survey solutions supported by computer-assisted personal interviews (CAPI). The survey tool had four key modules; namely, (i) socio-economics (age, sex, education, household size, gender, and experience); (ii) farm (seed system) characteristics (distance to the seed source, access to credit, access to agricultural information, membership in a farmer group, ownership of farm assets and access to extension); (iii) potato varieties cultivated during 2015 - 2016; and (iv) potato varietal attributes. The data were collected at household and plot levels; the latter the size of which was an average of 0.2 hectares grown with potatoes.

Some farmers had more than one plot, but mostly with the same potato varieties; however, for this study, all plots with the same potato variety were lumped up into one and the land area was estimated in hectares. It was rare for farmers to plant multiple varieties in the study districts; henceforth, the latter group of farmers was excluded from data analysis.

For yield, a yield track record book was left with the farmer at the time of data collection; and this was collected at harvest time. The summary descriptives of the variables used in this study are illustrated in Table 1.

Empirical model. To determine the drivers of farmer choice of potato varieties, a multinomial Probit (MNP) model was estimated. The model was preferred because it permits the analysis of decisions across more than two categories, in the dependent variable with the probability of selecting a given variety dependent on a set of farmer and variety attributes. In addition, since the probability of choosing one potato variety is not independent of the choice of another variety, the independence of irrelevant alternatives (IIA) cannot hold.

The multinomial Probit model, which is a natural alternative model that relaxes the independence restrictions built into the multinomial logit (MNL) model, was also estimated (Greene, 2012) and used in the present study. The dependent variable is categorical, taking on three outcomes representing three alternative options for a farmer to choose either one, two, or all but planted in different plots: $Y \in \{1, 2, 3\}$.

$$Y_{ph} = \begin{cases} 1 \text{ is farmer choice to plant variety denoted by 1} \\ 2 \text{ is farmer choice to plant variety denoted by 2} \\ 3 \text{ is farmer choice to plant variety denoted by 3} \end{cases}$$

Where:

Y is the variety choice which takes on three outcomes planted on plot p by household h in each season.

TABLE 1. Summary statistics of variables for assessing varietal choice and change

Variable	Description	P/M
Kinigi variety	Is equal to one (1) if a farmer planted Kinigi, and zero (0) Otherwise	68
Rwangume	Is equal to one if a farmer planted Rwangume and zero (0) Otherwise	48
Other[1]	Is equal to one if a farmer planted another variety, and zero (0) otherwise	31
Variety change	Is equal to one (1) if a farmer changed variety, and zero (0) otherwise	85
Access to credit	Is equal to one (1) if a farmer accessed credit and zero (0) otherwise	86
Access to extension	Is equal to one (1) if a farmer received extension info and zero (0) otherwise	77
House household head is married	Is equal to one (1) if the couple in the household is married and zero (0) otherwise	89
House head sex	Is equal to one (1) if the household head is a male, and zero (0) otherwise	86
The educational level of the household head	Is equal to one (1) if the household head acquired Primary level & above, and zero (0) if he/ she acquired no formal education	76
Household house type	Is equal to one (1) and temporary if the house is made up of mud and wattle; zero (0)& permanent if the house is made up of bricks and cement	36
Seed source	Is equal to one (1) if the farmer used accredited sources like NARO, UNSPPA & NAADS, and zero (0) from their farm harvest	88
Land tenancy type	Is equal to one (1) when one used their land and zero (0) otherwise (rent)	81
Soil type	Is equal to one (1) if the farmers' plot had Loam soil type and zero (0) otherwise (sandy clay loam)	98
Tuber skin texture	Is equal to one (1) if the skin texture is rough/ hard/thick and zero (0) otherwise	88
Cooked food nature	Is equal to one (1) if the cooked food is firm &chips crispy and zero otherwise (mealy floury)	59
Household size	Number of people living in the household	5.1
Household headage	Average age of the household head (years)	43
Seed source distance	Distance to the seed source (Km)	3.9
Experience	Duration for which the farmer has grown/ known a variety (years)	9.6
Resistance to bacterial wilt	Is equal to one if the variety is reported to be resistant to bacterial wilt, and zero (0) otherwise.	13
The maturity period of the variety	Is equal to one if the variety is reported to be Early maturing and zero (0) otherwise	27
Varietal market	Is equal to one (1) if the variety is reported to be marketable and zero (0)	93

Other[1]: Victoria, Nakpot 2& 5, Kachpot 1,2 &5, Rutuku, Cruza, Mbumbamagara, Rwashaki, Kimuri

The estimated model for drivers of farmer choice of potato varieties is represented by Equation:

$$Y_{ph} = \alpha_{ph} + \beta A_{ph} + \gamma_{ph} + \partial M_{ph} + \rho D_{ph} + \varepsilon_{ph}$$

..... Equation 1

Where:

p and *h* denote plot and household, respectively; *Y* represents one of the three outcomes, namely, (i) a farmer planted or chose the variety Kinigi, (ii) a farmer planted or chose the variety Rwangume, and (iii) a farmer planted or chose the other varieties other than Kinigi and Rwangume; and *A* is a vector of varietal attributes which include early maturity, high yields, resistance to bacterial wilt, marketability and dry matter content.

F is a vector of farm-level and institutional variables, including distance to access to extension services, access to credit, seed source, and distance to seed source; *M* is a vector of household attributes, inclusive of age, gender, education, marital status, and experience of household head in potato production as well as type of dwelling. *D* is a vector of district-level fixed effects; and, α and ε are constant and error terms, respectively; while β, γ, ∂ and ρ are [kx1] vectors of parameter estimates associated with the respective independent variables.

A Probit model was estimated to determine the drivers of farmers' decisions to change potato varieties planted in the first and second seasons in Kisoro and Kabale districts. The model was estimated using variables in Equation 1, with dependent variable Y taking a value of "1" if the farmer changed the potato variety and zero otherwise.

RESULTS

Major potato varieties grown. The commonest potato varieties grown in the study districts included those identified as local and improved (Table 2). Of all these, varieties Kinigi and Rwangume were associated with a commercial value, while NAROPOT 4 (Rwangume), NAROPOT 3, NAROPOT 2, NAROPOT 1, KACHPOT 3, KACHPOT 2, and KACHPOT 1 were preferred for household consumption. Varieties Kinigi, KACHPOT 1 NAKPOT 1, and NAROPOT 4 are high yielding, early maturing, and resistant to several major potato diseases.

Socioeconomic characteristics. The main socioeconomic characteristics that influenced the potato farmers' decisions to change to growing another variety in the subsequent seasons included, in their descending order, household size, education level and house owned by a household (Table 3). The farmers fell into two categories; those who retained

TABLE 2. Levels of local and improved potato varieties grown in seasons 2015B and 2016A in the southwestern highland agro-ecological zone of Uganda

Variety name	Variety level (2015B) (%)	Variety level (2016A) (%)	Level of change (%)
Kinigi	50.30	45.6	-4.70
Rwangume	34.20	31.6	-2.70
Other[1]	15.50	22.8	7.30
Total	100.00	100.0	

Other[1]: Victoria, Nakpot 2 and 5, Kachpot 1,2 and 5, Rutuku, Cruza, Mbumbamagara, Rwashaki, Kimuri

TABLE 3. Characteristics of sampled households based on variety change extent

Variables	Variety retainers (66%)	Variety changers (34%)	
	Mean/proportion	Mean/proportion	Difference
Credit access	0.53	0.60	0.07
Access to extension services	0.51	0.52	0.01
Being married	0.92	0.89	-0.03
Education level household head	0.59	0.47	-0.12*
Household house type	0.33	0.19	-0.14*
Land tenancy type	0.86	0.79	-0.07
Household size	6.33	5.03	-1.30*
Household head age	43.90	42.40	-1.50
Seed source distance	3.20	4.20	1.00

the potato variety grown in 2015B (Retainers) and those who changed the variety in 2016A (Changers). Household socio-economic attributes were cross-cutting for all respondent households, except household size, nature of the household house, and education levels of the household heads. The average household size was six and five, among retainers and changers, respectively ($P < 5\%$).

The proportion of temporary household dwellers who retained the potato varieties was 33%, compared to 19% for those who changed ($P < 5\%$). The proportion of household heads with formal education who retained varieties was 59%; compared to 47% for those who changed.

The subsequently results revealed that in the short rainy season, 66% of the farmers cultivated the varieties they grew in the previous long rainy season; while the other 34% changed or did not retain the variety they grew in the next rainy season. Interestingly, farmers who cultivated varieties Victoria and Nakpot5 in the long rainy season did not cultivate Victoria in the short rainy season (Fig. 1).

The results showed that the yields for the two most adopted varieties (Kinigi and Rwangume) were 11 and 9 metric tonnes per hectare, respectively; while the mean yield for other varieties was a peltry 4 t per hectare (Table 4). Results from the t-test of unequal variances indicated the presence of evidence ($P<0.5$) in the next cropping system that the yields of two main adopted varieties were different from other varieties (Table 4), but no significant evidence ($P>0.05$) existed to suggest that Kinigi and Rwangume varieties yield differently at farmer level.

Potato varietal attributes. Varietal attributes that significantly influenced the potato farmer's decision to switch from one variety to another across seasons included, in descending order, tuber skin texture, dry matter content, and resistance to bacterial wilt (Table 5). Hard tuber skin texture increased the likelihood for a farmer to change to another potato variety grown by 18.2% (Table 6). This was irrespective of tuber size and shape.

Seed-based system attributes. The key seed-based system attributes that influenced the potato farmers' decision to change from growing one variety to another included, in descending order; experience in terms of cultivating the same variety for more than 7 years; and distance to seed source (Table 6). Distance to the seed source was likely to reduce the farmers' ability to change varieties

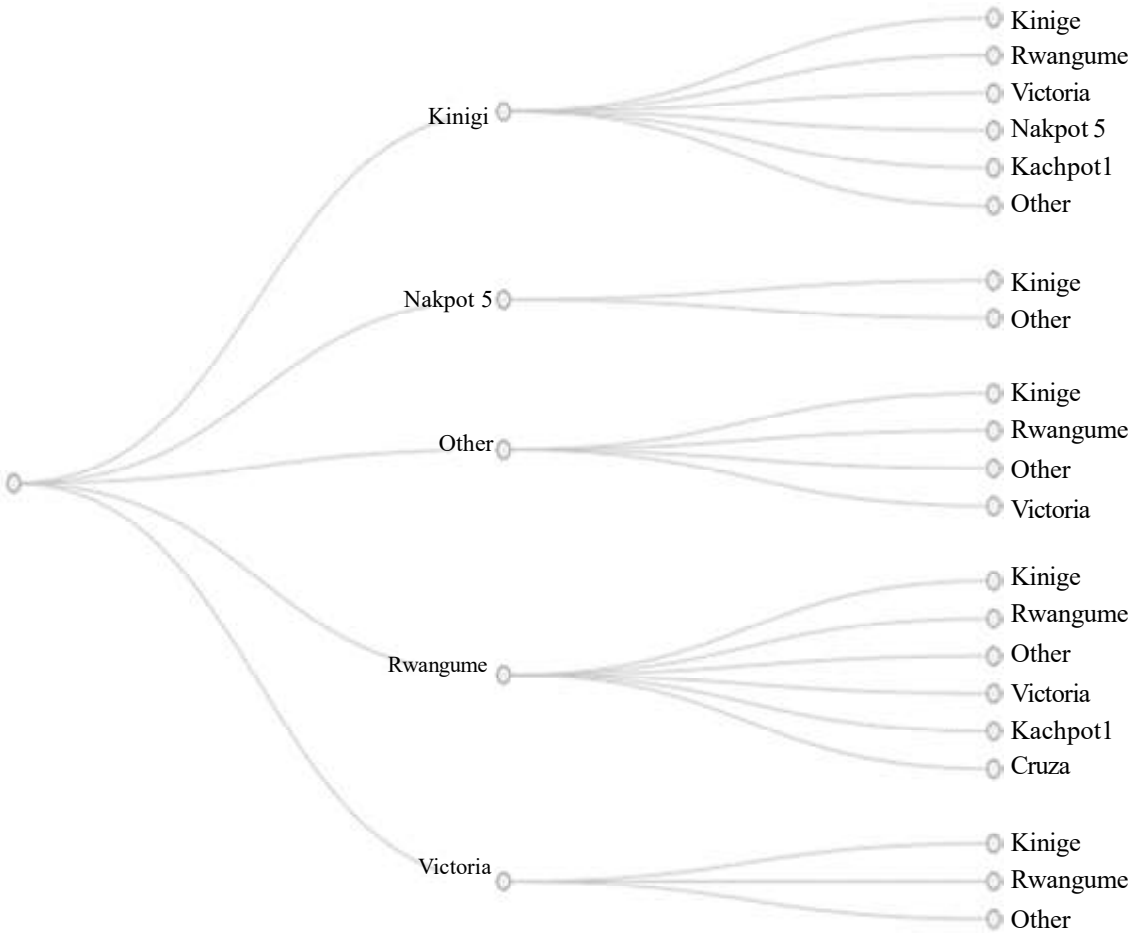

Figure 1. Dendrograms showing varietal change between two seasons: 2015B and 2016A.

TABLE 4. Difference in yields of potato varieties grown in farmer fields in 2015A and 2016B seasons

Purity threshold: 95%	Difference
Kinigi variety - Rwangume variety	810
Kinigi variety - Other varieties	2471***
Rwangume Variety- Other varieties	1661*

Here, the P values are * P<0.05, ** P<0.01, *** based on the t test of unequal variances

TABLE 5. Determinants of farmer choice of potato varieties in the Southwestern highland agro-ecological zone of Uganda

Variables	Marginal effects (Kinigi choice)	Marginal effects (Rwangume)	Marginal effects (Other choice)
Gender	0.522*(0.25)	-0.426**(0.23)	-0.095(0.23)
Household size	-0.034*(0.01)	0.021** (0.016)	0.024*(0.016)
Resistance to bacterial wilt	0.336**(0.135)	-0.438** (0.127)	0.075 (0.111)
Early maturing	-0.057(0.099)	0.109 (0.070)	-0.039 (0.089)
Market availability	-0.021(0.081)	-0.057(0.075)	0.085 (0.073)
Seed source distance	-0.009*(0.004)	-0.000 (0.003)	0.005 (0.003)
Credit access	0.053(0.0076)	0.080 (0.063)	-0.096 (0.064)
Access to extension	0.253(0.075)	0.020 (0.066)	-0.071 (0.068)
Marital status dummy	0.670***(0.143)	-0.619**(0.113)	0.039 (0.119)
Education level of household head	0.015(0.074)	-0.009 (0.067)	0.016 (0.063)
Household house type	0.172*(0.090)	-0.082 (0.079)	-0.114* (0.083)
Household head age	0.038**(0.020)	-0.023* (0.016)	-0.018 (0.019)
Household head age^2	0.000(0.000)	0.0001* (0.000)	0.000 (0.000)
Experience	0.005(0.006)	0.001 (0.004)	-0.006 (0.004)
Soil type	0.134**(0.076)	-0.031 (0.064)	-0.112* (0.064)
Seed source	0.002(0.013)	0.112 (0.072)	-0.012 (0.072)
Plot yields	0.002*(0.001)	-0.001 (0.000)	0.000* (0.000)
Tuber skin texture	0.122(0.075)	-0.134* (0.058)	-0.003 (0.065)
Dry matter content	0.245***(0.652)	-0.325* (0.056)	0.094 (0.057)
Kisoro			
Constant			
N			147
Wald Chi^2(36)			126.65
Prob > chi			0.000

t-statistics in Parentheses and the P values are *P<0.05, **P<0.01, ***P<0.001

by 1.4%. In addition, farmers who cultivated the same variety for a long time were also less likely to change potato varieties by 1.2%.

DISCUSSION

Socioeconomic characteristics. The effect of marital status on the decision to change between varieties cultivated (Table 5) is believed to be a reflection of economic status, as married farmers easily adopt improved technologies because they can afford them (Ogunlana, 2004; Deressa *et al*., 2008; Abebe *et al*., 2013). On the other hand, the significant effect of household age on farmers' choice between potato varieties across rainy seasons (Table 5), is attributed to the belief that age is a proxy for experience and level of knowledge of agricultural technologies (Matuschke and Qaim, 2009).

Kinigi potato variety was considered to be more productive than its counterpart, Rwangume variety. On the other hand, Kinigi variety was chosen by a majority of households probably because they had low family sizes, permanent dwellings, and had better soils, all factors known to be reflective of poverty status and household living conditions (Fiadzo *et al.*, 2014). Different empirical studies have shown that household

TABLE 6. Driver of farmer decision to change potato varieties planted in the Southwestern highland agro-ecological zone of Uganda

Model	Probit with district-level fixed effects	Marginal effects
Variables	Probit coefficients	
Gender	0.820(0.63)	0.248(0.18)
Household size	0.080 (1.28)	0.025 (1.30)
Plot yield differences	0.005 (0.24)	0.002 (0.24)
Resistance to bacterial wilt	0.263 (0.58)	0.081 (0.59)
Early maturity	0.107 (0.36)	0.033 (0.36)
Marketability of the variety	0.083 (0.31)	0.025 (0.31)
Distance to seed source	-0.046* (-2.21)	-0.014* (-2.28)
Access to credit	-0.011 (-0.04)	-0.003 (-0.04)
Access to extension	0.260 (1.07)	0.080 (1.07)
Married household heads	0.504* (2.17)	0.456* (2.25)
Education level of household head	0.160 (0.67)	0.049 (0.68)
Household house type	0.437 (1.37)	0.134 (1.40)
Household head age	0.125* (2.39)	0.037* (2.46)
Household headage^2	-0.001* (-2.16)	-0.000* (-2.21)
Variety experience	-0.039* (-2.39)	-0.012* (-2.47)
Soil type	0.400 (1.55)	0.123 (-1.58)
Seed Source	0.082 (0.30)	0.025 (0.30)
Tuber skin texture	0.594* (2.40)	0.182* (-0.25)
Dry matter content	-0.003 (-0.01)	-0.000 (-0.01)
Kisoro	-0.004 (-0.02)	-0.324 (-0.86)
Constant	-4.891*** (-3.86)	-0.001 (-0.02)
N		147
Wald chi^2(16)		42.46
Prob > chi^2		0.0015
Pseudo R^2		0.2028

t statistics in parentheses and the P values are * P<0.05, ** P<0.01, *** P<0.001

living standards or economic status have a significant impact on the adoption of better technologies. Hence, as improved varieties are generated to improve household livelihoods, there must be household economic status considerations to facilitate variety uptake by potato farmers in south-western Uganda.

Potato varietal attributes

Skin texture. Kinigi the preferred variety over Rwangume has thicker tuber skin texture than Rwangume. As stated earlier, thick potato tuber skin prevents pathogen invasion and fluid loss, thus providing a tuber with a natural defense mechanism against pathogen invasion (Barel and Ginzberg, 2008; Niederwieser, 2014). Moreover, the thick potato tuber skin enables the potato tuber to be kept for a longer shelf life without deteriorating and reduces the likelihood of the skin peeling off during transportation, which is an attribute that attracts farmers to take up choices, as well as improve their income status.

Dry matter content. Kinigi potato variety is also preferred over Rwangume because of its higher dry matter content. The high dry matter content on the other hand is linked to high net returns because 100 tubers of the variety with high dry matter content will weigh more than the 100 tubers of the variety with low dry matter content (Norell *et al*., 2016)). These attributes make Kinigi potato variety a more marketable and desirable variety compared to other varieties.

Resistance to diseases. The significance of varietal resistance to bacterial wilt as a factor in influencing the potato farmer's choice of alternative varieties across rainy seasons (Table 5), was attributed to the fact that the wilt is an endemic and catastrophic potato disease in Uganda, with no known efficacious intervention, once it strikes (Kaguongo *et al*., 2008). Of the most preferred potato varieties grown in south-western Uganda, the Kinigi variety was more resistant to bacterial wilt than Rwangume; the latter of which was rated susceptible. Resistance to bacterial wilt should, therefore, be an issue for consideration in programmes geared towards the promotion and breeding of potato varieties in south-western Uganda.

Seed-based system attributes. The main seed system-based attributes that drove varietal change include distance to the seed source and the years a farmer spent cultivating the variety (Table 6). Implicitly, reducing the distance to the seed market or source would increase the adoption of new varieties and specifically, switching between varieties grown across rainy seasons. This view conforms to an earlier report by Shiferaw *et al*. (2014); that the duration over which a farmer keep a variety makes them to get used to it, thus changing to cultivation of alternative potato varieties becomes difficult, unless the new seed (variety) is readily available and has special varietal attributes.

CONCLUSION

The attributes that drive varietal choice by potato farmers in south-western Uganda, accross rainy seasons are household size, household head education level, nature of the house, tuber skin texture and dry matter content, varietal resistance to diseases, distance to the seed source, and years spent by a farmer cultivating a given variety. Bacterial wilt is a major factor influencing the choice of alternative varieties across rainy seasons because the wilt is endemic and catastrophic potato disease in Uganda, with no documented efficacious intervention. Kinigi variety was more resistant to bacterial wilt, and Rwangume variety was rated the most susceptible to the disease.

ACKNOWLEDGMENT

This study was funded by the Kachwekano Zonal Agricultural and Development Institute (KAZARDI) of the National Agricultural Research Organisation (NARO), Uganda. We also thank the Standing Panel for the Impact Assessment of the Consultative Group on International Agricultural Research (CGIAR) for the technical support.

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