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Barriers and enablers of crop varietal replacement and adoption among smallholder farmers as influenced by gender: the case of sweetpotato in Katakwi district, Uganda

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Sweetpotato is climate smart crop, grown with limited external inputs (fertilisers, pesticides, less labour) making it an attractive crop for resource-constrained smallholder farmers. It is also a major cash and food crop for many countries in sub-Saharan Africa. However, adoption of the high yielding and nutritious improved varieties has been disappointingly low. This study uses qualitative methods to explore the barriers and enablers of farmer varietal replacement and adoption. Unlike the extant quantitative studies that identify the determinants of adoption, we delve deeper into understanding the reasons for or against the preference for specific varieties. We used a rich set of information collected via focus group discussions which explore *why* farmers prefer certain varieties over others and *how* they perceive the new improved varieties from the national breeding programs. Doing so enabled us to unravel specific traits or trait combinations that farmers seek and identify those that they perceive needing improvement. We find that the most preferred traits were 'yield' and 'good taste'. Implying that the neglect of sensory attributes by breeders contributes to the low adoption of improved sweetpotato varieties. Moreover, we find that altruism among the respondents plays an important role in farmer use of, and sharing of information about improved sweetpotato varieties. Women and men farmers obtained most of their information from neighbours, NGOs and radios. For women, the most important source of planting materials doubled as their most important source of information. Thus, concerted efforts to minimise information constraints are essential for unravelling the adoption puzzle.

KEYWORDS

sweetpotato, improved varieties, varietal replacement, enablers and barriers, sexdisaggregated data, Uganda

Introduction

Uganda used to be the second highest sweetpotato producer in Africa with the total production of 1.7 million tonnes (FAO Statistics, 2004) before it dropped to the current fifth position (Tavva and Nedunchezhiyan, 2012). Moreover, the total national production and yield have reduced by 23 and 7%, respectively, in the last decade (FAOSTAT, 2021). Despite the reduced production, sweetpotato remains an important crop in Uganda. It is the third leading staple in the country after banana and cassava (Mwanga et al., 2021a,b) with an estimated *per capita* consumption of 95 kg/year (Abong et al., 2016). The Eastern region is the highest producer of sweetpotato in Uganda (Uganda Bureau of Statistics, 2020) despite being drought prone. The crop is grown mainly by women who are responsible for sourcing seed and replacing varieties (McEwan, 2016). Sweetpotato is grown for multiple uses in the region namely: food, feed and fuel. The sweetpotato storage roots are mostly consumed in the boiled form, or freshly roasted popularly known as *amukaru*. The fresh roots are also chipped or flaked and dried to make more shelf-stable products namely, *amukeke* and *inginyo*. Leaves are also consumed as vegetable relish while small non-marketable roots, vines and peels are used as animal feed. Recently the practice of making briquettes from sweetpotato residues has emerged among communities as another utilization form (Odikor, 2019; Bot et al., 2022). The crop is also grown for income generation in majority of the households.

Most improved varieties are not only high yielding but also early maturing providing food three months after planting, thus playing a crucial role of bridging the hunger gap and thus addressing food insecurity (Ssemakula et al., 2013). This endears the crop to women given their role of food provision in the household. Women thus dominate sweetpotato production comprising over 60% of sweetpotato farmers in Uganda (Polar et al., 2022). They are responsible for seed sourcing, selection and conservation and, inherently, identification of new varieties with good culinary properties; usually through informal and closed networks due to their immobility (McEwan et al., 2023). These local networks play an important role in commercial seed exchange and diffusion especially in arid and semi-arid areas (Rachkara et al., 2017). Women also usually decide which varieties are best suited for food and the market (Mudege et al., 2016).

Many people are currently employed within the sweetpotato value chain as farmers, traders and processors. Sweetpotato is also climate smart and can be grown with limited external inputs (fertilisers, pesticides, less labour) making it an attractive crop for smallholder resource-constrained farmers. It is specifically suited to marginal areas yielding comparatively better than other crops (Bashaasha et al., 1995). Due to its short maturity period, sweetpotato also serves as emergency/disaster response crop (Heck et al., 2020). However, given the bulkiness of the crop's planting material, coupled with women's immobility (due to time poverty, limited access to transportation and low agency) the varietal replacement is low (Heck et al., 2020). Ultimately, this results in delayed planting and low yields. This is further exacerbated by limited access by women to agricultural resources, knowledge and technologies. Zawedde et al. (2014) cited strong preference for local land races as another reason for low varietal replacement. Access (i.e., availability and cost) to improved[1] planting material was also reported as a major production constraint (Zawedde et al., 2014). Consequently, most farmers continue to grow local low performing cultivars and recycle poor-quality planting material.

The negative trend in total production has remained despite long-term breeding efforts to develop high yielding, stress tolerant, and nutrient-rich varieties (Mwanga and Ssemakula, 2011). For instance, improved varieties such as NASPOT 8, an orange fleshed variety biofortified with provitamin A, and NAROSPOT 1 (white fleshed) have potential productivity of 33 and 35 MT/ha, respectively (Mwanga et al., 2009) but with reported actual yields of 4.4 t/ha at the national level (Loebenstein et al., 2003; Magunda, 2020). Furthermore, these varieties are not widely grown by farmers (Barker et al., 2009; McEwan et al., 2022). Past studies have sought to address farmers' low uptake of improved varieties. For example, Mwanga et al. (2021a,b) assessed men and women's trait preferences in the value chain to develop gender responsive varieties in Uganda. Mashonganyika (2018) redesigned the breeding objectives to include perspectives from multi-functional teams including end users in Kenya. Thiele et al. (2021) urged for consideration of eating quality traits during variety selection in Ethiopia. Okello et al. (2022) gathered market intelligence from sweetpotato value chain to assess the priority trait packages of different actors in Uganda. Okello et al. (2023) tested the effectiveness of behavioural interventions in stimulating demand for improved sweetpotato varieties among smallholder farmers in Uganda and found that social incentive combined with goal setting had no significant effect on knowledge and experimentation by progressive farmers, and on willingness to pay for improved seed.

Existing research have shown that behavioural interventions (nudges) can be used to stimulate adoption of agricultural technologies especially where conventional extension approaches for technology diffusion strategies have failed to work (Ben Yishay and Mobarak, 2019; Shikuku, 2019; Balew et al., 2022). The development of a behavioural intervention to incentivise farmers to regularly replace planting materials and use good agronomic practices is intended to induce adoption of improved technologies (Ben Yishay and Mobarak, 2019). While these past nudge studies have demonstrated that social incentives can increase adoption of improved varieties, Okello et al. (2023) find the converse. Rather than increasing demand for improved varieties, social incentive nudges acted to reduce it. This study interrogates the findings of Okello et al. (2023) using qualitative data collected from the same farmers. It specifically attempts to understand the barriers and enablers of variety replacement among smallholder men and women sweetpotato farmers and gives suggestions for improvement in the existing varieties. The study focuses on two objectives, namely it:

i Explores how farmers' tastes and preferences influence varietal preferences, and hence adoption and replacement.
ii Examines constraints to adoption of existing improved and local sweetpotato varieties.

Varietal replacement is the rate at which farmers replace older varieties with newer improved varieties that have been bred for better performance, and it is considered critical for farmers to achieve sustained yield gains (Spielman and Smale, 2017). Several other factors affect yield, including soil fertility and crop management practices (Adeola et al., 2019).

Improved sweetpotato varieties (ISVs) are developed to boost yields, overcome biotic and abiotic stresses that limit productivity.

1 Improved means planting material that is free from pests (sweetpotato weevils) and diseases (SPVD and Alternaria blight).

They (ISVs) are bred to address nutritional deficiencies and meet sensory acceptance (Low et al., 2017; Danso-Abbeam et al., 2022). Farmers adopt ISVs if their expected utility, through yield and other benefits, is greater than that of local varieties (Adeola et al., 2019). The adoption of improved sweetpotato varieties and varietal replacement is therefore a function of different socio-economic, institutional, and environmental factors (Adeola et al., 2019). Further, farmers replace older varieties when the genetics of the newer ones improves their utility, in function of the same factors (Spielman and Smale, 2017).

In the initial phases of agricultural intensification, there is no market for improved varieties of vegetatively propagated crops, requiring the public sector to develop them and produce the seed through parastatals (Low et al., 2017). However, once farmers start to adopt ISVs, creating a market for seed and other inputs, the private sector assumes a leading role because in principle it is more efficient in producing and disseminating the seed. As the seed sector's life cycle evolves, the private sector can take over the development of newer varieties (Mastenbroek et al., 2021).

Understanding the barriers and enablers of varietal replacement is important to plant breeders. It informs breeders about the success of their programs. It also enables researchers to better understand agricultural intensification and the development of the seed industry therein. Policy makers can, on the other hand, learn about the success of their policies. Finally, understanding the processes in the adoption of improved varieties and varietal replacement in sweetpotato is particularly important for food security in East and Southern Africa, where it is a very important food crop. The study hypothesises that varietal replacement would be increased by training (which provides information on agronomy and marketing) and the social incentive.

Materials and methods

Study purpose and scope

This study builds on an earlier research conducted in March to May 2022 by CIP and Katakwi District Production and Marketing Department (DPMD). The study tested the effectiveness of nudges on demand for improved sweetpotato varieties. The current study comprises of two parts. The first was a quantitative study to understand farmers' sources of agricultural information, the effect of knowledge of improved sweetpotato varieties, role of social networks in the diffusion of knowledge and improved varieties in the social network, and performance of the introduced varieties. The second part was a qualitative study that sought to understand the barriers and enablers of sweetpotato varietal replacement. This study focuses on the qualitative part which was implemented in November and December 2022, jointly by NARO, CIP and Katakwi DPMD.

Study location

This study was conducted in the Teso sub-region of eastern Uganda (1°55′10.0"N, 33°57′41.7"E). The region is characterised by two cropping seasons (April–June and July–November) which are followed by a long dry spell (December–March). During the dry spell, farmers lose most of the sweetpotato planting material to drought and grazing cattle. Consequently, during the first cropping season, farmers normally do not have planting material and have to wait for the residual roots to sprout to raise seed that is then planted in the second cropping season. These sprouts usually have accumulated viruses and weevils (Okello et al., 2023) and result in low yields and poor root quality.

The study covered all the three counties and 16 sub-counties of Katakwi district (Figure 1), which borders with the Karamoja region whose livelihood activity is cattle keeping. Accordingly, during the dry season herders graze their cattle in crop fields and destroy any remaining sweetpotato vines, including those planted in the lowlands to preserve planting material. This results in conflicts between herders and farmers. Additional conflicts are caused by frequent cattle raids by the Karamojong, which often result in displacement of farmers.

Data collection and analysis

This study used a series of focus group discussions (FGDs) accompanied with semi-structured interviews to collect data. A well-structured questionnaire in form of a checklist was developed interactively by the research team to guide the discussions. The main themes were, major varieties grown by farmers, trait preferences, seed sources; experience with introduced varieties; information and social networks and altruism. The FGDs were administered by a team of enumerators comprising three men and three women. The enumerators worked in pairs – one man and one woman. Prior to the actual data collection, the six enumerators were trained in qualitative methods of data collection. The guide was discussed and translated into local language. The guide was then pre-tested with sweetpotato farmers in a neighbouring district (i.e., Kapelebyong district), refined and finalised.

Farmers who participated in the first study by Okello et al. (2023) were traced and re-interviewed in mixed sex FGDs. Care was taken to ensure that both men and women were represented. In each of the FGDs, there was at least one farmer who bought the vines during the auction and therefore had grown improved sweetpotato varieties. In addition, a farmer who had been trained on sweetpotato agronomy (including importance of quality seed), marketing and seed quality maintenance [henceforth, referred to as the disseminating farmer (DF) participated in the FGD]. The DF had been linked to designated number of co-villagers and encouraged to share information obtained in the training about quality seed of ISV.

A total of 16 FGDs were conducted in 16 purposively selected villages / parishes. Eight of the selected villages had previously received nudges [i.e., the DF was promised a reward in form of public recognition (social incentive)] while the rest had not. In each of the selected villages, only the 11 farmers who participated in the first study were invited to take part in the FGD. Each FGD was moderated by two enumerators comprising a facilitator and note taker. Prior to commencement of the FGD's, each participant was verbally requested for their consent to take part in the study. FGDs were conducted in the local language and verbal and visual observations were noted by the lead researcher. The session proceedings were also audio recorded. Each session lasted approximately 2 h. After the session, data were transcribed, coded and analysed using Atlas.ti software (Muhr, 1993). Analysis of themes was used to analyse both interview and focus group data. Tables of results on numerical values were generated using

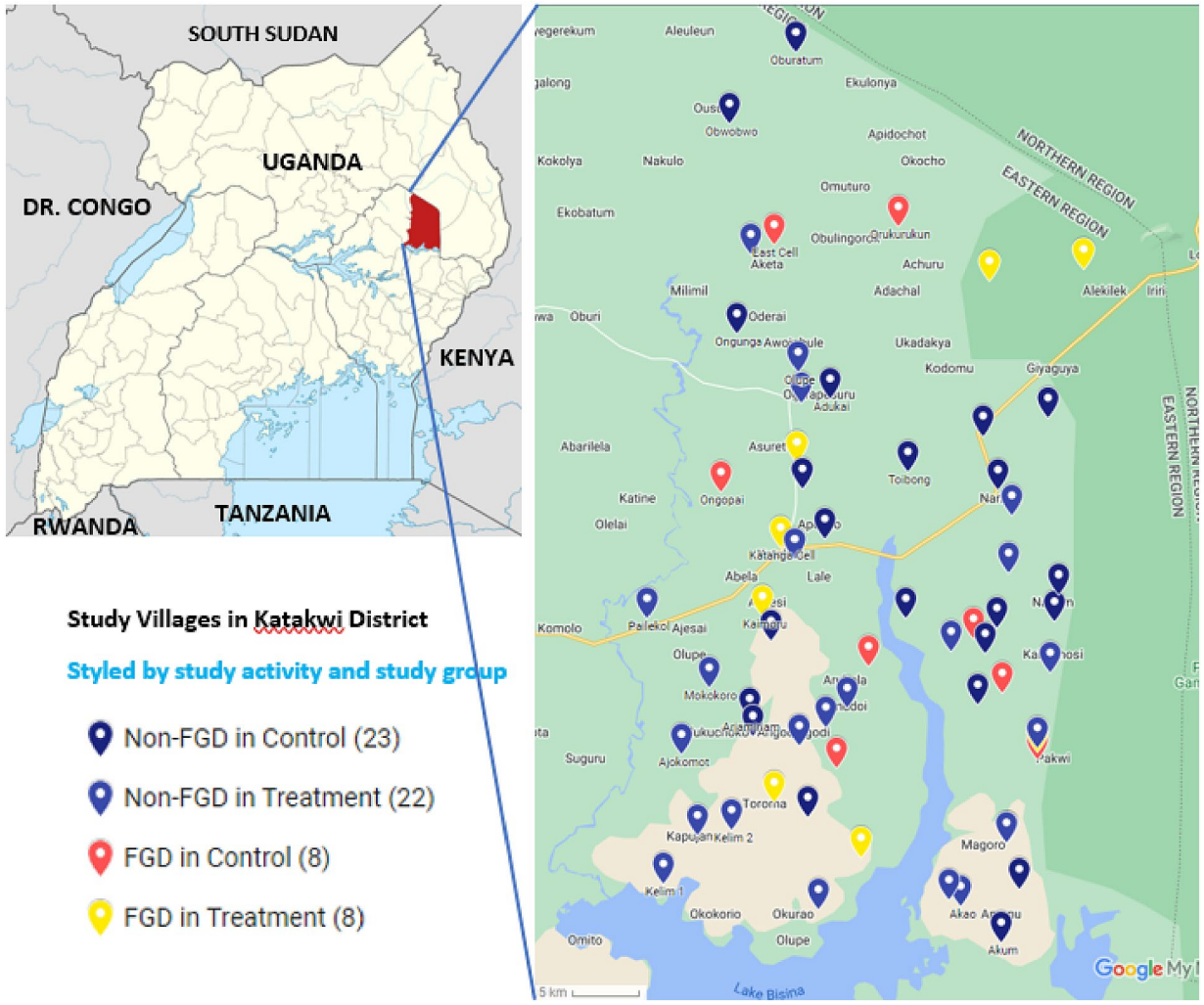

FIGURE 1
Map of Uganda showing the study area.

STATA and excel software. Representative quotes were extracted and used to back up some results.

Results and discussion

Characteristics of FGD participants

A total of 158 farmers (50.3% female and 49.7% male), participated in the FGDs (Table 1). Among the participants, 52% did not receive the nudges (control group), while 48% did (treatment group). The average age of participants was 41 years; there was no significant difference in age between the treatment and control group. Half of the participants (50%) were married and lived together with their spouses. The average education level of the participants was 5 years of schooling. Participants who received nudges had, on average, one more year of education than those who did not. The low levels of education have negative implications towards the understanding of new technology. This is in line with Oduro-Ofori et al. (2014) who found that as education level increases, output also increases. More than 80 and 90% of the participants in treatment and control groups, respectively, were engaged in farming as the main occupation.

Most planted sweetpotato varieties

Results show that the most planted varieties were local landraces (Figure 2). Among the farmers who participated in the FGDs, 28 mentioned *Iboii/Esapat*, a local landrace, as the most planted variety. This was followed by *Ekampala, Osukut* (Tanzania), then *Kakamega* and *Araka*, in that order. Among the varieties promoted under the first study, only *Ejumula* and *Osukut* (Tanzania) were mentioned, each by only two farmers. Results show that farmers consistently ranked *Iboii/Esapat*, *Osukut, Ekampala* and *Kakamega*, among the top five most commonly grown varieties, although the ranks assigned to each variety varied amongst FGD groups.

Participants also mentioned other landraces besides the top five varieties above. These included; *Ateseke, Epeet* and *Obongkwap*. These results, in general, underscore farmers' preference for the landraces to improved varieties. Clearly, *Iboii/Esapat* was the most widely grown

TABLE 1 Sociodemographic characteristics of FGD participants.

Individual and household characteristics	Total (*n* = 158)	Control (n = 82; 51.9%)	Treatment (*n* = 76; 48.1%)	*p*-value*
Gender of the respondent, (Male), *n* (%)	77 (49.7)	46 (58.5)	31 (42.1)	0.04
Farmer's age (years), mean (sd)	40.48 (17.30)	41.20 (19.25)	39.71 (15.02)	0.59
Farmer is married and live together with spouse (Yes), *n* (%)	85 (53.8)	49 (59.8)	36 (47.4)	0.12
Farming is the main occupation, (Yes), *n* (%)	145 (91.8)	78 (95.1)	67 (88.2)	0.11
Respondent's education(years), mean (sd)	5.36 (3.88)	4.96 (3.25)	5.79 (4.45)	0.18

Data source: Authors survey data (2022). *p-values are results of Student's t-test and Pearson's Chi-Square test for continuous and categorical variables, respectively.

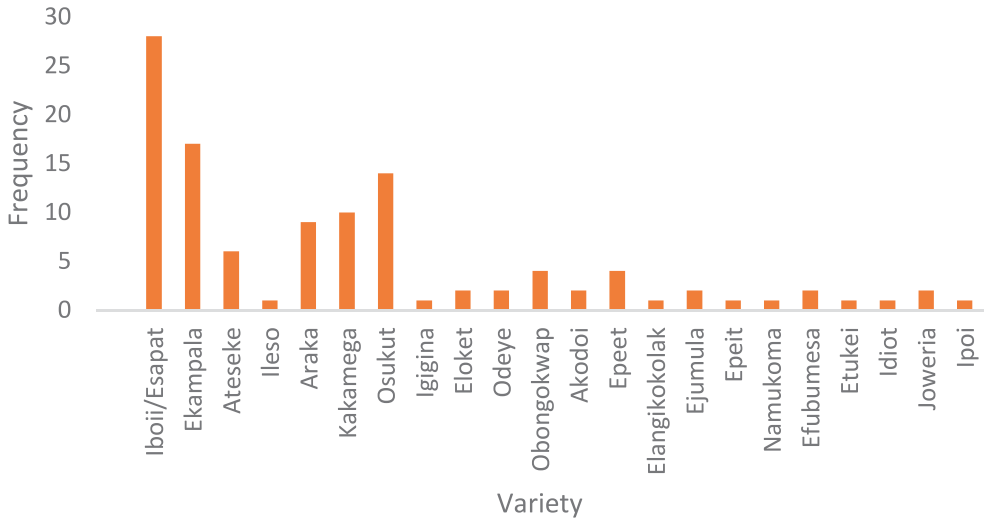

FIGURE 2
Most planted sweetpotato varieties by study participants (*n* = 155).

variety by the study participants. In most FGDs, for instance in *Adidit, Apeleun, Aterai*, and Angiriny villages, all the farmers reported growing the variety.

Altogether, participants identified more than 21 different varieties of sweetpotato that are maintained by the study communities. This finding is in line with previous studies which have indicated that a wide range of sweetpotato varieties are grown in Uganda (Zawedde et al., 2014; Yada et al., 2017; Okello et al., 2022).

Preferred traits/characteristics

Among the most preferred traits mentioned, 'yield' and 'good taste' were the leading as shown in Figure 3. It is interesting that participants emphasised the value of yield and taste because breeders have been focusing mainly on yield at the expense of eating quality traits such as good taste. Thiele et al. (2021) attributes the low adoption of improved sweetpotato varieties to the neglect of good eating qualities.

Figure 3 presents the most frequently mentioned characteristics of the top five varieties by the participants. Yield was most frequently cited for *Iboii* and *Ekampala* while good taste was mostly cited for *Iboii* and *Kakamega* as shown in the participants' sentments below. *Iboii* had a balanced combination of the traits farmers look for in a variety (i.e., high yielding, high dry matter content, pest and disease resistant, good sweet taste, good for processing, long ground storage, drought resistance, non-fibrousness, root size). Although listed among most preferred, *Kakamega* and *Araka* were not reported to have early maturity and weevil resistance characteristics, respectively.

> *'Iboii has good taste. When you cook amukeke and add peanut butter, it is really tasty'*. Female respondent, FGD Apeleun.

> *'It's amukeke has good taste when cooked, it is just as sweet as sugar'*. Male respondent, FGD Orukurukun village.

The early maturity trait is important for bridging the hunger gap following long drought periods, which characterise the Teso sub-region (International Organization for Migration, 2023). Preference for early maturity trait in varieties most liked by farmers is as elaborated below:

> *'Araka if you plant it this week, next week you will weed, a week later you find the heaps already have cracks. That is why it is called Araka, it saves you from hunger. It is early maturing'*. Male respondent, FGD Apeleun.

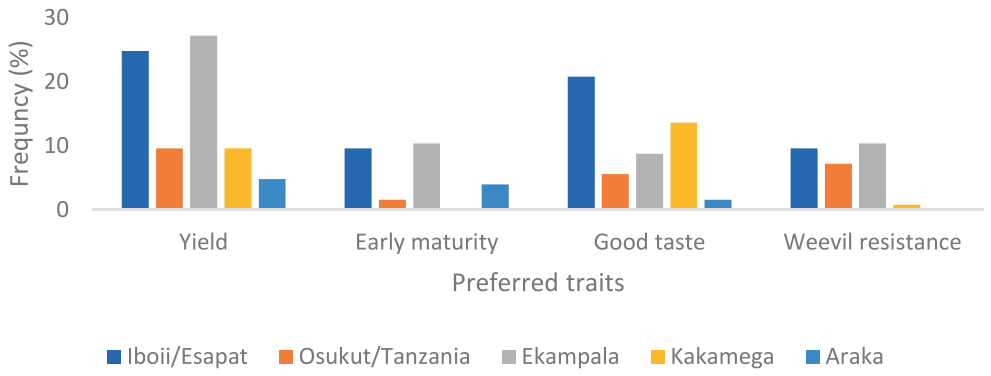

FIGURE 3
Preferred traits for the most frequently mentioned characteristics of the top five varieties of sweetpotato.

In fact the variety is named '*araka*' meaning "quick" alluding to how quickly it takes to mature.

> *'It is high yielding, you can get money from it and when you plant early people will keep coming to you to buy the roots'*. Female respondent, FGD Epaku village.

Ekampala was praised for its early maturity as elaborated below:

> '*What we like about Ekampala is that it is high yielding and early maturing and can relieve you from famine*'. Male respondent, FGD Abelan village.

Weevils are pests of major economic importance in the study area. For example, sweetpotato weevils can cause up to 100% yield loss, especially under dry conditions in susceptible varieties (Collins et al., 2019). With regards to weevil infestation, one respondent noted that:

> *'Iboii is resistant to sweetpotato weevils. Even when you slice the potatoes of Iboii* variety, *they are not easily attacked by weevils'*. Female respondent, FGD Abelan.

Osukut used to be the defining variety for the Teso sub-region but has since been overtaken by others because of biotic and abiotic constraints. The popularity of *Osukut* is captured below:

> '*Why we like to grow Osukut, it does not rot from the garden quickly, because for us, we do not have the manpower to dig out all the sweetpotatoes and peel it all, so, we dig little by little, that helps us, that's why we like Osukut*'. Male respondent, FGD Adidit.

Among the other landraces, *Ateseke* and *Epeet* were positively perceived for their high yield and good taste. *Obongkwap* was perceived to be high yielding and resistant to weevils. Of the varieties promoted in the first study, *Joweria* was reported to be high yielding, early maturing, marketable, and rich in vitamin A. *Ejumula* was mentioned in Congo village as a preferred variety and perceived to be high yielding, disease resistant, big and long roots, good taste, and sells easily.

Performance of varieties promoted in the first study

This section focuses on the four varieties that were promoted to study participants during the first study. These were *Ejumula*, *Joweria*, New *Dimbuka* and *Osukut*/Tanzania. Quality seed of these varieties were presented to farmers in an auction setting in each study village and one farmer purchased one of them. We therefore were keen to assess how the four varieties fared and were perceived by the participants of the current study.

Majority of the participants in the current study reported that the four varieties were high yielding, pest and disease resistant, early maturing, did not rot, and had big long roots with a good taste. For instance, a farmer said:

> *'They grow faster, had high yield'. It only lacked water due to little rain. I also did not observe any disease infection'*. Participant, FGD Amaratoit village.

Resistance to pests and diseases here was less related to variety performance and more related to the fact that the seed they purchased at the auction were clean. This is likely to have contributed to what farmers observed as higher yield that is described by the respondent from Amaratoit village above.

In addition to the high yield, the promoted varieties gave farmers an opportunity to re-plant some of their popular varieties which had disappeared from community. For instance one farmer said:

> *'The vines gave me the opportunity of planting a very good old variety of vine called* ***Osukut****, and indeed everyone who saw it from my garden would ask me, where did you get that variety* ***Osukut*** *from?, I also want it. I would tell them that there is an NGO that brought it and I managed to be the winner, who paid the highest bid, that's how I got it. They would also request to get some and multiply, I would then tell them, to get from the garden.'* Participant, FGD Epaku village.

The overall experience with the varieties promoted in the first study was positive. This is regardless of the fact that the study area was affected by drought during the first season. Indeed the period immediately following the introduction of the vines was characterised

by a dry spell that affected vine establishment. Both male and female farmers nonetheless reported that they re-planted the introduced varieties in the second season further supporting their preference for them.

Suggested improvements in the existing varieties

Among the top five varieties, for both men and women farmers, no improvements were suggested for *Iboii* and *Osukut* (Table 2). This finding is congruent with the earlier finding that Iboii had a balanced set of farmer-preferred characteristics. For *Araka*, however, both men and women farmers suggested the need to: (i) improve root shape and, (ii) reduce incidence of rotting. Participants also recommended the need to reduce the incidence of rotting in *Kakamega* and *Ekampala*. Additional improvements suggested for *Kakamega* were: the need for increased root size, pest and disease resistance, drought resistance, reduced root fibrousness, and increased skin smoothness. Improvements recommended for *Ekampala* were: increase in yield, pest resistance, good taste, early maturity, nutrition and reduced incidence of rotting. Regarding the promoted varieties, improvements in yield and root size were recommended for *Joweria*, while pest and disease resistance were recommended for *Ejumula* in order to increase their preference. In line with previous findings, enhancing root shape and size in varieties that have good taste, nutrition and agronomic attributes has the potential to increase preference for improved varieties in general and reduce the gender technology adoption gap in particular (Mulwa et al., 2023).

Constraints to adoption of existing improved and local sweetpotato varieties

Sources of sweetpotato planting material.

FGD participants cited multiple sources of planting materials (vines). The most common source was neighbours followed by local market, own gardens/plots and vine multipliers (Figure 4). There were subtle but important differences in the most commonly used sources by men and women. While more women (71.8%) than men (67.5%) opted to source vines from neighbours, the reverse was true for markets (Figure 4). Male participants in Adidit village mentioned that they did not obtain vines from Ochorimogin, their main market, because of distance. Their sentiment is highlighted by one respondent who said:

> '*The market is located three to four km away from the village and accessing it is an obstacle to many farmers.* Man participant, FGD Adidit.

This would especially constrain women who tend to have limited mobility. The women's mobility challenge is not only a problem in sourcing sweetpotato vines but in general for women in agriculture. Nchanji et al. (2020) found significant differences in access to new varieties and yield gap of beans between men and women due to limited mobility; among others.

With regards to sourcing from neighbours, a female respondent from Adidit stressed that in order to obtain the vines; one had to "beg the neighbours." In Congo village, a female respondent mentioned that once a neighbour agrees to give vines, she had to send grandchildren to cut and bring the vines home. This alludes to the gendered division of roles in farming, and highlights the role children play in supporting family farming as well as the gendered differences in source of seed and especially of new varieties. Men in the same village mentioned that some neighbours give vines for free, while others sell them. In Agirinyi village for example, 6 farmers (3 M, 3F) indicated that they have bought vines from their neighbours in the past, which corroborates the findings by McEwan et al. (2022) and Rachkara et al. (2017) with regards to the commercial perspective of vine sourcing in arid and semi-arid regions when compared to those with bimodal rainfall patterns.

In Adidit village, Aparisa Parish, women respondents mentioned that when there is scarcity, they buy vines from Ochorimogin market, which also serves as their source of agricultural inputs. Men in the same village also indicated that it was difficult to conserve own vines because animals destroyed the vines during the dry periods. Hence, they mostly sourced vines from the market. Both women and men noted that the vines sourced from the local market were quite expensive – probably because they come from outside the community and have to be transported at high cost and tight timelines due to perishability. Men further observed that apart from the market being distant; in times of scarcity, farmers would search for vines for up to 1 week before getting them. This finding is similar to findings by Lukonge et al. (2015) who found that farmers in Meatu, Tanzania, would have to travel long distances in search of vines. The emerging picture is that of acute case of vine/seed insecurity resulting from poor access due to unavailability and costliness.

Participants further stated that vines from own gardens were mostly maintained through local conservation methods. In Apeleun, men mentioned that they multiply the vines under trees which conserves them for up to a year. Participants in other FGDs also mentioned that they conserve vines by fencing off the areas/plots with vines to prevent them from being destroyed by animals. They further mentioned that they purposely leave roots in the ground during harvesting in order for them to sprout during the next season as a way of conserving vines. These roots sprout after the onset of next season rains providing vines. These findings are in line with those of Namanda et al. (2011) and Okello et al. (2015) who found that farmers in dryer regions of Uganda and Tanzania, respectively, use volunteer plants from roots left over in the ground for planting during the new season.

There were also cases of sweetpotato farmers conserving and multiplying vines in the wetland[2] for sale to other famers. However, this was one of the least used source of planting materials. A female respondent from Kaimoru village noted that a bag of vines could cost as high as UGX 40,000 to UGX 50,000 at the onset of first season rains when vines are very scarce. This is quite expensive when compared to prices elsewhere in the country that range from UGX 15,000 to UGX 20,000 shillings moreover for improved varieties (Rachkara et al., 2013). Rachkara et al. (2017), on the other hand, indicate that local multipliers in Gulu sell a bag of local vines at only UGX 10,000. This probably explains the low utilization of this source. At the same time,

2 These are not the conventional trained multipliers – source: DAO, Katakwi.

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TABLE 2 Missing attributes that need to be improved in the most preferred sweetpotato varieties.

Variety	Productivity		Biotic and abiotic stress			Ground storage	Root characteristics			Eating quality		
Top ranking varieties	High yield	Pest resistance	Disease resistance	Early maturity	Drought resistance	Rotting	Big root size	Shape	Skin smoothness	Good taste	Non fibrousness	Nutrition
Iboii	No	No	No	No	No	No	No	No	No	No	No	No
Ekampala	Yes	Yes	No	Yes	No	Yes	No	No	No	Yes	No	Yes
Osukut	No	No	No	No	No	No	No	No	No	No	No	No
Kakamega	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	No
Araka	No	No	No	No	No	Yes	No	Yes	No	No	No	No
Promoted varieties												
Joweria	Yes	No	No	No	No	No	Yes	No	No	No	No	No
Ejumula	No	Yes	Yes	No	No	No	No	No	No	No	No	No

Yes = Attribute needs to be improved; No = no improvement needed.

it could prevent farmers with limited resources from using this important service. Nonetheless, such multipliers provide an important service especially in arid areas where farmers are hard pressed to conserve own vines (Rachkara et al., 2017).

Auction was mentioned as a new form of obtaining vines, but only by a few. This finding is in line with *a priori* expectations (Okello et al., 2023). By design, only one farmer was able to buy vines at the auction making it quite a limited source. Further, our results indicate that this source was mostly mentioned by men. While this is novel in the area, it nonetheless points to technology access leaning more towards men than women (Diiro et al., 2015).

Difficulties in accessing sweetpotato planting material

FGD participants reported a number of challenges relating to acquiring vines for planting (Figure 5). Poor quality vines was the universal crosscutting challenge. It was mostly associated with vines sourced from local markets, followed by own sources, neighbours, multipliers and those sourced from auction in descending order. Participants associated poor quality with adulteration of varieties, immature vines, and undesirable varieties, among others. Vines sold during the auction were deemed poor quality when leaves were wilted or yellowish (not "fresh"). Thus, farmers' perceptions of quality differed from the scientists' definition: the latter definition focusing on vines that are free from pests and diseases. Barker et al. (2009) argue that poor quality and insufficient planting materials were the most limiting factors in acquiring vines among farmers in northern Uganda. Given the effect of vine quality on sweetpotato productivity, there is therefore the need for training and sensitization on quality assessment (diagnosis) and assurance (i.e., how it is communicated) if yields are to be improved.

Pest and disease infested vines was the second most important challenge mentioned by respondents. This problem primarily, but not exclusively, occurs in vines sourced from farmers' own fields. Vines sourced from neighbours and farmer multipliers were also associated with high infestation with pests and diseases. Participants mentioned that it was difficult for them to discern infested vines from good ones, because of the "credence[3] good" nature of the quality. They indicated that they could only tell that the vines were poor quality after they have planted and obtain pencil-like tiny roots. They linked pencil-like roots to repeated use of vines especially those sourced from own fields. Studies indicate that the sweetpotato virus disease can cause devastating outcomes of up to 80% yield loss in susceptible varieties in arid and semi-arid regions (Yada et al., 2015; Okello et al., 2023).

Participants highlighted the high cost of vines as a challenge for planting material sourced from the market, multiplier and neighbours in descending order.

Lack of sufficient vines to plant when needed was a major challenge for farmers who rely on vines sourced majorly from neighbours. Participants mentioned that they would be asked to wait

3 Credence good are one whose true nature can only be deduced after consumption/use but not by visual observation.

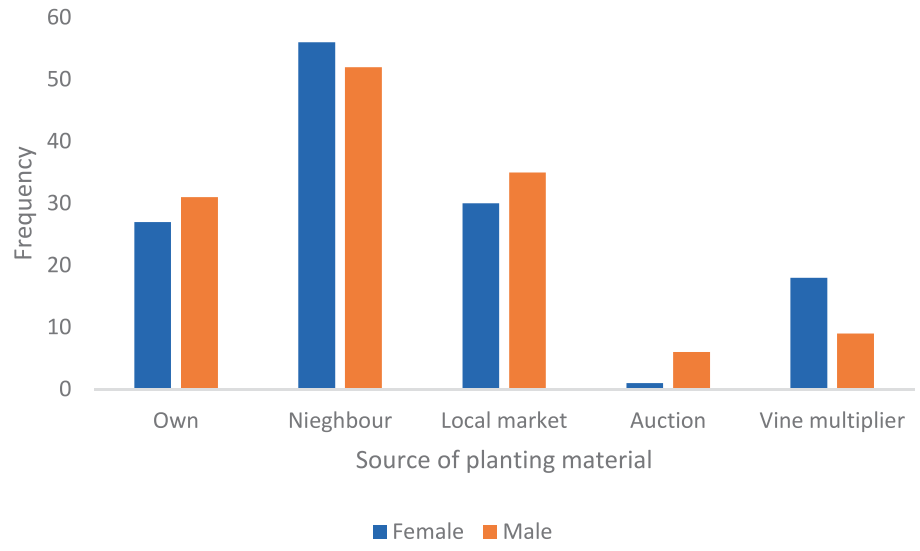

FIGURE 4
Common sources of Sweetpotato planting material by male and female farmers.

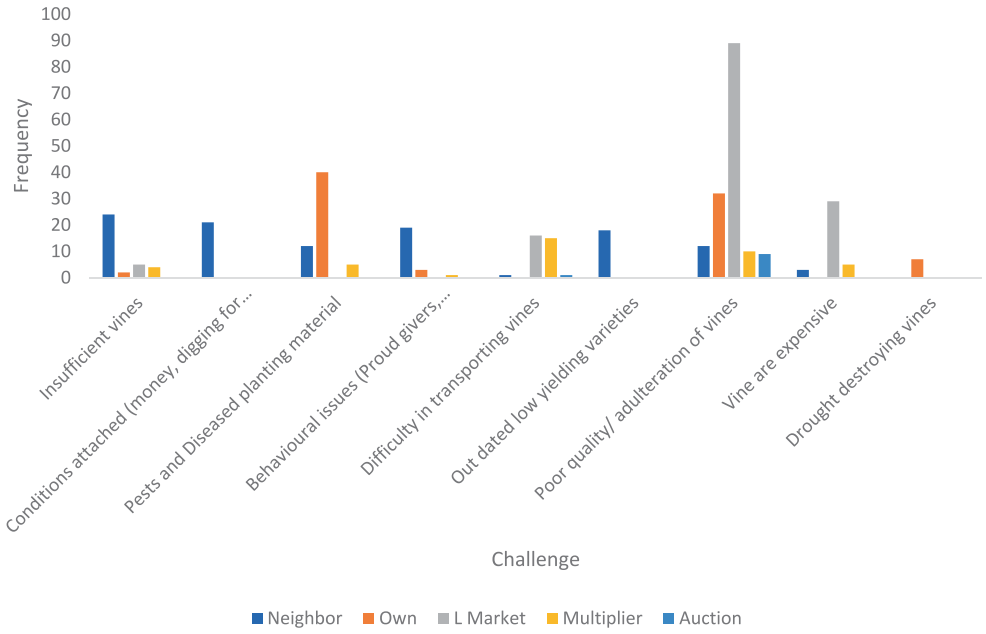

FIGURE 5
Challenges in accessing sweetpotato planting material from different sources.

when neighbours run out of planting materials, which led to late planting. One male participant shared:

> *'Sometimes you can go to the neighbour after you have made the sweetpotato heaps but the neighbour tells you: 'Wait, because I have not yet cut (vines) for myself'. This means you cannot plant in time.* Male respondent, FGD Apeleun.

Participants also indicated that neighbours attach conditions to vines as a common challenge. This includes working to get the vines. For instance, digging for vines or paying cash for vines. This appeared strange to farmers because they are used to obtaining vines from the neighbours' sweetpotato fields for free. One farmer mentioned that:

> *Sometimes you are told to first dig for the owner [of] vines before you can be given the vines. Nothing is for free.* Female respondent, FGD Amaratoit.

In some cases, farmers would not get any planting materials at all from neighbours because the vines would have been 'overcut' (i.e., overharvested) and all that remained were just the main stems. Failure to grow sweetpotatoes in some seasons for lack of vines can affect food

and income security. This is evidenced by Mwangi et al. (2020) who noted that seed security influences food security and seed access.

Sources of farming advice

Generally, the most preferred source of farming advice was neighbours followed by radio, NGOs, village chairmen, agricultural officers, model farmers and newspapers; in descending order (Figure 6). For women, neighbours were the most important source followed by NGOs and radio. Neighbours as a source of information ties with their most important source of seed and corroborates the findings by Gilligan et al. (2020). Neighbours were preferred because of their close proximity and accessibility; while also being appreciated as a conduit of knowledge received from other sources such as NGOs.

> *The one way I prefer for getting agricultural information on seed and input quality is through our brothers around (peer farmer), he has been taught some good information on farming, I can also learn from him so that I can be strong in farming because I can learn from him what NGOs have taught him.* Female participant, Kaimoru FGD.

Participants, especially women, appreciated radio as a source of agricultural information because of its consistency and the diversity of knowledge shared. They indicated that from radio, they were able to learn about new crop varieties and the associated agronomic practices.

> *I prefer the radio because you get to know the new varieties that have come up and when to plant them because such information is lacking from experienced elders.* Female participant, Katanga FGD.

Some participants however felt that radio was not an optimal channel for getting agricultural information. They mentioned that while you can listen to the radio, the broadcasters would not get to you physically nor give you inputs as is the case with NGOs. In Omwatok, a female participant commented that 'without dry cells you cannot listen to radios'.

In a similar study conducted in Ethiopia and Ghana, Mayanja et al. (2020) found that women did not prioritise radio as a communication channel because of limited access to radio sets and batteries.

For men, the most preferred source of information was also radio followed by NGO and neighbours, in descending order. Participants from several villages mentioned that they preferred information from NGOs because it was accompanied by practical trainings. Some farmers mentioned making organic pesticides as an example where knowledge from NGOs was more helpful than radios. These organizations were acknowledged to be hands-on and for providing physical inputs such as seed as starter packages. Participants stated that such inputs especially seed would give them good harvests. NGOs were also noted to have a wide outreach and were commended for keeping time. Men in particular were appreciative of the information received from NGOs are elaborated as below:

> *'I prefer NGOs because they can teach you how to properly farm and how to make manure on how to grow well your crops'* Male participant, FDG Adidit village.

> *'I prefer NGOs because I had never been taught agricultural practices not until this organization came to our village´* Male participant, FDG Ongopai village.

The downside though was that they took long to follow up. In line with this finding, Rees et al. (2000) also found that though NGOs are important sources of information, they lack resources to do extensive follow-up in communities leading to information distortion.

Only men mentioned newspaper as a preferred source of farming advice, probably due to low literacy levels and immobility of women that deters access to this channel. Men also had better access to information from Agricultural Officers and model farmers compared to women. Further, men participants shared the multiple services Agricultural Officers provide. They were also held in high esteem because they were educated as highlighted below:

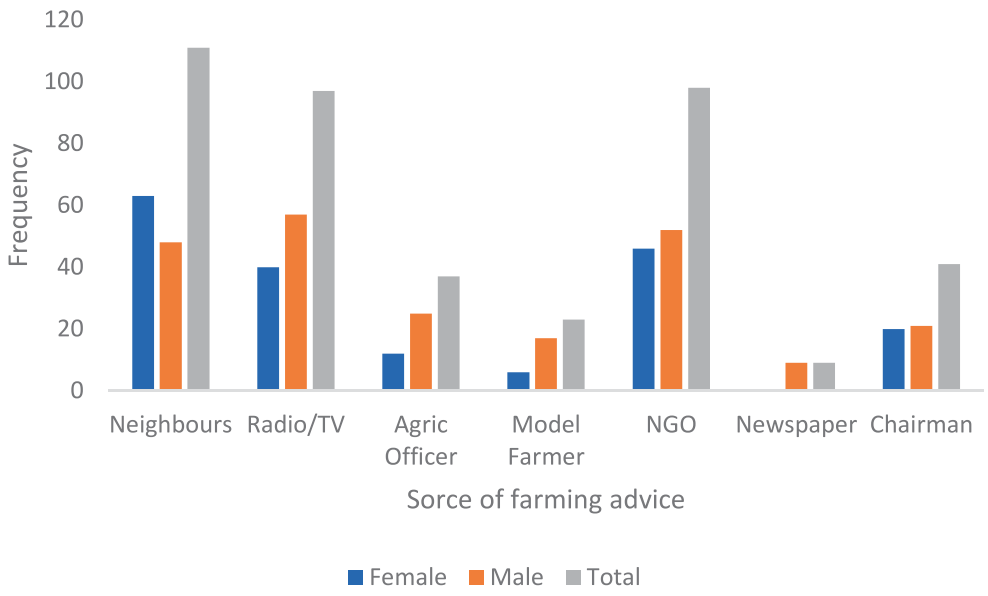

FIGURE 6
Preferred source of farming advice by men and women.

> *I prefer most agricultural officer of the sub county because he can come and check if any diseases have attacked the crops in the garden, he prescribes the pesticides to use on the various diseases.* Male participant, Adidit FGD.

> *I prefer agricultural extension worker because they have experience since they are educated.* Male participant, Angirinyi FGD.

Several studies have highlighted women's limited access to agricultural extension information, demonstrated by the gender yield gap in productivity (Zawedde et al., 2014; Heck et al., 2020; Nchanji et al., 2020). Efforts to disseminate new sweetpotato technologies in the area therefore need to take note and strive for strategies to improve women's access to agricultural information.

The participants stated that they get agricultural information from informal sources. For example in Orukurukun, Abelan and Omwatok villages eight participants (five men and three women) mentioned that they got information from agro-dealers as they purchased the agricultural inputs. Similar to findings by Katungi et al. (2008), eight participants from Abelan village mentioned church as a source of information. Other informal sources of agricultural information mentioned were friends, parents, drinking joints and social media. The social networks in communities like churches and drinking joints trigger discussions that end up generating useful agricultural related information that can be used to improve their farming enterprises. A study by Skaalsveen et al. (2020) found that interpersonal networks are important for farmers and influence farmer learning and decision making since they depend on each other for information. Additionally, Dapilah et al. (2020) reported that social networks form an essential source of information for agricultural technologies.

Community information networks thus play an important role in diffusion of new seed technologies especially to women because they are the ones who mostly participate in these gatherings. As noted by McNiven and Gilligan (2012), such networks played a substantial role in providing initial access to OFSP vines and later in the sustained adoption of the technology.

Altruism

The findings of this study suggest that during times of scarcity, farmers face challenges getting vines from neighbours even though the tradition has been to share vines for free. We therefore assessed the extent of altruism among the study participants to determine its role in farmer use of, and sharing of information about improved sweetpotato varieties. All the study farmers participated in an experiment designed to assess their altruistic behaviour. They were specifically asked to donate to a charity organisation out of an endowment of 5,000 UGX provided as part of the experiment.

According to Shikuku (2018) altruistic behaviour is denoted by a donation exceeding the median value of the donations. In the current study the median value of the donations was 2000 UGX. Twenty four percent of the participants gave donations that were above the median value suggesting that majority of the FGD participants were not altruistic. There are several reasons why this could be the case. For instance, at the time of the study, farmers were emerging from a long dry period characterised by food scarcity. The COVID-19 pandemic had also imposed mobility restrictions on the farmers thus disrupting the food systems. Part of the study area especially neighbouring the Karamoja region also experienced insecurity caused by cattle-raid by the Karamojong herders. These were associated with the following statements:

> *I felt like this, that what will my children eat but I was happy, I also gave the NGO little money.* Female participant, FDG Adidit village.

> *I felt bad. This is the first time I am giving to charity. There was a call for donating for village initiatives but people were not willing to give. I also gave but painfully.* Female participant, FDG Aterai village.

> *I never felt happy at all because how can they give me their money and then ask me to give back again yet you came in the name of helping me.* Male participant, FDG East cell village.

> *I felt happy when I was told that the money was mine but then when I was told to also donate, my heart folded a bit because in my mind I knew that some of my bills were going to be sorted. It is my first time to donate.* Female participant, FDG East cell village.

Men (28%) seemed more inclined to altruism compared to women (21%). This could be related to their giving nature that could render them more altruistic with the aim of spreading the feeling of giving and wellbeing within the community.

Conclusion

In this study, we used qualitative methods to understand the barriers and enablers of varietal replacement and constraints to adoption among smallholder men and women sweetpotato farmers. The main causes of low varietal replacement can be summarised as the persistent dominance of local varieties and the strong preference of older varieties due to possession of preferred traits compared to newer varieties. Among the wide diversity of varieties grown in the study area were *Iboii, Ekampala, Osukut*/Tanzania, *Kakamega* and *Araka*, in the order of importance. These varieties were mostly preferred because of high yield and good taste. While *Iboii* and *Osukut* stood out for having a balanced set of preferred traits, *Ekampala, Araka* and *Kakamega* lacked some key characteristics such as early maturity, weevil and disease resistance, and drought tolerance.

The three most common sources of planting material for both men and women were neighbours, local market and own field. There was little infusion of planting material from outside the community. Hence, poor quality of the vines was highlighted as the most important challenge across the different sources. Pests and disease infested planting material, high costs and unavailability of vines were also highlighted as major challenges. Farmers also had different understanding of quality from how scientists define it and had difficulty knowing/assessing quality of vines *a priori*. This implies the need for a credible signal of quality such as certification

label that is commonly used in cereals. Women and men farmers obtained most of their information from neighbours, NGOs and radios. For women, the most important source of planting materials doubled as their most important source of information. The public agricultural extension system was not among the dominant information sources as would have been expected.

The study found some evidence of altruism among the farmers even though the level did not reach the threshold recommended by existing in literature. The finding that neighbours stood out as the main source of information and planting materials also exemplifies the existence of altruism among study farmers. However, scarcity seems to be eroding this virtue as farmers increasingly seek compensation for their vines from neighbours. The use of social information sources such as churches and drinking joints additionally illustrates the presence of altruism in the community. Nonetheless, there is no clear link between altruism and technology diffusion among farmers.

Vines that circulate in the community have high loads of pests and diseases which contributes to poor quality hence low sweetpotato productivity. This implies that there is a need to introduce sources of quality vines in the community or link the community to external sources of quality vines. Key traits that are preferable across varieties, like early maturity, pest and disease resistance and yield, are must-have traits in breeding objectives. Similarly, good sweet taste is a critical trait for enhanced demand for improved varieties, especially among women. Entrenching these traits in breeding objectives has the potential of increasing demand for improved varieties in general, and reducing the gender technology adoption gap in particular, through higher adoption among women.

The finding that there was limited use of public extension system as sources of agricultural information suggests the need to revamp the system. Additionally, there is need to invest more in extension work by training and sensitizing the agricultural officers. Thus, improved coordination between actors around the value chain will be critical to maximizing benefits for the wider seed sector and society. Given the importance of informal information sources as demonstrated in this study, the consideration for their inclusion in technology adoption strategies is justified. Thus, concerted efforts to minimise information constraints are essential for unravelling this adoption puzzle. The lack of a clear link between altruism and technology diffusion suggests the need for further research to examine its role in agricultural technology diffusion and adoption.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by International Livestock Research Institute (ILRI), Internal review board (IRB), (ILRI-IREC2022-13). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

IB: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing, Validation, Visualization. JO: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing, Visualization. SM: Conceptualization, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. MN: Conceptualization, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. SN: Conceptualization, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. FO: Conceptualization, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. SO: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – review & editing. KS: Conceptualization, Investigation, Methodology, Validation, Visualization, Writing – review & editing. C-JL: Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Validation, Visualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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