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Farmer demand for clean planting material of biofortified and non-biofortified vegetatively propagated crop varieties: The case of sweetpotato

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ABSTRACT

Biofortified orange-fleshed sweetpotato (OFSP), rich in beta carotene, is currently being promoted due to its role in fighting vitamin A deficiency. To promote farmer access to OFSP planting material (i.e., vines) projects establish vine multipliers who are expected to operate commercially. However, most sweetpotato farmers are used to getting vines from social networks free of cost. In this study, we compare farmers' willingness to pay for clean (i.e., pest and disease free) vines of biofortified and popular non-biofortified sweetpotato varieties. The study thus holds vine "health" constant while assessing the influence of vitamin A biofortification on demand. We then use seemingly unrelated regression technique and data from 481 farmers to assess factors affecting the demand for both types of vines. We find higher willingness to pay for clean non-biofortified sweetpotato vines than biofortified sweetpotato vines of similar health, because of the higher nutritional value, good taste, and firmness of the roots of the former. Factors affecting demand for clean vines include the number of children a farmer has, farmer's age, tastes, preferences, sweetpotato yield and income. These effects differ between biofortified and non-biofortified varieties. We conclude that demand for clean OFSP vines is high, but still lower than for white-fleshed varieties, and discuss implications of the findings.

Introduction

Micronutrient malnutrition and hunger are major problems affecting developing countries, especially in Sub-Saharan Africa [7]. A leading micronutrient deficiency facing these countries is vitamin A [40]. The effect of vitamin A deficiency (VAD) is especially intense among the poorer populations who can't afford the artificial food supplements and whose options for food diversification are limited [4, 23]. Biofortification, a food-based approach that seeks to combat VAD by improving the nutritional quality of staple food crops consumed by poor households has thus attracted a lot of interest among the

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development community [3]. Its attraction emanates from the fact that it can supply the needed micronutrient to combat VAD among the vulnerable groups at low or no cost [23, 36]. Proof-of-concept studies conducted in Uganda, Mozambique, Kenya and Rwanda find strong evidence that OFSP can provide significant quantities of vitamin A needed to overcome VAD among vulnerable groups, namely children under five years and pregnant and lactating women [11, 13, 14, 15, 22]. In addition, Van Jaarsveld et al., [39] have found that consumption of moderate amounts of boiled OFSP by children, at least three times a week, significantly improved their vitamin A levels in the blood.

One of the major constraints to farmers' adoption of OFSP, and hence the campaign to tackle VAD using OFSP, has been the lack of access to clean planting materials (or vines[1]). Majority of the farmers still depend on own sweetpotato vines or those obtained free or cost from close social networks [32]. The resulting widespread practice of recycling planting materials of this clonally propagated crop usually lead to accumulation of pests (especially sweetpotato weevil) and diseases (e.g., sweetpotato virus diseases – SPVD) which reduces its performance, especially yields [10, 16, 28]. For OFSP, the poor access to quality planting materials is exacerbated by unavailability of the clean pest/disease-free materials and the challenges of conserving planting materials during the dry periods [1, 9, 35].

In response to this bottleneck, the International Potato Center (CIP), jointly with the public and private sector partners, has spearheaded efforts to promote farmer access to clean sweetpotato planting materials, often free or at heavily subsidized prices. One such case was the joint partnership involving CIP, the government of Tanzania and non-governmental organizations under a project known as "Marando Bora" (i.e., better vines). The project focused on promoting farmers' access to clean vines at 50-100% subsidy. The vines promoted included both the OFSP varieties and non-OFSP (that is, the white-fleshed sweetpotato (WFSP)) varieties. The OFSP vines originated from breeding and seed bulking sources and were free from the devasting pests and diseases. The vines of WFSP varieties promoted by the project were first cleaned[2] of these SPVD prior to distribution to farmers, hence of healthier than farmer seed. The project also sensitized farmers on the nutritional value of consuming OFSP [35] and the need to use clean planting materials and the nutritional benefits of OFSP. The sensitization activity was in form of farmer training in groups and during field days in which agronomic practices, disease diagnosis based on symptoms, nutritional benefits were explained. The activity was conducted by non-governmental organizations, including World Vision and Young Women Christian Association. In addition, messages about the nutritional benefits of OFSP and where one could obtain vines were disseminated through community FM radios and billboard erected on the roadside near a vine multiplication plot. It is estimated that more than 10,000 farmers benefited from this intervention [32], with vines given either free or at heavily subsidized prices.

The current efforts to scale up the production and consumption of OFSP among the vulnerable populations has led to questions regarding whether farmers would be willing to pay for clean planting materials (that is, vines that are SPVD-free) if the current subsidies were removed and how much they would be willing to pay. To date, studies that have assessed the willingness to pay for OFSP [24, 25, 30, 31, 37] have mainly focused on fresh roots. The exception, [17], obtained willingness to pay values for OFSP planting materials in Mozambique using an experimental auction. In the current study willingness to pay values are obtained after more than two seasons of farmer experimentation with the clean seeds of OFSP and WFSP varieties through planting and observation of their performance in own farm fields. The willingness to pay bids/values are thus based on real rather than hypothetical experience of the varieties. This improved the method used to collect the bids which has been criticized for overestimating or underestimating the true willingness to pay since it was based on hypothetical situations.

This study uses data from a carefully designed field study that controlled for vine health to examine farmers' willingness to pay for biofortified and non-biofortified sweetpotato vines, that is, OFSP and WFSP vines. It addresses two specific research questions: 1) Are farmers willing to pay a higher price for clean planting material of OFSP than non-OFSP varieties? 2) What are the determinants of farmers' willingness to pay for clean sweetpotato planting material? Notably, because the project first cleaned the non-OFSP varieties prior to their distribution alongside the clean OFSP varieties, we are able compare the price farmers are willing to pay for the two types of varieties.

The rest of this paper is organized as follows. Section 2 discusses the study methods and also presents the analytical framework. Section 3 discusses the empirical methods. Section 4 presents and discusses the results while Section 6 concludes and draws some policy implications.

Study methods

This study is based on the Lanchaster's consumer theory which is a refinement of the traditional approach to the theory of consumer behavior. The Lancaster theory is based on the proposition that consumers value goods due to their attributes rather than the good per se [19]. Specifically, the Lancasterian demand theory posits that consumers derive utility from the characteristics or properties of a good rather than the good being the direct object of utility. This implies that a good by

[1] Throughout this paper, the term vines is used interchangeably with sweetpotato planting material.

[2] Cleaning of vines is done in the thermotherapy machine where temperatures alternate from 42 degrees (day) and 39 degrees (night) for 21 to 30 days. The idea is to kill virus(es) and other diseases. After these days, meristem tips of plantlets put in thermotherapy are extracted and cultured in vitro (tissue culture laboratory). The in vitro plantlets are tested again for virus or disease using the ELISA method or indicator plant (*Ipomeoa setosa*). If no virus or diseases are found, the plantlets are acclimatized in protected greenhouses and multiplied to eventually have the vines were plant outside greenhouses.

itself does not give utility to the consumer; rather, its attributes in terms of characteristics and features do. In general, a good will possess more than one attribute, and attributes may be shared by more than one good.

Consumer valuation of non-market goods

The contingent valuation (CV) technique is the most widely used method in the valuation of consumer goods that are not commonly traded in the markets, such as sweetpotato vines, due to its flexibility and ease of application ([6,27]; Meyerhoff et al [38]). Among the elicitation techniques available under this method, the open-ended (OE) questions has greater empirical appeal because of its equivalence to dichotomous methods that seek "Yes/No" response to pre-selected amount/value [2, 5, 8, 21, 33]. In this study, we used contingent valuation method with an open-ended question, namely: "how much extra money are you willing to pay for this.....?" . We did this because of the study design which enabled the farmers to observe the characteristics of the vines under field condition and also because of ease of administering an open-ended questions in a rural/farming context and avoids the problem of anchoring bias [20, 34]. Hence after detailed description of the good (see scenario description below), we ask the respondents to state how much money they would be willing to pay for the vines.

Scenario description and the elicitation of the willing to pay

As part of the scenario description, the respondent was asked a series of questions related to effects of sweetpotato pest (weevil) and diseases (sweetpotato virus diseases - SPVD). The questions included: do you sometimes see "tired looking" sweetpotato plant in your field(referring to virus infection)? Have you ever seen such symptoms (pointing at virus infected plant or weevil infected root)? What disease/pest causes these symptoms? What do when you see such symptoms? These questions exposed the respondent to the symptoms of major sweetpotato pests and diseases, specifically the sweetpotato weevil and sweetpotato viral diseases, respectively. The respondent was then shown samples and pictures of a virus-infected sweetpotato plant and asked whether he/she had experienced similar symptoms in his/her plot(s). The cause of such symptoms were discussed and explained. Next, the respondent was informed that the project vines, and which comprised both OFSP and WFSP varieties, were healthier because they were free from sweetpotato weevil and virus diseases. Then, the respondent was shown a picture of cleaned (healthy) vines and also informed that such clean vines had higher yield than those found locally among the sweetpotato farmers (i.e., farmer seed) in the same area.

Next, the respondent was informed that some of the clean biofortified sweetpotato vines had ability to produce sweetpotato that are rich in vitamin A while the white-fleshed non-biofortified sweetpotato vines did not. The biofortified varieties that could provide vitamin A were introduced and marked as Kabode, Jewel, and Ejumula, while those that could not were introduced and marked as *New*[3] Polista and *New* Ukerewe. Additional information on sweetpotato pests and diseases and the nutritional benefits of OFSP was provided through radio broadcasts and market information boards located in the local markets in the study region. Information provided through radio broadcast and market information boards targeted both project and non-project participants (i.e., all the respondents) alike. Additional information on sweetpotato production was provided specifically to project participants through the vine multipliers and hence is expected to have reached farmers that had contact with (or received/purchased clean vines from) these multipliers.

Prior to the study, the project participants were offered free clean/healthy vines of OFSP and WFSP varieties and asked to plant and utilize (eat and/or market) the roots. The farmers planted the clean vines for two seasons. The planting and utilization sweetpotato enabled the farmers to "evaluate/experience" any differences in performance of clean OFSP and WFSP vines in terms of taste, dry matter, and resistance to the sweetpotato weevil and virus diseases.

In order to collect the bid prices for the clean vines, respondents were first asked to remember the information they had received from the project, via radio and billboards and through visits by project team and consider their experience of planting and utilizing the sweetpotato vines from the project. Ultimately, the respondents were asked how much money they would be willing to pay for a bundle comprising one hundred 30-centimetre vine cuttings of the OFSP variety and similar bundle of WFSP variety. Bid values were recorded in Tanzania shillings (Tshs). Some farmers were not willing to pay anything for clean OFSP and WFSP vines and were assigned a willingness to pay value of zero.

Additional information was collected using a pre-designed and pre-tested questionnaire. The Information collected included farmer attitudes and perceptions towards sweetpotato, demographic characteristics (including gender, education and age), household income, and food consumption frequency.

Analytical framework for assessing the factors influencing WTP for clean sweetpotato vines

The factors influencing willingness to pay for the five varieties was assessed using Seemingly Unrelated Regression (SURE) model to cater for any possible correlation in the WTP between and among the different varieties. The SURE model is a system of linear equations containing only exogenous regressors and has error terms that are correlated across equations for a given individual but are uncorrelated across individuals.

[3] The term New was introduced to distinguish vines from the well-known popular local varieties that had been cleaned of pests and diseases from local unclean farmer seed/vines.

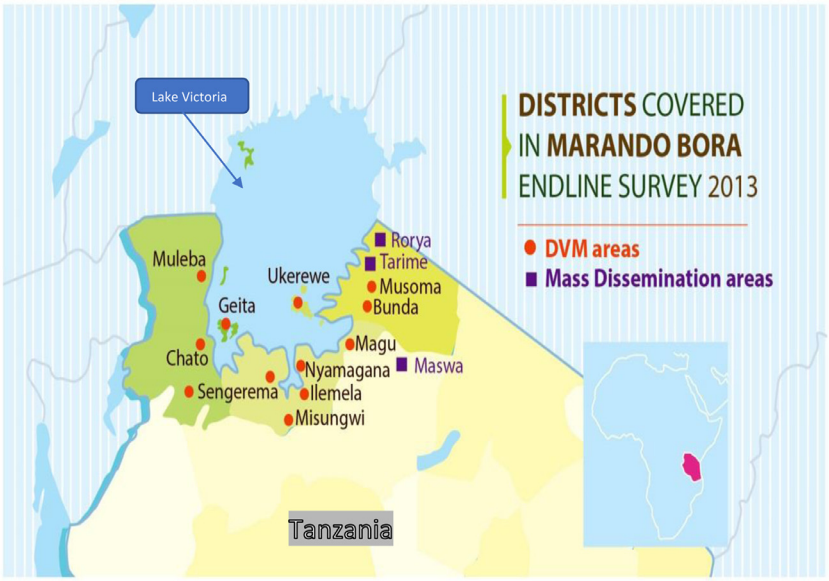

Fig. 1. A map of Lake Victoria region showing study areas.

SURE uses a three stage least squares (3SLS) technique which, in turn, uses asymptotically efficient and feasible generalized least-squares (FGLS) algorithm [12]. Therefore, the estimator generated by SURE is asymptotically equivalent to the generalized least squares (GLS) estimator which is unbiased and efficient.

The general structure of the empirical model estimated was specified as;

$$WTP = X\beta + \mu \tag{1}$$

Where;

$$WTP = [WTP_1, \quad WTP_2, \ \ldots, \ WTP_5] \tag{2}$$

$$X\beta = [X_1\beta_1, \ X_2\beta_2, \ldots, \ X_k\beta_k], \text{and} \tag{3}$$

$$\mu = [\mu_1 \ldots \ \mu_5] \tag{4}$$

$WTP_{1...5}$ are the are the dependent variables (measured as willingness to pay) for the 5 estimated equation, X_1 to X_k are vector of explanatory variables in each equation and β_1 to β_k are respective coefficients to be estimated, while μ_1 to μ_5 are the error terms assumed to be correlated for an individual respondent, but uncorrelated across individual respondents. The five equations are estimated for Kabode, Jewel, Ejumula, New Polista and New Ukerewe sweetpotato varieties respectively.

Data and sampling procedures

This study used data collected from sweetpotato farmers in January and February 2013 in four regions of Tanzania. Multi-stage sampling technique was used to select farmers. The study focused on Mara, Mwanza, Shinyanga, and Kagera regions of Tanzania, which were targeted by a project that sensitized farmers on the benefits of planting and consuming OFSP and of using clean planting materials. Hence these regions were purposively selected. Next, fourteen districts were also purposively chosen based on the areas where the project was actually implemented. The specific districts covered are shown in Figure 1. As shown in the map, the project reached beneficiary households with vines using 2 strategies namely through decentralized vine multiplier (DVM) and through mass distribution of the vines (MD). The former involved an individual farmer redeeming a voucher for subsidized vine while the latter targeted many farmers and issued vines for free. The subsidy in the DVM model was about 50% of the price.

A list of all the administrative Wards in these districts was the drawn and Wards randomly sampled from the list. Similarly, for each ward, a list of all villages was compiled and a random sample of villages drawn. In each of the sampled village, separate lists of households that participated in the project and those that did not was compiled, and a random sample drawn from each list using probability proportional to size sampling technique. Each farm household was then interviewed using pretested questionnaires. In total 481 project participants and 251 non-project participants were interviewed. This paper focuses on the 481households that participated in the project and therefore benefited from project activities. However, 31 of the responses were not fully completed and were dropped the analysis. The results discussed in this paper are therefore based on 450 project participants who fully responded to the willingness module of the survey in addition to the other module. Non-project participants did not bid for clean vines.

Results

Definitions of the variables used in the Seemingly Unrelated Regression model (SURE) and their summary statistics are given in Table 1. It shows that, among the OFSP varieties, the respondents were willing to pay Tsh 140 and Tsh 141 more for Kabode vines than for a bundle of 100 (30-cm) vines of Ejumula and Jewel, respectively. Clearly, this finding indicates that the farmers have a higher demand for the OFSP varieties than the non-OFSP which is manifested by the higher amount of money they are willing to spend on the former.

Paired t-tests of the hypothesis that there is no differences between the mean WTP for Kabode vines and the vines of Ejumula and Jewel varieties yielded p-values of 0.0008 and 0.0000, respectively, further indicating that farmers are willing to pay statistically significantly higher price for Kabode than Ejumula and Jewel. This finding is attributed to the good attributes of Kabode roots, especially in terms of taste, dry matter content and resistance to diseases. Okello et al [32], for instance, find that farmers rate Kabode much higher in terms of these attributes than the other varieties. Good taste has been reported to be a key attribute in decision to adopt and consume OFSP, and sweetpotato, in general by other studies as well. For instance, Lagerkvist et al [18] showed good sensory attributes (especially taste) influence decision to grow and consume OFSP. Zawedde et al [41] argue that taste has major role in the kind of varieties farmers adopt and maintain in their fields.

Results also show that farmers are willing to pay, on average, higher prices for same quantity of clean vines of New Polista and New Ukerewe varieties than for the OFSP varieties, except for Kabode which has slightly higher price than New Ukerewe. The results therefore indicate that New Polista dominates all the OFSP and local varieties in terms of its demand. That is, farmers like it more than the other varieties and therefore were willing to pay a higher price for it that the others. This was mostly attributed to its higher dry matter (that is, its boiled roots don't mash) and mealiness compared to the OFSP varieties.

Pairwise comparison of the mean WTP across the varieties shows that the study respondents were willing to pay Tsh 133 and Tsh 124 more for New Polista vines than for New Ukerewe and Kabode vines, respectively. Further, the individual paired t-test of the hypothesis that there is no difference in mean WTP for New Polista vines and the vines of New Ukerewe and Kabode yield p-values of 0.0004 and 0.0000, respectively, indicating that farmers are willing to pay statistically significantly higher price for New Polista vines. A paired t-test of difference in mean WTP between Kabode vines and New Ukerewe vines however indicate that the difference in the price the study respondents were willing to pay for the vines of these two varieties (i.e., Kabode and New Ukerewe) is not statistically significant.

The results of the paired t-tests of differences in means also indicate that mean willingness to pay for vines of New Ukerewe variety is higher than for the Jewel and Ejumula vines, and that the differences are statistically significant at 1% level. This indicates that farmers prefer the cleaner vines of this white-fleshed sweetpotato variety to those of the two OFSP varieties. Together, these findings indicate that even though OFSP varieties offer nutritional benefits, farmers still strongly prefer the white fleshed sweetpotato varieties, especially once they are cleaned from the diseases that affect their production. The findings demonstrate that farmers had higher preference and demand for non-OFSP varieties due to inherent varietal characteristics, especially the taste of boiled roots, but also because of higher root drymatter context (i.e., firmness of the roots) and ease of access to vines. Vines of non-OFSP varieties are easier to find in the communities and can withstand dry conditions [32].

Results further show that the mean education level of the study respondents was 6 years, indicating that majority of the farmers have, on average, attained only primary level of education. Okello et al [32] indicate that education increases WTP for some value addition processes but not others. Hence, the finding implies that adoption of OFSP in study communities is likely to be hampered by the low level of education. At the same time, Table 1 further shows that most of the study respondents were of middle age (i.e., 45 years) and had at least one child that is under two years of age. Children under the age of two years are more vulnerable to vitamin A deficiency, and therefore usually of major interest to projects that promote OFSP.

Table 2 presents the results of the regression analysis. The equations were estimated simultaneously using *sureg* command (in Stata) which accounts for the correlation in the errors, thus yielding efficient estimates. The dependent variables were the natural logarithm of the respondents' willingness to pay (measured in Tanzanian shillings (Tsh)) for each of the five sweetpotato varieties covered in this study namely. We discuss the results of each model below.

Starting with Kabode, the results indicate that the number of children in the household, age of the respondent, yield performance of the clean OFSP variable, preference for Kabode, distance to market, asset index, crop income and the number of years a farmer has experimented with the non-OFSP during the project period affect the willingness to pay for clean planting materials of the Kabode variety, an OFSP. The results further indicate that farmers with more assets are willing to pay more for the Kabode variety. The asset elasticity of demand is 0.12, implying that the higher the value of assets, the likelihood that they would Kabode vines.

The results of the models estimated for Jewel and Ejumula varieties, the other two OFSP varieties, closely resemble those of Kabode. They show that the number of children under age 5 years, age of the respondent, perception about the yield performance of the variety, distance to the market, and the number of years farmers had experimented with non-OFSP during the project all increase the willingness to pay for both Jewel and Ejumula vines. Results also show that distance to the source of clean materials has an effect on the willingness to pay for the vines of Jewel variety but not for Ejumula

Table 1
Description and summary statistics of socioeconomic and demographic variables used in empirical estimations of the SURE model (N=450).

Variables	Description	Mean	Std Dev
Dependent variables			
WTPK	Willingness to pay for a bundle of one hundred (30cm) vines of Kabode variety (Tshs)	1097	1041
WTPJ	Willingness to pay for a bundle of one hundred (30cm) vines of Jewel variety (Tsh)	956	1070
WTPE	Willingness to pay for a bundle of one hundred (30cm) vines Ejumula variety (Tsh)	957	1055
WTNP	Willingness to pay for a bundle of one hundred (30cm) vines of New Polista variety (Tshs)	1221	1213
WTPNU	Willingness to pay for a bundle of one hundred (30cm) vines New Ukerewe variety (Tshs)	1088	1223
Independent variables			
Gender	Dummy variable 1=male, 0 female	0.29	0.45
Education	Years of formal schooling	5.66	3.10
Numchild	Number of children 5years of age and below	1.21	1.13
Age	Age of respondent in years	45	12.17
Asset index**	Asset index	3.61	2.16
Lncropinc	Natural logarithm of crop income (in Tanzania Shillings, Tshs)	6.66	8.68
Lndistmkt	Natural logarithm of distance to output market in minutes	1.27	1.63
Lndistvi	Natural logarithm distance to vine source in walking minutes	3.19	0.81
Favrt-K	Dummy variable=1 if Kabode is the most preferred variety, 0 otherwise	0.21	0.41
Favrt-J	Dummy variable=1 if Jewel is the most preferred variety, 0 otherwise	0.06	0.23
Favrt-E	Dummy variable=1 if Ejumula is the most preferred variety, 0 otherwise	0.04	0.19
Favrt-NP	Dummy variable=1 if New Polista is the most preferred variety, 0 otherwise	0.36	0.48
Favrt-NU	Dummy variable=1 if New Ukerewe is the most preferred variety, 0 otherwise	0.18	0.38
Yld2	Dummy variable = 1 if respondent strongly agrees or agrees that OFSP yield more than OFSP, 0 otherwise	0.58	0.49
Yld1	Dummy variable = 1 if respondent strongly agrees or agrees that WFSP yield more than OFSP, 0 otherwise	0.42	0 .49
Tast1	dummy variable =1 if respondent strongly agrees or agrees that OFSP taste better than WFSP, 0 otherwise	0 .73	0.45
Tast2	dummy variable =1 if respondent strongly agrees or agrees that WFSP taste better than OFSP, 0 otherwise better than those that are orange inside,0 otherwise	0.27	0.45
Sale	Dummy variable=1 if sweetpotato was grown for sale	0.36	0.48
OFSP-experience	Dummy variable=1 if grew OFSP in 2010, 2011, or 2012	0.96	0.21
Non-OFSP-experience	Dummy variable=1 if grew Non-OFSP in 2010, 2011, or 2012	0.79	0.41

Source: Survey results (2014); * The exchange rate at the time of this study was 1USD = Tsh 1750; ** Computed following McCulloch and Ota [26]

Table 2
Determinants of willingness to pay for clean planting materials among Tanzanian sweetpotato growers: results of SURE regression (N=450)

Variables	WTP Kabode coeff.	Std. Err	WTP Jewel coeff.	Std. Err	WTP Ejumula coeff.	Std. Err	WTP New Polista coeff.	Std. Err	WTP New Ukerewe coeff.	
	Gender	0.12	0.242	0.12	0.289	-0.05	0.286	-0.22	0.217	
0.25	0.277									
Education	0.01	0.035	0.01	0.042	0.02	0.042	0.04	0.032	0.04	0.041
.Numchild	0.22	0.096**	0.33	0.115***	0.36	0.114***	0.14	0.086	0.26	0.110 **
Lnage	0.75	0.293***	0.21	0.350***	0.02	0.346**	0.63	0.263***	0.67	0.336**
Yield	0.80	0.218***	1.01	0.260***	1.31	0.257 ***	-0.45	0.195**	-1.17	0.249***
Favourite variety	1.03	0.198***	0.80	0.334**	1.56	0.406***	0.70	0.174***	0.10	0.221
Lncropinc	-0.03	0.015 *	-0.01	0.018	-0.04	0.018 **	-0.02	0.013*	-0.02	0.017**
Ln distmkt	0.19	0.075***	0.13	0.090*	0.15	0.089 **	0.15	0.068**	0.25	0.086***
Asset index	0.12	0.049**	0.12	0.059**	0.09	0.058	-0.01	0.044	0.00	0.057
Lndistvi	0.06	0.132	0.21	0.158*	0.01	0.156	0.12	0.119	0.06	0.152
Taste dummy	0.12	0.240	0.39	0.286	0.61	0.283**	0.34	0.215*	-0.38	0.275
Sale dummy	0.35	0.240	0.00	0.287	0.42	0.285	-0.10	0.216 -0.31	0.276	
OFSP-Experience	-0.30	0.302	-1.65	0.359**	-0.97	0.356	-1.03	0.270**	-0.86	0.345
Non-OFSP-Experience 0.50	1.047*	1.03	1.252***	1.06	1.239***	0.78	0.941***	0.84	1.202**	
Constant	0.99	1.447	-0.63	1.730	-0.09	1.712	3.27	1.312*	2.88	1.671

***; **; * = significant at the 1%, 5%, and 10% level,

variety. They indicate that the higher the distance to source of vines, the greater the willingness to pay for clean planting materials of the Jewel variety, other things constant.

The results of the willingness to pay for the clean planting materials of the white-fleshed sweetpotato (WFSP) varieties are presented in the last two columns of Table 2. They bear much similarity to the results of OFSP varieties. In particular, farmers' perceptions about yield, level of income from crop sales, distance to market, and the years a farmer has experimented with non-OFSP all affect the willingness to pay for both New Polista and New Ukerewe, just as it was the case with the OFSP varieties.

Discussion

In this section we discuss the key findings above. Starting with the model for WTP for Kabode, the findings demonstrate thathouseholds with higher number of children under 5 years of are willing to pay higher amounts for the clean planting materials of Kabode. This may be due to the fact the project emphasized the importance of OFSP to children under 5 years of age due to the elevated need of such children for vitamin A. Similarly, age of the respondent also increased the willingness to pay for clean planting materials of Kabode. An increase in the age of the respondent by one unit increased the willingness to pay for the clean planting materials of the Kabode variety by 0.76, other things constant. This suggests that older farmers are willing to pay more for clean sweetpotato planting materials than the younger farmers. This is probably because older farmers are more likely to be caregivers of young children (under the age of 5 years) and therefore would be keen to plant OFSP varieties to feed the children. However, Zawedde et al [41] note that beyond 50 years, farmers are less likely to adopt new varieties of sweetpotato in general, preferring instead to maintain the old varieties they like because of taste and other varietal attributes. The finding that age is positively correlated with the adoption of Kabode upto a certain point has implications for the targeting of farmers. It indicates that adoption of Kabode is likely to be higher among farmers that are neither very young nor very old. This could be because younger farmers consider sweetpotato in general as a low value subsistence crop. This finding clearly underscores the importance of educating farmers about the OFSP is nutritious food that can be sold distinctively as healthy food hence can fetch higher prices. The finding that asset ownership is associated with adoption of Kabode vines could be because farmers are not used to buying vines and therefore putting the poor respondents off. That is, this study find wealth has an effect on adoption of Kabode vines. It is therefore important that pricing of vines takes this into account in order not to marginalize the poorer farmers. It also suggests that farmers with more assets see much more value in purchasing and growing a variety of sweetpotato that is nutritionally enhanced.

Results however show that income earned from the sale of crops has a negative effect on willingness to pay. Indeed, the income elasticity of demand is -0.03, suggesting that as the households get higher incomes, they are likely to shift from buying Kabode vines to other consumption purchases. This finding is in line with the consumer literature which indicates that consumer shift from consuming staples (in this context, boiled sweetpotato roots) to processed foods such as bread. This consumption shift is expected to result in less demand for clean vines of Kabode variety. These results are comparable with those of Mukras et al [29] whose analysis of demand for sweetpotato at the farm found that 1% change in the consumers' incomes resulted in a decrease in demand for sweetpotato roots by 0.309%. The finding shows that as incomes rise, consumers are likely to shift consumption away from OFSP. While this has been reported for sweetpotato in general, the implies the need to educate consumers about the superior nutrition attributes of OFSP. Indeed, farmers who had experimented with non-OFSP during the project were willing to pay more for Kabode, which implies that the demonstration effect of observing the performance of Kabode vine, and the information on benefits of OFSP received from the project, increased its demand.

Turning to the next two OFSP varieties, namely Ejumula and Jewel, we find different effects on income on adoption of Ejumula and Jewel. While the level of income earned from crop sales affect the willingness to pay for Ejumula vines, it has no effect on the willingness to pay for Jewel vines. This suggests that the respondents did not perceive Jewel vines to be superior to others, and therefore, statistically, were not willing to pay a higher price for them than they would pay for the local varieties. The direct relationship between willingness to pay for vines and distance to vine source is expected. Distance to source of vines determines transport and other transaction costs of access to this input, therefore, it is expected that when farmers face high costs of getting the other sources of vines, they will turn to buying it when more readily available, for instance at a nearby multiplier. The results further show that taste of cooked OFSP roots affects the willingness to pay for clean planting materials of the Ejumula variety but has no effect on the willingness to pay for the vines of other OFSP varieties. They imply that farmers are willing to pay a higher price for Ejumula vines due to its taste. Moreover, the results demonstrate that the number of years a farmer experimented with OFSP over the project life has weak but significant effect on the willingness to pay for Jewel vines but not on Ejumula or the rest of the OFSP varieties. This finding implies that experiencing and observing the performance of OFSP in the field increases the demand (i.e., WTP value farmers attach to the Jewel variety). That is, farmers will be more likely to adopt Jewel only observing how it performs in the field.

Lastly, considering the results of the models estimated for the non-OFSP varieties, findings showed that while perceptions about yield increased the willingness to pay for the OFSP varieties, it was inversely related to the willingness to pay for New Polista and New Ukerewe. This finding may be due to the fact that farmers grow these non-OFSP varieties because of their superior sensory attributes rather than yield. Indeed, yield tended to be lower for these non-OFSP varieties due to pest and disease infestation of the vines Between the two WFSP varieties, the findings suggest that taste of the roots increases the willingness to pay for clean vines of New Polista but has no effect on New Ukerewe. This finding indicates that even within

the WFSP varieties, consumer demand for the vines is by the taste of roots. It implies that breeding whether for orange-fleshed or non-orange-fleshed varieties should pay close attention to this sensory attribute. On the contrary, the number of children under five years old in the household increases the willingness to pay for clean vines of New Ukerewe but has no effect on the New Polista. This finding, though similar to those of Kabode, is likely to be due to a different reason. The positive relationship between number of children and willingness to pay for New Ukerewe variety probably because of the food security role sweetpotato plays in general. A large-sized family may therefore want to plant more vines/sweetpotato hence the higher WTP for vines. Sweetpotato can store in the ground deep into the dry season thus providing food during times of the major staples As expected, results further indicate that number of years that the farmers had experimented with OFSP has negative effect on willingness to pay for New Polista but does not influence willingness to pay for New Ukerewe. This finding implies that farmers who have experienced the benefits of OFSP have a lower demand for planting materials of WFSP. It underscores the importance of demonstrating the performance and benefits of OFSP varieties if their adoption is to be improved.

Conclusions and implications

This study assessed smallholder farmers' willingness to pay for clean sweetpotato planting materials. It finds that, among the orange-fleshed sweetpotato (OFSP) varieties, Kabode vines have the highest willingness to pay hence is the most preferred, and that white-fleshed sweetpotato (WFSP) varieties still dominate OFSP in terms of popularity. The study concludes that demand for OFSP vines is high, as evidenced by the high willingness to pay. However, farmers are willing to pay significantly more for non-biofortified sweetpotato varieties than for biofortified varieties. These findings imply that the attributes of sweetpotato is of great importance in the adoption of OFSP varieties. They imply the need for greater effort in educating farmers about the importance of good nutrition and benefits of OFSP. The finding that taste significantly affects willingness to pay implies the need to focus breeding efforts in producing OFSP varieties that appeal to farmers in terms of taste.

Declaration of competing interest

None

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