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Factors driving adoption and constraining the non-adoption of biofortified orange fleshed sweet potatoes (OFSP) among farmers in Abia State, Nigeria

Jane M. Chah, Ifeoma Q. Anugwa*, Ifeanyi M. Nwafor

Department of Agricultural Extension, University of Nigeria, Nigeria

Abstract

This study sought to determine the factors that drive the adoption and constrain the non-adoption of Orange Fleshed Sweet Potato (OFSP) varieties among farmers in Abia State, Nigeria. Multistage sampling procedure was used in selecting sixty sweet potato farmers (thirty adopters and non-adopters each). Participatory tools such as structured interview schedule, key informant interviews and personal observation were employed for quantitative and qualitative data collection. The data were analysed using descriptive statistical tools like, percentage, mean scores and factor analysis. The results of the study revealed that a greater percent of both adopters and non-adopters of OFSP were males. Although the adopters were older than the non-adopters, they were more educated, cosmopolite, cultivated larger farm sizes, earned more income, had more extension contact and access to credit than the non-adopters. The majority of adopters had high knowledge, while non-adopters had moderate knowledge of OFSP. The adopters were motivated to adopt the OFSP mainly as a result of its pleasant taste, profit from the sale of its roots and vines and not necessarily because of its perceived health benefits of supplementing vitamin A. Perceived constraints to the adoption of OFSP by non-adopters were particularly the complexity of OFSP production techniques and the high cost of OFSP vines and roots. Thus, extension agents should create more sensitisation and provide education about OFSP to farmers. Additionally, concerted efforts should be made by the research institutes to provide adequate and easily accessible inputs (vines and other planting materials) so that more farmers can produce vitamin A rich OFSP.

Keywords: Adoption, constraining factors, farmers, motivational factors, orange-fleshed sweet potatoes varieties, vitamin A

1 Introduction

Sweet potato (*Ipomoea batatas* L.) is a dicotyledonous plant from the morning glory family (*Convovulaceae*), which produce roots that are edible (Yahaya *et al*., 2015). Nigeria is the second largest producer of sweet potato in the world after China with an annual output of 3.46 million metric tons per year (Udemezue, 2019). Sweet potato has the ability to thrive in less fertile soils, but beyond this, the broad agro-ecological adaptability of the crop makes it a food security and staple crop as it can be grown in all of Nigeria's 36 states (eHealth Africa, 2016; Maru, 2017; Sugri *et al*., 2017). As a staple crop, it has been fortified in key vitamins especially vitamin A and minerals whose deficiency in most rural diets continue to pose a very serious constraint to human health and economic development (Global Panel, 2015).

Globally, about 3 million pre-school children have been reported to present ocular signs of vitamin A deficiency (Mendu *et al*., 2019). In sub-Saharan Africa, it has been estimated that 43 million children under the age of 5 are vitamin A deficient (Stathers *et al*., 2018). In Nigeria, the prevalence of vitamin A deficiency (VAD) affects 29.5 % of her population, resulting to the World Health Organization (WHO) listing Nigeria as one of the "category one" countries (eHealth Africa, 2016) with the highest risk of vitamin A deficiency (Kuku-Shittu *et al*., 2016). Vitamin A deficiency is also a major risk factor for pregnant and lactating women and a leading cause of visual impairments such as xerophthalmia,

* Corresponding author – ifeoma.irohibe@unn.edu.ng

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corneal scars and corneal xerosis (Tariku *et al*., 2016). In extreme cases, it leads to premature death in children and pregnant women (United State Agency for International Development [USAID], 2016).

Efforts to control vitamin A deficiency include supplementation and elemental fortification, each of which has been reported effective, but slow in combating the deficiency (Pritwani & Mathur, 2015). In the recent past, emphasis in many countries has been placed on supplementation programs using vitamin capsules. Though effective to an extent, yet, there is need for repeated distribution every six months, which is costly and may not be accessed by some rural poor with impassable roads (Low *et al*. in Yanggen & Nagujja, 2006). Food-based approach (with an exception of animal sources because of unaffordability to most rural communities due to high cost) has been reported as the most sustainable solution to this unenviable situation of food and nutrient deficiency, especially bio-fortification (Van den Berg *et al*., 2007; Pritwani & Mathur, 2015).

Bio-fortification is used to reduce micronutrient deficiency through traditional breeding of certain crops that contain higher levels of essential micronutrients (USAID, 2016). The orange-fleshed sweet potato (OFSP) variety has been biofortified to contain high levels of beta-carotene, the precursor to vitamin A (Global Panel, 2015). A weight of 125 grams of a fresh sweet potato root from most orange-fleshed varieties contain enough beta-carotene to provide the daily pro-vitamin A needs of a pre-schooler (CIP, 2018) and non-lactating women (eHealth Africa, 2016). In addition to addressing VAD, OFSP has a sweeter taste, higher storability, lower fat concentration, higher dry matter content, and higher and fast-maturing yields than other sweet potato varieties (Okello *et al*., 2015; eHealth Africa, 2016; USAID, 2016; van Vugt & Franke, 2018; Neela & Fanta, 2019).

Orange fleshed sweet potato varieties were introduced to the National Root Crop Research Institute (NRCRI) in Umudike, Nigeria from the International Potato Centre, Lima Peru between 2005 and 2006 (Ukpabi *et al*., 2017 in Uzoigwe *et al*., 2019). Information about OFSP varieties have been disseminated to rural farmers in Abia State through the research and extension efforts of the National Root Crops Research Institute (NRCRI), Umudike, and other collaborating institutions. The aim is to encourage farmers to adopt and derive the full benefits of consuming its products. Adoption, is a decision-making process in which the potential adopter takes into consideration various factors before making a choice on whether to adopt an innovation or not (Adekambi *et al*., 2018; Adeola *et al*., 2019).

Given the potentials of OFSP and the level of awareness created by NRCRI and other institutions, it is expected that farmers in Abia State should adopt this variety. However, it is important to note that rural farmers routinely make complex decisions, based on a number of factors, especially regarding agricultural technologies (Asiabaka & Owens, 2002) which may either encourage or discourage its adoption. Loevinsohn *et al*. (2012) further add that farmers' decisions about whether and how to adopt a new technology are conditioned by the dynamic interaction between characteristics of the technology itself and the array of their prevailing conditions and circumstances.

Hence, interplay of several factors could affect the adoption and non-adoption of agricultural technologies. It is therefore necessary to determine factors that influence or constrain its adoption in Abia State, Nigeria. Specifically, the study sought to: ascertain farmer's sources of information on OFSP production; determine knowledge of farmers on OFSP production techniques; ascertain factors motivating farmers' adoption of OFSP and; identify perceived constraints to the adoption of pro-vitamin A biofortified OFSP variety from the perspectives of non-adopters.

2 Materials and methods

2.1 Study area

The study was carried out in Abia State, Nigeria. Abia State is located in the South-East part of Nigeria with its capital in Umuahia, and Aba as the major commercial city. The state has 17 local government areas and a population of 2,881,380 (National Bureau of Statistics, 2007). It has three (3) agricultural zones namely, Aba, Ohafia, and Umuahia; 38 blocks and 228 circles (Igwe & Onyenweaku, 2013). Agriculture is one of the most viable sectors of the state's economy, precisely, in employment generation potentials as well as its contribution to the state's internally generated revenue. As an agricultural state with a rich soil, which stretches from the northern to the southern parts of the state, there is diversified crop production. Also, subsistence farming is peculiar in this part of the country with about 70 % of the population engaging in it; although, a few farmers also produce on a large scale. Farming in the state is determined by the seasonal distribution of rainfall; with few farmers using irrigation. The food crops grown are mainly; yam, cassava, rice, cocoyam, sweet potato and maize while the cash crops include oil-palm, rubber, cocoa, banana and various types of fruits (Abia state government, n.d.). The National Root Crops Research Institute (NRCRI) responsible for the genetics, breeding and field trials of improved crop varieties is located in Umudike, Abia State.

2.2 Sampling procedure and method of data collection

The population of the study comprised all full or part-time farmers who cultivated the various sweet potato varieties either as a major or minor crop. Multi-stage and purposive sampling procedures were used in selecting the respondents for the study. In stage one, two (2) agricultural zones namely; Umuahia and Ohafia were purposively selected due to the preponderance of sweet potato farmers and its relative closeness to National Root Crop Research institute (NRCRI), Umudike which is in charge of the scientific production of the OFSP varieties. In stage two, one block was purposively selected from Umuahia (Olokoro block) and Ohafia (Alam block) zones, respectively because of the concentration of adopters of OFSP, giving rise to a total of two blocks. In stage three, three circles each from Olokoro (Umuda-Ofeme, Umuogu-Ubakala and Umegwu) and Alam (Ndiokorie-Abam, Ozu-Abam and Ndioji-Abam) blocks were selected through simple random sampling technique from the eight circles in each block, giving a total of six circles. In the fourth stage, a list of 45 sweet potato farmers was collected from the Chairman of the Potato Out-grower Multiplier Association of Nigeria (POGMAN), Abia State chapter. Out of the list, twelve (12) adopters of OFSP from within the six circles were purposively selected. It is important to note that not all members of POGMAN had fully adopted OFSP varieties. Some of them were in the trial and evaluation stages of the adoption process. Snowball sampling procedure was used in selecting the remaining eighteen (18) adopters and thirty (30) non-adopters of OFSP from within the selected circles. This gave rise to a total of sixty (60) respondents for the study comprising thirty adopters and thirty non-adopters of OFSP. This study was conducted between March and August 2017.

It is important to note that the adopters who were interviewed for this study were sweet potato farmers who planted the different varieties of OFSP for at least one year based on their awareness of the technology. The non-adopters were sweet potato farmers who are aware of the technology but did not plant the OFSP variety. Also, since the dissemination of OFSP is relatively new (about five years from when the study was conducted), there are few adopters of the technology in the State. Hence, this limited the scope and sample size for the study.

Both qualitative and quantitative data were employed in eliciting responses from the respondents through the use of participatory tools. Qualitative data for the study was collected through in-depth interview with key stakeholders responsible for the scientific production of OFSP vines and dissemination of the technology at the National Root Crop Research Institute, Umudike; extension agents in ADP (Agricultural Development Programme office responsible for the dissemination of scientific technologies to farmers) in Umuahia, Abia State, Chairman of the Potato Out-grower Multiplier Association of Nigeria (POGMAN), Abia State chapter, some key sweet potato farmers (informants) in the communities visited as well as through personal observation. The Information gotten from these sources included, among other things, the start year of the dissemination of OFSP technology, OFSP production technologies disseminated to the farmers, varieties of OFSP vines distributed to farmers and most commonly cultivated ones, specific areas in the State where the technology had been disseminated, number of recorded farmers who have adopted the OFSP variety, etc. Quantitative data for the study was collected from the study population through the use of a structured interview schedule, which was validated by lecturers in the Department of Agricultural Extension, University of Nigeria, Nsukka. The relevant questions addressed in the interview schedule were socio-economic characteristics of the respondents, OFSP production characteristics, knowledge of OFSP production techniques, drivers and constraints to OFSP production.

2.3 Measurement of variables and data analysis

Farmers' sources of information on OFSP technology were measured by providing a list of the various sources of agricultural information. The respondents were required to tick 'Yes' or 'No' against each option. They were also required to indicate their preferred source of information on OFSP. This was eventually ranked in their order of preference.

In order to determine the knowledge of farmers on OFSP production techniques, relevant knowledge statements were drawn. To eliminate guessing by the respondent, the statements were divided into positive and negative statements. A total of 21 knowledge items were employed and the respondents were asked to tick 'Yes' to each correct statement and 'No' to an incorrect statement. Each correct answer had 1 point, the highest score was 21 points and the lowest was 0. Based on the weighting criteria above, the farmer's knowledge of OSFP was categorised as follows: no knowledge (0), low knowledge (1–7), moderate knowledge (8–14), and high knowledge (15–21). The scores were converted to percentages.

To ascertain motivating factors to the adoption of OFSP, the adopters were asked to indicate their opinion on a five point Likert-type scale; to a very great extent = 4, to a great extent = 3, to a moderate extent = 2, to a little extent = 1 and no extent = 0. The mean cut-off point was 2.0. Variables with mean scores equal to and above 2.0 were regarded as motivational factors, while variables with mean scores

less than 2.0 were regarded as non-motivational factors to the adoption of OFSP. To determine perceived constraints to the adoption of OFSP by the non-adopters, the data on this were subjected to factor analysis (Varimax rotation and Kaiser Normalisation where a variable with a loading of 0.4 and above is considered as having a high loading and was used in naming a factor) in other to identify major constraints (Madukwe, 2004). Data for the study were analysed using frequency, percentage, mean scores and factor analysis. The statistical package for service solution (SPSS) version 22 was used in the data analysis.

3 Results

3.1 Personal and socio-economic characteristics of the respondents

The average age of adopters and non-adopters of OFSP was about 54 and 40 years, respectively (Table 1). The majority of both adopters (76.7 %) and non-adopters (63.3 %) were males. For the adopters, the average years spent in formal education was about 13 years, while the non-adopters spent an average of about 11 years. The average household size for both adopters and non-adopters was six persons indicating the probable availability of household labour for the production of OFSP. Also, 36.7 % of the adopters indicated that they cultivated sweet potato as a major crop alongside yam. However, all non-adopters indicated cultivating sweet potatoes as a minor crop. This may be the reason why they have not adopted the OFSP variety. Farmers who did not adopt OFSP may not have found the technology consistent with their needs. The adopters cultivated an average farm size of about 2ha, while that cultivated by the non-adopters was about 1ha. The mean annual income from farm activities generated by the adopters was NGN 458,400.00, while that for the non-adopters was NGN 216,481.48. A relatively higher income earned from farm activities could be the reason for adoption of OFSP by the adopters such that they may have some spare cash to invest in OFSP production.

3.2 Institutional characteristics of the respondents

Table 2 reveals that the majority (80.0 % and 93.3 %) of both adopters and non-adopters did not have access to credit in the past five years for their farming activities. A low percentage (adopters 43.3 %; non-adopters 30.0 %) had contact with extension agents in the past one year. The average number of extension contacts was about five times and three times in the past one year for adopters and non-adopters, respectively. Based on their cosmopolitan outlook, a greater proportion (53.3 %) of adopters went outside their communities to seek for information on OFSP about 2 to 4 times over the past one year. The average of the cosmopolitan outlook was about 5 times. The non-adopters that went out to seek information accounted for 3.3 % with an average of about 3 times. All (100 %) the adopters and non-adopters were members of different social organisations.

Table 1: *Socio-economic characteristics of respondents.*

Variables	*Adopters*	*Non-Adopters*
Age (years)		
<30	-	13.8 %
30-39	6.9 %	37.9 %
40-49	31.0 %	34.5 %
50-59	27.6 %	3.4 %
>59	34.5 %	10.3 %
Mean	*53.93 years*	*40.17 years*
Sex		
Male	76.7 %	63.3 %
Female	23.3 %	36.7 %
Educational status		
No formal education	-	6.7 %
Primary education attempted	3.3 %	3.3 %
Primary education completed	13.3 %	20.0 %
Secondary school attempted	6.7 %	3.3 %
Secondary school completed	16.7 %	33.3 %
Tertiary education	60.0 %	33.3 %
Mean	*12.97 years*	*11.17 years*
Household size (persons)		
1-5	34.5 %	46.7 %
6-10	65.7 %	50.0 %
Above 10	-	3.3 %
Mean	*6.0 persons*	*6.0 persons*
Major crops grown		
Sweet potato	36.7 %	0.0 %
Cassava	46.7 %	80.0 %
Yam	6.7 %	3.3 %
Oil-palm	6.7 %	-
Amaranthus	3.3 %	-
Rice	-	16.7 %
Farm size (hectares)		
Less than 1	63.3 %	70.0 %
1 – 3	23.3 %	20.0 %
Greater than 3	13.4 %	10.0 %
Mean	*1.87 ha*	*1.31 ha*
Estimated annual income from farm activities (NGN)		
Less than 100,000	16.0 %	25.9 %
100,000 – 300,000	44.0 %	51.9 %
301,000 – 500,000	20.0 %	14.8 %
Above 500,000	20.0 %	7.4 %
Mean	*458,400.00 NGN*	*216,481.48 NGN*

Table 2: *Institutional characteristics of respondents.*

Variables	*Adopters*	*Non-Adopters*
Access to credit		
Yes	20.0 %	6.67 %
Sources of credit facilities		
-Institutional-		
Commercial bank	16.7 %	-
Cooperative societies	33.3 %	-
Microfinance bank	33.3 %	100.0 %
-Non institutional-		
Friends	16.7 %	-
Extension contact		
Yes	43.3 %	30.0 %
Number of times visited by extension agent in the last one year		
Less than 2	15.4 %	22.2 %
2-4	69.2 %	66.7 %
Above 4	15.4 %	11.1 %
Mean	*5.00 times*	*3.00 times*
Cosmopolitan outlook in the last one year		
Less than 2	13.3 %	100.0 %
2-4	53.3 %	-
Above 4	33.3 %	-
Mean	*4.47*	*1.00*
Membership of social organisation		
Yes	100.0 %	100.0 %
Type of social organisation		
Farmers group	20.0 %	22.2 %
Religious group	50.0 %	59.3 %
Cooperative/thrift society	26.7 %	7.4 %
Men/women group	-	3.7 %
Political group	3.3 %	7.4 %

3.3 Sources of information on OFSP among farmers

Entries in Table 3 indicate that both adopters (53.3 %) and non-adopters (46.7 %) mainly sourced for information on OFSP from fellow farmers (other sweet potato farmers). It is noteworthy that half (50.0 %) of the adopters also sourced for information on OFSP from agricultural cooperatives. However, it was observed that very few adopters sourced information on OFSP from extension agents, while none of the adopters sourced such information from extension agents.

3.4 Preferred sources of information on OFSP

Table 4 indicates that the adopters most preferred source of information on OFSP was the agricultural cooperative. Others were: fellow farmers (2^{nd}), friends/neighbours (3rd), and research institutes (4^{th}). On the other hand, the non-adopters' sources of information in order of preference were fellow farmers (1^{st}), friends/neighbours (2^{nd}), and radio (3^{rd}).

Table 3: *Sources of information on Orange Fleshed Sweet Potatoes.*

*Sources of information**	*Percentage of respondents*	
	Adopters	*Non-Adopters*
Extension agents	10.0	-
International agencies	3.3	-
Fadama (Project)	6.7	-
Fellow farmers	53.3	46.7
Friends/neighbours	36.7	20.0
Families	3.3	-
Print media	3.3	3.3
Religious organisation	3.3	-
Research institutes	30.0	6.7
Radio	3.3	16.7
Community leaders	6.7	-
Television	6.7	3.3
Agric. Cooperatives	50.0	3.3
Community meetings	6.7	-
Internet	3.3	-
Mobile phone	13.3	-
Input dealers	3.3	-
Market	3.3	20.0

*Multiple responses

Table 4: *Respondents' preferred sources of information on Orange Fleshed Sweet Potatoes.*

Sources of information	*Adopters*		*Non-Adopters*	
	%	*Ranking*	*%*	*Ranking*
Extension agents	6.7	6^{th}	-	-
Fellow farmers	20.0	2^{nd}	46.7	1^{st}
Friends/neighbours	16.7	3^{rd}	20.0	2^{nd}
Research institutes	13.3	4^{th}	6.7	5^{th}
Radio	-	-	13.3	3^{rd}
Television	-	-	3.3	6^{th}
Agric. Cooperatives	33.3	1^{st}	-	-
Mobile phone	10.0	5^{th}	-	-
Market	-	-	10.0	4^{th}

3.5 Knowledge of farmers on production techniques of OFSP

Table 5 shows the percentage of correct answers of the knowledge statements for the production techniques of OFSP by the adopters and non-adopters. From the results,

both adopters and non-adopters (96.7 %) each were highly knowledgeable over the fact that 'propagation of OFSP involves the use of vine cuttings from older plants'. On the other hand, the respondents had least knowledge about 'OFSP grown on a flat ground' (adopters (10.0 %), non-adopters (9.3 %)) and 'ploughing the land before making bed' (adopters (10.0 %), non-adopters (3.3 %)). Generally, high to moderate knowledge was observed for both adopters and non-adopters on OFSP.

Table 5: *Knowledge of adopters and non-adopters on Orange Fleshed Sweet Potatoes production techniques.*

Knowledge statements	*Adopters* %	*Non-Adopters* %
Propagation of OFSP involves the use of vine cuttings from older or mature plant	96.7	96.7
Land preparation for OFSP production involves clearing so as to remove weeds and also limit the impact of some weed-borne pest	96.7	86.0
It is not good to plough the land before making bed	10.0	3.3
OFSP is grown on flat ground	10.0	9.3
It is good to plant OFSP one month before rainy season and without watering.	26.7	5.0
OFSP vines should be planted horizontally in the soil.	73.3	53.3
Plants should be spaced at about 30 cm apart in rows and 100 cm between rows	80.0	70.0
It is good to water OFSP vines after planting to avoid death.	93.3	93.3
It is not good to add manure before planting but can be added after planting.	60.0	56.7
It is good to stop watering one month before harvest to avoid root rot and delay in enlargement of root.	53.3	43.3
Manual weeding is the only means of removing weed.	70.0	70.0
To prevent disease and pest incidence, it is good to rotate OFSP with other crops every year.	70.0	66.7
Planting a green manure crop after harvest helps to suppress any re-growth of weeds and add to soil nutrient.	56.7	60.0
Planting disease free vines cannot control disease	33.3	33.3
Use of every kind of inorganic fertilizer is recommended	20.0	33.3
Earthening-up practice is not good for OFSP production	30.0	43.3
Rain-fed production of OFSP involves planting around February and March	46.7	43.3
It is only long vine cuttings that have 10-20 nodes should be used in propagation	13.3	6.7
Any diseased plant should be treated	93.3	80.0
OFSP is good for harvest 3–4 months after planting.	93.3	86.7
It is better to store OFSP in a less-ventilated place and high temperature.	16.7	16.7

3.6 Knowledge level of farmers on OFSP production techniques

Data in Figure 1 reveal the knowledge level of adopters and non-adopters on OFSP production. The majority (73.3 %) of adopters had high knowledge while 23.3 % of them had moderate knowledge of OFSP production. The remaining 3.3 % of them had no knowledge of OFSP production techniques. On the other hand, the majority (90.0 %) of the non-adopters had moderate knowledge while 10.0 % of them had low knowledge of OFSP production techniques.

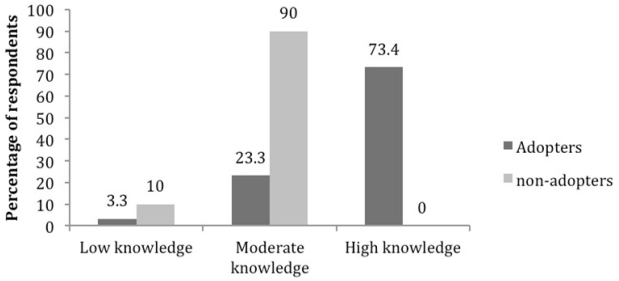

Fig. 1: *Knowledge level of respondents*

3.7 Motivational factors driving the adoption of OFSP

Table 6 shows that the motivational factors that influenced the adoption of OFSP by the adopters were; pleasant taste of OFSP ($\bar{x} = 2.90$), profit from sale of OFSP roots ($\bar{x} = 2.73$) and profit from sale of OFSP vines ($\bar{x} = 2.47$).

3.8 Perceived constraints to the adoption of OFSP among non-adopters

Two factors were extracted based on the item loadings as perceived constraints to the adoption of OFSP by non-adopters (table 7). These are: technological (factor 1), and production/institutional (factor 2). Specific constraints that loaded high under technological factors were; difficulty in integrating OFSP production technologies into existing production system (0.793), high cost of herbicide (0.785), low consumer preference associated with sweet potato product (0.698), high cost of OFSP vines needed for planting (0.623), unpleasant taste of OFSP (0.600), and high cost of inorganic fertiliser (0.438). Under the production/institutional factors, the major constraints were: inefficient transport system (0.836), high cost of labour (0.768), recommended production practices are too complex to carry out (0.756), lack of market to sell OFSP (−0.508) and.

4 Discussion

The non-adopters of OFSP were generally younger than the adopters and as such were predominantly in their eco-

Table 6: *Motivational factors influencing the adoption of Orange Fleshed Sweet Potatoes.*

Variables	*Mean*	*Std. Deviation*
Pleasant taste of OFSP	2.90*	0.583
Profit from sale of OFSP roots	2.73*	0.721
Profit from sale of OFSP vines	2.47*	0.697
High consumer preference	0.77	1.357
Availability of market for the sale of OFSP product	1.27	0.650
Adequate knowledge of OFSP	1.30	1.622
Relative cheaper cost of innovation	0.37	0.999
Simplicity in using the recommended production practices	1.47	1.224
Moderate price of herbicide	0.13	0.507
Moderate price of inorganic fertilizer	0.30	0.952
Access to OFSP vines	0.53	1.224
Availability of OFSP vines	1.20	1.769
Availability of credit	1.83	1.840
Availability of labour	0.63	1.326
Combats vitamin. A deficiency	0.40	1.221
High yield of OFSP	1.95	0.632
Nutrient content of OFSP	0.13	0.730
Other health benefits of OFSP	0.13	0.730

*Mean cut off point ≥ 2

Table 7: *Perceived constraints to the adoption of Orange Fleshed Sweet Potatoes among non-adopters.*

Variables	*Technological*	*Production/ institutional*
Low soil fertility	0.385	−0.018
Low consumer preference associated with sweet potato product	0.698	−0.347
Lack of market to sell increased quantityof OFSP being produced	0.259	−0.508
High cost of OFSP vines needed for planting	0.623	0.322
High cost of herbicide	0.785	0.280
Recommended production practices are complex to carry out	0.236	0.756
Unpleasant taste of OFSP	0.600	−0.160
Lack of capital to carry out necessary farm activities	0.141	0.148
Difficulty in integrating OFSP production technologies into existing production system	0.793	0.006
High cost of OFSP root	0.606	0.284
Lack of knowledge of OFSP	0.220	0.157
High cost of inorganic fertilizer	0.438	0.155
High cost of labour	0.135	0.768
Inefficient transport system	0.114	0.836
Inaccessible road to farmland	−0.028	−0.369

*Varimax rotation and Kaiser Normalisation loading ≥ f 0.4 = High loading

nomically active age who would be more open to accepting innovations. However, since older farmers are more experienced than younger ones, they probably adopted the OFSP variety because of its long-term benefits, especially its health potentials in terms of combating vitamin A deficiency. It was observed that OFSP varieties were adopted by males more than females. Although sweet potato is termed a 'female crop' (due to the fact that men were not interested in harvesting the roots because roots were usually not sold), the lower adoption rate among women may be due to their limited access to information as well as newer agricultural technologies arising from gender inequalities such as time constraints, poor education, lack of decision-making power, access to production resources and socio-cultural values and norms (Mignouna *et al*., 2011; Stathers *et al*., 2018; Theis *et al*., 2018). Educated farmers were found to adopt the improved variety more than the less educated ones. This is not unexpected as education complements ones' ability to receive, decode and comprehend information relevant to making decisions on adopting the OFSP variety. Adeola *et al*. (2019) found that formal education increased the adoption of improved sweet potato varieties among farmers in Nigeria. Although household size generally influences the adoption process positively (Mignouna *et al*, 2011), on the part of non-adopters it was not so in this study. Although they had a large household size, it did not cause them to adopt the OFSP. This situation is addressed by the fact that a single factor does not determine adoption (Rogers, 1995).

Since the adopters cultivated larger farmlands than non-adopters, it increases their likelihood of devoting some portion of their farmland for trying the new sweet potato variety. The smaller farm size cultivated by the non-adopters may constrain them from trying out the new technology. The varieties of OFSP mainly cultivated by the farmers were *King J.*, *Mother Delight* and *Solo Gold.* It is interesting to note that even though the adopters of OFSP had no access to credit, they still produced OFSP variety probably from their personal savings. Contrary to a priori expectations (Orinda *et al*., 2017), the fact that adopters still cultivate the OFSP varieties shows that their continuous interest may be because of the perceived benefits of cultivating OFSP. The probable reason for non-adoption of OFSP by non-adopters may be explained by inadequate finance to cultivate OFSP since it is more expensive to produce than other varieties of sweet potato. The reason, according to the respondents, is that OFSP requires more inputs such as herbicides (due to the need for increased weeding) than other varieties of sweet potato. Although labour may be available because of the large household size of respondents, herbicides were prob-

ably used as available labour for hand weeding might not have been enough. The respondents indicated that extension contacts have been low over the past one year preceding the study; even though the adopters were visited more often than the non-adopters. This may have increased the chances of the former getting information about OFSP. Although OFSP production techniques are not part of the mandates of extension programmes by the ADP, the extension agents interviewed by the researchers noted that they sometimes provided farmers with informal information on the production techniques of OFSP especially when they requested such information. The adopters were more cosmopolite than the non-adopters of OFSP and this supports the fact that cosmopolitans are innovators since they adopt innovation before other categories of persons. They tend to be more open to acceptance of innovation as well. Poojary (2019) highlighted that cosmopolitans are more receptive to innovation and are not hindered by their cultural beliefs.

The dominance of fellow farmers as sources of information on OFSP may be a result of availability and accessibility of information from them. Wabwile (2016) found that fellow farmers were the major sources of information on improved sweet potato varieties to farmers in Kenya. A greater proportion of both adopters and non-adopters sourced for information on OFSP mainly from informal sources (fellow farmers, friends and neighbours). This reiterates the importance of informal sources of information in the dissemination of innovation in rural areas. It was observed that although the adopters mainly sourced information from fellow farmers, a greater number of them preferred sourcing information from the Potato Out-Grower Multiplier Association of Nigeria (POGMAN) – of which they are members. This cooperative society is the agent through which the research institute disseminates the new varieties of sweet potatoes. Agricultural cooperative society, in addition to helping to increase the proceeds of its members, provides them with information on new technologies, market prices etc. During an in-depth interview with the chairman of the cooperative, he said that in the course of their meetings, the farmers got more information about the OFSP variety as well as the effective use of the technology and this facilitated adoption. Information such as the different varieties of the OFSP vines available, where to source for the vines and other inputs, where to sell the product, market price etc were usually communicated to the farmers. The reasons given for preference of agricultural cooperative for information on OFSP by the adopters was that they viewed the source as the most credible, and information received from there was perceived to be effective when applied in the production process. Furthermore, they also learned from one another how to grow and market the OFSP varieties. On the other hand, the non-adopters preferred sourcing information about OFSP from fellow farmers possibly as a result of their easier access to them. Sourcing for information on OFSP may likely reduce the uncertainty about the performance of the variety; hence it may change an individual's assessment from purely subjective to objective over time. Meanwhile, sourcing for information about a technology does not necessarily mean that it will be adopted by all farmers (Mwangi & Kariuki, 2015) since the technology can be evaluated subjectively by them (Uaiene *et al*., 2009).

The adopters were observed to have a relatively higher knowledge of OFSP production techniques than the non-adopters. It is noteworthy that the non-adopters had a fairly high knowledge of OFSP. The probable reason for this is that since most non-adopters cultivated sweet potatoes as a minor crop; their responses to the knowledge questions was not based on OFSP but on their experiences with sweet potato production. This signifies that their inability to adopt is not a function of low knowledge of sweet potato production practices but probably for other reasons. The adopters of OFSP variety with no knowledge of OFSP were part-time farmers who viewed farming as a hobby and not necessarily a means of livelihood.

The adopters generally noted that OFSP had a sweeter taste, was fast maturing and showed higher yields than other sweet potato varieties. Fast-maturing variety makes it possible for farmers to grow 3 to 4 cycles in a year; this increases profit. In congruence to this, Foster & Rosenzweig (2010) highlighted that a key determinant of the adoption of a new technology is the net gain to the farmer from adoption. Stathers *et al*. (2013) also opined that farmers would be motivated to adopt sweet potato varieties with higher yield potential, sweet taste and earlier maturity date, in addition to other favourable characteristics.

A closer look at the major motivating factors for adopting OFSP showed that adopters of the biofortified OFSP cultivate the variety not necessarily because of its health benefits, in terms of combating vitamin A deficiency (which is one of the major reasons for promoting its adoption), but for the sweeter taste and marketing profit. The reason may not be far-fetched. An earlier finding in this study revealed that the farmers mainly sourced information on OFSP from fellow farmers and the later may emphasize the financial benefits of venturing into OFSP production since OFSP has a higher yield potential than the other sweet potato varieties. In agreement, Jenkins *et al*. (2018) reported that farmers in Mozambique were more willing to adopt OFSP because it was increasingly seen as a crop for business given its higher value when compared with white-fleshed sweet potato.

It is important to note that farmers' perception about the characteristics of a technology may either encourage or hinder its adoption (Okello *et al*., 2015). Perceived difficulties inherent in a technology can hinder its adoption. The non-adopters of OFSP cited the complexity of carrying out the recommended production practices of OFSP as well as difficulty in integrating OFSP into their existing production system as major barriers hindering their adoption of OFSP. The cost of the technology is another factor a farmer puts into consideration before adoption. The non-adopters of OFSP noted that the costs of herbicides, OFSP vines and roots discouraged them from adopting it. Since OFSP production requires more weeding than WFSP, it would require purchasing more herbicides to combat weed infestation. In the study area OFSP vines were multiplied and sold in bundles by the Umuahia chapter of POGMAN. Usually, a bundle of OFSP was sold at NGN 500 and several bundles were needed to cultivate a plot. On the other hand, the farmers reported that they do not buy WFSP vines since these mostly grow as weeds on their farms. Orange-flesh sweet potato vines and roots have also been reported to be more expensive than the WFSP varieties in Zambia and Mozambique (Chilala & Kajoba, 2017; Jenkins *et al*., 2018). Thus, from the perspectives of the non-adopters, it is more expensive to produce OFSP than other sweet potato varieties and this discourages them from adopting the variety.

5 Conclusion and Recommendations

Drivers to the adoption of OFSP were profit from the sale of OFSP as well as the pleasant taste of OFSP. The non-adopters were constrained to produce OFSP due to technological and production-related constraints, particularly perceived complexity of OFSP production techniques and high cost of OFSP vines and roots Government should include OFSP in the mandate of extension and provide adequate incentives to them so that they can give the right information, materials and tools to farmers in order to promote OFSP production. Also, farmers should be properly educated by extension agents on the benefits and advantages of OFSP especially as it concerns reducing VAD deficiency among pregnant women and children under five years of age. This may encourage more farmers to start full-scale production of OFSP. Concerted efforts should be made by the research institutes and other collaborating agencies to ensure the timely and easily accessible production inputs (vines and other planting materials).

Since informal sources of information, such as fellow farmers and friends/neighbours, were more frequently used by the farmers, it is important for research institutes and extension agencies to consider their impact and influence in the diffusion of OFSP innovation.

Conflict of interest

Authors state they have no conflict of interests.

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