Vol. 12(1), pp. 50-58, January-March 2020
DOI: 10.5897/JDAE2019.1117
Article Number: 585585763325
ISSN 2006-9774

http://www.academicjournals.org/JDAE

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Journal of Development and Agricultural Economics

Full Length Research Paper

Assessing the likelihood of adoption of orange-flesh sweet potato genotypes in Sierra Leone

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Received 12 September, 2019; Accepted 6 January, 2020

The adoption of research outputs to bring the desired impacts is a major factor of any research work. Based on this premise, adoption likelihood analysis was used to determine the maximum likelihood of adoption of orange flesh sweet potato (OFSP) in Sierra Leone. The study was conducted in Western Area, Moyamba, Bo, Kenema and Bombali districts. A multi-stage sampling procedure was employed to select the study samples. Data was collected from 200 sweet potato farmers using android devices programme with the Census and Survey Processing System (CSPro 6.3) software package. Descriptive statistics was used to analyze the awareness and level of cultivation of OFSP genotypes and inferential statistics to determine the maximum likelihood (rate) of adoption. From the results, there is a high level of awareness (57.7%) of OFSP genotypes by sweet potato farmers within the treatment communities as opposed to farmers in the control communities (19.2%). The high level of awareness of OFSP genotypes by the farmers within the treatment communities is as a result of the establishment of SLARI trials and with frequent discussions taking place between farmers, research scientist and technicians. The results of the adoption likelihood analysis showed that different maximum adoption rates can be achieved by combining different dimensions in the three-function adoption likelihood model. Based on the farmer's category, production goals and environments model, OFSP genotypes are likely to be adopted by farmers in the study area (MAR = 98.04%). However, the adoption rate is likely to be higher for farmers who prefer improved varieties, mainly cultivating for income, and have access to both upland and lowland ecologies. Therefore, those recommended factors should be considered in the future planning for OFSP interventions in Sierra Leone.

Key words: Adoption, likelihood analysis, orange flesh sweet potato (OFSP) genotypes, treatment communities, control communities.

INTRODUCTION

Sweet potato (*Ipomoea batatas* L. Lam) is currently ranked among the most tenth important crop in the world

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with a total production of 103 million tonnes in 2013. It also ranked as the 3rd largest cultivated root crop (7.9 million ha) after potato and cassava worldwide (Sugri et al., 2017). In the area of cultivation, the crop has a good adaptive ability due to the short growth cycle and ability to survive in diverse agro-ecologies, marginal lands and water stress soils (Sugri et al., 2017).

Sweet potato is an important food crop in sub-Saharan Africa (SSA) providing an affordable source of energy and nutrients. In many countries in sub-Saharan Africa (SSA) the preferred types of sweet potato are those that are higher in dry-matter content (28 - 30%) and have little to no sweetness (Mwanga et al., 2007). The leaves are a source of protein, containing 2.7 to 3.4 g/100 g of raw fresh leaves (Kanju, 2000) and it also contains a substantial amount of beta-carotene (-800 mg/100 g) contributing as much as 86% of the daily dietary requirement in Asia and 80% in Africa (Oke, 1990). The leaves can be used as vegetable and roots utilize in various forms for consumption which will also contribute towards food security.

Sweet potato has become the second most important root crop after cassava in Sierra Leone. About 4.2% of agricultural households in the entire country is involved in sweet potato cultivation scattered all over the 14 districts and can thrive in all the five agro-ecological zones and cultivated, both upland and lowland. This was made up of 2% in the Northern region, 1% in the Eastern region, 0.9% in the Southern region and 0.3% of agricultural households in the Western region (Gboku et al., 2017). The importance of sweet potato in Sierra Leone cannot be overemphasized. It has been a poor man’s food and substitute food crop especially where the first (rice) and second staple (cassava products) are not available. The roots can be consumed in different forms: boiled, fried as chips, roasted, and often made into porridge in Sierra Leone. On the other hand, the leaves are widely used in traditional dishes and are also rich in micro nutrients.

Currently, Sierra Leone produces 132,214 tonnes in 30,656 ha from 1995 to 2016 (FAOSTAT, 2018). This production level shows that sweet potato production in Sierra Leone is very low as less than 10% of the total 5.4 million ha of land cropped in every year compared with cassava and rice. This is because women farmers are the primary producers and suppliers of sweet potato planting materials, as well as the custodians of sweet potato knowledge in the local sweet potato system in Sierra Leone. Most of the smallholders’ farms are between 0.1 and 2 ha with less use of inputs (Agrochemicals and Machineries) and recommended agronomic practices.

In Sierra Leone, breeding efforts on sweet potato at Njala Agricultural Research Canter (NARC) in past several years was focused mainly on white flesh sweet potato varieties. Orange Flesh Sweet Potato genotypes were only introduced at NARC in the late 2013 that have high levels of β-carotene and have the potential to alleviate vitamin A deficiency (VAD) in children and lactating mothers. These genotypes were characterized and evaluated during the 2014 and 2015 cropping seasons at the on-station research site at Njala before multi-locational evaluation during the 2016 cropping season in all the agro-ecological zones in Sierra Leone. After evaluation, 3 elite OFSP genotypes were selected based on their resistance to pest and disease, root yield, organoleptic quality and carotenoid content and other desirable consumers’ characteristics. These genotypes with the popular white fleshed sweet potato (as checks) were further evaluated through farmer-led participatory on-farm trials under fertilized and non-fertilized conditions in the 2017 cropping seasons.

Sierra Leone has the fifth highest child mortality rate and malnutrition in the world, and 17% of children aged six months to five years of age suffer from VAD (R). Lack of VAD can lead to blindness, and also increase the risk of illness and death from malaria and measles (R). Therefore, OFSP has been proven to combat VAD, malnutrition, and many other illnesses in under-five children, pregnant women and lactating mothers (NBS, 2011; CIP and HKI, 2014). In Sierra Leone, sweet potato is widely eaten by almost every household; hence, having a variety with such nutrient component could be a double advantage. It is a situation where a food-based vitamin A supplement is compared to capsule based; where the latter is becoming more expensive. Moreover, cost-effectiveness is based on the fact that it can be grown in all agro-ecological zones within Sierra Leone and can easily be accessed and utilized by poorest households who are mostly affected by VAD due to poor dietary intake. The adoption of OFSP genotypes for production and consumption is seen as the opportunity which could not only provide the significant micro nutrients of vitamin A but also more cost-effective compared to the VAS programme (Utoni, 2016).

Despite the desirable characteristics of OFSP, competition with white fleshed sweet potato (WFSP) varieties that farmers are already growing will be obvious when introduced. Adoption of research outputs to bring the desired impacts is a major factor of any research work (Knowler and Bradshaw, 2007).

However, the level of adoption of agricultural technologies in most developing countries is low and depends on the number of factors. Even though there are studies on adoption of agricultural technologies, but Socioeconomic characteristics associated with adoption do vary with time and space (De Graaff et al., 2008). Hence, circumstances in the target research areas, farmer’s practices, resources availability and uses need to be thoroughly analyzed to minimize incidences of low adoption. According to Tenge et al. (2013), most adoption studies have been done after the introduction of the technology (ex-post). The value of such studies can be added if factors for adoption of a certain technology can be identified before introduction (ex-ante), as it will be possible to take necessary measures and increased adoption.

For appropriate and sustainable agricultural innovation, it is essential that efforts be made to ensure that recommended agricultural technologies will be adopted by the intended farmer categories within the recommendation domains. The eventual adoption of the recommended technologies should be the constant concern of the research in all its various phases. Based on this premise, adoption likelihood analysis was the tool used to determine the maximum likelihood of OFSP genotypes adoption in Sierra Leone. The objectives were awareness and source of information of OFSP genotypes, level of cultivation of OFSP genotypes, dissemination of OFSP genotypes to other farmers and analysis of maximum possible adoption rate of OFSP genotypes.

METHODOLOGY

Description of study locations

The study was conducted in five (5) districts in Sierra Leone such as Western Area, Moyamba, Bo, Kenema and Bombali districts (Figure 1). The criterion for selecting those districts was based on the Njala Agricultural Research Centre (NARC) on-station and on-farm research activities on the OFSP genotypes. Due consideration was also given to the delimitation agro-climatic zone in the country during the establishment of the on-station and on-farm trials. Within those districts, we have both the treatment and control communities where the focus group discussions (FGDs) and individual interviews were conducted.

Sampling procedures

The sampling scheme designed for this study by the team was economical, easy to operate and provide unbiased estimates with small variance. The sampling frame consists of sweet potato producers in Sierra Leone (Table 1).

Sweet potato producers were selected using a multi-stage sampling procedure. The first stage involved the selection of districts and chiefdoms for both the treatment and control communities using the purposive sampling technique. The selection of the treatment communities was based on NARC research activities on OFSP genotypes within the country and the control communities, based on volume of sweet potato production and their proximity to the treatment communities, but at different chiefdoms. A total of five (5) districts and 30 communities (15 for the treatment and 15 for control communities). Purposive sampling technique has been recommended in social research as it focuses directly to the area intended to be studied (Kothari, 2004).

The second stage involved the selection of respondents from the selected communities. A total of 200 respondents were sampled (100 respondents for the treatment and 100 for control communities) for individual farmer's interview, and a total of 10 communities for the FGDs. Two (2) communities were randomly selected for individual interviews and the one (1 community selected for FGD in both the treatment and control communities within each of the five districts). Listing of sweet potato producers was done in each community and the individual interviews were held. Ten respondents were randomly selected from the list of producers for individual interviews using structured questionnaires in each community.

Data collection

This study entails primary and secondary data. Primary data involves both qualitative and quantitative which was collected through conducting field interviews: focus group discussions, individual interviews, personal observation, while secondary data was collected from scientific reports, maps and statistical abstracts used as additional sources of data (Saunders et al., 2004). The individual interviews were conducted with android devices programme with the Census and Survey Processing System (CSPro 6.3) software package. The process is called electronic data capture. The total number of 15 team members was involved during the data collection process. The type of data collected includes awareness and level of cultivation, source of information, willingness, and means of disseminating and maximum likelihood (rate) of adoption of OFSP genotypes.

Data analysis and presentation

Qualitative data from FGDs was analyzed using non-statistical methods. This involved extracting the information and clustering it into themes and sub-themes and ranking according to priorities, weights or proportional of responses in a certain category to support the individual interviews (Bryman, 2012). Quantitative data from household individual interviews was exported from CSPro to various statistical packages such as Statistical Analysis Systems (SAS 9.3), Microsoft Excel 2010 and Statistical Package for the Social Sciences (IBM SPSS Statistics 2) for analysis using different analytical tools in statistics.

Descriptive statistics (frequency and percentages) in the form of tables and charts was used to analyze quantitative data related to the respondent's awareness and level of production, source of information, willingness, and means of disseminating OFSP genotypes. Inferential statistics (maximum adoption rate) was used to predict the likelihood or rate of OFSP adoption.

Based on the characteristics of targeted sweet potato growers, it is possible to calculate and predict their maximum adoption rate before any action is undertaken to test or diffuse it. This priority estimation needs a good understanding of the producers' population, and the production goals for which the genotypes are meant to be. Likelihood to adopt the OFSP genotypes was analyzed using a three functions adoption model (Sheikh et al., 2006). The adoption model assumed that technology adoption is a function of the relationship between farmer's category, production goals and production environment and summarized in the following equation:

$$MAR = \frac{\{cf(i,n) * gf(i,n) * ef(i,n)\}}{10000}$$

where MAR = Maximum adoption rate (%) $cf(i,n)$ =Frequency of farmer categories (%), $gf(i,n)$ =Frequency of Production goals (%), and $ef(i,n) = \text{Frequency of production envrionment}$ (%).

Two categories of farmers were identified based on the type of sweet potato variety preferred (local and improve), three production environments based on the ecologies for sweet potato cultivation (upland only, IVS only, and both upland and IVS) and two production goals based on the reasons for growing sweet potato (food security and income generation) were identified in the study

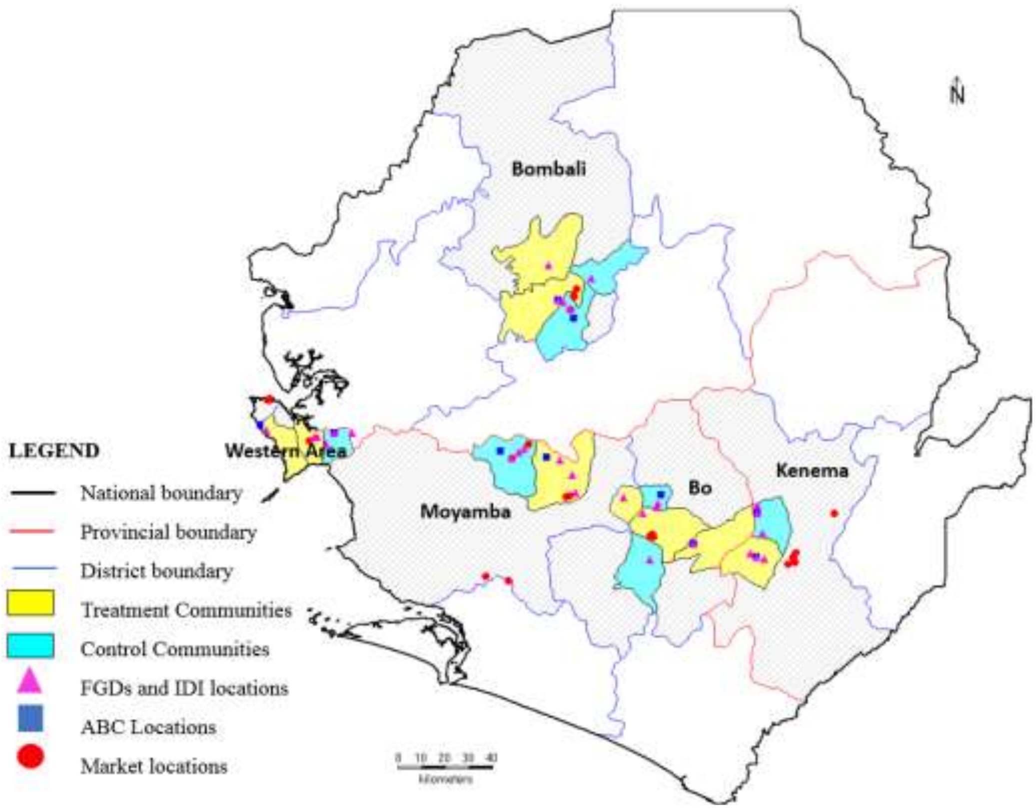

Figure 1. Map of Sierra Leone showing study locations.

Table 1. Sample size of the study.

Data collection method	Sweet potato actor	District					Total
		Moyamba	Bo	Kenema	Bombali	Western Area	
Individual interviews	Producer	40	40	40	40	40	200
FGDs	Producer	2	2	2	2	2	10

Source: Survey Data (2018).

area.

RESULTS

Awareness and source of information of OFSP genotypes

The level of awareness and source of information of OFSP varieties is illustrated in Figure 2. Majority (57.7%) of the farmers in the study area are aware of OFSP genotypes. 70% were aware of Chipka, 65% aware of Kaphulira and 60% aware of Mathuthu. In the control area, 19.2% of sweet potato farmers are aware of OFSP varieties. Twenty-five percent (25%) of these farmers are aware of the three OFSP genotypes. The major source of information for OFSP varieties of the treatment areas is from Research Institutions (75%). In the control areas, 15% access information from Research Institutions, followed by family/friends (5%) and other sweet potato growers (5%).

Level of cultivation of OFSP genotypes

The result in Figure 3 indicates that 50% of the farmers in the treatment areas have planted OFSP genotypes whilst 15% within the control area. Within the treatment, 53.9% of the farmers planted Mathuthu, 46.2% planted Chipka and 23.1% planted Kaphulira whilst 23.1% planted each of the OFSP genotypes in the control area. 38.5% of respondent planted at least one of the OFSP genotypes

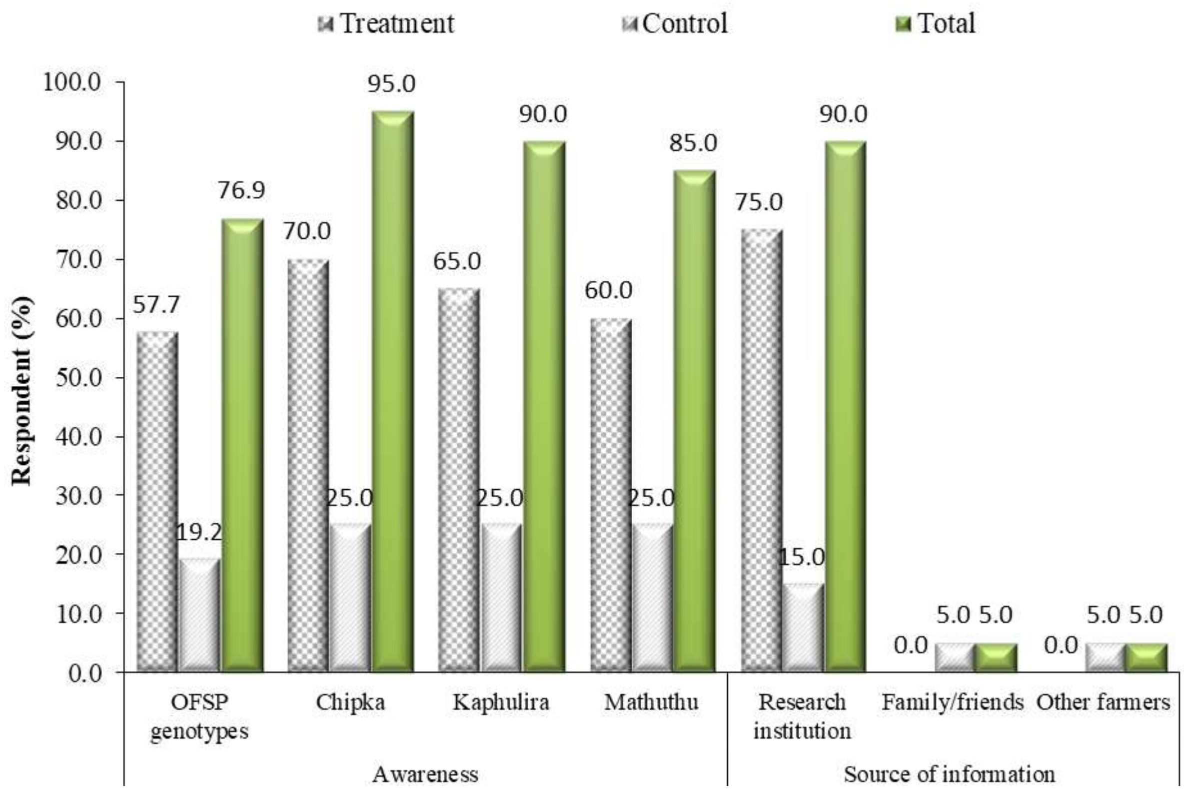

Figure 2. Awareness and source of information of OFSP genotypes.
Source: Survey Data (2018).

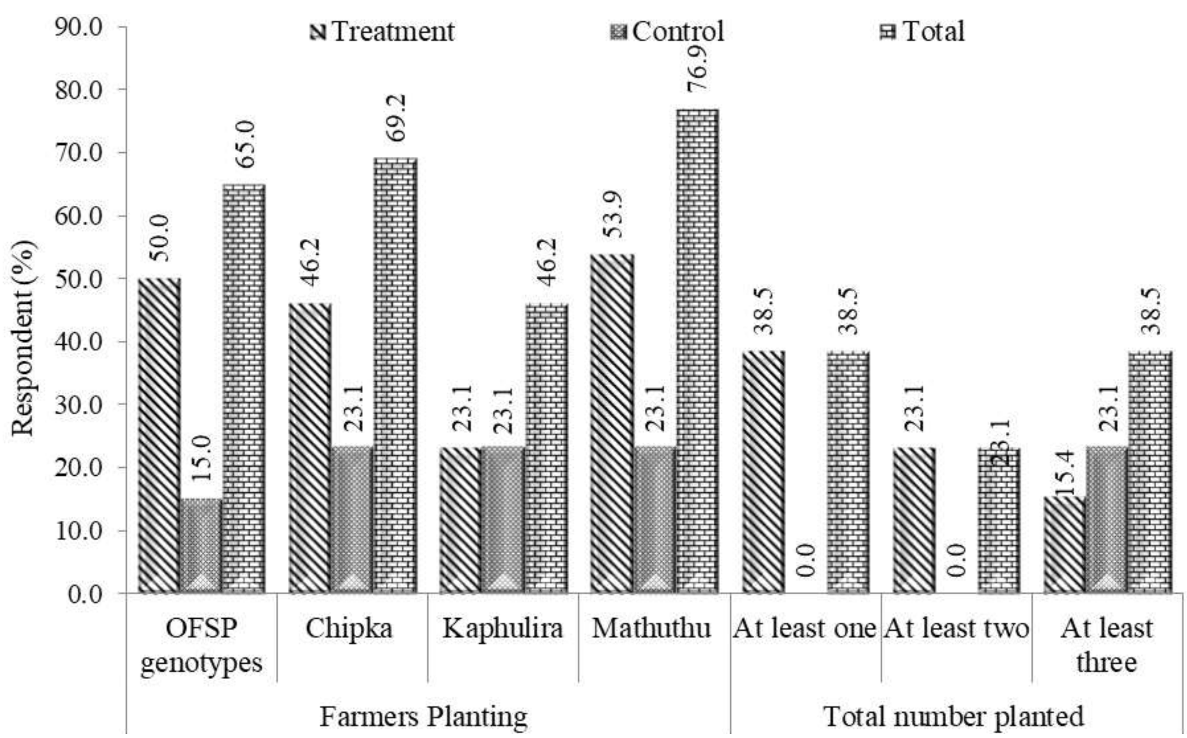

Figure 3. Level of cultivation of OFSP genotypes.
Source: Survey Data (2018).

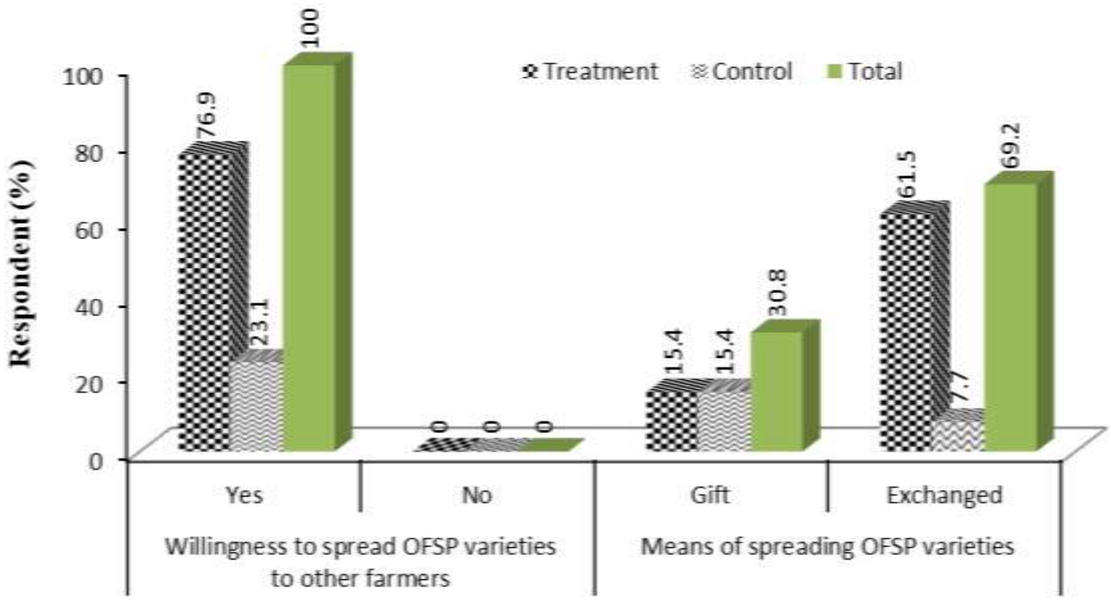

Figure 4. Dissemination of OFSP genotypes between farmers.

(Treatment areas only), 23.1% planted at least any two of the OFSP genotypes (Treatment areas only) and 38.5% planted all the three varieties (23.1% for control and 15.4% treatment areas).

Dissemination of OFSP genotypes between farmers

The total number of farmers who have already planted the OFSP genotypes during the 2017 cropping seasons in both the treatment (76.9%) and control areas (23.1%) are willing to spread the OFSP genotypes to other farmers through the exchange of materials (69.2%) and gift (30.8%). All the farmers who have not planted any of the OFSP genotypes will be willing to plant the OFSP genotypes if they have access to the vines (Figure 4).

Maximum likelihood (rate) of adoption of OFSP genotypes

The result of the maximum adoption rates for different scenarios that are based on the farmer's category, production goals and environments is illustrated in Table 2.

Scenario 1

Using farmers' category (Type of preferred variety for planting), sweet potato varieties which are applicable for two production goals (1 and 2) and two production environment (1 and 3) will have a maximum adoptions rate of 4.45% by category A farmers and 93.59% by category B farmers. This accumulates to a total maximum adoption rate of 98.04%.

Scenario 2

Using farmers' category (type of preferred variety for planting), sweet potato varieties which are applicable for production goal two and production environment three will have a maximum adoptions rate of 1.63% by category A farmers and 47.18% by category B farmers. This accumulates to a total maximum adoption rate of 48.81%.

Scenario 3

Using farmers' category (type of preferred variety for planting), sweet potato varieties which are applicable for production goal two and two production environment (1 and 3) will have a maximum adoptions rate of 2.94% by category A farmers and 71.13% by category B farmers. This accumulates to a total maximum adoption rate of 74.07%.

DISCUSSION

The high level of awareness (57.7%) of OFSP genotypes by farmers within the treatment communities is as a result of the establishment of SLARI trials and with frequent discussions taking place between farmers and research

Table 2. Maximum possible adoption rate of OFSP varieties.

There are two categories of farmers with two production goals and three production environments	
Category A = 4.5%	**Category B = 95.5%**
G_1 = 34%; G_2 = 66%	G_1 = 24%; G_2 = 76%
E_1 = 44%; E_2 = 1%; E_3 = 55%	E_1 = 33%; E_2 = 2%; E_3 = 65%
$C_AG_1E_1$ rate = (4.5 × 34 × 44) / 10000 = 0.67%	$C_BG_1E_1$ rate = (95.5 × 24 × 33) / 10000 = 7.56%
$C_AG_1E_2$ rate = (4.5 × 34 × 1) / 10000 = 0.02%	$C_BG_1E_2$ rate = (95.5 × 24 × 2) / 10000 =0.46%
$C_AG_1E_3$ rate = (4.5 × 34 × 55) / 10000 = 0.84%	$C_BG_1E_3$ rate = (95.5 × 24 × 65) / 10000 = 14.90%
$C_AG_2E_1$ rate = (4.5 × 66 × 44) / 10000 = 1.31%	$C_BG_2E_1$ rate = (95.5 × 76 × 33) / 10000 = 23.95%
$C_AG_2E_2$ rate = (4.5 × 66 × 1) / 10000 = 0.03%	$C_BG_2E_2$ rate = (95.5 × 76 × 2) / 10000 = 1.45%
$C_AG_2E_3$ rate = (4.5 × 66 × 55) / 10000 = 1.63%	$C_BG_2E_3$ rate = (95.5 × 76 × 65) / 10000 = 47.18%
If the technology is applicable to production goals 1 and 2 and for production environments 1 and 3, then MAR = 98.04% (4.45 + 93.59)	
If the technology is applicable to production goal 2 and production environment 3, then MAR = 48.81% (1.63 + 47.18)	
If the technology is applicable to production goal 2 and production environment 1 and 3, then MAR = 74.07% (2.94 + 71.13)	

C_A = Farmer category 1 (% of farmers that preferred to plant local varieties); C_B = Farmer category 2 (% of farmers that preferred to plant improved varieties); G_1 = Production goal 1 (% of farmers for Consumption/Food security); G_2 = Production goal 2 (% of farmers for Market/Income); E_1 = Production environment 1 (% of farmers that cultivate upland); E_2 = Production environment 2 (% of farmers that cultivate lowland); E_3 = Production environment 3 (% of farmers that cultivate both upland and lowland).
Source: Survey Data (2018).

scientist and technicians (75%). From the data and FGDs, the 25% of farmers that are aware of those newly introduced genotypes from the control communities are as a result of high family and friend connection existing between farmers (Figure 2). Therefore, the frequent contact between research officers or extension agents increased the probability of being aware of the newly introduced genotypes. This is in consonance with Simtowe et al. (2012).

Most (65.0%) of the farmers are currently planting or adopting at least one of the OFSP genotypes from those that are aware (76.9%). This indicates that, there is a high tendency of OFSP adoption if farmers are aware or planting materials available because, only 11.9% of farmers are aware but not planting. According to Mbanaso et al. (2012), Bouis and Islam (2012) and Amengor et al. (2018), dissemination efforts should include effective awareness creation about the improved sweet potato varieties across the country for enhanced adoption which is in support of these results. Among the three OFSP genotypes distributed to farmers, Mathuthu (76.9%) is the highest genotype cultivated followed by Chipka (69.2%). The high number of farmers cultivating Mathuthu is as a result of its field performance during the field trails. The agronomic data and FGDs also support why the farmers preferred cultivating Mathuthu (Figure 3).

All (100%) the farmers that has planted at least one of the OFSP genotypes are willing to give to other farmers through exchange (69.2%) and others as form of gift (30.8%) (Figure 4). This is an indication of the weak formal seed systems in Sierra Leone and hence most farmers source their planting material (vines) through the informal seed systems and the strong social ties existing among our farmers which facilitate majority of planting materials (vines) acquisitions/distributions through exchange and gift without cash payment (Adam et al., 2018). The FGDs result also confirms the most common way on how sweet potato farmers obtained their planting materials between themselves which is through exchange and gift. Therefore, the findings provide entry points both for entities that seek to enhance small-scale farmers' access to improved, high quality sweet potato genotypes, as well as broader efforts to strengthen research and development strategies for integrating formal and informal seed systems.

From Table 2, in scenario one (where we have two production goals and two production environment), the total maximum adoption rate is 98.04%; scenario two (where we have one production goal, and one production environment), the total maximum adoption rate is48.81% and scenario three (where we have one production goal and two production environment), the total maximum adoption rate is 74.07%. The results of the adoption likelihood analysis showed that, in situations where there is an interaction between different production environments, goals, and farmer categories, blanket recommendations have low maximum adoption rates. Therefore, to increase the maximum adoption rates, flexible recommendations that combine several-dimensions of the technology are needed. This is clearly shown in the analysis for the different scenarios.

CONCLUSION AND RECOMMENDATION

There is a high level of awareness (57.7%) of OFSP genotypes by sweet potato farmers within the treatment communities as opposed to farmers in the control communities (19.2%). The high level of awareness of OFSP genotypes by the farmers within the treatment communities is a result, the establishment of SLARI trials and with frequent discussions taking place between farmers, research scientist and technicians. Majority of those that are aware and have access to the planting materials are cultivating at least one of those genotypes. The farmers are also willing to give those planting materials (Vines) to other farmers through exchange and gift which is a good indication of high level of OFSP genotypes adoption if disseminated.

The results of the adoption likelihood analysis showed that, different maximum adoption rates can be achieved by combining different dimensions in three function adoption likelihood model. Based on the maximum adoption rate calculations (MAR) between farmer's category, production goals and environments, OFSP genotypes are likely to be adopted in the study area (MAR = 98.04%). However, adoption rate is likely to be more for farmers who prefer improve varieties (MAR = 93.59%) than those who preferred local varieties (4.45%), mainly cultivating for income and have access to both upland and lowland ecologies. Adoption of OFSP genotypes is likely to increase and be sustainable with flexible recommendations that address farmer's criteria, production goals and environments. Therefore, those recommended factors should be considered in the future planning for OFSP interventions in Sierra Leone.

Therefore, SLARI, the National Seed Board and other partners should facilitate the official release of the three OFSP genotypes (Mathuthu, Chipka and Kaphulira) that have been evaluated and selected by the farmers. After the release, development partners and the government agencies working on OFSP to combat VAD among under five children should develop robust promotion and dissemination strategies for out-scaling OFSP genotypes.

ACKNOWLEDGEMENT

The Research team is indebted to Helen Keller International and Irish Aid for their financial support for OFSP Adoption Likelihood studies with particular reference to Mr. Hamid Turay for his assistance in the coordination of the survey. The team is grateful to Sierra Leone Agricultural Research Institute (SLARI) authorities for their technical advice, Dr. Abdul Rahman Conteh (Acting Director-Njala Agricultural Research Centre) and Mr. Moses Joseph Tucker (OFSP former Project Coordinator) for their inputs in this study. They also acknowledge the time and effort provided by many that participated in focus groups and surveys for this project, and thank them for their contributions.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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