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APPRAISAL OF DETERMINANTS OF ORANGE-FLESHED SWEET POTATO PRODUCTION AND UTILIZATION IN ISIOLO COUNTY, KENYA

Kavoo AM[1]*, Mwajita RM[1], Kariuki LW[1] and LM Kiirika[1]

Agnes Kavoo

*Corresponding author email: agneskavoo@gmail.com

[1]Department of Horticulture and Food Security, Jomo Kenyatta University of Agriculture and Technology, P.O. Box 62000 – 00200 Nairobi, Kenya

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ABSTRACT

Micronutrient deficiency remains a leading challenge among children and pregnant women in arid and semi-arid areas (ASALs) of Kenya. An important strategy for supplementing dietary intake of micronutrients, especially vitamin A, is through food fortification. Vitamin A deficiency (VAD) affects 190 million pre-school children and 19 million pregnant women globally. Orange-fleshed sweet potato (OSP) is a rich plant-based source of beta-carotene which is converted into Vitamin A upon consumption and has the potential to alleviate this deficiency among ASALs communities. In this study, household surveys were conducted to profile Orange-fleshed sweet potato (OSP) farmers' knowledge, production practices, constraints, acceptance and willingness to grow OSP in Isiolo County, Kenya. The overall aim of the study was to enhance adoption and improve food and nutrition security. Farmers were purposively sampled depending on their involvement in sweet potato farming for at least one year. A total of 150 farmers representing three wards namely: Burat, Ngaremara, and Bulla Pesa were interviewed. Data were collected using structured questionnaires via face-to-face interviews as well as focused group discussions (FGDs). Collected data was analysed using Statistical Package for Social Sciences (SPSS) software Version 16.0. A total of six sweet potato varieties were grown in the study area. The yellow fleshed variety cultivated by 40% of the respondents was cited as the most palatable variety (60%). Only 52.4% of the farmers were aware of OSP and its benefits with 100% of the farmers willing to grow the OSP varieties. Several constraints were reported to influence production of OSP which included pests and diseases, lack of improved varieties, short shelf life, and lack of market (76.2%, 81%, 71.4% and 61.9%, respectively). The most common forms of OSP utilization were whole cooked products and dual purpose, that is, food and feed (81% and 52% of respondents, respectively). The dual nature of sweet potato utilization suggests a huge potential for up-scaling production to satisfy a demand for dietary diversification, value addition and product diversification and eventual increase in household incomes and reduced resource related conflicts among pastoralist communities.

Key words: Orange-fleshed Sweet Potato, Adoption, Malnutrition, dietary-diversification, Food security

INTRODUCTION

Undernourishment and malnutrition, which are closely related to deficiencies of vitamins and minerals have led to more than two billion people in the world suffering from hidden hunger [1]. A third of the 3.1 million child deaths globally result from under nutrition which is accredited to micronutrient deficiencies [2]. Vitamin A deficiency (VAD) which is caused by inadequate vitamin A rich foods intake, poor vitamin A absorption or loss of vitamin A due to sickness affects 190 million pre-school children and 19 million pregnant women globally [3]. Vitamin A deficiency weakens the immune system of children hence interfering with their health and survival. An effective approach of reducing VAD is through fortification of diets with vitamin A [4].

Food and nutrition insecurity are among the leading challenges facing communities living in the arid and semi-arid (ASAL) areas of Kenya [5]. Isiolo County lies within the ASAL areas in North eastern Kenya, and is dominated by pastoralists (67%) with only 26% agro-pastoralists and the remaining 7% being charcoal/firewood vendors [6]. Low agricultural productivity, prolonged drought and high temperatures, low and erratic rainfall, poverty and conflicts between communities are some of the factors contributing to food and nutrition insecurity in the county [7]. In this county, there has been an increase in Global Acute Malnutrition (GAM) and Severe Acute Malnutrition (SAM). In 2017, GAM was estimated at 18% and SAM at 3.3% as opposed to 2016 where GAM was reported to be 12.3% and SAM at 1.2%, respectively [6]. Severe underweight score has been increasing to the range of 1.7% in 2015 to 4.5% in 2017 regardless of the investments of the ministry of education in school feeding programs [6].

In Kenya, there is a trend to convert previously non-agricultural lands to cultivated land in an effort to reduce chronic food insecurity and loss of livestock through drought. Thus, in Isiolo County, despite the drought status, the livelihoods of the 26% agro-pastoralists who reside in four sub-counties and farm along the Ewaso-nyiro river can be improved through building a climate resilient community. Exploiting this opportunity by growing a variety of drought resistant food and feed crops for dietary diversification could mitigate the problem of food insecurity and malnutrition problems among these communities.

Sweet potato (*Ipomoea batatas* L.), being a drought tolerant crop which grows on marginal lands in SSA, plays a significant role as a food security crop. Its vines and storage roots are utilized in livestock production to supplement animal feeds hence; the crop is an essential component in animal feed industries [7]. Sweet potato is regarded as a climate-smart crop because of its short growing cycle coupled with the ability to grow in harsh environments with little amount of rainfall.

In SSA, sweet potato is ranked third in production after cassava and yams where it is mainly cultivated by small-scale farmers [8]. Between 2012 and 2014, the average annual sweet potato production in SSA was 24.2 million tons of which East Africa

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produced 54%, West Africa, Southern Africa and the Middle Africa produced 21%, 16% and 9%, respectively [9].

In Kenya, sweet potato production is mainly practiced by small-scale farmers concentrated in either arid or semi-arid areas where it is an essential food crop besides maize. The crop is being accepted by many farmers in Kenya due to its ability to yield adequately under unfavorable soil and climatic conditions including low or no external inputs [10]. Its attributes of having a short maturity period, flexible harvesting time and drought tolerance, makes it a suitable household food security crop and thus an essential livelihood scheme for small scale farmers [11]. Sweet potato also plays a key role in addressing food security problem in Kenya as it can be harvested in piece-meal and stored for future use [12].

Sweet potato bio-fortified with beta-carotene, the precursor of vitamin A has the potential to alleviate the VAD within the rural communities in Isiolo County. The bio-fortified sweet potatoes are orange in color, hence the name orange fleshed sweet potato. The roots are a rich source of vitamins A, C, K, E and B and they also provide potassium and phosphorus. OSP vines are also a good source of lutein, calcium, vitamins K and B [13]. In SSA, especially in Eastern, Central and Southern Africa, sweet potato production is dominated by women since the crop is comparatively easy to grow. VAD mostly affects children and women who are the farmers and food preparers [14].

The acceptance, consumption and adoption by farmers of bio-fortified crops with visible traits will determine the success of OSP. This may rely on a number of aspects such as yield, maturity period, taste, nutritive value, disease and pest resistance, growth type amongst others, which the targeted people might consider [15]. A participatory rural appraisal through household surveys was conducted in Isiolo County to profile farmers growing OSP. Farmers' knowledge, production practices, constraints, acceptance and willingness to grow OSP was also assessed. The ultimate goal of this work was to document the constraints of OSP production and overall adoption potential and consequently develop mitigating measures for improving food and nutrition security among the arid and semi-arid agro-pastoralist communities.

METHODOLOGY

Study area: The study was conducted between October and December, 2019 in Isiolo central sub-county covering three wards including; Burat, Ngaremara, and Bulla Pesa. Isiolo county is located in lower eastern region of Kenya and lies on the geographical co-ordinates of 00°21'North and 37°35'East. The area experiences an average annual rainfall of 580.2 mm with short rains between October and December and long rains between March and May and with the wettest months being November and April [16].

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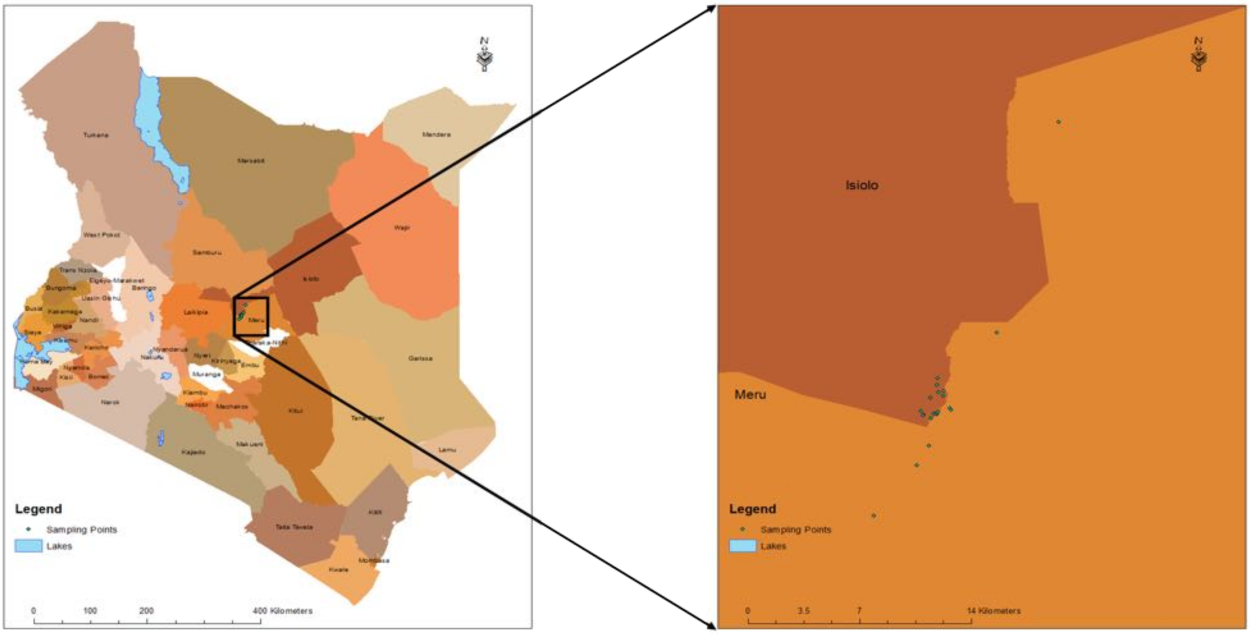

Figure 1: Map of Isiolo County-Kenya showing the household survey study area

Field survey and data collection

Household surveys were conducted in selected wards in Isiolo County including Burat, Ngaremara, and Bulla Pesa representing the three sub-counties in Isiolo. Farmers were purposively sampled depending on their involvement in sweet potato farming for at least once a year. A total of 150 farmers representing each of the three wards were interviewed.

Data were collected using structured questionnaires via face-to-face interviews as well as focused group discussions (FGD). The questionnaire was integrated into the Open Data Kit (ODK) application software which has a set of tools used to manage data collection via a mobile phone. The socio-demographic information captured in the questionnaire included age, gender, educational level and household composition. Information on production operations such as seed source, agronomic practices, quantity harvested, storage and utilization, integrated pest management strategies employed farmers' knowledge and perception on OSP and production constraints were also covered. Participatory rural appraisal tool via group discussions was employed to capture other qualitative data.

Data analysis

Statistical analysis of the collected data was carried out using the Statistical Package for Social Sciences (SPSS) software Version 16.0. Data reporting was accomplished through descriptive and inferential statistics which involved the use of frequencies and means. Inferences were drawn from tables, graphs and pie charts.

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RESULTS AND DISCUSSION

Socio-demographic characteristics

Age category and education level

The survey results indicated that farming in Isiolo was practiced by mainly (42.9%) the upper quartile of the middle aged (46-60 years). Only a small percentage of the respondents represented the youth and the elderly (19% and 4.8% respectively) (Table 1). More than half of the respondents (52.4 %) had undergone post primary education training although close to 20% of the respondents indicated that they had never been to school (Table 1). Post-secondary education training is an important parameter in estimating the adoption/ technology uptake potential of a community. It is also important for understanding community training needs and designing training tools and models.

Age and education are important determinants of technology adaptation decisions [17]. In a study evaluating the influence of social capital on climate change adaptation decisions, age and education of the household head was reported to positively influence the probability of taking up adaptation techniques such as agroforestry and irrigation and concluded that older and educated farmers have a higher probability of adopting these techniques than younger and non-educated ones, In addition, the same study by Yaméogo *et al.* [17] reported a significant negative relationship between age and technology adaptation suggesting that farmers of advanced age are less likely to adapt to new technologies. In our study, only a small percentage (4.8% of the respondents) of the elderly farmers was cultivating sweet potato. This finding is consistent with the findings of a study conducted in western Kenya which reported a 2% increase in the odds in favor of not adopting with every one year increase in age of the household head [10]. The study suggested a review of the methods of technology dissemination to make them attractive to both young and old farmers.

Educational status has also been reported to increase the farmers' awareness of the benefits of improved crop varieties to reduce the impact of climate change [18]**.** Other findings [19, 20, 21] similarly reported a higher likelihood of enhanced access to information for improved technology up take and higher farm productivity by farmers with higher education levels.

Gender category

Interestingly, more than two thirds of the respondents were male with only one third representing female-headed households (Table 1). This could indicate the serious involvement of the male gender in farming activities in an area that is culturally and historically dominated by pastoral activities. This could also be an indicator of a social and/or economic shift by the Isiolo county communities from overly pastoralists to crop farmers. The results could also indicate a high likelihood of households to take up OFSP technologies, especially those related to climate change adaptation. Some studies have indicated that male-headed households adapt more readily to climate change [22].

Farm ownership and household farm size
At least two thirds (66.7%) of the respondents were the actual owners of the farms visited during the interview exercise (Table 1). This corresponds to the proportion of males interviewed and could be an indicator of household decision making in regards to farm use.

Farmers were identified to own different land sizes as presented in figure 5 with the largest land size being 12 acres. The average land owned by the farmers was identified to be 2.65 acres. Farm size has a significant influence on farmers' decisions on agricultural diversification and adoption of new agronomic technologies such as crop diversification. Large farm sizes allow farmers to diversify their crop and livestock options and help spread the risks of loss associated with climate change and resource scarcity [23].

Household size
Survey results revealed that most households in Isiolo central sub-county were medium-sized consisting of 5-8 members. Other households were categorized as small (consisting of 1 to 4 members) and a small proportion (4.8%) was categorized as large (having more than 12 household members) (Table 1). Sweet potato farming is less labour demanding and therefore the household size may not influence adoption of OFSP technologies. Household size is, however, a key determinant to uptake of farming practices in labour intensive crops such as finger millet [24].

Sources of income
The main source of household income within Isiolo central sub-county was from crop farming, constituting close to 50% of the total household income (Table 1). This could be indicative of a shift from a traditionally pastoral community to a more settled agricultural community. This forms a good entry point for transfer of crop related technologies and especially for commercially viable commodities. This could also suggest a high likelihood for uptake of improved sweet potato varieties such as OFSP which are perceived to be high yielding and fetch higher prices in the market as compared to local varieties. This could in turn increase household incomes and encourage more investment in the production of the improved varieties and access to in-puts required for enhanced production. Results by Assaye *et. al.* [18] implied that availability of farm income improves farmers' financial position, which in turn, enables them to purchase farm inputs such as, improved seeds and fertilizer. Similarly, other findings [19, 20, 25] have reported that adoption of new crop varieties requires more financial resources than adoption of other adaptation strategies. This could, however, be cushioned by enhanced income from adaptation of the new improved varieties.
The socio-demographic findings can be collated to a study conducted in Ghana on OFSP which revealed a similar trend on the influence of gender, education level and community primary occupation. The study by Sugri *et al.* [26], revealed that sweet potato production was a male dominated activity (85% of respondents) contrary to the common belief that the crop is a 'women crop'. In another study evaluating farmers' perception on OFSP production [27] it was reported that majority of participants (more

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than 90% of male and female participants) rejected the perception that sweet potato is not men's food.

Production systems

Sweet potato farming: farm size and duration

The study revealed that sweet potato was cultivated on various sizes of land ranging from 0.25-12 acres. Majority of the farmers had cultivated sweet potatoes for less than 4 years (Figure 2) suggesting sweet potato farming to be a relatively new agricultural activity among the interviewed farmers.

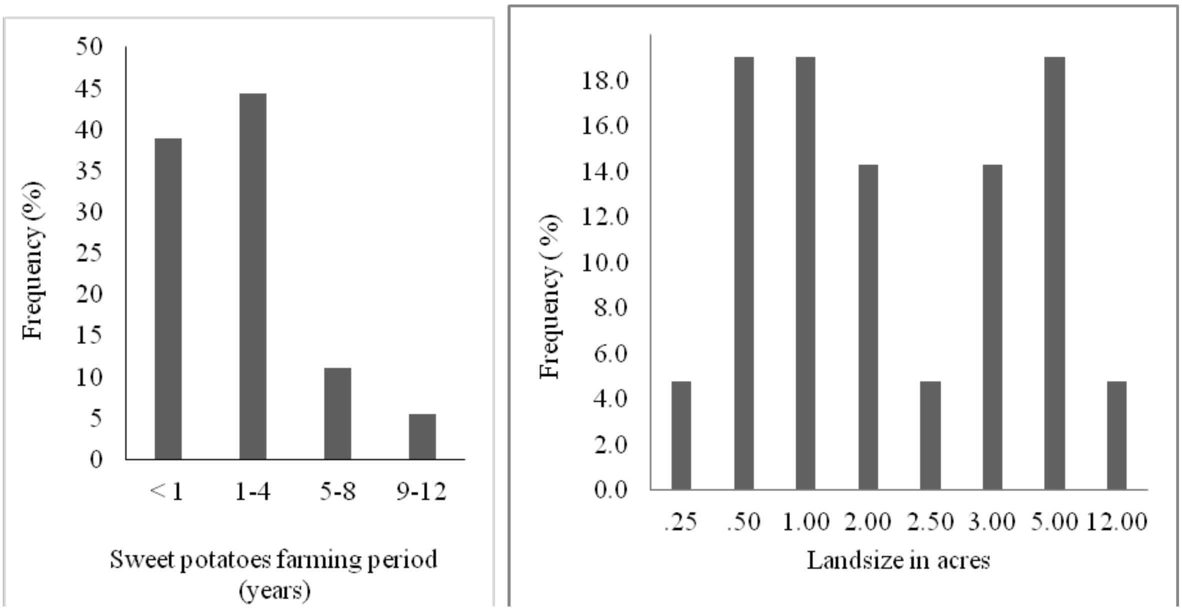

Figure 2: Sweet potato farming duration and acreage in Isiolo central, Kenya *(N=150)*

Sweet potato varieties cultivated and reason for cultivation

A total of six sweet potato varieties were identified to be cultivated in the study area. The most commonly cultivated variety was the white skin-white flesh (52.4%) followed by the red skin –white flesh (28.6%) while the least cultivated was purple skin-orange flesh (4.8%) sweet potato varieties (Table 2). The reason for cultivation also varied from one farmer to the other with majority of farmers citing the reason for their preference for white skin-white flesh variety as seed availability (100%) followed by high yielding (45%). The white skin orange flesh variety, cultivated by 40% of the respondents was cited as the most palatable variety (by 60% of the respondents). As reported by Sugri *et al*. [26], farmers' decision to adopt a particular variety is related to yielding capacity, field performance, marketability and consumer taste preference or palatability. The preference of orange flesh variety on the basis of palatability (most palatable) confirms the improvements so far made on the crop that previously had a low uptake due to its perceived 'flat taste' and squash-like flavour [28, 29]. Furthermore, reports indicate that preference to cultivate has increased as a result of improved dry matter content [30], reduced starchiness and stickiness, less dense texture, strong flavor and a good mouth-feel [26].

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Sweet potato planting season, methods and time to maturity

The majority of the farmers (58.8%) planted sweet potato during the long rains (March-May) and the rest (41.2%) planted during the short rain period (October-December). Half of the cultivated sweet potato varieties (local, white skin-white flesh, purple skin-orange flesh) were planted during the long rain season while the remaining half (Cream skin, yellow flesh; Red skin white flesh and White skin orange flesh) were planted in the short rain season. Majority of farmers (82.4%) planted sweet potatoes on ridges while the rest used raised beds (Figure 3).

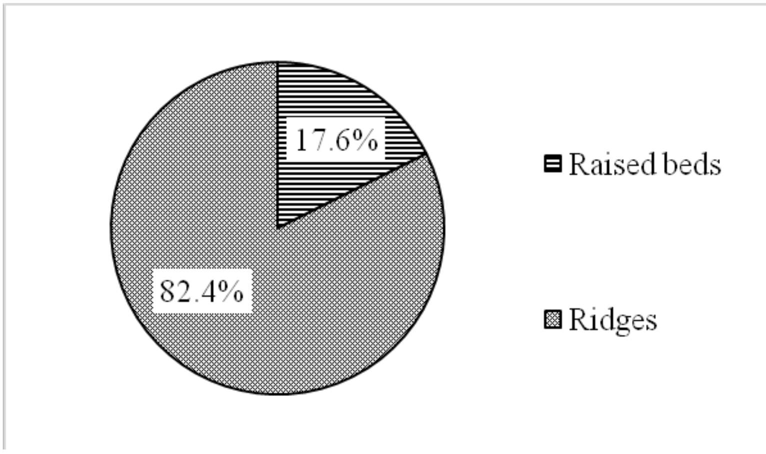

Figure 3: Planting methods of sweet potatoes. ***(N=150)***

Red skin-white flesh sweet potato variety took the longest time to mature (4 months), followed by the white skin-orange flesh variety (3.7 months) (Table 3). Notably, the purple skin orange flesh, white skin white flesh sweet potato varieties matured within the shortest period (3 months). Sweet potato varieties with a short cropping season are important for enhancing food security especially among small holder farmers in the arid and semi-arid areas who rely on rain-fed agriculture. Such early maturing sweet potato varieties are particularly important when selecting food security crops and for ensuring an all-year round food availability. Sweet potato is perceived as a food security crop. In a study conducted in Tanzania in 2015, more than 84% of OFSP project participants either agreed or strongly agreed with the statement that 'sweet potato plays a significant role during food deficit periods'. The study, however, revealed a large gap in perception between project participants and non-participants with fewer (58%) male respondents strongly agreeing that sweet potato is a reliable crop during times of food scarcity [27].

Harvesting, storage and shelf life of sweet potato tubers

Majority of respondents (81%) admitted to piece-meal harvesting as opposed to one-time bulk harvesting after physiological maturity. Only a small percentage of farmers (24%) reported storing the harvested sweet potato for a period of one to four weeks (Figure 4). For those who stored, temporal shed and wooden shelves were the most common storage methods. The local variety had the longest shelflife (8 weeks) while the red skin white flesh had the least shelf-life of less than one week (Figure 3). This suggests a need to develop intervention programs that take into consideration the traditional methods of sweet potato preservation, especially among resource poor farmers who may not have access to modern methods of preservation. This will guarantee food availability over a prolonged period of time.

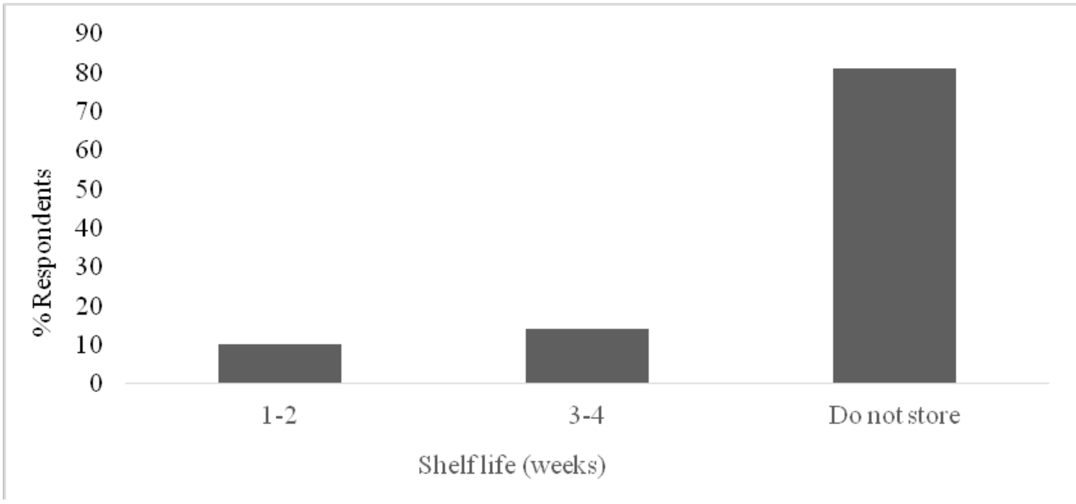

Figure 4: Shelf life of harvested sweet potato tubers; *(N=150)*

Sources of sweet potato seed

Seeds were obtained from different sources with majority of farmers (47.1%) utilising certified or improved sweet potato seeds while 23.5% obtained from friends (Table 4). 81% reported recycling seed with majority (52.9%) recycling for one to two years and a few farmers recycling seed for more than 6 years (Figure 5). Availability of planting materials influences adaptation of OFSP negatively and significantly suggesting that an intervention program that includes training farmers on seed sourcing and preservation is more likely to increase adoption [10].

Agronomic activities

Land preparation and weeding were the leading agronomic activities (90.5%) with the least being pest and disease management (Table 5). Only 23.8% of those who encountered pest and diseases adopted pest management methods which included use of neem, ash and insecticide.

About 28.6% of all the farmers utilised manure while 4.8% utilised NPK fertilisers. Only 33.3% of the farmers were identified to undertake soil fertility practices. Of those who had the practices, all applied the practices before planting, 14.3% at planting and another 14.3% practiced top dressing (application after planting).

In addition to the common agronomic practices, about 88.9% of the farmers encountered pest and diseases in their production. The most common pest (accounting for 38% of all reported pests) was sweet potato weevil followed by termites and leaf feeder hoppers. The most prevalent insect pest reported by the farmers was sweet potato weevil while the least was whiteflies (Figure 4). This finding is consistent with other studies by Muyinza *et.al.* [31] and Tanzubil [32].

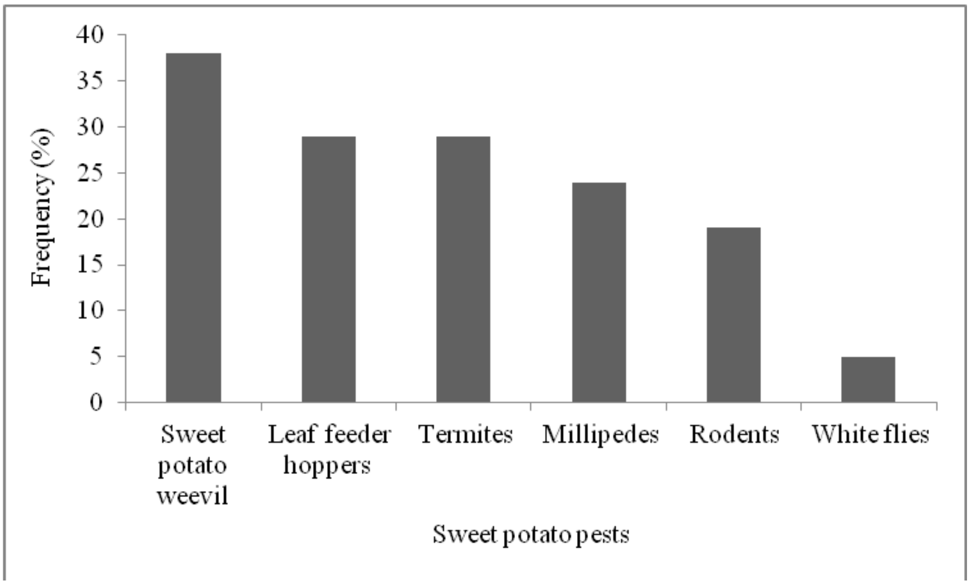

Figure 5: Sweet potato pests reported in Isiolo central sub-county *(N=150)*

Cost of production

Among the respondents, only 33.3% admitted incurring production costs mainly during ploughing, sowing, weeding and purchase of inputs (Table 6). The cost of insecticides was the highest ($84.9 /acre), followed by the cost of seeds ($77/acre). Insect pests are a major challenge in root and tuber crop production as reported by Shonga *et. al.* [33] and Tanzubil [32] and this may explain the high cost of insecticide incurred by sweet potato farmers in the area of study. This finding may also suggest that farmers in Isiolo region are aware of appropriate methods of pest and disease control.

The average cost of production per acre was estimated at $283. The low number of respondents incurring production costs may suggest that farmers utilized own or household labour during crop production. Sweet potato crop production requires minimal crop husbandry demands making it an easily adoptable crop by small-scale farmers.

Yield and income from sweet potatoes

On average, farmers harvested 465 kg of sweet potatoes per acre and a total income of $196.25 per acre translating to $0.422/Kg, a much higher farm price compared to the conventional farm price of $0.25-0.35/ kg.

Time sweet potatoes are available for own consumption

Majority of the farmers (35.3%) reported that sweet potato produce was available for consumption for 3-4 weeks with 29.4 percent reporting availability for 5-8 weeks after physiological maturity (Figure 6). Estimation of food availability after a cropping cycle is critical to understanding community food security status. Since majority of sweet potato farmers practice piece meal harvesting due to the short shelf life, it would be

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important to have a staggered cropping system to ensure food availability throughout the year.

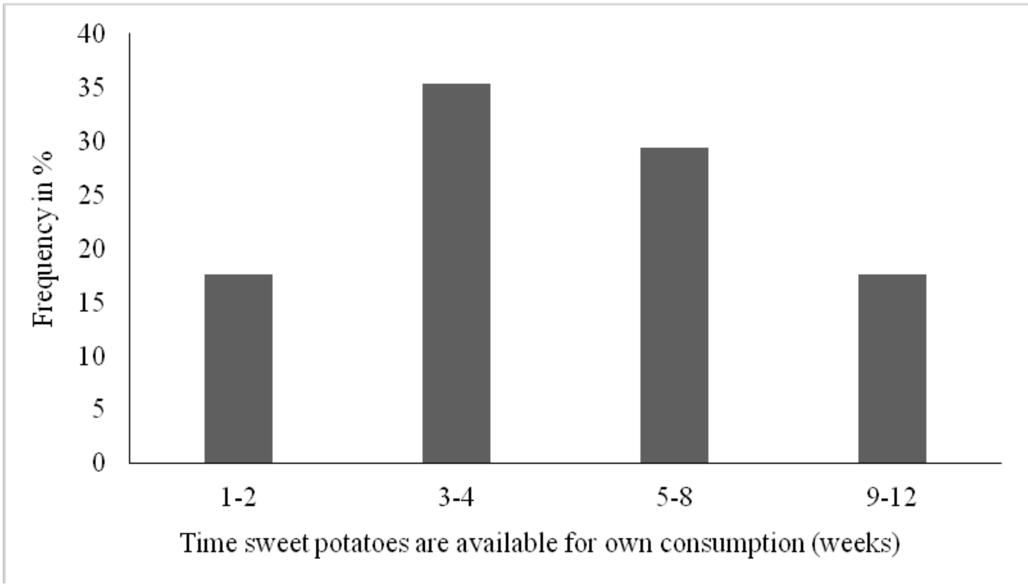

Figure 6: Time duration when sweet potatoes are available for own consumption *(N=150)*

Sweet potato crop utilisation

Sweet potatoes were utilised by 81% of respondents as boiled, fried, roasted or baked tubers. The dual purpose utility of sweet potato was reported with 52% of the respondents utilising vines and roots as supplementary animal feed (Table 7). Previous studies have suggested an option of utilizing sweet potato fodder and silage for livestock feeding due the high protein content and digestibility index [7, 8]. Non-conventional options of sweet potato utilization including baby weaning and processed products were also identified by minority of respondents (47.5%) and this could inform decisions on future utilization. In Ghana, for example, some local bakers are using sweet potato puree to make yoghurt and bread and attempts are being made to include sweet potato in traditional recipes, school feeding programmes, and complementary feeding for pregnant and lactating women [26]. Orange fleshed sweet potato has been evaluated for enriching probiotic yoghurt and its puree for use as a functional food [34, 35]. The nature of sweet potato utilization in different ways suggests a potential for upscaling its production in order to meet the demand for dietary diversification, value addition and product diversification and eventually increased incomes and improved livelihoods.

Sweet potato production constraints

Various constraints to sweet potato production were identified by the respondents as presented in Table 8. Among the constraints, access to extension services and difficult to process harvested tubers into a storable form were reported as the main constraints by over 60% of all respondents. Other major constraints included access to improved seed, poor access to credit, pests and diseases and inadequate rainfall accounting for 41.2%, 44.4%, 50% and 31.3%, respectively of all interviewed farmers. Such information is considered important when devising capacity development tools and policies for upscaling OFSP activities within Isiolo County and the larger ASALs region in general. A sweet potato value chain analysis reported by Sugri *et al.* [26], revealed similar constraints in Ghana, prioritized as access to seed, cost of chemical fertilizers, short shelf life, field pests and diseases, and declining soil fertility. Other major reported constraints to sweet potato production include lack of improved seed, lack of good markets and high perishability in Ghana [36]; planting of local varieties that are susceptible to pests and diseases in Tanzania [31]. Access to quality seed, especially during the planting season was reported as a major constraint in Kenya [37] and that may explain the high cost of seed reported by nearly half of the respondents in Isiolo central.

Government support and awareness and willingness to adopt improved OFSP varieties

Only 4.8% of the farmers reported Government intervention in seeking nutrition sensitive agriculture. The intervention was linked to extension services through non-governmental organizations (NGOs). Only 52.4% of the farmers were aware of improved OFSP and its health benefits. All the farmers were willing to adopt the improved OSP varieties. The success of adoption is based on willingness of farmers to take up new technologies and support from key stakeholders. Government support through farmer trainings and extension services would be important in influencing adoption of OFSP technologies and alleviate the impact of climate change within the ASAL communities. Creation of awareness and frequency of extension visit to the households has significant influence on adaptation to climate change related technologies [19, 38, 39, 40] as was hypothesized in our study. Increased extension services enable farmers to have more access to information and technical assistance on agricultural activities thus creating more awareness of the consequences of climate change [41]. This in turn influences farmers' decisions on climate adaptation and adoption of strategies that mitigate the effects of climate change. Kaguongo *et al.* [10] also suggested aggregating farmers into commercial villages making it easy and cost effective to access extension services and planting materials. These researchers found out that the odds for farmers in an aggregated program adopting OFSP were three times higher than those not in the program. The findings on the willingness of farmers to adopt OFSP as a result of awareness of its nutritional and health benefits is consisted with Kaguongo *et al.* [10] who reported that creating awareness of the potential benefits of OFSP among value chain actors increases its competitiveness against local varieties and enhances the probability for adoption.

CONCLUSION

From this study, we conclude that there exists an opportunity for scaling up the adoption of orange fleshed sweet potato (OSP) in Isiolo county. This is based on the willingness of the Isiolo community to take up the proposed OSP production and utilization technologies. In addition, the dual nature of sweet potato utilization suggests a huge potential for up-scaling production to satisfy a demand for dietary diversification, value addition and product diversification and eventual increase in household incomes and reduced resource related conflicts among pastoralist communities.

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Table 1: Household Socio-demographic characteristics in Isiolo County, Kenya

Socio-demographic characteristics	Description	Respondents (%)(N=150)
Age	<20	4.8
	21-35	19
	36-45	28.6
	46-60	42.9
	>60	4.8
Gender	Female	33.3
	Male	66.7
Education level	Uneducated	19
	Primary	33
	Secondary	24
	College	14
	University	10
Relationship with farm owner	Son or Daughter	9.5
	Wife	19
	Self	66.7
Household size	1-4	38.1
	5-8	57.1
	>12	4.8
Household Farm size (acres)	0.25	4.8
	0.5	19
	1	19
	2	14.3
	2.5	4.8
	3	14.3
	5	19
	12	4.8
Sources of income	Crop related	76.2
	Livestock	4.8
	Others	19

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Table 2: **Sweet potato varieties cultivated and reasons for cultivation**

Sweet potato variety	Reason for cultivation High yielding (%)	Disease resistant (%)	Palatability (%)	Shelf life (%)	Seed availability (%)	Total (%)
Local	0	0	50	0	50	9.5
Purple skin, Orange-flesh	0	0	0	0	100	4.8
Red skin white flesh	40	20	33	40	0	28.6
White skin-white flesh	46	9	27	18	100	52.4
White skin orange flesh	40	0	60	0	0	23.8
Cream skin, yellow flesh	33	0	33	0	33	14.3

(N=150)

Table 3: Sweet potato varieties maturity period and shelf life in Isiolo central, Kenya

Sweet potato varieties	**Average maturity period (Months)**	**Shelf life (weeks)**
Local	3.5	8
Purple skin orange flesh	3.0	3
Red skin white flesh	4.0	< 1
White skin-white flesh	3.0	2
Cream skin, yellow flesh	3.3	8
White skin orange flesh	3.7	6

No. Of respondents=150

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Table 4: Sweet potato seed sources

Characteristic	Description	Respondents (%) *(N=150)*
Seed source	Friends	24
	Improved/Certified seed	47
	Own seed	12
	Recycled seed	18
Seed recycling	1-2 Years	43
	3-5 Years	33
	6-10 Years	5

Table 5: Agronomic practices

Agronomic practices	**Respondents** (%) *(N=150)*
Land preparation	90.5
Weeding	90.5
Early planting	81.0
Early harvesting	57.1
Fertilizer application	28.6
Scouting for pests	28.6
Late harvesting	23.8
Pest and disease management	23.8

Table 6: Production cost and estimated incurred cost per acre in Isiolo central, Kenya

Item	**Estimated cost per acre ($)**	**% Respondents *(N=150)***
Insecticide	85	19.1
Ploughing	40	33.3
Sowing	34	28.6
Seed	77	14.3
Weeding	30	28.6
Fertilizer	17	14.3
Total cost	283	

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Table 7: Utilisation of sweet potato crop in Isiolo central sub-county

Utilization options	**Frequency (%)** *(N=150)*
Boiled, fried, roasted, or baked tubers	81.0
Vines and roots used in supplementary animal feeding	52.4
Tubers used for baby weaning and complementary feeding	9.5
Tubers processed into French fries, crisp, and chips	9.5
Green leaves used in different vegetable dishes	9.5
Tubers dehydrated into chips and flour	9.5
Boiled and mixed with chapati flour to make chapati	9.5

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Table 8: Constraints associated with sweet potato farming in Isiolo County, Kenya

Contraint	Not a problem (% respondents)	Minor constraint (% respondents)	Average Constraint (% respondents)	major constraint (% respondents)	Total number of farmers citing the constraint (% respondents)
Access to improved seed	41.2	5.9	11.8	41.2	81.0
Difficult to process into a storable form	12.5	18.8	6.3	62.5	76.2
Access to farm labour	75.0	6.3	18.8		76.2
Access to extension services		11.1	27.8	61.1	85.7
Cost of chemical fertilizer	53.3	6.7	13.3	26.7	71.4
Low profit	43.8	12.5	31.3	12.5	76.2
Poor price at harvest	61.5		7.7	30.8	61.9
Vines are expensive	78.6		7.1	14.3	66.7
Lack of improved varieties	47.1		17.6	35.3	81.0
Drudgery production operations	61.5	7.7	7.7	23.1	61.9
Perceived as food for poor households	75.0	6.3	18.8		76.2
Poor storage or short shelf life	53.3	6.7	13.3	26.7	71.4
Poor soil fertility	82.4	11.8		5.9	81.0
Inadequate rainfall	18.8	12.5	37.5	31.3	76.2
Poor access to credit	38.9	5.6	11.1	44.4	85.7
Pests and diseases	31.3	12.5	6.3	50.0	76.2
Poor market for produce	46.2	23.1	23.1	7.7	61.9

Number of respondents=150

REFERENCES

1. **Food and Agriculture Organization (FAO).** The State of Food and Agriculture Rome, 2013.

2. **Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, Mathers C and J Rivera** Maternal and Child Under nutrition Study Group. Maternal and child under nutrition: global and regional exposures and health consequences. *Lancet* 2008; **371(9608**):243-260.

3. **World Health Organization (WHO).** Global Prevalence of Vitamin A Deficiency in Populations at Risk 1995–2005, WHO Global Database on Vitamin A Deficiency, WHO Geneva 2009.

4. **Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, De Onis M, Ezzati M, Grantham-Mcgregor S, Katz J, Martorell R and R Uauy** Group Maternal and Child Nutrition Study. Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* 2013; **382**:427-451.

5. **Bailey RL, West Jr. KP and RE Black** The Epidemiology of Global Micronutrient Deficiencies. *Annuals of Nutrition & Metabolism* 2015; **66:** 22-33.

6. **Government of Kenya (GOK).** County Integrated Development Plan - Isiolo County. Government of Kenya, Nairobi 2013.

7. **Sala SM, Otieno DJ, Nzuma J and SM Mureithi** Determinants of pastoralists' participation in commercial fodder markets for livelihood resilience in drylands of northern Kenya: Case of Isiolo Pastoralism: *Research, Policy and Practice* 2020.

8. **Low J1, Ball A, Magezi S, Njoku J, Mwanga R, Andrade M, Tomlins K, Dove R and T van Mourik** Sweet potato development and delivery in sub-Saharan Africa. *African Journal Food Agriculture Nutrition & Development* 2017; **17(2)**: 11955-11972.

9. **FAO STAT.** Production/Yield quantities of Sweet potatoes: Food and Agriculture Organization of the United Nations 2014.

10. **Kaguongo W, Ortmann GF, Wale E, Darroch MAG and J Lowi** Factors influencing adoption and intensity of adoption of orange flesh sweet potato varieties: evidence from an extension intervention in Nyanza and Western province, Kenya. African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA), South Africa. Conference paper. September 19 – 23, 2010.

11. **Nungo RA, Ndolo PJ, Kapinga R and S Agili** Development and promotion of sweet potato products in Western Kenya. Proceedings of the 13th ISTRC symposium 2007; 790-794.

12. **Global Food Security Strategy (GFSS).** Kenya Country Plan April 2018.

13. **Gurmu F, Hussein S and M Laing** The potential of orange-fleshed sweet potato to prevent vitamin A deficiency in Africa. *International Journal for Vitamin and Nutrition Research* 2014; **84(1-2)**:65-78.

14. **Tofino A, Tofino, R, Cabal, D, Melo, A, Camarillo W and H Pachón** Evaluacion agronomica y sensorial de frijol *(Phaseolus vulgaris* L.) mejorado nutricionalmente en el norte del departamento de Cesar, Colombia. *Perspectivas en nutricion humana* 2011; **13**:16-177.

15. **Tomlins K, Ndunguru G and K Stambul** Sensory evaluation and consumer acceptability of pale-fleshed and orange-fleshed sweet potato by school children and mothers with pre-school children. *Journal of the Science of Food and Agriculture* 2007; **87**: 2436-2446.

16. **Government of Kenya (GoK).** The weather outlook for the “long rains” (March April-May) 2021 season & review GoK of the weather during the October – December 2020 “short rains” season. Ministry of environment and forestry Kenya meteorological department. Issue Date: 19 February 2021.

17. **Yaméogo TB, Fonta WM and T Wünscher** Can Social Capital influence Smallholder Farmers' ClimateChange Adaptation Decisions Evidence from Three Semi-Arid Communities in Burkina Faso West Africa. *Social Sciences* 2018; **7**:33.

18. **Assaye A, Mengistu Ketema M and A Bekele** Smallholder Farmers' Adaptation Strategies to Climate Change: The Case of Ankesha Guagusa District of Awi Zone, Northwestern Ethiopia *Journal of Agricultural Economics and Rural Development* 2020**; 6(2):** 760-772.

19. **Temesgen D** Factors affecting the choices of coping strategies for climate extremes Environment and production technology division IFPRI discussion paper 01032, 2010.

20. **Aemro T, Jemma H and K Mengistu** Climate change adaptation strategies of smallholder farmers: The case of Babilie district, East Harerghe Zone of Oromia Regional State of Ethiopia *Journal of Economics and Sustainable Development,* 2012; **3(14)**: 1-12.

21. **Gutu T, Bezabih E and Ketema M Mengistu** Econometric analysis of local level perception, adaptation and coping strategies to climate change induced shocks in North Shewa, Ethiopia. *International Research Journal of Agricultural Science and Soil Science*, 2012; **2(8):** 347-363.

22. **Deressa T, Hassan Rashid MH, Ringler C, Tekie A and Y Mahmud** Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change* 2009; **32(11):** 248-255.

23. **Hassan R and C Nhemachena** Determinants of African farmers' strategies for adapting to climate change: multinomial choice analysis. *African Journal of Agricultural and Resource Economics* 2008**; 2(1):** 83–104.

24. **Mbinda W, Kavoo A, Maina F, Odeph M, Mweu C, Nzilani N and M Ngugi** Farmers' knowledge and perception of finger millet blast disease and its control practices in western Kenya. *CABI Agriculture & Bioscience 2021;* ***2****:13.*

25. **Gebre H, Kindie T, Girma M and K Belay** Farmers' climate change adaptation options and their determinants in Tigray Region, Northern Ethiopia. *African Journal of Agricultural Research* 2015; **10(9):** 956-964.

26. **Sugri I, Maalekuu BK, Gaveh E and F Kusi** Sweet Potato Value Chain Analysis Reveals Opportunities for Increased Income and Food Security in Northern Ghana. *Advances in Agronomy* 2017. ID 8767340.

27. **Okello JJ, Shikuku KM, Sindi K and J Low** Farmers' perceptions of orange-fleshed sweetpotato: Do common beliefs about sweet potato production and consumption really matter? *African Journal of Food, Agriculture, Nutrition and Development* 2015; **15:**4.

28. **Tomlins K, Rwiza E, Nyango A, Amour R, Ngendello T, Kapinga R, Rees D and F Jolliffe** The use of sensory evaluation and consumer preference for the selection of sweetpotato cultivars in East Africa. *Journal for Science Food and Agriculture* 2004; **84**:791–799

29. **Kwach JK, Odhiambo GO, Dida MM and ST Gichuki** Participatory consumer evaluation of twelve sweet potato varieties in Kenya. *African Journal of Biological Sciences*. 2010; **9**: 1600-1609.

30. **Naico ATA and JL Lusk** The value of a nutritionally enhanced staple crop: results from a choice experiment conducted with orange-fleshed sweet potatoes in Mozambique. *Journal of African Economies*. 2010; **19**: 536-558.

31. **Muyinza H, Talwana HL, Mwanga ROM and PC Stevenson** Sweet potato weevil (*cylas spp*.) resistance in African sweet potato germplasm," *International Journal of Pest Management*. 2012; **58**: 73-81.

32. **Tanzubil PB** Insects associated with sweet potato (*Ipomea batatas*) in the Sudan savanna zone of Ghana. *Journal of Entomology & Zoology studies* 2015; **3**: 124-126.

33. **Shonga E, Gemu M, Tadesse T and E Urage** Review of entomological research on Sweet potato in Ethiopia. *Journal of Agriculture and Food Science* 2013; **1**: 83 - 92.

34. **Muchiri MN, McCartney AL and L Methven** Sensory profile and consumer preference of novel probiotic yoghurt enriched with Orange sweet potato (*Ipomoea batatas*). *African Journal of Agriculture, Food, Nutrition & Development* 2020; **20(5):** 16471-16489.

35. **Muchiri MN and AL McCartney** Evaluation of Kenyan Orange Fleshed Sweet Potato (Ipomoea batatas Lam.) Purees for Functional Food Production. *Journal of Life Sciences* 2014; **8(2)**: 128-133.

36. **Bidzakin JK, Acheremu K and E Carey** Needs assessment of sweet potato production in northern Ghana: implications for research and extension efforts, ARPN. *Journal of Agriculture and Biological Sciences* 2014; **9**: 315-319.

37. **Wang'ombe JG and MP van Dijk** Low potato yields in Kenya: do conventional input innovations account for the yields disparity. *Agriculture & Food Security* 2013; **2**: 1, 14.

38. **Aymone GG** Understanding farmers' perceptions and adaptation to climate change and variability: The case of the Limpopo basin, South Africa. IFPRI Discussion paper 00849, *International Food Policy Research Institute* 2009: Washington DC.

39. **Minale AS and KK Rao** Impacts of land cover/use dynamics of Gilgel Abbay catchment of Lake Tana on climate variability, Northwestern Ethiopia *Applied Geomatics* 2012; **4:**155–162.

40. **Belaineh L, Yared A and B Woldeamlak** Smallholder Farmers' Perceptions and Adaptation to Climate Variability and Climate Change in Doba District, West Hararghe, Ethiopia, *Asian Journal of Empirical Research*, 2013; **3(3):** 251-265.

41. **Assaye A, Mengistu Ketema M and A Bekele** Smallholder Farmers' Adaptation Strategies to Climate Change: The Case of Ankesha Guagusa District of Awi Zone, Northwestern Ethiopia. Journal of Agricultural Economics and Rural Development 2020; **6(2):**760-772.