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ASSESSMENT OF PRODUCTION CONSTRAINTS AND FARMERS' PREFERENCES FOR SWEET POTATO GENOTYPES

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A B S T R A C T

Sweet potato is one of the most important staple food crops with significant role for food security and also a potential commercial crop in many sub Saharan African countries. In Kenya, its production is hindered by numerous biotic, abiotic and social factors. A baseline survey study was conducted in central, eastern and western Kenya between September and December 2012, to determine the farmers' preferences of Sweet potato varieties, production constraints and farmers' coping strategies. A structured questionnaire was randomly administered to 345 farmers in five counties. Data on households demographics, Sweet potato varieties grown, sources of seed, cultural practices, and production constraints were collected and analyzed using statistical package for social scientists (SPSS). Results indicated that 60% of the farmers interviewed were women and family sizes varied between 3-5 persons in 55% of the households. Farm sizes ranged 0.41-0.8 ha with 90% of Sweet potato being grown on 0.24 ha or less. The main food crops grown on the surveyed farms included maize, beans, Sweet potato, cassava, sorghum, and pigeon peas, while the main cash crops were; kale, banana, sugarcane, bean, maize, Sweet potato and groundnut. The average Sweet potato yield on the farms surveyed ranged from 5.5-7.4 t ha^{-1}. The preferred Sweet potato varieties were Vitaa, Kembu 10, and Kabonde because they were orange fleshed with high beta carotene. Production constraints in the three regions were basically similar, with 35% of the farmers identifying weevils as the major pest, and Sweet potato virus disease (SPVD) as the major disease. Drought was identified by 28% of the farmers as a major production constraint. Farmers indicated the use of clean seed, high yielding varieties, high planting density, and manure application as some of the strategies they used to cope with the production constraints. To improve Sweet potato production in Kenya, these production constraints need to be addressed.

Keywords: Food security, farmers' preferences, production constraints, households, Sweet potato genotypes.

INTRODUCTION

Sweet potato is a major crop in most eastern and southern African countries such as Uganda, Rwanda, Kenya, Tanzania, Ethiopia, Zambia, Mozambique and South Africa (FAOSTAT, 2009; Shonga *et al*., 2013). In Kenya, about 59.2 thousand ha of land are grown to Sweet potato annually with an estimated productivity of 9.53 t ha-1, which is less than the world average of 14.1 t ha-1(FAOSTAT, 2009). The crop is grown from sea level to 2200 m asl in various agro-ecological zones with major production concentrated in the arid or semi-arid areas of Kenya. The crop is mostly harvested in piece meal and stored on a flexible time schedule, which qualifies it as food security crop (Ekanayake, 1990). Moreover, breeding and use of orange-fleshed Sweet potato is being promoted by research organisations with the aim of ensuring food security, income generation and reducing vitamin A deficiency.

Sweet potato has numerous potential uses and benefits. As food, Sweet potato storage roots are boiled and eaten or chipped, dried and milled into flour which is then used to prepare snacks and baby weaning foods (Kidmose *et al.,* 2007). The consumption of orange fleshed Sweet potato, rich in pro-vitamin A helps in ensuring normal vision especially in the night, healthy

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skin and mucous membranes, proper cell growth, reproduction and immunity to diseases such as measles, malaria, respiratory diseases and diarrhoea in the body (Stathers *et al.,* 2005). Also, deep orange fleshed Sweet potato roots are reported to be rich in Fe (50 ppm DM) and Zn (40 ppm DM) with about 3.5%-9.5% DM protein, in storage roots, stems and leaves (Çalifikan *et al*., 2007; Grüneberg *et al*., 2009). Some farmers also sell fresh storage roots in the market for income generation. Also, some companies contract farmers and buy the storage roots, cook them, place them in a tin for local and probably export markets. In some developed countries, light industries use Sweet potato as an industrial raw material to produce starch, natural colorants and fermented products such as wine, ethanol, lactic acid, acetone, and butanol (Duvernaya *et al*., 2013). Importantly, farmers use almost all parts of the Sweet potato plant as livestock feed (Claessens *et al*., 2008). This illustrates the inherent potential of Sweet potato which is unexploited in many African countries including Kenya.

Despite the numerous potential uses and benefits of Sweet potato, the production of the crop is below the potential level in many parts of Kenya. Sweet potato has a yield potential of 20-50 t ha^{-1} of storage roots in the tropics (Çalifikan *et al*., 2007). This yield potential is yet to be realized as farmers in sub-Saharan Africa (SSA) produce on average, less than 10 t ha^{-1} (FAOSTAT, 2009).These low yields are as a result of several socio-economic, biotic, and abiotic constraints. Socio-economic constraints in the production of Sweet potato include, poor post-harvest handling and storage facilities, lack of processing skills, lack of clean seed, and poor seed distribution system and poor agronomic varieties (Ames *et al*., 1996; Njeru *et al*., 2004; Gichuki *et al*., 2006). The major biotic factors affecting Sweet potato include pests (Sweet potato weevil, weeds, and nematodes) and diseases (viruses, alternaria blight, and root rots among others). Yield losses of 20-78% due to viruses (Zhang *et al*., 2006) and 45% due to Sweet potato weevil (*Cylas formicarius*) have been reported (Lagnaoui*et al*., 2000). Virus and weevil infected plants also become susceptible to other pests and diseases resulting to yield loss of up to 100%. Other diseases affecting Sweet potato include alternaria blight, bacterial wilt and fusarium wilt (Ames *et al*., 1996). Yield increases of 160% (40.8 t ha^{-1}) due to use of virus-indexed planting materials has been reported (Zhang *et al*., 2006). Also, an annual benefits worth $145 million (11.6 billion shillings) due to using virus-indexed sweet potato seeds has been reported in China (Fuglie *et al*., 1999). Abiotic constraints affecting production of Sweet potato include drought stress and soil nutrient deficiencies. Drought stress reduces the quantity and quality of the storage roots and vines, in Sweet potato.

The above literature generally outlines the Sweet potato production constraints across regions. However, biotic, abiotic, socio-economic constraints and farmers' preferences differ across agro ecologies. White fleshed Sweet potato with 28-32% dry matter (DM) is preferred in Brazil and east African countries; a trend that is changing with the awareness of vitamin A rich orange fleshed Sweet potato varieties. West Africa countries prefer less sweet, high DM, dark orange fleshed, cylindrical but tapering at both ends of the storage roots genotypes (Grüneberg *et al*., 2009). Consequently, validation of the Sweet potato production constraints and their prioritising, and documenting the farmers' preferences of Sweet potato varieties based on country's ecological zones, which has not been done in Kenya, is required. In this study, a baseline survey using a structured questionnaire was conducted in western, eastern and central Kenya in order to identify farmers' Sweet potato production constraints, priorities and variety preferences.

MATERIALS AND METHODS

Study area: The study was conducted in eastern, western, and central Kenya (Figure 1) in September 2012 just before farmers harvested the crop. In eastern Kenya, two counties namely Machakos (longitude: 36.9°E-37.6°E and 0.7°S-1.7°S) and Makueni (longitude: 37.0°E-38.7°E and latitude: 1.4°S-3°S) were selected (Figure 1). Their elevation ranged from 400-2100 m asl and about half of the total land is under agricultural use (Claessens *et al*., 2012). The soils are deep, friable, and of low fertility especially deficient in nitrogen, phosphorus and soil organic carbon. The soil texture varies from sandy clay loam to sandy clay. This region has semi-arid climatic conditions with bimodal rainfall characterized with low, variable and unreliable rainfall. The annual rainfall ranges from 500-1300 mm of which short rains occur from November - January and long rains from March - June (Jaetzold *et al*., 2006). The average annual temperature ranges from 15^{o}C-25^{o}C. Long term observation indicates drought episodes occur after every four to five years in this region (Tiffen *et al.*, 1994).

In western Kenya, Homa Bay county was selected. Homa Bay lies at latitude: 0°-1.5°S and longitudes: 34°E-35°E (Figure 1). The soils in Homa Bay are moderately drained, deep, dark brown clay loam, which is moderately fertile. The area receives bimodal rainfall where the long rains come March - April and short rains in September - December. Temperatures range from 22-32°C and the altitude is about 1225 m asl and the rainfall ranges from 1000-1250 mm annually (Jaetzold *et al*., 2006).

In Central Kenya, Murang'a and Kirinyaga counties were selected. Murang'a lies at latitude: 0.5°S-1°S and longitude 36.7°E-37.5°E and Kirinyaga lies at latitude: 0.15°S-0.7°S and longitude 37.3°E-37.9°E) (Figure 1). In both Murang'a and Kirinyaga counties, the soils are well drained, fertile, deep, volcanic red loam usually referred as nitisols. The area receives bimodal rainfall with long rains in March - April and short rains in September - December. Temperatures range from 14-26°C and the altitude range was 1500-2000 m asl while the rainfall ranges from 1500–1800 mm annually (Jaetzold *et al*., 2006).

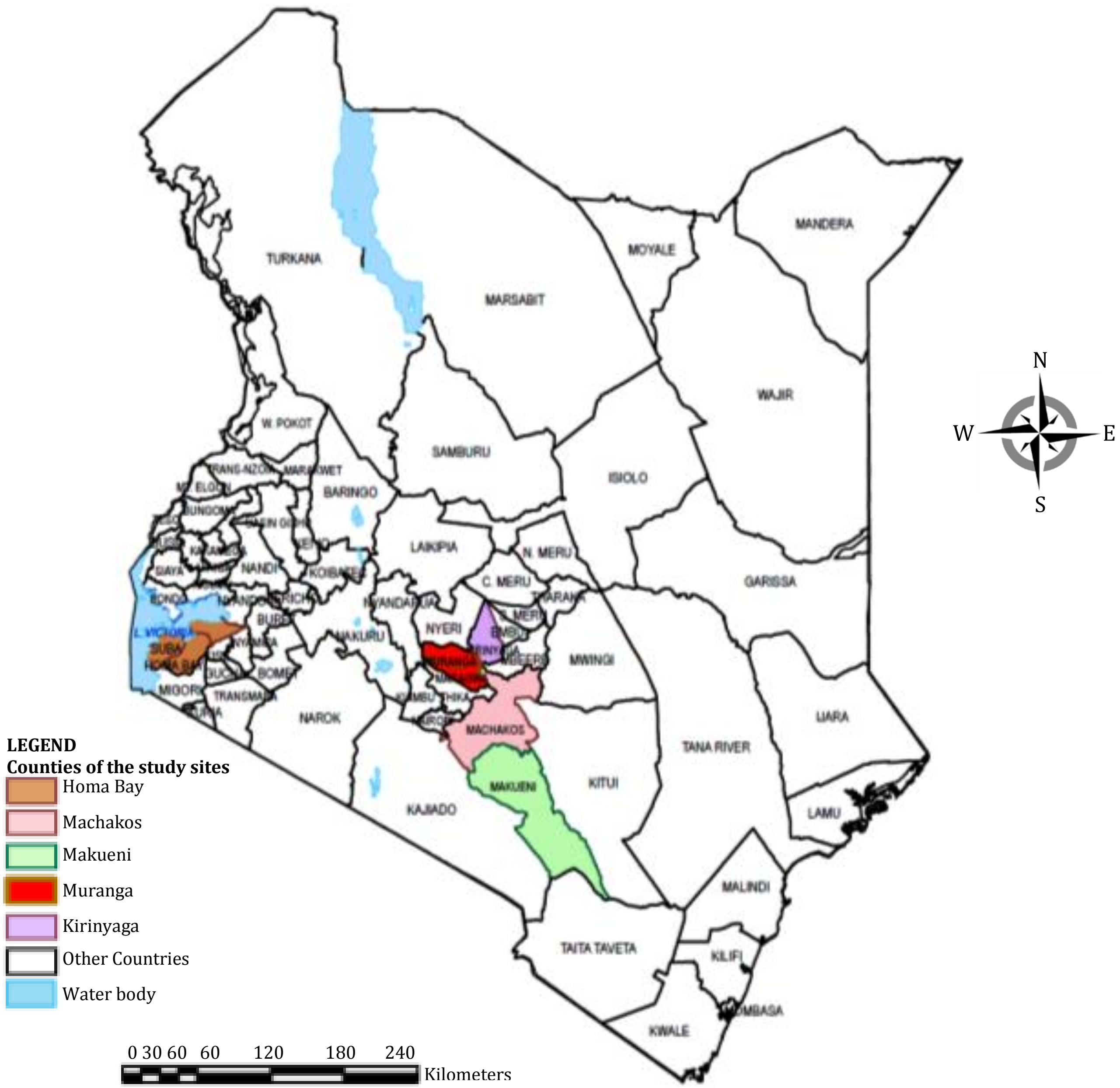

Figure 1. A map of Kenya showing the regions where the survey was conducted in eastern, central, and western Kenya.

Sampling procedures and data collection: Four districts were selected in each region (eastern, central and western Kenya) with the assistance of the extension officers. Sweet potato farmers were selected from two divisions in each of the selected districts but spread across the villages of the divisions, with the help of extension officers in the localities. Structured questionnaires were administered to the farmers by a multidisciplinary research team comprising of a breeder, agronomist, and socio-economist. A community leader accompanied the survey team as a guide. For individual interviews, the household head present was interviewed. In cases of language barrier, a member from the community or household was asked to translate. Data on household demographics, farmers' agronomic and crop husbandry practices (farming systems, planting time, cropping pattern, and use of fertilizers and manures), current varieties grown, planting material sources, and production constraints were collected. About 30 copies of the questionnaire were administered in each district. A total of 345 farmers were interviewed in all the regions.

Data analysis: The collected data were entered into excel spread sheets. The data were analyzed using Statistical Package for Social Sciences (SPSS, 2007). Cross tabulations were used in the analysis and the percentage respondents were calculated and presented in the results.

RESULTS

Farmers interviewed in four selected districts/divisions: The proportions of farmers interviewed in each district/division are shown in Figure 2.

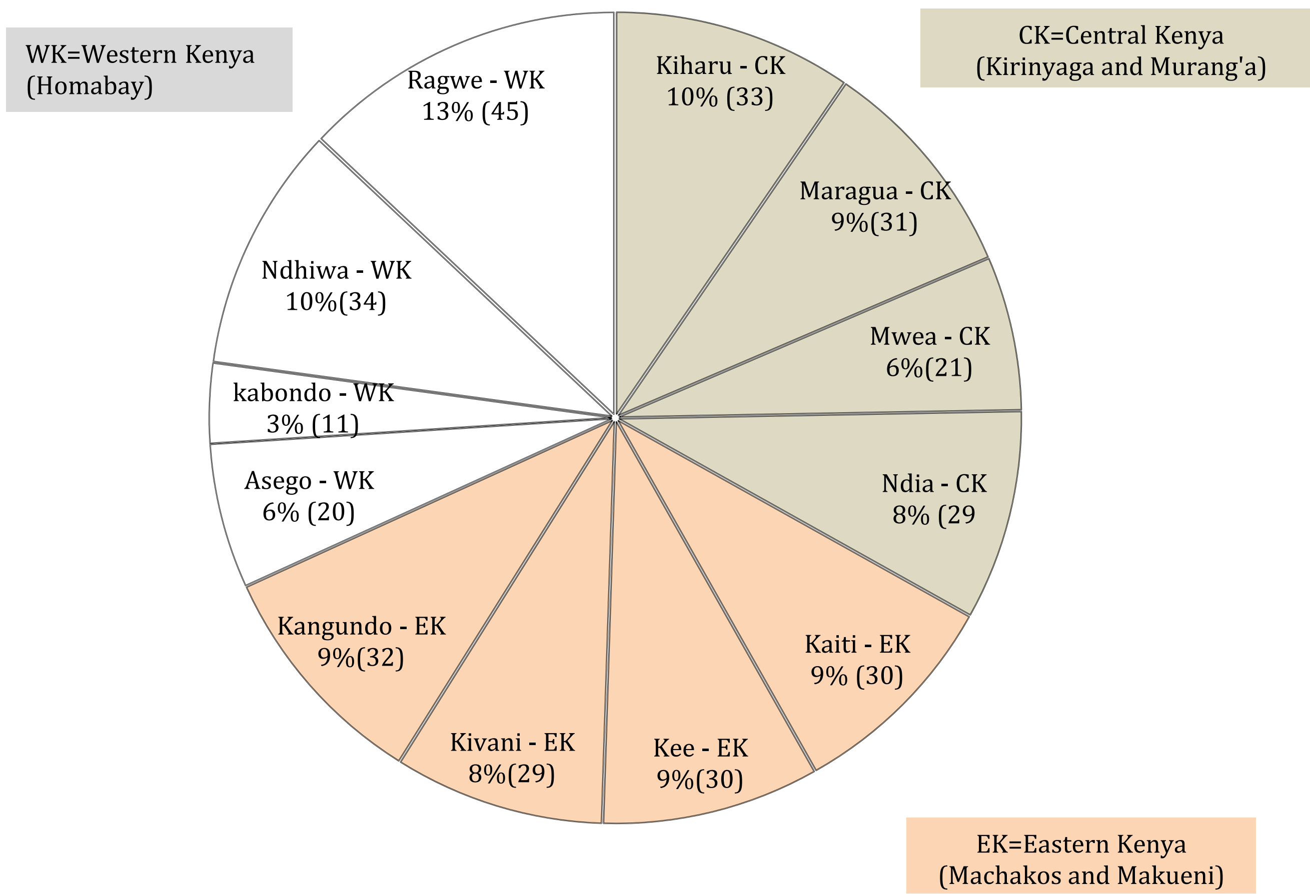

Figure 2. The proportions (%) of interviewed farmers in the four districts/divisions selected in each region

Demographic information

About 60% of the farmers interviewed were women, and the majority of the farmers were between 41-50 years. Most farms ranged between 0.41–0.8 ha (32%) in size, with Sweet potato being grown on an average of 0.24 ha. Family sizes averaged 3-5 persons (55%), and the majority of the household members were between 21-40 years (Figure 3).

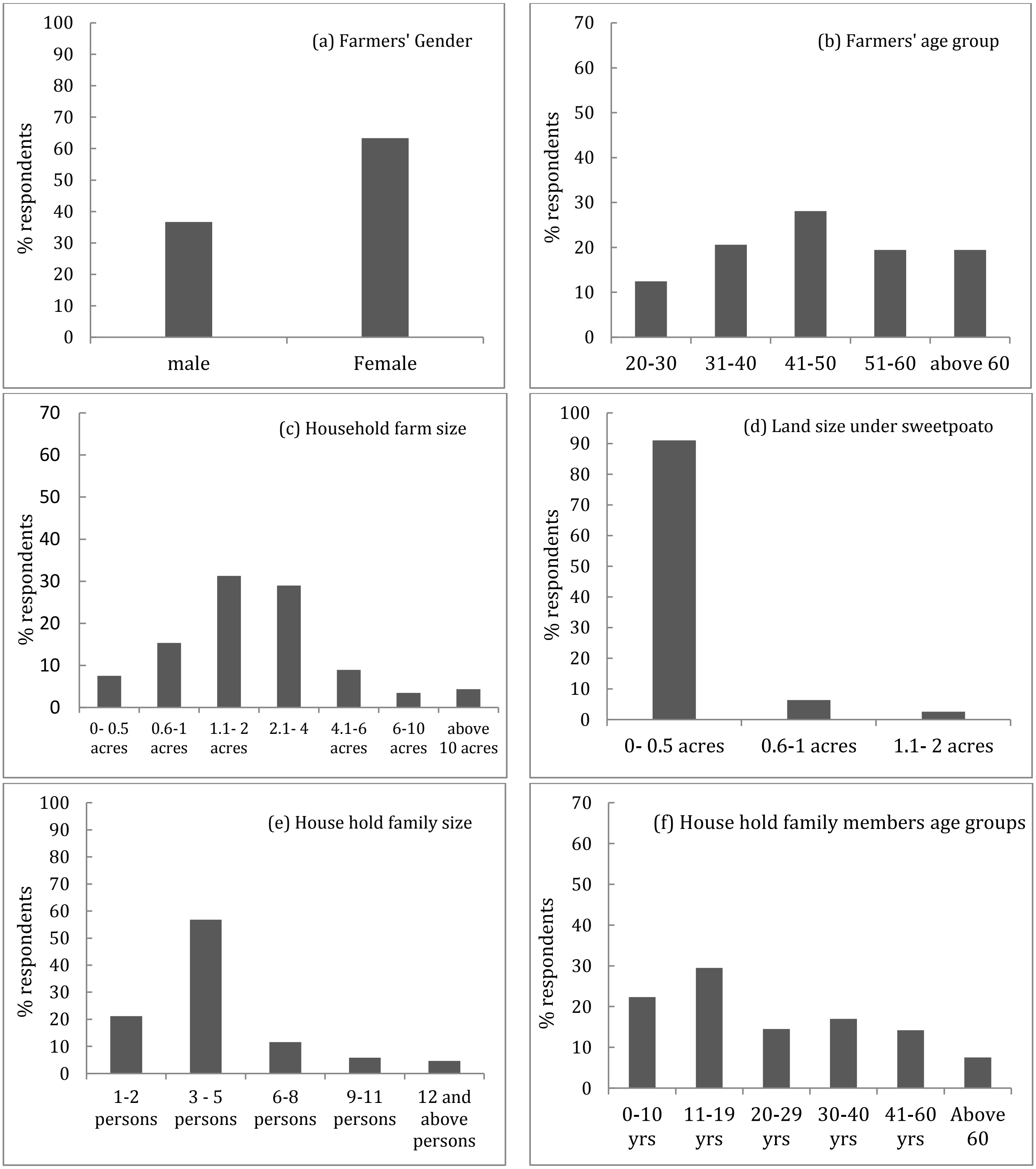

Figure 3. The (a) gender, (b) farmer's age group, (c) household farm size, (d) Sweet potato farm size, (e) family size, and (f) age group of household members of the farmers interviewed.

Food and cash crops grown by the farmers in the regions: The food crops identified by about 10% and above of the respondents were; Sweet potato, beans, maize, cassava, sorghum, and pigeon peas. The cash crops identified by about 5% and more of the respondents were kale, banana, sugarcane, beans, maize, Sweet potato and groundnut (Figure 4).

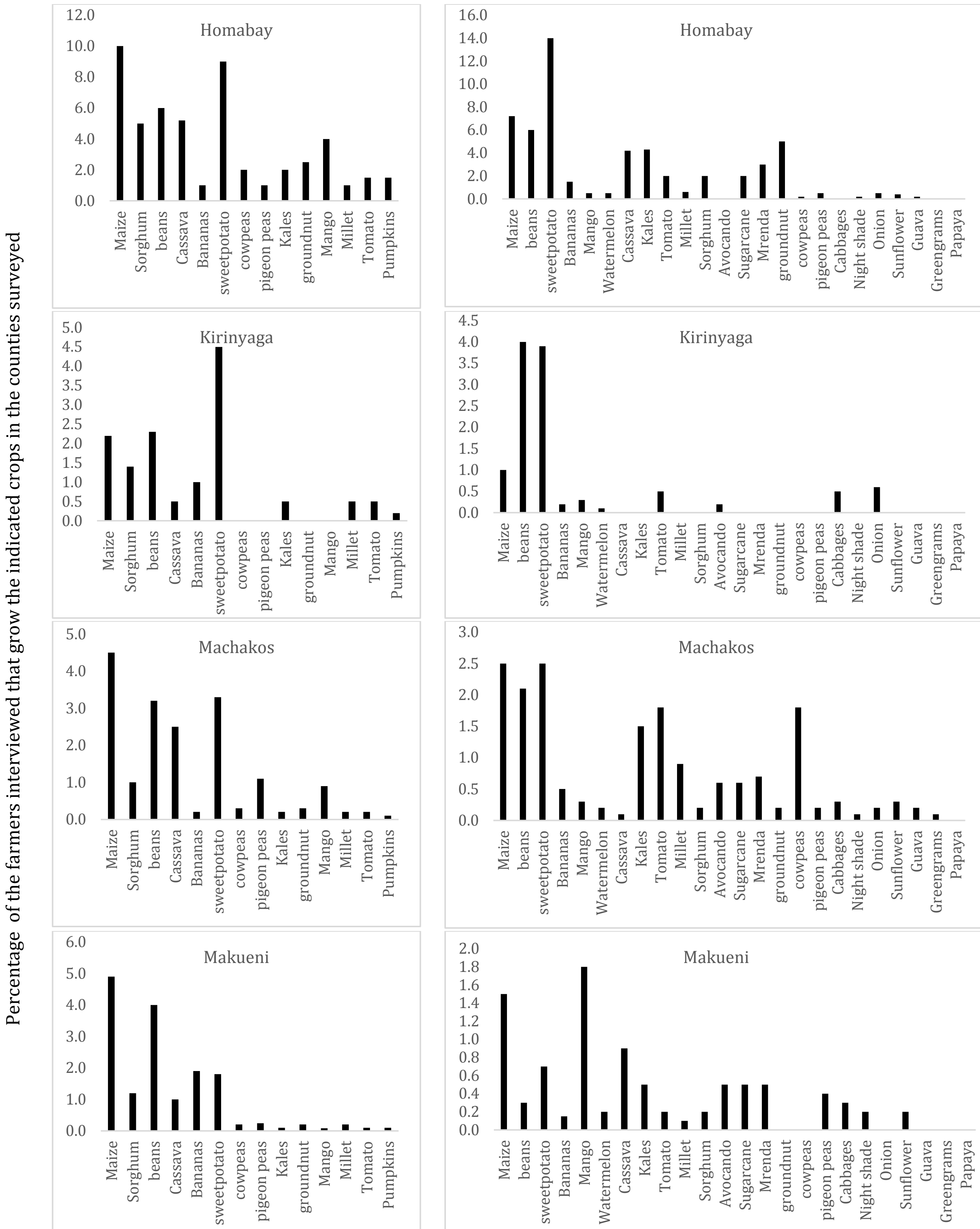

Figure 4. The food crops (a) and cash crops (b) grown by farmers interviewed (%) in different counties.N.B.

Sweet potato varieties grown by farmers: The varieties Vitaa (13%), Kembu 10, and Kabonde (12%) were grown by most of the farmers. Qualities of the most preferred genotypes were; orange fleshed (OFSP), favourable sugar content (FSC), favourable starch content (FSC), low fibre content after cooking (LF), do not overcook in normal cooking time (NO), high yielding (HY), and improved varieties (IV). The less preferred were white fleshed (WFSP), high starch content (HS), local landraces (LL), and favourable storage root yield (FY) (Table 1). **Sweet potato planting material conservation method:** Most farmers (33%) conserved planting materials in the field, while the rest used other methods as indicated in Table 2.

Table 1. Varieties and the percent of respondent farmers growing them per region and across the surveyed regions.

Genotype	Western Kenya (%)	Central Kenya (%)	Eastern Kenya (%)	Total (%)	Why preferred
Vitaa	3	4	6	13	OFSP,FSC,FSC,LF,NO,HY,IV
Kembu10	3	4	5	12	OFSP,FSC,FSC,LF,NO,HY,IV
Kabonde	3	5	5	12	OFSP,FSC,FSC,LF,NO,HY,IV
Bungoma	0	5	4	9	FSC,FSC,LF,NO,HY,IV
SPK 04	0	5	4	9	FSC,FSC,LF,NO,HY,IV
Kiganda	0	5	4	8	FSC,FSC,LF,NO,HY
Maruko	0	5	3	8	FSC,FSC,LF,NO,HY
Mwavuli	2	1	4	7	WFSP,HS,LL,FY
Amina	2	0	3	5	WFSP,HS,LL,FY
Mweiumme	2	0	3	4	WFSP,HS,LL,FY
Mvita	0	0	1	1	WFSP,HS,LL,FY
Kiluu	0	0	1	1	WFSP,HS,LL,FY
Blanketi	2	0	0	2	HS,LL,FY
Kalambyanyerere	2	0	0	2	HS,LL,FY
Kunyikibonjwi	1	0	0	1	HS,LL,FY
NilikujaKuzaa	1	0	0	1	HS,LL,FY
Nyakeya	1	0	0	1	HS,LL,FY
Nyasoda	1	0	0	1	HS,LL,FY
Nyatonge	1	0	0	1	HS,LL,FY
Odhieyo	1	0	0	1	HS,LL,FY
Total	27	34	39	100	-

Table 2. Methods of Sweet potato seed conservation by farmers (%).

Conservation method	Western Kenya	Central Kenya	Eastern Kenya	%Total
Left on-farm	15	8	10	33
Plant after harvest	3	3	6	12
Wet land	2	5	4	11
Irrigated nursery	5	2	4	11
Under shade	1	4	5	10
Plant on soil embankment	3	3	3	9
Put in a hole	2	3	2	7
Do not conserve	2	2	3	6

OFSP=orange fleshed Sweet potato, FSC= favourable sugar content, FSC=favourable starch content, LF= low fibre content after cooking, NO=do not overcook in normal cooking time, HY=high yielding, IV=improved varieties, while the less preferred were WFSP=white fleshed Sweet potato, HS=high starch content, LL= local landraces, and FY= favourable yield.

Cultural practices: The majority of farmers (50%) used Sweet potato planting material from their previous crop or from their neighbours (34%). Only 8% of the farmers used certified planting materials (Figure 5). Sixty percent of the farmers planted Sweet potato on ridges. Results on cropping type indicated that 38% of farmers practiced mixed cropping, 35% mono-cropping and 20% intercropping with other food crops (Figure 5). Most farmers (45%) used manure and less than 10% of the farmers used inorganic fertilizers. However 55% of the farmers did not use any fertilizer in Sweet potato production (Figure 5).

Sweet potato farmers' yields: The on-farm Sweet potato produced average yields of 5.5-7.4 t ha^{-1}, while a few produced about 3.5 t ha^{-1} and below or 10 t ha^{-1} and above (Figure 6).

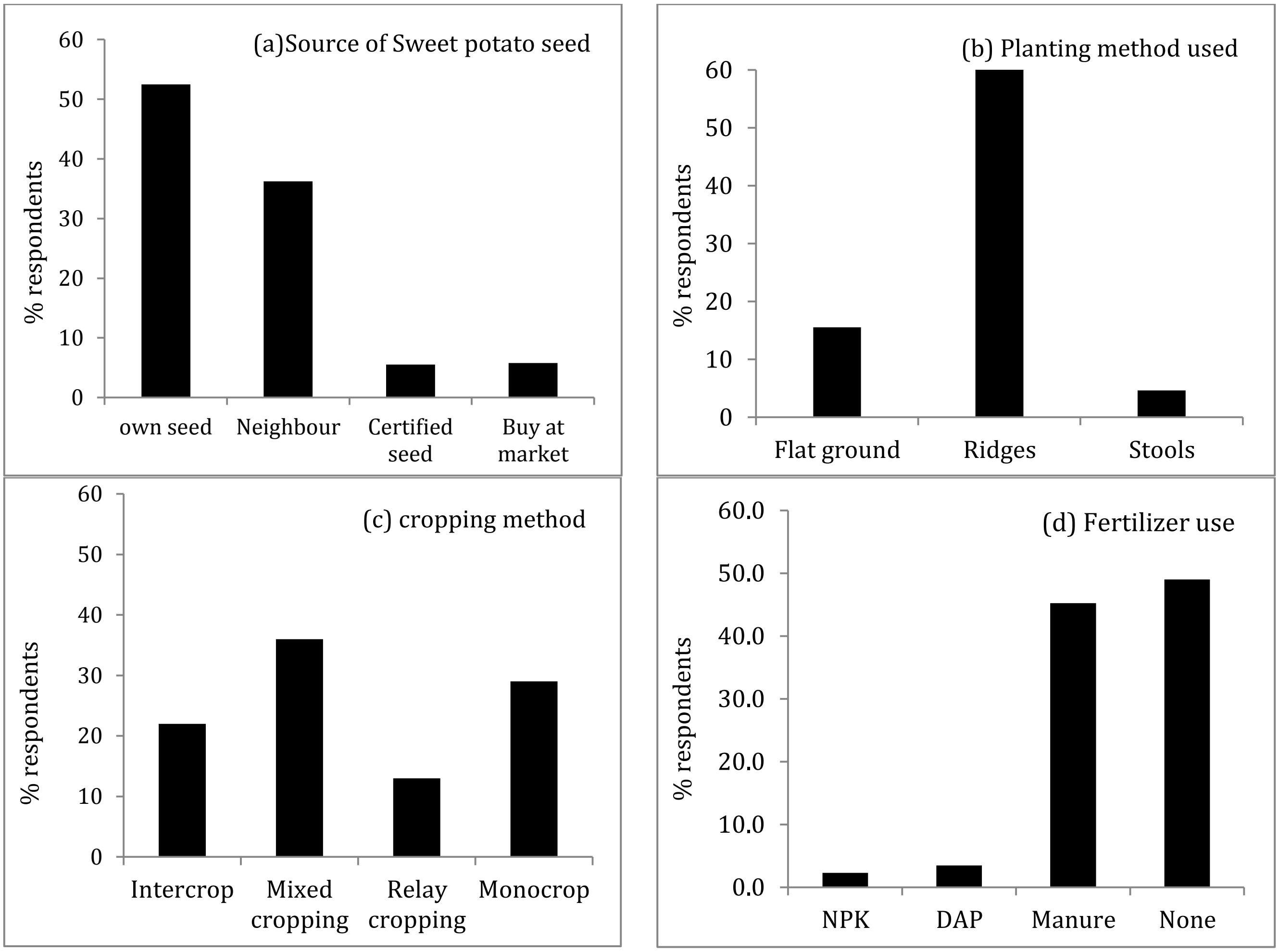

Figure 5. Cultural practices by Sweet potato farmers in Kenya (a) sources of planting materials, (b) planting method used, (c) cropping system and (d) fertilizer use.

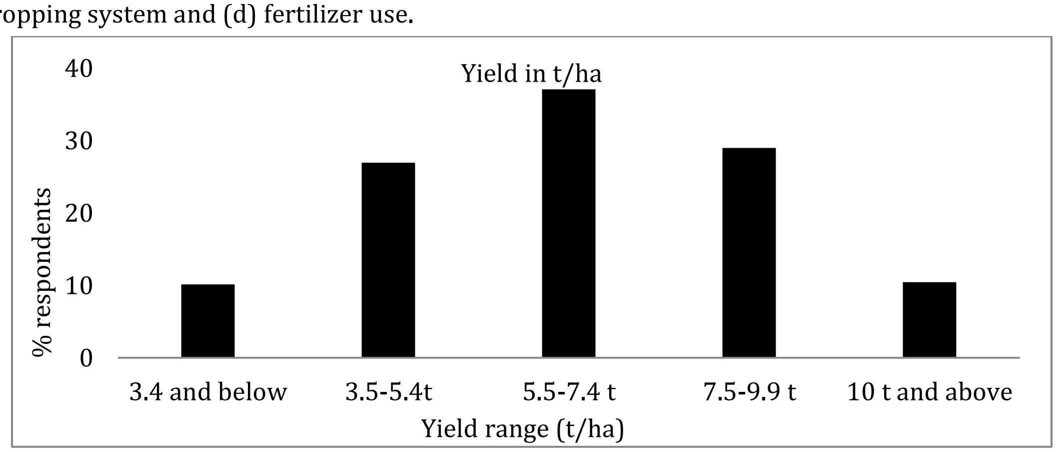

Figure 6: The Sweet potato yield of the households interviewed.

Sweet potato production constraints: Most farmers (28%) identified drought associated with hard soil pan as a major land preparation and planting constraint, as well as lack of clean and enough planting materials (18%) and high cost of inputs (11%). Drought (26%) was again the major constraint during harvesting, which led to increased damages inflicted to the storage roots during harvesting (19%) (Figure 7; Table 3 a).

Figure 7. A photograph showing (a) Sweet potato crop under no drought stress, (b) under drought stress, (c) weevil infested storage root, (d) Sweet potato meal, (e) group of farmers who were interviewed, (f) Sweet potato packaging for sale, taken in the field during the participatory rural appraisal (PRA) survey interviews.

Table 3a. Percent respondents on Sweet potato land preparation, planting and harvesting constraints during the PRA survey interviews

Constraint	Western Kenya	Central Kenya	Eastern Kenya	% Total
Land preparation and planting constraints				
Drought resulting to soil hard pan	10	6	13	28
Lack of clean, enough planting material	8	4	7	19
High cost of inputs	2	3	5	10
Lack of funds	4	2	3	9
Lack of ploughing oxen	2	2	2	6
Scarcity of manure	2	2	3	7
Lack of machinery	1	2	3	6
Water logging	2	1	2	5
Weeds	2	2	2	6
Labour scarcity	1	1	2	4
Total	34	25	42	100
Harvesting constraints				
Drought causing hardpan making digging out the roots difficult	7	9	10	26
Some storage roots damaged while harvesting	2	5	12	19
Roots damaged by moles	2	6	4	12
Weevil infestation	2	4	3	9

Continue…

Labour shortage	1	4	2	6
Lack of funds to hire harvesting labour	1	2	2	5
Expensive labour	1	2	2	5
Pricked by thorny weeds while harvesting	1	2	2	4
Get poor yields after investing a lot	1	2	1	4
In piece meal harvesting the small sized and leaving the large sized deep in soil	2	1	1	4
Some storage roots left underground	1	1	2	3
Roots damaged by hippopotamus	1	1	1	3
Total	22	39	42	100

The main pest and disease constraints were weevils (35%), and viruses (40%) (Figure 7; Table 3b).

Table 3b. Percent respondents on Sweet potato pests and disease constraints of farmers interviewed

Constraint	Western Kenya	Central Kenya	Eastern Kenya	% Total
Pests				
Sweet potato weevil (*Cylas spp.*)	10	14	11	35
Red spider mite *(Tetranichus cinnabrinus)*	5	6	9	21
Moles	11	3	4	18
Leaf worms *(Spodoptera littorallis)*	6	3	4	13
Whitefly *(Bemisia tabaci)*	1	3	3	7
Aphids *(Aphis gossypii)*	3	1	2	6
Total	36	30	33	100
Diseases				
Unaware	9	10	8	27
SVPD (SPFMV + SPMMV)	12	18	10	40
Alternaria blight (*Alternaria bataticola*)	7	12	5	24
Fungal Black Rot (*Ceratocystis fimbriata)*	2	4	3	9
Total	30	44	26	100

SPVD = Sweet potato virus disease, SPFMV= Sweet potato feathery mottle virus (transmitted by aphid potyvirus) and SPMMV= Sweet potato mild mottle virus (SPMMV) transmitted by whitefly-transmitted potyvirus

Farmers' coping strategies for the constraints: Farmers coped with soil hardpan as a result of poor rains (drought) by irrigation (41%) while 36% suggested use of drought tolerant varieties. A majority of farmers (36%) stated that they would maintain planting materials and multiply it in wetlands to ensure they had clean and enough planting materials at the onset of rains. Also, farmers indicated that they used high yielding and drought tolerant varieties (59%) to address poor yields if available (Table 4a).

The coping strategies of the farmers on pest constraints were mainly use of clean planting materials (20%), use of crop rotation (15%) and early harvesting practice (15%). On diseases, majority farmers (24%) again used clean planting materials as control for virus disease, followed by crop rotation (22%) and use of resistant clones (19%) (Table 4b).

Table 4a. Percent respondents on strategies of coping with Sweet potato land preparation, planting and harvesting constraints during the PRA survey interviews

Constraints	Farmers' coping strategy	Western Kenya	Central Kenya	Eastern Kenya	Total
Soil hard pan due to drought	Irrigation	20	8	13	41
	Use oxen	7	4	3	14
	Wait for rains	5	2	4	11
	Drought tolerant varieties	15	9	12	36
	Total	45	23	32	100

Continue…

Lack of clean, enough seed	Plant after harvest	12	3	2	17
	Buy from market or multiplier	7	10	4	21
	Maintain and multiply in wet land,	13	9	14	36
	Maintain and multiply in irrigated nursery beds	11	8	7	26
	Total	43	30	28	100
Weeds	Weeding regularly	10	7	6	23
	High planting density	11	11	15	37
	Manure application	6	11	5	22
	Fertilizer application	1	2	1	4
	Total	43	30	27	100
Poor yields	High yielding variety	19	17	22	59
	Fertilizer application	3	4	5	13
	Manure application	11	6	11	29
	Total	34	28	39	100

Table 4b. Percent respondents on strategies of coping with pests and disease constraints on Sweet potato production of farmers interviewed

Constraints	Farmers' coping strategy	Western Kenya	Central Kenya	Eastern Kenya	Total
Pests	Resistant varieties	4	6	3	13
	Early harvesting	6	5	4	15
	Crop rotation	6	3	6	15
	Irrigation	3	3	4	10
	Using clean seed	6	6	8	20
	Manure application	3	3	4	10
	Chemical spray	2	2	3	7
	Trapping	3	1	2	6
	Scaring away	2	0	1	4
	Total	35	29	36	100
Diseases	Using clean seed	8	8	8	24
	Early harvesting	7	5	4	16
	Resistance varieties	6	6	7	19
	Crop rotation	6	7	9	22
	Irrigation	4	4	4	11
	Chemical spray	2	2	4	7
	Total	34	31	35	100

DISCUSSION

Demographic information: The majority of the 345 farmers interviewed were women. Most of the women had 1-5 children; the majority of the female farmers aged 21-40 and many household had children aged 0-10 years. This indicates the need to promote growing of OFSP as a source of vitamin A especially for the children aged 3-10 years and the lactating mothers in these households. In many households men are the head and decision makers even concerning farming activities. However, most of the men work and reside in the urban areas, which explains why the majority of the farmers interviewed were women. The absence of men on the farms causes delays in decision making which in turn causes delays in farm preparation and planting and consequently contributes to poor yields. Considering both gender, most farmers were aged between 41-50 years. This could be explained by the tendency of young people moving to urban centres in search of work after finishing school/college. The majority of the household farm sizes were also small with Sweet potato grown on 0.5 acres and below. Results from this study were in agreement with those reported by Shonga *et al.* (2013) who reported that farmers grew Sweet potato on characteristically small sized plots in Ethiopia. This is because farmers try to produce enough for subsistence use, because there is no long term storage method for Sweet potato after harvesting. If the Sweet potato crop is ready for harvesting, leaving storage roots un-harvested will result to considerable losses as they lose their quality and are typically infested heavily by weevil. Similar findings were reported by Mmasa *et al.* (2012) in Tanzania who further recommended the increase of land area under Sweet potato production in order to boost productivity.

Food and cash crops, and Sweet potato varieties: Farmers classified almost all the food crops also as cash crops. Many of the farmers interviewed used part of their produce for food and sold the rest to generate cash income. However, increased commercialization of the crop and the fact that supermarkets and hotels are retailing Sweet potato storage roots and French fries is an indication that Sweet potato is a potential cash crop, which farmers could produce in large scale for income generation.

The varieties Vitaa, Kembu 10, and Kabonde were grown by most of the farmers. These varieties have high beta carotene and thus are used as health foods. Moreover, sensitization of orange fleshed Sweet potato as source of vitamin A has created a demand for these varieties, hence generating market. Moreover, this also shows that farmers were receptive to improved and released varieties compared to local landraces.

Cultural practices: Sweet potato planting materials were mainly recycled from the previous crop, since only a very small portion of the farmers indicated they used certified planting material. This shows that either most farmers do not understand the importance of using clean and certified planting materials or do not have an alternative. This partially explains why Sweet potato yields continue to be low. Fuglie (2007) conducted survey work on Sweet potato constraints across many countries, and similarly found that lack of clean and enough planting material was a major constraint in most of African countries. In this study, farmers preferred to use manure rather than inorganic fertilizers such DAP and NPK, while a large number of farmers did not use any fertilizer. The farmers believe inorganic fertilizer makes the Sweet potato grow vegetative and results in tasteless storage roots. Some believe that Sweet potato does not require a lot of soil nutrients and thus would do well with low soil fertility. These arguments may not be too far from the truth; however, research is required towards the development of a fertilisation model that improves the yields of Sweet potato but maintaining the palatability qualities. Most farmers used ridges in planting Sweet potato, probably because this planting method leads to better yields than the other types of cultivation (Githunguri and Migwa, 2007). Mixed cropping with other food crops was the most preferred method, meaning farmers prefer planting crops in a mixture to spread the risk of failure to harvest in case of drought or any other unexpected constraint. However, some farmers planted Sweet potato as a monocrop, which suggests that the perception of the farmers on the value of the crop is changing.

Sweet potato planting material conservation method: Most farmers leave the Sweet potato planting materials in the field. Consequently, the materials are heavily infested with virus and other pests and diseases. The aftermath is a reduction of the yield by 50% relative to the previous crop. These results are similar to those reported by Namandaa *et al.* (2013) who demonstrated that Sweet potato planting material sourced from swamp or irrigated on farm plots were infested with virus and getting it from volunteer plants after rains led to planting delays. In this study, roots conserved under sand and planted 10 cm deep and watered for 5-10 weeks before the onset of rains produced enough clean planting materials at the onset of the planting season. There is significant need to develop a working system of developing clean and enough planting materials for Sweet potato ready at the onset of the rains. Most farmers preferred higher planting densities, that is, 75 x 30, 60 x 60 and 75 x 60 cm, indicating a preference for intensive farming to maximise the productivity of their scarce land. This is supported by Belehu (2003) who reported that high density resulted to increased yield in Sweet potato. Also, higher density planting suppresses the weeds and at the same time minimises evaporation of soil moisture, resulting to improved yield (Kivuva *et al*., 2005).

Sweet potato yields: Most Sweet potato yields on-farm ranged 5.5-7.4 t ha^{-1}, which is below the average production of 9 t ha^{-1} in Kenya. Shonga *et al*. (2013) in their review on Sweet potato production constraints reported average Sweet potato yield in Ethiopia of 8 t ha-

[1] relative to 18 t ha^{-1} in the Asian countries. This indicates production constraints need to be addressed to improve the productivity of the Sweet potato.

Sweet potato production constraints and coping strategies: Most farmers identified drought associated with hard soil pan, lack of clean and enough planting material and high cost of inputs as major constraints for land preparation and planting. Shields and Fletcher (2013) reported similar results in Uganda. This calls for researchers to devise methods of breaking the soil hardpan, and production of enough and clean Sweet potato planting materials. Breeding drought tolerant varieties, especially the deep rooted, may also minimise storage root yield losses due to soil surface hard pan and weevil infestation. This also concurs with Mmasa *et al.* (2012) who reported shortage of planting material, lack of capital, drought and pests and diseases as Sweet potato production constraints in Tanzania.

The major constraint experienced during harvesting was drought. Thus there is need for ways of simplifying harvesting when terminal drought occurs making the soil surface hard to break. Irrigating the field softens the soil surface and simplifies harvesting. Also, use of oxen and tractors would simplify the harvesting, hence, reduce root damages during harvesting. But these practices are not readily available to poor farmers. Research is also required for the best way to effectively control moles that cause damage to Sweet potato storage roots. Farmers engage the services of skilled mole trappers, which is expensive to sustain.

Most farmers in this study identified weevils as a major pest and Sweet potato virus disease (SPVD) as a major disease affecting their crop. This concurs with Ngailo *et al.* (2013), who reported that SPVD reduced yields 50-80% in Tanzania. They also indicated that the cheapest control method for the resource poor farmers was breeding for resistance. In this study, most farmers used unconventional weevil control methods such as manure application, which improves soil structure and irrigation which reduced the soil cracking and thus reduced the weevil infestations. This is similar to results by Ehisianya *et al.* (2013)in Nigeria who reported that a mixture of 50 ml of neem seed oil extract and 30 ml of diazinon in either 2 or 10 litres of water and cuttings dipped for 30 minutes (unconventional weevil control method) controlled *Cylas puncticollis* by 35.5%. However, data collected also showed a number of farmers were ignorant of pests and diseases that affected Sweet potato. This implies that there is need to sensitize farmers on diseases and other aspects of Sweet potato. Degu *et al.* (2013) also reported the need to improve the capacity for farmers to take up and continue with developed varieties and technologies. The lack of resistant varieties as well as disease and pest free Sweet potato planting materials were the major hindrance to pest and disease control. Thus breeders need to identify resistant varieties as well as promote production of clean seed to improve Sweet potato production. This is in agreement with results of work done on resistant gene expression on Sweet potato virus resistance (McGregor *et al*., 2009). Furthermore, Tefera *et al*. (2013) have also reported SPVD as a major constraint of Sweet potato production in Ethiopia. They also, reported that *Alternaria blight* was a constraint even though not serious, which concurs with the findings in this study.

As coping strategies some farmers indicated used clean planting materials, and improved varieties tolerant to drought, pests and diseases in order to have improved yields. This implies that farmers are willing to embrace research technologies aimed at improving Sweet potato production.

CONCLUSION

Varieties Vitaa, Kemb 10, and Kabonde were grown by most of the farmers interviewed in this study which indicated that farmers were receptive to adoption of improved OFSP varieties. The farming households comprised groups of persons aged 0-10 years and 21-40 years (comprising young children and lactating mothers), thus, there is a need to promote breeding and production of OFSP varieties which are rich in beta carotene. Research on use of inorganic fertilizers, such as DAP and NPK, to boost production is required since most farmers never used any soil fertility enhancing method. Both infrastructural and personnel capacity building is required on alternative skills and better methods of conserving Sweet potato planting material to maintain them clean and also to control weevil and viruses infestation. Intensified research is required towards generating resistance varieties to drought, weevil, and virus which were the major constraints to Sweet potato production found in this study. Lastly, appropriate technology and seed multiplication and distribution method is required to ensure availability of clean and enough planting materials at onset of rains.

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