Uganda Journal of Agricultural Sciences, 2014, 15 (2): 101 - 111 ISSN 1026-0919

Evaluation and delivery of disease-resistant and micronutrient-dense sweetpotato varieties to farmers in Uganda

G. Ssemakula[1], C. Niringiye[1], M. Otema[1], G. Kyalo[2], J. Namakula[1] and R.O.M. Mwanga[2]

[1]National Crops Resources Research Institute, P. O. Box 7084, Kampala, Uganda
[2]International Potato Center (CIP), Box 22274, Kampala, Uganda

Author for correspondence: nankingag@yahoo.com

Abstract

Uganda is among the African countries reported to be at high risk of Vitamin A deficiency (VAD) with prevalence of VAD among children and women at 28 and 23%, respectively. Promoting orange-fleshed sweetpotato (OFSP) (*Ipomoea batatas*) rich in Vitamin A will play a significant role in combating VAD. However, sweetpotato virus disease is a major constraint to OFSP. The National Crops Resources Research Institute (NaCRRI) under took research on improvement, evaluation and delivery of promising OFSP to farmers. Selected parents with complimentary traits are planted to a crossing block annually and true seed is harvested and used to establish nurseries the plants of which are individually screened for reaction to SPVD, Alternaria blight, and depth of the orange colour in the root flesh. Promising selections are evaluated through a series of verification multi-locational trials on-station. Selections are subsequently advanced on-farm to test their performance under farmer managed conditions and for their acceptability by farmers and consumers for both food and other uses. To date nine OFSP varieties have been released and disseminated to farmers.Generally, most of the released OFSP varieties are susceptible to weevils (*Cylas* spp.), but moderately resistant to both SPVD and Alternaria blight.

Key words: Alternaria blight, Vitamin A, weevils

Introduction

Sweetpotato (*Ipomoea batatas*) is widely consumed in sub-Saharan Africa (SSA), especially Uganda. With its relatively high productivity on marginal soils, flexible harvest dates and ability to withstand disease, drought, and pests; sweetpotato is a remarkably adaptable and hearty crop, consumed where drought, poverty, and malnutrition are often prevalent. The main nutritional importance of sweetpotato has been its starch content (Dominquez, 1992); however, sweetpotato can also be a source other nutritionally important nutrients such Vitamin A, Ascorbic acid, thiamin, riboflavin, and niacin (Dominguez, 1992). Sweetpotato roots have low protein, fat and fibre levels; while they have a high nitrogen free-extract fraction that is indicative of potential value as energy source. Vines have a lower carbohydrate content, but higher fibre values and protein. Carbohydrates generally make up between 80-90% of the dry weight of sweetpotato roots (Dominguez, 1992).

β-carotene is an important micronutrient for the proper functioning of the human body. Many families in SSA, and in Uganda in particular that consume

conventional white-fleshed sweetpotato as a staple, especially the poor who seldom afford supplementary foods that are rich in essential nutrients (HarvestPlus, 2012) suffer from micronutrient malnutrition. The most vulnerable groups are the women, adolescents, and children, who also constitute the larger portion of the population. These age and gender groups have higher requirements for micronutrients because they are more active and/or still growing. Malnutrition contributes to over one-half of child deaths in the developing world. The groups most affected are also the most difficult to reach with the traditional types of nutritional programs. According to WHO (1995), people in many parts of SSA who eat sweetpotato as staple suffer from vitamin A deficiency (VAD), resulting in progressive eye damage. In women, VAD increases risk of dying during pregnancy, as well as giving birth to under-weight children, and may increase the spread of HIV/AIDS virus infection (Ryder *et al*., 1989).

The orange fleshed sweetpotato (OFSP) has high pro-vitamin A content which makes it valuable for combating widespread VAD, particularly among children and pregnant mothers (HarvestPlus, 2010; Holtz *et al* ., 2012). Results from the 2011 Uganda Demographic and Health Survey (UDHS) indicate that 25 percent of children are stunted (low height-for-age) and 16 percent are underweight (UBOS and Macro International Inc., 2011). The same survey found that 49 percent of women suffer from anemia, and 19 percent are vitamin A deficient. Studies in Kenya and Uganda (Carey *et al*., 1999) comparing different varieties ranging from white to deep orange-fleshed showed that small quantity (70-100 g) of orange-fleshed sweetpotato is required for daily requirements of pro-vitamin-A for adults. A more recent study conducted in Uganda (Holtz, 2012) showed that, more vitamin A was obtained from eating OFSP was associated with higher amounts of vitamin A in the blood in children and a lower likelihood of having marginal VAD in women.

To contribute towards solving the VAD problem, a programme was initiated to enhance the content of vitamin A precursors in sweetpotato through breeding and delivering a bio-fortified crop to the needy. An important aspect in enhancing beta-carotene levels in sweetpotato, is ensuring that the micronutrient is embedded into an agronomic background with good food qualities combined with resistance to biotic stresses. Yield, taste, and resistance to diseases are important factors that contribute to the acceptability of new genotypes.

Approach

Development and evaluation of OFSP varieties

OFSP clones were introduced in Uganda through the International Potato Centre (CIP).Uganda received approximately 200 *in vitro* sweepotato plantlets directly or indirectly from CIP, Lima, Peru, through CIP based at Muguga, Kenya (Mwanga *et al.,* 2009). In Uganda, the clones received were evaluated in different agro-ecologies. Almost 100% of the clones were not adapted to the growing conditions and were not suitable for local consumption. They had low dry matter (DM) content and were susceptible to *Alternaria bataticola* blight and SPVD. Promising clones with complimentary traits were included in a crossing block at

NaCRRI, Namulonge. NaCRRI, in collaboration with CIP, works on improving OFSP for SPVD resistance and other desirable traits. The parents in the crossing blocks are exploited to produce populations that combine important traits such as resistance to *A. bataticola* blight, SPVD, high beta-carotene concentration, high DM (30% or more), good root shape, good taste and high biomass.

Hundreds of breeding populations (seed) have been generated from 2002 to date. About 20-40% of the seed is sent to collaborating countries in SSA; while the remainder is used locally. Seed populations are used to establish nurseries, from which plants are individually screened for reaction to SPVD, Alternaria blight and depth of the orange colour in the root flesh. Promising selections are evaluated through a series of verification multi-locational trials on-station. Therefore, consumers' preferences, shape, markets and adoption of varieties are given due consideration during selection.

Consumers prefer varieties that are mealy with high dry matter content. Three to ten selections are subsequently advanced for farmer participatory on-farm evaluations, to test their performance under farmer managed conditions and for their acceptability for both food and other uses. Table 1 shows average performance of OFSP cultivars evaluated on-station and released in 2007 in Uganda; while Table 2 shows an example of an advanced yield trial from which 4 selections were advanced for farmer-participatory evaluation under on-farm conditions. Table 3 shows results of yield and palatability tests from on-farm trials wherefrom two farmer-choice selections (SPKOO4/2006/1136 and NASPOT7/2006/292) were released in 2013. The clones endorsed by farmers are then taken through a process

Table 1. Yield, quality attributes and disease reaction of 5 Orange-fleshed sweetpotato cultivars evaluated in Uganda, and released in 2007 in comparison to a local check clone

Attribute	NASPOT 7	NASPOT 8	NASPOT 9 O	NASPOT 10 O	Dimbuka-Bukulula	Tanzania (local check)
Dry matter % (range)	31.7 (28.4-34.9)	32.0 (30.5-36.1)	30.1 (27.5-31.1)	30.5 (27.8-32.5)	32.4 (26.9-35.9)	32.0 (27.5-35.5)
Cooked texture	Some what dry	Some what dry	Some what dry	Some what dry	Some what dry	Somewhat dry
Sweetness	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Field reaction to SPVD	M	M	M	M	S	M
Field reaction to Alternaria stem blight	M	M	M	M	M	M
Mean storage root yields (t/ha)	20.4	17.8	16.5	16.0	25.0	17.6

S = susceptible; M = moderate; R = resistant

Table 2. Mean performance of 3 Orange-fleshed sweetpotato (OFSP) cultivars and 5 check clones evaluated at three on-station locations in an advanced yield trial in Uganda, 2012

Genotype	Root yields (t/ha)	Mean harvest index	SPVD	Commercial yield	Flesh colour	Weevil damage
JEWEL(OP)/2005/6 (yellow)	13.7	0.22	3.2	12.8	2	1.7
NASPOT7/2006/1185	23.3	0.29	2.7	22.2	8	2.3
NASPOT7/2006/292	25.7	0.39	3.4	24.5	8	2.1
SPKOO4/2006/1136	30.9	0.49	3.0	29.5	7	2.0
DIMBUKA (Non-OFSP Check)	12.2	0.20	2.6	10.4	2	1.6
NASPOT1(Non-OFSP Check)	30.4	0.42	3.4	29.4	2	2.3
NASPOT11(Non-OFSP Check)	32.1	0.51	3.0	31.4	2	1.9
NKA (Non-OFSP Check)	7.4	0.12	2.2	7.4	2	1.2
NASPOT8 (OFSP check)	40.6	0.49	2.6	39.7	6	2.0
Mean	24.03	3.79	2.9	23.03	NA	1.9
LSD	5.9	0.08	0.5	5.9	NA	,
CV	30.1	27.95	19.0	31.3	NA	16.9
Means by environment						
NaCRRI	42.1	0.43	4.1	41.4	NA	2.3
Ngetta	20.2	0.43	2.2	18.3	NA	1.0
Serere	9.8	0.18	2.4	9.4	NA	2.4
Mean	24.03	3.79	2.9	23.03	NA	1.9

SPVD = Sweetpotato virus disease severity, SPVD, weevil, and Alternaria damage scored on a scale of 1-9, where 1 =no symptoms and 9 = very severe damage symptoms. NA = Not applicable

of variety release and are given official release names. Table 4 shows the OFSP varieties released between 1999 and 2013 as a result of screening, evaluation, and selection from introductions, landraces, and breeding materials. The Varieties Kakamega, Ejumula, NASPOT 9 O (Namulonge sweetpotato orange-fleshed) and NASPOT10 O have been introduced into several African countries (Mwanga and Ssemakula, 2011).

Dissemination of OFSP varieties

In order for OFSP to achieve the desired impact, there is need for functioning seed delivery systems for growers to obtain the planting material (especially of improved varieties) and better management practices, to translate genetic potential into actual yields. NaCRRI, under the umbrella of the National Agricultural Research Organisation (NARO), has been very successful in developing new OFSP and non-OFSP cultivars. A total of 22 cultivars have been released in batches in different years; the OFSP varieties were released between 1999 and 2013 (Mwanga *et al.,* 2007b; Mwanga *et al.,* 2009; Ssemakula *et al.,* 2013).

Table 3. Yield and palatability results of four test orange sweetpotato clones in five districts of Uganda under farmer managed conditions, 2012

District	Clone	Total root yield (t/ha)	Biomass (t/ha)	SPVD	Alternaria blight	Flesh colour	Preference (%)
Isingiro	NASPOT 10 (check)	10.8	23.3	2.8	1.3	7	23.8 n=21
	NASPOT 7/2006/1185	8.0	38.8	3.5	1.3	8	0
	SPK004/2006/1136	18.5	36.2	2.9	1.6	8	33.3
	NASPOT 7/2006/292	11.1	26.0	2.8	1.6	8	9.5
Buyende	NASPOT 10(check)	11.3	25.4	2.3	1.0	8	65.9 n=42
	NASPOT 7/2006/1185	4.6	35.0	3.0	1.0	8	4.7
	SPK004/2006/1136	17.5	36.2	2.6	1.0	8	47.6
	NASPOT 7/2006/292	8.2	25.4	2.1	1.1	8	64.3
Rakai	NASPOT 10(check)	7.4	19.0	3.1	1.0	8	34.7 n=49
	NASPOT 7/2006/1185	7.3	27.5	3.5	1.1	8	6.1
	SPK004/2006/1136	12.9	27.4	3.6	1.1	8	16.3
	NASPOT 7/2006/292	9.2	25.6	3.0	1.0	8	34.7
Oyam	NASPOT 10(check)	18.4	32.7	1.3	1.0	8	67.4 n= 89
	NASPOT 7/2006/1185	6.7	34.6	1.4	1.0	8	7.7
	SPK004/2006/1136	18.9	35.3	1.9	1.3	8	75.3
	NASPOT 7/2006/292	14.2	33.2	1.6	1.0	8	67.2
Kabale	NASPOT 10(check)	7.7	21.1	1.5	1.3	7	-
	NASPOT 7/2006/1185	2.7	31.9	2.1	1.3	8	-
	SPK004/2006/1136	13.4	33.7	2.0	1.6	7	-
	NASPOT 7/2006/292	11.5	29.8	2.1	1.6	8	-
$LSD_{0.05}$		2.7	6.5	1.0	0.5	NA	-
CV		55.7	49.0	41.2	42.3	NA	-

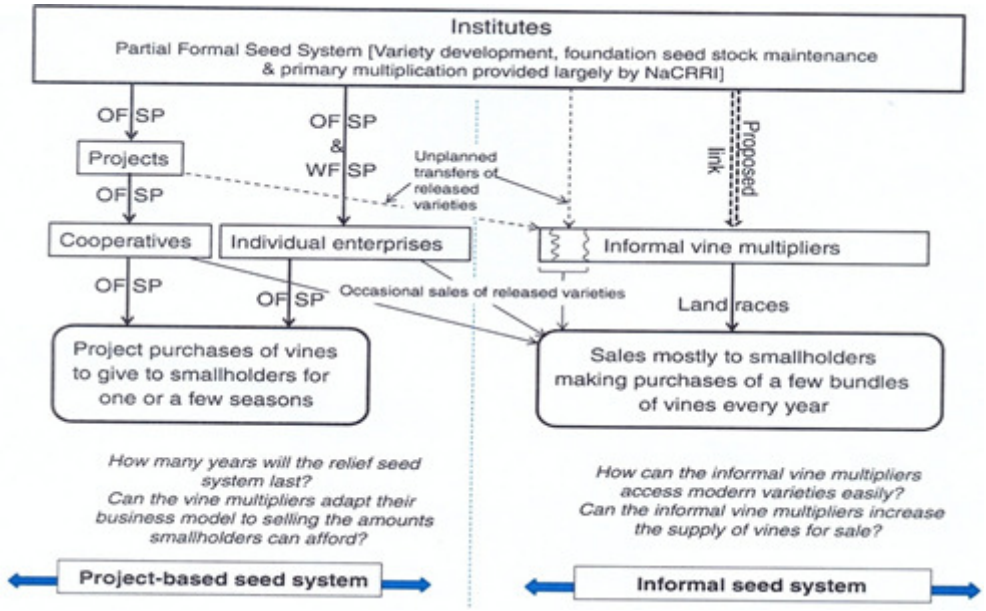
LSD- Least significant difference at 5 %, Fresh color: 7-Light orange, 8- Deep orange, NA - Not applicable. SPVD and Alternaria blight scored on a scale of 1-9: 1=no symptoms, 9=very severe symptoms

Table 4. Released orange-fleshed sweetpotato varieties in Uganda and their attributes

Clone/cultivar	Root yield (t/ha)		Year released	β-carotene concentration	Dry matter content (%)	Disease resistance	
	On-station	On-farm				SPVD	Alternaria
NASPOT 5	23	16	1999	143.26 (îg/g DWB)	34.2	M	R
Ejumula	19	15	2004	26.08 (îg/g DWB)	33.2	S	M
Kakamega	15	12	2004	108.1 (m/g DM)	31.7	M	M
NASPOT 7	25	12	2007	143.6 (m/g DWB)	32.0	M	M
NASPOT 8	20	16	2007	314.5 (m/g DWB)	30.1	M	M
NASPOT 9 ('Vita')	20	13	2007	246.2 (m/g DWB)	30.5	M	M
NASPOT 10 ('Kabode')	18	12	2007	175.7(m/g DWB)	30.3	M	M
NASPOT 12 O	25	16	2013	94.5 (m/g DWB)	32.7	M	R
NASPOT 13 O	38	11	2013			M	R

S = susceptible; M = moderate; R = resistant

In Uganda, as well as other Sub-Saharan Africa (SSA) countries, food security relies heavily on seed systems dominated by an informal sector, which supplies between 85 and 90 percent of the required seed, with a low availability of clean, healthy planting material. The sweetpotato seed system is largely informal and dominated by the private sector (Namanda *et al.,* 2011; Gibson, 2013), with occasional formal distributions of new varieties as part of disaster relief by government or NGOs. Gibson (2013) describes three operational sweetpotato seed systems in Uganda; (i) the limited/ partial formal seed system, (ii) project-based system that involves a few private-enterprise multipliers being funded to supply NGOs with tens of thousands of sacks of vines, which are then distributed freely to relatively few needy households, and (iii) the self-sustaining informal seed system involving moderate numbers of small-scale multipliers who sell small bundles of vines to many smallholders over large areas. For example, OFSP varieties Kakamega (SPK004) and Ejumula released in 2004 and NASPOT 9 O, and NASPOT 10 O released in 2007 (Mwanga *et al.*, 2009) were deployed under the Dissemination of New Agricultural Technologies in Africa (DONATA) project of the Association for Strengthening of Agricultural Research in Eastern and Central Africa (ASARECA), and the Reaching End Users (REU) project of the HarvestPlus Program in Uganda. 'NASPOT 9 O' and 'NASPOT 10 O' were given new names, 'Vita' and 'Kabode', respectively, in the HarvestPlus project areas (HarvestPlus, 2010). Figure 1 is a flow diagram showing how planting material of released varieties move in Uganda, contrasting it with the movement



Source: Gibson (2013)

Figure 1. A flow diagram showing how planting material of released varieties moves in Uganda, contrasting it with the movement of landraces in the northern informal seed system.

of landraces in the northern informal seed system.

In the limited/partial formal seed system (Gibson, 2013), NaCRRI breeds and tests OFSP varieties and together with other national institutions provide vine stocks to project-based seed systems involving large private sector multipliers, which are found predominantly in east and central Uganda. These are mainly either cooperatives derived from smallholder groups organised by projects or are individual farmers with large holdings, who had hosted participatory variety selection trials. The private sector multipliers sell planting materials of released varieties to projects, which distribute them, free to selected households. Projects buy hundreds and occasionally thousands of sacks of vines but they distribute them to only a limited number of needy households and for only one or a few seasons. The informal system functions predominantly in areas with a long dry season, in which vines cannot survive. Its vine multipliers use the wetter lowlands to maintain mostly landraces, which they sell as small bundles of vines to many smallholders at the onset of the rains. Thus, with a ready market, the system is sustainable but quantities sold are price limited.

International programmes, NGOs and projects have played a major role in distributing vines. HarvestPlus is a global programme of the International Center for Tropical Agriculture (CIAT) and the International Food Policy Research Institute, aiming to disseminate micronutrient enriched crops including OFSP. In Uganda, through its offices in Kampala, it facilitates the purchase each year of many sacks of OFSP vines at about US$4 per sack. HarvestPlus works in 13 districts out of a total of 132 in

Uganda, and in some it subcontracts NGOs to distribute seed to households. One of these NGOs is World Vision that works in Koro sub-county of Gulu district; it targets families with children under five or women of child-bearing age. In 2012, World Vision gave half a sack of OFSP vines to each of 1,350 households and each household was expected to grow them and supply to two other households with a similar quantity of cuttings (making 4,050 households in all). Information about OFSP and training in production, marketing and processing was also provided to households.

The Arbeiter-Samariter-Bund Deutschland (ASB) is a German NGO with a country office in Kampala, Uganda. In 2012, it had three OFSP projects in northern and eastern Uganda, funded by the EU, GoU and UN. Each project provided training and half a sack of vines to each of several thousand target households, delivering them through its own extension staff and those of a local partner. Vines were purchased from a vine multiplier cooperative, the Soroti Sweetpotato Producers and Processors Association (SOSPPA). Although ASB and HarvestPlus are supplying tens of thousands of sacks of vines each year, distribution is likely to affect only a small proportion of Ugandans as the country's estimated population is 37 million.

Community Health and information network (CHAIN) Uganda is another local NGO which has acted as a broker among 11 vine multipliers / vine multiplier groups and farmer customers in the western Central Region since 2007. CHAIN arranges sales of a few thousand sacks of vines each year and making a brokerage charge of ~ US$0.3 on each sack sold. It received no project funding for this. None of its vine multipliers grew >1 ha of sweetpotato and the customers for the vines were mostly large commercial farmers living along Masaka road and supplying Kampala market with roots (Gibson, 2013).

Gibson (2013) reported that the four largest multipliers of released varieties are all cooperatives; the rest are owned by individuals who had originally been farmers or agricultural traders. The cooperatives mainly produce vines of OFSP varieties; while the individually owned enterprises often grow non-OFSP varieties and more rarely, landraces. The customer bases of the seed multipliers also differ: the cooperatives sell mainly to NGO projects wanting OFSP varieties, but individual enterprises also sell to Government of Uganda (GoU) programmes, especially, the NAADS, though the latter often want non-OFSP released varieties. With all the above efforts in multiplication and dissemination of OFSP, it is estimated that the adoption rate is 29.2 % under a total area of 177, 828 ha; the total are of land under sweetpotato production in Uganda is 620,000 ha.

Discussion

Combining DM and disease (SPVD) resistance remains a major challenge in Uganda, since all the OFSP varieties released have only moderate levels of resistance (Tables 1 and 2). This suggests need for determination of degeneration rates for the varieties and recommendation of recycling frequencies in OFSP seed systems. Despite this, the varieties have comparable yields to the already released and acceptable varieties; and their palatability is acceptable though varies

with area. For example NASPOT 7/2006/292 had a low preference value (9.5%) in Isingiro; while in Buyende (64.3%) and Oyam (67.2%) it had very high preference values. This calls for a need to capture the differences in varietal attributes that farmers prefer by area and conduct targeted breeding and selection activities.

On seed systems, while a group structure allows members to combine their fields to meet large orders for vines, quality (variety purity and health) is difficult to maintain. The cooperatives and individual multipliers frequently receive orders for vines from projects, each sack at US$4 - 7; thus it is a relatively lucrative market for them. However, given the number of multipliers involved, it also confirms that the project-based seed system is delivering only limited quantities of vines annually compared to the needs of the population of Uganda.

One major issue with project-based seed systems is sustainability; projects function only while funds last, resembling relief seed systems in this respect. Thus, the formal seed systems, together with the project-based seed system, fail to provide all the requirements of a complete seed system. By contrast, the informal seed system, through sales, provides farmers with a regular annual supply of vines, with supply chains reaching distances of >100 km (Gibson, 2013). Despite the perishable nature of vines, the operations of the informal seed system are neither wholly local nor entirely farmer-driven; planting material being distributed over large areas by traders and street vendors. However, prices are a limiting factor; smallholders are able to afford only small quantities of vines. Varietal diversity is also limited; few informal multipliers supply released varieties.

Challenges to expanded production of OFSP

Maintaining seed quality (variety purity and health) at farmer-group level is difficult. There is lack of markets to dispose of planting materials and capital to expand the production of sweetpotato for processing into high quality flours, Low dry matter content of available orange-fleshed varieties limits their increased utilisation at household level mainly by adults. Similarly, for the communities that have initiated the processing into flours, it has been observed that very small quantities of flour are obtained when low dry matter varieties are used. High acceptance is still limited to children because adults prefer dry textured roots and Majority of varieties introduced from outside Africa easily succumb to SPVD infections, hence establishment and adaptability in high-pressure zones is generally poor. Many potential high yielding varieties have been lost in this way.

References

Carey, E.E., Hagenimana, V., K'osambo, L., Oyunga, M.A., Benesi, I., Smit, N., Ocittip'Obwoya, C., Turyamureeba, G., Ndolo, P.J. and Low, J. 1999. Using orange-fleshed sweetpotato varieties to combat vitamin A deficiency and enhance market opportunities for smallholder farmers in sub-Saharan Africa, pp.157-168. In: *Food Security and Crop Diversification in SADC Countries: The Role of Cassava and Sweetpotato,* M.O. Akoroda and J.M. Teri (Eds.). Proceedings of the scientific workshop of the Southern African Root Crops Research Network (SARRNET) held at

Pamodzi Hotel, 17-19 August, 1998, Lusaka, Zambia. 476p.

Dominguez, P.L. 1992. Feeding of sweetpotato products to monogastric animals. In: Proceedings of the FAO expert consultation on roots, tubers, plantains and bananas in animal feeding, Cali, Colombia. Animal Production and Health Paper No 95, pp 217-233. FAO, Rome, Italy.

Gibson, R. 2013. How sweetpotato varieties are distributed in Uganda: Actors, constraints and opportunities. *Food Security* 5(6): 781-791.

HarvestPlus. 2010. Reaching and Engaging End Users (REU) with Orange Fleshed Sweetpotato (OFSP) in East and Southern Africa, Final Report submitted to the Bill and Melinda Gates Foundation, Washington DC, USA.

HarvestPlus. 2012. Disseminating Orange-Fleshed Sweetpotato: Findings from a HarvestPlus Project in Mozambique and Uganda. 2012. Washington, D.C.: HarvestPlus.

Hotz, C,. Loechl, C., Lubowa, A., Tumwine, J., Ndeezi, G., Masawi, A.. Baingana, R., Carriquiry, A., Brauw, de; Meenakshi, J. and Gilligan, D. 2012. Introduction of [Beta]-Carotene-rich orange sweetpotato in rural Uganda resulted in increased vitamin A intakes among children and women and improved vitamin A status among children. *Journal of Nutrition* 142(10):1871-1880.

Mwanga, R.O.M. and Ssemakula, G. 2011. Orange-fleshed sweetpotatoes for food, health and wealth in Uganda. *International Journal of Agricultural Sustainability* 9 (1): 42-49.

Mwanga, R.O.M., Niringiye, C., Odongo, B., Opio, A.F., Lemaga, B., Kyadondo, B., Sserunjogi, L., Owori, C. and Kapinga, R. 2007a. Partnership: An approach to promote orange-fleshed sweetpotato, experiences from Uganda. In: R. Kapinga., R. Kingamkono, M. Msabaha, J. Ndunguru, B. Lemaga, and G. Tusiime (Eds). Proceedings of the 13th International Society for Tropical Root Crops (ISTRC). Tropical Root And Tuber Crops: Opportunities for Poverty Alleviation and Sustainable Livelihoods in the Developing World. November 10-14, 2003, Arusha, Tanzania. pp. 770-779.

Mwanga, R.O.M., Odongo, B., Niringiye, C.N., Alajo, A., Abidin, P. E., Kapinga, R., Tumwegamire, S., Lemaga, B., Nsumba, J. and Carey, E.E.. 2007b. Release of two orange-fleshed sweetpotato cultivars, 'SPK004' ('Kakamega') and 'Ejumula' in Uganda. *HortScience* 42(7):1728 - 1730.

Mwanga, R.O.M., Odongo, B., Niringiye, C.N., Alajo, A., Kigozi, B., Makumbi, R., Lugwana, E., Namakula, J., Mpembe, I., Kapinga, R., Lemaga B., Nsumba, J., Tumwegamire, S. and Yencho, C.G. 2009. 'NASPOT 7', 'NASPOT 8', 'NASPOT 9 O', 'NASPOT 10 O', and 'Dimbuka-Bukulula' Sweetpotato. *HortScience* 44(3):828–832.

Namanda, S., Gibson, R. and Sindi, K. 2011. Sweetpotato Seed Systems in Uganda, Tanzania and Rwanda. *Journal of Sustainable Agriculture* 35(8):870-884.

Ryder, R.W., Nsa, W., Hassig,S.E., Behets, F., Rayfield,M ., Ekungola, B.., Nelson, A.M., Mulenda, U., Francis, H., Mwandagalirwa, K., Davachi, F., Rogers, M., Nzilambi, N., Greenberg, A., Mann, J., Quinn, T.C. ,

Piot, P. and Curran, J.W. 1989. Perinatal transmission of the human immunodeficiency virus type 1 to infants of seropositive women in Zaire. *New English Journal of Medicine* 320:1637-1642.

Ssemakula, G., Niringiye, C., Otema, M., Yada, B., Kyalo, G., Namakula, J., Alajo, A., Kigozi, B., Makumbi, R., Yencho, C. and Mwanga, R.O.M.. 2013. Submission to the variety release committee for release of sweetpotato varieties. National Crops Resources Research Institute, NARO, Entebbe, Ugamda. pp. 34.

UBOS and Macro International Inc. 2006. Uganda Bureau of Statistics, Kampala, and Macro International Inc. Calverton, Maryland, USA, August 2007 pp. 467.

WHO. 1995. World Health Organisation Global prevalence of vitamin A deficiency. Micronutrient Deficiency Information System (MDIS) Working Paper No. 2. WHO, Geneva, Switzerland.