Cover photo: A farmer in her garden planted with vines from Triple S technology in Oyam district, taken by Sam Namanda, CIP Uganda

Delivering and Disseminating Biofortified Crops in Uganda

Quarterly Report July–September 2013

Prepared for:
HarvestPlus

Submitted by:
International Potato Center (CIP)

Delivering and Disseminating Biofortified Crops in Uganda

International Potato Center (CIP), National Crops Resources Research Institute (NaCRRI)/National Agricultural Research Organization (NARO), Makerere University (MAK) and BioCrops

Quarterly Report
July–September 2013

Prepared by:

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Summary

During this reporting period, MAK has continued conserving in vitro plantlets of three OSP varieties (Kabode, Vita and Ejumula) as backup for NaCRRI and BioCrops. BioCrops has since January 2013 delivered 33,200 vines (13,600 of Ejumula, 11,600 of Kabode and 8,000 of Vita) to CIP and vine multipliers. CIP in collaboration with the National Crops Resources Research Institute (NaCRRI) of the National Agricultural Research Organization (NARO) planted 28 on-farm trials at Oyam, Buyende and Rakai. The trials were setup with eight OSP clones, Ejumula(OP)2012/3, Ejumula(OP)2012/11, Ejumula(OP)2012/9, Ejumula(OP)2012/10, Resisto (OP)2012/1, SPK004/2006/1136, NASPOT7/2006/292 and NASPOT 10 O (common check). CIP also harvested and planted trials for clean vs farmer materials in Mukono, Kamuli, Buyende and Rakai districts. Generally Ejumula farmer material was almost five times more infected by sweetpotato virus disease (SPVD) than Biocrops first cycle material. Biocrops re-cycle 1 Kabode material was as less infected as Biocrops first cycle material but Ejumula Biocrops recycle 1 was more infected than Biocrops first cycle material. Generally SPVD infection levels were higher in Mukono than Kamuli and Buyende districts for both varieties. On average, Ejumula from BioCrops yielded three times better than farmer material while Kabode from BioCrops yielded 2.3 times better than farmer material. CIP also set up post-harvest experiments in Masaka and Rakai. The experiments will run for the next three months.

1.0 Introduction

This is the second year of the project, "Delivering and Disseminating Biofortified Crops in Uganda," which started in January 2012. The project is implemented by partners, the International Potato Center (CIP), HarvestPlus, Makerere University, Department of Agricultural Production, College of Agricultural and Environmental Sciences (MAK), the National Crops Resources Research Institute (NaCRRI) of the National Agricultural Research Organization (NARO), and a private company, BioCrops Uganda Limited. In this project, MAK is providing virus free tissue culture derived sweetpotato plantlets/cuttings to the private company, BIOCROPS (U) Ltd, for the initial commercial multiplication of disease-free material. During this year 2 of the project MAK is conserving virus free plantlets as a backup and for supply to NaCRRI and BIOCROPS (U) LTD. NaCRRI is continuing with breeding activities, on-station and on-farm trials, while BioCrops is continuing with multiplication and supply of virus free OSP materials. CIP has continued coordinating all activities and to lead research on Triple S, post-harvest handling of sweetpotato roots and on-farm evaluation of OSP clones in partnership with NaCRRI. This is the quarterly report (July- September, 2013) for the second year of the project with component objectives and activities (Tables 1 to 6, photos A to I, appendices 1 to 5).

1.1 Project Objectives

The project's main objectives are to:

1. Establish a sustained supply and conserve virus-free plantlets of major OSP varieties at Makerere University and at NaCRRI.
2. Establish capacity of a private sector operator (BioCrops) to produce cuttings of primary foundation material.
3. Facilitate the adoption of at least three new OSP varieties to local conditions of northern and western Uganda.
4. Identify in every district, two commercially oriented, large-scale vine multipliers with excellent management skills.
5. Have at least 30% of target households in areas with prolonged dry seasons (>4 months) adopt the Triple S technology.

6. Test and refine recommended practices for curing sweetpotatoes by smallholder farmers to increase longevity in storage.

2.0 Major Accomplishments during the reporting period

2.1 Planting on-farm and on-station trials

On-farm trials for season 2013B were established in Oyam (30/7-2/8/2013), Rakai (2-4 September 2013) and Buyende (17-22/9 2013) districts (Photo F). A total of 28 trials (10-Oyam, 10-Buyende, and 8-Rakai) were planted with farmers with eight orange sweetpotato (OSP) clones, Ejumula(OP)2012/3, Ejumula (OP)2012/11, Ejumula (OP)2012/9, Ejumula (OP)2012/10, Resisto (OP)2012/1, SPK004/2006/1136, NASPOT7/2006/292 and NASPOT 10 O (Kabode as common check) (Appendix 4). We planted 5 -33 heaps per clone per farmer depending on availability of planting materials with 3 cuttings (30 cm) per heap. The heaps were spaced 1 m from each other. The same clones were planted at two locations (Namulonge and Serere) in Uganda in a preliminary yield trial. Preliminary data has been collected and is presented in Table 1.

Table 1. SPVD, Alternaria (Alt), vigour (Vig) and Establishment (Est) of 7 clones planted at Namulonge and Serere

Location	Trait	Ejumula(OP) /2012/3	Ejumula(OP) /2012/9	Ejumula(OP) /2012/10	Ejumula(OP) /2012/11	Resisto (OP)/2012/2	Boy (check)	Naspot 10 (Check)
Serere	**Est**	5	1	4	1	6	1	1
	Vig	1	1	1	1	2	1	2
	SPVD	1	1	5	1	2	1	2
	Alt	1	1	1	1	3	1	1
Namulonge	**Est**	2	2	3	1	3	.	1
	Vig	2	2	2	2	2	.	2
	SPVD	2	2	2	2	2	.	3
	Alt	1	1	1	5	1	.	1

SPVD and Alternaria blight scored on a scale of 1-9: 1=no symptoms, 9=very severe symptoms

2.2 Planting and screening seedling nursery at NaCRRI

A seedling nursery has been established at Namulonge comprising of families locally obtained from OSP clones and others sourced from a sister institute in Mozambique (Appendix 6).

2.3 Planting of season 2013B trials for clean vs. farmer materials

Trials for clean vs. farmer materials for season 2013B were planted in Mukono, Kamuli, Buyende and Rakai districts (09-27th September) with Kabode and Ejumula varieties (Photos A, E). The trials were established with clean materials from Biocrops Uganda Ltd, farmer materials and recycled clean materials for season 2 2012and season 1 2013 (See Table 2 for details). Data on visual symptoms of SPVD (scale of 1 – 9) will be recorded at one and two months after planting. Other data on marketable, unmarketable storage root yield and foliage weight will be taken at 100 – 120 days.

Table 2. Design sources of experimental cuttings for Ejumula and Kabode varieties for planting during 2012b to 2014a seasons

Season	Biocrops	Biocrops re-cycled	Farmer source

2012b	Biocrops lot 1	-	Existing
2013a	Biocrops lot 2	Biocrops lot 1: cycle 1	Farmer 2012b
2013b	Biocrops lot 3	Biocrops lot 1: cycle 2 Biocrops lot 2: cycle 1	Farmer 2013a
2014a	-	Biocrops lot 1: cycle 3 Biocrops lot 2: cycle 2 Biocrops lot 3: cycle 1	Farmer 2013b

2.4 Pre-harvest monitoring/evaluation of on-farm trials

Pre-harvest evaluation of on-farm trials was done in Isingiro, Buyende, Oyam and Rakai districts. Trials were assessed for SPVD, Alternaria blight and vigor. Trials in Isingiro, Oyam and Rakai were progressing well while trials in Buyende and Kabale were severely affected by drought. The clones generally had SPVD scores below 4 indicating some level of resistance.

2.5 Harvesting trials for clean vs farmers' materals in Buyende, Mukono and Rakai

First season 2013 trials for clean vs farmer materials were harvested in Mukono, Kamuli and Buyende districts (9-27th September) (Photo B). All the trials in Rakai were destroyed by drought, none was harvested. Generally SPVD infection levels were low across treatments attributed to very irregular and limited rains during the growing period although Ejumula farmer material was almost five times more infected by SPVD than Biocrops cycle zero material. Both Ejumula and Kabode Biocrops material had the lowest SPVD scores. Biocrops re-cycle 1 Kabode material was as less infected than Biocrops cycle zero but Ejumula Biocrops recycle 1 was more infected than Biocrops cycle zero. Generally SPVD infection levels were higher in Mukono than Kamuli and Buyende districts for both varieties (Table 3). On average, Ejumula from BioCrops yielded 3 times more than farmer material (Photos C and D) while Kabode BioCrops yielded 2.3 times more than farmer material. There were no significant differences between both Kabode and Ejumula from BioCrops and cycle 1 materials, but cycle 1 materials had root yields almost twice the farmer materials (see Table 4 and appendix 5 for details). Preliminary evaluation of the two sources of planting material has confirmed that clean material performs better than farmer material recycled season after season. Planting a crop using cleaned vine cuttings greatly increases the storage root yield for both susceptible and resistant varieties but with more yield increase on susceptible varieties.

Table 3: Virus score on Ejumula and Kabode varieties planted using different sources of planting material in three districts during season 2013a

Farmer	Ejumula variety			Kabode variety		
	Biocrops	Biocrops cycle 1	Famer	Biocrops	Biocrops cycle 1	Famer
Buyende 1	1.0	1.3	3.3	1.0	1.0	2.6
Buyende 2	1.0	1.7	3.0	1.0	1.0	1.0
Av. Buyende	1.0	1.5	3.2	1.0	1.0	1.8
Kamuli 1	1.0	1.0	3.0	1.0	1.0	1.7
Kamuli 2	1.0	2.0	3.7	1.0	1.0	2.0
Av. Kamuli	1.0	1.5	3.4	1.0	1.0	1.9
Mukono 1	1.0	2.0	5.0	1.0	1.0	3.0
Mukono 2	1.0	3.0	4.3	1.0	1.0	2.0
Av. Mukono	1.0	2.5	4.7	1.0	1.0	2.5

$Lsd_{0.05}$ = 0.5 for source x variety x farmer interactions

Table 4: Relating average virus infection levels with storage root yield (tons/ha) and of Ejumula and Kabode varieties planted using different sources of planting material during season 2013a

Attribute	Ejumula variety			Kabode variety			Lsd
	Biocrops	Biocrops cycle 1	Farmer	Biocrops	Biocrops cycle 1	Farmer	0.05
SPVD infection score	1.0	1.8	3.7	1.0	1.0	2.1	0.2
Marketable roots yield	3.2	1.7	0.9	5.1	2.4	2.1	NS
Root yield	4.4	3.2	1.4	6.6	3.8	2.9	NS
Foliage yield	7.4	11.2	17.1	9.2	7.9	9.4	1.6
Total Biomass yield	11.8	14.4	18.5	15.8	11.7	12.3	2.2
% root yield of Biomass	37.3	22.2	7.6	41.8	32.5	23.6	

NB: SPVD scored on a scale of 1-9: 1 = (no symptoms, 9 very severe)

2.6 Setting up of post-harvest experiments

Post-harvest experiments were setup in Masaka and Mukono starting 28th September 2013. The trials were set up with two curing treatments- under-ground curing for 2-5 and 7 days and curing in moist saw dust for the same period (Photos G, H,I). Storage experiments will also be setup with three treatments- storage in sand, storage in house-hold sand and storage in the open. Roots stored in sand will be cooked and palatability tests done to determine up to what time the roots can remain palatable while in storage.

2.7 Release of promising clones SPK004/2006/1136 and NASPOT7/2006/292

Clones SPK0042006/1136 and NAS7/2006/292 that were more preferred by farmers were planted for distinctiveness, uniformity and stability (DUS) tests; the tests were performed by the Ministry of Agriculture officials in August, 2013. The variety release document for the two promising clones has been prepared and submitted to the Variety Release Committee. We proposed that the two clones be released the official naming as NASPOT 12 O and NASPOT 13 O (O following the numeral = orange), respectively. The final release (verdict) of the two clones depends on when the Variety Release Committee calls a meeting to release plant varieties for which applications have been filed.

2.8 Tissue culture plantlet multiplication – MAK

MAK is maintaining the in vitro plantlets of three orange sweetpotato (OSP) varieties at Makerere University Plant Tissue Culture Laboratory at Kabanylo. A total of 100 in vitro plantlets of each variety, namely Ejumula, Kabode (NASPOT 10 O) and Vita (NASPOT 9 O) were originally received from CIP-Nairobi in year 1. The in vitro plantlets are being sub-cultured onto multiplication medium every 3-4 weeks, and later hardened and weaned in the screenhouse at Kabanyolo. MAK is also maintaining three varieties (Ejumula, Kabode, and Vita in the screenhouse at Kabanyolo as climbing (trellised) vines. The vines planted in the screenhouse have been replanted this September 2013. MAK has so far delivered about 50 and 20 in vitro sweetpotato plantlets (culture bottles) to BIOCROPS (U) Ltd and NaCRRI for primary multiplication and sand hydroponics multiplication, respectively. Under this new phase at least two other technicians from BIOCROPS will be trained in sweetpotato tissue culture techniques during November 2013. The previous plans to train two more technicians were foiled by the industrial action (strike) by the Makerere University staff.

2.9 Vine multiplication at BioCrops

The target for BioCrops in 2013 was to provide 40,000 vines to CIP and vine multipliers. The deliveries of vines and status of multiplication are summarised in Table 5 below.

Table 5. Summary of status of the activities from 15 June to 15 September 2013

Activity/Milestone	Targeted output	Target date	Baseline	Status	Comment
A constant supply of clean vines maintained	40,000 virus free vines	31 December 2013	32,000 vines were delivered up to June 2013: Ejumula = 13,000 Kabode = 11,000 Vita = 8,000	83% delivery achieved	Total of 33,200 vines have now been delivered since January 2013: Ejumula = 13,600 Kabode = 11,600 Vita = 8,000
In vitro cultures of indexed sweetpotatoes established	Have at least 100 in vitro cultures of Ejumula, Kabode and Vita and at least two other farmer preferred varieties	By end of July 2013	A three phase line has been laid up to BioCrops. An application has been made to UMEME to upgrade the electricity supply to a industrial level (3 phase).	Full lighting of the growth room awaits installation of the 3 phase supply	The cooling system (AC) has been installed in the culture room that will handle sweet potato culturing. 40 cultures of Kabode, 20 of Ejumula and 20 of Vita are multiplying in vitro
BioCrops staff trained by MAK in tissue culture of sweetpotato	4 staff trained	First week August 2013	Two staff trained by MAK in 2012 in sweet potato tissue culture and screen house propagation.	Training of staff has been achieved	A s a follow up and completion of the training, in house training of staff in tissue culture and weaning was provided by MAK

Photos

A

B

C

D

E

F

G

H

I

A: Farmers cut BioCrops vines cycle 1 to be planted as cycle 2 in the clean vs. farmer's material trials
B: Farmers participate in harvesting of clean vs farmer material trials in Buyende
C: Sweetpotato roots from 3 m^2 harvested area from Ejumula BioCrops material
D: Roots from 3 m^2 harvested area of Ejumula farmer materials
E: Farmers share some clean vines from BioCrops
F: Farmers participate in the planting of second season on-farm trials in Rakai district
G: Curing sweetpotatoes by removing the top cover
H: Curing sweetpotatoes in saw dust
I: storing cured roots in the farmer's house

3.0 Summary of personnel commitments

Dr. Robert Mwanga and Mr. Gerald Kyalo have continued to serve as Principal Investigator and Field Crops Agronomist for the project, respectively. Our partners, NaCRRI, Makerere University and BioCrops also continued with their activities as stipulated in their contracts. At NaCRRI, one Scientist (10% time), 1 technician (50%) and 1 driver (30%) are involved in the project. At Makerere, Dr. Ssetumba Mukasa has two technicians who are committed to the project.

4.0 Major equipment acquired

None.

5.0 Description of significant travel

During the reporting period, CIP staff undertook travels to accomplish project objectives. Table 6 below summarizes the travels.

6.0 Delays, Problems, Suggestions

The planned project activities are on course.

Table 6. Summary of significant travels

Date	Name	Institution	Locations	Travel objective	Output
02-7.7.2013	Gerald Kyalo	CIP	Rakai, Masaka, Soroti, Mukono	Monitoring materials for post-harvest experiments	Gardens monitored, planning for post-harvest experiments done

Date	Name	Institution	Locations	Travel objective	Output
29.7-8.8.2013	Gerald Kyalo Joweria Namakula	CIP NaCRRI	Oyam Buyende, Rakai, Isingiro	Planting 2nd season OSP trials Monitoring 1st season trials	Ten trials planted in Oyam, Pre-harvest and establishment data collected.
09-14. 09.13	Gerald Kyalo	CIP	Mukono, Kamuli,	Harvesting 1st season clean vs farmer trials, planting 2nd season clean vs farmer materials	Four trials harvested, 6 trials planted.
17-21.09. 2013	Gerald Kyalo	CIP	Buyende	Planting 2nd season OSP trials, harvesting & planting clean vs farmer material trials	10 OSP trials planted in Buyende, 3 trials of clean vs farmer materials harvested, 3 trials of clean vs farmer material planted.
26-28.09. 2013	Gerald Kyalo	CIP	Rakai, Masaka	Planting 2nd season trials of clean vs farmer materials.	3 trials planted
02-05.9.13	Gerald Kyalo	CIP	Rakai, Masaka	Planting 2nd season OSP trials, setting up post-harvest experiments	8 trials planted, post-harvest trials set up in Bukakata subcounty.
8-14. 7.13	Sam Namanda	CIP	Masaka, Rakai	Monitoring 1st season clean vs farmer trials, planning for 2nd season trials	Pre-harvest data taken, host farmers for 2nd season trials identified
15-23.8.13	Sam Namanda	CIP	Mukono, Kamuli, Buyende, Gulu, Oyam, Lira and Kole districts	Monitoring trials on clean vs farmer material, planning for 2nd season planting, follow up on Triple S technology.	Pre-harvest data taken, farmers to host trials for clean vs farmer material in 2nd season identified. A total of 5 seed root production fields planted each in Lira, Kole, Oyam and 2 in Gulu districts.

Appendix 1: Progress on Objectives and Outcomes for CIP

Milestone	Targeted outputs	Baseline	Progress/ Status	Comments
Objective 1:	**Ensure disease-free supply of primary foundation seed**			
Provide training, and ensure that the private sector partner can produce quality primary material using plantlets from MAK, initially obtained from KEPHIS, Muguga, Kenya.	40,000 cuttings of primary material produced	Required pathogen-tested in vitro OSP varieties not available at MAK	A total of 32,000 vines delivered by BioCrops since January 2013. 1. Ejumula = 13,000 2. Kabode = 11,000 3. Vita = 8,000 80 % delivery achieved.	Activity is on schedule
Asses the cost of tissue culture multiplication in Uganda.	Capacity of Biocrops to multiply clean foundation planting material established, two vine multipliers identified per district and trained on vine multiplication techniques	No experience of multiplying pathogen-tested OSP vines	Seven vine multipliers visited BioCrops on 10th December 2012 and were taken through the tissue culture procedure of generating virus free shoots and how the clean status is maintained in the insect proof nets/screen houses and on farm. They were also trained in weaning and nursery management.	Tracking of costs at BioCrops is on-going
Objective 2:	**Transfer the Triple S technology at scale and build a cadre of trained extension personnel to monitor its adoption**			
Select key dry areas for testing this technology at scale.	Triple S technology validated and scaled up with farmers in key dry areas, 30% of target households in areas with prolonged dry seasons adopt the technology	Triple S technology not yet tested in HarvestPlus project areas	One site was planted in each of the districts of Oyam, Lira, Kole and Gulu using Kabode and Kakamega varieties. Seed roots will be shared with other farmers	Activity is on schedule
Train extension personnel to effectively implement the technology.	At least one lead farmer from each county hosting OSP trials trained in OSP production	No extension personnel trained in OSP production	More identified farmers and extension workers will be trained	Activity is continuous
Monitor adoption of technology and make any needed changes in approach	At least 30% of communities in project areas adopt Triple S.	OSP is not grown in the project areas	Not done	Activity planned for later years

Milestone	Targeted outputs	Baseline	Progress/ Status	Comments
based on addressing any emergent constraints to adoption.				
Evaluate characteristics of adopters and non-adopters.	Percent adoption and characteristics of adopters	Technology absent in project area	Not done	Activity planned for later years
Objective 3:	**Accelerate evaluation of on-farm of promising OSP clones**			
Conduct on-farm trials with extensive farmer participation in key target areas.	New OSP clones evaluated with farmers and at least two clones selected for further evaluation	New OSP clones from NaCRRI have not been tested in HarvestPlus project areas	2nd season OSP trials for 2013 have been planted in Buyende, Mukono and Rakai districts with OSP clones Ejumula(OP)2012/3, Ejumula(OP)2012/11, Ejumula(OP)2012/9, Ejumula(OP)2012/10 and Resisto(OP)2012/1. A total of 28 trials have so far been planted	Activity is on schedule
Provide at least two new clones for cleanup for the seed system by year 4	Promising clones cleaned up before they are provided to vine multipliers and farmers	New clones from NaCRRI not yet cleaned	Promising clones SPK004/2006/1136 and NASPOT7/2006/292 have already been sent to KEPHIS, Kenya, for cleaning.	Promising clones will be cleaned as and when they come up
Objective 4:	**Improve curing techniques and investigate other ways to improve post-harvest quality and extend post-harvest shelf life of traded OSP**			
Design and conduct trials and curing demonstrations	Conditions for curing established	There is no curing of OSP in E. Africa	Curing trials have been setup in Masaka and Mukono with one farmer in each district. Some of the gardens were affected by drought and are not yet ready for harvest. About 70% of target completed	The remaining curing trials will be set up when the materials are ready.
Evaluation of improved curing methods vs. current practice	Improved curing and storage techniques tested with farmers	Limited shelf life of sweetpotatoes	Curing experiments have already been setup with some farmers	Activity on schedule

Milestone	Targeted outputs	Baseline	Progress/ Status	Comments
Work with implementation team to improve training on handling of roots during harvest and postharvest.	Partners in project areas trained in post-harvest handling (PHH)	No trained partners with experienced in PHH in project areas	Trainings on post-harvest handling will be scheduled at an appropriate time	Activity planned for later years
Objective 5:	**Backstop Implementation Team and Broader Dissemination Objectives**			
Respond to emergent problems concerning sweetpotato multiplication and production as requested by the implementation team.	Emerging problems solved	Issues among partners vary	CIP staff backstop HarvestPlus team on training of farmers, extension personnel and vine multipliers	Activity is continuous
Ensure that experience is documented and any relevant materials and findings are loaded on the Sweetpotato Knowledge Portal.	Documented experiences	No experiences on new OSP varieties and Triple S in HarvestPlus project areas	Quarterly and mid-term technical reports have been written	Activity is continuous

Appendix 2: Progress on Objectives and outcomes for NaCRRI

Milestone	Targeted out puts	Baseline	Progress	Comments
Objective:	**Accelerate evaluation on-farm of promising OFSP clones**			
Conduct on-farm trials with extensive farmer participation in key target areas.	New OFSP clones evaluated with farmers and at least two clones passed on to the farmers	New OFSP clones from NaCRRI have been tested on-station.	OSP clones Ejumula(OP)2012/3, Ejumula(OP)2012/11, Ejumula(OP) 2012/9, Ejumula(OP)2012/10 and Resisto(OP)2012/1 have been planted in on-farm and on-station trials. A total of 28 on-farm trials have so far been planted. Release document for SPK0042006/1136 and NAS7/2006/292 has been submitted to the Variety Release Committee (VRC).	The remaining trials will be planted once the weather becomes favorable. Activity is on schedule The final release depends on the VRC
Objective:	**Backstop Implementation Team and Broader Dissemination Objectives**			

Respond to emergent problems concerning sweetpotato multiplication and production as requested by the implementation team.	Provide solutions to urgent problems	No research institution ready to backstop partners consistently	NaCRRI team backstops partners as need arises	Activity is continuous
Ensure that experience is documented and any relevant materials and finding are loaded on the Sweetpotato Knowledge Portal.	Documented information is readily available	Information on OSP in target districts lacking	Quarterly and mid-term technical reports have been written	Activity is continuous

Appendix 3: Progress on Objectives and Outcomes for MAK and BioCrops

Milestone	Targeted out puts	Baseline	Progress	Comments
Objective :	**Ensure disease-free supply of primary foundation seed**			
Provide training, and ensure that the private sector partner can produce quality primary material using plantlets from MAK, initially obtained from KEPHIS, Muguga, Kenya	40,000 cuttings of primary material produced by BioCrops	BioCrops has clean OSP from MAK	Total of 33,200 vines have now been delivered since January 2013: Ejumula = 13,600 Kabode = 11,600 Vita = 8,000 83 % delivery achieved 100 bottles (of 2-3 plantlets) of each variety are being maintained at MAK.	Activity is on schedule. Sub-culturing is done at least once every month. Plants have already been established in the screenhouse for further multiplication. MAK will continue delivery to BIOCROPS.
Asses the cost of tissue culture multiplication in Uganda	Capacity of Biocrops to multiply clean foundation planting material established	No experience with OSP multiplication	Tracking of costs at BioCrops is on-going	Activity is continuous

Appendix 4: List of farmers participating in on-farm trials in Oyam, Buyende and Rakai districts

District	Name of farmer	Sub county	Parish
Oyam	Awapu Denis	MinaKulu	Atek
	Adon Jenipher	MinaKulu	Atek
	Abor David	MinaKulu	Atek
	Joyce Amoyi	MinaKulu	Atek
	Omara Christopher	MinaKulu	Atek
	Egong Richard	MinaKulu	Atek
	Francis Agoma	MinaKulu	Atek
	Owani Christopher	MinaKulu	Atek
	Otim Florence	MinaKulu	Atek
	Lilly Ongom	MinaKulu	Atek
Buyende	Safani Isabiryr	Bugaya	Namulikya
	Wakoli Irene	Bugaya	Namulikya
	Eliot Mukyala Bagoole	Bugaya	Kitukiro
	Moses Gente	Bugaya	Kitukiro
	James Mwase	Buyende	Ndorwa
	Aidha Nakiduli	Buyende	Ndorwa
	Sylvia Bisirikirwa	Buyende	Ndorwa
	Jane Amuge	Buyende	Ndorwa
	Irene Mukyala	Buyende	Ndorwa
	Sarah Kweberaawo	Buyende	Ndorwa
Rakai	Goretti Namusoke	Kirumba	Kyengeza
	Nalongo Kavuma	Kirumba	Kyengeza
	Hanifa Najjemba	Kalisizo Rural	Nsumba
	Loenard Kanwagi	Kalisizo Rural	Nsambya
	Sabena Nansonko	Lwankoni	Lwenkanja
	Nsumba Ahmed	Buwunga	Buyanja
	Madina Kalema	Buwunga	Kitengesa
	Joseph Katerega	Kalisizo town council	Minzi

Appendix 5: Draft report of clean vs farmer materials for season 2013A

Comparing performance of tissue culture matrial against farmers existing sweetpotato planting material in Kamuli and Mukono districts during season 2013a

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Background of Demo plots

HarvestPlus is implementing promotion of Vitamin A rich sweetpotato varieties including Ejumula, Kabode, Kakamega and Vita in 13 target districts in Uganda representing the different country agro-ecologies. Planting vines are sourced from contact vine multipliers in Mukono, Kamuli and Bukedea districts, areas of earlier, Reaching End User (REU) project implementation during 2007 – 2010 periods. Most vine multipliers have reported increased lack of Ejumula variety, and reluctant to continue multiplying it because of being more susceptible to sweetpotato virus disease (SPVD) and overtime the root yield has greatly declined. Ejumula landrace is among the varieties high in provitamin A and most preferred for consumption.

HarvestPlus in partnership with CIP, Biocrops and Makerere University are promoting the use of cleaned up planting material from tissue culture plantlets, free from disease. Clean planting materials are conserved and multiplied under protected net tunnels by Biocrops. The aim is to flash out the degenerated material at farmer level with the clean vines. Pre-requisite for promoting use of cleaned vines is farmers to conceptualize the use of clean planting material through on-farm demonstrations. Thus, the purpose of the trial is to demonstrate the performance of clean against farmer own source of material.

Biocrops (cleaned material, referred to in this report as cycle 0) and farmer (not cleaned) sources of vines of Ejumula (SPVD susceptible variety) and Kabode (SPVD resistant variety) were planted in Buyende, Kamuli, Mukono and Rakai/Lyatonde districts. Kamuli and Mukono districts were reaching End-User (REU) project areas, where dissemination of Ejumula and Kabode varieties were initially introduced in 2007 and have since been sources of planting material to other areas. Buyende and Rakai/Lyatonde are part of the HarvestPlus implementation areas where initial introductions of orange sweetpotato materials including Ejumula were pilot disseminated. Unfortunately most of the varieties especially Ejumula succumbed to sweetpotato virus disease due to the existing high virus pressure in the recipient areas. Thus need to promote the use of clean planting material through demonstrations on clean and unclean planting material using susceptible (Ejumula) and resistant (Kabode) varieties across the implementation areas.

In 2012b season (planted in September), limited quantities of clean (Biocrops) material were available to establish not more than two sites, each in Mukono and Kamuli districts. Unfortunately, the site in Mukono was lost because the famer missed early crop weeding and the crop was over grown and suppressed by couch grass besides being late planted. Although the Kamuli site was also affected by late planting and could not obtain sufficient data; the host farmer successfully conserved and multiplied the material by source and variety in the valley bottom during dry season. Besides the Biocrops source, the dry season conserved and multiplied crop provided the planting material (recycled and farmers') for planting in the subsequent season, 2013a (April planting) at all sites in different districts. During 2013a season, three farmer groups from each of the four districts (Buyende, Kamuli, Mukono and Rakai/Lyatonde) were selected to host the trial on comparing the performance of tissue culture and farmers own sources using two varieties (Ejumula and Kabode). Each variety treatment was planted on 36 heaps, each 1 m^2 and 3 cuttings, each 30 cm long and replicated 3 times at each host farmer group. Pre-harvest data on sweetpotato disease performance was conducted at 30 and 60 days after planting and harvested 100 days after planting. Harvest data on number and weight of both marketable and unmarketable roots, and foliage weight were recorded. At 60 - 75 days after planting, vines from all the treatments were sourced from the peripheral rows plus Biocrops source for establishment of the successive trial for season 2013b.

Experimental design

In season 2012b (planted in September), planting material for both Ejumula and Kabode varieties were sourced from Biocrops and farmers existing planting material and planted at two sites only. In subsequent two trial seasons: 2013a (planted in April) and 2013b (September), the re-cycle source treatment was added to Biocrops and farmer sources as indicated in the table below. In the coming season, 2014a (planting in April) sourcing from Biocrops will be excluded but continue follow up on re-cycled against farmers material.

Table 1: Design sources of experimental cuttings for Kakamega and Kabode varieties for planting during 2012b to 2014a seasons

Season	Biocrops	Biocrops re-cycled	Farmer source
2012b	Biocrops lot 1	-	Existing
2013a	Biocrops lot 2	Biocrops lot 1: cycle 1	Farmer 2012b
2013b	Biocrops lot 3	Biocrops lot 1: cycle 2	Farmer 2013a
		Biocrops lot 2: cycle 1	
2014a	-	Biocrops lot 1: cycle 3	Farmer 2013b
		Biocrops lot 2: cycle 2	
		Biocrops lot 3: cycle 1	

NB: the number of total cycles for individual BioCrops lot of material will be dropped when the yield obtained is almost equal to the farmer own yield. Assumption is that farmers had reported dropping what they had due to poor performance. At this point a record of number seasons will give an indication of how many seasons are needed to flash out the existing material.

Data collection

The numbers of plants with visual symptoms of SPVD (scale of 1 – 9) where 1 = no symptoms and 9 = severe symptoms were recorded at one and two months after planting. Plants showing early disease symptoms were rouged out to minimize the disease transmission to other plants. Whole harvesting of a sample of five heaps per treatment was done 120 days after planting and data on marketable, unmarketable and the respective weights were recorded. Data were computed and summarized using excel spread sheets.

Results

Table 2: Virus score on Ejumula and Kabode varieties planted using different sources of planting material in three districts during season 2013a

	Ejumula variety			Kabode variety		
Farmer	Biocrops	Biocrops cycle 1	Famer	Biocrops	Biocrops cycle 1	Famer
Buyende 1	1.0	1.3	3.3	1.0	1.0	2.6
Buyende 2	1.0	1.7	3.0	1.0	1.0	1.0
Av. Buyende	1.0	1.5	3.2	1.0	1.0	1.8
Kamuli 1	1.0	1.0	3.0	1.0	1.0	1.7
Kamuli 2	1.0	2.0	3.7	1.0	1.0	2.0
Av. Kamuli	1.0	1.5	3.4	1.0	1.0	1.9
Mukono 1	1.0	2.0	5.0	1.0	1.0	3.0
Mukono 2	1.0	3.0	4.3	1.0	1.0	2.0
Av. Mukono	1.0	2.5	4.7	1.0	1.0	2.5

$Lsd_{0.05}$ = 0.5 for source x variety x farmer interactions

- Generally sweetpotato virus disease (SPVD) infection levels were low across treatments attributed to very irregular and limited rains during the growing period.
- Ejumula farmer material was almost five times SPVD more infected than Biocrops cycle zero material.
- Both Ejumula and Kabode Biocrops material had the lowest scores
- Biocrops re-cycle 1 Kabode material was as less infected as Biocrops cycle zero but Ejumula Biocrops recycle 1 was more infected than Biocrops cycle zero
- Generally SPVD infection levels were higher in Mukono than Kamuli and Buyende districts for both varieties

Table 3: Analysis of variance for virus scores on Ejumula and Kabode varieties planted using different sources of planting material in three districts during season 2013a

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication stratum	2	0.07407	0.03704	0.39	
Source	2	70.90741	35.45370	376.45	<.001
Variety	1	18.75000	18.75000	199.09	<.001
Farmer	5	8.15741	1.63148	17.32	<.001
Source x variety	2	12.50000	6.25000	66.36	<.001
Source x farmer	10	9.98148	0.99815	10.60	<.001
Variety x farmer	5	3.63889	0.72778	7.73	<.001
Source x variety x farmer	10	2.61111	0.26111	2.77	0.006
Residual	70	6.59259	0.09418		
Total	107	133.21296			

- There was significant difference (P< 0.05) in SPVD infection levels between farmer and Biocrops sourced planting material.

- There was no significant difference (P> 0.05) in SPVD infection scores between Kabode Biocrops re-cycle 1 and Biocrops recycle zero.
- There were significant differences in SPVD infection levels between Ejumula Bicorops recyle 1 and Biocrops recycle zero sources of planting material

Table 4: Relating average virus infection levels with storage root yield (tons/ha) and of Ejumula and Kabode varieties planted using different sources of planting material during season 2013a

Attribute	Ejumula variety			Kabode variety			Lsd $_{0.05}$
	Biocrops	Biocrops cycle 1	Farmer	Biocrops	Biocrops cycle 1	Farmer	
SPVD infection score	1.0	1.8	3.7	1.0	1.0	2.1	0.2
Marketable roots yield	3.2	1.7	0.9	5.1	2.4	2.1	NS
Root yield	4.4	3.2	1.4	6.6	3.8	2.9	NS
Foliage yield	7.4	11.2	17.1	9.2	7.9	9.4	1.6
Total Biomass yield	11.8	14.4	18.5	15.8	11.7	12.3	2.2
% root yield of Biomass	37.3	22.2	7.6	41.8	32.5	23.6	

NB: SPVD scored on a scale of 1-9: 1 = (no symptoms, 9 very severe

- Sweetpotato disease infection scores were inversely proportional to total root yield. Higher infection disease scores and lower storage root yields especially for marketable portion of the yield
- Storage root yields were generally low and there were no significant differences (P> 0.05) in yield between different sources of planting material
- Percent root yield of total biomass for Ejumula planted using farmers' own materials was only about 8 % which is less than ¼ of the Biocrops source of planting material.

Table 5: Average matrix summary of least significant differences at Lsd0.05 for foliage yield of Ejumula and Kabode varieties planted using planting material of different sweetpotato virus disease levels

Source of planting material	**Ejumula variety**		**Kabode variety**	
	Biocrops re-cycle 1	**Farmer**	**Biocrops re-cycle 1**	**Farmer**
Biocrops	**Significant**	**Significant**	**Significant**	**Not significant**
Biocrops re-cycle 1		**Significant**		**Not significant**

Kabode was not significantly different between the different source-variety treatments but Ejumula varied in all source-variety treatments for production of foliage

Discussion

In Table 2, the generally low levels of sweetpotato virus infection recorded on both varieties; Ejumula (susceptible) and Kabode (resistant) was attributed to lack of sufficient rains during the growing period. However, the susceptible variety, Ejumula, still recorded higher relative infection trends than the levels recorded on Kabode (resistant variety). Mukono districts recorded the highest levels of disease

infection scores because it is located in the central region where the virus pressure is generally more severe. The generally more severe infection scores on Ejumula Biocrops re-cycle 1 than Kabode Biocrops re-cycle 1 was an indicator of the faster degeneration of the susceptible variety and need for rigorous measures such as tunnel nets for maintaining clean planting on-farm as it is more costly to keep replenishing from Biocrops and may not take many seasons before the clean material breaks down. Although Kabode is generally a resistant variety, the significant difference ($P<0.05$) (Table 3) between farmer source and both Biocrops levels of planting material indicates gradual build-up of the disease after several seasons of on-farm re-cycling. Generally Mukono district, an area where the disease pressure is higher than Buyende and Kamuli districts, the flash out window period will be expected to be fewer seasons.

In Table 4, moving from 1 to 3.7 sweetpotato virus disease score on Ejumula, the total root yield reduced from 4.4 tons/ha to 1.4 tons/ha, which translates to 68% yield loss. Also on-farm open re-cycling of the clean planting of Ejumula variety for one season resulted into loss of 1.2 tons/ha of root yield which is 27% loss in root yield during the second planting cycle. The proportion of marketable storage root yield decreases as the disease pressure increases irrespective of the variety susceptibility. The more the foliage biomass on a susceptible variety like Ejumula, the higher the virus disease score and the lower the storage root yield but it is not consistent observation on the Kabode, the resistant variety. Kabode percent root yield of total biomass was higher than Ejumula, probably Kabode is more efficient in translocation of photosynthates to the storage roots than to the foliage.

In Table 5, the varying significant disease levels between Biocrops and cycle 1 in Kamuli and Mukono districts imply that the sweetpotato virus disease pressure or intensity levels are lower in Kamuli than Mukono district. The susceptible variety, Ejumula, has a faster degeneration rate to disease in Mukono than Kamuli district.

Recommendation

Repeat the trial with the BioCrops generation1 and 2 materials against the farmer source of material to verify findings.

Conclusion

Preliminary evaluation of the two sources of planting material has confirmed that clean material performs better than farmer material recycled season after season. Planting a crop using cleaned vine cuttings greatly increases the storage root yield for both susceptible and resistant varieties but more yield increase occurs in the susceptible varieties. Evidently, farmers were quick to acknowledge the performance of cleaned material because they discriminately sourced cuttings from the Biocrops plots before maturity for presentation during the farmers' field show.

Appendix 6: Orange sweetpotato (OSP) true seed families established in a seedling nursery in Uganda

Family	Seeds	Source	Family	Seeds	Source
105413-4	200	Mozambique	KML 756	756	NaCRRI, Uganda
105055-7	200	Mozambique	SRT 37	312	NaCRRI, Uganda
105268-5	200	Mozambique	LUW 1274	1560	NaCRRI, Uganda
105199-29	200	Mozambique	MAGABALI	689	NaCRRI, Uganda
107038-8	200	Mozambique	NAS5/58	209	NaCRRI, Uganda
107033-17	200	Mozambique	KML 756	500	NaCRRI, Uganda
107038-3	200	Mozambique	RAK 819	225	NaCRRI, Uganda
105268-7	200	Mozambique	RAINHA	800	NaCRRI, Uganda
107011-2	200	Mozambique	MAYAYI	800	NaCRRI, Uganda
MUSG11004-2	200	Mozambique	DIMBUKA	400	NaCRRI, Uganda
MPG1158	2550	NaCRRI, Uganda	OTADA	2290	NaCRRI, Uganda
RAK 73	2106	NaCRRI, Uganda	TIS 9265	228	NaCRRI, Uganda
KML961	580	NaCRRI, Uganda	91/282-1	2880	NaCRRI, Uganda
SRT 41	1008	NaCRRI, Uganda	MKN 1224	936	NaCRRI, Uganda
RAK 862	208	NaCRRI, Uganda	KYABAFURUKI	480	NaCRRI, Uganda
MBR 552	680	NaCRRI, Uganda	TIS 9265X CRROT C	56	NaCRRI, Uganda
KML 960	1200	NaCRRI, Uganda	TIS 9265XSPKOO4	20	NaCRRI, Uganda
MSD 382	382	NaCRRI, Uganda	NAS10XDIMBUKA	25	NaCRRI, Uganda
MSK 1079	1079	NaCRRI, Uganda	NKAXBEAURGARD	56	NaCRRI, Uganda
TORORO 3	210	NaCRRI, Uganda	SPK	200	NaCRRI, Uganda
NASPOT 1	962	NaCRRI, Uganda	KSR 622	126	NaCRRI, Uganda
SRT 37	702	NaCRRI, Uganda	KML 960	120	NaCRRI, Uganda
RAK 819	105	NaCRRI, Uganda	IGA 978	264	NaCRRI, Uganda
KRE 691	691	NaCRRI, Uganda	RAK848	80	NaCRRI, Uganda
RUW 1274	506	NaCRRI, Uganda	CIP400011	84	NaCRRI, Uganda
ARA 224	912	NaCRRI, Uganda	BUNDUGUZAXIGA994	225	NaCRRI, Uganda
SILK	510	NaCRRI, Uganda	TEDOLOKERENI	209	NaCRRI, Uganda
# 83	608	NaCRRI, Uganda	CIP 199062-1	571	NaCRRI, Uganda
MPG 1128	740	NaCRRI, Uganda	OSAPAT	46	NaCRRI, Uganda
KBL 611	260	NaCRRI, Uganda	RUW 1274	121	NaCRRI, Uganda
KSR 622	300	NaCRRI, Uganda	HUARMEYANO	30	NaCRRI, Uganda
# 84	50	NaCRRI, Uganda	NAS5/58X SPKOO4	16	NaCRRI, Uganda
LIR 302	2405	NaCRRI, Uganda			