Delivering and Disseminating Biofortified Crops in Uganda

Final Report
January–December 2014

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Cover Photo: *Farmers in northern Uganda carry out a palatability test of orange-fleshed sweetpotato* (Credit: Gerald Kyalo–CIP Uganda).

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ACRONYMS

ANOVA	Analysis of variance
BioCrops	BioCrops Uganda Ltd
CIP	International Potato Center
HH	Households
MAK	Makerere University, Department of Agricultural Production, College of Agricultural and Environmental Sciences
NaCRRI	National Crops Resources Research Institute
NARO	National Agricultural Research Organization
OFSP	Orange-fleshed sweetpotato
OSP	Orange sweetpotato

SUMMARY

During the third year of the "Delivering and Disseminating Biofortified Crops in Uganda" project, the International Potato Center (CIP), in collaboration with the National Crops Resources Research Institute, planted 100 on-farm trials to evaluate six promising orange sweetpotato (OSP) clones in Rakai, Buyende, Oyam, Isingiro, and Kabale districts:

1. 'Ejumula (OP) 2012/3'
2. 'Ejumula (OP) 2012/11'
3. 'MKN1224 (OP) 2013/1'
4. 'Ejumula (OP) 2012/9'
5. 'Ejumula (OP) 2012/10'
6. 'Resisto (OP) 2012/2' .

Of the 100 trials, we harvested 60 that were planted in 2014 and conducted five palatability tests to determine farmers' preferences for the new clones. The clone 'MKN1224 (OP) 2013/1' had the highest yield (9.6 t/ha), followed by 'Ejumula (OP) 2012/10' (8.2 t/ha) and 'Resisto (OP) 2012/2' (6.2 t/ha). 'MKN1224 (OP) 2013/1' and 'Resisto (OP)/2012/2' are, however, susceptible to sweetpotato virus disease (SPVD) and Alternaria blight in some of the districts (e.g., Isingiro) compared with other clones; neither is preferred by farmers. CIP has also set up the third round of curing trials using sweetpotato varieties, 'Kabode', 'NASPOT 8', 'NASPOT 1', and 'SOCCADIDO' in Masaka, Rakai, and Mukono districts. CIP established demonstration sites for Triple S technology with farmer groups in each of the four districts of Gulu, Oyam, Kole, and Lira. Sixty-three participants (36 women, 27 men) were trained in Triple S application. CIP also harvested trials of clean farmer materials (vines) for the 2014A season.

Generally, SPVD expression on foliage depends on the number of times the clean material has been replanted. The results show that after three successive seasons of recycling planting material of 'Ejumula'—a variety susceptible to SPVD—yield significantly dropped at cycle 4 by almost five times the yield of season 1. Planting clean material, free from SPVD especially of a susceptible variety, increases root yield by more than five times in farmers' fields. CIP also planted 2014B trials of cleaned farmer materials in Kamuli, Buyende, Mukono, and Rakai.

Twelve trials were established. BioCrops continued with vine multiplication activities in the screen house and supplied over 16,000 vine cuttings to CIP for conducting different trials. Makerere University continued conserving in-vitro plantlets of the three varieties 'Ejumula', 'Kabode', and 'Vita'.

1. INTRODUCTION

This is the third year of the five-year project "Delivering and Disseminating Biofortified Crops in Uganda" (BIOFORT Uganda) and is a continuation of year 1 and 2 activities, with annual contracts to partners. The project is implemented by five 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)
- A private company, BioCrops Uganda Ltd (BioCrops).

During year 3 of the project, MAK continued to conserve virus-free orange sweetpotato (OSP) plantlets as a back-up and for supply to NaCRRI and BioCrops. NaCRRI continued with breeding activities and on-station and on-farm trials, and BioCrops continued with multiplication and supply of virus-free OSP materials. CIP coordinated all activities and led research on the Triple S technology, postharvest handling of sweetpotato roots, and on-farm evaluation of OSP clones in partnership with NaCRRI. Details of the report are presented in Tables 1–11, Figures 1–3, and Appendices 1–10. This is the project's third year final report with component objectives.

1.1 PROJECT OBJECTIVES

The project's main objectives are to:

- Establish a sustained supply of and conserve virus-free plantlets of major OSP varieties at Makerere University and at NaCRRI
- Establish capacity of a private sector operator (BioCrops) to produce cuttings of primary foundation material
- Facilitate the adoption of at least three new OSP varieties to local conditions of northern and western Uganda
- Identify in every district in the project area, two commercially oriented, large-scale vine multipliers with excellent management skills
- Have at least 30% of target households (HH) in areas with prolonged dry seasons (>4 months) adopt the Triple S technology
- Test and refine recommended practices for curing sweetpotatoes by smallholder farmers to increase longevity in storage.

2. MAJOR ACCOMPLISHMENTS DURING THE REPORTING PERIOD

2.1 ON-FARM EVALUATION OF PROMISING OSP CLONES

On-farm trials for season A and B 2014 were successfully established in Isingiro, Kabale, Rakai, Buyende, and Oyam districts (Fig. 1B). The trials were established with seven OSP clones: 'Ejumula (OP) 2012/3', 'Ejumula (OP) 2012/11', 'Ejumula (OP) 2012/9', 'MKN1224 (OP) 2013/1', 'Ejumula (OP) 2012/10', 'Resisto (OP) 2012/1', and 'NASPOT 10 O' ('Kabode', common check). One-hundred trials were planted, 20 per district, 10 in each season. Depending on availability of planting

materials, we planted 10–33 heaps per clone per farmer with three cuttings (30 cm each) per heap or 10–17 cuttings on a ridge at a spacing of 30 cm between cuttings and 1.0 m between ridges. The heaps were spaced 1 m from each other. The trials were monitored to collect pre-harvest data at one month after planting and one month before harvest.

Figure 1. Establishment of on-farm trials and curing of sweetpotatoes.

A. Joweria Namakula (NaCRRI) takes data during harvesting of 1st season 2014 on-farm trials in Oyam district.

B. Farmers planting on-farm trials in Isingiro district.

C. The clone 'MKN1224 (OP) 2013/1' showing symptoms of SPVD.

D. Alternaria blight symptoms on 'Ejumula (OP) 2012/11'.

E. In-ground curing in Rakai district.

F. Curing in polythene bags.

On-farm trials for first season 2014 were harvested in August–September 2014, depending on location (Fig. 1A). We also carried out five palatability tests (one per district) to determine farmers' preferences for the new clones. Overall, clone 'MKN1224 (OP) 2013/1' had the highest yield (9.6 t/ha), followed by 'Ejumula (OP) 2012/10' (8.2 t/ha) and 'Resisto (OP) 2012/2' (6.2 t/ha). There were significant differences between the performances of clones in the different districts. For

example, in Isingiro district, 'Resisto' (12.3 t/ha), 'Ejumula (OP) 2012/10' (15.9 t/ha), and 'Ejumula (OP) 2012/11' (12.8 t/ha) performed better than 'MKN1224/2013/1' (10.6 t/ha), which performed consistently well in the rest of the districts. The clones did not perform well in Kabale and Rakai due to the prolonged drought experienced during the growing period.

Despite having the best yields, 'Ejumula (OP) 2012/11' and 'MKN1224' were the most susceptible to SPVD and Alternaria blight (Table 1). 'Ejumula (OP) 2012/11' showed infection levels of 60–90% due to Alternaria blight in all districts (Fig. 1D). During the palatability tests, farmers preferred 'Ejumula (OP) 2012/9' for its aroma, taste, starchiness, and sweetness. The next preferred genotype (though not in all districts) was 'Resisto/2012/2' for its sweetness. Note that the most preferred variety during palatability tests, 'Ejumula (OP) 2012/9', had the lowest yield (3.1 t/ha). Moreover, the highest yielding clones—'MKN1224/2013/1' and 'Ejumula (OP) 2012/10'—have major setbacks due to susceptibility to SPVD (Fig. 1 C) and Alternaria blight; both are not liked by farmers. On the basis of the above results, none of the clones from the 2014 on-farm trials could be advanced for release. The next set of promising clones is shown in Table 2.

Table 1. Average performance of 7 OSP clones evaluated in on-farm verification trials in Kabale, Isingiro, Rakai, Buyende, and Oyam districts (trials planted in April–May and harvested in August–September 2014)

District/Clone	Mean Root Yield (t/ha)	Total Biomass (t/ha)	Mean Weevil Damage Score	Mean SPVD Symptom Score	Mean Alternaria Symptoms Score	Flesh Color
Buyende						
Ejumula/2012/10	6.4	13.4	3.0	2.3	1.5	8
Ejumula/2012/11	5.3	12.5	1.8	2.0	5.8	8
Ejumula/2012/3	4.5	15.5	3.0	1.5	1.3	7
Ejumula/2012/9	2.4	10.9	2.1	1.3	1.0	6
MKN1224/2013/1	8.7	15.3	2.3	1.8	2.0	8
NASPOT 10 O	7.7	18.5	2.0	1.8	2.0	8
Resisto/2012/2	7.2	14.8	3.8	1.7	2.0	8
Isingiro						
Ejumula/2012/10	15.9	29.3	3.4	3.7	1.9	8
Ejumula/2012/11	12.8	33.7	3.0	6.0	6.0	8
Ejumula/2012/3	5.9	42.3	3.3	1.8	1.0	7
Ejumula/2012/9	4.6	32.0	2.8	1.5	1.0	6
MKN1224/2013/1	10.6	29.0	3.3	5.2	2.5	8
NASPOT 10 O	3.0	27.4	2.0	1.2	1.0	8
Resisto/2012/2	12.3	22.3	3.1	2.6	2.3	8
Kabale						
Ejumula/2012/10	4.3	7.1	1.0	2.3	4.5	8
Ejumula/2012/11	1.1	2.8	1.0	4.0	8.1	8
Ejumula/2012/3	4.4	11.7	1.0	3.8	1.8	7
Ejumula/2012/9	2.2	16.0	1.0	1.8	1.5	6
MKN1224/2013/1	16.5	28.9	1.0	1.8	1.5	8
NASPOT 10 O	5.5	11.7	1.0	1.8	1.3	8
Resisto/2012/2	3.0	6.3	1.0	1.8	5.0	8
Oyam						
Ejumula/2012/10	7.8	15.5	1.5	1.5	2.3	8

District/Clone	Mean Root Yield (t/ha)	Total Biomass (t/ha)	Mean Weevil Damage Score	Mean SPVD Symptom Score	Mean Alternaria Symptoms Score	Flesh Color
Ejumula/2012/11	5.9	14.5	1.2	2.0	6.8	8
Ejumula/2012/3	4.9	17.7	1.3	1.3	1.0	7
Ejumula/2012/9	2.5	17.3	1.0	1.3	1.0	6
MKN1224/2013/1	7.2	15.5	1.5	1.8	3.0	8
NASPOT 10 O	6.6	15.8	1.5	1.0	1.0	8
Resisto/2012/2	6.8	17.2	1.3	1.8	4.2	8
Rakai						
Ejumula/2012/10	5.3	12.3	3.3	2.0	1.0	8
Ejumula/2012/11	3.7	14.3	2.0	2.0	6.8	8
Ejumula/2012/3	4.5	23.9	2.3	2.5	1.3	7
Ejumula/2012/9	3.5	22.2	2.3	2.5	1.3	6
MKN1224/2013/1	5.1	13.6	3.5	2.3	1.0	8
NASPOT 10 O	6.1	15.1	2.3	2.5	1.3	8
Resisto/2012/2	5.4	14.4	3.3	2.0	3.8	8
Mean	6.3	18.0	2.1	2.2	2.6	NA
$LSD_{0.05}$	3.2	8.1	0.6	0.4	0.6	NA
CV	15.8	26.8	14.8	16.4	9.9	NA

Performance Across Districts

District/Clone	Mean Root Yield (t/ha)	Total Biomass (t/ha)	Mean Weevil Damage Score	Mean SPVD Symptom Score	Mean Alternaria Symptoms Score	Flesh Color
Ejumula/2012/10	8.0	15.5	2.4	2.3	2.2	8
Ejumula/2012/11	5.8	15.6	1.8	3.2	6.7	8
Ejumula/2012/3	4.9	22.2	2.2	2.2	1.3	7
Ejumula/2012/9	3.1	19.7	1.8	1.7	1.1	6
MKN1224/2013/1	9.6	20.5	2.3	2.5	2.0	8
NASPOT 10 O	5.8	17.7	1.8	1.6	1.3	8
Resisto/2012/2	6.9	15.0	2.5	2.0	3.5	8
Mean	6.3	18.0	2.1	2.2	2.6	NA
$LSD_{0.05}$	3.2	8.1	0.6	0.4	0.6	NA
CV	15.8	26.8	14.8	16.4	9.9	NA

NA = not applicable. Pests and diseases scored on a 1–9 scale, where 1 = no infestation/damage and 9 = very severe damage. Flesh color scored: 6 = pale orange, 7 = intermediate orange, and 8 = dark orange.

Table 2. Performance of OSP clones at preliminary yield trial stage at Namulonge, planted in April and harvested in September 2014

Clone	Vigor	SPVD	Alternaria	Weevil	Yield (t/ha)	Harvest index	Flesh Color
CARROT (OP) 2012/10	3.7	3.7	1.7	2.0	16.5	0.6	8
EJUMULA (OP) 2013/2	4.7	7.3	1.7	2.0	8.5	0.5	8
EJUMULA (OP) 2013/3	4.3	7.0	2.7	2.0	28.7	0.9	8
KBL611 (OP) 2013/2	3.3	6.3	2.0	2.0	14.7	0.5	8
KBL691 (OP) 2013/2	5.0	6.7	3.0	2.0	9.2	0.7	8
KBL691 (OP) 2013/4	5.7	7.3	3.3	2.0	6.0	0.6	6
KML756 (OP) 2013/1	3.7	7.0	2.3	2.0	25.3	0.8	8
KML756 (OP) 2013/2	3.3	5.7	2.0	2.0	21.9	0.7	2
KML756 (OP) 2013/3	4.0	7.3	3.0	2.3	13.0	0.4	8
LIR302 (OP) 2013/1	3.0	5.3	2.3	1.7	7.2	0.5	8
LIR302 (OP) 2013/3	3.3	6.0	3.0	2.7	23.8	0.7	8
LWR1274 (OP) 2013/1	3.7	6.7	2.0	2.0	11.1	0.5	8
LWR1274 (OP) 2013/2	3.3	6.3	1.7	2.3	5.8	0.6	8
LWR1274 (OP) 2013/3	4.0	7.7	2.0	2.0	4.8	0.2	8
MKN1224 (OP) 2013/2	4.3	6.3	2.0	1.7	9.2	0.7	8
MKN1274 (OP) 2013/1	3.7	7.0	2.0	2.0	15.7	0.6	8
MKN1274 (OP) 2013/3	4.3	7.0	2.3	2.0	6.5	0.5	8
MPG1158 (OP) 2013/6	3.0	6.0	1.3	2.0	12.3	0.4	8
MPG1158 (OP) 2013/7	3.0	5.3	1.3	2.3	23.3	0.5	8
MPG1158 (OP) 2013/8	2.7	4.0	1.3	1.7	15.0	0.4	8
MSD382 (OP) 2013/1	2.7	7.0	1.7	2.3	21.0	0.5	8
NO.84 (OP) 1013/4	4.0	7.3	1.7	2.0	13.2	0.6	8
NO.84 (OP) 2013/5	4.0	7.7	2.0	2.7	8.8	0.6	8
NO.84 (OP) 2013/2	3.7	5.3	1.7	2.0	15.6	0.6	8
OTADA (OP) 2013/1	3.3	7.3	1.7	2.3	29.9	0.4	8
SILKXEJUMULA/2012/6	2.7	5.3	2.0	2.3	22.2	0.6	2
SRT37 (OP) 2013/1	4.7	7.3	2.3	2.0	15.6	0.7	8
SRT41 (OP) 2013/1	5.0	7.3	2.0	2.0	13.4	0.7	8
SRT41 (OP) 2013/2	5.0	7.3	2.0	2.3	10.6	0.7	8
SRT41 (OP) 2013/3	2.3	5.0	1.7	1.0	2.4	0.1	8
SRT41 (OP) 2013/5	4.3	7.3	1.7	1.7	6.4	0.4	8
TIS9265XCARROTC/2013/4	5.0	7.0	2.0	2.3	8.7	0.8	8
TIS9265XSPK004/2013/1	3.0	6.3	1.3	2.0	8.4	0.5	8
NASPOT 11 (Check)	1.3	2.0	1.0	1.3	24.9	0.6	2
NASPOT 8 (Check)	1.7	2.3	1.7	1.7	35.8	0.6	8
Mean	**3.676**	**6.229**	**1.981**	**2.019**	**14.722**	**0.564**	**7.429**
Variance	**0.911**	**1.967**	**0.273**	**0.108**	**64.175**	**0.026**	**2.873**
Standard deviation	**0.954**	**1.402**	**0.522**	**0.328**	**8.011**	**0.162**	**1.695**

Pests and diseases scored on a 1–9 scale, where 1 = no infestation/damage and 9 = very severe damage. Flesh color scored: 6 = pale orange, 7 = intermediate orange, and 8 = dark orange.

2.2 IN-GROUND AND OUT-OF-GROUND CURING EXPERIMENTS

Curing experiments were set up in Rakai, Masaka, and Mukono districts with sweetpotato varieties 'Kabode' ('NASPOT 10 O'), 'NASPOT 8' (OSP), 'NASPOT 1', and the local variety 'SOCADIDO' (cream-fleshed), respectively (Fig. 1E, F). Treatments included:

- Curing sweetpotato by covering freshly harvested roots with a polyethene sheet raised 15.2–20.3 cm (6–8 in.) above the roots. This was done for 2, 3, 4, 5, and 7 days.
- Dehaulming/detopping 2, 3, 4, 5, and 7 days before harvest. In this case, the mounds were detopped then harvested after 2–5 and 7 days.
- Farmers' practice (leaving the roots in the open) after harvest.

The roots are being assessed for rot, sprouting, shriveling, and attack by weevils using a 5-point scale (0 = absence of defect, 5 = severe) by visual assessment. The trials were set up in December 2014 and data collection is underway. Results will be reported in subsequent reports.

2.3 ON-STATION EVALUATION OF OSP CLONES AND CONSERVATION OF IN-VITRO OSP STOCK

Two trials were established and evaluated. The preliminary yield trial was harvested at Namulonge. Seven promising clones with good yields (≥15 t/ha) and moderate resistance to SPVD were identified (Table 2). Multiplication of these lines in the swamp continues and will be taken for concurrent on-station and on-farm evaluation next year. At advanced yield trial, five promising clones were tested against five check clones at three locations. Harvesting was done only at Namulonge (see Table 3).

NaCRRI has 125 in-vitro plantlets of 'NASPOT 9 O' ('Vita'), 112 of 'NASPOT 10 O' ('Kabode'), 12 each of 'NASPOT 12 O' and 'NASPOT 13 O'. The number of 'NASPOT 9 O' and 'NASPOT 10 O' was double of what is reported, but half of each was weaned to feed into the net tunnel project.

Table 3. Mean performance of 5 OSP clones at the advanced yield trial stage at Namulonge in 2014, planted in April and harvested in October

Clone	Vigor	SPVD	Alternaria	Weevil	Yield (t/ha)	Harvest Index	Skin Color	Flesh Color
EJUMULA (OP) 2012/10	4.3	5.7	2.7	3.3	5.4	0.7	2.0	8.0
EJUMULA (OP) 2012/11	3.7	5.3	1.3	1.7	7.0	0.4	8.0	8.0
EJUMULA (OP) 2012/3	2.7	3.0	1.7	2.3	9.8	0.4	2.0	8.0
EJUMULA (OP) 2012/9	6.0	6.7	7.3	2.0	3.5	0.5	8.0	6.0
REISISTO (OP) 2012/2	3.7	4.7	3.3	2.0	8.7	0.5	8.0	8.0
NASPOT 10	3.3	2.7	1.0	1.7	2.4	0.4	8.0	8.0
NASPOT 12	2.3	2.0	1.3	1.7	8.6	0.4	8.0	8.0
NASPOT 13	2.7	4.7	2.0	2.7	12.0	0.6	2.0	8.0
NASPOT 8	3.3	5.0	2.7	3.0	16.0	0.5	8.0	8.0
NASPOT 11	3.3	4.7	2.0	2.7	18.7	0.6	8.0	2.0
Mean	**3.53**	**4.43**	**2.53**	**2.30**	**9.20**	**0.49**	**6.20**	**7.20**
Variance	**0.982**	**1.890**	**3.027**	**0.321**	**24.202**	**0.008**	**7.560**	**3.360**
Standard deviation	**0.991**	**1.375**	**1.740**	**0.567**	**4.920**	**0.087**	**2.750**	**1.833**

Pests and diseases scored on a 1–9 scale, where 1 = no infestation/damage and 9 = very severe damage. Flesh color scored: 6 = pale orange, 7 = intermediate orange, and 8 = dark orange.

2.4 FARMER TRAINING

Farmers in Mukono and Mpigi districts were trained on 3–7 March 2014 on the benefits of OSP, disease and pest management, rapid multiplication, and agronomy. The farmers were also provided with clean stocks of planting materials of 'NASPOT 9 O' and 'NASPOT 10 O' (see Appendix 9a). NaCRRI trained 13 lead farmers in disease management and rapid multiplication (Appendix 9b and Table 4).

Table 4. Status of progress by NaCRRI

Planned Activities	Targets	Actual Achievements	Remarks
Evaluate on-farm trials	At least two promising clones for potential release identified	Six promising OSP clones: Resisto (OP) 2012/2, Ejumula (OP) 2012/3, Ejumula (OP) 2012/9, Ejumula (OP) 2012/10, Ejumula (OP) 2012/11, & MKN1224 (OP) 2013/1 were evaluated on farm	MKN1224 (OP) 2013/1, Resisto (OP) 2012/2, & Ejumula (OP) 2012/10 had good yields but are susceptible to SPVD, Alternaria blight, or both and could not be advanced for release
Evaluate on-station trials	On-station trials (observation, PT, AT) evaluated at different locations; potential clones for on-farm trials identified	A PT of 33 clones was evaluated at Namulonge against 2 check clones. An AT of 5 clones was also evaluated at 3 locations	12 clones had yields of ≥15t/ha Only one location of AT has been harvested
Conserve in-vitro OSP stock	Establish a clean stock of plantlets of major OSP varieties at NaCRRI	NaCRRI has 125 in-vitro plantlets of 'Vita', 112 of 'Kabode', 12 each of 'NASPOT 12 O' and 'NASPOT 13 O'	The number of Vita and Kabode was double what is reported but half of each were weaned to feed into the net tunnel project.
Workshops/ meetings	Train lead farmers in non-project areas; attend project meetings	Thirteen lead farmers were trained in disease management and rapid multiplication	
Document research findings and experiences	Information published in journals or presented at conferences	At the NARO scientific conference Dr. Ssemakula Gorrettie presented a paper, "Evaluation and delivery of disease-resistant and micronutrient-dense sweetpotato varieties to farmers in Uganda", 3–7 Nov. 2014	

PT = preliminary yield trial; AT = advanced yield trial; OSP = orange-fleshed sweetpotato

2.5 TRANSFER OF THE TRIPLE S TECHNOLOGY AT SCALE AND BUILDING A CADRE OF TRAINED EXTENSION PERSONNEL TO MONITOR ITS ADOPTION

2.5.1 Background

During the dry season (between mid-November and mid-March in northern Uganda), sweetpotato vines desiccate. At the onset of the rainy season in mid-March, farmers normally lack planting material to plant and typically wait for the roots that remained in the ground to sprout and grow before sourcing for planting materials. Most households (HH) normally need a short-maturing crop such as sweetpotato for an early supply of food to fill the gap of pronounced food shortage that starts at the beginning of planting period, as most granaries have been exhausted and the next harvests, especially of cereals, take long to mature. With the traditional method, planting is normally delayed by about two months after the beginning of the rains. Delayed planting not only delays early supply of food, but also contributes to poor growth performance of the late-planted crop because sweetpotato requires at least two months of sufficient moisture in the soil to produce adequate yield.

Maintaining a growing crop during the dry season is not only tedious. It also greatly competes for the limited availability of water sources that are prioritized for domestic uses and livestock-keeping on the green islands in northern Uganda's wetlands. Thus, easy irrigation water-saving approaches such as Triple S to produce sweetpotato planting material during the ending of the dry season are timely and fitting.

2.5.2 Triple S orientation, review, and training workshop

At a workshop, 63 participants (36 women, 27 men) were taught how to apply the Triple S method (Fig. 2A–D). CIP, World Vision staff, and the participants reviewed the protocols of Triple S with reference to the leaflet. Participants proposed to develop a Triple S calendar for 2015 and initiated ideas on the photos and messages to be included on the different calendar pages based on what activities distinctively reflect or occur during a particular month. The trainings and review meetings were co-facilitated by World Vision staff who had gained the expertise during the previous seasons. Table 5 illustrates the range of topics covered in the training. Ideas, including photos to be included on the calendar for particular months, were suggested and will be reviewed until the final version is drafted. A total of 200 copies of the final 2015 calendar were planned to be printed by December for distribution to each farmer who participated in the process of demonstrating and reviewing the Triple S method.

Figure 2A–D. Review of the Triple S leaflet and planting seed root bed demonstration.

A. Group review and activity planning meeting.

B. Review of Triple S leaflet.

C. Partner staff facilitatating Tripls S review session.

D. Participant contributing to discussions on Triple S.

The steps of the method were revised based on Triple S leaflet hand-outs and observations of sprouting roots by addressing the gaps identified such as curing before storage, sourcing roots from clean planting material, age of roots, spacing during planting, timing of storage, and storage containers. Revision of the protocols will continue during the course of data collection in subsequent seasons.

Table 5. Template for teasing out annual Triple S schedules

Month	Activities in Lira/Kole	Activities in Gulu/Oyam	Comments/Illustration
January	Seed bed preparation and planting	Seed roots in-storage	OSP roots packed in the container
February	Watering	Field preparation and planting seed root beds	A group of farmers or farmer planting sprouted roots
March	Watering and weeding	Land preparation, heaping and planting	A group of farmers or farmer planting sprouted roots
April	Harvesting and planting	Heaping/planting and weeding	A group of farmers or farmer planting sprouted roots
May	Weeding	Heaping and weeding	
June		Second weeding and piece meal harvesting	
July	Harvesting roots	Harvesting and marketing	Photo: Farmers harvesting
August		Field preparation, heaping, harvesting, consumption and marketing	
September	Marketing	Same as in August	
October		Planting in wetlands	
November	Postharvest (slicing and drying)	Slicing and seed root storage	
December	Sorting and storing in basin	Slicing, seed root storage and marketing	

2.5.3 Assessment of progress of stored seed roots

After about 45 days in storage the seed roots are inspected for progress in sprouting and health of the roots. Rotten seed roots are sorted out and discarded. Roots not ready for planting are put back for extended storage.

2.5.4 Establishment of demonstrations on Triple S

Three demonstration sites were established with farmer groups in each of the four districts of Gulu, Oyam, Kole, and Lira on 20–24 January 2014 (Fig. 2E–H). Twelve host farmers (4 women, 8 men), one for each of the groups, were selected to establish a group demonstration, including a single school Triple S field. Twenty more farmers established individual Triple S beds. Several farmer-preferred varieties (e.g., 'Kakamega', 'Kabode', and 'Ejumula') were stored under Triple S. Storage started in December 2013 and beds were established at the end of January 2014 after a training and review workshop of the Triple S method. Cutting of vines for planting started at the end of March 2014.

Figure 2E–H. Review of the Triple S leaflet and planting seed root bed demonstration.

E. Identifying the infested roots.

F. Digging holes for planting sprouted seed roots.

G. Planting the Triple S sprouted roots in bed.

H. Covering planted seed roots and watering.

2.5.5 Results

Two lots of 30-cm long vines cuttings of 'Ejumula', 'Kakamega', and 'Kabode' varieties from the Triple S plots and previous fields were harvested and counted at the onset of rains and at 60 days from onset of rains.

Table 6a shows that significant differences in numbers of cuttings harvested were due to the different methods used for vine conservation and multiplication, varieties, and the method by variety interaction effects. In Table 6b, 'Kakamega', a variety that readily spreads produced more cuttings during the initial cutting. Subsequently, 'Ejumula', a semi-spreading type, produced more cuttings than both 'Kakamega' and 'Kabode' due to better secondary foliage growth. Table 6c shows that at the onset of rains no vines can be sourced from the previous fields until two months later during the rains. Apart from the reported late planting when farmers depend on previous fields for sourcing planting material (Namanda et al. 2013), Tables 6b and c show that the Triple S method still produces more planting material even at 60 days after the rains have started. Generally, significantly (p<0.001) more vines are generated using the Triple S method of vine conservation and multiplication of sweetpotato planting material.

Table 6a. Analysis of variance (ANOVA) for mean total number of 30-cm-long cuttings harvested from each root of different varieties from previous farmers' fields of Triple S plots at onset of first rains during season 2014a

Source of Variation	D.F.	S.S.	M.S.	V.R.	$F_{pr.}$
Sampling sites	5	1456.6	291.3	139	
Method of multiplication	1	50572.6	50572.6	241.29	<.001
Varieties	2	8939.8	4469.9	21.33	<.001
Method x variety	2	5583.3	2791.7	13.3	<.001
Residual	133	27876.1	209.6		

Table 6b. No. of 30-cm-long cuttings harvested in two lots from each root of different varieties from previous farmers' fields of Triple S plots at onset of first rains during season 2014a

	No. of Cuttings Harvested per Root of Each Variety			
Period of Harvesting	Ejumula	Kakamega	Kabode	Average
Onset of rains	26	41	11	26
60 days after onset of rains	38	18	20	25
Total no. of harvested per root	64	59	31	51

$LSD_{0.05}$ = 8.3 for period of harvesting x variety.

Table 6c. No. of 30-cm-long cuttings harvested in two lots from each established root-vines of different varieties from previous farmers' fields at onset of first rains during season 2014a

	No. of Cuttings Harvested per Root of Each Variety			
Period of Harvesting	Ejumula	Kakamega	Kabode	Average
Onset of rains	1	1	0	1
60 days after onset of rains	15	14	11	13
Total no. harvested per root	16	15	11	14

$LSD_{0.05}$ = 8.3 for period of harvesting x variety.

Table 7a shows that significant (p<0.001) low percentage of pest infestation (Table 7b) on both varieties was attributed to the Triple S method of vine conservation and multiplication.

Table 7a. ANOVA for percent infested growing root-vines of different OSP varieties under Triple S and previous farmers' fields methods at onset of first rains during season 2014a

Source of Variation	D.F.	S.S.	M.S.	V.R.	$F_{pr.}$
Sampling sites	5	1275.1	255.0	0.89	
Method of multiplication	1	175623.1	175623.1	614.59	<.001
Varieties	2	482.5	241.2	0.84	<.432
Method x variety	2	2184.4	1092.2	3.82	<.001
Residual	133	38005.6	285.8		

Table 7b. Percentage of growing root-vines of different OSP varieties infested with pests under Triple S and previous farmers' fields conservation and multiplication methods during season 2014a

	Percent No. of Seed-Vine Roots Infested per Variety			
Source	Ejumula	Kakamega	Kabode	Average
Triple S	0.5	5.9	2.5	3.0
Previous harvested fields	76.8	64.8	76.8	72.8

2.5.6 Result, discussion, and recommendation

Initiating vine growth through minimal watering of presprouted roots planted in fenced root beds produces adequate clean mature planting material at the onset of rains because vine growth is artificially initiated prior to the start of rains. Greater number of vines are produced using Triple S because roots are kept free from pests. Early planting of sweetpotato improves food security and incomes as early harvests fetch higher prices because they occur when most competing crops are premature.

2.6 COMPARING PERFORMANCE OF TISSUE CULTURE (CLEANED MATERIALS) AGAINST FARMERS' EXISTING SWEETPOTATO PLANTING MATERIAL IN KAMULI AND MUKONO DISTRICTS

2.6.1 Rationale

HarvestPlus, in partnership with CIP, BioCrops, and MAK, are promoting the use of cleaned-up planting material from disease-free tissue culture plantlets. HarvestPlus promotes dissemination of pro-vitamin A sweetpotatoes, and MAK hardens tissue culture plantlets that are conserved and multiplied by BioCrops before dissemination to selected farmer vine multipliers. The concept of clean planting materials needs to be clearly understood and appreciated prior to wide dissemination for effective on-farm management. Researchers need basic information to project the performance of the material over successive seasons. Thus, the main objective is to demonstrate the yield benefit of using cleaned sweetpotato planting materials compared with the farmers' own materials from previous seasons and determine the rate of degeneration of cleaned materials.

2.6.2 Establishment of demonstrations

Trials of clean planting material using 'Ejumula' and 'Kabode' varieties were planted in Buyende, Kamuli (near eastern region) and Mukono and Rakai (central region) districts in April 2014. In each district, three host farmers were selected from each of the existing participating farmer groups. More than 50% of 12 host farmers were married women of men-headed HH. As in previous seasons, we sourced cleaned materials of 'Ejumula' and 'Kabode' (also called "cycle 0") from BioCrops. The successive cycles 1, 2, 3, and 4 were sourced from previous season's planting material. All the cycles (0–4) were planted in the farmers' fields alongside farmers' materials, which were disseminated 8–10 years ago (Mwanga et al. 2007, 2009). Thirty mounds per treatment and three vines per heap were planted.

2.6.3 Sampling and data collection

Preharvest data were collected on crop establishment, vigor, and incidence of SPVD and Alternaria blight. Yield sampling was done at harvesting. Five middle heaps (5 m^2) in each treatment were harvested for yield assessment as prescribed by Grüneberg et al. (2009). Data were analyzed using GenStat package (Tables 8a, b and 9a, b).

2.6.4 Results

Preharvest data were collected on SPVD; root and vegetative data were collected at harvest. Table 8a shows that SPVD pressure (Table 8b) varied significantly (p<0.001), attributed to number of times the planting material was recycled, varieties, and the interaction effects.

Table 8a. ANOVA for mean SPVD score on 'Ejumula' and 'Kabode' varieties planted in different agro-ecologies during season 2014a

Source of Variation	D.F.	S.S.	M.S.	V.R.	$F_{pr.}$
Districts	3	40.0000	16.3333	25.30	
Vine cycle level	4	203.1250	50.7812	78.67	<.001
Varieties	1	84.0500	84.0500	130.20	<.001
Vine cycle level x variety	4	24.5750	6.1438	9.52	<.001
Residual	67	43.2500	0.6455		

Table 8b. SPVD score on 'Ejumula' and 'Kabode' varieties with varying cycle levels planted on-farm during season 2014a

Cycle Level	Actual No. of Seasons Planted	SPVD Score by Variety	
		Ejumula	Kabode
0 (BioCrops)	1	1.5	1.3
1	2	3.0	1.5
2	3	4.5	2.4
3	4	6.3	3.0
> 20 (Farmer)	> 20	7.4	4.3

$LSD_{0.05}$ = 0.8 for cycle level x variety.

Table 9a shows that SPVD (vine cycle level) was significant (p<0.001), expression on foliage depends on the number of times the clean material has been replanted, and the variety by number of times interactive effect. Table 9b shows that after three successive seasons of recycling planting material of 'Ejumula', a variety susceptible to SPVD, yield significantly (p<0.001) dropped at cycle 4 by almost five times the yield of season 1 (Fig. 3). After cycle 4, the yield of both 'Ejumula' (susceptible) and 'Kabode' (resistant) varieties declined to less than the on-farm average yield of 7 t/ha (HarvestPlus report 2013).

Table 9a. ANOVA for mean root yield (t/ha) of sweetpotato planted using planting material with varying cycles in different districts during season 2014a

Source of Variation	D.F.	S.S.	M.S.	V.R.	$F_{pr.}$
Districts	3	56.36	18.79	1.84	0.156
Vine cycle level	4	1250.55	312.64	30.59	<.001
Varieties	1	0.43	0.43	0.04	0.839
Vine cycle level x district	12	101.12	8.43	0.82	0.625
Vine cycle level x variety	4	117.50	29.38	2.87	0.035
District x variety	3	63.32	21.11	2.06	0.120
VCL x district x variety	12	114.87	9.57	0.94	0.522
Residual	40	408.83	10.22		

Table 9b. Root yield (t/ha) of sweetpotato planted using planting material with varying cycles in different districts during season 2014a

Seasons Planted	Root Yield of 'Ejumula' and 'Kabode' Varieties	
	Ejumula	Kabode
1	14.9	11.3
2	13.4	12.3
3	9.7	8.6
4	3.1	6.1
> 15	2.7	4.8

$Lsd_{0.05}$ = 3.2 for cycle level (number of successive seasons planted) x variety.

Figure 3. Different visual disease infection intensities on selected crop cycles of 'Ejumula' and 'Kabode' varieties planted in September 2013 in Mukono and Rakai districts.

A. 'Ejumula' initial BioCrops material in Rakai district during September 2013 planting season.

D. 'Ejumula' farmer material in Rakai district during September 2013 planting season.

B. 'Ejumula' second cycle of planting in Mukono during September 2013 planting season.

E. 'Kabode' BioCrops material in Mukono district during September 2013 planting season.

C. 'Ejumula' second cycle of planting in Rakai district during September 2013 planting season.

F. 'Kabode' farmer's material in Mukono district during September 2013 planting season.

2.6.5 Results and discussion

Planting clean material free from SPVD, especially of a susceptible variety, increases root yield by more than five times in farmers' fields. Because the clean material is grown in an environment with high disease pressure due to existing infested plants and poor management practices, a susceptible variety such as 'Ejumula' can effectively be recycled for not more than three cycles, particularly in areas with high disease pressure (Table 9b).

2.7 TISSUE CULTURE PLANTLET MULTIPLICATION—MAK

MAK has been able to maintain the in-vitro plantlets of three OSP varieties ('Ejumula', 'Kabode', and 'NASPOT 10 O') and 'Vita' ('NASPOT 9 O') at its Plant Tissue Culture Laboratory at Kabanyolo. One-hundred in-vitro plantlets of each variety are still being conserved. The in-vitro plantlets are sub-cultured onto multiplication medium every 3–4 weeks and later hardened and weaned in the screen house at Kabanyolo. MAK also maintains three varieties ('Ejumula', 'Kabode', and 'Vita') in the screen house at Kabanyolo. The vines planted in the screen house were replanted in September 2013 (Table 10).

Table 10. Status of achievements for MAK

Planned Activities	Targeted Outputs	Target Date	Baseline	Status	Comments
In-vitro multiplication and maintenance	100 in-vitro plantlets of each variety	Dec. 2013	% 0 bottles	100% (continuous activity)	In-vitro multiplication was continued at lower scale. Plants have already been established in the screen house for further multiplication.
In-vitro maintenance	50 in-vitro culture in tubes	Continuous till Dec. 2014	50		Acquired 2 new varieties ('NASPOT 13 O' and 'NASPOT 12 O') for cleaning in addition to 'Ejumula', 'Vita', and 'Kabode' that are maintained in vitro. 100 bottles (of 2–3 plantlets) of each variety are maintained. Sub-culturing is done at least once every month.

2.8 VINE MULTIPLICATION AT BIOCROPS

Since 2012, BioCrops has partnered with CIP to develop the company's capacity for multiplying virus-free sweetpotato vines. This has been implemented under the umbrella of developing and delivering biofortified crops in Uganda. Under this arrangement, BioCrops' role is to ensure availability of clean pre-basic OSP vines. In 2014 BioCrops worked to increase the multiplication rates in the screen house to meet the demand being created and to establish and strengthen nurseries operated by nursery operators. New indexed sweetpotato tissue culture plantlets of 'Ejumula', 'Kabode', and 'Vita' were introduced from KEPHIS (Kenya) in January 2014 for in-vitro multiplication and maintenance at BioCrops.

Mite infestation had become a problem in the screen house at BioCrops. For effective control, the screen house was emptied of the old stock of OSP varieties. New materials were established in the small screen house for further multiplication in the big screen house. This will also be used for carrying out experiments to increase the screen house multiplication by at least twofold. (See Table 11 for more BioCrops achievements.)

Table 11. Summary of achievements for BioCrops

Activity/Milestone	Targeted Output	Target Date	Baseline	Update	Status
Maintenance of in-vitro cultures of indexed sweetpotatoes	Have at least 100 in-vitro cultures of 'Ejumula', 'Vita', & 'Kabode'	Continuous activity	10 in-vitro culture plantlets of each variety	In-vitro cultures: 'Ejumula' = 40, 'Vita' = 390, & 'Kabode' = 500	In vitro culture maintenance in progress
Maintaining a constant supply of clean vines	40,000 virus-free vines of 'Ejumula', 'Kabode', & 'Vita'	31 Dec. 2014	New shoots for starting screen house multiplication: Ejumula = 120, Kabode = 300, Vita = 174.	Vines delivered since Jan. 2014: 'Ejumula' = 3,000; 'Kabode' = 3,000	Progress was affected by mite infestation. Big screen house was recently discarded of all old material and new materials are continuously weaned and established in small screen house for multiplication in the big screen house.
Increasing screen house multiplication rates	At least 13,400 vines per variety produced in 11 months	Oct. 2014	No stocks of clean hardened plants	In-vitro stock of OSP varieties now under multiplication	This activity is waiting for availability of enough vines to set up experiments

3. 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. Dr. Sam Namanda has continued to serve as the project's seed systems specialist. Our partners, NaCRRI, MAK, and BioCrops, also continued with their activities. At NaCRRI, one scientist (10% time), 1 technician (50%), and 1 driver (30%) are involved in the project. At MAK, Dr. Settumba Mukasa has two technicians committed to the project.

4. MAJOR EQUIPMENT ACQUIRED

None.

5. DESCRIPTION OF SIGNIFICANT TRAVEL

Appendix 10 summarizes the travels made by CIP staff during the reporting period to accomplish project objectives.

6. DELAYS, PROBLEMS, SUGGESTIONS

The planned project activities are on course.

7. REFERENCES

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APPENDIX 1. PROGRESS ON OBJECTIVES AND OUTCOMES FOR CIP

Milestone	Targeted outputs	Baseline	Progress/ Status	Comments
Objective 1: Ensure supply of disease-free 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.	Have at least 100 in-vitro cultures of 'Ejumula', 'Vita', & 'Kabode' at MAK 40,000 virus-free vines of 'Ejumula', 'Kabode', & 'Vita' (BioCrops).	10 in-vitro culture plantlets of each variety New shoots for starting screen house multiplication: 'Ejumula' = 120, 'Kabode' = 300, & 'Vita' = 174.	In-vitro cultures: 'Ejumula' = 30, 'Vita' = 54, & 'Kabode'= 45 Vines delivered by BioCrops since Jan 2014: 'Ejumula' = 3,000 & 'Kabode' = 3,000	In-vitro culture maintenance in progress Progress was affected by mite infestation. Big screen house was recently discarded of all old material and new materials are continuously weaned and established in small screen house for multiplication in the big screen house
Asses the cost of tissue culture multiplication in Uganda	Capacity of BioCrops to multiply clean foundation planting material established	No experience of multiplying pathogen-tested OSP vines	Tracking of costs at BioCrops is ongoing	
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 HH in areas with prolonged dry seasons adopt the technology	Triple S technology not yet tested in HarvestPlus project areas	Three demonstration sites were planted in each of the districts of Oyam, Lira, Kole, and Gulu using 'Ejumula', 'Kabode', and 'Kakamega' varieties	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 based on addressing any emergent constraints to adoption	At least 30% of communities in project areas adopt Triple S	OSP is not grown in the project areas	Planning for the activity continues	Activity planned for completion 2015
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 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	1st and 2nd season OSP trials for 2014 have been planted with OSP clones 'Ejumula (OP) 2012/3', 'Ejumula (OP) 2012/11,' 'Ejumula (OP) 2012/9', 'Ejumula (OP) 2012/10', and 'Resisto (OP) 2012/1'. 100 trials were	Performance of 2014a trials in Kabale and Rakai were affected by drought Activity is on schedule.

Milestone	Targeted outputs	Baseline	Progress/ Status	Comments
			planted. First-season 2014 trials (50) and second-season trials (10 in all) were harvested.	
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	200 and 125 plantlets of 'NASPOT 12 O' and 'NASPOT 13 O', respectively, are available at NaCRRI	The two newly released in-vitro virus-indexed OSP varieties ('NASPOT 12 O' and 'NASPOT 13 O') are now maintained in vitro at NaCRRI
Objective 4: Improve curing techniques and investigate other ways to improve postharvest quality and extend postharvest 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	'Kabode', 'NASPOT 8', & 'NASPOT 1' have been planted in Masaka, Mukono, and Rakai for postharvest experiments. Activity is on schedule.	Data collection from the curing experiments is ongoing
Evaluation of improved curing methods vs. current practice	Improved curing and storage techniques tested with farmers	Limited shelf life of sweetpotatoes	Third round of curing trials have been set up in Rakai, Mukono, and Masaka districts	Data collection is ongoing
Work with implementation team to improve training on handling of roots during harvest and postharvest	Selected lead farmers from project areas trained in postharvest handling	No trained farmers in postharvest handling	Training in postharvest handling will be scheduled with farmer groups and commercial farmers in partnership with HarvestPlus	CIP and HarvestPlus will conduct the training
Objective 5: Backstop implementation team and broader dissemination objectives				
Respond to emerging problems on sweetpotato multiplication and production as requested by the implementation team	Emerging problems solved	Issues among partners vary	CIP staff backstopped HarvestPlus team on training of farmers, extension personnel, and vine multipliers	
Ensure that experience is documented and any relevant materials and finding are loaded on the Sweetpotato Knowledge Portal.	Documented experiences	No experiences on new OSP varieties and Triple S in HarvestPlus project areas	All technical reports have been written since project inception. A manuscript on the recent OSP releases has been drafted.	The draft has been sent out for peer review before submitting to a journal for publication

APPENDIX 2. PROGRESS ON OBJECTIVES AND OUTCOMES FOR NaCRRI

Milestone	Targeted out puts	Baseline	Progress	Comments
Objective: Accelerate evaluation of on-farm 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 passed on to the	New OSP clones from NaCRRI have been tested on-station.	100 on-farm trials were planted in Oyam, Buyende, Rakai, Isingiro, and Kabale between April and September 2014	The trials have been established with OSP clones 'NASPOT 10 O' ('Kabode') (common check variety), 'Resisto (OP)

	farmers		Out of 100 trials, 60 have been harvested.	2012/2', 'Ejumula (OP) 2012/3', 'Ejumula (OP) 2012/9', Ejumula (OP) 2012/10', 'Ejumula (OP) 2012/11', and local checks selected by the farmers. Some of the trials were affected by drought especially in Rakai and Kabale.
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	
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	A manuscript on the recent OSP releases is underway Quarterly and final 2014 technical reports have been written	After peer review the manuscript will be submitted to a journal for publication

APPENDIX 3. PROGRESS ON OBJECTIVES AND OUTCOMES FOR MAK AND BioCROPS

Milestone	Targeted out puts	Baseline	Progress/ status	Comments
Objective: Ensure supply of disease-free 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	New shoots for starting screen house multiplication: 'Ejumula' = 120, 'Kabode' = 300, & 'Vita' = 174	Vines delivered since Jan 2014 by BioCrops: 'Ejumula' = 3,000 & 'Kabode' = 3,000	Progress was affected by mite infestation. Big screen house was recently discarded of all old material and new materials are continuously weaned and established in small screen house for multiplication in the big screen house MAK acquired two new varieties ('NASPOT 13 O' and 'NASPOT 12 O') for cleaning in addition to 'Ejumula', 'Vita', & 'Kabode' that are being maintained in vitro. 100 bottles (of 2–3 plantlets) of each variety are being maintained. Sub-culturing is done at least once every month.
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 ongoing	

APPENDIX 4. FARMERS HOSTING OSP ON-FARM TRIALS PLANTED 6 APRIL–8 MAY 2014

Name	Sex	Sub county	District
Lawrence Owani	M	Alito	Kole
Jenipher Obore	F	Alito	Kole
Apio Susan	F	Alito	Kole
Florence Odyek	F	Alito	Kole
Susan Ochen	F	Alito	Kole
Johnson Odong	M	Alito	Kole
Julius Echen	M	Alito	Kole
Elweny David	M	Alito	Kole
Betty Ochen	F	Alito	Kole
Agnes Obong	F	Alito	Kole
John Kintu	M	Bukakata	Masaka
Irene Nambusi	F	Bukakata	Masaka
Lukyamuzi David	M	Bukakata	Masaka
Nakiyimba Sylvia	F	Lwankoni	Rakai
Bale Christopher	M	Kalisizo	Rakai
Senyonga Dominico	M	Kalisizo	Rakai
Namagembe Angelina	F	Kirumba	Rakai
Sabavuma Herman	M	Kirumba	Rakai
Godfrey Bukenya	M	Lwankoni	Rakai
Nalumaga Joyce	F	Lwankoni	Rakai
Lungyereza Teddy	F	Hamulwa	Kabale
Busingye Justine	F	Hamulwa	Kabale
Moleda Twebaze	F	Hamulwa	Kabale
Ahimbisibwe Agnes	F	Hamulwa	Kabale
Peteronia Byarugaba	F	Ikumba	Kabale
Byamugisha Grace	M	Ikumba	Kabale
Babwekyeka Flora	F	Ikumba	Kabale
Dafuloza Muatabazi	F	Ikumba	Kabale
Jane Twesigye	F	Ikumba	Kabale
Arinaitwe Grace	M	Hamulwa	Kabale
Nakiduli Aidha	F	Buyende	Buyende
Kweberawo Sarah	F	Buyende	Buyende
Kiwanuka Socius	M	Buyende	Buyende
Namukose Alice	F	Buyende	Buyende
Nabiryo Resty	F	Buyende	Buyende
Nakisuyi Base	F	Buyende	Buyende
Isooba Arafat	M	Bugaya	Buyende
Bagenda Charles	M	Bugaya	Buyende
Ezemani Eridad	M	Bugaya	Buyende
Buyinza David	M	Bugaya	Buyende
Mary Ruhwabwoba	F	Nyakitunda	Isingiro
Alice Kaada	F	Nyakitunda	Isingiro
Vanice Kyomuhangi	F	Nyakitunda	Isingiro
Gloria Nimusiima	F	Nyakitunda	Isingiro
Annet Tweheyo	F	Kikagati	Isingiro
Stella Katwire	F	Kikagati	Isingiro
Marble Twesigye	F	Kikagati	Isingiro
Birungi Ruth	F	Kikagati	Isingiro
Christine Musinguzi	F	Kikagati	Isingiro
Musinguzi Bright	M	Nyakitunda	Isingiro

Total 50, 32 (64 %) Female

APPENDIX 5. PARTICIPANTS FROM GULU DISTRICT SENSITIZED AND TRAINED IN TRIPLE S METHOD OF PRODUCING SWEETPOTATO PLANTING MATERIAL

Name of Farmer	Sex	Sub-county	Parish	Status of Participant			
				CRP	CDA/FEW	Farmer	Demo Host
Betty Anek Otim	F	Bobi	Paidwe	1	0	0	1
Betty Oroma	F	Bobi	Paidwe	1	0	0	0
Stella Akajo	F	Bobi	Paidwe	1	0	0	0
Lilly Okulu	F	Bobi	Palwo	1	0	0	0
Romano Okello	M	Bobi	Palwo	1	0	0	0
Winfred Okot	M	Bobi	Paidwe	1	0	0	0
Charles Acaye	M	Bobi	Paidwe	1	0	0	0
Santo Okoya	M	Bobi	Paidwe	1	0	0	1
Gaudensio Okello	M	Bobi	Paidwe	1	0	0	1
Felix Otiti	M	Bobi	Paidwe	1	0	0	1
Tony Abic	M	Bobi	Paidwe	1	0	0	0
Mariano Ojok	M	Bobi	Paidwe	1	0	0	0
Marino Atim	M	Bobi	Palwo	1	0	0	0
Alfonse Woo	M	Bobi	Palwo	1	0	0	0
Alex Omara	M	Bobi	Paidwe	0	1	0	0
Richard Obura	M	Bobi	Paidwe	1	0	0	1
Geoffrey Okenya	M	Bobi	Palwo	1	0	0	0
Micheal Ocen	M	Bobi	Palwo	1	0	0	1
Walter Ocan	M	Koro	Acoyo	1	0	0	0
Agnes Auma	F	Koro	Acoyo	0	0	1	0
Harriet Akello	F	Koro	Acoyo	0	0	1	0
Franka Lakot	F	Koro	Acoyo	1	0	0	0
Haron Akello	F	Koro	Acoyo	0	0	1	0
Saritha Alanyo	F	Koro	Acoyo	1	0	0	1
Alice Oroma	F	Koro	Acoyo	0	0	1	1
Laker Kevine	F	Koro	Acoyo	0	0	1	0
Anna Ayol	F	Koro	Acoyo	0	0	1	0
Margaret Acaye	F	Koro	Acoyo	1	0	0	1
Beatrice Acen	F	Koro	Acoyo	0	0	1	0
Richard Odong	M	Koro	Acoyo	1	0	0	0
Lucy lakot	F	Koro	Acoyo	0	0	1	0
Beatrice Auma	F	Koro	Acoyo	0	0	1	0
Filda lanyero	F	Koro	Acoyo	0	0	1	0
Isaac Ojok	M	Koro	Ibakara	0	0	1	0
Susan Apiyo	F	Koro	Ibakara	0	0	1	0
Denisi okello	M	Koro	Ibakara	1	0	0	0
Jimmy Odongo	M	Koro	Ibakara	0	0	1	0
Richard Ojok	M	Koro	Ibakara	1	0	0	1
Jovin Okello	M	Koro	Ibakara	0	0	1	0
Simon Peter Opiyo	M	Koro	Ibakara	1	0	0	0
Everly Otika	M	Koro	Ibakara	1	0	0	1
Aber Stella	F			0	1	0	0
Total				**26**	**2**	**14**	**11**

CRPs = Community Resource Persons, FEWs-Field Extension Workers, CDAs-Community Development Assistants

APPENDIX 6. PARTICIPANTS FROM OYAM DISTRICT SENSITIZED AND TRAINED IN TRIPLE S METHOD OF PRODUCING SWEETPOTATO PLANTING MATERIAL

Name of Farmer	Sex	Sub-county	Parish	Status of Participant		
				CRP	CDA/FEW	Host
Richard Obong	M	Minakulu	Atek	1	0	1
Tonny Amai	M	Minakulu	Atek	1	0	1
Samuel Otodi	M	Minakulu	Atek	1	0	0
Bonny Omara	M	Minakulu	Atek	1	0	0
Richard Ogola	M	Minakulu	Atek	1	0	1
Lawrence Ongom	M	Minakulu	Opuk	1	0	0
Bosco Odongo	M	Minakulu	Opuk	1	0	0
Agnes Ongom	F	Minakulu	Opuk	1	0	1
Annet Opio	F	Minakulu	Atek	1	0	0
David Abor	M	Minakulu	Atek	1	0	0
Densh Apunyu	M	Ngai	Acut	1	0	0
Patrick Ayu	M	Ngai	Omac	1	0	1
Beatrice Ojuk	F	Ngai	Omac	1	0	0
Richard Akaki	M	Ngai	Omac	1	0	0
Calvin Odongo	M	Ngai	Omac	1	0	0
Maxwel Nam	M	Ngai	Acut	1	0	1
Patrick Oyile	M	Ngai	Acut	1	0	0
Lawrence Ocan	M	Ngai	Acut	1	0	0
Dicken Okello	M	Ngai	Acut	1	0	0
Robert okello	M	Ngai	Omac	1	0	1
Walter Ekuba	M	Ngai	Acut	1	0	0
Michael Opio	M	Ngai	Acut	1	0	0
Aldo Ocen	M	Ngai	Acut	1	0	0
Santo Okello	M	Ngai	Acut	1	0	1
Francis Opio	M	Ngai	Omac	1	0	0
Hahab Renuls	M	Ngai	Omac	1	0	0
Grace Ekanya	F	Ngai	Omac	1	0	0
Ray Okello	M	Ngai	Acut	1	0	0
Patrick Okello	M	Ngai	Omac	1	0	1
Patrick Aluku	M			0	1	0
Oyena Emmy	M			0	1	0
Total				**29**	**2**	**9**

CRPs = Community Resource Persons, FEWs-Field Extension Workers, CDAs-Community Development Assistants

APPENDIX 7. PARTICIPANTS FROM LIRA DISTRICT SENSITIZED AND TRAINED IN TRIPLE S METHOD OF PRODUCING SWEETPOTATO PLANTING MATERIAL

Name of Farmer		Sex	Sub county	Status of Participant			
				CRP	CDA/FEW	Farmer	Host
1	Stephen Odongo Leo	M	Aboke	0	1	0	0
2	Lamex Dongo	M	Barr	1	0	0	1
3	Geoffrey Otim	M	Barr	1	0	0	0
4	Tonny Amai	M	Barr	1	0	0	0
5	Alfred Otim	M	Barr	1	0	0	0
7	Alfred Olila	M	Barr	1	0	0	1
28	George Ogwang	M	Barr	0	0	1	0
29	Junira Ocen	M	Barr	0	0	1	0
30	Joe Olinga	M	Barr	1	0	0	0
31	Moses Ajula	M	Barr	1	0	0	0
32	Vincent Okeng	M	Barr	0	0	1	0
33	Moses ogwang	M	Barr	0	0	1	1
6	George Obong	M	Ngetta	1	0	0	0
8	William Opio	M	Ngetta	1	0	0	0
9	Patrick George Ojok	M	Ngetta	1	0	0	0
10	Tom Aguma	M	Ngetta	1	0	0	0
11	Tonny Omara	M	Ngetta	0	0	1	0
12	Bonifance Keny	M	Ngetta	0	0	1	0
13	Janan Okello	M	Ngetta	1	0	0	0
14	Tonny Okello	M	Ngetta	1	0	0	0
15	David Agoro	M	Ngetta	1	0	0	0
16	Patrick Opolo	M	Ngetta	0	0	1	0
17	Jasper Ayo	M	Ngetta	0	0	1	0
18	Monica Kibuka	F	Ngetta	1	0	0	0
19	Harriet Okaka	F	Ngetta	1	0	0	0
20	Teddy Opio	F	Ngetta	1	0	0	0
21	Grace Omara	F	Ngetta	1	0	0	0
22	Susan Okello	F	Ngetta	0	0	1	1
23	Milly Omara	F	Ngetta	1	0	0	0
24	Perpetua Okolo	F	Ngetta	0	0	1	0
25	Jasper okello	M	Ngetta	0	0	1	0
26	Betty Rose Aceru	F	Ngetta	0	0	1	0
27	David Odwar	M	Ngetta	0	1	1	0
34	Hellen Grace Akullu	F	Ngetta	0	1	1	1
35	Doreen Ayuru	F	Ngetta	0	0	1	0
Total				**19**	**3**	**15**	**5**

CRPs = Community Resource Persons, FEWs-Field Extension Workers, CDAs-Community Development Assistants

APPENDIX 8. PARTICIPANTS FROM KOLE DISTRICT SENSITIZED AND TRAINED IN TRIPLE S METHOD OF PRODUCING SWEETPOTATO PLANTING MATERIAL

Name of Farmer	Sex	Status of Participant			
		CRP	CDA/FEW	Farmer	Host
Mario Okullu	M	1	0	0	0
Fred Munu	M	1	0	0	0
Jimmy Awady	M	0	0	1	0
Denish Okello	M	0	0	1	1
George Apoka	M	0	0	1	0
Monica Alupu	F	1	0	0	0
Florance Omara	F	1	0	0	0
Miriam Oduca	F	0	0	1	0
Simpo Akullu	F	0	0	1	1
Silvia Awidi	F	0	0	1	0
Anna Ogwang	F	0	0	1	0
Kenneth Acuti	M	1	0	0	0
Lawrence Omony	M	1	0	0	0
Geoffrey Okabo	M	0	0	1	0
Tobia odongo	M	0	0	1	0
Vincent Alobo	M	1	0	0	1
George Akenya	M	0	0	1	0
Peter Silivesto Obong	M	0	0	1	0
Geoffrey Okello	M	0	0	1	0
Tom Opio	M	0	0	1	0
Alfred Ojok	M	0	0	1	0
Sam Okello	M	0	0	1	0
Samuel Ojok	M	0	0	1	0
Charles Oyar	M	0	0	1	0
Benard Oming	M	1	0	0	0
Milton Obong	M	0	0	1	0
Rose Akoi	F	1	0	0	0
Monica Akullu	F	0	0	1	0
Tom Ayo	M	1	0	0	0
Jacob Aripa	M	1	0	0	1
Fred Amot	M	0	0	1	0
Tonny Agulu	M	0	0	1	0
Cyprano Oyel	M	0	0	1	0
Denish Ayo	M	0	0	1	1
Charles Okidi	M	0	0	1	0
Robert Okello	M	0	1	0	0
Geoffrey Ocuku	M	0	1	0	0
	Total	**11**	**2**	**24**	**5**

APPENDIX 9A. FARMERS TRAINED IN MANAGEMENT OF SWEETPOTATO DISEASES, RAPID MULTIPLICATION AND AGRONOMY (3–7 MARCH 2014)

Name	Village	Sub-county	District
Agnes Kalya	Ntove	Nakisunga	Mukono
Kigongo Emanuel	Ntove	Nakisunga	Mukono
Nnalongo Prose Sentamu	Masaba-Kyampologoma	Ngongwe	Mukono
Kibirango Sebastian	Masaba Central	Ngongwe	Mukono
Kasozi Steven	Mulajje	Nkokonjeru	Mukono
Kizito Anthony	Nkokonjeru TC	Nkokonjeru	Mukono
Kankobe Catholic Parish	Nindye A	Nkozi	Mpigi
Semanda Godfrey	Nindye B	Nkozi	Mpigi
Ssebagala Edward	Nindye B	Nkozi	Mpigi
Namusoke Juliet	Lubanda A	Nkozi	Mpigi
Mawejje Ronald	Kikoota	Nkozi	Mpigi
Namukwaya Jane	Kiguli	Nkozi	Mpigi
Rehema Setyabula	Manyama	Zirobwe	Luwero
Sekiyanja Joweria	Mayirikiti	Nyimbwa	Luwero
Mbogo Dickson	Kakute LC	Nyimbwa	Luwero

APPENDIX 9B. DETAILS OF FARMERS WHO WERE TRAINED IN SWEETPOTATO DISEASE MANAGEMENT AND RAPID MULTIPLICATION IN WAKISO DISTRICT, CENTRAL UGANDA (21–27 JULY 2014)

Name	Village	Parish	Sub-county	District
Annett Nalumu Ssozi	Muyenje	Lukwanga	Wakiso	Wakiso
Annette Namata Semulimi	Muyenje	Lukwanga	Wakiso	Wakiso
Ssalongo Deziderio Nakabale	Luggi	Lukwanga	Wakiso	Wakiso
Francis Ssewatifu	Luggi	Lukwanga	Wakiso	Wakiso
Anatoli Owembabazi	Luggi	Lukwanga	Wakiso	Wakiso
Ruth Namuddu	Lugeye	Lugeye	Kakiri	Wakiso
Herbert Wasajja	Sebbi-Lugeye	Lugeye	Kakiri	Wakiso
Samuel Kakooza	Bukelekele	Kikandwa	Kakiri	Wakiso
Harriet Nakilaga	Bukelekele-Mpogo	Kikandwa	Kakiri	Wakiso
Florence Kawuki	Bukelekele	Kikandwa	Kakiri	Wakiso
Fred Kayira	Mpegwe-Nankulamude	Kikandwa	Kakiri	Wakiso
Nuru Namuli	Bukasa LCI	Namusela	Mende	Wakiso
Vincent Lubi	Kongojje	Bakka	Mende	Wakiso
Galiwango Kyolobi	Kongojje	Bakka	Mende	Wakiso
Arthur Musisi	Kongojje	Bakka	Mende	Wakiso

APPENDIX 10. SUMMARY OF SIGNIFICANT TRAVELS IN 2014

Date	Name	Institution	Locations	Travel Objective	Output
5–17 Feb.	Gerald Kyalo Joweria Namukasa	CIP NaCRRI	Oyam, Buyende, Isingiro, Kabale, Rakai	Harvesting 2nd season trials Monitoring and preharvest assessments of OSP trials	Trials harvested in Oyam and Buyende Trials monitored successfully
4–7 Mar.	Gerald Kyalo	CIP	Mukono, Rakai, Masaka	Monitoring on-farm trials and planning for postharvest experiments	Planning for postharvest experiments done
23–26 Mar.	Gerald Kyalo Joweria Namakula	CIP NaCRRI	Rakai	Harvesting 2nd season OSP trials	2nd season trials harvested
31 Mar.–4 Apr.	Gerald Kyalo Joweria Namakula	CIP NaCRRI	Oyam	Planting on-farm trials for 1st season 2014	10 trials planted
8–12 Apr.	Gerald Kyalo	CIP	Rakai, Masaka, Mukono	Planting 1st season 2014 trials Planting materials for postharvest materials	10 OSP trials planted, 9 acres planted for postharvest experiments
22–28 Apr.	Gerald Kyalo	CIP	Kabale	Planting 1st season 2014 OSP trials, harvesting 2nd season 2013 OSP trials	10 trials planted, 7 trials harvested
29 Apr.–4 May	Gerald Kyalo Joweria Namakula	CIP NaCRRI	Buyende	Planting on-farm trials	10 on-farm trials planted
5–12 May	Gerald Kyalo Joweria Namakula	CIP NaCRRI	Isingiro	Planting 1st season 2014 OSP trials, harvesting 2nd season 2013 OSP trials	10 trials planted, 7 trials harvested
17–26 Jan.	Sam Namanda	CIP	Lira, Kole, Gulu and Oyam	Conduct review and training workshop for Triple S ppts and follow up establishment of multiplication root beds	53 stakeholder participants including field extension workers trained in triple S method. The Triple S leaflet was reviewed and demonstrations on triple S established
6–12 Feb.	Sam Namanda	CIP	Lyatonde, Rakai, Buyende, and Kamuli districts	Harvesting the clean planting material trial for season 2013b and preparing for March/April 2014 season planting	Trial on clean planting material was harvested and data collected. Reference photographs were taken
19–20 Feb.	Sam Namanda	CIP	Kamuli and Mukono	Harvest trial on clean planting material	Trial on clean planting material was harvested and data collected. Reference photographs were taken
25–26 Feb.	Sam Namanda	CIP	Mukono and Namulonge	Dr. Olapeju field and on-station orientation on sweetpotato activities	Orientation of Dr. Olapeju Phorbee from Nigeria to sweetpotato activities in Uganda, and conduct on-farm group review of the trial on clean planting material
2–9 Mar.	Sam Namanda	CIP	Gulu, Oyam, Kole and Lira	Attend seed systems meeting in Gulu and follow up on Triple S activities	Partner review of sweetpotato seed systems activities in northern Uganda and follow on Triple S demonstrations in northern Uganda

Date	Name	Institution	Locations	Travel Objective	Output
29–31 May	Gerald Kyalo	CIP	Rakai, Masaka, Mukono	Monitoring postharvest gardens and organize for 1st weeding	1st weeding done successfully
10–19 June	Gerald Kyalo	CIP	Oyam, Rakai	Preharvest data collection	Preharvest data collection done
2–8 July	Gerald Kyalo	CIP	Buyende, Kabale	Preharvest data collection	Preharvest data collection done
3–11 Aug.	Gerald Kyalo Joweria Namakula	CIP NaCRRI	Oyam	Planting 2nd season trials Harvesting 1st season trials	10 trials planted, 10 trials harvested
8–14 Sept.	Gerald Kyalo Joweria Namakula	CIP NaCRRI	Buyende	Planting 2nd season trials Harvesting 1st season trials	10 trials planted, 10 trials harvested
13–20 Oct.	Gerald Kyalo Joweria Namakula	CIP NaCRRI	Kabale, Isingiro	Planting 2nd season trials Harvesting 1st season trials	10 trials planted, 10 trials harvested
3–6 Nov.	Gerald Kyalo	CIP	Masaka, Rakai	Preparing curing experiments	Curing experiments planned to be set up the next week.
17–23 Nov.	Gerald Kyalo	CIP	Oyam	Pre-harvest data collection	Pre-harvest data collected successfully
24–30 Nov.	Gerald Kyalo	CIP	Masaka, Rakai	Setting up curing trials	Curing trials successfully set up at 2 sites
4–6 Dec.	Gerald Kyalo	CIP	Masaka, Rakai	Monitoring curing trials	Progress of curing trials successfully monitored
8–11 Dec.	Gerald Kyalo HarvestPlus	CIP HarvestPlus	Soroti/ Bukedea	Vine multipliers workshop	Workshop successfully conducted
11–19 Dec.	Gerald Kyalo Joweria Namakula	CIP NaCRRI	Lira Mukono Masaka/ Rakai	Harvesting 2nd season trials Setting up curing experiments Data collection in curing experiments	10 trials harvested Curing trials setup in Mukono Data collected in curing experiments
24–26 Apr.	Sam Namanda	CIP	Kamuli and Buyende	Plant trial on clean material for season 2014a	A total of 9 sites planted
22 May – 2 June	Sam Namanda	CIP		Collect harvest data on Triple S trial and prepare to plant the harvested vines	Harvest data on triple S collected
10–13 July	Sam Namanda	CIP	Buyende, Kamuli and Mukono districts	Harvest season 2014a and plant 2014b trial on clean material	A total of 6 sites harvested of previous season and 9 planted for season 2014b
7–10 Sept.	Sam Namanda	CIP	Lyatonde and Rakai districts	Plant trial on clean material for season 2014a	A total of 6 sites planted
8–12 Sept.	Sam Namanda	CIP	Nairobi	Present on progress on sweetpotato seed systems research activities in Uganda	Presented on progress on promoting use Triple S and clean planting material in Uganda
23–27 Sept.	Sam Namanda	CIP	Rakai and lyatonde districts	Plant and harvest trials on clean material	Trial on clean material planted at 4 sites in 2 districts. Previous season trial on clean material harvested
28–30 Sept.	Sam Namanda	CIP	Entebbe	Present on the proposed potato business case to RTB forum meeting	Poster on potato business case presented
8–12 Oct.	Sam Namanda	CIP	Buyende, Kamuli and Mukono districts	Collect pre-harvest data on clean planting material trial	Pre-harvest data collected on clean planting material trial

Date	Name	Institution	Locations	Travel Objective	Output
14–22 Oct.	Sam Namanda	CIP	Lira, Oyam and Gulu districts	Data collection on Triple S demos and review of Triple S calendar activities	Harvest data on triple S collected and triple S calendar reviewed
18–20 Nov.	Sam Namanda and Meherati	CIP Uganda and Ethiopia	Lira, Oyam, Gulu, Mukono, NaCRRI and BIoCrops	Orientation of Ethiopian scientist to Sweetpotato seed systems in Uganda	Orientation to demonstration sites in northern Uganda, on-farm mini-screen houses and tunnel nets completed. A visit to BioCrops and NaCRRI seed systems activities successful.
25–29 Nov.	Sam Namnada	CIP	Buyende and Mukono districts	Follow up on clean plant trials	Preharvest data on clean trial collected
3–7 Dec.	Sam Namanda	CIP	Kamuli, Buyende and Mukono districts	Harvesting trial in Kamuli and follow up in Buyende and Mukono districts	Harvest data on clean material collected at 6 trials sites
16–22 Dec.	Sam Namanda	CIP	Lira, Oyam and Gulu	Final review of draft calendar and organize storage of roots	Calendar reviewed and 6 groups facilitated to store seed roots