SASHA

PHASE 2-YEAR 3

Annual Main Technical Report

JULY 2016 - JUNE 2017

SASHA

Sweetpotato Action for Security and Health in Africa

BILL & MELINDA GATES foundation

Progress Narrative

Use this form to provide updates to your foundation program officer regarding progress made toward achieving your project's stated outputs and outcomes.

The Progress Narrative must be submitted in Word, as PDFs will not be accepted.

General Information

Investment Title	Renewal 53344 SASHA II: Sweetpotato Action for Security & Health in Africa		
Grantee/Vendor	International Potato Center (CIP)		
Primary Contact	Jan Low	**Investment Start Date**	June 30, 2014
Feedback Contact[1]	Jan Low	**Investment End Date**	July 31, 2019
Feedback Email[1]	j.low@cgiar.org	**Reporting Period Start Date**	July 1, 2016
Program Officer	Jim Lorenzen	**Reporting Period End Date**	June 30, 2017
Program Coordinator	Amy Pope	**Reporting Due Date**	July 31, 2017
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[1] Feedback Contact/Email: The full name and email of the contact whom foundation staff queries for various surveys.

Submission Information

By submitting this report, I declare that I am authorized to certify, on behalf of the grantee or vendor identified on page 1, that I have examined the following statements and related attachments, and that to the best of my knowledge, they are true, correct and complete. I hereby also confirm that the grantee or vendor identified on page 1 has complied with all of the terms and conditions of the Grant Agreement or Contract for Services, as applicable, including but not limited to the clauses contained therein regarding Use of Funds, Anti-Terrorism, Subgrants and Subcontracts, and Regulated Activities.

Date Submitted	22 August 2017	**Submitted by Contact Name**	Jan W. Low
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Progress and Results

1. Progress Details

I. Executive Summary. This has been an incredible year of recognition and celebration of the progress made in biofortification, and for vitamin A-rich orange-fleshed sweetpotato (OFSP) in particular. The awarding of the 2016 World Food Prize to three CIP scientists supported by SASHA (Jan Low, Maria Andrade, and Robert Mwanga) and Howdy Bouis, of HarvestPlus, on 13 October 2016, was a memorable event. A highlight of the associated Borlaug Dialogue was a panel discussion with the co-laureates moderated by former Bill & Melinda Gates Foundation (BMGF) CEO Jeff Raikes. There has been extensive media coverage of the award, and the CIP laureates involved in 18 speaking events due to the award. Two papers were published in *Global Food Security* in early 2017 summarizing progress in biofortification and OFSP development and dissemination. The team deeply appreciates the key role BMGF played in helping turn an innovative concept into reality and the catalytic role it has played in getting other donors to support the going-to-scale effort.

SASHA2 is building on the successes realized during SASHA1, with a strategic focus on adaptive research to break the remaining bottlenecks to unleash the potential of sweetpotato to reduce undernutrition and food insecurity. Substantial progress was made in year 3. The only scientific disappointment being that the *Bt* approach for developing a weevil-resistant sweetpotato has not succeeded after several attempts to increase expression of the transformed genes. Agreed subgrant agreements (SGAs) for year 3 were finalized for 17 subgrantees. The updated results tracker is provided in Appendix A. Of the 32 key milestones, 3 have been completed (9%), 19 are on track (59%), and 10 are behind schedule (31%). Most of those behind schedule are due to postharvest experiments and seed system activities taking longer than anticipated. Appendix B provides the detailed expenditures by CIP-HQ finance for year 3 of SASHA2 (July 2016–June 2017).

Research Program (RP)1. Breeding. Population development is conducted at "sweetpotato support platforms" (SSPs) in Uganda, Mozambique, and Ghana, with backstopping from CIP-HQ. Collaboration with 14 national partners ensures efficiency of breeding efforts, with an overall breeding goal in SASHA2 of 30 new improved varieties available by mid-2019. Specific breeding objectives are to (1) continue to improve sweetpotato population development in sub-Saharan Africa (SSA) linked with participatory varietal selection at the national level; (2) breed for key biotic constraints in Africa; (3) breed OFSP populations for drought-prone regions in Africa; and (4) breed quality types of sweetpotato for urban markets. By the end of year 3, significant progress had been made in genetic gains experiments, improved techniques for collecting and analyzing breeding data, and seed distribution from the Uganda and Mozambique population development programs to national agricultural research systems (NARS) partners. Experimental heterosis populations work continues to be on track. One clone (MUSG15052-2) was identified in the Mozambique high-iron (Fe) breeding effort that, at 4.4 mg/100 g, exceeded the minimum target level of 2.4 mg/100 g (25% of RDI for a child 4–8 years old) set by the breeding program. In Ghana, 21 diverse genotypes were assessed for sensory attributes related to poundability and fry quality, and their starch properties were assessed using a rapid visco-analyzer.

Different approaches were used at CIP-HQ, Mozambique, and Ghana to assess genetic gains based on breeding program progress. At CIP-HQ, over the last two decades leading up to 2014, yield storage root gain at 90 days ranged from 0.18 to 0.34 t/ha per year; at 120 days, this increased to 0.36–0.58 t/ha per year. In Ghana, a storage root yield gain of 0.27 t/ha per year occurred between 1999 and 2012. In Mozambique, total storage root yield increased by a range of 0.287–0.303 t/ha annually and foliage yield by 0.084–0.104 t/ha annually between 2000 and 2016.

The need for continued breeding at a subregional level was verified by testing the 2011 successful Mozambique released varieties in Ghana and Uganda. The Mozambican varieties succumbed to viruses in both settings. Although 13 national breeding programs are now using the accelerated breeding scheme (ABS) approach, it is of great concern that the Alliance for a Green Revolution in Africa (AGRA) issued no new breeding grants for sweetpotato during the past 2 years. Only one African-bred variety was released this year. To date, during phase 2, the population development program in Uganda has provided 361,366 seeds to 8 NARIs; the one in Mozambique distributed 128,570 seeds to 12 NARIs.

A new, highly interactive data analysis platform (HIDAP) was released in January 2017, and breeders trained on its use for 1.5 days at the annual SpeedBreeders meeting in May 2017. The breeding team led or were co-authors on six breeding-related articles this year, reflecting the finalization of breeding cycles and several experiments. A draft chapter on sweetpotato breeding for a book is at the proofing stage.

RP2. Weevil Resistance. Over the last eight years, transgenic sweetpotatoes with sweetpotato-like *cry* genes and with high-expresser *cry* genes were developed at the Applied Biotechnology Laboratory (ABL) in Peru and the Donald Danforth Plant Science Center (DDPSC) in the USA as a strategy to confer resistance to weevils. Well over 150 transgenic events were produced of which a total of 132 transgenic events were tested in a bio-assay using storage roots infested with 10 weevil females. We identified 12 with apparent differences with the nontransgenic materials in adult emergence. Storage roots from 10 of them were shipped from DDPSC to Biosciences eastern and central Africa (BecA) and tested for resistance against weevils. Six showed no significant difference in adult emergence compared with the untransformed storage roots. The remaining 4 presented various degrees of differences such as small number or delayed adult emergence. New repetition of the bioassay on several of these positive events did not confirm previous observation. These results, and those obtained previously, indicate that the amount of *Cry* protein accumulating in the storage roots is not high enough to confer significant level of resistance to the sweetpotato weevils.

The RNAi genes targeting weevil genes have been used in agro-infection of leaf with petiole and embryogenic calli from the sweetpotato variety 'Jonathan'. Up to now, six regenerants from infected leaf-with petiole were confirmed to be polymerase chain reaction (PCR) positive, whereas more regenerants from infected embryogenic calli are being isolated. Next steps, high expressers, storage root production, and bio-assays will take place when new sources of funding become available.

RP3. Seed Systems. All but one of the milestones in this diverse RP are on track. Concerning **technology improvement**, **net tunnel** validation research was completed in Tanzania and Ethiopia and a scientific paper is in preparation. A revised net tunnel brochure is ready for layout and printing. In Rakai District, Uganda (high virus pressure area), preliminary data from the ongoing trial comparing use of the standard net tunnel and mini-screenhouse, indicate that per unit area, for 'Ejumula' and 'Kabode' (but not 'NASPOT 11'), the highest number of cuttings is produced from the net tunnel compared with the mini-screenhouse. Comparative cost-benefit analysis is in progress. **Triple S**[1] activities are now under way in eight countries through collaboration with other projects. In Tigray, on-station validation experiments have shown that the roots survived more than 7.5 months of dry period, extending the potential of Triple S to fit up to 9 months of dry period. The findings from the validation process across different countries are now being consolidated into training of trainers (ToT) and farmer resource materials. In Tanzania, the on-station and on-farm study to assess different **types of irrigation equipment and schedules** is nearing completion. Overall, experimental plots performed better than farmer plots with highest number of vines produced under 10 kPa[2]. Data collection for the second **sandponics** experiment was completed.

Technical production capacity for pre-basic and basic sweetpotato seed production is being consolidated across the 11 countries. Screenhouse or mobile net tunnel production capacity ranges from 120–145 m^2 to 1,670 m^2. Year 3 estimated total production is 2,029,074 pre-basic and 7,103,890 basic three-node cuttings. NARI colleagues continue to increase multiplication rates and reduce costs through further experimentation. Fully updated cost structures (based on real-time cost data collection) have been completed for the Kenya Plant Health Inspection Service (KEPHIS) and the Crops Research Institute (CRI) of Ghana. The revised cost structures have been used to determine the break-even price, discuss mark-up and margins, and develop pricing strategies. The business plan templates have now been adapted to include production targets for different categories of seed, unit production cost, total recurrent production costs, proposed prices, current availability of revolving funds, and projected revenue. The filled-in templates will drive the SGA modifications for the remaining 18 months of this component.

The study protocol for the **pre-basic/early generation seed (PBS/EGS) validation study** was prepared and piloted with KEPHIS and the Rwanda Agricultural Board (RAB) using a participatory peer-to-peer methodology. The objective is to document pre-basic seed production models and to assess the changes in capacities and the level of institutionalization of the business plans in the NARIs. An improved methodology, drawing on the pilot experience, will be implemented with the remaining 11 institutions between August 2017 and June 2018.

[1] Triple S is the method in which roots, not cuttings from vines, are the main sources of seed. Designed for areas with at least 4 months of dry season, the roots are **S**tored in **S**and during the dry season and then **S**prouted when the roots are planted out in a protected garden 6–8 weeks before the rains start.
[2] kPa refers to kilopascal, which is a unit of measurement, in this case for soil water content; 0 kPa = very wet and 100 kPa = very dry.

Research to test and document models for medium- to large-scale basic seed production (the "missing middle") is ongoing in Uganda, Tanzania, and Ethiopia. Training was provided in seed agronomy (including inspection standards), enterprise, and marketing skills in all three countries. Business plans have been prepared and implementation started in northern Uganda and Ethiopia.

Efforts to encourage the **development and institutionalization of protocols for seed standards** for sweetpotato are proceeding well. In Tanzania, the seed standards for sweetpotato, potato, and cassava (pre-basic, basic, certified 1, and certified 2) were officially gazetted on 20 January 2017, joining Ethiopia, Kenya, and Zambia. The process continues in another seven other countries. As countries roll out the implementation of seed standards and inspection procedures, bottlenecks are emerging as evidenced in Ethiopia.

In the Agoro Irrigation Scheme in Uganda, the second and third cycles of the **rice-sweetpotato rotation experiment** were harvested in October 2016 and May 2017, respectively. There was a significant difference in net profits for both rice and sweetpotato in the rotation versus the control. All rice varieties had significantly higher net profits in the rotation than in the control. In contrast, for sweetpotato, there was no significant difference in net profits in the rotation and the control.

Research on determining the potential importance of sweetpotato **begomoviruses** continued. A field survey has been conducted in five out of the six regions that produce sweetpotato in Kenya. Symptoms associated with begomoviruses were present in most of the fields visited. Three-hundred samples have been tested by PCR to confirm presence of begomoviruses. Yield impact will be accessed by field testing in July–December 2017, at the Kenya Agriculture and Livestock Research Organization (KALRO) Kiboko and Marigat.

Diagnostic tools. A fourth iteration of ClonDiag was designed by FERA with improved performance and newly discovered viruses. The following viruses can be detected: CMV, SPCSV, SPV2, SPFMV, SPVG, SPVZ, SPMMV, SPCV, SPVCV, SPC6V, SPPV, and TSV. To analyze the result from the arrays, a smartphone app was developed and finalized into a stable version. A successful validation experiment was performed on 25 samples at CIP-KEPHIS. This obtained a good signal quality and the correct viruses were identified. Detailed analysis comparing ClonDiag results from Lima and KEPHIS versus the standard indexing practice is being undertaken.

Progress has also been made in the development of a thermostabilized loop mediated isothermal amplification (LAMP) test for sweet potato virus disease (SPVD). It is in a ready-to-use form, user-friendly disease detection technique and requires no cold chain. We are currently optimizing parameters such as effect of lyophilization on PCR reagents, accessing heat stability of lyophilized PCR mixture, and improvement of heat stability. LAMP assays were previously developed for eight sweetpotato viruses but, owing to performance issues, we decided to focus on the main viruses sweet potato chlorotic fleck virus (SPFMV), sweet potato chlorotic stunt virus (SPCSV), and begomoviruses. Testing will continue through the remainder of 2017. We envisage that the portable LAMP device will be used in seed systems diagnostic and regulatory functions across SSA countries.

At the June 2016 breeder's meeting, 116 "best bet" varieties and elite materials at SSPs were selected to be fully characterized through field phenotyping and fingerprinting. To date, 86 best bet varieties out of the 116 have been submitted. Twenty-five varieties were established at the KALRO Kiboko field station for phenotypic trait characterization at the end of 2016; another 25 were established in May 2017. Twenty-five varieties were sampled for genotyping by simple sequence repeat markers at the BecA–International Livestock Research Institute (ILRI) Hub. All varieties will undergo virus cleaning by meristem tip culture and thermotherapy, be virus indexed, and conserved in-vitro tissue culture (TC) and in-vivo screenhouses. Core amounts of pathogen-tested cuttings will be maintained at KEPHIS to facilitate prompt response for specific varietal requests.

RP4. Postharvest and Nutritional Quality. The Natural Resources Institute (NRI) leads fresh root storage trials in Kenya comparing a solar-powered unit to an electrical-powered unit with generator backup. The fourth storage trial conducted from December 2016 to April 2017 was successful, with over 70% of the root weight of all treatments able to be processed into purée after 4 months' storage at 20–23°C in the solar-powered store. The variety and vertical height position of the crate in the store room had the most significant effect on the quality of the stored roots, followed by

whether the store room was solar or mains powered. Full details of the storage trial are given in the Milestone report "Storing fresh sweetpotato roots long-term to reduce purée supply chain risks" (OBJ4MS4.1.B) and the design of the evaporative cooling storage facility in OBJ4MS4.1.C. EcoTech, a South African firm, did initial testing of the use of the "coolbot" to force AC units to store at lower temperatures. Results indicate that 12°C can be obtained. A model using a 20-ft container was built starting in May 2017 and will be field tested in Mozambique in year 4.

During year 3, the RP4 team achieved its goal of a shelf-storable OFSP purée that could store at room temperature for 4 months using locally available preservatives. Trials in Kenya showed that OFSP purée treated with 1% citric acid, 0.2–0.5% potassium sorbate, and 0.2–0.5% sodium benzoate, together with vacuum packing, can extend the shelf-life of OFSP purée by 3–6 months under ambient conditions. However, the preservative potassium sorbate affects yeast during dough development used in bread, lengthening dough proofing time and decreasing bread volume. This required further recipe development to mitigate these two negative side effects. Another breakthrough was the introduction of a stronger puréeing machine that could manage the sweetpotato peel in addition to the flesh. Combined with improved root-washing protocols, this enabled the production of *high-fiber* sweetpotato purée. Seven experiments regarding OFSP purée or OFSP purée bread were conducted during this period.

The development of shelf-storable purée has been done in collaboration with another project, SUSTAIN-Kenya, and the Organi Ltd factory in Ringa, Nyanza Province, Kenya. Working with this private sector company to establish a value chain linking OFSP farmers to the factory-making purée to the bakery division of Tusky's supermarket chain in Nairobi, has meant that the cost and logistic aspects of purée development have been captured as part of the purée product development process. This helps to ensure that the OFSP purée can be an economically viable, convenient product. The development of this value chain has been captured in an article published by *Open Agriculture* entitled "From Lab to Life: Making orange-fleshed sweetpotato purée a commercial reality" (OBJ4MS4.3.A).

Capacity to perform beta-carotene and other high performance liquid chromatography (HPLC)-based analysis (e.g., vitamin C) at the Food and Nutrition Evaluation Laboratory (FANEL) increased after another used HPLC, obtained from CIP-HQ, was installed in September 2016. During year 3, FANEL conducted 2,302 analyses of beta-carotene, including for cassava and maize samples from HarvestPlus and OFSP products from the University of Development Studies (UDS) (Ghana). FANEL evaluated the beta-carotene content and proximate analysis for four bakery products used in Rwanda. In addition, it assessed the beta-carotene content and proximate analysis for OFSP breads prepared by substituting wheat flour with 0%, 20%, 30%, 40%, and 50% OFSP purée. Testing for bacteria, molds, and yeast continued to expand, confirming that Organi Ltd is compliant in food safety procedures and as part of shelf-life analyses of OFSP-processed products. FANEL developed a cost-recovery business plan to help assure its long-term sustainability as a regional lab of excellence in nutrient composition and food safety services. This will come into effect in August 2017. To date, FANEL has hosted eight graduate students working on OFSP and other roots, tubers, and banana (RTB) crops.

RP5. Support Platforms, Knowledge Management, and Governance. Twenty-one different organizations attended the 1.5-day 7th Annual SPHI technical meetings (Milestone report OBJ5MS1.2.E). The associated SASHA Project Advisory Committee (PAC) and SPHI Steering Committee (SCC) meetings were held on 7–8 October 2016, in Addis Ababa, Ethiopia. The SPHI meeting, with 94 participants, was aligned with two key events also held in Addis Ababa: the 10th Triennial African Potato Association (APA) Conference, held on 9–12 October (with 300 participants), and a cocktail celebrating CIP's 45th anniversary as an organization and the awarding of the World Food Prize for biofortification. Not surprisingly, the theme of the meeting was *A Time of Celebration.* Annual briefs were prepared: 15 for SASHA project updates and 24 for other sweetpotato projects, plus the second Status of Sweetpotato in SSA report.

The 16th Sweetpotato SpeedBreeders Annual Meeting was held on 15–18 May 2017, at the Grand Legacy Hotel in Kigali, Rwanda. It highlighted the introduction of the new program, HIDAP, for designing, collecting, analyzing, and reporting trial data (Milestone report: OBJ5MS1.1.C). Four other community of practice (CoP) technical meetings were held between December 2016 and July 2017, with detailed minutes (OBJ5 Milestone reports MS1.3.H, MS1.3.I, MS1.3.J, and MS1.3.K) and presentations available on the Sweetpotato Knowledge Portal (SKP). The SKP was relaunched in February 2016, and a monthly E-Digest began in May 2016, circulated to all registered members. Significant progress was made in developing and testing standardized data modules, including Open Data Kit (ODK) and CSPro software programs, for collecting data using smartphones or tablets with Android operating systems. A manual was prepared for nine core

monitoring and evaluation (M&E) modules for indicators needed by most dissemination projects (OBJ5MS1.4.E) and training provided in its use at the monitoring, learning, and evaluation (MLE) CoP meeting.

II. Main Progress Report (1 July 2015–30 June 2016)

A. RP1: Breeding (details provided in Appendix C)

The overall breeding objective under SASHA2 is to ensure that sweetpotato breeding programs efficiently produce superior varieties to serve producer and consumer needs for food and nutrition security, fresh markets, diversified nutrition value chains, and processed products for expanding urban populations. Population development is conducted at support platforms in Uganda, Mozambique, and Ghana, with backstopping from CIP-HQ. Work is done in an integrated and collaborative fashion with national partners to ensure efficiency of breeding efforts. Specific breeding objectives are to (1) continue to improve sweetpotato population development in SSA through the validation of improved breeding methods, linked with participatory varietal selection at national level; (2) breed for key biotic constraints in Africa; (3) breed OFSP populations for drought-prone regions in Africa; and (4) breed quality types of sweetpotato for urban markets. Heterosis exploiting breeding schemes (HEBS) and reciprocal recurrent selection (RRS) are combining outbreeding and inbreeding and the hypothesis is that they can considerably improve genetic gains (GG) in sweetpotato. This annual report details achievements for each of the breeding objectives, and discusses a workshop held on heterosis in sweetpotato and potato together with the German institution, IPK Gatersleben, in May 2017. Of the 10 breeding milestones, 8 are on track and 2 are behind schedule (Appendix A).

At CIP-HQ (Appendix C1), breeding focuses mainly on addressing objective **MS1.1.2: Estimates of yield gains achievable by repeated recurrent selection (RRS) in sweetpotato**. The HQ breeding team also backstops efforts of regional breeders and the global CoP through strategic leadership and statistical backstopping. During year 3, good progress continued on Milestone 1.1.2, whose objective is to develop and validate strategies for heterosis exploitation by the end of SASHA2. This CIP-HQ progress report covers (1) experimental heterosis populations, (2) improvement of statistical analysis of heterosis studies, (3) GG studies, (4) improvement of field-trial designs and other methods, (5) SPVD resistance breeding, and (6) workshops and collaboration with advanced research institutions (ARIs).

(i) Experimental heterosis populations. In SASHA1, two mutually heterotic genepools, namely 'Population Jewel' (PJ) and 'Population Zapallo' (PZ), were established as well as the base hybrid population (H0) that demonstrated a 20% storage root yield advantage. H1 refers to a hybrid population created after a complete recurrent selection cycle on top of the H0 population. In SASHA2, a complete RRS cycle will be completed for three different targets in sweetpotato population improvement for which a H1 population must be established. This will meet the objective of determining the GG for one complete RRS cycle using HEBS. HEBS is potentially a game-changing tool for improving sweetpotato breeding populations, and these experiments will provide the necessary proof by February 2018. The three experimental HEBS efforts require (1) genepool separation (completed); (2) demonstrating the existence of mutually heterotic genepools (completed); and (3) one complete RRS cycle (80% complete). This is being done for three breeding objectives and six different partially inbred populations PJ' and PZ' and three H1 hybrid populations, respectively. Previous experiments are summarized in Appendix C1.1. The three breeding objectives are:

1. OFSP wide adaptation and earliness **(H1 WAE),** targeting 90-day sweetpotato (typical trials are harvested at 120 days). This year, 742 H1 families were planted together with 41 PJ' and 41 PZ' parents, and 80 baseline clones (grandparents). Parents and grandparents were planted in replications and each family comprised up to 16 clones which were not replicated. Field design of Westcott (1981) with two check clones (Dagga/CIP-199062.1 and Cemsa-74-228/CIP-400004) were planted alternatively every 10 plots. The harvests of WAE will be in the third week of August 2017, and in the third week of September 2017.
2. **No or low sweetness after cooking (LSSP).** This year, the recombination of 25 PJ' and 28 PZ' LSSP parents resulted in 336 new H1 hybrid families (PJ x PZ) with 3,742 H1 hybrid clones. Field design was as described for WAE with replicated parents and grandparents and no replication for H1 offspring clones. The harvest of LSSP in Canete is completed and the harvest in Satipo is in 2 months.
3. **High Fe and Zn (HIFE).** This year, the recombination of 28 PJ' and 28 PZ' HIFE parents resulted in 272 new H1 hybrid families (PJ x PZ) for HIFE with 3,292 H1 hybrid clones. Field design was as described for WAE with replicated parents and grandparents and no replication for H1 offspring clones. The harvests of HIFE in Canete is completed and the harvest in Satipo is in 2 months.

(ii) Improvement of statistical analysis of heterosis studies. We are actively collaborating with Jochen Reif, the head of breeding at IPK Gatersleben in Germany, former staff member of University of Hohenheim and a leading expert in the implementation of heterosis breeding. Jochen Reif contributed to a heterosis and hybrid breeding workshop for potato and sweetpotato conducted on 30–31 May, at CIP-HQ and visited the H1 population field trials. So far, we can report:

- On the basis of mixed model analysis and new least square mean estimates, the heterosis increment in our H0 population was not 17% but 20% for storage root yield fresh and dry (in our case a yield jump of 5 t/ha). Select crosses with heterosis increments of up to 100% were observed.
- In the H0 hybrid population, the variance component for general combining ability (GCA) was estimated for PJ and PZ parents to be about 1.7. This is 2.1 times larger than the variance component estimation for specific combining ability.
- In H0, there are two potential testers in each pool (PJ and PZ)—in total four parents—with positive medium to high GCA to the complementary genepool, which were also involved in many combinations.

Further details of the analysis are provided in **Appendix C1.2**. Note that the large GCA variance component indicates that the populations PJ and PZ are complementary (carrying different favorable alleles for the same breeding target) with considerable potential for improvements. If the large GCA is again observed in H1, HEBS is nearly certain to speed up of GG in population improvement form breeding cycle to breeding cycle. It is now possible to start using testers (two to three testers to reduces risk) to evaluate more parents for their value in population improvement and/or reduce the workload in combining parental material.

Our efforts in improving statistical analysis will be strengthened by the recent approval by GIZ to support a CIM/GIZ integrated expert positon at CIP in plant breeding statistics. The recruitment process will start in September 2017.

(iii) Genetic gain studies and breeding progress by new sweetpotato varieties. The objective of the GG studies at CIP-HQ is to document breeding progress by sweetpotato varieties in Peru and to present/apply new approaches to estimate GG. Usually, GG is estimated based on sets of officially variety released trials across at least one decade. GG in Peru are ongoing by so called modified demonstration trial (MDT), described in Appendix C1. GG are estimated in two agro-ecological zones: the arid Pacific coast and the humid tropics. The MDTs can easily be used to estimate the rate of GG by calculating the slope of the regression line for change in a specific trait (GG) over years:

1. **Genetic gain estimates short crop duration (90 days) arid Pacific coast.** The slope of regression line for the past two decades up to 2014 of 0.18 t/ha per year for storage root yield and 0.026 per year for number of commercial roots per plant. For 2014, the model predicts 11.3 t/ha storage root yield and 1.2 commercial roots per plant. **Genetic gain estimates normal crop duration (120 days) arid Pacific coast.** The slope of regression line for the past two decades up to 2014 of 0.36 t/ha per yield for storage root yield and 0.042 per year for number of commercial roots per plant. For 2014, the model predicts 26.7 t/ha storage root yield and 2.4 commercial roots per plant. This result aligns with medium to good farmer yields in the major sweetpotato production area (Peruvian coast), mainly driven by the variety 'Benjamin' released by INIA/CIP in 2010, which yields up to 60 t/ha.
2. **Genetic gain estimates short crop duration (90 days) humid tropics Amazon basin.** The slope of regression line for the past two decades up to 2014 of 0.340 t/ha per yield storage root yield and 0.032 number of commercial roots per plant. For 2014, the model predicts 16.8 t/ha storage root yield and 1.7 commercial roots per plant. **Genetic gain estimates normal crop duration (120 days) humid tropics Amazon basin (so far 2 locations 1 season).** The slope of regression line for the past two decades up to 2014 of 0.582 t/ha per year for storage root yield and 0.044 commercial roots per plant. For 2014, the model predicts 26.4 t/ha storage root yield and 2.2 commercial roots per plant.

(iv) Field trials and other methods. In year 3, CIP-HQ implemented the use of the design proposed by Westcott (1981) for all observation trials (OTs)/population evaluation trials to adjust for differences in performance of genotypes due to soil fertility in trials with a very large number of unreplicated entries. The design is standard design for unreplicated field trials used by many breeding companies (Peters et al. 1991) and is being extended to the African population development programs as new OTs are designed. Check clones used in the design are 'Dagga' (CIP-199062.1) and 'Cemsa-74-228' (CIP-400004).

CIP-HQ has bought the program "**ASReml,**" which allows one to estimate genetic co-variances among traits in uncomplete field designs. The Wescott design option has been built into the new breeding software HIDAP. Two **portable equipment "BRIX" (**REFRACTOMETRO PORT. 0.0-53.0% DIGITAL Marca: ATAGO Modelo: PAL-1) were

purchased for the CIP-HQ and West Africa breeding programs. BRIX estimates total sugar in fresh and cooked material, and validation tests show that it is sufficiently precise.

(v) Progress in SPVD resistance breeding. Efforts to develop molecular markers for SPVD resistance in applied breeding, to locate resistance loci in the sweetpotato genome, and to increase the frequency of SPVD resistance from less than 0.2% to 2% out of 1,000 clones in breeding populations at Namulonge, Uganda, continues to progress. As part of this activity, we are seeking to identify appropriate markers for virus resistance. At CIP-HQ, one DArT marker (7548044) appears to be correlated with 0.693 with the titers in enzyme-linked immunosorbent assay (ELISA) tests for SPCSV. We propose to use this marker on the parental material in Namulonge (140 clones in two crossing blocks) to investigate if this marker has also predictive value in those materials. (The breeding platform in Namulonge has good information on SPVD resistance/susceptibility across seasons with respect to parental material in use.) CIP-HQ continues to maintain 79 families with 436 clones comprising pre-breeding material with germplasm resources exhibiting confirmed SPVD resistance as well as 61 advanced breeding clones exhibiting no SPVD susceptibility in fields with high SPVD pressure in Peru. Details about the material and progress in SPVD resistance breeding is provided in Appendix C1.

(vi) Workshops and Collaboration with ARIs. A workshop on heterosis and hybrid breeding in potato and sweetpotato was held on 30–31 May 2017, with 28 persons participating (10 from Africa participating by Webex) in collaboration with IPK Gatersleben in German. Ten presentations were given. Following the workshop, CIP and IPK agreed to establish a collaboration on heterosis and hybrid breeding and is now being formalized. An executive summary of the workshop is provided in Appendix C1.3.

Sweetpotato breeding work at the **Breeding Support Platform for East and Central Africa (SSP-ECA) in Uganda (details in Appendix C2)** has four main milestones, each described below.

(i) MS1.1.1. Studies demonstrating that significant GG (2% per year in yield) can be achieved in 2 years in early generations and 4 years for selected varieties; and MS1.2.3. Selected hybrid progeny demonstrating yield jumps of 10–20% from populations with SPVD resistance. Results from field trials designed to study heterosis in sweetpotato under stressful environments in East Africa were obtained in Uganda during the first half of 2016. The objective of the heterosis study was to estimate yield gains in early generation sweetpotato clones derived from inter- and intra-population crosses of two East African genepools (Population Uganda A and Population Uganda B in 8 x 8 crosses) hypothesized to be mutually heterotic. Sixty-four families developed from crosses made between 8 x 8 parents from the two genepools were evaluated in field trials. Data from OTs in four test environments indicated an overall storage root yield heterosis increment of 16% for the BxA population. Following the heterosis trials, 55 genotypes were selected for further evaluation at Namulonge, Serere, and Kachwekano; 10 plants in two rows, four checks, 'Tanzania', 'Resisto', 1999062, 'NASPOT 10 O', and 'NASPOT 11' in a randomized complete block design. Planting was in April 2016, and harvesting in October/November 2016. Of the selections from the heterosis trials (55 genotypes), two families—New Kawogo x SPK004 and New Kawogo x 'NASPOT 10 O'—outperformed the best improved check, 'NASPOT 11', in biomass yield and SPVD resistance. However, virus expression was not as expected at all the three sites during the two seasons due to drought effects. Identification of "good" parents in the two populations is important in developing families and selection of high-yielding and SPVD-resistant clones targeted under MS1.2.3.

(ii) MS1.1.3. At least 14 African sweetpotato breeders breed using the latest knowledge and efficient methods. To date, 13 countries have a crossing block and implement some form of ABS with increasing interaction among the sweetpotato breeders across the globe. Twelve countries (Burundi, Burkina Faso, Ghana, Nigeria, Ethiopia, Rwanda, Kenya, Tanzania, Uganda, Zambia, Mozambique, and South Africa) are using some molecular breeding techniques; some (Burkina Faso) have expanded the range of activities in their sweetpotato projects. Côte d'Ivoire (Ivory Coast) and Madagascar engage only in sweetpotato evaluation and screening activities without active breeding, but have a target of releasing improved selections. Under SASHA2, Burundi and Madagascar receive limited support by BMGF for their varietal selection efforts. Côte d'Ivoire registered three OFSP for dissemination in 2015, two of which are varieties from Mozambique ('Irene', 'Bela'). However, 11 OFSP Mozambican varieties (released in 2011 in Mozambique) under high virus pressure conditions in Uganda revealed that after two seasons of exposure, 10 were susceptible and the remaining variety ('Delvia') had much lower yields than the check varieties. Details comparing the performance of the same

varieties in Mozambique, Ghana, and Uganda are given in Appendix C2, highlighting the need for breeding in each sub-region for sub-regional-specific conditions.

In addition, to finalize a SASHA1 activity for selecting for cold-tolerant sweetpotato clones suitable for dual-purpose use in East Africa, Benjamin Kivuva, a KALRO scientist, evaluated five clones (one orange-fleshed, three yellow-fleshed, and one white-fleshed) as candidates for National Performance Trials (NPT) in 2016/2017, the last step prior to release (data for variety release will be presented to the NPT committee near the end of 2017 or early 2018; see Appendix C2 for details).

(iii) MS1.2.1. At least 250,000 seeds with increased frequencies of resistance to SPVD (2–10%) disseminated to at least 10 NARS partners. At least 250,000 seeds with increased frequencies of resistance to SPVD (2–10%) disseminated to at least 10 NARS partners. During the current reporting period, 569,537 polycross seed (394,161 and 175,346 from crossing blocks B and A, respectively) were generated in 2016/2017. Additionally, between the two crossing blocks, 75,812 controlled cross seeds were generated. Only Kenya/BecA (897 seeds of 14 families) for the Genomic Tools for Sweetpotato project and Burundi (66,197 seeds) requested and received seed during the reporting period. Cumulatively, 361,366 seeds have been distributed to eight national program partners during the 2014–2017 period (the seed target has been reached for the SASHA2 goal in terms of amount and is close in terms of number of countries).

Progress continued at the **Breeding Support Platform for Southern Africa (SSP-SA) in Mozambique.** Details in Appendix C3 for its four main objectives and described below.

(i) MS1.1.1 Studies demonstrating that significant GG (2% per year in yield) can be achieved in 2 years in early generations and 4 years for selected varieties. Trials to search for new sources of drought tolerance and estimation of GG made from 2000 to 2016 were established and harvested between July 2016 and June 2017. The trials were OTs, preliminary yield trials (PTs), advanced yield trials (ATs), and multilocation trials at Umbeluzi, Gurué, and Maniquinique research stations. The GG trials were established at Umbeluzi, Maniquinique, and Nwalate (southern Mozambique); Gurué (central Mozambique); and Mansa in Zambia. In addition, trials on estimation of storage root yield stability and root quality over four different harvesting dates—that is, 90 days after planting (DAP), 120 DAP, 150 DAP, and 180 DAP—were carried out at Umbeluzi and Gurué research stations. Drought tolerance trials were carried out at Umbeluzi. Highly significant differences (p<0.0001) were observed among the tested clones at both sites for the orange-fleshed and purple-fleshed OTs. At Umbeluzi, 'Tio Joe' and 'Resisto' (both OFSP) as male parents contributed many progenies with the orange-flesh color. Families with 'Tio Joe' or 'Resisto' had more progenies with the orange-flesh coloration. Families with 'Xiphone' as a male progenitor had more progenies with white- or yellow-flesh. Six check clones were included in the OTs at Umbeluzi: 199062.1, 'Resisto-Mozambique', 'Tanzania', 'Namanga', 'Irene', and 'Delvia'. There were highly significant differences (p<0.0001) between the check clones (CC) and the experimental clones (EC) at Gurué and Umbeluzi. EC had higher mean for storage root yield than CC (31.28 t/ha vs. 17.89 t/ha) at Umbeluzi Research Station. Among the CC, 'Resisto-Mozambique' had a poor performance for storage root yield under the drought treatment. The first generation of released varieties was a direct result of selection of adapted germplasm from different breeding programs (2000 and 2006 releases) and followed by selection from locally bred clones in the ABS (2011) and clones from recurrent selection in the ABS. New breeding tools like HEBS need to be implemented to improve the storage root yield gains in sweetpotato.

Apart from domestic consumption, sweetpotato is now a major player in the major urban market of Maputo and is finding way into processing industry with specific root sizes. Selection has also improved marketable storage root yield. An annual increase of 3.03% was recorded between 2000 and 2016 on total storage root yield on dry weight (DW) basis. Sweetpotato needs in southern Africa a critical amount of vine yield to plant in the next growing season and for feed, particularly where land availability is scarce. An annual increase of 1.0% on vine yield has been achieved from 2000 to 2016 in Mozambique on fresh weight basis (fwb). In absolute terms, total storage root yield increased by 0.287–0.303 t/ha annually and foliage yield by 0.084–0.104 t/ha annually between 2000 and 2016. Combined analysis of data across the harvesting periods showed that genotypes had highly significant effect on commercial root yield, noncommercial root yield, total vine yield, dry matter (DM), beta-carotene, and starch. Harvesting period also had a highly significant effect on commercial root yield, noncommercial root yield, weevil damage, other root injury, DM, zinc (Zn), and starch. Harvesting date did not affect Fe content. Genotypes had similar reaction to weevil damage or physical injuries. This was

expected, given that selections for these traits were done by the same team. Non-marketable root yield was significantly higher at 180 DAP than the other harvesting dates. However, no significant difference on total storage root yield was observed between 150 and 180 DAP. Weevil damage and other root injury or damage was significantly higher at 180 DAP than other harvesting dates. Storage roots were significantly smaller at 90 DAP than other harvesting periods. Storage root size stabilized from 120 to 180 DAP. DM content increased with DAP. However, no significant differences existed between 150 and 180 DAP for DM. Fe content was stable from 90 up to 180 DAP. Zinc content stabilized from 120 to 180 DAP. Beta-carotene was stable from 90 up to 150 DAP and significantly increased at 180 DAP. The starch content also significantly increased from 90 to 150 DAP and then dropped slightly at 180 DAP. The varieties 'Irene', 'Sumaia', 'Melinda', 'Victoria', 'Ivone', 'Alisha', 'Bita', and 'Caelan' are early bulking and could be recommended for production in areas with short rainy seasons.

(ii) MS1.3.1. At least 150,000 seeds with drought tolerance genes disseminated to at least 10 NARS partners in SSA and Southwest and Central Asia (SWCA). Two distinct OFSP breeding populations were generated from crossing blocks established at Instituto de Investigação Agrária de Moçambique (IIAM) stations at Umbeluzi (with 68 parents) and Gurué (with 56 parents) in January 2015, and Umbeluzi (68 parents) and Gurué (66 parents) in January 2016. Another mini-block with purple-fleshed clones was established in Gurué with 35 parents in 2015 and 51 parents in 2016. All the 124 parents for OFSP improvement program were selected based on history of drought tolerance, beta-carotene content, DM levels, Fe and Zn contents. The three crossing blocks gave a total of 102,923 botanical seeds from 538 families in 2015, and 42,705 seeds mainly from polycrosses were distributed to 12 NARS programs in East and Central Africa, Southern Africa, West Africa, and Asia by June 2016. In 2016, 437,698 botanical seeds were produced from the three crossing blocks. A total of 33,500 OFSP botanical seeds were distributed to 11 NARS partners in SSA during the annual breeders meeting held in Kigali, Rwanda, on 14–19 May 2017. In addition, 5 NARS partners in South East Asia (SEA) will receive their purple-fleshed sweetpotato (PFSP) botanical seed in due course. Each NARS partner in SSA got 3,000 botanical seed (poly crosses) for the OFSP, whereas NARS partners in SEA will each receive 2,820 for the PFSP. The breeding program has already established nurseries of 3,000 clones each at both Umbeluzi and Gurué. An additional nursery of 2,820 seeds for PFSP was established at Gurué. OTs will be established in June 2017 at Umbeluzi and Gurué following the Westcott (1981) design. In total, 128,570 seeds have been distributed to 12 NARS partners since the beginning of SASHA2.

(iii) MS1.3.3. Hybrid progeny exhibiting yield jump of 10–20% in hybrids from populations with drought tolerance and enhanced efficiency for drought tolerance breeding. About 2,820 (Umbeluzi), 3,086 (Gurué), and 2,106 (Gurué) seeds planted as OTs at Umbeluzi and Gurué were harvested from November to December 2016. There were highly significant differences (p<0.0001) between the CC and the EC, 17.89 t/ha and 31.28 t/ha, respectively, for storage root yield at Umbeluzi Research Station. Highly significant differences (p<0.0001) were also observed among the EC and CC for storage root yield at Gurué in both OFSP and PFSP populations. Among the CC, 'Resisto-Mozambique' had a poor performance for storage root yield under the drought treatment. The heterosis trial showed heterotic increments in inter-A x B population than the two intra-gene progenies for storage root yield. Our results over three seasons show that the hybrid population A x B had superior means under both drought and irrigated conditions.

Three experiments were conducted at Umbeluzi in August 2016, with the following objectives: to (1) determine cultivar response to mid-season drought; (2) determine best traits for improvement of storage root yield in the mid-season water-stressed period corresponding to initiation of storage roots compared with non-stressed environments; and (3) assess the selection criteria for identifying drought tolerance in sweetpotato cultivars that could be recommended for regular use in breeding programs. The experiments involved three trials with two watering treatments, irrigated and water-stressed. Each trial consisted of 48 genotypes, composed of 24 released varieties, 16 landraces, and 8 introductions from different countries. The results indicated that water stress was successfully applied in this trial, variation existed among the tested clones on most traits measured, drought sensitivity was higher among the released varieties, clones from other countries, and international checks than farmer varieties. Some clones among the released varieties had the highest root yield under stress than the other groups. Low yield under the not-irrigated treatment can be associated with lower number of roots formed under this environment.

(iv) MS1.3.4 Clones with 200% recommended daily allowance (RDA) for young children of pro-vitamin A, 25% RDA of Fe, and 35% RDA of Zn under regular root intake levels. Three crossing blocks were established at IIAM sites in Gurué

and Umbeluzi in January 2015, December 2016, and January 2017. The 125 parents were selected based on history of drought tolerance, beta-carotene content, DM levels, and Fe and Zn contents. A total of 2,820, 3,086, and 2,106 seeds from the three crossing blocks were germinated, multiplied in March 2016, and planted as OTs at Umbeluzi and Gurué in June 2016. The OTs were harvested from November to December 2016, and quality analysis using near-infrared spectrometer (NIRS) has been conducted for clones planted at Umbeluzi and Gurué. The root quality data for the 2,820 clones harvested at Umbeluzi showed that beta-carotene content had a mean of 27.4 mg/100 g DW among experimental clones and 26.7 mg/100 g DW for check clones ('Irene', 'Delvia', 199062.1, 'Namanga', and 'Resisto'). Another nursery was established between December 2016 and February 2017, with each site establishing 3,000 clones for OFSP and with Gurué having an extra of 2,820 clones of PFSP. More than 200 clones were identified from the OTs planted at Umbeluzi in 2016, and sent for verification of Fe and Zn through x-ray fluorescent (XFR) in Lima. The initial selection of clones was based on NIRS results in Maputo. Per our milestone, our clones should provide a target of 25% RDA of Fe (2.4 mg/100 g DW) and 35% RDA of Zn (1.2 mg/100 g DW) under high intakes. XFR analysis showed 30 clones with higher Fe content than the targeted 2.4 mg/100 g DW. Among the top 10 clones with high Fe content, 'Tio Joe' featured on 40% of the clones as a male parent. These clones were sent to CSIRO in Australia to test for aluminum and titanium contamination using the more precise inductively coupled plasma (ICP) method. Readings between the XRF in Lima and the ICP in Australia were highly correlated for Fe ($R^2 = 0.808$) and Zn ($R^2 = 0.745$). Only one clone could be classified as non-contaminated with Fe levels at least 58% higher than the target: 4.4 mg/100 g measured by the ICP and 3.9 measured by the XRF. For Zn, the value for both machine readings are 0.8 mg/100 g.

Key requirements to achieve both milestones for the **Support Platform for West Africa (SSP-WA)** (details in Appendix C4) are the capacity to make crosses readily and to have a good understanding of traits to be improved in mutually heterotic gene pools, to be recombined to achieve yield targets. During the past year, the work of the SSP-WA in Ghana continued to focus on the development of adapted populations with less-sweet taste important for consumer acceptance and processed product utilization in W. Africa, and on improved shelf-life. We continued to implement separate selection programs for southern and northern agro-ecologies, working with CSIR-CRI in the south and with Savanna Agricultural Research Institute (CSIR-SARI) in the north. This approach permits development of varieties with lower levels of resistance to SPVD than are required in the forest and coastal agro-ecological zones, but routine testing of selected genotypes across regions ensures the identification of individuals with broad adaptation.

(i) MS1.4.1. At least 100,000 seeds with less-sweet taste genes disseminated to at least 10 NARS partners in SSA and SWCA. During year 3, we dramatically improved seed production using controlled crossing in a protected screenhouse environment. Through an extended visit by an experienced technician from CIP-HQ, we evaluated options for improving flowering and seed set (grafting to *Ipomoea nil*, short-day treatments, and use of bouquet method where flowering vines are brought into the screenhouse for crossing). The screenhouse environment was found to markedly improve seed set in comparison with the open field, principally through the exclusion of pests, which are difficult to control in the field. While a few genotypes did not respond to efforts to induce flowering, the majority could flower and produce seed, primarily on flowering vines brought into the screenhouse for crossing. More than 22,000 seeds were produced from approximately 600 different cross combinations, with large differences among genotypes with respect to cross- and self-compatibility. For the 2017 crossing, we have (1) included new selections from northern and southern populations, (2) are evaluating the use of grafting to prolifically flowering sweetpotato clones to induce flowering in non-flowering genotypes, and (3) will try to improve production of open pollinated seed in the field through improved pest and disease control to meet our target seed numbers for international distribution.

(ii) MS1.4.3. Hybrid progeny with yield jumps of 10–20% from less-sweet, less perishable parents. To ensure hybrid progeny with yield jumps of 10–20% from less-sweet, less perishable parents, we are evaluating progenies produced in 2016 to identify those showing such yield increments. This is being done in a replicated trial (four 5-plant plots per progeny and parents) at Kumasi using 222 families from 27 parents with a minimum of 20 individuals per family. Forty-three of the families from 20 parents had sufficient seed to repeat the seedling nursery experiment in Tamale as well. Evaluation of progeny performance in year 4 will identify families showing heterosis increments, and selected individuals from the trial will advance to OTs in their respective regions. Data will be analyzed to identify parents with good general combining ability, and molecular diversity assessment will be used to place promising parents in separate heterotic groups for longer-term improvement of heterosis through reciprocal recurrent selection.

GG due to breeding efforts in Ghana were assessed using two approaches: demonstration trials including the released varieties for which we had pathogen-tested planting material (so as not to confound health status with GG), and performance of genotypes in ATs over years in relation to the performance of a check. For the first approach, trials were conducted at three southern sites and one northern site. Yields and number of commercial roots were regressed on year of release for 8 varieties released in 1999, 2005, or 2012. Overall, we measured a gain of 0.27 t/ha per year and 0.04 roots/plant per year. There were differences among selection sites in this regard, with greatest gains indicated at Komenda (coastal savanna) and Nyankpala (Guinea savanna). Trials are being repeated in 2017. The second approach, evaluation of yield and commercial root numbers in ATs from 2012 to 2016, in relation to 'Ogyefo' (a check variety used in all trials over the period), indicated a clear progression over time in the number of commercial storage roots per plant; but the trend was not clear for total yield. Since there is normally a strong correlation between number of roots per plant and yield, we may anticipate increasing yield along with number of storage roots per plant. Note that from 2012 through 2016, genotypes in the ATs went from 100% introductions to predominantly Ghana-bred materials, indicating that GG were due to breeding progress in Ghana.

Development of low sweet varieties is a priority for the Ghana breeding program, which has been focusing on development of staple type varieties since its first releases in 1999. We routinely measure sugars in samples of raw sweetpotato and can relate this to sweetness, which increases in variable amounts during cooking resulting from of starch hydrolysis to maltose, a sugar with low sweetness relative to sucrose. There is a strong negative correlation between sweetness index and starch content in raw sweetpotato, with most released varieties and advanced genotypes in the Ghana program falling into the low sweet or non-sweet class. Consumers in Ghana indicate a high degree of liking of most genotypes from the breeding program. However, we still need to more clearly refine our understanding of sensory attributes of cooked and processed sweetpotato, and particularly in terms of consumer acceptance in Ghana. Development of a trained sensory panel to assist with this task is a priority for this year.

During the reporting period, we continued efforts to screen parental germplasm for postharvest perishability and utilization attributes. Twenty-one genotypes, including released varieties, commercially important farmer varieties, and advanced selections from the Ghana breeding program were grown at CRI and at SARI field sites. Genotypes were assessed for sensory attributes related to poundability and fry quality, two relevant types of utilization in West Africa, and their starch properties were assessed using a rapid visco-analyzer. Low sweet types suitable for pounding were identified, though the evaluated germplasm lacked the quick cooking trait related to low peak viscosity temperature. Production of adequate quantities of storage roots of the parental genotypes to be used to develop of protocols for routine screening was a challenge, and we were unable to develop and implement tests for factors contributing to perishability, such as susceptibility to *Rhizopus* soft rot and ability to lignify and quickly heal wounds. To ensure a continuous adequate supply of roots for this work, we are planting production plots of these materials on a regular bi-monthly basis. We do not anticipate continuing problems with implementing these important trials for our breeding program in the coming year.

B. RP2: Weevil Resistance (details provided in Appendix D)

Weevils, *Cylas puncticollis* and *C. brunneus*, are responsible for 28% of crop losses in Uganda, according to a farmer survey (Kiiza et al. 2009). There is currently little farmers can do when weevils infest their fields, other than to quickly harvest and salvage what is left of their crop. In addition, one of our studies has also highlighted a potential health threat when farmers consume the undamaged parts of infected sweetpotato storage roots due to high accumulation of plant toxins. Our goal is to have proof-of-concept of weevil resistance in sweetpotato roots using a transgenic approach. There are two major milestones representing distinct approaches to tackling the problem. Unfortunately, we have concluded that the *Bt* approach has not succeeded and this research is now concluded. As indicated below, the RNAi approach appears promising but will need additional resources to be able to continue.

In addition, we are happy to report that the fifth doctoral candidate associated with this research program, Katterinne Prentice, has just been accepted to defend her PhD thesis entitled "RNA interference-mediated strategy to control African sweetpotato weevils," at Gent University, Belgium.

(i) MS2.1.4. *Bt* Approach: Mortality assessment for each transgenic event with enough *Cry* protein to expect efficacy. We have introduced synthetic *cry* genes that produce proteins with activity against sweetpotato weevils into various

sweetpotato varieties, including some grown in SSA (i.e., 'Jewel', 'Jonathan', 'Huachano', an unknown variety, and 'Imby') after improving sweetpotato regeneration protocols (Manrique-Trujillo et al. 2013). Two series of gene constructs were used to generate more than 100 transgenic events in ABL Peru and DDPSC in the USA. We used a whole-storage roots bio-assays to test activity against weevils (Runyararo et al. 2013). A first screening of storage roots for apparent difference in weevil adult emergence led to the identification of a small number (12). Here we report the screening of these events using the same bio-assay using new storage roots.

Selected transgenic events were grown in pots at the BecA greenhouse in Nairobi, but none of them produced storage roots of size compatible with the bio-assays. New substrate (sand) and NPK fertilizer formula (6:9:15) have been used and succeeded in improving storage root formation. Fortunately, storage roots were harvested at DDPSC in the USA and then shipped to BecA in Kenya. Bio-assays were conducted on these materials.

Of the 10 transgenic events tested, 6 did not show significant differences with the untransformed storage roots whereas 4 presented notable differences (see Appendix D for tables with details).

Conclusion of the *Bt* sweetpotato. Of the 12 transgenic events to be tested, 8 were using storage roots provided by the DDPSC team in the USA. Two additional transgenic events not tested before were included as well; 4 have shown differences with the untransformed storage roots. The observation that five transgenic events with previous observation "no damages" were in this repetition not different from the untransformed storage roots confirms previous suspicion that the bio-assay could identify false resistant materials. However, it does not rule out that those transgenic events with apparent difference in this second repetition are not resistant. We decided to continue this experiment with a new production of storage roots and bio-assay at BecA. All the transgenic events tested in this third bio-assay turned out to have either nonsignificant differences or no differences at all with the untransformed materials. Hence, it appears more clearly now that none of the sweetpotato transgenic events have an accumulation of *Cry* protein in their storage roots at a level sufficient to confer full weevil protection. It is possible, however, that some of the events with apparent differences in our bio-assay may display field resistance under low-level infestation.

(ii) MS2.2.2. RNAi Approach: Efficacy data for several dsRNA (single and in combination) against weevil larvae. An RNAi strategy was developed to complement the *Bt* strategy. Our partners at the University of Ghent have identified three target genes that have given good mortality results for both weevil species using nano-injections of dsRNA, soaking, and artificial diets: Proteasome 20 kD subunit, ribosomal protein S13e and *snf7* genes. Five hairpin gene constructs were designed based on Prot20kd and snf7 from *C. puncticollis* (Cp) and *C. brunneus* (Cb) in single and double combinations (two fragments in sense and two in the anti-sense separated by an intron). All hairpin genes are driven by the double enhancer 35s promoter, uses the 5'UTR of PVA, intron from catalase gene, and the nos gene poly-adenylation signal sequence. These genes are inserted into a pCAMBIA backbone vector. Here we report the progress in producing transgenic events from Jonathan using two of these gene constructs.

Two gene constructs have been used to produce transgenic events: (1) pUG01 contains the ds-snf7 (Cp24) hairpin targeting *Cylas puncticollis*; and (2) pUG04 contains ds-Prot20Kd (Cb12) hairpin targeting *C. brunneus*.

At the ABL, we have decided to use the best genotype for genetic transformation ('Jonathan') using *Agrobacterium tumefaciens* and somatic embryogenesis methods which were optimized previously (Manrique-Trujillo et al. 2013). Of 4,800 explants (leaves with petioles) infected with pUG01, 71 regenerated on media with 25 and 50 mg/L kanamycin; 169 were obtained from 3,672 explants infected with pUG04. However, the use of higher concentration of kanamycin (100 mg/L) did not confirm these regenerants as resistant. Molecular characterization (nptII-PCR) resulted in 5 for pUG01 and 1 for pUG04 PCR-positive transgenic events (see Appendix D for details).

Conclusion of the RNAi sweetpotato. The identification of transgenic events from 'Jonathan' with RNAi genes has started and will continue in the next couple of months. A low efficiency of transformation via organogenesis has been observed (only 6 putative transgenic events from 4,800 explants infected). In the coming months, more putative transgenic events will be isolated from the embryogenic calli infected earlier and selected on kanamycin selective media. The next steps—selection of high expressers, transfer to BecA, production of storage roots, and bio-assays—will be conducted when a new source of funding is available.

C. RP3: Seed Systems (details provided in Appendix E)

Our vision of success for SASHA2 seed systems management is that cost-effective technologies and strategies for both male and female farmers will ensure improved access to quality planting materials. All but one of the eight milestones are on track. There are four major objectives linked to major milestones:

(i) Objective 3.1 aims to refine the efficiency of disease-free planting material production and better understand how virus degeneration and reversion affect specific varieties.

Low-cost net tunnel technology. Results from the Tanzania study on the durability of the net tunnel technology and different closure methods were shared at the 10th APA Conference held in Ethiopia on October 10–12 2016. A poster on strategies for scaling of the net tunnel technology was presented during the World Café organized by the CGIAR RTB Research Program held in Dar es Salaam, Tanzania, on 10 March 2017. In Tigray, Ethiopia, the study assessing different types of mulch in the net tunnels showed higher vine output and reduced incidence and diversity of weeds, when using pre-emergence herbicide and black plastic, compared with grass mulch, herbicide alone, or the control plot. A paper with results from the Tanzania and Ethiopia (SNNPR and Tigray) work on validation of the net tunnel technology is under preparation. A revised net tunnel brochure with updated construction and management recommendations based on experiences from Tanzania, Nigeria, and Ethiopia is ready for layout and printing.

Triple S activities are now under way in eight countries through collaboration with other projects and partners. In northern Uganda, under the HarvestPlus Biofort project, training for scaling out Triple S continued in five districts, with an accumulative total of 1,500 farmers and extension workers trained. The Triple S calendar for 2017 was prepared, with 1,500 copies printed. A snapshot study around Gulu assessed the market price for planting material to compute value of planting material produced through Triple S. A study of the uptake of Triple S in northern Uganda has started with interviews of beneficiaries from Gulu, Omoro, Kole, Oyam, and Lira districts which are being analyzed as part of the HarvestPlus baseline information for the new MENU project, the 2nd Phase of the scaling project supported by the United States Agency for International Development (USAID). We expect that this will provide new insights into the scaling process and lay the basis for a wider uptake study. A reflection meeting held in Gulu at the end of 2016, highlighted the following findings: selection of appropriate storage container to avoid rotting of roots; Triple S produces more pest-free cuttings than conventional methods; early planting increases yield; and radio programs are a useful means to spread information about the technology. In Burkina Faso, five decentralized vine multipliers (DVMs) and 54 households (HH) in five communities have been trained in Triple S. In western Kenya, the SUSTAIN project and SASHA2 funds have supported implementation in three counties. The start-up in April 2016 sensitized and trained 40 farmer leaders and extension workers as ToTs (F: 14, M: 27), who subsequently trained and mentored 400 farmers (66% female) through the different Triple S steps. Planting material from root-based beds was planted in April/May 2017, for storage root yield evaluation with harvesting expected in September. In Mozambique (with VISTA and Irish Aid funds), scaling has started. In Tanzania, the VISTA project supported the training of 155 (M: 66%, F: 54%) village and ward extension officers, farmers, and researchers in the Triple S technology at the end of year 2, June 2016. Questions related to the uptake and farmers' practice of Triple S are planned for inclusion in the VISTA endline survey in August 2017. In Nigeria, training in Triple S was conducted in October–November 2016, in 14 locations with 62 farmers and partners were then supported to establish demonstration sites. However, follow-up and data collection have been delayed as the focal person had a serious accident. In Ethiopia, after validation of the technology under SASHA2, the Triple S method is being promoted by all dissemination projects that are now targeting HH for implementation. In SNNPR during 2016, SASHA2, Irish Aid, and USAID's Better Potato for a Better Life project supported on-farm demonstrations and training of trainers in 20 woredas, with a total of 2,328 HH. Scaling-up plans are being developed for SNNPR with a target of at least 15,000 HH in eight woredas supported by EU/PIM and SASHA2 projects. In Tigray, on-station validation experiments have shown that the roots survived more than 7.5 months of dry period, extending the potential of Triple S to fit up to 9 months of dry period. The technology is now being demonstrated with three farmer groups in Hawazane and Enderta woredas of Tigray region. The CIP-Ethiopia Research Associate (Mihiretu Cherinet), based in Hawassa, took up his Borlaug fellowship at Louisiana State University, (February–June 2017) under the supervision of Dr. Arthur Villordon. The findings from the validation process across different countries are now being consolidated into ToT and farmer resource materials for Triple S. Tanya Stathers (NRI) was contracted to work with a core team to prepare these; the final draft is under review.

Testing irrigation methods. In Tanzania, the on-station and on-farm study to assess different types of irrigation equipment and schedules is nearing completion. Overall, experimental plots performed better than farmer plots with highest number of vines produced under 10 kPa. The analysis of variance for vine yield showed that there were significant main effects of variety, soil water tension, and management with a significant interaction effect between these three factors. Vines produced in the net tunnels were longer and weighed more than those produced in the open fields. The cost-effectiveness of the various irrigation techniques will also be measured using a recall method. In Ethiopia, the experiment faced some challenges in the first half of year 3, with faulty equipment. In April 2017, the experiment was redesigned to assess irrigation schedules under two scenarios: rain-fed supplemental irrigation and deficit irrigation where the plots are fully covered by plastic sheeting. The experiment will be repeated in September and December 2017, and results compiled.

Testing cost benefits of sandponics as an alternative to conventional screenhouse multiplication. In year 3, a second experiment was established to compare screenhouse sweetpotato vine production under a sandponics system with the conventional soil system and to conduct a cost-benefit analysis of the two systems. Real-time cost data collection for inputs, labor, and equipment was being implemented under the guidance of the regional agricultural economist to calculate the cost-benefit analysis. The last harvest was completed in May 2017, with results due in August 2017. The incoming assistant plant breeder (based in Uganda) has taken over regional technical backstopping activities. He has started to consolidate and analyze the existing data sets with NARI partners (e.g., Mozambique, Malawi, and Zambia). This will draw out cross-country lessons and recommendations and identify additional research needs.

Support to 10 national programs to improve management and oversight of quality pre-basic (foundation) seed production. Under this component, we have 14 partners with SGAs. Twelve with national sweetpotato programs (two institutes in Ethiopia), one national rice program (Uganda NARO for collaborative activities at the Agoro Irrigation Scheme), and one private sector TC laboratory (Biocrops (Uganda) Ltd). KEPHIS passed the annual audit to maintain ISO17025 accreditation for sweetpotato virus testing. This is critical to their role as regional center of excellence for germplasm management and exchange. The Seed System CoP held two meetings (details under RP5 reporting).

Technical production capacity for pre-basic and basic sweetpotato seed production is being consolidated across the 11 countries. Screenhouse or mobile net tunnel production capacity ranges from 120–145 m^2 (DARS-NaCRRI) to 1,670 m^2 (Tanzania at three stations). However, the utilizable space is an estimated 60%, depending on type of containers and methods used. Pre-basic seed cuttings output ranges from 9,000 (CRI & NaCRRI) – 585,109 (Tanzania at three sub-centers). Year 3 estimated total production is 2,029,074 pre-basic and 7,103,890 basic three-node cuttings. This excludes any production contracted separately by CIP projects (e.g., SUSTAIN, VISTA, Jumpstarting). Outputs depend on season, reporting period, and pre-basic and/or basic production model. NARI colleagues continue to increase multiplication rates and reduce costs through fine tuning: fertility management; staking/trellising; using troughs versus pots; temperature management; and experimenting with different substrate type and size. Fully updated cost structures, based on real-time cost data collection, have been completed for KEPHIS and CRI. Tanzania's Lake Zone Agricultural Research and Development Institute (LZARDI) and the NRCRI of Nigeria have faced some challenges in completion. The revised cost structures have been used to determine the break-even price, discuss mark-up and margins, and develop pricing strategies. This has led to a review of the price structure for pre-basic seed in several institutions. For example, KEPHIS's prices now range $0.10–$0.35 compared with $0.50 for 2015–2016. This compares to CRI's price for pre-basic cuttings of $0.21–$0.35. Both institutions have developed a differential pricing strategy based on the type of customer (institutional or private multiplier) and whether advance orders and payments are made. The business plan templates have now been adapted to include production targets for different categories of seed, unit production cost, total recurrent production costs, proposed prices, current availability of revolving funds, and projected revenue. These templates will form the basis for the SGA modifications for the remaining 18 months of the pre-basic seed production component. The templates allow for different production scenarios and illustrate how the proportion of recurrent and total production costs met from the revolving fund increases, as the proportion met from SGA decreases. By December 2018, we aim to show that if a NARI has a revolving fund of $5,000–$10,000, this is sufficient to maintain production of around 90,000 pre-basic and/or basic cuttings. There are still several risks associated with setting production targets in an uncertain market, and the use of revolving funds by public institutions. Thus monitoring and visits to different partners will continue to ensure that senior management understands and supports the approach.

The study protocol for the PBS/EGS validation study was prepared and piloted with KEPHIS and RAB, using a participatory peer-to-peer methodology. The objective is to document PBS production models and to assess the changes in capacities and the level of institutionalization of the business plans in the NARIs. The study uses an adapted institutionalization framework and Likert scale questionnaire based on four pillars: technical, socio-cultural, administrative and financial, and policy. The questionnaires are completed by technical/scientific, administrative-financial, and senior management staff in the NARI, firstly as individual self-assessments, then as a joint reflection and assessment; finally the external peer institution completes the questionnaire. This process allows the perceptions and practices of different types of team members and levels of seniority to be captured, and then reviewed by the external peer institution and CIP. The findings highlight areas of convergence and disparity in relation to the implementation of the business plan. This is then used to prepare a strengths, weaknesses, opportunities, threats analysis followed by developing business strategies to optimize the strengths and opportunities and minimize vulnerabilities and threats. On reviewing the initial results from the PBS/EGS validation study, RAB's director general decided to present to the senior management team. This has led to an immediate change in the pricing structure used by the institution. The methodology will be improved based on feedback during the pilot, and then the study will be implemented with the remaining 11 institutions between August 2017 and June 2018. This will be used to draw lessons on the different business models being used, and scan the in-country landscape for potential public-private partnership arrangements for EGS production.

Evaluating the effect of begomoviruses. The potential importance of sweetpotato begomoviruses has been overlooked because visual symptoms are not common. Yield reductions of 10–80% have been reported in infected sweetpotato plants despite lack of obvious symptoms associated with begomoviruses infections. A field survey has been conducted in five out of the six regions (Western, Nyanza, Coast, and Eastern) that produce sweetpotato in Kenya. One region (Central Kenya) will be surveyed in July 2017. Symptoms associated with begomoviruses were present in most of the fields visited. The symptoms include chlorosis/interveinal chlorosis/roll up/roll down. Seven hundred samples were collected and established in quarantine screenhouses at CIP–KEPHIS. Three hundred samples have been tested by PCR to confirm presence of begomovirus. Selected samples testing positive for begomoviruses will be sequenced by next generation sequencing to establish variability. This will give information on the begomoviruses species present in Kenya. In addition, plants which tested negative (i.e., clean) of 'Kakamega' and 'Ejumula' varieties were graft inoculated with the following isolates in December 2016: Begomo, Begomo + SPCSV, Begomo + SPFMV, SPFMV, SPCSV, clean–'Kakamega' and 'Ejumula' (negative control), and multiplied. Inoculated plants have been confirmed for virus presence by testing with real-time PCR. Multiplication and hardening are currently underway and yield impact will be accessed by field testing in July–December 2017, at KALRO Kiboko and Marigat.

(ii) Objective 3.2 aims to improve and validate diagnostic methods for support of seed quality, germplasm management, and exchange. Previously, three successive iterations toward a universal diagnostic sweetpotato virus tube-array (ClonDiag) were developed, which were validated against samples from East and West Africa. A fourth iteration was designed by FERA with improved performance and newly discovered viruses. The following viruses can be detected: CMV, SPCSV, SPV2, SPFMV, SPVG, SPVZ, SPMMV, SPCV, SPVCV, SPC6V, SPPV, and TSV. To analyze the results from the arrays, a smartphone app was developed and finalized into a stable version, which is functioning well. A successful validation experiment was performed on 25 samples at CIP-KEPHIS. This obtained a good signal quality and the correct viruses were identified. The following assays were conducted: sensitivity, specificity, and repeatability. Parallel testing was conducted between Lima and KEPHIS, where Lima used the smartphone app developed for the data analysis and KEPHIS used both the smartphone app and the dedicated array reader. Detailed analysis comparing ClonDiag results from Lima and KEPHIS with the standard indexing practice is being undertaken. This will identify discrepancies in probes and recommend improvements. There will be preliminary results for discussion by the September SPHI annual meeting.

LAMP is a virus rapid and sensitive diagnostic tool that can be used in field set-up. LAMP assays were previously developed for eight sweetpotato viruses; but owing to performance issues we decided to focus on the main viruses SPFMV, SPCSV, and begomoviruses. Primers for SPCSV and begomoviruses were redesigned to improve performance and are expected by the end of June 2017. A simple extraction method for sweetpotato leaves was developed consisting of macerating leaves in a plastic bag with alkaline buffer and does not require sophisticated and expensive laboratory equipment. Results indicate that the nucleic acid extracted gave similar results with nucleic acid extracted by kit. We have established that LAMP is equally sensitive and reproducible compared with real-time PCR in detection of SPFMV (Figure LAMP can detect up to 0.001 ng/µl of sample). An initial "on-farm" field trial of the LAMP kit at Kakamega during

September 2016 was successful. The aim is to develop a thermo-stabilized LAMP test for SPVD which is in a ready-to-use form and requires no cold chain. To achieve this, we are currently optimizing parameters such as effect of lyophilization on PCR reagents, accessing heat stability of lyophilized PCR mixture, and improvement of heat stability. There was a delay of a couple of months in evaluating these parameters due to appearance of contaminations in the lab and all reagents and primers had to be re-ordered. Currently, we have determined that dNTPs, primers, gsppsd (a new LAMP enzyme we have switched to, because of its higher activity), reverse transcriptase, and MgSO4 can be lyophilized together. Eva green, betaine, and remaining buffer ingredients must be stored separately and mixed just prior to running the LAMP reaction. Although crude extract remains stable relatively long at room temperature (>1 hr), the reconstituted LAMP reagent mixture quickly loses its activity (within 30 min) if not run at once. In a complementary BMGF-funded project (next-generation phytosanitation), the LAMP primers designed in SASHA are being implemented in multiplex format on a microfluidic platform and will be tested later in 2017. From July to December 2017, work continues to test stability of LAMP reagents in kit format (up to 1 year) by preparing aliquots and testing each month (July–December 2017); optimize the begomovirus/SPCSV redesigned primers; and validate field use using lyophilized products and Genie (portable LAMP device available at KEPHIS). We envisage that the portable LAMP device will be used as part of seed systems diagnostic and regulatory functions across SSA countries.

Fingerprinting all released and elite materials at SSPs to ensure correct identity and remove duplicates. The final selection for the best bet consists of 116 clones/varieties. These represent 16 African countries (Burkina Faso, Côte d'Ivoire, Ethiopia, Madagascar, Nigeria, Ghana, Rwanda, South Africa, Sierra Leone, Burundi, Kenya, Malawi, Mozambique, Tanzania, Uganda, and Zambia). Eighty-six samples out of the 116 have been collected and 24 samples are yet to be received from different countries. Six samples need to requested again, due to poor quality or drying. Twenty-five varieties were established at the KALRO Kiboko field station for phenotypic trait characterization at the end of 2016. Another 25 were established in May 2017; 25 varieties were sampled for genotyping by SSR markers at BecA–ILRI Hub. Twenty varieties are in the process of initiation for in vitro/thermotherapy. All varieties will undergo virus cleaning by meristem tip culture and thermotherapy, virus tested, and indexed and conserved in-vitro TC and in-vivo screenhouses.

(iii) Objective 3.3 aims to further adapt quality declared planting material (QDPM) standards and inspection protocols in collaboration with national regulatory bodies. In Tanzania, the seed standards for sweetpotato, potato, and cassava were finally officially gazetted (pre-basic, basic, certified 1, and certified 2) on 20 January 2017. The standards for Quality Declared Seed (QDS) for all crops will be published separately. In Uganda, the final document with the standards and inspection protocol (under leadership of Makerere University and with HarvestPlus support) is awaiting official publication by MAAIF. In Malawi, inspectors on the sweetpotato seed standards and inspection protocol were trained in May 2017. In Ghana, the Jumpstarting project has supported printing of the QDPM standards for sweetpotato, for final approval by the regulatory body. In Nigeria, in collaboration with the national regulatory body, a stakeholder meeting was held in May 2017, to review the final draft of the sweetpotato standards. In Kenya, sweetpotato seed standards have been gazetted; however, earlier suggestions were not fully incorporated. In Rwanda, the seed standards are being implemented in the field while still awaiting official approval by the Rwanda Standards Board. In Mozambique, stakeholder consultations on the draft seed standards continue. As countries roll out the implementation of sweetpotato seed standards and inspection procedures, bottlenecks are emerging. In Ethiopia, the roll-out of implementation of the sweetpotato seed inspections was being supported by the USAID Better Potato Better Life project, which closed in December 2016. Therefore, the regional regulatory bodies in Ethiopia do not yet have full capacity for implementation (e.g., crop-specific knowledge, time, and logistical support) and official labels are not yet available.

(iv) Objective 3.4: Test and document models for medium- to large-scale basic seed production ("The Missing Middle"). This objective aims to understand how to strengthen the institutional linkages and fill the gap between upstream, pre-basic seed production with DVMs providing QDS at community level. Multipliers who will operate seed and root enterprises have been identified and established as cost–share ventures (around 40% own investment). There are four in Lake Zone, Tanzania. In SNNPR, Ethiopia, across five woredas there are 27 farmers (being organized into seed producer cooperatives) and three farmer training centers operating as the "missing middle" with a total of 0.8 ha under basic seed production in the rainy season and QDS under irrigation in the dry season. In northern Uganda, there are 15 seed entrepreneurs in Lamwo, Kitgum, and Pader districts. Training was provided in seed agronomy (including inspection standards) enterprise and marketing skills in all three countries. Business plans have been prepared and implementation started in northern Uganda and Ethiopia. In Tanzania, the initial level of sales has been low, but is hoped to pick up

during September/October, the peak period of demand for planting material. In Ethiopia, five days of training was given for farmers and board of agriculture agricultural experts from five woredas. Two cooperatives have been formed and currently are producing seed in Sodo Zuria and Humbo woredas. The Humbo Cooperative has successfully conducted internal and external inspections. In northern Uganda, marketing strategies have been developed with each multiplier using signboards, FM radio station "spots," and using local market opportunities. The seed entrepreneurs in Kitgum, Pader, and Lamwo have formed an association called the East Acholi Sweetpotato Growers Association.

Experiments to address several technical questions (e.g., use and effectiveness of isolation distances and barrier crops to ensure minimum virus disease levels in the seed crop; rotation practices; and the economics of large-scale irrigation for off-season crop production) are continuing.

In Tanzania, experimental plots were established at three different sites in March 2017, to determine the effectiveness of different isolation distances in limiting the spread of SPVD.

In the **Agoro Irrigation Scheme** (northern Uganda), the second and third cycles of the rice-sweetpotato rotation experiment were harvested in October 2016 and May 2017, respectively. There was a significant difference between treatments (p<0.05). Generally, the average sweetpotato storage root yield in the rotation was 32.6 t/ha compared with 25.1 t/ha in the control. Except for 'NASPOT 10 O', which had a slightly higher yield in the control than in the rotation, the rest of the varieties had a higher yield in the rotation. The yield of rice was significantly higher in block 2 where rice followed sweetpotato and low in block 3 with continuous rice cropping (i.e., rice after rice). Time required for land preparation was less, and weed population and diversity were lower in the sweetpotato-rice block than in the rice-rice block. For sweetpotato, yields were higher in the second rotation (average yield = 28.9 t/ha) than in the third rotation (average yield = 7.9 t/ha). The low yields in the third rotation are attributed to the long dry season, which also led to water shortages in the scheme. Results for economic analysis are presented for the second rotation (planted October 2016). Generally, all rice varieties had a higher average profit in the rotation than the control. Except for 'NASPOT 11', which had a higher profit in the control than in the rotation, the rest of the sweetpotato varieties had a higher profit in the rotation than the control. There was a significant difference in net profits for both rice and sweetpotato in the rotation versus the control. Rice in the rotation had a significantly higher net profits than that in the control. All rice varieties had significantly higher net profits in the rotation than the control. Overall, there was no significant difference in net profits between the sweetpotato in the rotation and the control. The net profit for 'Ejumula' variety was, however, significantly positively higher in the rotation compared with the control, whereas the net profit of 'NASPOT 11' was significantly lower in the rotation than in the control. The highly positive profit of all rice varieties in the rotation is due to reduced costs on land preparation, which results when rice in planted in a field previously planted with sweetpotato. The superior yield of rice in the rotation could be related to better water percolation in the rotation plots compared with the control plots. Although the profit for 'NASPOT 10' was not significantly different in the rotation than was the control, it was positive.

In **Rakai District** (high virus pressure area), preliminary data from the ongoing trial comparing use of the standard net tunnel and mini-screenhouse indicate that per unit area, for 'Ejumula' and 'Kabode' (but not 'NASPOT 11'), the highest number of cuttings is produced from the net tunnel compared with the mini-screenhouse. Planting materials from Rakai were sampled from mini-screenhouses, net tunnels, and open fields. The samples were then grafted to *I. setosa* for detection of viruses, after which the specific type of virus was identified using NCM-ELISA. The 'Ejumula' variety from the mini-screenhouse and open fields at Joseph Kasekende's farm tested positive for virus. The rest of the varieties in the mini-screenhouse and net tunnels there were free from virus. The materials from mini-screenhouses, net tunnels, and open fields from the rest of the farmers tested positive for virus. Using NCM-ELISA, only one type of virus (SPCSV) was identified in the materials at Rakai. The net tunnels and mini-screenhouses at Joseph Kasekende's farm were well managed, which explains the relatively low virus levels in materials sampled from his place. The rest of the farmers managed their screenhouses and net tunnels poorly, therefore their materials contracted viruses. The high incidences of virus in open fields explains the fact that mini-screenhouses and net tunnels, if well managed, can keep planting materials clean for over a year. Comparative cost-benefit analysis of using mini-screenhouses, net tunnels, or open-field multiplication is in progress.

D. RP4: Postharvest and Nutritional Quality (details provided in Appendix F)

This is a diverse research program, jointly led by NRI and CIP to address postharvest bottlenecks that are slowing down value chain development. Four of the six milestones are behind schedule by a few months; the other two are on track (Appendix A). The first three objectives were to be completed in three years but will now take 4 years to finalize; the last in 5 years.

(i) Objective 4.1: To develop cost-effective technologies to enable commercially oriented farmer organizations to supply quality sweetpotato roots year-round to specific agro-processors or urban markets. The key output is to develop cost-effective technologies that do not require access to the national electricity grid to cure and then store fresh OFSP roots at medium to large scale for up to 6 months. In Kenya, the appropriate storage facility is linked to a purée processor. Storage for 1–3 months is needed to smooth supply. A 9-t storage facility in two sections (each of which could cure, then store roots), with powered ventilation, was built under the guidance of Andy Marchant of NRI and was ready by June 2015. The design of the unit is described in Milestone report OBJ4MS1.C. Two rounds of trials were conducted in year 2; then a third trial was initiated in May 2016. Temperature control was improved over the previous trial by increasing air flow across evaporative cooling system. A new pump and timer circuit were added. However, several technical problems occurred that prevented efficient temperature pull-down after curing and weevil infestation was significant.

A fourth storage trial was initiated on 12–15 December 2016. The trial aimed to assess the quality and utility of the stored roots of two different OFSP varieties ('Kabode' and 'Vita') after 2, 4, 6, 8, 13, and 16 weeks of storage. The effect of washing or dry manual removal of soil from the roots prior to storage was also evaluated. The trial showed fresh root storage is an effective way for processors (or other stakeholders) to extend and manage the availability and quality of sweetpotato roots for processing into purée. Over 70% of the root weight of all treatments could be processed into purée after 4 months stored at 20–23°C in the solar-powered store.

The variety and vertical height position of the crate in the store room had the most significant effect on the quality of the stored roots, followed by whether the store room was solar or mains powered. Whether the roots were washed or not prior to storage had little effect on root quality, with just a slight effect on the percent portion (by weight) of the roots being discarded due to weevil damage. Overall, 'Vita' performed better in storage than 'Kabode'.

Root storage could also be effective for farmers and traders in extending the availability period of sweetpotato roots in the markets and preventing postharvest deterioration and loss during root peak root supply periods. Preliminary tests found consumers were willing to buy sweetpotato roots that had been stored for 4 months. Full details of the storage trial are given in the Milestone report OBJ4MS1.B.

Despite the success of the evaporative cooling stores in maintaining the quality of sweetpotato roots during 4 months of storage in a tropical part of Africa, further work is being undertaken to investigate the impact of root storage at cooler temperatures of ≤ 15°C. The goal is to have at least 90% of the root weight available for processing after 4 months. Cooler temperatures are expected to reduce or delay root rotting and sprouting and prevent the development of the *C. puncticollis* and *C. brunneus* weevil life stages within and on the roots. This system uses a solar-powered standard refrigeration systems in an ex-transport container. The unit was constructed by NRI engineer Marcelo Precoppe in June 2017, and will be tested in year 4. Details on the design of this new storage facility are provided in Appendix F.

Late in 2016, together with SUSTAIN in Mozambique, SASHA developed a partnership with EcoTech Hydro & EcoTech Energy, a small engineering firm based in Knysna, South Africa, which has ample experience in solar power and water engineering. In December 2016, the firm tested using a coolbot, which is a device readily available on the market for about $400 that forces a conventional AC to lower its temperature. The test was successful. In May, the construction of a container-based cooling facility began, again using solar panels to provide the energy to cool the container. Once construction and testing are completed in South Africa in August 2017, the unit will be moved to Mozambique where storage trials will be conducted.

Research was undertaken by a UDS M.Sc. student, Sampson Alhassan, in Ghana during sweetpotato harvest time. Two long-distance transport experiments were carried out: from the Eastern Region to Agbogbloshie market in Accra in September–October 2015, and from the Upper East Region to Bittou market in Burkina Faso in December 2015. The

transportation study was repeated in 2016 between August and October for the Afram Plains to Agbogbloshie route, and in November for the Bawku to Bittou route. Results from the validation work conducted in 2015 and 2016 were fully reported in the year 3 midterm report. In 2017, the authors prepared a draft publication describing the existing root transport systems and packaging currently in use in Northern Ghana, attached as Milestone report OBJ4MS1.A. Four different containers were tested: the commonly used 130-kg polypropylene sack and the 130-kg jute sack, and two new methods—polypropylene sack holding just 50 kg of roots and a wooden crate, typically used for tomatoes, also holding just 50 kg of roots. Bruises, breaks, and cuts at the production site (prior to packing) and the market site (after transport) were evaluated. The wooden crate was best at preventing damage, and consumers at the market judged them to have the best quality roots. However, aggregators found them hard to handle. The second-best method for reducing damage was the polypropylene sack with only 50 kg.

Drawing on the findings from a handling study conducted in Kenya (led by NRI) and this study in Ghana, Tanya Stathers of NRI is preparing graphic-based extension materials on improved harvest and postharvest handling and transport.

(ii) Objective 4.2: To ensure year-round supply of OFSP in nutritionally at-risk households, develop convenient and low-cost methods for fresh root storage. Northern Ghana was selected as the principal site for this research because of its 6-month dry season and high existing demand for fresh root storage (even at commercial levels). Research by UDS student Richard Atuna in year 2 found that the sand box method (known as "Double S") was superior to the traditional heap method. In year 3, Atuna published results (Article OBJ4MS4.2.B) from comparing dehaulming (cutting off the vines prior to root harvest to encourage wound healing) and field-piling. This is a practice used by some sweetpotato farmers in Northern Ghana, in which fresh, carefully harvested sweetpotato roots are piled in a large heap in the field and covered by sweetpotato vines for up to 7 days before being stored in the home. He found that storage roots cured by field-piled curing method resulted in significantly better wound healing ability than dehaulming 7 days prior to harvest. Over the 7-day curing period, the higher DM content (27%) variety 'Nane' had a significantly higher and stable DM content than did the lower DM content (19%) variety 'Apomuden'.

On the basis of these findings, the Ghana team prepared a Double S brochure that is being finalized for printing. Moreover, the Ghana team received in June 2017, 1 year of funding from USAID–OFDA to introduce the Double S method at scale over the next season. This should enable testing a storage period beyond 2 months and an evaluation of more varieties under storage conditions in Northern Ghana.

(iii) Objective 4.3: To develop appropriate production and storage methods for quality sweetpotato purée and ensure that products made from stored purée are safe and nutritious. The goal is to be able to store quality purée for 4–6 months without a cold chain, and to ensure that the products made from stored purée are not markedly different from those from fresh purée. Seven sets of experiments were conducted in this period related to purée and OFSP bread development (see Appendix F for details). In addition, a storage facility for maintaining purée at 20°–25°C was constructed in September 2016. A trial looking at the effect of duration of storage on purée quality and bread quality was undertaken for which data analysis is still ongoing.

Results from the experiments completed during this period indicate that:

1. OFSP purée treated with preservatives (citric acid, sodium benzoate, potassium sorbate) and stored for 12 weeks at ambient temperatures (16°–25°C) retained 60% of its beta-carotene content, compared with 70% retention of beta-carotene when refrigerated at 4°C.
2. Thirty-five purée handlers were administered before and after examinations on food safety knowledge, attitudes toward safety, and appropriate food-handling practices. Overall, initial knowledge was only moderate and the training significantly improved overall scores.
3. When the preservative-treated purée was "challenged" by inoculating samples with the pathogens *E. coli* and *S. aureus*, and then evaluated at 12 weeks, results indicated that the preservatives were adequate to counteract the pathogen increase even at room temperature.
4. A survey of 1,024 OFSP bread consumers at Tusky's retail stores in five counties were interviewed to develop a profile of OFSP bread consumers. Of these, 80% were 30 years or older, 60% were female, and 58% were formally employed. Almost all were aware of the nutritional advantage. Acceptance ratings ranged from 7.4 to 7.7 on a 9-point hedonic

scale, indicating "liked moderately." Most stored their bread in the open (42%); 38% in the refrigerator, and the rest in closed cupboards.

5. Refrigeration increased hardness, crumb firmness, and chewiness of both white, wheat flour bread and OFSP purée bread. The specific volume (cm^3/g) of white bread was significantly higher than the OFSP purée bread.
6. Storage of OFSP purée bread at 30°C decreases its shelf-life and beta-carotene content significantly. Storage of OSP purée bread at 25°C and below is recommended.
7. Shelf-stable OFSP purée produces a bread with almost the same volume as white bread (Tusky's recipe) by adjusting the yeast from 1% to 1.5–2% and including baking power in the formulation at 1%.

It has been 24 months since the commercialization of OFSP purée bakery products by Tusky's Supermarkets in Kenya (a value chain project under SUSTAIN Kenya). Since October 2016, Tusky's has not been purchasing the purée consistently due to internal management problems. On average, they are still ordering around 1,000 kg of OFSP purée a week. Therefore, it was agreed that Tusky's would no longer be the exclusive purchaser of purée and other outlets would be actively sought. Bakers at the supermarket chain Naivas in Nairobi have been trained on OFSP bread preparation, along with five small bakeries within a 100-km radius of Organi Ltd. In addition, Organi Ltd initiated OFSP bread production at its facility.

An article, "From lab to life: Making storable orange-fleshed sweetpotato purée a commercial reality," describing the development of OFSP purée as a commercial product in collaboration with Organi Ltd, was presented at the APA and published in *Open Agriculture* (2017; 2: 148–154).

(iv) Objective 4.4: To develop the regional capacity and appropriate protocols for analysis of roots and derived products at reasonable cost to ensure that they have adequate nutritional quality and meet safety standards. The key outcome is the establishment (achieved in early 2015) and use of FANEL, based at the BecA–ILRI Hub, a joint effort by BecA and CIP. The lab is led by Tawanda Muzhingi, a CIP food scientist, and supported by two CIP technicians, one of whom is financed under SASHA2 to carry out biochemical analysis and assist in lab management. In addition to analytical chemistry, FANEL has capacity for food microbiology analysis because food safety concerns are a growing focus in Africa, and a strong food science capability would also support the work. FANEL has acquired state-of-the-art equipment for proximate analysis to conduct food composition analysis of OFSP roots and food products derived from OFSP. In September 2016, a used HPLC instrument in good condition and donated by CIP-QNL in Lima to FANEL was installed. This expanded the capacity of the laboratory for OFSP nutrient analysis and carotenoid analysis for other clients such as HarvestPlus and UDS in Ghana. FANEL is now tracking the number of samples processed and charging outside clients for services. During year 3, FANEL conduct 2,302 beta-carotene analyses; 594 total viable counts of microbes and other tests summarized in Table F9 in Appendix F.

Under the SPHI framework, a key goal is to ensure that OFSP-processed products have sufficient beta-carotene content to be considered good sources of vitamin A. This year, FANEL analyzed four baked products in use in Rwanda. The beta-carotene content in the products was 1.9, 2.3, 2.4, and 3.0 mg/100 g of product on a fwb for OFSP mandazi, cakes, biscuits, and bread, respectively. One-hundred grams of each OFSP product in this study could provide more than 50% of vitamin A body requirements in children aged 1–3 years and more than 40% of vitamin A requirements to school-aged children aged 4–8 years. Detailed findings are presented in Appendix F.

An additional study analyzed the effect of different OFSP purée proportions on nutritional composition of OFSP breads. OFSP breads were prepared by substituting wheat flour with 0%, 20%, 30%, 40%, and 50% OFSP purée. Consumption of 100 g of bread formulated with 50% OFSP purée can meet daily vitamin A requirements in children between 1–3 years, school-going children aged 4–8 years, and pregnant women. The same amount can provide about 60% of vitamin A body requirements in lactating mothers. OFSP purée is a suitable ingredient for improving beta-carotene and mineral content (ash) of breads. Detailed findings are presented in Appendix F.

To date, FANEL has hosted 8 graduate students working on OFSP and other root and tuber crops. These include five M.Sc. students in the food safety and quality management program of the University of Nairobi, and one North Carolina State University (NCSU) PhD student from Malawi working on bioaccessibility of beta-carotene from fresh OFSP roots and processed products.

E. RP5: Support Platforms, Knowledge Management, and Governance (see Appendix G)

In SASHA2, the SSP concept has been adjusted to meet the demands of its users. To support the achievement of the SPHI vision, CIP is working with national sweetpotato program partners, development actors, and other sweetpotato stakeholders to establish an Africa-wide network of technical support. The Regional Technical Sweetpotato Support Platform (SSP), established during SASHA1, is composed of three subregional breeding platforms hosted by national programs: Mozambique (IIAM), Ghana (CRI), and Uganda (NaCRRI). These host institutes have NIRS analytic capabilities. The subregional facilities are linked to KEPHIS, which is responsible for sweetpotato germplasm clean-up and distribution within the entire region and, under SASHA2, training technicians. In addition, BecA now has the support function of sweetpotato genomics, transgenics, and nutritional composition and microbial analysis. The subregional SSPs provide parent material to the national sweetpotato programs for further varietal selection and evaluation and technical backstopping from three CIP breeders in the region, each supported by a post-doc as a part of CIP's succession strategy. Because of the additional supplementary funding, there are now two meetings (not one) annually of the Seed Systems and Crop Management group, for the other three CoP domains: (1) marketing, processing, and utilization; (2) MLE; and (3) breeding and genomics, with the genomics component support by the NCSU-led Genomic Tools for Sweetpotato Project.

This was the second year that the Phase 2 governance structure operated. This consists of (1) the PAC, which has technical experts to critically review SASHA progress (see last year's annual report for a description of each PAC member), and (2) the SSC, which consists of organizations committed to the SPHI vision of reaching 10 million HH in SSA by 2020 with improved varieties of sweetpotato. In 2017, two additional nongovernmental organizations (NGOs) joined SPHI: Farm Africa, which is active in East Africa, and Catholic Relief Services, a large international organization active throughout SSA. In addition, the Peace Corps technical advisor for agriculture was an observer at the 2016 SPHI Steering Committee meeting. Peace Corps subsequently sent 13 technical trainers to attend the 10-day *Everything you ever wanted to know about sweetpotato training course*, conducted by the Kwame Nkrumah University for Science and Technology in May 2017.

All four milestones are on track for this research program (Appendix A). The vision of success for RP5 is a vibrant and growing sweetpotato CoP, in which knowledge advances are shared through virtual media and meetings, field visits, trainings, and services for key functions of germplasm exchange, virus diagnostics, and comprehensive training on sweetpotato. Key activities achieved during year 3 are discussed below.

(i) Hold annual SPHI meetings that bring SASHA2 and non-SASHA sweetpotato projects together for information exchange and review. RP5 and the Ethiopian CIP country team successfully organized and held the 1.5-day 7th Annual SPHI Technical Meeting and the aligned SASHA PAC and SCC meetings on 7–8 October 2016, at the ILRI campus in Addis Ababa, Ethiopia. The agenda of the meeting is provided in Annex G1. The meeting was aligned with two key events, also held in Addis Ababa: the 10th Triennial APA, held on 9–12 October, and a cocktail celebrating the International Potato Center's 45th Anniversary as an organization and the awarding of the World Food Prize for biofortification. Not surprisingly, the theme of the meeting was *A Time of Celebration.* (Milestone report 2OBJ5MS1.2.E). This year's SPHI technical meeting had 94 (24 women, 70 men) participants, representing 21 organizations, who came from 17 SSA countries, the UK, the US, Peru, and Germany. In preparation for the meeting, 15 SASHA update briefs and 24 non-SASHA project update briefs were prepared (compared with 18 non-SASHA briefs the previous year). Progress specifically on SASHA2 was reviewed by the project's PAC (Milestone report OBJ5MS1.2.F) during a half-day meeting on 8 October 2015.

Minutes of the 2nd SSC meeting, chaired by the representative of the executive director of Forum for Agricultural Research in Africa (FARA), Nelson Ojijo, who is working on biofortification advocacy under the Better Nutritious Foods project, are presented in Milestone report 2SSOBJ5MS1.2.G.

SASHA sponsored 20 participants at the subsequent APA meeting, all of whom had abstracts accepted for oral or poster presentations. (These abstracts are available in in Milestone report 2SSOBJ5MS1.2.E.) The SASHA project itself had 1 keynote presentation, 14 oral presentations, and 2 posters. Papers associated with the presentations have been submitted to *Open Agriculture*, which agreed to publish all outputs from the APA meeting. As of June 2017, 10

sweetpotato papers have been published, 6 representing SASHA supported research. An exhibition was held at the APA, with a booth focused on SPHI activities.

(ii) Hold technical CoP meetings at the regional level. This is the second year of conducting CoP technical meetings at the regional level instead of the subregional level support platform meetings. In this period, we received supplementary funding that permits an additional CoP meeting to be held by the Seed System and Crop Management CoP group. This year we held five CoP meetings, three on Seed Systems and Crop Management; one on MLE; one on Marketing, Processing, and Utilization; and one on Breeding and Genomics. Table 1 summarizes dates and venues for the CoP meetings for year 3 to date and leadership of each CoP. It also provides the reference to detailed minutes of each meeting (provided as separate milestone reports due to size. These reports contain findings from the participants' evaluation of the meeting). Overall, satisfaction with the quality and content of the meetings is very high. Many participants requested more days for the meeting; but our ability to add days is not possible under current funding. A comprehensive report is available on each meeting and presentations made are available on the SKP.

Table 1. Dates and attendance at SPHI CoP meetings in 2016

CoP Meeting (Milestone Report No.: OBJ5MS...)	Co-led by	Date	No. of Women	No. of Men	No. of Organizations	Venue
Sweetpotato Seed Systems Community of Practice: Sixth Consultation–Sustainable Pre-basic Seed Production (1.3.H)	Jean Ndirigue (RAB, Rwanda), Gorrettie Ssemakula (NaCRRI, Uganda), Jude Njoku (NRCRI, Nigeria)	6–8 Dec. 2016	16	37	15	Nairobi, Kenya (Pride Inn, Rhapta Road)
Monitoring, Learning & Evaluation Community of Practice Meeting (1.3.I)	Julius Okello (CIP),	30 Jan.–2 Feb. 2017	4	26	7	Maputo, Mozambique, Hotel Maputo
Marketing, Processing & Utilization Community of Practice Meeting (1.3.J)	Tawanda Muzhingi (CIP), Francis Amagloh (UDS, Ghana), Madjaliwa Nzamwita (RAB, Rwanda)	1–3 Mar. 2017	20	27	23	Kisumu, Kenya, Sovereign Hotel
Sweetpotato SpeedBreeders and Genomics Annual CoP Meeting (1.1.C)	Robert Mwanga (CIP) and Craig Yencho (NCSU)	15–18 May 2017	13	30	17	Kigali, Rwanda, Grand Legacy Hotel
Sweetpotato Seed Systems Community of Practice: Seventh Consultation- Sustainable Pre-basic Seed Production (1.3.K)	Jean Ndirigue (RAB, Rwanda), Gorrettie Ssemakula (NaCRRI, Uganda), Jude Njoku (NRCRI, Nigeria), Srini Rajendran (CIP)	12 May 2017	8	16	15	Mukono, Uganda, Colline Hotel
Seed Systems and Crop Management Community of Practice Meeting (1.3.L)	Jean Ndirigue (RAB, Rwanda), Gorrettie Ssemakula (NaCRRI, Uganda), Jude Njoku (NRCRI, Nigeria)	13–14 May 2017	17	45	27	Mukono, Uganda, Colline Hotel

There are two distinct Seed Systems CoP groups. One is the broad Seed Systems and Crop Management CoP with range of NARI, NGO, and private enterprise participants that meets yearly. The other consists of NARIs and one private enterprise receiving subgrants from SASHA2 to work on developing sustainable pre-basic seed systems. Since this requires organizations to collect cost data and develop business plans, they meet twice a year. These meetings typically include substantial training sessions on tools used to advance the sustainable business plan development and implementation.

Update on sweetpotato breeding information systems. The three breeding programs in Ghana, Mozambique, and Uganda continued using CloneSelector and AccuDataLog to manage and analyze breeding data. AccuDataLog is a field data collection software (app) that runs on Windows mobile and Android platforms, with integrated 1D and 2D barcode labeling support.

CIP's Research Information Unit has been involved in developing an improved breeding trial management software tool (HIDAP) since 2015. In addition to the features found in CloneSelector, the meteorological data and metadata will be better integrated. Moreover, the R-statistical program is more easily imbedded in the software, hence installation should be easier than for CloneSelector. The first complete version was launched in January 2017, and was tested and revised

with the SASHA data manager, Luka Wanjohi, closely involved. The 1.0 version was used in a 2-day training course for the SpeedBreeders as part of the 2017 meeting in May. During use, some problems were discovered and corrected in June and July. The new version, HIDAP 1.0.2, is available at https://research.cip.cgiar.org/gtdms/hidap/. The version also contains the Westcott design for analyzing heterosis trial data. In year 4, efforts will be made to ensure that HIDAP databases can be integrated into Sweetpotato Base, a software tool being developed by the Boyce Thompson Institute at Cornell University.

(iii) MLE, capturing dissemination efforts across countries. The second phase of SPHI is focused on "achieving the potential." This means going-to-scale efforts being intensified to reach 10 million African HH by 2020 with improved sweetpotato varieties and their diversified use. As SPHI expands, more partners and programs will come under the SPHI umbrella. At the first SPHI technical meeting in 2010, there were 5 distinct sweetpotato projects represented; by year 7 (year 2 in SASHA2), we had 28 projects represented, 11 led by someone other than CIP.

At the SSC meeting, Julius Okello presented the second annual *Status of Sweetpotato in sub-Saharan Africa* report (Milestone report 2SSOBJ5MS1.4.D submitted at midterm). As of September 2017, SPHI had reached 2.89 million HH, representing 29% of its goal.

This was the second year of geo-referencing all vine multipliers and collecting standardized information on each multiplier using smartphone with ODK software was undertaken in nine countries. In total, 345 individual multipliers and nine groups were mapped in seven SSA countries. Contact information for these multipliers (if they agreed) has been posted on the SKP under the tool "Find Vines."

Collection of quality M&E data and their integration into program management activities continued to improve significantly with increased uptake of electronic data collection. Since 2014, SASHA2 has been evaluating the suitability of using smartphones to collect M&E data in sweetpotato research for development in SSA. It has been testing applications using two software packages: ODK, which has been found to be particularly suitable for short surveys used for monitoring activities, and CSPro for Android, which is best for larger, more complex HH surveys.

The MLE team[3] continued to work on developing the tools and the associated manual "Tools and Techniques for Monitoring Key Indicators of Sweetpotato Interventions in SSA: A Practitioner's Guide." The core modules, with their associated data collection instruments, are:

- Design and description of the data collection effort
- Household background information
- Trends in using sweetpotato
- Sweetpotato production and sales volumes
- Household food insecurity
- Dietary diversity score
- Frequency of consumption of vitamin A-rich foods
- Geo-referencing the location
- Capturing sweetpotato vine dissemination
- Yield estimation using crop cuts
- Sweetpotato root market prices.

The monitoring kit has two key parts: the chapters in this book and the files in subdirectories that are found on the internet. A description of all the recommended tools for collecting the key indicators is presented in Chapters 2–10 of the manual. The user has two options to choose from: collecting the data on forms printed out from Excel spreadsheets or collecting the data electronically using ODK forms (also in Excel) on a tablet, smartphone, or computer. If the data are collected on paper, data entry programs using the CSPro software are accessed through the internet link. Data digitized either using ODK programs or CSPro programs need to be transferred to STATA databases for statistical analysis. All the STATA programs for doing the basic analysis of the data needed for reports are provided through an internet link. The

[3] Julius Okello, Temesgen Bocher, Jan Low, and Luka Wanjohi.

manual was introduced at the annual MLE meeting after pre-testing all modules in Rwanda. Subsequently, revisions were made based on feedback from initial users and the manual finalized (Milestone report OBJ51.4.E).

(iv) Communication Activities: SKP and Exhibition and Meeting Participation. The major public instrument for disseminating information is the SKP, created in open-source software and launched in November 2011. Because of a Sentinel Grant from BMGF, the SASHA project received support to redesign the portal, which was relaunched on 15 February 2016, based on Wordpress. Improvements have continued through June 2017, and the SKP is now more user friendly. There are currently 496 registered users and 2,067 files on the SKP. The number of sessions recorded on SKP use increased 22% between year 2 and year 3.

The monthly e-newsletter, known as the Sweetpotato Knowledge Portal E-Digest, was sent out to members of a master list, which includes participants of all the meetings, subscribers from the portal and the wider RTB community as well as subscribers from exhibitions. The list currently stands at 1,584 contact addresses. The e-newsletter contains latest news, events, publications, success stories, and announcements linked to the SKP. Major stories are also included on the RTB and CIP websites.

Clearly, this was a banner year for the recognition of biofortification in general and OFSP as the example of most advanced of the biofortified crops. On 28 June 2016, Maria Andrade, Robert Mwanga, and Jan Low of CIP, together with Howdy Bouis of HarvestPlus, were named as the 2016 World Food Prize Co-Laureates for their work on biofortification. This announcement was made at the U.S. State Department in the USA. Subsequently, all attended the Borlaug Dialogue week on 10–14 October in Des Moines, Iowa, with a televised ceremony held on 13 October 2016, at the Iowa Statehouse (http://site.iptv.org/video/story/24351/2016-world-food-prize). A major event at the Borlaug Dialogue was a 1-hr panel discussion on the morning of Friday the 14th, with the four co-laureates on biofortification; Jeff Raikes, former CEO of BMGF, moderated.

Since the announcement there have been more than 200 media outputs linked to the awarding of the prize. Some key highlights have been:

- The recognition of adapted OFSP by *Time* magazine as one of the 25 best innovations of 2016
- Excellent coverage on the BBC website
- Recognition of Robert Mwanga as one of the "100 Most Influential Africans" in the *New African* magazine
- Recognition of Jan Low and Maria Andrade for their work as mentors as well as scientists by the African Women in Agricultural Research & Development program at an event linked to the African Green Revolution Forum.

The CIP co-laureates were invited to speak at many events due to the award (see Appendix G for details). In terms of other meeting participation, a major investment was sponsoring a 0.5-day symposium highlighting key findings from the Mama SASHA study (SASHA1) at the Micronutrient Forum in Cancun, Mexico, on 23–28 October 2016 with 71 attendees.

SASHA and SPHI continued to have a strong presence at exhibitions during year 3, with booths displaying SASHA panels and providing copies of briefs available at:

- 7th Africa Agriculture Science Week (hosted by FARA) in June 2016
- Africa Knowledge Conference in August 2016
- African Green Revolution Forum, hosted by AGRA, in September 2016
- APA Conference in October 2016
- Integrated Nutrition Conference, hosted by CRS, in November 2016
- National Nutrition Conference for Kenya in November 2016
- 13th International Symposium for the International Society for Tropical Root Crops—Africa Branch in March 2017.

To encourage sweetpotato researchers and practitioners to publish, Jan Low used a portion of her 2016 World Food Prize monetary award to establish the Excellence in Sweetpotato Endowment at CIP. This will enable two prizes worth $500 each to be awarded at annual SPHI meetings, one for best scientific paper and one for best communication output (which includes articles, training manuals, videos, songs, etc.), known as the Communication for Change Award (details of criteria for these awards are provided in Appendix G).

(v) Open Access Commitment. This period saw a major commitment being made to build the capacity of researchers and staff on BMGF and CGIAR open access requirements. With CIP-HQ support, SASHA2 hosted an open access workshop on 4–8 July 2016, to educate relevant researchers on how to prepare their data and articles for loading on Dataverse, the open access repository that CIP has adopted. Three facilitators (two from CIP-HQ) ran the workshop for 24 CIP staff members (6 women, 18 men), each of whom came with one to two data sets to work on. In addition, a 2-day training was held for 4 CIP seed systems researchers who could not attend the initial training. Preparing databases for open access is now part of SASHA scientific staff work plans. An open access officer was hired in September 2016, 50% supported by SASHA and 50% by CIP-HQ, to help clean larger data sets and spearhead the open access process. In total, 13 SASHA-related data sets were cleaned; 10 have been completely documented and loaded into the Dataverse open access system during year 3.

2. Project Adjustments

For each outcome or output that is behind schedule or under target, explain what adjustments you are making to get back on track.

RP1. Breeding. We are committed to building the next generation of breeders that will combine knowledge of conventional breeding with practical molecular breeding techniques. A postdoctoral plant breeder, Dr. Charles Tendo Ssali, joined CIP-Uganda at the start of May 2017 to replace Dr. Charles Wasonga, who left CIP in mid-September 2016. He will assist Robert Mwanga in the subregional breeding responsibilities. To accelerate progress in the West Africa SSP, in a shared position with the genomic tools project, a postdoctoral plant breeder, Dr. Jolien Swanckaert, joined Ted Carey in June 2017. The major problem of insufficient seed from crossings in West Africa was resolved by a very qualified technician from CIP-HQ assisting the Ghana team in how to effectively cross in screenhouses. The other problem experienced are issues with contamination, most likely by dust or soil, during preparation of the freeze-dried root samples in the quality laboratory in Maputo. Contamination affects Fe and Zn readings, and hence when present, means that samples must be re-prepared and re-analyzed, a costly endeavor. Steps are underway to improve protocol adherence in the Maputo NIRS lab.

RP2. Weevil Resistance. The funding for the RP2 is now finished. While the *Bt* approach was not successful, the RNAi approach is promising and additional funding will be sought to continue this work.

RP3. Seed Systems. The El Niño-related drought in much of East and Southern Africa continues to put pressure on water resources at research stations. In response, we are supporting increased storage capacity and more efficient irrigation practices. The drought also affects the activities of multipliers and root producers, making demand for pre-basic and other classes of seed more unpredictable.

The costing out of pre-basic and basic seed production by NARIs and the institutionalization of business plans are progressing. A request was submitted and approved to continue this activity through December 2018, as it is taking longer than anticipated for most NARIs to complete this task. SASHA's agricultural economist, Srini Rajendran, is spending most of his time developing tools for costing and backstopping the NARIs on their business plan development. Several NARIs and Biocrops still struggle with submitting timely and correct financial reports. Biocrops recently engaged a new accountant, so it is likely that reporting will improve in year 4.

Ten countries have now prepared or gazetted sweetpotato seed standards (in addition, Zambia has sweetpotato standards that need to be revised). However, to ensure appropriate implementation, there is an urgent need for resources to support systematic capacity building for seed producers and seed inspectors. Moreover, while a QDS approach has been advocated, in some cases, the "formalization of the informal" has led to unintended consequences.

RP4. Postharvest. Developing solar-powered storage facilities for sweetpotato roots has proved to be more challenging than anticipated. The fourth trial using the evaporative cooling facility developed by Andy Marchant of NRI was the most successful to date. However, we still have not reached the desired storage temperature of 15ºC. NRI engaged a new agricultural engineer in 2017, Marcelo Figueira De Mello Precoppe, who has designed and constructed a unit with a cooling system that will be tested in year 4. In addition, there is a South African company developing an air-cooled unit that is also container based. It is expected that one of these units will achieve that technical goals of the storage research by the end of year 4.

RP5. SSPs, Knowledge Management, and Governance. The redesign of the SKP proved to be more technically complex than originally thought. The first contracted service provider, Netmidas, failed to provide the needed quality. A new firm, Badili Ltd, was hired in December 2016, that is Kenya-based, which enables them to work more closely with the SASHA data manager and the SASHA communication specialist. Their work is to be completed by 31 July 2017. SASHA has received additional support from ALINE to finance this SKP renovation. In addition, 6-month interns have supported the transfer of documents from the old Portal to the new SKP throughout the year.

3. Geographic Areas to Be Served

Location Served	Foundation Funding	Year 1 Expenses	Year 2 Expenses	Year 3 Expenses	Total	Total Balance
	U.S.$	U.S.$	U.S.$	U.S.$	U.S.$	U.S.$
Ethiopia	**926,737**	146,474	202,486	207,082	556,042	**370,695**
Kumasi, Ghana	**3,732,977**	754,680	778,479	706,627	2,239,786	**1,493,191**
Maputo, Mozambique	**4,241,184**	868,949	1,042,154	633,607	2,544,710	**1,696,473**
Kenya	**4,445,374**	822,475	1,040,174	804,576	2,667,224	**1,778,150**
Namulonge, Uganda	**3,848,329**	681,308	869,536	758,153	2,308,997	**1,539,331**
Tanzania	**748,133**	21,630	158,293	268,956	448,880	**299,253**
SSA in general	**1,416,776**	90,390	276,904	352,280	719,573	**697,203**
World in general	**2,284,198**	300,234	181,244	663,087	1,144,564	**1,139,634**
Total	**21,643,707**	**3,686,139**	**4,549,269**	**4,394,369**	**12,629,777**	**9,013,930**

Note: Foundation funding budget has been redistributed in line with actual expenditures in the areas served.

4. Geographic Location of Work

Location of Work	Foundation Funding	Year 1 Expenses	Year 2 Expenses	Year 3 Expenses	Total	Total Balance
	U.S.$	U.S.$	U.S.$	U.S.$	U.S.$	U.S.$
Ethiopia	573,155	75,626	98,905	114,086	288,617	**284,539**
Kumasi, Ghana	2,643,070	389,650	380,249	432,448	1,202,347	**1,440,723**
Lima & San Ramon Peru	3,936,145	938,264	1,165,764	950,767	3,054,794	**881,351**
Maputo, Mozambique	3,159,682	448,648	509,042	386,754	1,344,444	**1,815,239**
Nairobi, Kenya	4,811,777	1,108,167	1,538,651	1,670,671	4,317,489	**494,288**
Namulonge, Uganda	3,557,778	351,767	424,726	460,598	1,237,091	**2,320,687**
Tanzania	698,271	11,168	77,319	152,524	241,011	**457,260**
UK	523,322	161,166	219,361	69,749	450,276	**73,046**
Other SSA	1,148,066	46,669	135,254	156,773	338,696	**809,370**
Other World	592,440	155,014		-	155,014	**437,426**
Total	**21,643,707**	**3,686,139**	**4,549,269**	**4,394,369**	**12,629,777**	**9,013,930**

2. Feedback for the Foundation

Provide one to three ways the foundation has successfully enabled your work so far. Provide one to three ways the foundation can improve.

As stated earlier, biofortification would never have received the World Food Prize without the tremendous financial and networking support provided by the Foundation to both CIP and HarvestPlus. BMGF's support for sweetpotato was catalytic for getting the potential of this underinvested crop recognized. We are deeply grateful.

We were very pleased to learn this year of the Foundation's willingness to support the open access process by providing financial support so that articles in major journals with high open access fees can be made available easily to interested users. Four SASHA2-supported research articles published this year have open access status due to this support. The Foundation has also been supporting greater integration of nutritional concerns into agricultural projects and programming. Since this is a key entry in the utilization of OFSP, this type of support encourages other donors to support dissemination efforts. The Foundation is good at listening to any needed changes in approach that may also require shifts in funding allocation. The Foundation strategically links SASHA2 to other projects it is funding, which permits useful synergies to be

exploited. For example, the Foundation's support of the Genomic Tools for Sweetpotato project, led by NCSU, is working closely with SASHA2 management in planning a joint annual meeting for sweetpotato breeders in SSA. From CIP's institutional standpoint, it would be easier if the Foundation were willing to cover more of the regional office costs and research support costs as direct costs. The Foundation could improve by providing more financial support to networking regional organizations, strengthening NARIs' institutional management capabilities, and for more African scientists to attend scientific conferences and other capacity-strengthening opportunities.

3. Global Access and Intellectual Property

If your funding agreement is subject to Intellectual Property Reporting, please click the following link to complete an Intellectual Property (IP) Report.

If not, please acknowledge by typing "N/A": N/A

To delegate permissions to another member of your project team or for any questions regarding the Intellectual Property Report, please contact GlobalAccess@gatesfoundation.org.

4. Regulated Activities

Do you represent that all Regulated Activities[1] related to your project are in compliance with all applicable safety, regulatory, ethical and legal requirements? Please mark with an "X":

_____ N/A (no Regulated Activities in project)

___X___ Yes

_____ No (if no, please explain below)

The RP2 transgenic weevil resistance component has previously submitted reports demonstrating compliance with all applicable safety, regulatory, ethical, and legal requirements.

Are any new Regulated Activities[1] planned which were not described in any documents previously submitted to the foundation? Please mark with an "X":

___X___ No

_____ Yes (if yes, please explain below)

Financial Update

1. Summary

Briefly describe how total project spending to date compares against the budget and how your assumptions may have changed as the project progressed.

By the end of year 3, SASHA2 project's overall spending is 90%. This is $4,383,742 against allocated budget of $4,863,304, leaving us with a balance of $479,561. Subgrants total spend amounts to $507,972 out of $766,491 budget, leaving a balance of $258,519.

Table 1. End of year 3 annual budget vs. expenditure status

Budget Category	Year 3: Revised Budget	Year 3: Expenditure	% Spent	Year 3: Balance
	USD	USD	USD	USD
Personnel	**1,772,656**	**1,721,662**	97	50,994
Travel	**563,254**	**507,584**	90	55,670
Sub Grantees	**766,491**	**507,972**	66	258,519
Equipment	**68,699**	**46,118**	67	22,581
Consulting	**38,849**	**30,035**	77	8,813
Direct Costs	**1,019,012**	**998,579**	98	20,433
Indirect costs	**634,344**	**571,792**	90	62,551

	Total	**4,863,304**	**4,383,742**	**90**	**479,561**

2. Latest Period Variance

Provide explanation for any cost category variances outside the allowable range. Explain causes, consequences for the project, and mitigation plans if relevant. Report whether or not approval for the variance has been obtained from your Program Officer.

As of end of project year 3, most budget categories were fairly spent, apart from travel, sub grants, capital equipment and consulting whose spending variances were less than 10%.

Budget Category	Year 3: % Spent	Comment
Travel	**90%**	Some of the costs of travel were not captured before end of June 2017, hence they will charged in the first quarter of Year 4.
Sub Grants	**66%**	Our major reason for underspending is in the category of seed systems, where we are working with 10 national programs and one private sector partner to understand the real costs of producing early generation seed and developing business plans. This has required institutional support from each NARS director and the setting up of rotation funds. Some countries started more slowly, while others and three organizations (DARS in Malawi, IIAM in Mozambique, and Biocrops in Uganda) fell behind in financial reporting because of problems with departing or unqualified staff in the accounting department. We have been working with our partners to fix these issues. We already discussed with our program officer, the need to extend the seed system sub-grantee work through December 2018, by which time we expect almost all of the organizations to have the ability to keep producing pre-basic seed without additional project support. This was approved by the BMGF program officer. In breeding, the two partners underspent in years 1 & 2, and we are working with them to increase their burn rate. These two partners were expended to operate in years 4 &5. Under post-harvest, NRI also was delayed in getting their last storage experiment using evaporative completed and a new design is being tried now by both NRI and a firm in South Africa, known as ECOTECH, of which the program officer is aware and this research component has been extended through year 4. Again, the goals in all cases are to use funds effectively and make adjustments so that the milestones are achieved before the end of phase 2.
Capital Equipment	**67%**	In the report, we justify the differences in expenditure. Equipment was 14,699 more than the budget (a 27% increase). This was due to the major repair needed for freezer drier in Uganda, an essential piece of equipment for the quality lab. The second was for the construction of a storage facility using a cooling approach. There was an error in the report. This is destined for Mozambique, not Ghana. The BMGF program officer approved that we could undertake this approach when the evaporative cooling method used was not obtaining the lower temperature levels needed for long-term sweetpotato root storage.
Consulting	**77%**	Consultancy was underspent because the weevil component ended up not needing to use the $3000 set aside for this work, due to the non-positive results for this work. In addition, work on Triple S training material preparation was done under the NRI sub-grant instead of a consultancy as originally envisioned.

3. Budget Plans for Next Reporting Period

Explain any significant reforecasting, any impact that the reforecasting will have on the total budget, and how your organization will be able to successfully perform within the reforecasted budget.

1. BUDGET ADJUSTMENT

During the first half of year 3 implementation, it has been necessary to make budget adjustments as indicated in Table 2. Most of the budget category adjustment percentage rates are below 10%; however, both equipment and consulting budget categories are above 10% which required BMGF approval. Equipment: increased equipment budget is to support our postharvest storage research, which has required changing the storage method used to be able to achieve desired temperature range. Consulting: Decreased budget was due to moving of Euro Ingredients Ltd, Kenya year 3 budget provision to other direct costs as they are now engaged under a service agreement.

Table 2. Approved annual year 3 budget vs. revised mid-year 3 budget adjustment

Budget Category	Adjustment Budget	Original Y3 Budget	Variance	Variance	Effect	Approval
	USD	USD	USD	USD		
Personnel	1,772,656	1,820,170	(47,514)	-3%	Reduction	Project Manager
Travel	563,254	523,253	40,001	8%	Increase	Project Manager
Subgrants	766,491	800,480	(33,989)	-4%	Reduction	Project Manager
Equipment	**68,699**	**54,000**	**14,699**	**27%**	**Increase**	**BMGF**
Consulting	**38,849**	**43,657**	**(4,808)**	**-11%**	**Reduction**	**BMGF**
Other direct costs	1,019,012	987,400	31,612	3%	Increase	Project Manager
Indirect cost	634,344	634,344	0	0%	-	
TOTAL	**4,863,304**	**4,863,304**	**0**	**0**		**-**

	Notes:	
1	**Personnel:**	1) Decreased personnel costs under East Africa Breeding program following departure of the deputy sweetpotato breeding. Took two rounds of interviews to find a suitable replacement, who will only start in March 2017. 2) Decreased cost due to M&E officer moving to another project; post will be filled ASAP.
2	**Travel:**	1) Increased travel budget under seed systems after Rice Scheme program used up their budget allocation prior to end of the study. 2) increased budget under West Africa Breeding who had utilized most of their allocated budget. 3) Increase SSP & governance program to facilitate remaining CoP meetings in the second half of year 3.
3	**Subgrants:**	1) Decreased NRI–UK partner budget following corrections on total expenditures in year 3. Amounts deducted from NRI–UK budget was used to increase ISABU-Burundi partner budget and Seed Systems CoP partners' budgets. 2) Euro Ingredients Ltd, Kenya year 3 budget provision (which was split between subgrantees and consulting) was moved to other direct costs as they are engaged under service agreement.
4	**Equipment:**	1) Increased budget under East Africa Breeding program to cover final payment for parts for freeze drier repair and voltage regulator for Namulonge in year 3. 2) Increased budget under postharvest to facilitate construction of storage facility in Ghana.
5	**Consulting:**	1) Increased budget due to engagement of a consultant to train team working on open access data compliance, especially clean and documentation of survey datasets. 2) Euro Ingredients Ltd, Kenya year 3 budget provision (which was split between subgrantees and consulting) was moved to other direct costs as they are engaged under service agreement.
6	**Other Direct Cost:**	1) Increased postharvest other direct costs budget as required laboratory supplies and purée-producing supplier costs are higher than anticipated. 2) Euro Ingredients Ltd, Kenya year 3 budget provision (which was split between subgrantees and consulting) was moved to other direct costs as they are engaged under service agreement.

2. YEAR 3 CARRY-OVER BALANCE

End of year 3 budget balance amounts to $479,561, which amounted to 10% of the year 3 budget.

Table 3. Year 3 budget vs. annual expenditures

	Budget	Expenditures	Balance	% Balance
Budget Categories	**Year 3**	**Year 3**	**Year 3**	**Year 3**
	USD	**USD**	**USD**	**%**
Personnel	**1,772,656**	1,721,662	50,994	3%

Travel	**563,254**	507,584	55,670	10%
Subgrants	**766,491**	507,972	258,519	34%
Capital Equipment	**68,699**	46,118	22,581	33%
Consulting	**38,849**	30,035	8,813	23%
Other Direct Costs	**1,019,012**	998,579	20,433	2%
Direct Costs, Total	**4,228,960**	**3,811,950**	**417,010**	**10%**
Indirect Costs, Total	**634,344**	571,792	62,551	10%
Total	**4,863,304**	**4,383,742**	**479,561**	**10%**

3. YEAR 4 AND YEAR 5 BUDGET REVISION

We propose to distribute year 3 carry-over funds equitably across the remaining 2 years. The balance has been distributed between year 4 and year 5 at 58% and 42% (Tables 4 and 5). We also propose for approval an increase in the approved year 4 and year 5 budgets by $277,407 and $202,154, using year 3 carry-over funds. This redistribution will enable us to achieve our targets as the funds have been reallocated to ensure that delayed milestones are accelerated. A revised budget for end-of-year 3 is shown in Table 6.

Table 4. Year 4 budget vs. revised budget

	Budget	Revised Budget	Variance	Variance	Variance
Budget Categories	**Year 4**	**Year 4**	**Year 4**	**Year 4**	**Year 5**
	USD	**USD**	**USD**	**%**	
Personnel	**1,990,215**	1,974,445	(15,770)	-1%	Decrease
Travel	**551,792**	412,561	(139,231)	-25%	Decrease
Subgrants	**455,061**	548,055	92,994	20%	Increase
Capital Equipment	**-**	75,315	75,315		Increase
Consulting	**8,615**	46,500	37,885	440%	Increase
Other Direct Costs	**949,258**	1,139,288	190,030	20%	Increase
Direct Costs, Total	**3,954,940**	**4,196,164**	**241,223**	**6%**	
Indirect Costs, Total	**593,241**	629,425	36,184	6%	
Total	**4,548,181**	**4,825,588**	**277,407**	**6%**	

Table 5. Year 5 budget vs. revised budget

	Budget	Revised Budget	Variance	Variance	Variance
Budget Categories	**Year 5**	**Year 5**	**Year 5**	**Year 5**	**Year 6**
	USD	**USD**	**USD**	**USD**	**USD**
Personnel	**1,980,793**	2,047,504	66,711	3%	Increase
Travel	**510,835**	273,841	(236,994)	-46%	Decrease
Sub-grants	**213,158**	296,248	83,090	39%	Decrease
Capital Equipment	**-**	12,500	12,500		Increase
Consulting	**-**	4,000	4,000		Increase
Other Direct Costs	**768,141**	1,014,620	246,479	32%	Increase
Direct Costs, Total	**3,472,928**	**3,648,714**	**175,786**	**5%**	
Indirect Costs, Total	**523,886**	550,254	26,368	5%	
Total	**3,996,814**	**4,198,968**	**202,154**	**5%**	

Table 6. Revised budget as of the end of year 3

	Expenditures	Expenditures	Expenditures	Revised Budget	Revised Budget	Total Revised Budget	Original Budget	Variance	Variance	Variance
Budget Categories	**Year 1**	**Year 2**	**YEAR 3**	**YEAR 4**	**YEAR 5**	**Project Y1-Y5**	**Project Life**			
	USD	**USD**	**USD**	**USD**	**USD**		**USD**	**USD**	**%**	**Effect**
Personnel	1,459,545	1,585,841	1,721,662	1,974,445	2,047,504	**8,788,996**	**9,456,501**	(667,505)	-7%	Decrease
Travel	373,832	569,595	507,584	412,561	273,841	**2,137,413**	**2,312,273**	(174,861)	-8%	Decrease
Sub-grants	463,696	628,429	507,972	548,055	296,249	**2,444,400**	**2,444,400**	(0)	0%	
Capital Equipment	138,289	84,797	46,118	75,315	12,500	**357,019**	**209,000**	148,019	71%	Increase
Consulting	-	45,494	30,035	46,500	4,000	**126,029**	**31,188**	94,841	304%	Increase
Other Direct Costs	769,978	1,044,293	998,579	1,139,288	1,014,620	**4,966,758**	**4,367,252**	599,506	14%	Increase
Direct Costs, Total	**3,205,339**	**3,958,449**	**3,811,950**	**4,196,164**	**3,648,714**	**18,820,614**	**18,820,614**	**(0)**	**0%**	
Indirect Costs, Total	**480,801**	**590,821**	**571,792**	**629,425**	**550,254**	**2,823,092**	**2,823,092**	**(0)**	**0%**	
Total	**3,686,139**	**4,549,269**	**4,383,742**	**4,825,588**	**4,198,968**	**21,643,706**	**21,643,707**	**(0)**	**0%**	

4. Sub-awards (if applicable)

Use the chart to provide the name(s) of the sub-grantee(s) or subcontractor(s), actual disbursement for this reporting period, total disbursement to date from the primary grantee to sub-awardee, total spend to date by the sub-awardee and total contracted amount.

	Organization Name	Actual Disbursement for this Reporting Period ($USD)	Total Disbursed from Primary Awardee to Sub to Date ($USD)	Total Sub-awardee Spent to Date ($USD)	Total Contracted Amount ($USD)
1	Burundi-Support for Breeding (PhD training at Makerere plus field support)	25,415	45,503	**45,381**	**60,390**
2	Kenya- Cold tolerance	22,346	53,780	**53,752**	**57,185**
3	FIompiana FAmbolena Malagasy NORveziana (FIFAMANOR), Madagascar	35,517	68,310	**56,760**	**72,156**
4	Ghent University IPBO (Belgium)	0	63,014	**63,014**	**63,014**
5	BecA/ILRI platform and training	0	35,296	**35,296**	**35,296**
6	Donald Danforth Plant Science Centre (DDPSC)	-	92,000	**92,000**	**92,000**
7	Rwanda Agricultural Board (RAB)	36,453	91,337	**90,078**	**105,869**
8	Sugar Research Institute (SRI)–Tanzania	38,474	100,339	**86,455**	**99,308**
9	South Agricultural Research Institute (SARI), SNNPR Ethiopia	20,011	60,556	**56,303**	**58,437**
10	Tigray Agricultural Research Institute (TARI)–Ethiopia	24,260	51,050	**53,883**	**58,559**
11	Department of Agricultural Research Services (DARS)–Malawi	12,831	38,910	**37,885**	**49,034**
12	Institut de l'Environnement et de Recherches Agricoles (INERA)	23,791	41,615	**30,939**	**38,281**
13	Zambia Agriculture Research Institute (ZARI), Zambia	39,303	68,227	**56,551**	**66,670**
14	National Root Crops Research Institute (NRCRI), Nigeria	6,016	17,305	**17,305**	**44,712**
15	CSIR-Crops Research Institute	14,916	26,158	**17,584**	**26,158**
16	Biocrops (U)Ltd	11,322	18,850	**13,065**	**26,533**
17	National Agricultural Research Organization (NARO) - Rice Program	18,208	24,824	**11,499**	**27,287**
18	NARO, NaCRRI - Uganda	8,643	39,207	**40,134**	**50,573**
19	Instituto de Investigação Agrária de Moçambique (IIAM), Mozambique	11,018	58,393	**55,452**	**72,235**
20	Kenya Plant Health Inspectorate service (KEPHIS), Kenya	54,726	112,446	**101,504**	**116,102**
21	FERA Science Limited (FERA)	-	43,803	**43,803**	**48,803**
22	University Development Studies (UDS), Ghana	-	24,000	**24,000**	**24,000**
23	Seed Systems Subgrants CoP	45,983	81,163	**81,163**	**91,255**
24	Natural Resources Institute (NRI) Faculty of Engineering and Science, University of Greenwich, UK	90,366	393,578	**406,473**	**444,942**
25	Euro Ingredients Ltd, Kenya	-	29,817	**29,817**	**29,817**

Note that during the first half of project year 2, the Nigerian government froze the NRCRI account. We have been working with the key principal investigator (PI). The Central Bank opened an account in July 2015, for all the BMGF projects in a single account. Funds were put into this account in 2016; however, they are not separated by project. The PI is still waiting to be given access to utilizing these funds. We will continue to work on getting the situation resolved.

5. Other Sources of Support (if applicable)

List and describe any sources of *in-kind* project support or resources received in the reporting period.

CIP is complementing SASHA2 project through coverage of office and research support costs not permitted to be charged to the Foundation.

Describe how interest earned and/or currency gains were used to support the project.

Interest earned in project year 3 amounts to $1,721 and will be plowed back into project activities implementation.

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For Foundation Staff to Complete

Analysis (required if contingent payment or PO assessment differs from grantee/vendor assessment)

Progress Analysis

Include analysis of significant project variances and key learnings that may inform portfolio discussions for progress against the strategic goals.

Budget and Financial Analysis

Include analysis of unexpended funds or over expenditures. Refer to the Unexpended Grant Funds Policy for options available when recommending how to handle unexpended grant funds, or reach out to your primary contact in GCM.

Scheduled Payment Amount	$
Carryover Amount	$
Recommended Payment Amount	$

Approver Comments (if applicable)

Name	Title	Date Approved

Comments

APPENDIX A. RESULTS FRAMEWORK: PROGRESS ON SASHA2 AT THE END OF YEAR 3

Milestone #	Responsible	Key Milestones	Due Date		Current Status	Revised Date		Comment Concerning Current Status	Planned % of milestone as of 1 July 2017	% progress of milestone as of 1 July 2017	% progress/ planned July 2017
			Mon.	Year		Mon.	Year		Year 3	Annual	
1.1.1	MA & RM	Studies demonstrating that significant genetic gains (GG) (2% per year in yield) can be achieved in 2 years in early generations & 4 years for selected varieties	6	2019	On track	6	2019	**Y1:** Results (average root yields) from unreplicated trial from Namulonge of yield gains above 2% will be confirmed from analyzed data from multiple sites; data from several trials available in Mozambique & gain above 2%. **Y2:** 7 clones in Mozambique already released on 29 Feb. 2016. Dec 2015: established GG trials in Maputo & Zambézia; heterotic increment in Uganda 16% based on 8 parents X 8 parents crossing (1,196 clones); examining yield of parents enables selection for better parents. Heterosis study for drought tolerance in Mozambique (2016 harvest) indicated an increase in yield for the inter-population A x B over intra- population A. These results confirm our previous findings. In Uganda, there is a need to confirm the heterotic groups using testers or work with a different set of parents. In Mozambique, registered 9 clones in HortScience and released 7 in 2016. Moz: 4 advanced clones in 2015 multilocational trials had significantly higher yield than the international and local check clones. **Y3:** 25 more trials harvested in 2016 and 2017. GG trials were harvested at 5 locations: 4 in Mozambique and 1 in Mansa, Zambia. Year of release was significantly different among the measured traits. Results from regression analysis indicated an annual gain of 3.03% on total storage root yield, 2.36% on commercial storage root yield, both on dry weight basis, and 1.0% on vine yield on fwb. At HQ: from 1992 to 2.014 at 120 days: 0.36 t/yr for storage root yield; for 90-day period 0.18 t/yr.	45	45	100

Milestone #	Responsible	Key Milestones	Due Date		Current Status	Revised Date		Comment Concerning Current Status	Planned % of milestone as of 1 July 2017	% progress of milestone as of 1 July 2017	% progress/ planned July 2017
			Mon.	Year		Mon.	Year		Year 3	Annual	
1.1.2	WG	Estimates of yield gains achievable by reciprocal recurrent selection (RRS) in sweetpotato	6	2019	On track			**Y1:** Have crossed with partially inbred populations, selected parents & crossed again. **Y2:** Seeds need to be planted out once have enough seed & then one selection cycle will be done. **Y3:** Planted B (non-sweet) & C (high Fe and Zn) in Satipo in November 2016, for Fe & Zn; harvest in April 2017. Under analysis after harvesting: 9,881 H1 wide adaptation and earliness (WAE) (early maturing) clones; 3,742 H1 NSSP (non-sweet) clones; 3,292 H1 HIFE (high Fe) clones in field experiments plus each parent 8 plots and each grandparent 8 plots (80 x 8).	45	45	100
1.1.3	RM	At least 14 African sweetpotato breeders breed using the latest knowledge & efficient methods	6	2019	On track			**Y1:** 14th breeders meeting held in Mukono, Uganda, 25 June 2015. Needs of breeding programs discussed during meeting. Field day emphasized diversified end-user involvement in varietal selection. **Y2:** Backstopping trips made to Madagascar (2015/07) and Burundi (2016/02); Ghana & Ethiopia received AGRA breeding grants, but funds not given to Ethiopia because of strategy change at AGRA. **Y3:** Backstopping visit to Burundi (Oct. 2016): Worked on plans for breeding trials and supplying OFSP planting materials to partners. Breeders from 14 SSA countries agreed to mainstream beta-carotene trait—at least 50% of clones submitted for release will be OFSP. The 16th Annual Sweetpotato SpeedBreeders and Genomics CoP Meeting held in June 2017 in Kigali updated breeders on progress in sweetpotato genomics and launched HIDAP program for breeding.	45	45	100
1.2.1	RM	At least 250,000 seeds with increased frequencies of resistance to SPVD (2–10%) disseminated to at least 10 NARS partners	6	2019	On track			**Y1:** First results on frequencies for SPVD-resistant phenotypes were presented at Sweetpotato Breeders meeting on 2–5 June 2015, Mukono, Uganda. Seed distributed will be families with high frequencies of SPVD-resistant phenotypes. Total of 159,680 seeds were distributed by 5 June. **Y3Q2:** More seed	40	40	100

Milestone #	Responsible	Key Milestones	Due Date		Current Status	Revised Date		Comment Concerning Current Status	Planned % of milestone as of 1 July 2017	% progress of milestone as of 1 July 2017	% progress/ planned July 2017
			Mon.	Year		Mon.	Year		Year 3	Annual	
								has been generated in 2016 for sharing with NARS partners (341,463 during July–Dec. 2016 period). The genomics project at BecA was allocated 13 families (903 seeds) by CIP–Uganda. To date NARS partners have received 260,316 seeds.			
1.2.3	RM	Selected hybrid progeny demonstrating yield jumps of 10–20% from populations with SPVD resistance	6	2019	On track			**Y1:** Hybrid progeny with target yield jumps will be identified in populations in objective 1.1.1 study. Preliminary results from Namulonge show some high SPVD-resistant progeny from inter-population crosses with yield jumps. **Y2:** Pop. A has 80 parents; Pop. B 50 parents. In Ug: clear evidence of heterotic gain after 3 seasons; in addition, clear most heterotic increment potential comes from a combination of a few parents. Next step will be to eliminate bad parents from the two populations (crossing blocks).	40	40	100
1.3.1	MA	At least 150,000 seeds with drought tolerance genes disseminated to at least 10 NARS partners in SSA and SWCA	6	2019	On track			**Y1:** 35,000 seeds distributed to 7 SSA NARS **Y2:** 102,923 seeds collected (25,000 controlled crosses) available; 45,000 seeds available—two requests (6,570 to Madagascar, Bangladesh) by Jan. 2016. Distributed 42,600 seeds to 11 other countries (June 2016). **Y3**: 33,000 true OFSP seed were disseminated to 11 NARS from SSA and 11,400 PFSP seed ready for distribution once import permits are sent from 5 NARS in SEA. Total distributed = 128,570 for the past 3 years.	50	50	100
1.3.3	MA	Hybrid progeny exhibiting yield jump of 10–20% in hybrids from populations with drought tolerance & enhanced efficiency for drought tolerance breeding	6	2019	On track			**Y1:** Pop. A is in Umbeluzi with 68 parents; Pop. B in Gurué with 56 parents. **Y2:** Pop. A with 66 parents & Pop. B with 56 parents; 2nd round of progeny planted 20 Aug. 2015. At Umbeluzi 2,820 OTs planted & at Gurué 1,736 OTs planted all OFSP. Also in Gurué, another 1,200 OTs planted with PFSP population. Three crossing blocks planted in Dec. 2015 (2 in Gurué, 1 in Maputo). Crossing. OTs (from Dec. 2015 crossing) planted in June 2016 has 2,820 OFSP clones (Umbeluzi); in Gurué 2,400	40	40	100

Milestone #	Responsible	Key Milestones	Due Date		Current Status	Revised Date		Comment Concerning Current Status	Planned % of milestone as of 1 July 2017	% progress of milestone as of 1 July 2017	% progress/ planned July 2017
			Mon.	Year		Mon.	Year		Year 3	Annual	
								OFSP clones; 2,106 (purple-fleshed). In Feb. 2016, 7 new varieties released: 3 OFSP for dual purpose & 2 OFSP for food only; and 3 PFSP. 2nd cycle of varietal release using accelerated breeding in Mozambique. **Y3**: Three unreplicated OTs were harvested from two treatments (optimum conditions & water stressed) at Umbeluzi (2,820 OFSP clones) and Gurué (1,868 OFSP & 1,246 PFSP clones). From these OTs, 499 OFSP and 239 PFSP clones were advanced to preliminary yield trials (PYTs) at Gurué based on higher storage root yield than check clones. At Umbeluzi, 294 OFSP clones were advanced to PYTs. There were highly significant differences (p<0.0001) for storage root yield between the check clones (17.89 t/ha) and the experimental clones (31.28 t/ha) at Umbeluzi. Two OFSP seedling nurseries have been established at Maputo and Gurué, each with 3,000 clones; they will be established as OTs in July 2017 following the Westcott design.			
1.3.4	MA	Clones with 200% RDA for young children of pro-vitamin A, 25% RDA of iron, and 35% RDA of zinc under high intakes	6	2019	On track			**Y1:** Fe and Zn measured with NIRS in Mozambique. **Y2:** 200 clones identified and will be sent to Lima for confirmation with XFR on 22 Feb.; samples were sent to Lima and results obtained. Some results need confirmation in an Australian lab. We have chosen our parents for the 2016 crossing blocks based on high Fe and Zn obtained from NIRS & new crossing block established in Dec. 2015 (started collecting seed in Mar. 2016). **YQ2:** Results from CSIRO obtained indicating 2 genotypes with high Fe and borderline contamination. The OTs were harvested from Nov. to Dec. 2016, and NIRS have been read for clones planted at Umbeluzi. Two crossing blocks were renewed in Dec. 2016. **Y3:** The OTs were harvested from November to December 2016, and NIRS have been read for	45	45	100

Milestone #	Responsible	Key Milestones	Due Date		Current Status	Revised Date		Comment Concerning Current Status	Planned % of milestone as of 1 July 2017	% progress of milestone as of 1 July 2017	% progress/ planned July 2017
			Mon.	Year		Mon.	Year		Year 3	Annual	
								clones planted in Mozambique. The best 200 clones with high Fe and Zn (NIRS) from OTs at Umbeluzi were sent to Lima for determination of Fe & Zn using the XFR methodology. 30 clones had Fe content higher than the targeted 2.3 mg/100 g DW in our milestones and sent to Australia for confirmation. Only one of these clones was found not to be contaminated. Hand crossings were initiated in May 2017, and would last until Sept. 2017 at both Gurué and Umbeluzi.			
1.4.1	TC	At least 100,000 seeds with less-sweet taste genes disseminated to at least 10 NARS partners in SSA and SWCA	6	2019	Behind schedule			**Y1:** Distributed 5,580 seed distributed to Burkina Faso & Nigeria; plan put in place to improve seed output. **Y2:** Preparing OPV seed; **Y2Q3:** Plan for technician from Lima to troubleshoot crossing. Y**2Q4:** With comprehensive approach to improving hybridization, including 4-month visit of best technician from Lima to Ghana, we are confident that using grafting, short-day treatments, and protected environment that we will boost production of seed from all cross combinations required. Given that our major deliverables come in years 4 and 5, we are confident of getting back on track with seed production capacity, while characterizing parental material for postharvest and quality attributes during year 3. **Y3Q1 update:** Good progress underway with crossing and seed production in screenhouses. **Y3Q2:** ~20,000 seeds produced at Kumasi from 31 of 34 parents used in the crossing block. Key to success was protected environment. Seed available for Ghana breeding and international distribution. **Q4:** Plans under way to ramp up seed production through controlled and polycross nursery.	50	40	80
1.4.3	TC	Hybrid progeny with yield jump of 10–20%	6	2019	Behind schedule			**Y1:** Approach to formulating the populations will be based now on agro-ecology (northern & southern); initial approach of Pop. B	50	45	90

Milestone #	Responsible	Key Milestones	Due Date		Current Status	Revised Date		Comment Concerning Current Status	Planned % of milestone as of 1 July 2017	% progress of milestone as of 1 July 2017	% progress/ planned July 2017
			Mon.	Year		Mon.	Year		Year 3	Annual	
		from less sweet, less perishable parents						material did not work. **Y2:** Will separate populations using progeny performance & fingerprinting. **Y2 end update**: Evaluation of progenies for heterosis increment complemented by molecular characterization initiated. Will be further pursued in year 3. Tester development for further allocation to heterotic groups will also be part of the year 3 activities. **Y3:** Separate populations in north and south continue under development. M.Sc. student Nikiema completed data collection, with preliminary results regarding molecular and yield assessment for identifying heterotic combinations. Characterization of parental panel for utilization and postharvest traits continuing. **Y3Q4:** Large trial underway to repeat the previous minimal effort of Nikiema.			
2.1.1	MG	15–30 transgenic events per new *cry* gene constructs	6	2014	Achieved			**Y1:** 39 produced at ABL Peru, 2 at BecA Kenya, and 125 at DDPSC in USA.	100	100	100
2.1.3	MG	At least 3–5 storage roots per transgenic event	4	2015	Achieved	2	2016	**Y1:** Storage roots are harvested in BecA greenhouse regularly. **Y2:** 80% of the transgenic events produced roots. The missing 20% are likely due to difficulties to produce storage roots in greenhouse—a problem experienced at all three locations (ABL, Danforth, BecA).	100	100	100
2.1.4	MG	Mortality assessment for each transgenic event with enough *Cry* protein to expect efficacy	7	2015	Achieved	12	2016	All the transgenic events were tested at least once for efficacy. Several have been tested twice. Those events that seemed to have apparent differences with the untransformed storage roots (12) were retested and turned out to be susceptible.	100	100	100
2.2.2	MG	Efficacy data for several dsRNA (single and in combination) against weevil larvae	6	2017	Behind schedule	12	2017	Two of the five RNAi gene constructs used for agro-infection. To date, no transgenic events have yet been confirmed. Regenerants from agro-infected somatic embryos will be harvested in the next couple of months. New funding will be sought to test them for resistance against weevils.	80	50	62.5

Milestone #	Responsible	Key Milestones	Due Date		Current Status	Revised Date		Comment Concerning Current Status	Planned % of milestone as of 1 July 2017	% progress of milestone as of 1 July 2017	% progress/ planned July 2017
			Mon.	Year		Mon.	Year		Year 3	Annual	
3.1.1	MM	Brochure with improved protocols for implementing Triple S method & study of uptake	6	2017	On track	3	2018	**Y2Q1:** 8 target countries status: Dissemination: Uganda; Testing/Adaptation: Ethiopia, Ghana, Mozambique, Malawi; Training planned: Kenya–SUSTAIN (Nov. 15); Tanzania–VISTA (Q1 2016); Activities under discussion: Malawi-SUSTIAN/VISTA–Kenya: AVCD; Jumpstarting: BF, Nigeria. **Midyear 2:** Research activities continuing in Ethiopia. In Mozambique tested in 3 districts; challenges with data collection. Training in Tanzania and Kenya postponed to period of root harvest. Trials planned for Ghana in 2nd half of 2016. **Y2Q3:** Kenya: Training in 3 counties under SUSTAIN completed March–May (40 participants). Will scale to 400 HH by Sept. 2017; Tanzania: proposed start in June 16. Target 7 districts, 120 HH until July 2017. Mozambique: 8 districts (IA) May 2016–Dec. 2017; 6 districts (VISTA); Ethiopia: SNNPR 4 woredas; Tigray on-station. Malawi: Triple S training to be included with ToT–awaiting plans for implementation. BF planned Nov 16; Nigeria: currently on-station. Will be included in ToT under Jumpstarting and MIIST. 6/8 countries committed to test & implement. Namanda taking regional lead. Propose change in due date to 3/2018 to allow all countries to test for at least one season & consolidate write up. **EndY2:** ToTs conducted in Mozambique, Tanzania, and Kenya. **Y3Q1:** Tanya Stathers will support documentation: Scoped needs. W. Kenya under SUSTAIN continuing implementation. **Y3Q2:** 7/9 countries testing & implementing. Activities started in Ghana & Nigeria (JS supported). Small group worked on ToT materials with T. Stathers. Final draft expected end of June17. **End of Y3:** W. Kenya training and validating will be completed by Sept. 17; Ghana & Nigeria see JS Final Report. Ethiopia:	60	60	100

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			Mon.	Year		Mon.	Year		Year 3	Annual	
								completed in SNNPR; Tigray completion due by Dec. 17; Uganda under MENU projects trained 1,500 farmers in 5 districts and distributed 2017 Triple S calendars; TZ 155 farmers trained under VISTA: Burkina Faso testing with 54 HH and 5 DVMS; Mozambique 211 farmers trained under VISTA & Irish Aid.			
3.1.2	MM	Report on validation of pre-basic seed production methods and models in at least 10 national programs	1	2019	On track	3	2019	**Y2Q1:** SGA with 8 institutions (7 countries) supporting construction/rehabilitation & pre-basic seed production underway. NaCRRI behind schedule; Y2 SGAs with NRCRI, ZARI, INERA signed, funds transferred & production underway. ZARI waiting for cleaned up material from Moz. SSP. Sandponics: Kenya start-up Nov. 16; Uganda: suspended; Moz: need update; Malawi: RoH; Zambia: awaiting further USAID support. **Midyear 2:** Additional SGAs signed with Ghana (CRI) and BioCrops (U) Ltd. NARO-Rice in preparation (pre-basic seed production: 11 countries, 13 institutions). Business plans submitted by 10 institutions. Sandponics established in Kenya. Irrigation study for vine multiplication established in Tanzania and Ethiopia. Established CoP sub-group on sandponics (BW). **Y2Q3:** Pre-basic seed production activities continuing in 11 countries/13 institutions. Slow implementation rate: have increased financial reporting frequency. Challenges with drought in Ethiopia, Mozambique, Zambia. Propose some countries extend time frame to 12/2018 so change in due date to 3/2019 to allow write up. Status of sandponics in Malawi, Zambia, Mozambique to be reviewed at SS CoP May 2016. Irrigation studies ongoing in Ethiopia and Tanzania. **EndY2:** SGA countries making progress on technical components. Countries doing sandponics need systematic data collection to compare with conventional. **Y3Q1:** SGAs continuing implementation; slow	50	50	100

Milestone #	Responsible	Key Milestones	Due Date		Current Status	Revised Date		Comment Concerning Current Status	Planned % of milestone as of 1 July 2017	% progress of milestone as of 1 July 2017	% progress/ planned July 2017
			Mon.	Year		Mon.	Year		Year 3	Annual	
								turnaround of financial reporting. Continuing challenges with water and electricity supply in TC labs and drought affecting demand for vines along the seed value chain. Preparations for SGA review meeting in Dec. Methodology for validation study under preparation. **Y3:** 2,029,074 pre-basic and 7,103,890 basic cuttings production reported; 11 of 13 institutions have undertaken virus testing; 9 of 13 institutions supported visual inspections of basic multipliers; 67% of 12 institutions reported income to revolving fund. Methodology for EGS/PBS validation study prepared and piloted with KEPHIS & RAB. Business plan templates revised to link income from RF and SGA funds, to total production costs.			
3.1.4	JK	Report evaluating the effect of begomoviruses on yields	6	2018	On track			**Y1:** Bramwel Wanjala hired and trained 1 month in Lima, Peru, and 1 week in Uganda. Research protocol developed and material infected with begomoviruses at KEPHIS obtained. **MidY2:** PhD research protocol approved by University. NCM-ELISA & PCR testing on plants at KEPHIS with symptoms for begomoviruses showed negative using NCM-ELISA and 50% positive using PCR. **End of Y2:** Field samples collected in 4 out of 6 major growing areas of Kenya. **Y3:** Collected field data in 5th region of Kenya, tested 400 samples for begomovirus infection, infected 2 varieties with viruses for field trials. Evaluate effect of begomovirus on yield. Two varieties ('Ejumula' and 'Kakamega') graft inoculated with different virus combination. Field experiments to be set up in July 2017.	90	85	94
3.1.5	MM	Cost study on different methods of pre-basic seed production	1	2019	Behind schedule			**Y2Q1:** NARIs challenged with developing own business plans as tool to manage pre-basic seed production and sales as part of RF. Contracted consultant to visit & work with each NARI (KEPHIS, RAB, SRI, ZARI visits	60	55	92

Milestone #	Responsible	Key Milestones	Due Date		Current Status	Revised Date		Comment Concerning Current Status	Planned % of milestone as of 1 July 2017	% progress of milestone as of 1 July 2017	% progress/ planned July 2017
			Mon.	Year		Mon.	Year		Year 3	Annual	
								completed; IIAM, DARS, SARI/TARI in progress). Anticipate "biz plans" as working documents by Mar. 2016. Cost comparison of sandponics vs. conventional will be ongoing. Business plans submitted by 10 institutions, with cost structures for pre-basic and GMA for basic and QDS seed production. Cross-country synthesis document under preparation. Presentation & discussion at 4th CoP meeting in Dec. 2015. Sandponics established in Kenya. **Y2Q3:** Synthesis document of 10 biz plans prepared & captured 10 take home messages; biz plans preparation started in Ghana, Nigeria, and BF. Institutionalization framework developed to monitor implementation of biz plans. Data collection templates to validate existing cost structures for biz plans and cost structure for sandponics under preparation. **Y3Q1:** Real-time cost data collection ongoing in Ghana, Nigeria, LZARDI, Kenya, (BF); guidelines for updating costings for other countries prepared. Revised protocol for sandponics vs. conventional screenhouse multiplication for new set up of experiment. **Y3Q2:** Improved real-time cost data collection templates in use by CRI, KEPHIS, NRCRI, and LZARDI. Light templates developed for other countries. Data collection for sandponics ongoing, but design of experiment to be revisited (again). **EndY3:** Real-time cost data collection completed for KEPHIS and CRI, with NRCRI and SRI almost completed. Light data collection template in use by the other institutions. Sandponics vs. conventional comparative study on costs delayed. New postdoc in Uganda will take over regional backstopping responsibilities.			

Milestone #	Responsible	Key Milestones	Due Date		Current Status	Revised Date		Comment Concerning Current Status	Planned % of milestone as of 1 July 2017	% progress of milestone as of 1 July 2017	% progress/ planned July 2017
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3.2.1	JK	Availability of disease-free pre-basic material within 12 months of initiating clean-up	6	2017	Behind schedule			**Y1:** 3rd iteration of ClonDiag functional after resolving minor problems. **Y42:** 4th iteration necessary and delivered to Lima and Kenya in Dec. 2015; testing to take place in Q1 of 2016. **Y2Q3:** Delay in testing 4th iteration due to time-demanding other activities. **Y2Q4:** Testing of ClonDiag ongoing in Lima; reagents received for testing to begin in Muguga where will compare against grafting, NCM-ELISA, and PCR from Aug. to Dec. 2016. **Y3Q1:** Successful test run of 4th iteration done in Kenya. **Y3Q2:** KEPHIS accreditation for virus indexing renewed on 14 Dec. 2016, for 1 year. **Y3**: 4th iteration of ClonDiag received; inter-lab testing done between CIP Lima and CIP-KEPHIS. Sensitivity, specificity, repeatability, and reproducibility tested and data being analyzed in comparison with standard *I. setosa* grafting and testing.	100	85	85
3.2.1	JK	Validated portable LAMP tool for detecting SPFMV & SPCSV	6	2016	Behind schedule	6	2017	**Y1:** New LAMP assays from FERA designed, we have started testing repackaging with SPFMV and SPCSV assays; assay working for SPFMV and East African strain of SPCSV. **Y2:** A new software, LAMP Designer 1.13, was purchased and installed at CIP-Nairobi and Lima to enable efficient (re)design of LAMP primers for sweetpotato viruses. Can now field test in Lima and conduct trial to see how long key reagents could store. **Y2Q3:** Storability of LAMP reagent in current form <6 months. New tests being performed to improve stability. **Y2Q4:** Delay in arrival of reagents in Nairobi; will test Aug.–Dec. 2016; need to test different stabilizers for reagents in kit. **Y3Q1:** Trial run for detecting SPCSV and SPFMV in lab and field trial in Kenya in Aug. 2016 successful. **Y3:** New LAMP assays from FERA designed testing for SPFMV and SPCSV assays ongoing; assay working for SPFMV and East African strain of SPCSV. Primers for begomoviruses	100	95	95

Milestone #	Responsible	Key Milestones	Due Date		Current Status	Revised Date		Comment Concerning Current Status	Planned % of milestone as of 1 July 2017	% progress of milestone as of 1 July 2017	% progress/ planned July 2017
			Mon.	Year		Mon.	Year		Year 3	Annual	
								and SPCSV designed with LAMP Designer 1.13 software and ordered. Parameters for field test using LAMP optimized. This included sensitivity, specificity, repeatability, and reproducibility. Stability of reagents at room temperature to be evaluated.			
3.3.1	MM	At least three (5) countries have draft standards and protocols for quality assurance of sweetpotato seed based on evidence	1	2019	On track			**Y2Q1:** QDS write shop held in Ethiopia to capture lessons from development of seed standards, plan roll-out, and design study to assess where farmers benefit from QDS and inspection. Training of inspectors and roll-out in progress in 4 regions (SNNPR, Amhara, Oromia, Tigray). Tanzania: QDS inspections continue in LZ (Kinga Marando project) involving TOSCI officials. Inspection protocol under review by TOSCI. Uganda: discussions on draft standards with stakeholders including MAAIF led by MAK, training for 3 districts planned for Nov. Rwanda: Review of standards and training planned for Nov. Ghana, Nigeria, & Burkina Faso: Jumpstarting project meeting will start to discuss way forward for using QDS standards. **MidY2:** Tz: Formal & QDS standards still waiting ministerial approval. Uganda: Training delayed. Rwanda: Training postponed to Mar. 2016. Planning for Nigeria, BF, Ghana. Ethiopia: Study of roll-out will be done from June 2016. **Y2Q3:** QDS in Ethiopia being rolled out. Tanzania still waiting ministerial approval. Uganda: Training of inspectors in Apr. 2016. In Rwanda, 2 dialogue meetings with RAB and Rwanda Standards Board (RSB). RAB seed unit now officially requested RSB to prepare and submit standards. Zambia conducted annual training on seed standards; Mozambique, dialogue in process. In Malawi, unofficial standards in use. **EndY2:** Uganda piloting July 2016; DARS Malawi submitted revised draft standards to ministry for approval; Zambia	70	70	100

Milestone #	Responsible	Key Milestones	Due Date		Current Status	Revised Date		Comment Concerning Current Status	Planned % of milestone as of 1 July 2017	% progress of milestone as of 1 July 2017	% progress/ planned July 2017
			Mon.	Year		Mon.	Year		Year 3	Annual	
								will review after new Seed Act passed. **Y3Q1:** Rwanda (RSB) and Mozambique have draft standards for review; Ethiopia approved formal standards (PB, B, C). **Y3Q2:** Tanzania seed standards gazetted on Feb. 17. Uganda: Ready for publishing. Ethiopia study pending collaboration with RTB and PIM. **EndY3:** Nigeria drafted; Malawi trained inspectors in May 2017, but procedures still awaiting official approval; Kenya drafted. In Rwanda, standards still awaiting approval, but are in use in the field with positive feedback. In Ghana, QPDM standards printed; in Mozambique, stakeholder consultations on draft standards cont.; in Nigeria, stakeholder consultation to review final draft in May 2017; in Burkina Faso, draft submitted for approval. PIM-RTB-FTA study to review seed policy framework for VPCs will be piloted in Kenya end of June. 9 out of 11 countries now have drafted or revised SP seed standards.			
3.4	MM	Report on testing medium- to large-scale models for basic seed production	1	2019	On track			This started in Sept. 2015, with receipt of seed systems supplemental funding. Includes work in isolated rice schemes in Uganda. By June 2016, larger scale multipliers should have been identified & trained in Uganda, Tanzania, & Ethiopia. **MidY2:** Sites and medium-scale multipliers identified in Ethiopia and Uganda; ongoing in Tanzania. **Y2Q3:** Training and registration of cooperative ongoing in Ethiopia; sites under selection in Tanzania in collaboration with SeFaMaCo, Fast Track. SP-rice seed rotation study established in Agoro Irrigation scheme in N. Uganda. Rapid seed market assessment underway in Agoro (May 2016). **Y3Q2:** Basic multipliers established and received biz skills training in Ethiopia, Uganda, and Tanzania, where cost data were collected. 2nd cycle of rotation study data in Agoro, Uganda collected.	50	50	100

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			Mon.	Year		Mon.	Year		Year 3	Annual	
								EndY3: Uganda (Agoro): marketing strategy planned and implemented. Tanzania (LZ) marketing strategy under implementation. In Ethiopia 27 farmers registered as part of cooperatives and 3 farmer training centers as "missing middle" operators.			
4.1.1	DR/TS	Year-round supply of OFSP roots for a major urban market significantly improved	7	2017	Behind schedule	6	2018	**Y1:** Storage research linked to SUSTAIN projects in Kenya and Mozambique. Feasibility studies conducted in both countries. In Kenya, fresh roots will be linked to agro-processor of purée. In Mozambique, will target fresh root market. **Y2Q1:** Harvesting and pre-storage handling identified as having an important impact on root quality in Kenyan case study. **Y2Q2:** Report of trials on impact of handling and transport in Western Kenya. **Y2Q1:** Curing/holding facility created by upgrade of existing facility at purée processing plant in Kenya. Trials initiated to test efficacy of curing to improve midterm (1 month) storage. Two larger-scale longer term trials have been initiated. Curing conditions can be effectively maintained, but technical problems have meant that the target temperature for subsequent storage have not been maintained, and have highlighted the need for a robust system for identifying and solving equipment problems as they arise. Supply improvement has been delayed by delays in appropriate storage facility.	80	80	100
4.1.3	DR/TS	Improved techniques for larger-scale curing and storage appropriate for SSA developed & appropriate brochures/briefs produced	7	2017	Behind schedule	4	2018	**Y1:** Private sector partner, Organi Ltd, identified in Kenya; short-term holding facility constructed to improve the consistency of supply of OFSP roots to the processor. Protocols to improve handling of roots prior to storage developed. **Y2Q1:** Curing/holding facility created by upgrade of existing facility at purée processing plant in Kenya. Trials initiated to test efficacy of curing to improve midterm (1 month) storage. **Y2Q1:** Curing/	80	70	87.5

Milestone #	Responsible	Key Milestones	Due Date		Current Status	Revised Date		Comment Concerning Current Status	Planned % of milestone as of 1 July 2017	% progress of milestone as of 1 July 2017	% progress/ planned July 2017
			Mon.	Year		Mon.	Year		Year 3	Annual	
								holding facility created by upgrade of existing facility at purée processing plant in Kenya. Trials initiated to test efficacy of curing to improve midterm (1 month) storage. Two larger-scale longer term trials have been initiated. Curing conditions can be effectively maintained, but technical problems have meant that the target temperature for subsequent storage have not been maintained, and have highlighted the need for a robust system for identifying and solving equipment problems as they arise. **Y3Q1:** Testing improved evaporative cooling unit with simplified selection of curing or storing conditions. Q2 progress limited by delay in establishment of storage facilities. **Y3Q2**: 1st three trials did not achieve objective; re-worked storage facilities in July/Aug. 2016. New trials started comparing solar and grid energy supply in Dec. 2016, in Kenya but issues still exist with reaching desired temperature of 15°C. Alternative approach using coolbot under design in Southern Africa. **Y3:** Western Kenyan stores successfully constructed and tested capable of 4 months' storage of roots providing sufficient quality for processing (70% of weight of roots retained). Further trials on storage technology ongoing. Handling trials delayed. In June 2017, built new storage facility in W. Kenya with solar-powered air cooling system that will be able to lower temperatures to 15°C.			

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			Mon.	Year		Mon.	Year		Year 3	Annual	
4.1.4	DR/TS	Improved techniques for fresh root harvesting, packaging, and transport & appropriate brochures/briefs produced	1	2017	Behind schedule	3	2018	**Y1:** Trials initiated in Kenya on keeping qualities of different harvesting and roots-cleaning methods and packaging during transport. **Y2Q2:** Trials in Ghana for long-distance transport showed roots in tomato boxes suffered least damage; 2nd best were polypropylene sacks with **only** 50 kg of roots; **Y2Q1:** Harvesting and pre-storage handling identified as having an important impact on root quality in Kenyan case study. **Y2Q1:** UDS preparing for next round of trial. **Y2Q2:** Report of trials on impact of handling and transport in Western Kenya. Need to run more trials based on new knowledge. **Y3Q2**: UDS validation trials completed. 50-kg polythene bag best container (current method uses extended bags) in Northern Ghana. Storage trial in Kenya testing washed vs. unwashed roots—not much difference, if washed roots are briefly sun dried. Pre-storage handling to be focus for next project period. Brochure preparation for improved handling initiated.	100	70	70
4.2	TC	Report and brochures for improved methods for storing fresh roots for home consumption at the household level	12	2018	Behind schedule			**Y1:** Positive results from the Double S or sandbox storage method tested in Ghana & Malawi. **Y2Q2:** Brochure late being produced on root storage; in sand; sand box superior to moistened heaps (traditional practices in Ghana). Evaporative cooling trial started in Jan. 2016. **Q3:** No progress; must wait for next harvest period Sept./Oct. 2016. **Y3Q2:** Missed trial opportunity in Sept. 2016; draft brochure on Double S prepared and revised in 2017.	50	45	90

Milestone #	Responsible	Key Milestones	Due Date		Current Status	Revised Date		Comment Concerning Current Status	Planned % of milestone as of 1 July 2017	% progress of milestone as of 1 July 2017	% progress/ planned July 2017
			Mon.	Year		Mon.	Year		Year 3	Annual	
4.3	TM	Report on viability of storing purée/ concentrate without a cold chain and the quality and safety of products made from stored purée vs. fresh	6	2017	On track			**Y1:** Protocol designed and first and second rounds of testing in progress. Vacuum packing with preservatives and citric acid very promising. **Y2:** Repeated testing of vacuum packing & natural vs. chemical preservatives revealed 2 high potential solution for storage up to 6 months. Bread products with fresh purée have been analyzed for beta-carotene content but not yet with stored purée. We developed OFSP purée shelf-stable for 6 weeks at 20–23°C with sorbate, benzoate, and citric acid, and developed bread with it. The bread tastes good but it takes long to proof. **Y3:** Construction of storage facility just for purée constructed and purée shelf-life now being tested. OFSP bread—HPLC analysis complete; 4 manuscripts and 1 guidebook in preparation. Volume of bread made with OFSP purée with preservatives now attains same volume as 100% wheat flour bread with increased yeast % and adding baking powder. Purée able to withstand microbial "challenge" for 12 weeks at room temperature. OFSP bread quality best at storage temperatures not above 25°C. The preservative combinations of 1% citric acid, 0.25% potassium sorbate, and 0.25% sodium benzoate together with vacuum packing and stored at temperatures below 24°C can be stored for 3–4 months and used to make bread with a proofing time of 1 hr with 1.5% yeast and addition of 1% baking powder to actual the same bread volume at standard bread. Data on OFSP purée bread consumers collected from Tuskys. High-fiber purée developed.	90	90	100
4.4	TM	Reference laboratory for nutritional quality & food safety in use	6	2019	On track			**Y1:** FANEL established in collaboration with BecA. Lab now has CIP food scientist and technician; supplies procured. First run of HPLC in January 2015; microbial detection lab set-up in progress. **Y2:** HPLC fully functional for carotenoids and vitamins A, E, and C. Microbial lab functional and doing total viable	50	50	100

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			Mon.	Year		Mon.	Year		Year 3	Annual	
								counts. Cost data collected, awaiting analysis. First 4-month intern from Cornell University assisted in food safety training. Identified Malawian student at NCSU to work on bioaccessibility in Y3. **Y2Q3:** The proximate analysis equipment is being installed, the phytonutrient protocol was tested, and second used HPLC from CIP-HQ received in Sept. 2016. We have two interns (M.Sc. in food safety and quality management) from University of Nairobi working on OFSP purée storage, and OFSP bread consumer profiling studies. **Y3:** Additional HPLC installed in Sept. 2016, expanded analytic capacity; bio-accessibility studies initiated. To date, 8 graduate students working within FANEL. A new graduate student identified to work on sensory panels for bread made with different formulations with shelf-stable OFSP purée. University of Nairobi collaborator Dr. George Abong obtained ABCF fellowship from BecA to work on phytonutrient analysis of OFSP and in-vitro glycemic index of OFSP products. Sarah Chilungo from NCSU working on bioaccessibility studies of beta-carotene from OFSP flour products and OFSP purée products. Derick Malavi, Cecilia Wanjuu, and Joyce Musyoka submitted their masters' theses in June and will graduate in Aug. Mercy, another graduate student from University of Nairobi, will start survey of OFSP nutrition in children in western Kenya. Proximate and beta-carotene analysis of OFSP purée bread conducted at different levels of purée substitution. 4 baked OFSP products for Rwanda analyzed for beta-carotene and proximate analysis conducted.			
5.1.1	JL	Minutes of annual breeding meetings highlight progress being made in	7	2019	On track			**Y1:** Meeting held 2–5 June 2015, in Mukono, Uganda. **Y2:** Meeting held 6–10 June 2016, in Nairobi, Kenya. Minutes available as milestone reports. Updated breeding progress paper	50	50	100

Milestone #	Responsible	Key Milestones	Due Date		Current Status	Revised Date		Comment Concerning Current Status	Planned % of milestone as of 1 July 2017	% progress of milestone as of 1 July 2017	% progress/ planned July 2017
			Mon.	Year		Mon.	Year		Year 3	Annual	
		capacity building and info sharing						submitted to APA meeting in October 2016. **Y3:** Annual meeting 15–18 May 2017, in Kigali.			
5.1.2	JL	Presentations of SPHI meeting & evaluation of its usefulness	7	2019	On track			**Y1:** Phase 2 financed Sept. 2014 annual meeting; minutes available as milestone report. Presentations posted on renovated SKP. **Y2:** 6th annual meeting held in Kigali, Rwanda. **Y3:** 7th annual meeting held in Addis Ababa, Ethiopia. Minutes and evaluation completed. Minutes of PAC and SC meetings ready.	60	60	100
5.1.3	JL, in coor-dination with CoP leaders	Presentations and minutes of CoP meetings	7	2019	On track			**Y1:** Minutes available for meetings held: MLE (3–4 Mar. 2015); Seed Systems & Crop Management (28–29 Apr. 2015); and Marketing, Processing, and Utilization (20–21 May 2015); Breeding & Genomics (2–5 June 2015). **Y2:** Seed Systems Pre-basic Seed (8–10 Dec. 2015); Marketing, Processing, and Utilization (14–16 Mar.); MLE (27–29 Apr.); Seed Systems and Crop Management (9–12 May) in Arusha. **Y3:** 2nd Seed System meeting just for pre-basic seed system subgrantees held in Nairobi (6–8 Dec. 2016); MLE meeting in Maputo (30 Jan.–2 Feb. 2017); MPU meeting in Kisumu, Kenya (2–3 Mar. 2017); Seed Systems Pre-Basic subgroup and CoP meeting in Mukono, Uganda (12–14 June 2017).	50	50	100
5.1.4	JO	Database on dissemination efforts updated annually & use of SKP monitored	7	2019	On track			**Y1:** Tested monitoring with smartphones in collaboration with Nigeria project. Began mapping DVMs in each country; embarked on SKP redesign with Netmidas. 1st Sweetpotato in SSA update report prepared for SSC meeting held 2 Oct. 2015, in Kigali; 2nd update presented in Addis Ababa in Oct. 2016. Renovated SKP relaunched in Feb. 2016. Monthly E-Digest of highlights from SKP started in May 2016. **Y3:** Contact list for SSA still being updated. New Kenyan company hired to fix remaining SKP problems in Dec. 2016; expected to finish by 15 July 2017.	50	50	100

APPENDIX B. SASHA 2 YEAR 3 DETAILED BUDGET AND EXPENDITURES

Sweetpotato Action for Security and Health in Africa (SASHA): Phase 2

Organization Name: International Potato Centre (CIP)

Financial Year: 2016/2017 : Year_3_Financial_Report_as_of_June 30 2017

Budget Line Items	Year 1: Expenses	Year 2: Expenses	Y3: Budget	Y3: Expenses	Y3: Balance	% Spent
	USD	USD		USD	USD	USD
Total Personnel	**1,459,545**	**1,585,841**	**1,772,656**	**1,721,662**	**50,994**	**97%**
Breeding	**752,313**	**759,684**	**832,926**	712,766	120,160	86%
Weevil Resistance using Transgenics	**178,206**	**60,958**	**31,487**	31,985	(498)	102%
Seed Systems	**176,782**	**216,427**	**301,452**	310,769	(9,317)	103%
Postharvest management and nutritional quality	**26,463**	**36,887**	**72,292**	80,862	(8,570)	112%
Governance	**325,781**	**511,885**	**534,499**	585,280	(50,782)	110%
Total Travel	**373,832**	**569,595**	**563,254**	**507,584**	**55,670**	**90%**
Breeding	**133,976**	**189,320**	**179,571**	169,912	9,659	95%
Weevil Resistance using Transgenics	**20,428**	**3,787**	**-**	288	(288)	0%
Seed Systems	**35,991**	**94,401**	**156,270**	115,862	40,408	74%
Postharvest management and nutritional quality	**6,409**	**18,780**	**19,302**	13,215	6,087	68%
Governance	**177,028**	**263,306**	**208,111**	208,307	(196)	100%
Total Sub-grants to Others Organizations	**463,696**	**628,429**	**766,491**	**507,972**	**258,519**	**66%**
Breeding	**33,077**	**54,437**	**104,421**	70,634	33,788	68%
Weevil Resistance using Transgenics	**190,311**	**-**	**-**	-	-	0%
Seed Systems	**69,642**	**371,996**	**559,538**	373,275	186,263	67%
Postharvest management and nutritional quality	**170,666**	**201,997**	**102,532**	64,063	38,469	62%
Governance	**-**	**-**	**-**	-	-	0%
Total Equipment	**138,289**	**84,797**	**68,699**	**46,118**	**22,581**	**67%**
Breeding	**62,133**	**59,524**	**6,199**	6,199	-	100%
Weevil Resistance using Transgenics	**-**	**-**	**-**	-	-	0%
Seed Systems	**34,806**	**-**	**17,000**	14,245	2,755	84%
Postharvest management and nutritional quality	**41,350**	**25,273**	**45,500**	25,674	19,826	56%
Governance	**-**	**-**	**-**	-	-	0%
Consulting	**-**	**45,494**	**38,849**	**30,035**	**8,813**	**77%**
Breeding		**15,904**	**-**	-	-	0%
Weevil Resistance using Transgenics		**-**	**3,090**	-	3,090	0%
Seed Systems		**21,500**	**25,567**	19,843	5,723	78%
Postharvest management and nutritional quality		**-**	**-**	-	-	0%
Governance		**8,090**	**10,192**	10,192	-	100%
Other Direct Costs	**769,978**	**1,044,293**	**1,019,012**	**998,579**	**20,433**	**98%**
Breeding	**510,576**	**668,583**	**496,870**	482,858	14,012	97%
Weevil Resistance using Transgenics	**58,830**	**41,121**	**44,580**	44,232	349	99%
Seed Systems	**96,757**	**148,772**	**219,137**	216,218	2,919	99%
Postharvest management and nutritional quality	**29,624**	**88,684**	**90,000**	86,421	3,579	96%
Governance	**74,191**	**97,133**	**168,424**	168,850	(426)	100%
Total Direct Costs	**3,205,339**	**3,958,449**	**4,228,960**	**3,811,950**	**417,010**	**90%**
Total Indirect Costs	**480,801**	**590,821**	**634,344**	**571,792**	**62,551**	**90%**
Grand Total Costs	**3,686,139**	**4,549,269**	**4,863,304**	**4,383,742**	**479,561**	**90%**

Summary	Year 1 : Expenses	Year 2: Expenses	Y3: Budget	Y3: Expenses	Y3: Balance	% Spent
	USD	USD		USD	USD	USD
Total CIP Direct costs	**2,741,643**	**3,330,019**	**3,462,469**	3,303,978	158,491	95%
Total indirect costs	**480,801**	**590,821**	**634,344**	571,792	62,551	90%
Total Subgrantees	**463,696**	**628,429**	**766,491**	507,972	258,519	66%
Grand totals	**3,686,139**	**4,549,269**	**4,863,304**	**4,383,742**	**479,561**	**90%**

CIP

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