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| Concept | Pre-Proposal | Investment Development | Management & Close |

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.

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| General Information |
| Investment Title | Improvement of Banana for Smallholder Farmers in the Great Lakes Region of Africa |
| Grantee/Vendor | International Institute of Tropical Agriculture |
| Primary Contact | Rony Swennen | Investment Start Date | 1 October 2014 |
| Feedback Contact1 | Rony Swennen | Investment End Date | 30 September 2019 |
| Feedback Email1 | r.swennen@cgiar.org | Reporting Period Start Date | 1 October 2015 |
| Program Officer | Jim Lorenzen | Reporting Period End Date | 30 September 2016 |
| Program Coordinator | Josephine Day | Reporting Due Date | 30 October 2016 |
| Investment Total | US$13,873,600 | Opportunity/Contract ID | OPP1093845 |
| Scheduled Payment Amount (If applicable) | US$2,950,110 |  |  |
| 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, and Subgrants and Subcontracts.* |
| Date Submitted | 31st October 2016 | Submitted by Contact Name | Kristina Roing de Nowina |
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# Progress and Results

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| Progress Details |

Provide information regarding the current period's progress towards achieving the investment outputs and outcomes. In addition, submit the Results Tracker with actual results as requested.

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| **Background**:1. This project focuses on drastically improving the speed and efficiency of breeding bananas, in particular starchy staple food bananas in Eastern Africa: it aims to dramatically upscale existing breeding activities, build a breeding and selection pipeline, improve data management, and increase the pace and efficiency of breeding by conducting research for identifying methods for achieving higher rates of seed set and developing molecular markers for early selection of priority traits. We will combine genetic and genomic studies on segregating populations for mapping sources of resistance to the target pests and diseases. This will be complemented by improved characterization of the spread and virulence of the four target pests and diseases in five testing sites and the development and application of faster bio-assay screens.
2. Structure of the project: it has been structured around five strategic goals and one management goal (hereafter referred to by their short titles shown in bold below):
3. **Banana Breeding Pipeline:** Enhanced performance of banana breeding systems in Eastern Africa to deliver improved East African highland bananas with increased levels of pest and disease resistance, higher yields, and better consumer acceptability.
4. **Pest and Disease Control:** Enhanced host plant resistance to major pest and disease constraints through improved pathogen identification and accelerated early stage screening of resistance.
5. **Leveraging Genetics:** Improved breeding efficiency throughmolecular-basedgenetic studies for increased understanding of underlying genetics and development of DNA marker-based early selection.
6. **Empowering End-user Evaluation:** System for better tailoring breeding products and increasing adoption of new cultivars through end-user feedback systems and participatory evaluation of improved banana germplasm.
7. **Harnessing Data:** Driving improved efficiency of breeding systems and enhanced synergy in national, regional, and global partnership through an open-source database and tool box for banana breeders and researchers.
8. **Governance, Research Oversight, and Management**: Coordinating breeding efforts integration, capacity building, communication, and dissemination undertakings and to ensure long-term project impacts, through embedding breeding and research planning, and review in a users’ perspective forcing all in the research-for-development process into an adoption-orientated focus.
9. Organization of the strategic research goals:

**Part A**. The first 5 strategic goals are organized around 5 work packages (WP), while strategic goal 6 is implemented via a project leader, a steering committee, and a science advisory group.1. Banana Breeding Pipeline: led by NARO, in collaboration with IITA, KULeuven, EMBRAPA, and NRCB.
2. Pest and Disease Control: led by Univ. of Stellenbosch (South Africa), in collaboration with Univ. of Queensland (Australia), NARO, IITA, ARI (Tanzania), and Bioversity International.
3. Leveraging Genetics: led by IITA, NARO, SLU-Sweden, in collaboration with Univ. of Stellenbosch, Univ. of Malaya, Univ. of Queensland, and EMBRAPA.
4. Empowering End-user Evaluation: led by Bioversity International, in collaboration with ARI-Tengeru, NARO, and IITA.
5. Harnessing Data: led by BTI, Cornell Univ., in collaboration with IITA, NARO, NRCB, and EMBRAPA.

**Part B**. Status of Contracts and consequences: 1. In the previous Year 1 annual report, we reported that despite significant efforts, the contract with Univ. of Malaya (UM) was not implemented and the contract with NRCB, India remained unsigned.
2. We are pleased to report that UM has now become active, since the second half of Year 2. This has been effected through a number of changes, most importantly being the change in UM responsibilities. The responsibilities of the Project contact, Professor Dr Rofina Yasmin Othman, changed to Associate Vice Chancellor (Industry and Community Networks, and Director, University Malaya Centre for Innovation & Commercialisation (UMCIC)), and as such her responsibilities for the Project were passed on, and are now managed by the Centre for Research in Biotechnology for Agriculture University of Malaya (CEBAR). The Co-PI for this project is Prof Dr. Jennifer Ann Harikrishna who is the director of the centre. A project manager for CEBAR has been appointed to coordinate Project activities including timely reporting and comprehensive communication. CEBAR has included a collaborator for the work on segregating populations in the field—Dr Fatimah Kayat from University Malaysia Kelantan (UMK). The participation of Dr Kayat in the second Annual Project Workshop in May 2016 in Arusha proved very useful in paving the way for a smooth collaboration. Dr Fatimah was formerly with the banana group in UM but now leads the breeding program in UMK. UMK collaboration will be carried out as partners under the UM subcontract.
3. NRCB, India. Numerous efforts during project Year 2 have led to the signing of the contract on 12th October 2016 (in fact now just 2 weeks into project Year 3). Crucial was the involvement of Dr. Lava Kumar, IITA international staff, and the official announcement of the replacement of Dr Mustaffa by Dr Krishna Kumar, DDG-Horticulture and nodal point at ICAR (Indian Council of Agricultural Research), responsible for NRCB and partnerships. Interaction with Dr K. Kumar in December 2015 led to his participation in the Annual Project Workshop in May 2016 in Arusha. Since IITA and NRCB have no MoU, it was mutually agreed to conduct transactions through a contract between IITA and Bioversity Office in New Delhi. However, it took until 18th August to gain approval from ICAR for this. To enhance proceedings and facilitate progress, a visit by the NARO and IITA banana breeders to NRCB is scheduled soonest, for which a date has been delayed pending finalizing of contract details.
4. In the Results Framework and Results Tracker we provide information on the progress of each contract and variation of each output, and presented based on primary outcomes 1–9.
	1. primary outcomes 1: WP on Banana Breeding Pipeline
	2. primary outcomes 2: WP on Pest and Disease Control
	3. primary outcomes 3: WP on Leveraging Genetics
	4. primary outcomes 4–7: WP on Empowering End-user Evaluation
	5. primary outcomes 8: WP on Harnessing Data
	6. primary outcomes 9: WP on Governance and Management

This will be further discussed in detail, with additional details provided in Annexes 2–30; see Annex 1.1. Organization of the Governance, Research Oversight, and Management:
	1. Management: further to the termination of the incumbant manager during the probationary period in Year 1 because of unsatisfactory performance, the position was filled by an exisiting IITA staff member on a part time basis, Danny Coyne, who is familiar with the banana crop and most of the partners. He came on board in November 2015; an initial task was to recruit a Project Administrator, which resulted in the recruitment of Scola Ponera. Other significant activities have included organizing the Annual Project Workshop and coordinating SC meetings, WP meetings, and SAG interaction with Project members. Currently, Prof. Rony Swennen acts as the Project Coordinator and technical lead, Danny Coyne as Project Manager and Scola Ponera as the Administrator, all of whom work closely together as a team (Annex 2).
	2. Steering Committee (SC): consisting nine members (Annex 2) including the secretary and a BMGF non-voting member met at the Annual Project Workshop in a combined meeting with the Science Advisory Group (SAG) (Annex 3, 4). There have been no changes to the SC or SAG since the annual report for Year 1.
	3. Science Advisory Group (SAG): members Jane Gibbs and Eva Weltzein attended the Project Annual Meeting in person; Steve Rounsley and Richard Sikora attended certain sessions by skype. The SAG has been in contact with WP leaders and staff on an *ad hoc* basis and reviews project outputs twice annually against the existing Results Framework and Results Tracker.
	4. Annual Project Workshop was held successfully at the NM-AIST, Arusha, Tanzania between 2 and 5 May, 2016 (Annex 4).
	5. An exciting development during the year has been an African Development Bank (AfDB) initiative with IITA, and other prominent partners, e.g., FARA, other CG centers, National Programs, and African institutions, towards enhancing the delivery of proven technologies: Technologies for African Agricultural Transformation (TAAT). Banana and plantain value chain is included within this and currently has US$20 million apportioned for this, with a primary objective of upscaling the availability and regional suitability of the banana (known as NARITA: http://www.promusa.org/NARITA+hybrids) and plantain (known as PITA: http://www.promusa.org/PITA-16) elite hybrid material. This will enable the outputs of this current BMGFproject to be channeled through this initiative, facilitating product delivery. This AfDB initiative is planned to start in January 2017.
2. Capacity building and communications:
3. A total of 20 postgraduate students are currently associated with the project as shown in Table 1 and Annex 5, 6, similar to Year 1 (Annex 7). Capacity building is a key objective of the project and it aims to increase the number of associated students, using the project as a platform to support those with alternative funding for training and thesis work, especially female students.

**Table 1.**

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|  | Female | Male | Total | Supported by the project | Support from outside the project |
| PhD | 2 | 7 | 9 | 7 | 2 |
| MSc | 7 | 4 | 11 | 3 | 8 |

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|  | Work package |  |
|  | WP 1 | WP2 | WP 3 | WP 4 | WP 5 |
| PhD  | 3 | 3 | 1 | 2 | 0 |
| MSc | 3 | 2 | 2 | 4 | 0 |

1. During the year a range of outputs have been produced and communicated through various channels (Annex 8). The Annual Workshop in May and the official launch of the Tissue Culture Laboratory at NM-AIST (Nelson Mandela African Institution of Science and Technology, hosting IITA) in Arusha, Tanzania achieved major exposure through television, radio, and newspaper, as well as through the many attendees, including numerous prominent Tanzanian officials. A total of 12 book or journal articles were produced during this period by project staff/partners and at least 14 in process of review, drafting or being planned. Eight conference presentations were made, one invited and a further two poster presentations made at international meetings, such as through attendance at CORBANA and FAO convened for a. Some of this was funded by other projects but results are relevant for this project. In addition, a number of training workshops have been conducted which are reported on separately. In particular, additional funding was secured from VLIR (Belgium) for a Banana Breeding Training Workshop in Uganda (<http://www.isaaa.org/kc/cropbiotechupdate/article/default.asp?ID=14836>) with 28 participants (Annex 9) and associated with a recent publication (<http://www.iibn.eu/index.php?page=83>) describing breeding strategies in banana (Annex 10). Another prominent workshop involved a combined effort by WP2 and WP4 for training in sampling, data collection, and data recording (Annex 11) for which two training manuals were produced (Annex 12 and 13).
2. The investment outputs and outcomes: the major achievements are:

**primary outcomes 1: WP 1 on Banana Breeding Pipeline*** Most importantly the Project is on schedule and we anticipate reaching the primary Outcome 1 target for Year 5 as planned. This is due to several factors, such as the expansion of breeding fields, increased seed set, and current success in selection at the EET and PYT levels. Consequently, the Matooke and Mchare breeding pipeline has been substantially increased, with an anticipated 3-fold increase in seed production as opposed to the 15–20% target; already we have 113,153 seed of the 4x-2x crosses, for example, and 15,087 Mchare seed. See Table 2 for details. As this is so important, we present below a brief overview of the current state and projected state at the end of the project.

**Table 2.**

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| ***Primary Outcome 1:*** *Matoke and Mchare breeding pipeline performance increased by a 15-20% higher production of seeds facilitating a wider selection for the delivery of pest and disease resistant hybrids* |
| **Parameter** | **Target** | **Actual overall numbers** **(after 2 years)-** | **Actual number by NARO (after 2 years)-** | **Actual number by IITA-Uganda****(after 2 years)-** | **Actual numbers by IITA-Arusha****(after 2 years)** | **Expected results for the next 3 Years/****General remarks** |
| Seed increase in Matooke and Mchare | 15-20% | 3x-2x = 1,6504x-2x = 113,153 Mchare-2x =15,087 | 3x-2x = 10454x-2x = 62,166 Mchare-2x =357 | 3x-2x = 6054x-2x = 50,987 Mchare-2x =0 | 3x-2x = 04x-2x = 0 Mchare-2x =14,730 | A 3-fold increase in seed of Matooke and Mchare has been as a result of increased pollination blocks with increased flowered banana plants.  |
| improved diploids integrated into the matooke and Mchare breeding pipeline | 70 | 30 improved diploids are being characterized and already integrated in the NARO and IITA breeding pipeline. 20 parthenocarpic diploids received from EMBRAPA are under multiplication for characterized  | 30 improved diploids are being characterized and already integrated in the NARO and IITA breeding pipeline. | 20 parthenocarpic diploids received from EMBRAPA are under multiplication for characterized | - |  -26 improved diploids will be selected from diploid EETs (2616 hybrids) at a success rate of 1%.-Together the total number of diploids integrated into NARO-IITA breeding pipeline will most likely exceed 70. |
| Matooke hybrid under evaluation in the EET (early evaluation trial) | 12000 | 3008 hybrids from 4x-2x and 127 hybrids from 3x-2x crosses are in EETs. | - 2450 hybrids from 4x-2x are in EET.-110 hybrids from 3x-2x crosses are in EET. | - 558 hybrids from 4x-2x are in EET.-17 hybrids from 3x-2x crosses are in EET. | - 156 hybrids from Mchare -2x in EET. | 7500 hybrid seeds generated during July to September 2016 are undergoing embryo rescue and more seeds being generated. It is expected that enough matooke hybrid seeds will be generated next year (third) to meet the 12,000 project target. |
| Matoke hybrids (beyond NARITA 1-26)  tested in PYT (preliminary yield trial) | 95 | 25 potential hybrid selections for advancement to PYTs are already identified from an EET of 930 genotypes. This is an estimated rate of success of selection of 2.7%. | 25 potential hybrid selections for advancement to PYTs are already identified from an EET of 930 genotypes. This is an estimated rate of success of selection of 2.7%. | - | - | 2078 more hybrids not yet flowered are in EETs of 4x-2x. Assuming a selection intensity of 2.5% on a total 3008 hybrids already in EETs, 75 hybrids will be advanced to PYTs in the next 2 years. The 7500 seeds under embryo rescue and those being generated are expected to increase the number to about 110.  |
| Development of Mchare hybrids | 2400 seeds for embryo rescue | 15,087 Mchare seeds are so far generated.  | Mchare-2x =357 | Mchare-2x =0 | Mchare-2x =14,730 | More Mchare seeds are continuously generated.  |

Other striking achievements include:* The time lapse technology developed at KULeuven was successfully transferred to the field in Uganda and Tanzania.
* Time lapse movies were made over several days on the flowering process of Mchare/Matooke. The same process was observed as in the greenhouses at KULeuven.
* A comparison of seed fertile and seed sterile varieties showed that seed fertile banana varieties open their bracts earlier than seed sterile varieties, which open in the evening. In addition, first results show that stigmas can be receptive before flower opening. This information indicates that the current timing for pollination is suboptimal and that, in general, pollinations are conducted too late.
* The ongoing research on floral biology and cross-ability study in Matooke and Mchare has shown that use of a sucrose solution in pollination increases seed set by 108% compared to the conventional pollination technique (Annex 14).
* A partial pictorial catalog of Mchare/Matooke flowers at different developmental stages was developed (Annex 15 and 16), as a basis to optimize pollination time.
* A first draft catalog was made of 30 improved diploids assembling characterization data (Annex 17). This brings together information for the Musabase (<https://musabase.org/>) and for optimized selection for future breeding schemes.
* Improved diploids were obtained from EMBRAPA (Annex 18) and are now being multiplied for evaluation and future breeding use. This is a major achievement as these diploids were developed for Fusarium resistance and exchange of material from Brazil is usually a difficult undertaking.
* Large fields were planted with 15 Matooke varieties and 10 Matooke tetraploids to produce the planned number of seeds, and thus hybrids. Seed set results show that the most seed-fertile Matooke varieties are Nakawere, Enzirabahima, and Nakyetengu, Nakasabira, Nakabururu (NEW Annex 19). However based on past selections for NARITAs, Nakawere, Enzirabahima, and Entukura, Nfuuka, Kabucuragye appear to give rise to the best hybrids. As experienced with plantain, the best offspring is not neccesarily derived from the best seed-producing females. However with Nakawere and Enzirabahima we have identified 2 varieties that produce relatively high numbers of seed and results in good hybrids. See Annex 19 for descriptive catologue of these.
* Significant differences in female fertility of Mchare identified, therefore the ratio of cultivars in pollination blocks will be altered to reflect this, increasing Huti-white and reducing Kisukari Mchare.

**primary outcomes 2: WP on Pest and Disease Control*** Isolates of Foc (Annex 20), weevils, nematodes, and Sigatoka collected from breeding sites.
* Collections of Fusarium and Sigatoka established.
* Rapid and accurate methods to determine the identity for Fusarium and Sigatoka developed or transferred.
* Distribution map for Fusarium wilt and Sigatoka drafted.
* Evaluation of EAHB hybrids begun for resistance screening against Sigatoka leaf spot and banana weevil.
* Evaluation of Mchare hybrids begun for resistance screening against Sigatoka leaf spot and banana weevil.
* NARITA hybrids have been planted at five screening sites.
* Experiments initiated for early screening for Fusarium wilt, Sigatoka, and banana weevil resistance.
* Training of field technicians during a training workshop (Annex 11), using established techniques in resource materials provided to the workshop participants (Annex 21) and including the production of a dedicated manual for use by technicians and field workers (Annex 12). Jointly organize a FAO-supported regional workshop on Foc and other phytosanitary issues (Annex 22).
* Conduct training on *Mycosphaerella* species isolation and identification, further to difficulties encountered with populations from Tanzania (Annex 23).

**primary outcomes 3: WP on Leveraging Genetics*** 10 diploid mapping populations at IITA/NARO, with 2 mapping populations under development in Malaysia and Australia.
* A portion of the Australian mapping population, developed for Fusarium genetics, has arrived at IITA Tanzania (75 genotypes, 3 plants per genotype). More plants are prepared in Australia to complete the mapping population in 2017 in Tanzania with 200 genotypes.
* Univ. of Queensland (UQ) showed that genotype 852 (ssp. *malaccensis*) is heterozygous for a QTL associated with resistance to TR4 and SR4. Phenotyping continues for SR4 at UQ for 29 H, 11 A (R), and 4 B (S). Marker assay is complete for these genotypes. Progeny of the segregating population (self-cross of resistant parent) showed reduced disease severity, indicating that other susceptibility genes are possibly present in the susceptible parents but not in the resistant parents.
* 33 candidate genes analyzed by UQ for gene expression showed SNP variations between the resistant and susceptible parents. Analysis of gene expression in 22/33 genes in root tissues challenged with FOC SR4 showed that a WRKY transcription factor appears to be highly expressed in the roots relative to that in the leaves.
* 10 mapping populations at IITA/NARO under development, some of which are complete, others consisting of seeds for embryo rescue and with plants *in vitro*/nursery/field (Annex 24).
* Phenotyping is ongoing and segregation confirmed for Fusarium (Australian population) and nematode resistance, plant height, bunch orientation, and fruit parthenocarpy but analysis is incomplete as only part of the population has been phenotyped. Phenotyping for weevil response in one population has begun with a duplicate of this population now *in vitro*.
* 2 populations with at least 200 genotypes each (Calcutta 4 × Calcutta 4; Monyet × Kokopo) are under evaluation for Fusarium resistance segregation in Uganda. A third population is being assessed in Tanzania (Paliama × Borneo). Populations are being backed up *in vitro*.
* DNA has been extracted and is stored at -20°C for these 3 populations.
* GBS data of the Kasaska × Borneo mapping population indicates that the population could be a BC1, not F2. Hence before genetic analysis is restarted, the population is being genotyped at IEB (Czech Republic, new research partner) using SSR markers to determine segregation without ambiguity. This population was developed for weevil resistance and has the potential to show variation in vitamin A content and bunch orientation.
* Nematode screening has begun in the screenhouse in Uganda using a series of batches, given limitations in space and time (Annex 25).
* IEB team visited the breeding operations in Uganda in December 2015, and agreed to assist with genotyping.
* A major proportion of the mapping population parents have been phenotyped for Black Sigatoka, varying in their response to black sigatoka from very susceptible to very tolerant (Annex 26). We therefore have high expectations that some of the mapping populations will segregate also for Black Sigatoka resistance.
* A new intermediate outcome 3.10 and Output 3.10.1 has been added to the tracker.
* Intermediate outcome 3.10: SNP-based genetic model for breeding for yield and agronomic traits in Matooke and Mchare developed.
* Output 3.10.1: Predictive breeding model developed for the yield and agronomic traits in predominantly triploid banana training population (320 genotypes).
* A predictive breeding model, based on genomic selection, is under development for yield and agronomic traits for East African Highland bananas (320 genotypes) using 3 field trials, in 3 different environments; in the most advanced field we are recording data from the second ratoon; for Cycle 1- Cycle 2- Cycle 3, respectively: Flowering: 100% - 93% - 72%; Harvesting: 98% - 87% - 64%. SNP data for the training population were recalled using the revised DH Pahang sequence data. The power of prediction with alleles called for pulp diameter and plant height are with the BRR (Bayesian Ridge Regression) model 62% and 53%; and with the BL (Bayesian LASSO) model 63% and 51%.
* 200 genotypes have been selected from EET for genotyping and phenotyping to enlarge the training population.

**primary outcomes 4-7: WP on Empowering End-User Evaluation*** A major achievement was the completion of NARITA planting at the 5 testing sites.
* All plants at all 5 sites were labelled, both in alpha-numerical and in QR code format, with a unique code that allows the unambiguous identification of each plant in each trial to follow its development over time. A weather station was installed in each of the 5 sites.
* The protocols for the mother-baby trials were reviewed with partners and agreed on by all.
* An electronic data collection tool was developed to facilitate data collection, standardization of data entry, and real-time data sharing. The data collection protocols were revised, and an electronic data collection form was developed in Fieldtask (<http://sg.smap.com.au>). The form is uploaded on a tablet or smartphone, and guides the data collector through the sequence of measurements to be taken in the field, at various lifecycle stages.
* Enumerators were trained in the use of the baseline methods and tools. A workshop, organized in September 2016 with WP2 (Pests and Diseases), provided training for field staff in the use of field trial data collection protocols and tools (Annex 11).
* A draft training manual was developed, which was updated with feedback received during the workshop (Annex 13).
* Approximately 1000 households were visited for the baseline study.
* Members of WP 2 joined the baseline study team to collect leaf samples of black leaf streak and Sigatoka leaf spot.
* A Gender Specialist was recruited on a postdoc position, with additionally secured funds, to work on integrating gender, especially gendered trait preferences, into banana breeding in East Africa. The specialist will start in November 2016.

**primary outcomes 8: WP on Harnessing Data** * Musabase on line; the breeding database was set up for the banana breeding community of users, with a test site dedicated to trainings and user testing: [http://musabase-test.sgn.cornell.edu](http://musabase-test.sgn.cornell.edu/) and the “live” site <https://musabase.org/>, the final data repository for the project.
* Musabase code developed to include experimental data (field layouts) in the database and subdivided into developmental sub-plots (ratooning cycles, which is specific to banana).
* Also photocapturing was organized as well as uploading using the fieldbook application.
* Trait ontology established, covering breeding (WP1,2,3) and supplemental variables (WP4) <http://musabase-test.sgn.cornell.edu/tools/onto/> (Annex 27).
* Training workshops on trait ontology and the fieldbook application were held in September at IITA Tanzania (10 attendees) and IITA-NARO Uganda (15 attendees, as well as at IITA Ibadan for the plantain breeding team (3 attendees) (Annex 28).

**primary outcomes 9: WP on Governance** * Text and information has been assembled for the website and content arranged for selected pages, while the homepage wireframe has been developed and the address bananabreeding.iita.org provided. Project logo has been developed, distributed and is being used (Annex 29). Website has yet to be released however, awaiting greater completion to provide a more complete overview of the project.
* Annual General Meeting/Workshop successfully conducted in Arusha, Tanzania in May (Annex 4), with lessons learnt for planning and arranging Year 3 Annual Project Workshop which is underway (Annex 30).
* Quarterly WP leader meetings schedule has been arranged and links between SAG and WPs instigated.
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| 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.

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| Of the overall total of 70 (which includes a new Output for Year 2 in WP3) outputs listed, we discuss below those that encountered some minor to serious delays. Additional information can be found in the Results Tracker.**primary outcomes 1: WP on Banana Breeding Pipeline**Output 1: *Floral development stages at and after anthesis characterized in 2 Matoke varieties*. 25%-25%-100%. Two of the three tasks are well advanced: (1) Characterization of floral development stages of 2 Matooke varieties is progressing well; (2) there is (albeit partial) a pictorial catalog of flowers at various developmental stages with work progressing well. No obstacles are anticipated to complete this work.However the work on microscopy still needs to begin for stigma development and pollen tube growth, correlated with flower developmental stages (see remark in Output 2).Output 2: *Preliminary correlation between seed set and flower and stigma developmental stages.* 25%. Preliminary studies on flowers have given exciting results, especially on the patterns of seed set and the time that stigmas are most receptive, which is before flower opening and seed set occurs, mostly in the lower hands. No obstacles are anticipated to complete this work. The use of sucrose solution in pollination increases seed set by 108% in one seed-fertile Matooke compared to the conventional pollination technique. This exciting result stresses the importance to further investigate the effect of sucrose, which warrants delaying the planned microscopy research on stigma development and pollen tube growth.Output 3: *Partial pictorial catalog of flowers/stigma at different developmental stages in 2 Mchare varieties. 25%.* The partial pictorial catalog of flowers at different developmental stages is progressing well without problem. No obstacles are anticipated to complete this work.Output 4: *Floral development stage for pollinations to obtain maximal seed set determined in 2 Mchare varieties.* 50%. Preliminary studies on flowers, especially on the patterns of seed set and the time stigmas are most receptive show that the stigma can be receptive before flower opening and that seed set occurs mostly in lower hands. No obstacles are anticipated to complete this work. Output 5: *At least 60 diploids of the NARO/IITA breeding program catalogued and characterized for pollen fertility, disease/pest resistance and high yield*. 50%. All diploids have been planted at the same site and data collection on agronomic, pest and disease resistance traits, and pollen fertility in 30 diploids is in progress. Partial data for cycle 1 is available. No obstacles are anticipated to complete this work. Output 6: *At least 20 improved diploids from the EMBRAPA and NRCB breeding progams introduced to the NARO/IITA breeding program, characterized for pollen fertility, disease/pest resistance, and high yields*. 30%. The sub-agreements with EMBRAPA were signed in month 12 (Year 1) and 20 parthenocarpic diploids were received from EMBRAPA. These accessions are at the proliferation stage of micropropagation. No obstacles are anticipated to complete this work. The sub-agreement with NRCB was finalized in October 2016. No obstacles are anticipated to complete this work.Output 7: *At least 50 diploid hybrids generated and selected for pollen fertility, disease/pest resistance, and high yield*. 20%. No obstacles are anticipated to complete this work. Output 12: *First time generation of 200 chromosome doubled Mchare varieties.* 75%. 1 NARO and 1 IITA Arusha Research Technicians were trained at IITA Nigeria. Upon return the work was initiated at NARO while the IITA Technician resigned. Recruitment of a new technician is in progress.**primary outcomes 2: WP on Pest and Disease Control** As the work involved varies between the 4 target pest and diseases, each with a different level of complication, there cannot be given a general variance for each output. Therefore we give 4 variances in the order: Fusarium, Sigatoka, nematodes, and weevils. Output 15: *Pests and diseases characterized in breeding and testing sites and screening banana cultivars for resistance to Fusarium wilt, Sigatoka, nematodes, and weevils*. 5-10-30-30%. Foc and Sigatoka are being completed, weevil characterization has been delayed as cross border movement was not possible (Ug team cannot carry the weevil samples from Tz; now reorganized for work to be undertaken by ARI-Tz), while nematode sampling still to be completed at 1 site. No obstacles are anticipated to complete this work.Output 16: *Collect and preserve Fusarium wilt, Sigatoka, nematodes, and weevils from each breeding and testing site for characterization and rapid screening of bananas.* 0-30-0-30%. Sigatoka work was delayed by lack of suitable miscroscope to view spores and a lack of training. IITA West Africa provided a pathologist to train staff in East Africa (Annex 22). Nematode sampling remaining at 1 site. No obstacles are anticipated to complete this work.Output 17: *Rapid and accurate methods to determine the identity and fitness of Fusarium wilt, Sigatoka, nematodes, and weevils developed and validated.* 0-20-100-50%. Adequate ITS primers for Sigatoka are now available and work ongoing. Ug team cannot carry the weevil samples from Tz (now this work will be taken over by ARI-Tz). No obstacles are anticipated to complete this work.Output 18: *Map the distribution of Fusarium wilt, Sigatoka, nematodes, and weevils of banana and using GIS link to climatic and environmental data.* 20-20-50-50%. Awaiting data from colleagues and the application of skills obtained during the training to accelerate the work. Also plants were lost. No obstacles are anticipated to complete this work.Output 19: *Map natural populations of Fusarium wilt, Sigatoka, nematodes, and weevils on station and at regional field testing sites in Uganda and Tanzania and determine influence of plant development, environmental conditions, and season on disease severity*. 100-60-50-100%. 5 testing sites were planted further to much delay as delivery of the *in vitro* plants from suppliers was much delayed. No obstacles are anticipated to complete this work.Output 20: *Evaluate resistance of EAHB hybrids on station and determine influence of plant development, environmental conditions, and season on disease severity caused by Fusarium wilt, Sigatoka, nematodes, and weevils.* 0-20-100-0-%. Sigatoka work now corrected by proper training (Annex 23). No obstacles are anticipated to complete this work.Output 21: *Evaluate resistance of selected Mchare diploids on station and determine influence of plant development, environmental conditions, and season on disease severity caused by Fusarium wilt, Sigatoka, nematodes, and weevils.* 100-0-50-0. This was caused by the delay by the *in vitro* suppliers delivering the plants. All 5 fields are planted. No obstacles are anticipated to complete this work.Output 22. *Evaluate resistance of 27 NARITA hybrids under varied field conditions at 3 regional field test sites and determine influence of plant development, environmental conditions and season on disease severity caused by Fusarium wilt, Sigatoka, nematodes, and weevils.* 90-90-100-70%. This was caused by the delay by the *in vitro* suppliers delivering the plants. All 5 fields are planted. No obstacles are anticipated to complete this work.Output 23: *In vitro screening methods for Fusarium wilt, Sigatoka, nematodes, and weevils developed to increase the speed and number of samples that can be evaluated in breeding programs.* 50-50-50-70%. Delays in plant multiplication by *in vitro* lab, and insufficient starting material. No obstacles are anticipated to complete this work.Output 24: *Compare the reliability of young plant resistance testing compared to whole plant testing in field for evaluations against Fusarium wilt, Sigatoka, nematodes, and weevils*. 80-80-50-0%. Delays in plant multiplication by *in vitro* lab, and insufficient starting material. No obstacles are anticipated to complete this work.**primary outcomes 3: WP on Leveraging Genetics** Output 30: *Phenotypic data on resistance to Fusarium wilt race 1 and race 4 in the Maa population*. 30%. The loss of plants in Year 1 due to in vitro contamination has been dealt with. New crosses were made in Australia, plants analyzed and a first batch of 75 genotypes arrived at IITA Tz. The remaining 125 genotypes will be sent in 2017 to complete the population. Output 33: *1 SNP-based linkage map constructed on a diploid population segregating for nematode resistance.* 20%. DNA was extracted and genotyped; the GBS data indicates that the population could be a BC1, not F2, however. The population is therefore being genotyped using SSR markers to determine segregation without ambiguity (at IEB, Czech Republic).Output 37: *1 SNP-based linkage map is constructed using the weevil-segregating population.* 20%. Similar situation as in Output 33, as the same mapping population is used for both weevil and nematode segregating studies.**primary outcomes 4-7: WP on Empowering End-User Evaluation tell how to correct delay**Output 41: *TPEs defined and characterized in agroecological terms*. 30%. All 5 TPEs were visited; a KULeuven MSc student has also been brought on board to map the agroecological characteristics of the larger study area and conduct a land evaluation study in the target population environments (TPEs). The mapping of agroecological characteristics will be completed by the end of 2016, and the land evaluation study by mid-2017. Output 42: *TPEs defined and characterized in socioeconomic terms*. 20%. The final 2 TPEs (Arusha/Kilimanjaro and Mbeya) were visited in April and May to continue the baseline study making use of the same set of PRA tools. The MSc student from Clark University finished a first draft of her capstone paper. Results will be summarized and written up by the end of 2016. Upon arrival in November 2016, additional analysis will be conducted by the new gender postdoc.Output 43: *Key factors in germplasm adoption in target region identified.* 40%. An annotated bibliography on socioeconomic conditions, banana production systems, and technology adoption in the target region was finalized. This will provide the basis for the review paper. A draft review paper is expected by November 2016.Output 46: *Handheld electronic data collection tool, feeding into common database, available to partners for standardized data collection.* 10%. The electronic data collection tool is functional and enumerators trained. The link between the electronic data collection tool and Musabase is being discussed with the developers.Output 48: *27 NARITAs available for distribution from ITC*. 20%. Full virus indexing has been completed for seven of the NARITA hybrids. Indexing is ongoing for remaining hybrids and should be completed by the end of 2016. Output 50: *27 NARITAs evaluated for agronomic performance, bunch characteristics, postharvest and sensory characteristics, based on 1 crop cycle in mother trials.* 100%. Not yet started, due to the late supply of planting material by the commercial in vitro suppliers in Year 1. Now due to start soon.Output 56: *Results of agronomic, postharvest, and sensory characteristics of 27 NARITAs in mother and baby trials published in open access peer-reviewed journal, and data available in global database.* 100%. The same as for Output 50.Output 57*: Stakeholders perceptions integrated in project M&E processes and in future breeding.* 100%. The same as for Output 50.**primary outcomes 8: WP on Harnessing Data** Output 62: *Database populated with historic data from NARO and IITA breeding programs.* 50%. 1- Current trials, field layouts, and phenotypic data from IITA Arusha and Sendusu were added during workshops. -2- Field layouts were provided by WP4 and added. -3- NARO trial data is pending. -4- More historical data from the different WPs expected very soon as data managers receive training and database was adapted to the specificities of banana breeding. -5. MGIS germplasm data curation initiated with IITA and NARO. Feedback pending.Output 63. *Use banana database to manage crosses, trials, etc*. 20%. See Output 62. -1- Banana trait ontology was established in collaboration with WP1,2,3, and 4. Trait ontology is now available on the test site: http://musabase-test.sgn.cornell.edu/tools/onto/ while additional comments and suggestions were received from the workshops. Additional traits added to the current Ontology should be available in November http://musabase-test.sgn.cornell.edu/tools/onto/ --2- Trial manager folders and subplot phenotyping were added to handle multiple cycles and multiple plants per plots. -3- Development of new nursery and crosses manager including diallele and multiple crosses. -4- Creation of a selection index tool. **Primary outcome 9: Project Management** Output 66: *Website*. 50%. Much data, text, and information has been assembled for the website and content arranged for selected pages, while the homepage wireframe has been developed and the address bananabreeding.iita.org provided. However, it has been decided to wait for greater completion before releasing online so as not to appear incomplete.  |

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| Geographic Areas to Be Served |

**Provide the most updated list of countries and regions/states that have benefitted or will benefit from this work and associated dollar amounts. If areas to be served include the United States, indicate city and state. Reflect both spent and unspent funds.** Add more locations as needed. More information about Geographic Areas to Be Served can be found [here](https://docs.gatesfoundation.org/documents/geography-frequently-asked-questions.pdf).

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| --- | --- | --- |
| Location |  |  Benefit U.S. $ |
|  Uganda and Tanzania (by the Project directly) |  |  6,867,431  |
| W. Africa Breeding Programs (Nigeria/Ghana) |  |  1,664,832  |
| Producting Countries in the region (through Spillover) |  |  3,662,630 |
| All banana producting countries Worldwide (through Spillover) |  |  1,678,705 |
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| Geographic Location of Work |

**Provide the most updated list of countries and regions/states where this work has been or will be performed and associated dollar amounts. If location of work includes the United States, indicate city and state. Reflect both spent and unspent funds.** Add more locations as needed. More information about Geographic Location of Work can be found [here](https://docs.gatesfoundation.org/documents/geography-frequently-asked-questions.pdf).

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| Location |  | Foundation Funding (U.S. $) |
| India, Brazil |  |  929,568  |
| Belgium, South Africa |  |  598,622  |
| Uganda |  |  2,295,205  |
| Tanzania |  |  346,333  |
| Malaysia, France |  |  929,613  |
| USA, Australia |  |  1,124,712  |
|  BMGF |  |  60,000  |
|  IITA Uganda |  |  6,071,637  |
|  IITA Tanzania |  |  1,517,909  |
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| 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.

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| BMGF Support:The regular contact, either by phone, skype, or physical visit to the 3 sites of breeding, is much appreciated. It allows the BMGF staff to interact informally with staff and students involved to see the latest progress and understand daily operations, new challenges encountered, and how we handled them. Also it provides opportunities to consult and on how to manage issues as they arise in a timely manner. It is much appreciated that this interaction can be initiated both from our own as well as the Foundation’s side.It is much appreciated how the Foundation facilitates the work by following up the progress and bringing in new contacts, that can contribute. For example, as a result we are now interacting intensively with Prof Jaroslav Dolezel (IEB, Olomouc, Czech Republic) for genotyping germplasm and hybrids in support of breeding. We appreciate the Foundation’s patience with us on the long road to successfully bring EMBRAPA, Brazil, NRCB, India, and the Univ. of Malaysia on board. The project has now received 20 improved diploid hybrids from EMBRAPA in Year 2, and at the Univ of Malaya, 1 Ugandan student has begun his PhD research, and NRCB, India is now engaged and has agreed to join. So patience is paying off.A useful and positive development over the previous Year has been the support and promotion by BMGF for open access of research results and publications, and especially so through a channel that does not impede on project funds. **Recommendations to BMGF**:At the Annual Project Workshop there was a limited turn out of the SAG members, for various reasons. The SAG members are all busy, but it was considered that if a small financial incentive was made available this may have enhanced attendance? Further to enquiries to other similar sized BMGF projects, and BMGF staff, it became clear that there is no consistent mechanism for the SAG in each of the projects, with some providing a financial retainer, a workshop attendance fee in addition to travel and subsistence costs or no fee or retainer. It may be good for some consistent guidance from BMGF on what works best and how best to engage busy SAG members.Now the Project has made good progress, gathered pace, and creating data and research results, publications are beginning to appear, creating awareness. To reach a ‘higher’ level however and create awareness beyond disciplinary focused outlets, or general publicity from training and planning workshops, guidance on recruiting Science Writers or Science Publicity Specialists from BMGF on how this is performed with other projects may be useful, in order that Project Management can start to consider this aspect and work it into the coming phase. Continueing on a communications theme, and a common platform for communication within BMGF projects may be useful to explore, if it does not exist already, with some guidance on optimizing such communication and cross project fertilization. The breeding platform is established and the entire pipeline is established. Consequently, BMGF should reflect on whether or how to involve or not, experts of the Breeding Program Assessment Tool. |