Feed the Future Innovation Lab for Collaborative Research on Grain Legumes (Legume Innovation Lab)

FY 2017 WORKPLAN

Project Code and Title: SO1.A2
Improving Photosynthesis in Grain Legumes with New Plant Phenotyping Technologies

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Michigan State University

Host Country and U.S. Co-PIs and Institutions:
Tim Close, University of California, Riverside
Maren Friesen, Michigan State University
Kelvin Kamfwa, University of Zambia
James Kelly, Michigan State University
Wayne Loescher, Michigan State University
Kennedy Muimui, ZARI, Zambia
Phil Roberts, University of California, Riverside

I. Project Problem Statement and Justification:

To avert food shortages and feed its growing population, there is critical need for increasing the productivity of grain legumes in Zambia, which ranks 164 out of 184 countries in the Human Poverty Index. Grain legumes are important crops in Zambia constituting both critical sources of protein and income. Bean production is constrained by its low inherent photosynthetic efficiency which is highly sensitive to abiotic and biotic stresses, including diseases, pests, low soil fertility hear and drought.

To achieve major gains in yield, we need to improve both the robustness and the efficiency of photosynthesis. This is a complex problem requiring the combined application of advanced genomics and high throughput phenotyping approaches. We will take a critical step in this direction by establishing a base of phenotyping technologies and advanced genetics and genomics approaches to identify quantitative trait loci (QTLs) that condition more efficient and robust photosynthesis and productivity in cowpea and common beans. We will also test the ability of a newly developed research platform, PhotosynQ, to enable researchers and farmers to conduct plant phenotyping experiments, analyze data and share results, and thus allow improvements in breeding and management on local to global scales.

In previous years of the project we have identified environmental conditions that aid in the identification of QTL's in common bean and cowpea. Furthermore, we have successfully deployed PhotosynQ under field conditions in Zambia. However, a lack of infrastructure is constraining the development of a robust phenotyping center at the University of Zambia.

II. Project Activities for the FY 2017 Workplan Period (October 1, 2016 – September 29, 2017)

The ultimate goal of this project is to increase grain legume productivity in Africa. To achieve this goal, this project aims to 1) accelerate breeding efforts to improve grain legumes thru the development of two innovative phenotyping technologies (DEPI chambers and the PhotosynQ platform) and 2) integrate these phenotyping tools into a region-led effort to improve agricultural grain legume production in Africa. Specifically, we will undertake the following objectives:

Objective 1: Probing photosynthetic responses in RIL and GWAS lines.

In 2016, we identified a combination of genotypes and environmental conditions in common bean and cowpea that show strong indications that we can use DEPI and PhotosynQ technologies to map QTL's. In cowpea, the MAGIC line showed large differences in photosynthetic response to high day and nighttime temperature. In common beans, Tepary beans have shown large differences in response to heat and drought tolerance. In both cases, robust phenotypical differences can be observed in seedlings, which can lead to rapid identification of phenotypes.

In 2017, we will explore the feasibility of mapping QTL's for these traits using DEPI under simulated conditions. We will then repeat these experiments under dynamic conditions in the field using PhotosynQ at NDSU and UC Riverside. Furthermore, we will assess the mechanistic basis of heat and cold tolerance in cowpea using biochemical and biophysical analysis.

Collaborators:

Tim Close, University of California, Riverside
Maren Friesen, Michigan State University
James Kelly, Michigan State University
Wayne Loescher, Michigan State University
Phil Roberts, University of California, Riverside

Approaches and Methods:

1.1. Explore the effectiveness of mapping QTL's in common bean and cowpea lines under simulated high and low temperatures and drought conditions in DEPI chambers. The work will be carried out by students (Isaac Osei-Bonsu and Donghee Hoh) under the supervision of Greg Austic, Dan TerAvest, and Jeffrey Cruz (USA, Kramer Lab) (Target Date: Feb. 2017).

1.2. Based on the results of these experiments, we will repeat promising experiments in the field at NDSU and UC-Riverside using the PhotosynQ platform (Target Date: Sept. 2017).

1.3. Conduct biochemical and biophysical experiments to explore the mechanisms behind temperature and drought effects in cowpea and common bean (Target Date: Sept. 2017).

1.4. Train 3 graduate students at Michigan State University.

Objective 2: Develop a data management plan to improve the communication of ideas, results, and analysis to a large network of connected scientists.

As a part of the development process, we have proposed modifying the PhotosynQ platform to meet the needs of project collaborators while concurrently meeting the requirements of USAID's open data policy.

The PhotosynQ platform allows for rapid communication of ideas, results, and analyses. As emphasized by the Data Management Plan, we realize the need to maintain the privacy of researchers and students. Currently the PhotosynQ platform makes all results public at the time of measurements, leading to potential privacy issues. To address these issues, we will further develop and implement a system of privacy and annonymization layers into the PhotosynQ platform. This objective will require some resources in order to travel to consult with USAID and programming resources.

Collaborators:

Greg Austic (MSU)

Venturit (East Lansing)

Approaches and Methods:

2.1. Consult with USAID staff to ensure that PhotosynQ's privacy policy conforms to USAID's open data policy (Target Date: March, 2017).

2.2. Adjust the privacy policies on the PhotosynQ platform to address privacy concerns (Target Date: Sept. 2017).

Objective 3: Increase the capacity, effectiveness and sustainability of agriculture research institutions which serve the bean and cowpea sectors in the target FTF countries by establishing an African-USA community of networked scientists, extension agents, students and growers to address field-level research and production questions.

In 2016, we shipped PhotosynQ devices to the University of Zambia and began the process of training research technicians and undergraduate students. However, a lack of infrastructure (e.g. labor and supplies to manage field trials, printers, internet infrastructure, etc.) hampered the ability of our collaborators in Zambia to design, implement, and analyze robust field experiments. To overcome these constraints we will increase the budget allocated to the University of Zambia by $10,000 and will place an emphasis on developing the training modules and procedure's necessary to strengthen the capacity of plant breeders at the University of Zambia. Additionally, we will develop experimental design tools (e.g. randomization, etc) that are easy to use, do not disturb the PhotosynQ workflow, and enhance the quality of data.

Collaborators:

Kelvin Kamfwa (U. Zambia)

Wayne Loescher (MSU)

Kennedy Muimui, ZARI, Zambia

Jim Kelly (MSU)

Approaches and Methods:

3.1. Develop experimental design tools that connect to the PhotosynQ platform to aid in the design of robust experiments (Target Date: Dec. 2016).

3.2. Create training modules for PhotosynQ projects that teach users how to design and implement plant breeding projects with high statistical power (Target Date: Dec. 2016).

3.3. Provide researchers and students in Uganda with MultispeQ devices and training so that they can successfully use the PhotosynQ platform (Target Date: Feb. 2017).

3.4. Train field technicians and undergraduates at UZ and the national bean breeding program in PhotosynQ use (Target Date: Feb. 2017).

3.5. Using DEPI results from outcome 1, repeat these experiments in the field at the University of Zambia using the PhotosynQ platform (Target Date: April 2017).

3.6. Build the infrastructure needed to establish a field based phenotyping program at the University of Zambia. We will re-allocate $10,000 in the final year to accomplish this outcome. (Target Date: Sept. 2017).

3.7. Train XXX field technicians and undergraduate students on the PhotosynQ platform at the University of Zambia (Target Date: Sept. 2017).

3.8. Train 1 Masters student at the University of Zambia on the PhotosynQ platform.

III. Contribution of Project to USAID Feed the Future Performance Indicators:

The "Performance Indicators – Targets" forms for each country have been completed for the project following FTF guidelines.

IV. Outputs:

1) Narrow the target potential lines in the Durango and Magic diversity panels of common bean and cowpea to speed up the plant breeding timeline, improve the outcomes.
2) Understand the mechanisms behind heat tolerance in cowpea and common bean lines.
3) Establishment of a working phenotyping group in Zambia
4) Development and implementation of a Data Management Plan for PhotosynQ that includes critical privacy layers
5) Training of two graduate students at MSU and 1 at University of Zambia
6) Strengthen the capacity of researchers at the University of Zambia to conduct in-field phenotyping to improve their ability to select better adapted grain legume varieties.

V. Engagement of USAID Field Mission(s)

The current stage of work will set up the foundations for direct interactions with regional missions.

VI. Partnering and Networking Activities:

1) Establishment of interactions by education and short-term research visits.
2) Development of training modules that will allow HC researchers and students to use the PhotosynQ platform.

3) Establishment of links through the PhotosynQ platform. A key component of the PhotosynQ platform is the interactive data and project sharing. The training and technology transfer described in the project will enable researchers both in US and HCs to communicate and share results.

VII. Leveraged Resources: The project makes direct use of expertise, technology and on-going research experiments in USAID, McKnight and USDOE-funded projects. This leveraging of resources will allow us to perform the proposed work for very low cost. The leveraged resources include the following:

The MultispeQ sensor is being developed under three projects. The basic technology was developed under a grant from the U.S. Department of Energy. The initial MultiSpeQ sensor for the platform was developed under a grant from the McKnight Foundation "MultispeQ: A Deployable Sensor for the PhotosynQ Network to Enable Critical Plant, Soil and Seed Measurements for African Breeders and Extension Agents," which we have applied for a renewal. In addition the social networking aspects of the PhotosynQ platform were developed under a grant from USAID through the MSU Global Center for Food Safely Innovations.

VIII. Timeline for Achievement of Milestones of Technical Progress: See attached "Milestones for Technical Progress."

Appendix 1: Workplan for Training and Capacity Strengthening (FY 2017).

Degree Training:

First and Other Given Names: Susan
Last Name: Chipandwe
Citizenship: Zambian
Gender: Female
Training Institution: University of Zambia
Supervising Legume Innovation Lab PI: Kelvin Kamfwa
Degree Program for training: Masters
Program Areas or Discipline: Plant Breeding and Seed Systems
Host Country Institution to Benefit from Training: University of Zambia
Thesis Title/ Research Area: Genome-wide association analysis of photosynthesis-related traits in common bean
Start Date: 9/01/2016
Projected Completion Date: September 2018
Training Status: Pending
Type of Legume Innovation Lab Support (full, partial or indirect): Full

First and Other Given Names: Isaac
Last Name: Dramadri
Citizenship: Uganda
Gender: M
Training Institution: MSU
Supervising Legume Innovation Lab PI: James D. Kelly and Wayne Loescher
Degree Program for training: Doctorate
Program Areas or Discipline: Plant Breeding, Genetics and Biotechnology
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID? Yes
Host Country Institution to Benefit from Training: MSU/U. Zambia
Thesis Title/ Research Area: Physiological studies on drought tolerance in Andean beans.
Start Date: August 2013 on Legume Innovation Funding
Projected Completion Date: September 2017
Training Status: BHEARD Fellowship from USAID Mission, Kampala.
Type of Legume Innovation Lab Support (full, partial or indirect): Indirect – research support

First and Other Given Names: Donghee
Last Name: Hoh
Citizenship: Korea

Gender: F
Training Institution: MSU
Supervising Legume Innovation Lab PI: David M. Kramer
Degree Program for training: Doctorate
Program Areas or Discipline: BioMolecular Science/Microbiology & Molecular Genetics
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID? No
Host Country Institution to Benefit from Training: MSU
Thesis Title/ Research Area: WTL Analyses of cowpea and common bean photosynthesis
Start Date: July, 2015
Projected Completion Date: September 2018
Training Status: Second year graduate student
Type of Legume Innovation Lab Support (full, partial or indirect): Full

First and Other Given Names: Isaac
Last Name: Osei-Bonsu
Citizenship: Ghanaian
Gender: Male
Training Institution: Michigan State University
Supervising CRSP PI: Dr. David Kramer
Degree Program for training: Doctorate
Program Areas or Discipline: Plant Physiology
Host Country Institution to Benefit from Training: CSIR-Crops Research Institute
Thesis Title/Research Area: Heat Stress Effects On Photosynthesis in Legumes
Start Date: August, 2015
Projected Completion Date: 2019
Training status (Active, completed, pending, discontinued or delayed): Active
Type of Legume Innovation Lab Support (full, partial or indirect) for training activity: Indirect – research support

Short-term Training:

Type of training: PhotosynQ
Description of training activity: Training technicians from the Zambian national bean breeding program (Ministry of Agriculture of Zambia) on the use of PhotosynQ technologies in bean breeding experiments.
Location: Misanfu Research Station
Duration: 2 days
When will it occur? December, 2017
Participants/Beneficiaries of Training Activity: Robert Lungu (male), Mary Attoo (female)

PI/Collaborator responsible for this training activity: Kelvin Kamfwa
Approximate budget allocation from USAID funds for training: $100
Training justification: To ensure that collaborators in Zambia are trained to collect high quality in-field phenotyping data.

Type of training: PhotosynQ
Description of training activity: Train undergraduate students from the University of Zambia
Location: U. of Zambia, Lusaka
Duration: 2 days
When will it occur? January, 2018
PI/Collaborator responsible for this training activity: Kelvin Kamfwa
Participants/Beneficiaries of Training Activity: Male students-2, female students-1
Approximate budget allocation from USAID funds for training: $0
Training justification: To ensure that collaborators in Zambia are trained to collect high quality in-field phenotyping data.

Equipment to be purchased (costing >$5,000)**: None**

Appendix 2: Budget Narrative

Personnel Cost: Salary and fringe benefits totaling approximately $74,000 are requested for 2017. In the US, these funds will provide the full salary for one graduate student working on the project and for 3 months of salary for two PhotosynQ staff (D. TerAvest and G. Austic) who will provide technical support and training to collaborators in the USA and Zambia. In Zambia, the requested funds will provide full-time salary and fringe benefits for one graduate student.

Travel: Funds are requested for local travel in both the USA and Zambia to allow collaborators to travel to field research sites for PhotosynQ data collection ($3,159) and for international travel for David Kramer to travel to the University of Zambia ($4,000) for planning and collaborative meetings.

Supplies and Services: In the US, key supplies and services include managing the DEPI chambers ($2,234) and PhotosynQ devices and related devices (android phones, carrying cases, etc) that will be shipped to the University of Zambia ($6,704). In Zambia, we have increased our request for supplies due to a lack of infrastructure at the University of Zambia, which as inhibited our collaborators ability to conduct robust PhotosynQ field trials. Therefore, we have requested $16,162 in supplies and services for the following: field research plot management (seed, fertilizer, weeding), research supplies (stakes, labels, markers, printers, etc) and internet infrastructure (modems, internet service, etc).

Training: We are requesting $11,984 in tuition/support for one graduate student in the USA and $5,455 in tuition/support for one graduate student at the University of Zambia.

Indirect Costs: Total indirect costs for the 2017 fiscal year total $51,067 with the rates based on USAID requirements.

Split of direct costs: Of the total direct costs, 58% are going to support collaborators at the University of Zambia, either thru a direct sub-award to UZ, shipping PhotosynQ and related devices to UZ, or by providing training and technical support directly to UZ collaborators. 45% of direct project costs go to achieving project objectives in the USA.

Cost share: The Kramer lab will contribute an additional $9,283 in in-kind support to achieving the goals of this LIL project.

Institutional Capacity Building: Approximately 25% of the US funds for the host country ($11,000) are going to capacity building in Zambia by providing PhotosynQ and related devices and training to UZ staff. Half of the UZ sub-award will go to institutional capacity building by increasing the University's capacity to conduct robust phenotyping experiments using PhotosynQ.