LEGUME INNOVATION LAB FOR COLLABORATIVE RESEARCH ON GRAIN LEGUMES

FY 2017 WORKPLAN FORMAT

Project Code and Title: SO1.B1 IPM-omics: Scalable and sustainable biological solutions for pest management of insect pests of cowpea in Africa

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I. Project Problem Statement and Justification: *(Please describe constraint to be addressed, its importance, and status of research progress to date) Maximum 4000 characters*

Insect pests of cowpeas dramatically reduce yields for cowpea farmers in West Africa, many of who live on less than $2 per day. Arguably, the greatest biotic constraints on cowpea (*Vigna uguiculata* [L.] Walp.) production are insect pests. The major pests of cowpea in the field in northern Nigeria, Niger, and Burkina Faso include: (i) the legume pod borer, *Maruca vitrata* Fabricius; (ii-iii) the coreid pod-bugs, *Clavigralla tomentosicollis* Stal and *Anoplocnemis curvipes* (F.); (iv) the groundnut aphid, *Aphis craccivora* Koch; and, (v-vi) thrips, *Megalurothrips sjostedti* Trybom. Foundational work has been initiated to understand these insect pests in the areas where we propose to work to develop and deploy solutions. This foundational work, has positioned us well to have a better understanding of pest biology and population structure (due to molecular tools) – which will help direct current and future pest control strategies. Up until our last phase of this project, there were few alternatives to pesticide sprays for many of these pest species. Our program, over the past several years, has developed multiple promising integrated pest management (IPM) solutions for the pests of cowpeas. Additionally, for *M. vitrata*, there exists a potential biotechnology-based pest

control solution. Transgenic cowpea expressing the *Bt*-protein Cry1Ab, effective against *M. vitrata* already exists, but has not been released, and may be a component of IPM in the next phase of this project. However, before transgenic Bt-cowpea can be released there will be a need for an insect resistance management (IRM) plan and our program has already set the stage for just such a plan (Onstad et al., 2012). *Bt*-cowpea, even if/when it becomes available to farmers, will only control one of many pests that attack cowpea. For more immediately tangible control strategies, we have other pest control solutions at hand for *M. vitrata*. Host plant resistant traits are being brought forward by Dr. Phillip Roberts at California at Riverside (UC-R), some of which is being done in collaboration with our collaborators at INERA and IITA. We will continue our work with the aforementioned investigators, to bring forward such host plant resistance traits. However, over the past phase of this project we have developed multiple IPM pest control options for cowpea systems, many of which will require the next phase of research to bring them forward to larger-scale release and testing of impact.

Although biocontrol agents, transgenic plants, and traditional plant breeding for insect resistant varieties are all potentially effective methods for controlling pests of cowpeas, a continued refinement of our understanding of pest populations is needed in order to integrate these, and other, pest control options into an overall integrative pest management (IPM) plan to maximize cowpea production in the field. IPM refers to a pest control strategy where a variety of complementary approaches are used to minimize the negative effects of pests on a given crop or cropping system. As we develop, refine and deploy IPM strategies, we must understand the important life-history parameters of these pest insects in relationship to their environment. In the past phase of CRSP we developed a more in depth understanding of *M. vitrata* populations and have recently determined that *M. vitrata* living on cowpea have a great diversity of alternative host plants and common populations – this insight (due to the use of genomics tools) is extremely important as it means all alternative host plants, for *M. vitrata*, can likely act as a refuge for *Bt*-cowpea and when releasing biocontrol agents onto alternative host plants, programs can choose the host plants that are most useful and cost effective. We term the use of genomics tools to help direct IPM strategies as IPM-omics. The IITA group has demonstrated that the release of biocontrol agents, for *M. virata* control, on different alternative host plants can be done with varying levels of cost-effectiveness and IITA along with other partner groups the biocontrol agents are being released in targeted countries/areas. Additionally, we are moving into the final phases (in FY17) of completing studies on the population dynamics of all the major pests of cowpeas. We have developed molecular tools to accomplish such a task (Agunbiade et al., 2013). We have and will continue to investigate the presence of these insects on cowpea and the population structure of these species, as well, if they prove to be pests causing significant economic losses.

Over the upcoming year we will research, develop, implement and determine the impacts of an IPM-omics program for cowpea in West Africa. We have actualized larger-scale impact through donor community buy-in through a Bill and Melinda Gates Foundation grant.

II. Planned Project Activities for the Workplan Period (October 1, 2016-September 30, 2017)

Our objectives all emerge from the following vision, with three critical major objectives, supported and intertwined with the fourth objective of capacity building.

First, we define IPM-omics in the following "equation":

IPM-omics = ***define the pest problems*** + ***appropriate solutions*** + ***scaling of solutions***

In order to define "IPM-omics" we will (1) define IPM, "omics," and how these dovetail together, and (2) the operational approaches we will take over the next 1-year towards our goals. **IPM** was first defined in 1967, by Smith and Van Dan Bosch, as a concurrent application of multiple control measures to reduce damage caused by insects to crop plants. In practical terms, this involves understanding pest systems in detail to define when and where they are a problem, defining ecologically and economically viable solutions, suppression of pest populations below an economic threshold level for increased yields and sustainable solutions. **Omics** is a term used in molecular biology to describe biological processes in large scale or high throughput. We use it to describe large-scale approaches now available to us in IPM. Thus, we define **IPM-omics** as the use of scalable technologies to understand, develop and deliver pest control solutions. IPM-omics is both a paradigm shift in how we need to think about best control in the present and in the future based on the use of cutting edge technologies available to us right now.

In our IPM-omics "equation" we must first ***define the pest problems***. First, we must ask what are the paradigms and technologies that are in our "toolbox" and how can we use them? At the current moment we have the following "tools" to work with: (1) scouting, field experiments, light traps; (2) genomic markers to define pest and biocontrol agent populations – movement patterns and sources of the outbreaks; (3) computational modeling; and, (4) GIS systems – understanding pests in the background of their ecology and life history. These aforementioned combined tools will be focused on a regional understanding of pest problems on cowpea across West Africa.

In our IPM-omics "equation" the second step is ***appropriate solutions***. We have developed a Biocontrol/Biopesticide pipeline, in order to develop a series of environmentally and economically appropriate pest control solutions. This is not a pipeline of "magic bullets", but instead a diversity of technologies to provide farmers with a variety of solutions to suppress pest populations.

The final step in the IPM-omics "equation" will be the ***scaling of solutions***. When solutions have been developed we need mechanisms to effectively deploy them in a cost effective and sustainable manner. Discovering and testing such scaling pathways will be critical to determine which approaches will be most successful for scaling. Solutions, for

scaling, fall into three categories: (1) direct release into the environment and natural establishment; (2) educational solutions; and (3) private sector and NGO involvement. **Direct release into the environment and natural establishment** has and will involve the release of bio-control agents that ultimately become endemic in the environment and suppress the insect populations. The most effective places to deploy these bio-control agents is directly influenced by the knowledge we gain from our studies of "Defining the pest problems" and such agents come directly from our bio-control pipeline. **Educational solutions** are and will be pest control strategies that will require primarily educational interventions. Our past program has taken two educational approaches: (1) farmer field fora (FFF) (labor intensive, but scalable through partner organizations) and (2) cell phone animations (potentially highly scalable) voice overlaid in many West African languages and can be distributed by a variety of electronic mechanisms (through the Scientific Animations Without Borders, SAWBO, program). We will study models of deployment and scaling of solutions through these approaches. Two major questions arise around these. First, for the cell phone approaches we will continue to determine (experimentally) what people learn, what they retain, and what are their changes in behavior and what are the benefits for the farmers and their communities. In the past phase of the Legumes Innovations Lab (Dry Grain Pulses CRSP) our team collaborated with the INRAN team and Dr. Mywish Maredia's team to ask the question regarding if these animations would increase adoption of pest control technologies as much as a visit by an extension agent. A recent analysis of the results demonstrated that this approach has the potential to be a highly effective tool for teaching.

We will continue to explore the most efficient pathways for deployment of such educational content. How do we make it accessible and who will use it with the greatest impact? Second, for FFF how can we make this approach scalable through educational programs and technology packages for NGOs and other extensions groups, and can we demonstrate that these groups have had positive impacts in their target communities (e.g., increased production or reduced labor/input costs). Finally, solutions requiring **private sector involvement** (e.g., where a "product" needs to be produced and distributed) will continue to be explored and implemented through co-operatives and other business models that empower women and unemployed youth. Finally, we will test deployment strategies of an App that allow for the use of our "solutions" well beyond our own team – thereby allowing for greater impact. An App has already been created and tested over the past year with a set of users – 1.0 version has been completed and released with all legal disclaimers/approvals by UIUC. The App is already available for free use on select Android operating systems (explanation at https://www.youtube.com/watch?v=pPk16UiZ7bY) from offline file sharing systems and downloadable from a variety of websites (e.g., https://play.google.com/store/search?q=sawbo%20deployer&c=apps&hl=en). Briefly, a user can choose the country they are in, the language they want, and the topic – where we have the content available they can then download it onto their phone (e.g., at a WiFi location). Then, when they travel to a location to do a presentation the animation can be shown on the cell phone/tablet and then transferred to local cell phones using Bluetooth®. The user can also transfer the App to other users that have Android devices, such that they can have access

to the SAWBO library. Based on feedback and experiences from the 1.0 version, the SAWBO team will release in FY17 a 1.1 version, which will resolve outstanding issues discovered in the 1.0 version (mainly cosmetic) and the 1.1 version will be released and supported by the Pittendrigh laboratory from Michigan State University.

It is important to note that through another grant that the UIUC team has received from the ADM Institute for the Prevention of Postharvest Loss, to work in Ethiopia, we have had success with engaging local partners to invest in the development of deployment strategies for the animated content. In this separate project we worked with an Assistant Professor of Business at Adama Science and Technology University (Adama, Ethiopia) and the Ethiopian Agricultural Transformation Agency (ATA) to create animated content on the reduction of Postharvest Loss in teff. ATA purchased 640 tablet computers, loaded our animations onto these tablets, and distributed these devices to extension agents across the country. These extension agents are responsible for educating a total 168,000 teff growers (http://news.illinois.edu/news/14/0519sawbo_BarryPittendrigh.html). This group has recently received funding from the Ministry of Agriculture in Ethiopia to deploy SAWBO animations on a DigiSoft Android projection systems. Additionally, we have engaged NGOs in host countries in Africa, including one in Ghana that has included our animations both in their extension programs and as part of their ICT training sessions.

The World Health Organization (WHO) has also partnered with SAWBO on the creation and release of a Zika animation and a Yellow Fever animation. To date, the WHO has released these materials out to tens of thousands of end users. In addition to this, Drs. Pittendrigh and Bello-Bravo, through SAWBO, have a P20 NIH grant to work with health related issues within the midwest for minority populations (starting in the fall of 2016). Finally, the SAWBO website receives about 50,000-100,000 visitors every month, with about 7500 of those visiting the video library per month.

SAWBO has both trained their group directly in ICT approaches and participated in online ICT training sessions where their group has organized the participants in-country. We will continue to make efforts to engage partner groups who can use our content for their educational programs. For example, Dr. Samuele Amoa Mensa of the Center for Learning and Community Development (in Ghana) has been actively using SAWBO materials in his trainer of trainer programs and a TV station in Kano uses SAWBO animations as part of their programming in Hausa (with estimated viewers in the million to multiple millions). We have also engaged Dr. Robert Mazur's team, also of the Legume Innovations Lab to develop and test, directly with farmers, learning gains with the animations in Mozambique with excellent immediate and one-year later results. We have and will engage other programs within the Legumes Innovations Lab and other Innovations Labs (*e.g.*, the Innovation Lab for the Reduction of Post-harvest Loss) for creation and use of our educational content in their programs. In FY17 we will increase our focus on pathways for "pass off" of our educational content to other groups that can integrate these materials into their educational and extension programs. Most importantly we have already reached and exceeded our target numbers for our Impact Pathway for SAWBO educational content (Step 4.5 of Aim #4).

It is important to note that we have received funding from the Bill and Melinda Gates

Foundation on a planning grant involving an interactive IPM-omics system for identifying pest insect populations, making of management decisions and pushing back of solutions to farmers. This separate online system complements our work in this project, however, it is separate and beyond the scope of what we proposed to do in this project. It will focus on the development of a new App focused on assessing pest problems in the field and delivery of recommendations. We will start with *M. vitrata* in Southern Benin and our efforts will build on the insights gained in the last phase of the CRSP/Innovations Lab. We would hope that this planning grant would lead to a subsequent grant bringing in all our Legume Innovation Lab host country partners to scale this approach out across multiple countries in Africa.

However, it is important to note that multiple aspects of the IPM-omics equation are researchable questions that we expect will allow us to develop efficient pathways from IPM innovations to scaling of these solutions. As part of the development of our scaling pathways, we will work with multiple local and transnational programs such as AATF, FARA, and CORAF to play active roles in bringing pest management solutions to cowpea farmers. We will continue our ongoing work in Burkina Faso, Niger, Benin, and Ghana on all the above activities.

Objective 1: ***Define the pest problems***. First, we must ask what are the paradigms and technologies that are in our "toolbox" and how can we use them? At the current moment we have the following "tools" to work with: (1) scouting, field experiments, light traps; (2) genomic markers to define pest and biocontrol agent populations – movement patterns and sources of the outbreaks; (3) computational modeling; and, (4) understanding pests in the background of their ecology and life history. We expect to work on Steps 1 and 2 in our impact pathway for "1 – defining pest problems". In terms of "Program Logic" we will continue to work on Step 4.4 to 4.5 - Collection of pest populations using scouting throughout the year on cowpea crops and wild alternative host plants in Ghana, Burkina Faso, Niger, and Benin. Insects will be genotyped at MSU to determine pest movement patterns within regions (on cowpeas and alternative host plants). We will also complete an interface to summarize our findings in a visual format.

Collaborators:
Dr. Brad Coates, USDA, Iowa State University
Dr. Phil Roberts, UCR
Dr. Baoua Ibrahim, University of Maradi

Approaches and Methods:

The following activities will occur in FY17 (Step 4.4 in our Program logic/Impact Pathway Worksheet document). IITA, INERA, INRAN, CRI, and SARI will scout for insects in their respective countries, both on cowpea plants and on wild alternative hosts. Technicians and students will be trained at each institution to properly identify each species as well as the host plants where they are known to occur. We also will work with SO1.A5 on the analysis of collected insects from their field tests. The scouting will occur when and

where appropriate in each host country during the time intervals when cowpeas are not being grown. Once cowpeas are planted, the scouting intensity will occur in cowpea fields and on wild alternative host plants. Once by trimester (outing lasted ten days) insects will be collected, labeled and stored in box for molecular characterization studies in BF and US. Again, for example, the INERA team in the cowpea growing off-season, in cowpea seed production plots, will investigate damage on cowpea due to new emerging pests. Understanding such pest problems and developing solutions has the potential to allow farmers in some areas to ultimately develop a second season crop of cowpea – thus, these studies are extremely important for potentially increasing overall cowpea production. Samplings of insects on cowpea will be performed at the INERA/DI research station on the Sourou River, Bagré plain and the Kou valley near Bobo-Dioulasso, where foundation seeds are yearly produced.

Thus, all host country teams, except INRAB, will continue to perform field collections on cowpea pests on alternative host plants for genetic analysis. Field collected insects will be sent back to MSU for analysis. We have performed such an analysis with *M. vitrata* and we published this work in PLoS One in 2014 (Agunbiade et al., 2014). We will take the same strategy with the other pest insects of cowpea: collect insects on cowpea and wild alternative hosts. The UIUC team will continue to analyze the aphid samples from the Dr. Phil Roberts URC team – a collaboration we started in FY14 - with this collaboration we have made comparisons of pest populations.

The intent of these experiments will be to determine the location and host plants that provide a reservoir for the pest populations that ultimately move to the cowpea crops during the cropping system. In terms of the IITA budget $5,000 of salaries will be used for this effort and $500 in benefits, along with $6,000 in travel and $2,000 in supplies and costs. In terms of the INERA budget $5,000 of salaries will be used for this effort and $500 in benefits, along with $1,000 in travel and $1,000 in supplies and costs. In terms of the INRAN budget $5,000 of salaries will be used for this effort and $500 in benefits, along with $1000 in travel and $1,000 in supplies and costs. Both at SARI and CRI the following budget will be used for these activities: (1) $1,000 in salaries, (2) $100 in benefits, (3) $500 in travel; and $350 in supplies. Our primary focus will be on the pests beyond *M. vitrata*. The samples will be sent to UIUC for SNP and microsatellite analyses (the $71,260.74.00 in salaries and in $24,941.26 benefits along with $12,825 supplies will benefit this section). The UIUC and IITA team (in conjunction with the MO) has received funding for a planning grant from the Bill and Melinda Gates Foundation (BMGF) to develop a complex IPM-omics interface to collect data on pest populations (using cell phones) and deliver solutions (using cell phones) back into the field for people to make pest management decisions and push out to them educational solutions. However, we are currently (as part of this project) in the process of creating a much simpler website to make our work and insights highly transparent to other researchers and outside groups that can help deploy our IPM approaches. We have found from our experience with the SAWBO program that making such materials available online

in an easy to follow manner is important for bringing in other outside groups that can help us scale. Such will could then be fed into a more complex interface system; however, the BMGF system will be about a highly interactive approach to capturing pest problems in real time and then guiding farmer pest management decisions in real time (using cell phones). Thus, there is no funding overlap in terms of interfaces and our interface (for this program) will be focused on helping IITA and NARS programs make better IPM decisions within the context of this project.

Objective 2: In our IPM-omics "equation" the second step is ***appropriate solutions***. We have developed a biocontrol/biopesticide pipeline, in order to develop a series of environmentally and economically appropriate pest control solutions. As step 4.5 of the our Impact Pathways we will (a) do mass rearing of *Maruca* parasitoids and inoculative releases in all countries; (b) assessment of regional impact of thrips parasitoids; (c) deployment devices for pod bugs egg parasitoids tested in farmer participatory trials in at least two participating countries (e.g., Benin, Burkina Faso and where time and resources permit Niger); (d) seed-based application of endophytic strains of *Beauveria bassiana* field tested in partnership with private sector (Benin); and (e) *Maruca* virus bio-pesticide mixtures available in select locations on the local market in Benin and potentially in Niger and Burkina Faso.

During this phase we will continue (1) to test novel natural enemies of the pod borer, including novel parasitoids from South East Asia (IITA); (2) to continue scaling up for the rearing and releases of thrips parasitoids in all countries (IITA and NARS programs – funds for this work in Ghana will come from the IITA budget – however, they will interact with the NARS programs as part of these releases); (3) to develop and test novel release devices for egg parasitoids of pod sucking bugs (IITA) (including potential work with sex pheromones); (4) to develop and test endophytic strains of biopesticides (IITA); (5) and to address technical aspects of cost effective, income-generating production of bio-pesticide products by youth and women groups (IITA) and (INRAB); and (6) interact with the UCR group to develop in field tests for potential host plant resistant/tolerant varieties that we will test in our FY16, and onwards, program (INERA). We expect to work on Steps 1-4 in our impact pathway for "2 - Discover, document, and set the stage for scaling of appropriate solutions". In terms of "Program Logic" we will work on Step 4.5 for this section (as given above).

Collaborators:

Dr. Ramasamy Srinivasan, AVRDC, Taiwan
Dr. Rousseau Djouaka, IITA, Benin
Dr. Ousmane Boukar, IITA, Nigeria
Dr. Phil Roberts, UCR, USA

Approaches and Methods:

During FY17 we plan to conduct the following activities:

In terms of scaling up activities, our in country teams will perform the following activities. (1) Continue to carry out experimental releases of *M. vitrata* parasitoids *Therophilus javanus* (IITA, INERA, INRAN, CRI) and *Phanerotoma syleptae* (IITA, INERA) (2) Scaling out rearing of *T. javanus* and *P. syleptae* (IITA, INERA, INRAN). (3) We will continue to scale up the rearing and releases of the flower thrips parasitoid *Ceranisus femoratus* in all participating countries. For this purpose, nursery plots of *Tephrosia candida* will be used for the planned releases, targeting the Sudano-Sahelian zones of Burkina Faso (INERA) and Niger (INRAN/University of Maradi) as well as in Ghana (SARI/CRI). (4) We will continue investigating recently discovered male aggregation pheromones in pod sucking bugs (*Clavigralla tomentosicollis*) for developing release strategies for the egg parasitoid *Gryon fulviventre.* A PhD candidate jointly supervised with *icipe* will continue to elucidate the nature of these aggregation pheromones. (5) We will continue to develop and test microbiological and molecular techniques for detecting endophytic strains of the entomopathogenic fungus *Beauveria bassiana* applied to cowpea, both as seed application and as a foliar spray. Also, we will start testing mixed formulations of emulsifiable neem oils with *B. bassiana* in on-station trials (6) We will continue to follow up on the production of the MaviMNPV virus by the women's groups at multiple localities in Benin, with the aim of optimizing the workflow and assuring quality control. We will also continue to establish farmer-participatory trials with combinations of bio-pesticides including MaviMNPV. (7) Our INERA team will continue to work with UCR to determine potential host plant resistance and tolerance traits (e.g. thrips, pod sucking bugs, etc.) for in field studies in FY17. (8) It is important to note that in the last phase of the CRSP we found that neem sprays and neem+MaviMNPV sprays were very effective in minimization of cowpea pest populations. At INRAN and University of Maradi our team will continue to test and explore "pass off" of this approach to farmer groups. (9) At INERA studies on two promising parasitoids will be continued. *Gryon fulviventre* will be tested in a greenhouse for the control of pods sucking bug; and parasitoids of thrips will be tested on *Tephrosia candida* at Farakoba research station and Bama. After testing of these parasitoids, a sampling will be done to know the success level of this technology. (10) Our Ghana team (CRI and SARI) will continue to explore the potential for the development of a locally created low-cost neem press; reducing the costs of such a press and making it more portable has the potential to increase the numbers of women's groups that could enter in the neem oil production market. They have worked with (and will continue to do so) an individual(s) with mechanical skills to help determine if the development of such a device (using local materials) is feasible. They will also work jointly on this project and the same amount of funds for each of the two groups will be dedicated to this activity; both at SARI and CRI the following budget will be used for these activities: (1) $1,000 in salaries, (2) $100 in benefits, (3) $500 in travel; and $350 in supplies.

The following aspect of the IITA budget will be used for both these above steps and for the testing of these approaches in the field: (1) Salaries of $10,000, (2) benefits of $1,000, (3) $3,000 in travel costs, and (4) $17,145.00 in S&E costs. For the steps above that INERA will be involved in, the following funds will be used: (1) $5,000 in salaries, (2) $500 in benefits, (3) $1,000 in travel, and (4) $1,000 in supplies.

Objective 3: ***Scaling of solutions***. When solutions have been developed we need mechanisms to effectively deploy them in a cost effective and sustainable manner. Discovering and testing such scaling pathways will be critical to determine which approaches will be most successful for scaling. Solutions, for scaling, fall into three categories: (1) direct release into the environment and natural establishment; (2) educational solutions; and (3) private sector and NGO involvement. In terms of Program Logic, step 4.5 will occur: 1) Releases of biocontrol agents scaled out; 2) Educational solutions - ICT training materials, online and in-country ICT training sessions available for testing with current partners and potential new partners, FFF program available for testing of impact leading to educational packages for scaling, potential pathways for deployment of educational videos explored, and begin testing of pathways to deploy videos; and, 3) Private sector/NGO involvement. IITA will use $5,000 in salaries, $500 in benefits, $4,000 in travel and $3,000 in supplies to work with INRAB, UIUC, and MSU to investigate potential pathways for impact. For INERA the following funds will be used for scaling of solutions activities: (1) $10,000 in salaries, (2) $1,000 in benefits, (3) $1,000 in travel, and (4) $3,000 in supplies. For INRAN the following funds will be used for scaling of solutions activities: (1) $5,500 in salaries, (2) $550 in benefits, (3) $2,000 in travel, and (4) $1,500 in supplies.

Collaborators:

Mrs. Kemi Fakambi, Director of Enterprises Solidaires Benin (CBO)
Dr. Mywish Maredia, MSU
Dr. Byron Reyes, MSU

Approaches and Methods:

(1) Direct release into the environment and natural establishment - In FY17, we will continue to conduct inoculative releases of biocontrol agents against thrips (*Ceranisus femoratus*) and pod borers (*Therophilus javanus* and *Phanerotoma syleptae*) at selected locations in Burkina Faso (INERA) and Niger (INRAN) according to the priority ecological zones established in the previous phase of the project. Natural enemies will be either brought from the IITA cultures, or reared locally prior to the releases, depending on the available capacities and infrastructures. In Burkina Faso, these releases will occur in the area where we performed (in collaboration with Dr. Maredia) a pre-biocontrol agent assessment with cowpea farmers. In FY17, we will investigate the post release of an establishment impact on

cowpea crops and their expected positive impacts on cowpea farming systems and cowpea farmers themselves.

(2) Educational solutions – As part of 4.5 in our impact pathway, ICT training packages and content will be made available through online and in country training, available packages undergoing another year of tests of FFF for impact through collaborative organizations. We previously developed educational packages (both online and ones that are printed booklets and CDs/DVDs) that have and will be used to train both groups on our teams and with groups outside our program for long-term scaling (funded by our Chancellor's Office - UIUC). In FY15 we completed an Android App (SAWBO Deployer App) that allows users of select Android devices with the capacity to download and share all educational content. These have included and we will: (1) continue to create educational content that people can use to educate farmers about IPM techniques and about pest problems (including animations, written materials for the educators, and these materials in a diversity of formats for people to use – all will be made available online to be shared on the Scientific Animations Without Borders deployment sites); summarization of lessons learned from previous FFF and what the educators need to know to make these more successful along with beginning to develop training packages for educators (e.g., NGOs and extension agents) to successfully perform FFF on IPM for cowpeas and (2) refinement creation and deployment (online training sessions and in country training sessions) of ICT packages to educators outside of our groups on how to download our current content, translation of our current content into new languages (we continue to do the actual co-creation of new language variants). The ICT training package was completed in FY14 and has been used in training sessions in multiple countries. Our Chancellor's office at UIUC already funded in FY13 an in Ghana SAWBO training session for 28 representatives from two NGOs and one university. We have continued to host trainings sessions in Ghana, Burkina Faso, Benin, and countries funded by other programs/projects such as Mozambique, Ethiopia, Sierra Leone Bangladesh and Uganda. One of these NGOs has already started their own ICT training sessions, of which the SAWBO team has participated in through Skype. We continue to work with other people and groups from West Africa, through an online collaborative network, to create new West African language variants of existing animations. A study by Drs. Maredia, Reyes, Dabire, Ba, Bello-Bravo and Pittendrigh has demonstrated that the animations are basically as effective as extension agents for learning gains and in one technology encouraging the adoption of pest control technologies – suggesting real potential for the animated approach in dissemination of the technologies we have and will continue to develop. Additionally, we have an "App" for easy access and download for our educational materials. The Android App is available on "Google Play". The Android App allows deployers of the animations to easily access them on their cell phones, download them and then transfer them, VIA Bluetooth®, onto other simpler, but video capable phones that can be found in the hands of a significant number of farmers in West Africa.

For the upcoming Legumes Innovations Lab, we have educational animations on a series of IPM solutions: neem sprays, solar treating of cowpea seeds, the concepts explaining biocontrol, etc. In the past phase of the CRSP we observed that the animations spread rapidly, people learned from these videos the main concepts, they found these entertaining, and with groups outside of our CRSP program we worked with testing of animations as an educational tool, with the results strongly suggesting that people could easily understand the content and repeat the techniques (funded separately and done separately from the previous CRSP). Through a past study with Dr. Michelle Shumate at Northwestern University we have developed experience working with deployment pathways for technology-based educational materials in Burkina Faso. We previously completed studies on (1) which groups in the country are the most logical to deploy the educational materials. We need to continue to place many of these videos in more local languages – we have refined a system where we can work with groups virtually in a given country (they just need Internet access and a computer with a built in microphone) to develop new voiceovers in local languages and deliver videos back to them to use in the field. SAWBO, created as a direct output of CRSP funding, has also resulted in the creation of animations (funded by University of Illinois at Chicago Hospital systems) that help educate US citizens on topics such as cancer screening, use of inhalers with spacer and sickle cell treatment (all in US-base populations). SAWBO animations have been used in Illinois for issues associated with TB screening and prevention.

For the FFF that will be held in Niger and Burkina Faso we will work with partner groups where we will train them on proper experimental design such that from their results we will be able to obtain statistical data demonstrating potential increases in yields of specific IPM techniques. We will continue to incorporate animated videos into some of these FFF's to determine their usefulness in increasing learning in the FFF and potential impacts on positive outcomes of adoption of specific technologies.

(3) Private sector and NGO involvement - We will continue to collaborate with the self-help enterprise producing bio-pesticides in Benin, focusing on refining formulation and application methodology for bio-pesticides and their mixtures. Also, we will follow up the virus production by women groups who have undergone training in FY15 and FY16, making sure the production can be sustained and deliver a good quality product which can enter the already existing biopesticide 'value chain' within the self-help enterprise. The SAWBO program has had a significant amount of success with "passing off" educational animations to NGOs and we will seek to determine the numbers and the type of impact some of these organizations have had with such videos.

(4) Assessing Market Potential - We also need to assess the market potential for biopesticides, potential groups that can develop these materials and logical "pass-off" groups in our host countries for our various technologies. In Benin, INRAB has the mandate to assess the market potential for such biopesticides (e.g., what farmers are willing to pay, what will be the costs to enter the market place for small industries, what are skill-sets that need to

be developed for womens' groups to potentially make and profit from selling such materials) and what will determine the networks of NGOs and other organizations where we can "pass-off" educational approaches (be it FFF or animations or both) for scaling. The full INRAB budget (of $7,000) direct spendable will be used for these activities, including $1,500 (non-degree training) of which will be used in INRAB personnel time to train IITA staff of these assessment approaches. Another $2,000 will be used toward student-funded support for this project in order for the INRAB team to complete their projects where they are collaborating with the IITA team.

Objective 4: Capacity building - *To increase the capacity, effectiveness and sustainability of agriculture research institutions which serve the bean and cowpea sectors in the target FTF countries*

Collaborators:
Dr. Brad Coates, USDA, Iowa State University
Dr. Baoua Ibrahim, University of Maradi

Approaches and Methods:

Objective – Capacity Building - *To increase the capacity, effectiveness and sustainability of agriculture research institutions which serve the bean and cowpea sectors in the target FTF countries."* In terms of Program Logic, step 4.5 will occur, as well as (1) Ongoing undergraduate and graduate education across all four HCs will occur, (2) we will promote an App that will allow for easy access to our educational content and continue to make available the individual animations, (3) technician training on biocontrol agent production and release. Both at SARI and CRI $1,100 of their budgets will be used for this technician training.

Approach -

Degree training – We will have one West African graduate student (PhD), at UIUC, that has completed here UIUC PhD and is now a Postdoctoral fellow at Yale University, previously supported by a Howard Hughes Fellowship, and all of her papers have been accepted as of the end of FY16. We expect her final paper to be published in FY17. A second U.S. citizen (female PhD student) and a Korean student will also continue to be trained (no funds from the Legumes Innovations Lab will be directly used for their training). At IITA and all NARS programs the student training will continue and we will make every effort to make sure these students submit manuscripts towards publishing their work. We will continue to train students at the B.S,/B.Sc., M.S./M.Sc. and Ph.D. levels – each country will train students at different degree-levels depending on needs and opportunities – with a focus on completing as many of these students as possible in FY17.

We will continue with the students: (1) one BS student will be partially supported at SARI in Ghana (entomology - $1,500), (2) one BS student will be partially supported at CRI in Ghana (entomology - $1,500), (2) one PhD graduate student will work with both INRAB and IITA (but will be funded through IITA) (in order to strengthen their partnership – this student will assist on the assessment studies - $5,000 for this partial support), (3) one PhD student will be partially supported at INERA (entomology - $5,000), (4) one honors or MS student will be partially or fully supported at INRAN in Niger (entomology $2,950), and (5) three more PhD or MS students will be partially/fully supported at IITA in Benin (entomology – partial support for each student at $5,000 per student). This brings a total of eight students.

Short-term training – We continue to explore approaches for scaling of short-term training as part of a solution for cost-effective scaling of our outputs. We will develop tangible educational content for training of farmers both in terms of FFF and through ICT approaches. What emerged from our previous efforts is that "piggy backing" on other educational programs or existing extension/education networks is likely to provide us with the most "cost effective" pass off educational content to other groups that can use them in their educational programs.

For the ICT approaches we will (1) continue to place our existing animations in the diversity of major languages needed, make available educational content in a diversity of formats (online, on cell phones, USB-card SAWBO video libraries that people can carry in their wallets and distribute videos when needed, and we will hope to release an "App" for educators to easily gain access to content based on country, language and topics – such that they can download what they need – take it to the field and distribute it on to people's phones VIA Bluetooth), (2) we will promote and perform ICT training sessions for our collaborators and outside groups like NGOs, other government and international organizations. These sessions will be important as learning exercises for us to refine materials, but are absolutely critical for us to develop the necessary networks of outside collaborators who can help scale our efforts. It is important to note that with these ICT approaches we can measure online use and downloads of materials. Partner groups can also give us feedback on their use and potential for scaling in their programs. A total of $53,058.00 will be used at MSU to support activities to develop and implement training materials and sessions. An additional $2,030.00 will be set aside to provide HC scientists with offline tools (e.g., SAWBO USB cards and all-inclusive solar-powered portable project systems) to disseminate this educational content.

For the FFF program we will host a minimum of three (upwards of six) FFF in Niger and Burkina Faso. These will be hosted by outside groups that we will train and throughout the year we will work with them to develop the most effective training packages and ICT materials that can be incorporated into these programs. For INERA and INRAN each team will use $5,000 for FFF and ICT activities.

Additionally, we will hold technician-training programs for the biocontrol agents that will be released. This will involve sending technicians across to different programs (training primarily at IITA, however the NARS programs will also exchange between Burkina Faso, Niger, and Ghana where necessary). This will occur where necessary and where time and resources permit. We expect at least one exchange to occur in FY17. IITA will use $11,300 of their budget for these activities.

Capacity building awards. The details of these awards and activities were outlined in their proposals and approved by the TMAC. All activities are in progress or completed.

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

Please see our "Performance Indicators – Targets" form for the project for FY16.

IV. Outputs:

Defining the pest problems - We expect to collect a final year of data on the major pests of cowpeas (beyond *Maruca*) in terms of timing, location, and wild alternative host plants. We expect to continue to perform molecular work on these populations.

Appropriate solutions – We will bring forward, in the biocontrol pipeline, new promising agents. We expect to bring forward biopesticides and develop tools and an understanding to take them to the next step towards commercial production (not only the technology, but a better understanding of who to work with to "pass off" the technologies to the marketplace. We also expect to have an understanding of the potential for a low-cost neem press.

Scaling of Solutions – We expect to continue to perform inoculative releases of natural enemies in Niger, Burkina Faso, and Benin; we expect these to ultimately suppress insect populations. We expect to have developed and expanded on partnerships that can help us scale our solutions – we expect the most immediate tangible results will be NGOs using our educational materials. We expect this to be the beginning of developing larger-scale in country deployment networks for our materials. Also, as SAWBO materials have been translated into languages beyond these countries, we also expect to work with and interact with NGOs and other organizations that will use these materials in their educational programs. We also expect some of our assessments on the potential for scaling will give us important insights for continued scaling.

V. Engagement of USAID Field Mission(s)

Dr. Pittendrigh has met with the Ghana mission during our program planning meeting and Dr. Pittendrigh presented on IPM-omics at the Innovation Lab Workshop that was held in Accra, Ghana, on July 8 and 9, 2013, a meeting involving USAID Mission staff (FY13). Additionally, one of the Ghana mission's representatives contacted Drs. Tamo (at IITA) and Dabire (INERA) about the possibility of exploring intercropping of cowpea with crop(s) important for FTF value chains. They were interested in the IPM technologies we are working on and seek opportunities for connections with their focus. Our Ghanaian PI's were involved in the July 8 and 9 (2013) meeting involving USAID Mission staff. Dr. Pittendrigh also met with the USAID Mission staff in FY15 and hopes to have FY16/FY17 meetings respectively in the summers of 2016 and 2017. Thus, we will continue this important process of engaging missions in West Africa in regards to our program.

VI. Partnering and Networking Activities:

Our partnering activities have several aspects to them. First, IITAs development of novel pest control solutions (both technologies and biocontrol agents), through the biocontrol/biopesticide pipeline worked upon by the NARS programs for testing, use and are deployed in their host countries. The FFF will be conducted in conjunction with local NGOs and other non-Legumes Innovations Lab programs (i.e., groups that we are not funding, but can use our materials in their programs). We will have FFF in Niger and Burkina Faso, with these outside programs, and after training these groups on how to properly set up experiments in the FFF we will assess the impacts on yields in the experimental plots. We will also use our ICT training sessions (both online and one in-country – in year FY17 our focus will be Burkina Faso and Niger for pass off to) to meet with and partner with NGOs that can use our materials in scaling with their own educational programs. The travel funds for MSU will be used for MSU faculty, staff and/or students to visit with IITA and/or NARS scientists in the course of the FY17. We will continue to expand our networks with other NGO and international organizations – with the goal of "pass off" practical solutions to other groups that can integrate them in their programs for potential scaling.

VII. Leveraging of Legumes Innovations Lab Resources:

The MSU team will leverage funds from the startup and endowment funds. Additionally, the MO, IITA and UIUC/MSU have received a planning grant from the Bill and Melinda Gates Foundation (BMGF) of IPM-omics technologies. However, it is important to note that activities for the BMGF will be kept separate from our Legumes Innovation Lab objectives (no overlap in objectives). There exist multiple complementary technologies and scaling issues that required funding levels in keeping with a BMFG planning grant. IITA will continue to receive funding through the CGIAR Research Program on Grain Legumes, including competitive grants. We also view the use of the SAWBO animations by NGOs in their educational programs as a leveraging of the Legumes Innovations Lab resources.

VIII. Timeline for Achievement of Milestones of Technical Progress:

Please see out "Milestones for Technical Progress" form for the workplan period.

Training/Capacity Building Workplan for FY 2016 – 2017 (use format below)

Degree Training:

First and Other Given Names: Laura
Last Name: Steele
Citizenship: USA
Gender: Female
Training Institution: UIUC
Supervising CRSP PI: Pittendrigh
Degree Program for training: PhD in Entomology
Program Areas or Discipline: Entomology
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID? No
Host Country Institution to Benefit from Training: Benin, Niger, Burkina Faso, and Ghana – indirectly (this student has and will continue to play a major role in the development of ICT tools for these countries as well as work on the molecular aspects of our program)
Thesis Title/Research Area: To be determined
Start Date: Continuation (Started Fall 2011)
Projected Completion Date (Fall 2016)
Training status (Active, completed, pending, discontinued or delayed): Active
Type of Innovations Lab Support (full, partial or indirect) for training activity: Indirect

First and Other Given Names: Keon
Last Name: Seong
Citizenship: Korean
Gender: Male
Training Institution: UIUC
Supervising CRSP PI: Pittendrigh
Degree Program for training: PhD in Entomology
Program Areas or Discipline: Entomology
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID? No
Host Country Institution to Benefit from Training: Benin, Niger, Burkina Faso, and Ghana – indirectly (this student has and will continue to play a major role in the development of ICT tools for these countries as well as work on the molecular aspects of our program)
Thesis Title/Research Area: To be determined
Start Date: Continuation (Started Fall 2013)
Projected Completion Date (Fall 2017)

Training status (Active, completed, pending, discontinued or delayed): Active
Type of CRSP Support (full, partial or indirect) g for training activity: Indirect

First and Other Given Names: Djibril Aboubakar
Last Name: Souna
Citizenship: Benin
Gender: Male
Training Institution: IITA
Supervising CRSP PI: Tamò
Degree Program for training: PhD in Entomology
Program Areas or Discipline: Entomology
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID? Host Country Institution to Benefit from Training: Benin
Thesis Title/Research Area: Bio-ecology of *Therophilus javanus*, a promising biocontrol candidate against *Maruca vitrata*
Start Date: 2014
Projected Completion Date: 2018
Training status (Active, completed, pending, discontinued or delayed): Active
Type of CRSP Support (full, partial or indirect) for training activity: Partial

First and Other Given Names: Judith
Last Name: Honfoga
Citizenship: Benin
Gender: Female
Training Institution: IITA
Supervising CRSP PI: Tamò
Degree Program for training: MSc in Entomology
Program Areas or Discipline: Entomology
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID?
Host Country Institution to Benefit from Training: Benin
Thesis Title/Research Area: Detection and quantification of *Therophilus javaus* parasitism in *Maruca vitrata* larvae using species-specific qPCR primers.
Start Date: 2014
Projected Completion Date: 2016
Training status (Active, completed, pending, discontinued or delayed): Active
Type of CRSP Support (full, partial or indirect) for training activity: Partial

First and Other Given Names: Hilaire
Last Name: Kpongbe
Citizenship: Benin
Gender: Male
Training Institution: IITA
Supervising CRSP PI: Tamò
Degree Program for training: PhD in Chemical Ecology
Program Areas or Discipline: Entomology
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by

USAID?
Host Country Institution to Benefit from Training: Benin
Thesis Title/Research Area: Elucidating the nature of male aggregation pheromones of *Clavigralla tomentosicollis*
Start Date: 2015
Projected Completion Date: 2018
Training status (Active, completed, pending, discontinued or delayed): Active
Type of CRSP Support (full, partial or indirect) for training activity: Partial

First and Other Given Names: Nicolette
Last Name: Montcho
Citizenship: Benin
Gender: Female
Training Institution: IITA
Supervising CRSP PI: Tamò
Degree Program for training: MSc in Entomology
Program Areas or Discipline: Entomology
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID?
Host Country Institution to Benefit from Training: Benin
Thesis Title/Research Area: Host finding behavior of *Therophilus javanus*, a novel parasitoid of the pod borer *Maruca vitrata*
Start Date: 2015
Projected Completion Date: 2016
Training status (Active, completed, pending, discontinued or delayed): Completed
Type of CRSP Support (full, partial or indirect) for training activity: Partial

First and Other Given Names: Anne Marie
Last Name: Ahandessi
Citizenship: Benin
Gender: Female
Training Institution: IITA
Supervising CRSP PI: Tamò
Degree Program for training: MSc
Program Areas or Discipline: Entomology
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID?
Host Country Institution to Benefit from Training: Benin
Thesis Title/Research Area: Bacteria colonizing gut and frass of the pod borer *Maruca vitrata* feeding on different host plants
Start Date: 2015
Projected Completion Date: 2016
Training status (Active, completed, pending, discontinued or delayed): Completed
Type of CRSP Support (full, partial or indirect) for training activity: Partial

First and Other Given Names: Nazyath
Last Name: Imorou
Citizenship: Benin

Gender: Female
Training Institution: IITA
Supervising CRSP PI: Tamò
Degree Program for training: MSc
Program Areas or Discipline: Entomology
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID?
Host Country Institution to Benefit from Training: Benin
Thesis Title/Research Area: Olfactometric responses of *Therophilis javanus* to different host plants
Start Date: 2016
Projected Completion Date: 2017
Training status (Active, completed, pending, discontinued or delayed): Completed
Type of CRSP Support (full, partial or indirect) for training activity: Partial

First and Other Given Names: Fiacre
Last Name: Agbaka
Citizenship: Benin
Gender: Male
Training Institution: IITA
Supervising CRSP PI: Tamò
Degree Program for training: MSc
Program Areas or Discipline: Entomology
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID?
Host Country Institution to Benefit from Training: Benin
Thesis Title/Research Area: Interactions between *Therophilis javanus* and *Phanerotoma syleptae*
Start Date: 2016
Projected Completion Date: 2017
Training status (Active, completed, pending, discontinued or delayed): Completed
Type of CRSP Support (full, partial or indirect) for training activity: Partial

First and Other Given Names: Rahina
Last Name: Souley Mayaki
Citizenship: Niger
Gender: Female
Training Institution: INRAN
Supervising CRSP PI: Ibrahim Baoua/Amadou
Degree Program for training: Bsc in Entomology
Program Areas or Discipline: Entomology
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID?
Host Country Institution to Benefit from Training: Niger
Thesis Title/Research Area: The effects of Neem grain-based biopesticide on the development of *Clavigralla tomentosicollis* at rural level in the region of Maradi
Start Date: 2012
Projected Completion Date: 2016

Training status (Active, completed, pending, discontinued or delayed): Active
Type of Innovations Lab Support (full, partial or indirect) for training activity: Partial

First and Other Given Names: Soumaila
Last Name: Abdou Issa
Citizenship: Niger
Gender: male
Training Institution: INRAN
Supervising CRSP PI: Ibrahim Baoua/Amadou
Degree Program for training: Bsc in Entomology
Program Areas or Discipline: Entomology
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID?
Host Country Institution to Benefit from Training: Niger
Thesis Title/Research Area: The effects of Neem grain-based biopesticide on the development of *Clavigralla tomentosicollis* at rural level in the region of Maradi
Start Date: 2012
Projected Completion Date: 2016
Training status (Active, completed, pending, discontinued or delayed): Active
Type of Innovations Lab Support (full, partial or indirect) for training activity: partial

First and Other Given Names: Nafissatou
Last Name: Illa Boube
Citizenship: Niger
Gender: Female
Training Institution: INRAN
Supervising CRSP PI: Ibrahim Baoua/Amadou
Degree Program for training: in Entomology
Program Areas or Discipline: Entomology
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID?
Host Country Institution to Benefit from Training: Niger
Thesis Title/Research Area: Study of the population dynamics of *Maruca vitrata* on station.
Start Date: 2011
Projected Completion Date: 2016
Training status (Active, completed, pending, discontinued or delayed): Active
Type of Innovations Lab Support (full, partial or indirect) for training activity: partial

First and Other Given Names: Rakia
Last Name: Gonda
Citizenship: Niger
Gender: Female
Training Institution: INRAN
Supervising CRSP PI: Ibrahim Baoua/Amadou L.
Degree Program for training: Bsc. in Entomology
Program Areas or Discipline: Entomology
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by

USAID?
Host Country Institution to Benefit from Training: Niger
Thesis Title/Research Area: Study of the biology of *Clavigralla tomentosicollis* in laboratory
Start Date: 2012
Projected Completion Date: 2016
Training status (Active, completed, pending, discontinued or delayed): Active
Type of Innovations Lab Support (full, partial or indirect) for training activity: partial

First and Other Given Names: Kader
Last Name: Djibo Amadou
Citizenship: Niger
Gender: Male
Training Institution: INRAN
Supervising CRSP PI: Ibrahim Baoua/Amadou
Degree Program for training: Bsc in Entomology
Program Areas or Discipline: Entomology
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID?
Host Country Institution to Benefit from Training: Niger
Thesis Title/Research Area: Study of the development cycle of *Clavigralla tomentosicollis* in laboratory conditions
Start Date: 2012
Projected Completion Date: 2016
Training status (Active, completed, pending, discontinued or delayed): Active
Type of Innovations Lab Support (full, partial or indirect) for training activity: partial

First Name: Haouaou
Last Name: Issaka
Citizenship: Niger
Gender: Female
Training Institution: INRAN
Supervising CRSP PI: Ibrahim Baoua/Amadou
Degree Program for training: Msc in Entomology
Program Areas or Discipline: Entomology
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID?
Host Country Institution to Benefit from Training: Niger
Thesis Title/Research Area: Effect of biopesticide neem seeds extract for the control cowpea pods pest (*Maruca vitrata* and *Clavigralla tomentosicollis)* on station
Start Date: 2015
Projected Completion Date: 2016
Training status (Active, completed, pending, discontinued or delayed): Active
Type of Innovations Lab Support (full, partial or indirect) for training activity: partial

First name: TBD
Last name: TBD
Citizenship: Ghanaian

Gender: TBD
Discipline: Entomology
Host Country Institution to benefit from Training: Ghana
Supervising Legume Innovation Lab PI: Asante and Braimah through the University for Development Studies, Tamale, Ghana
Start Date of Degree Program: TBD
Program completion Date: TBD
Training Status During Fiscal – Year 2014: Undergraduate research project
Type of Legume Innovation Lab Support: Partial

First name: Akosua Addai Asare
Last name: Asare
Citizenship: Ghanaian
Gender: Female
Discipline: Entomology
Host Country Institution to benefit from Training: Ghana
Supervising Legume Innovation Lab PI: Asante and Braimah through the University for Development Studies, Tamale, Ghana
Start Date of Degree Program: Fall 2015
Program completion Date: 2016/2017
Training Status During Fiscal – Year 2015: Undergraduate
Type of Legume Innovation Lab Support: Partial

First name: Mariam
Last name: Derra
Citizenship: Burkinabè
Gender: Female
Discipline: Entomology
Host Country Institution to benefit from Training: INERA
Supervising Legume Innovation Lab PI: Traoré
Start Date of Degree Program: September 2014
Program completion Date: TBD
Training Status During Fiscal – Year 2016: Graduate student (PhD)
Training status (Active, completed, pending, discontinued or delayed): Delayed
Type of Legume Innovation Lab Support: Partial

First name: Appoline
Last name: SANOU
Citizenship: Burkinabè
Gender: Female
Discipline: Entomology
Host Country Institution to benefit from Training: INERA
Supervising Legume Innovation Lab PI: Dabiré and Traoré
Start Date of Degree Program: September 2013
Program completion Date: 2017
Training Status During Fiscal – Year 2016: Graduate student (PhD)
Training status (Active, completed, pending, discontinued or delayed): Active
Type of Legume Innovation Lab Support: Partial

First name: Edouard
Last name: Drabo
Citizenship: Burkinabè
Gender: Male
Discipline: Entomology
Host Country Institution to benefit from Training: INERA
Supervising Legume Innovation Lab PI: Traoré
Start Date of Degree Program: September 2015
Program completion Date: 2016
Training Status During Fiscal – Year 2016: Graduate student (Master II)
Type of Legume Innovation Lab Support: Partial

First name: Théodore
Last name: Ouédraogo
Citizenship: Burkina Faso
Gender: Male
Discipline: Entomology
Host Country Institution to benefit from Training: INERA
Supervising Legume Innovation Lab PI: Traoré
Start Date of Degree Program: May 2015
Program completion Date: 2016
Training Status During Fiscal – Year 2016: Graduate student (Master II)
Training status (Active, completed, pending, discontinued or delayed): Active
Type of Legume Innovation Lab Support: Partial

Short-term Training:

Type of training: FFF
Description of training activity: These will be training of NGOs and outside groups and then these materials will be used in FFF, where INERA and INRAN will work with them closely throughout the FFF sessions.
Location: Niger and Burkina Faso
Duration: Several months
When will it occur? Fall of 2016
Participants/Beneficiaries of Training Activity: We expect direct impact on NGOs and other groups that can use these in their educational programs. We expect benefits to cowpea farmers to also result.
Anticipated numbers of Beneficiaries (male and female): We expect >250 (equally split between males and females) to benefit
PI/Collaborator responsible for this training activity: Traoré and Baoua/Amadou
List other funding sources that will be sought (if any): N/A
Training justification: We have already observed that training outside groups in our educational content has significant potential for scaling of our technologies and approaches that have been developed. This will both be a training system and a

testing of scaling.

Type of training: ICT training sessions (online and minimally one in country)
Description of training activity: Minimally once in a year in Burkina Faso or Niger and several online when and where opportunity permits with collaborating organizations.
Location: One in Niger or Ghana or both and others virtually or during other training opportunities/trips.
Duration: Several hours to one-day sessions – followed by week long collaborative efforts for new content.
When will it occur? To be determined, but this will occur during other trips for other activities.
Participants/Beneficiaries of Training Activity: We expect direct impact on NGOs and other groups that can use these in their educational programs. We expect benefits to cowpea farmers to also result. We will also involve senior scientists and technicians in these training sessions.
Anticipated numbers of Beneficiaries (male and female). In FY17 we will have trained >200 individuals from NGOs/government agencies/private sector firms and we expect these groups (and out online systems) to impact >100,000,000 people to our materials. In fact, AREWA24, which broadcasts SAWBO animations has a viewership which is likely in the excess of multiple millions of viewers. We also expect "spill-over" of SAWBO animations into other countries and projects/regions. For example, SAWBO animations have been used by IIAM in Mozambique for hour-long training sessions (Pittendrigh and Bello in attendance with 100+ farmers) and in Ethiopia. Additionally, SAWBO animations are shown frequent on a Hausa TV station in Nigeria (Arewa24 - http://us9.campaign-archive1.com/?u=a2b1b23a8f7e117aa0402399c&id=a7349aa0fa), which broadcasts in Nigeria and Niger. Conservative estimates place the viewership in the million to millions level.
PI/Collaborator responsible for this training activity: Pittendrigh, Tamo, Traoré, Ibrahim/Amadou, Bello-Bravo
List other funding sources that will be sought (if any): Endowment funds and startup funds provided to Pittendrigh from MSU, P20 NIH grant to Pittendrigh and Bello-Bravo and (a) smaller NGO grant(s) provided to SAWBO.
Training justification: We have already observed that training outside groups in our educational content has significant potential for scaling of our technologies and approaches that have been developed.

Type of training: Technician cross-training
Description of training activity: Technicians will be cross-trained across IITA and the NARS programs
Location: Niger, Burkina Faso, Ghana, and Benin

Duration: 1-day to multiple weeks
When will it occur? Throughout FY17
Participants/Beneficiaries of Training Activity: Minimally 6 technicians and/or students
Anticipated numbers of Beneficiaries (male and female): We expect the NARS programs to benefit and increase their ability to have impact with biocontrol agents and biopesticides
PI/Collaborator responsible for this training activity: Tamo, Baoua/ Amadou, Traoré, Braimah, and Asante
List other funding sources that will be sought (if any): N/A
Training justification: We have found this a highly cost-effective way to exchange the technologies between institutions.

Equipment (costing >$5,000)**: N/A**
Specific Type of Equipment to be purchased
Justification for equipment to achieve workplan objectives
Institution to benefit from equipment
Institution to purchase equipment
Amount budgeted for equipment item

Appendix 2: Budget Narrative

We have outlined above how many of the expenditures relate to each of the activities for each of the groups involved in the overall program. The below explanations provide other details not given above.

U.S./H.C. Direct cost split – The direct cost split will be 48.79% to UIUC and MSU combined to 51.21% for the host countries. We are requesting that funds to support Dr. Pittendrigh's efforts will be moved to MSU. The MSU costs will focus on the molecular analysis of the cowpea pests (paying for primarily staff scientist time and technician time; combined salaries of $71,260.74 and 35% benefit rates totally $24,941.26), travel costs for Drs. Pittendrigh and Bello-Bravo (for one trip to Niger or Burkina Faso), as well as supply costs. Dr. Pittendrigh will cover for Dr. Bello-Bravo's travel costs from his MSU budget or from his endowment funds or both. For part of FY17 Dr. Bello-Bravo will work at UIUC and the later part she will move to MSU. The $53,058 will be used for staff support time and supplies and expendables to further scale and pass off the SAWBO educational content in the HCs. An overhead rate of 55% will be applied to these funds for a total of $263,012.00, which will go directly to the Pittendrigh laboratory at MSU as Dr. Pittendrigh will move to MSU prior to FY17 and he will remain as the Lead-Principle Investigator. The remaining $221,988.00 will go to UIUC, with a continued pass through to the HC collaborators of $212,416.00 and $9,300 remaining at UIUC for Dr. K. Paige for travel costs and O/H

($6,000 in travel costs and $3300 in overhead). Dr. K. Paige will be project Principle Investigator (PI) with signatory authority over all UIUC sub-subcontracts with host country institutions (UIUC). At MSU, an in-kind contribution of Dr. Pittendrigh's time (totally $26,641.00) will occur and at UIUC an in-kind contribution of Dr. Paige's time of $2,000 will occur.

For the H/C programs staff salaries (and benefits) are given as follows: (1) IITA - $20,000 ($2,000), (2) INERA - $20,000 ($2,000), (3) INRAN - $10,500 ($1,050), (4) INRAB - $3,000 ($300), (5) SARI - $2,000 ($200), and (6) CRI - $3,000 ($300). Travel expenses are highest for IITA (at $15,000) as Dr. Tamo will both travel to meet with HC collaborators in the year and will travel to meet with Dr. Pittendrigh outside of West Africa. The travel budgets for the remaining HC groups are primarily within country trips or neighboring countries or both. At IITA the $20,000 degree training budget represents partial or full support for multiple graduate students. At INERA and INRAN this is also the case. However, at INRAB all training will be non-degree and at CRI and SARI it will be used to support undergraduates who will work on projects towards their undergraduate degrees.

At all institutions 50% of the budget will be used in some way to perform institutional capacity building, in terms of training and development of staff, travel to build inter-institutional capacity, and finally generation datasets and tools that will be used by these institutions in their IPM recommendations. Additionally, for IITA, INRAN, INERA, CRI and SARI, they will ultimately have the capacity to rear or release or both biocontrol agents – a long-term capacity building effort that will be critical for IPM of cowpea pests in the region.