**LEGUME INNOVATION LAB FOR COLLABORATIVE RESEARCH ON GRAIN LEGUMES**

**FY 2013 – 2014 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

**Lead U.S. Principal Investigator (PI) and affiliated Lead U.S. University:**
Dr. Barry Pittendrigh, University of Illinois at Urbana-Champaign (UIUC)

**Host Country and U.S. Co-PIs and Institutions:**
Dr. Manuele Tamò, IITA-Benin
Dr. Clémentine Dabiré-Binso, INERA-Burkina Faso
Dr. Ibrahim Baoua, INRAN-Niger
Dr. Stephen Asante, SARI, Ghana
Dr. Haruna Braimah, CRI- Ghana
Dr. Julia Bello-Bravo, UIUC Co-PI
Dr. Leonard Hinnou, INRAB-Benin

**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. Thus, for more immediately tangible control strategies, we have other pest control solutions at hand for *M.*

*vitrata*. Additionally, 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. Thus, as we move forward over the next four years we will determine the population genetic structure of the other pests of cowpea. We have developed molecular tools to accomplish such a task (Agunbiade et al., accepted). We will also 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 will research and develop scalable solutions, with the potential for larger-scale impact with donor community buy-in.

**II. Planned Project Activities for the Workplan Period** (April 1, 2013 – September 30, 2014)

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*** = ***<u>define the pest problems</u>*** + ***<u>appropriate solutions</u>*** + ***<u>scaling of solutions</u>***

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 4-years 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 follows "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 flora (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. 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 need 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. Additionally, we need to test experimentally 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, something that we are well positioned to test experimentally. 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 be explored and implemented through co-operatives and other business models that empower women and unemployed youth. Finally, we will refine our online interfaces and create Apps that allow for the use of our "solutions" well beyond our own team – thereby allowing for greater impact. However, it is important to note that we are currently interacting with the Bill and Melinda Gates Foundation on a planning grant that, if funded, would involve an interactive IPM-omics system for identifying pest insect populations, making of management decisions and pushing back of solutions to farmers. If funded, this separate online system would complement our work in this project, however, it would be separate and beyond the scope of what we proposed to do in this project.

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. We will also test the impact of IPM approaches on farmer incomes, through studies with Dr. Mywish Maredia at MSU. As part of the development of our scaling pathways, we will work with multiple local and transnational programs such as AATF and CORAF.

We will continue our ongoing work in Burkina Faso, Niger, and Benin, however, we will also be adding the Feed the Future country Ghana to our program, as they have ongoing expertise in cowpea IPM and ongoing interactions with IITA on the development and deployment of IPM solutions. In the past phase of the CRSP we also worked with the FTF country Mali, but we were unable to continue these efforts due to the political situation in that country. If circumstances change in the next 4 years, we would hope to bring back the NARS program from Mali (IER) into our program.

**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) GIS systems – 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 work on Step 4.1 - 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 UIUC to determine pest movement patterns within regions (on cowpeas and alternative host plants). We will also develop interfaces to summarize our findings in a visual format.

**Collaborators:**
Dr. Brad Coates, USDA, Iowa State University (Genomics)
Dr. George Czapar, UIUC (GIS systems)

**Approaches and Methods:**
In FY13 we hosted a planning workshop to lay out the details of what will be accomplished in FY14.

The following activities will occur in FY14. 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 indentify each species as well as the host plants where they are known to occur. We also will work with SO1.A5 on the collection of insects from their field tests. As well, they will receive training in GIS documentation, so we can obtain information on when and where the species are occurring. This information will be placed up against GIS data (at UIUC) to better understand the impact of environmental parameters on the pest biology. The scouting will occur monthly during the time intervals when cowpeas are not being grown. Once cowpeas are planted, the scouting intensity will increase to upwards of once a week both in cowpea fields and on wild alternative host plants. Samples of these insects will be sent back to UIUC for SNP and microsatellite analyses. 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 $1000 in travel and $1000 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 $1000 in supplies and costs. Both at SARI and CRI the following budget will be used for these activities: (1) $1000 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 $66,497.00 in salaries and in $29,705.00 benefits along with $13,200 supplies will benefit this section and the development of the interface to make the outputs available to the rest of the community). The UIUC and IITA team (in conjunction with the MO) is currently seeking 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. If funded, we will

determine, in that BMGF planning grant, what will need to go into that interface (which would be created only if a full grant from the BMGF were to occur). However, we will make efforts (as part of this project) to create a much simpler website to capture when and where the materials, knowledge and information we have to date along with basic GIS data (rainfall/temperature/moisture levels/levels of vegetation at the time of sampling) (in collaboration with Dr. Cazapar) 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 data could then be feed into a more complex interface system, if funded by the BMGF; however, the BMGF site 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.

During this phase we propose (1) to test novel natural enemies of the pod borer, including novel parasitoids from South East Asia (IITA); (2) to continue scaling up 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); (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 FY15, 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 4.1 for this section: (a) Novel *Maruca* parasitoids from Asia introduced to the IITA laboratories for initial screening; (b) scale-up the rearing and release of the thrips parasitoid in all participating countries; (c) sex and aggregation pheromones for pod sucking bugs investigated; (d) PCR techniques developed for detecting endophytic strains of *Beauveria bassiana* in the different tissues of cowpea; e) feasibility of storing *Maruca* virus both as liquid and solid substrate investigated (IITA).

**Collaborators:**

Dr. Ramasamy Srinivasan, AVRDC, Taiwan (Biocontrol agents of M. vitrata)

Dr. Rousseau Djouaka, IITA, Benin (Molecular biology)

Dr. Ousmane Boukar, IITA, Nigeria (Resistant varieties)
Dr. Phil Roberts, UCR, USA (Resistant varieties)

**Approaches and Methods:**

During FY13-14 we plan to conduct the following activities:

(1) Testing at least two novel natural enemies of the pod borer *Maruca vitrata*, including novel parasitoids from South East Asia, which are currently in the process of being introduced into the IITA cultures in Benin (such as *Therophilus javanus and Phanerotoma philippinensis*). During FY13-14 we will be testing them in contained lab experiments, targeting interspecific competition with other available parasitoids, as well as host recognition in contained screenhouse trials.

(2) 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 established 9 months ahead of the planned releases, targeting the Sudano-Sahelian zones of Burkina Faso and Niger.

(3) We will start a new activity of investigating sex and aggregation pheromones in pod sucking bugs for developing rearing-cum-release devices for their egg parasitoids. During FY13-14 we will be carrying out olfactometric studies at IITA to detect responses of the egg parasitoid *Gryon fulviventre* to pheromones of the brown pod bug *Clavigralla tomentosicollis*.

(4) We will develop and test molecular techniques for detecting endophytic strains of the entomopathogenic fungus *Beauveria bassiana* applied to cowpea at planting, while developing inside the vascular tissues of the cowpea plant during its growth. At the same time we will conduct on station experiments to assess the impact of this approach to the main cowpea pests.

(5) We will assess the technical feasibility of storing *MaviMNPV* virus both as liquid and solid substrate for facilitating the cottage industry production of this bio-pesticide by self-help women groups. Production of the virus will continue at IITA and staff from the above grouping will undergo technical training sessions on how to produce good quality viral inoculum.

(6) 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 FY15.

(7) 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. Many aspects of the neem component of our program will be the focus of our proposed 1-year BMGF planning grant and thus will not be included in our planned activities, with one notable exception. Our Ghana team (CRI and SARI) will 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 will hire 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) $1000 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) $5000 in salaries, (2) $500 in benefits, (3) $1000 in travel, and (4) $1000 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. This section some level each of the Steps 1-3, in the impact pathway, should occur within this year. In terms of Program Logic, step 4.1 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) $10000 in salaries, (2) $1000 in benefits, (3) $1000 in travel, and (4) $3000 in supplies. For INRAN the following funds will be used for scaling of solutions activities: (1) $5500 in salaries, (2) $550 in benefits, (3) $2000 in travel, and (4) $1500 in supplies.

**Collaborators:**

Mrs. Kemi Fakambi, Director of Entreprises Solidaires Benin (CBO)
Dr. Michelle Shumate, Northwestern University
Dr. Mywish Maredia, MSU

**Approaches and Methods:**

(1) Direct release into the environment and natural establishment - In FY13-14, we will continue to conduct inoculative releases of biocontrol agents against thrips (*Ceranisus femoratus*) and pod borers (*Apanteles taragamae* and/or *Nemorilla maculosa*) 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 look at the post release and establishment impact on cowpea crops and their expected positive impacts on cowpea farming systems and cowpea farmers themselves.

(2) Educational solutions – Over F13-14 we will begin developing educational packages (both online and ones that will be printed booklets and CDs/DVDs) that will be used to train both groups on our teams and with groups outside our program for long-term scaling. These will include: (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 SusDeViKI system and the animations 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 will do the actual co-creation of new language variants). We expect the ICT package to be completed by the end of FY14. 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. Four new language variants were created in this session and are now available for use in Ghana. Additionally, both NGOs are currently incorporating these materials into their educational programs and we have continued to interact with them virtually to create more language variant content. Additionally, experiences from this training session will (1) allow us to refine and complete an ICT training system (2) refine how these need to be organized and (3) develop a reporting system to assess the effectiveness of this approach for scaling and set the stage for potential impact assessment studies. Additionally, we tested out a new "App" for each access and download for our educational materials. This new "App" and a redesign of our interface for the "lite" version of the SAWBO site will occur in FY14 to make our materials more accessible for people to find and rapidly download.

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). Dr. Shumate also has experience working with deployment pathways for technology-based educational materials in Burkina Faso. She has completed studies on (1) which groups in the country are the most logical to deploy the educational materials (through

a nodal analysis of how these groups interact with each other – her group can now tell us which groups are logical for partnering for deployment and which groups are unlikely to have impact – a hypothesis we can not test with our videos – see below). 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.

For the animations we are in a strong position to perform tests in learning, impact, and potential for scalability. In collaboration with Dr. Shumate and IITA we will perform before and after knowledge gain for cowpea farmers given the cowpea related videos on their cell phones. We will also perform a 1-month follow-up to determine how many time people have re-watched these videos, their knowledge retention, and their interest or use in adopting such technologies. As we already know the logical deployment partners in Burkina Faso, based on work by Dr. Shumate, we will take specific videos, label them with a code at the end of the video (with a unique code for each video given to each deployment group), and give each video out to groups we expect would deploy them and ones where we would expect to have little impact. For example, organization #1 we will give them the neem video and at the very end of the video we have a #1 on the screen and organization #2 will also be given the neem video and at the very end of the video we have a #2 on the screen. Our hypothesis, based on the nodal analysis was that group #1 would be more connected with the community to have impact. Thus, we will go into the community 1-2 months later to determine which videos people have on their cell phone – the one from group #1 or group #2. This will allow us to directly test which partner groups might be better in circulating these educational videos.

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 also 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 start training staff of the self-help group, with particular attention to women, in the production of pod borer larvae using the technology developed during the previous phase of the project, i.e. using cowpea sprouts. The larvae will be inoculated with the virus supplied by IITA (at least until they get their own stock cultures) and passed through 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.

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 will have 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 $5000) direct spendable will be used for these activities, including $1500 (non-degree training) of which will be used in INRAB personnel time to train IITA staff of these assessment approaches.

**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. Michelle Shumate, Northwestern University**
**Dr. Brad Coates, USDA, Iowa State University**

**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."* This section some level each of the Steps 1-3, in the impact pathway, should occur within this year. In terms of Program Logic, step 4.1 will occur: 1) Ongoing graduate education across all four HC and a student at UIUC (funded by HHMI), 2) initial ICT training tools in progress that will be primarily created at UIUC, 3) technician training initiated for biocontrol agents that will be released (this will involve sending technicians across to different programs with the training primarily occurring at IITA, however the NARS programs will also exchange between Burkina Faso, Niger, and Ghana where necessary). Both at SARI and CRI $1100 of their budgets will be used for this technician training.

Approach -

Degree training – We will have one West African graduate student (PhD), at UIUC, continue at UIUC through a Howard Hughes Fellowship. A second U.S. citizen (female PhD student) will also continue to be trained (no funds from the Legumes Innovations Lab

will be directly used for her training). At IITA and all NARS programs the incoming students will be identified and we will report to the MO when they begin. We expect eight or more new students will be identified and accepted into labs and programs in the fall of 2013 to begin their training on the next phase of this program. We expect IITA and all NARS programs to have at least one student (with IITA having more) trained in their program.

We expect the following graduate students: (1) one BS (e.g., for an honors project) or MS student will be partially supported at SARI in Ghana (entomology - $1500), (2) one BS (e.g., for an honors project) or MS student will be partially supported at CRI in Ghana (entomology - $1500), (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 work on assessment studies – degree program TBD - $5000 for this partial support), (3) one PhD student will be partially supported at INERA (entomology - $5000), (4) one honors or MS student will be partially or fully supported at INRAN in Niger (entomology $2950), and (5) three more PhD or MS students will be partially/fully supported at IITA in Benin (entomology – partial support for each student at $5000 per student). This brings a total of eight students. The HC student at UIUC will continue at least into FY14 under Howard Hughes fellowship and we expect her to complete her degree in 2014. This would in fact, bring our total to 9 students, however, the ninth student is completely supported by other funds and represents a student from a previous funding cycle. The UIUC program will be actively looking to find another MS or PhD student from one of the HC to attend UIUC, however, this will not occur in FY14, as it will not be possible to bring in a student (from an admissions prospective) until the fall of 2014.

Short-term training – We will be developing tools for short term training and testing these. We see developing 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.

For the ICT approaches we will (1) placing our existing animations in the diversity of major languages needed for each of these countries and initiate new animations where the educational content is needed), make available that 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 develop and test “Apps” 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 with Bluetooth), (2) we will develop and perform ICT training sessions for our collaborators and outside groups like NGOs, other government and international organization (such training sessions will occur online three times per year and one in-country once per year). 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 $53,057.00 will be used at UIUC to support activities to develop and implement training materials and sessions. An additional $5005.00 will be set aside to bring HC scientists to UIUC to plan activities in the host countries as well at $1000 for supplies for them.

For the FFF program we will host a minimal 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. Where six FFF will occur in a given country, three will occur without ICT approaches and three with ICT approaches. At the end of the year we will perform focus group sessions to determine learning outcomes. Additionally, the FFF will include replicates of the technologies in the fields and we will train partner groups on the need for replicates so we can analyze the data to determine if there has been statistically significant yield increases. For INERA and INRAN each team will use $5000 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 FY14. IITA will use $11,300 of their budget for these activities.

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

Please see our "Performance Indicators – Targets" form for the project for FY 2013, 2014 and 2015.

## IV. Outputs:

Defining the pest problems - We expect to collect 1 year of data on the major pests of cowpeas (beyond *Maruca*) in terms of timing, location, and wild alternative host plants. We expect to perform initial molecular work on these populations and we expect to lay these data over known GIS data.

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 – in the first year (FY14) 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)

*1.* USAID Mission Engagement- Dr. Pittendrigh, with Dr. Larry Beach, has already met with the Ghana mission during our program planning meeting and Dr. Pittendrigh will be presenting (this will likely be past tense by time the review of this document occurs) on IPM-omics at the Innovation Lab Workshop to be 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 has already begun to contact 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. Thus, we have already begun this important process of engaging missions in West Africa in regards to our program. Our Ghanaian PI's are slated to be involved in the July 8 and 9 meeting involving USAID Mission staff. In FY14 we will follow-up on the leads (including potential visits) and opportunities that emerge from these two major interactions with the USAID Mission staff.

## 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 will be handed to NARS programs for testing, use and deployment 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 one – Ghana) to meet with and partner with NGOs that can use our materials in scaling with their own educational programs. The travel funds for UIUC ($13,600.00) will be used for UIUC faculty, staff and/or students to visit with IITA and/or NARS scientists in the course of the FY14.

## VII. Leveraging of Legumes Innovations Lab Resources:

The UIUC team will leverage funds from the ADM Institute for the Prevention of Postharvest Losses, endowment funds, and funds from the Chancellor's Office (UIUC). Additionally, a Howard Hughes Doctoral Fellowship will fund graduate student support, for one West African student at UIUC, for the FY13-FY14. Additionally, the MO, IITA and UIUC are currently preparing a one-year planning grant proposal from the he BMGF for a one-year grant to scale some of our IPM-omics technologies – the scaling of neem and laying the foundation for an infield system, using cell phones, to assess pest problems and receive IPM recommendations for farmers to use. However, it is important to note that activities for the BMGF will be kept separate from our Legumes Innovation Lab objectives. There exist multiple complementary technologies and scaling issues that will require 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 2013 – 2014** (use format below)

**Degree Training:**

First and Other Given Names: Tolulope Adebimpe
Last Name: Agunbiade,
Citizenship: Nigeria (but formerly living in Ghana and previously worked for IITA)
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 – This student will be funded from a Howard Hughes Medical Institution grant
Host Country Institution to Benefit from Training: Benin
Thesis Title/Research Area: IPM-omics – Use of molecular tools to make better pest management decisions in cowpea cropping systems in West Africa
Start Date: Continuation (Started Fall 2009)
Projected Completion Date (Fall 2014)
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: 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 CRSP Support (full, partial or indirect) g for training activity: Indirect

**NOTE –** We expect to have eight (8) more students identified and in place in the Benin, Niger, Burkina Faso and Ghana by December of 2013. They are still, as of yet, to be named.

**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 2013
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 220 (equally split between males and females) to benefit
PI/Collaborator responsible for this training activity: Dabire and Baoua
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: Online (three times per year and one in country)
Location: Online and one in Ghana with a potential for a second one in Benin
Duration: 1 day sessions – followed by week long collaborative efforts for new content
When will it occur? One online in the fall of 2013 and two in the spring of 2014; the in-country session(s) will occur before the end of FY14
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 Fy13 we will have trained 28 individuals from NGOs in these technologies and expect over 100 NGO and government agents trained in this year (50 males and 50 females) – From these training sessions we expect that these groups will take these materials out to other groups, and expose upward of 5200 people to our materials (conservative estimate)
PI/Collaborator responsible for this training activity: Pittendrigh
List other funding sources that will be sought (if any): ADM Institute for the Prevention of Postharvest Loss and the Chancellor's office
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 FY14
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, Dabire, 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