

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

**FY 2014–2015 Annual Project Technical Progress Report
(October 1, 2014 – September 30, 2015)**

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 and University:

Dr. Barry Pittendrigh, University of Illinois at Urbana-Champaign (UIUC)

Collaborating Host Country and U.S. PIs and Institutions:

Dr. Manuele Tamò, IITA-Benin (HC-PI)

Dr. Clémentine Dabiré-Binso, INERA-Burkina Faso (HC-PI)

Mr. Laouali Amadou, INRAN-Niger (HC-PI) (Replacement for Dr. Ibrahim Baoua with Dr. Baoua still collaborating with our team)

Dr. Ibrahim Baoua, University of Maradi (collaborator with INRAN; funding goes through INRAN)

Dr. Stephen Asante, SARI, Ghana (HC-PI)

Dr. Haruna Braimah, CRI- Ghana (HC-PI)

Dr. Julia Bello-Bravo, UIUC (US Co-PI)

Mr. Eustache Biaou, INRAB-Benin (HC-PI)(Replacement for Mr. Leonard Hinnou)

I. Abstract of Research and Capacity Strengthening Achievements

Over the past year we have pushed forward our understanding of and solutions for the major pests of cowpeas in four West African countries: Benin, Niger, Burkina Faso and Ghana. We have characterized pest populations both through field-level and molecular tools, specifically focused on mitochondrial polymorphisms. Solutions to these pest problems have been developed and pushed forward including tangible solutions from our biocontrol agent pipeline, as well as a neem and *Maruca*-specific viral combined spray. We have also continued to develop and investigate the use of educational tools, involving animations voice overlaid into local languages, as a scalable system to deploy the outcomes of our research efforts to create and deploy locally sourced pest control solutions. Our capacity building efforts have included undergraduate and graduate training efforts in the host country programs, cross training of technicians across countries, and we have continued to test our animated educational approach, including ICT training sessions and the release of an Android App allowing collaborating organizations to easily access and use these materials in their educational programs. We continued to collaborate with Dr. Maredia's team at MSU and Dr. Mazur's team at ISU towards social science-oriented questions relating to scaling out technologies and approaches for pass-off to other groups.

II. Project Problem Statement and Justification

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, in Niger, Ghana, and in Burkina Faso include: (i) the legume pod borer, *Maruca vitrata* Fabricius; (ii-iii) the coreid pod-bugs, *Clavigralla tomentosicollis* Stål and *Anoplocnemis curvipes* (F.); (iv) the groundnut aphid, *Aphis craccivora* Koch; and, (v-vi) thrips, *Megalurothrips sjostedti* Trybom. Our program is focused on a three-step approach for (1) defining the pest problems, (2) developing appropriate pest control solutions and (3) exploring the scaling of these solutions. We have continued to develop an in depth understanding of the pest populations through a combination of field experiments and molecular tools to characterize and compare pest populations. We have developed solutions that will allow for the development of local cottage industries that can produce biopesticides for local sale and use – thereby facilitating the potential for local value chains that result in the development and sale of ecologically friendly pest control solutions. We have continued to investigate biological control agents in our biocontrol pipeline and we have promising candidates for scaling in the field, along with approaches to scale their release in a cost-effective manner. Additionally, we have (1) developed scalable educational solutions to train people in many of the pest control strategies in their own languages and for all literacy levels and (2) we are exploring pathways for passing these off to other groups that can deploy these in their educational programs. Finally, in terms of capacity building we (1) have been working with NGOs and local companies for pass off our of outcomes, (2) we have continued undergraduate and graduate training, and (3) a cross-country technician training program to facilitate capacity in biocontrol agent rearing and release as well as biopesticide development, deployment and pass-off to local commercial and non-commercial entities.

III. Technical Research Progress

Over the past 12 months we have researched, developed, implemented and performed and analyzed datasets around determining the potential for impacts of our strategies for cowpea farmers in West Africa. We have continued to research and develop scalable solutions, with the potential and actualization of larger-scale impact through donor community buy-in. As part of that donor community buy-in the Bill and Melinda Gates Foundation has funded outcomes of our past efforts on *Maruca* – the objectives of that grant do not overlap with the current USAID Legumes Innovations Lab grant. Our objects emerge from the following vision, with three critical major objectives, supported and intertwined with the fourth objective of capacity building. We term this approach IPM-omics – as a system to develop and deploy scalable solutions. First, we define IPM-omics in the following “equation”:

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

In the below objectives and outcomes we outline how we are actualizing each of these steps with institutional capacity building being integral to this overall process. Below are given our four objectives and our accomplishments under those objectives.

Objective 1. Define the pest problems: (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 the biology of pest populations to drive pest controls strategies.

1.1 Scouting and field experiments

The IITA, INERA, INRAN, CRI, and SARI teams all continue to perform surveys of the pest populations during cowpea cropping cycles and outside of these cycles. Insects found on diverse alternative host plants are stored in RNAlater or 70% ethanol to be sent to UIUC for molecular analyses. Additionally, the INERA team has established experiments to understand the pest populations that occur in the dry season in places where an extra cycle of cowpea could occur where irrigation by some farmers is possible. All of these studies are continuing and will continue to contribute to our understanding of the cycles of pest populations on cowpeas.

For example, in Ghana (from the SARI team) the results were as follows:

- Field studies were conducted at the Savanna Agricultural Research Institute (SARI), Nyankpala, Tolon district, northern region, Ghana, between July and September 2014 to identify the major insect pests of cowpea. The cowpea variety used was IT90K-277-2. The results indicated that leafhoppers, *Aphis*, *Aphis craccivora* Koch; thrips, *Megalurothrips sjostedti* T.; *Maruca vitrata* F.; Pod sucking bugs such as *Clavigralla tomentosicollis*, *Anaplocnemis curvipes*, *Riptortus dentipes* are the major pests. The thrip population was found to increase with the season and peaked with the rain in September. Incidence of *M. vitrata* and pod sucking bugs were low. These results are in keeping with observations from the previous year and this represents year two of multiple year field observations.
- Diagnostic as with FY14, surveys were conducted in farmers fields in 2015 and it was found that *M. sjostedti*, *M. vitrata* and *C. tomentosicollis* populations were high in Krachi West and West Gonja districts which are farther south of Nyankpala in Tolon District.
- As with FY14 the following have been identified as the alternative hosts of *M. sjostedti* and *M. vitrata*; *Glycine max* (L.), *Cajanus cajan* (L.), *Mucuna cochinchinensis* (Lour.), *Canavalia ensiformis*, L. and *Tephrosia* sp.

Our IITA, CRI, INERA and INRAN teams also continued to produce this type of important baseline data.

1.2 Molecular Analyses of pest populations

From IITA we have received pest populations for molecular analysis of insects have been collected from numerous host plant populations, for all species tested, across Benin, Niger, Burkina Faso and Ghana. The specimens have been stored at -80°C and the DNA extracts have been shipped to UIUC for further molecular analyses. Similar sample collections of insects have been received from our teams in Burkina Faso, Niger and Ghana. Molecular analyses (SNP and microsatellite analyses) are continuing at UIUC. However, this past year we have focused more intensely on SNP analysis of mitochondrial genes as we have developed a protocol that allows us to determine the relationships between the populations that will be more useful in. One additional series of experiments include populations of aphids collected by the UC-Riverside team (Dr. Phil Roberts) on different lines of cowpeas. We have been comparing these populations of aphids to determine if they are distinct biotypes.

1.3 Computational Modeling, GIS systems and Online System

The UIUC and IITA teams have continued to work on a flowchart system that

will be used in predictive responses to when and where cowpea farmers can or should intervene in pest control strategies. The IITA team continues to use modeling approaches with the graduate students under Dr. Tamo's direction to better characterize pest populations. The IITA and UIUC teams are continuing to explore the use of GIS systems to couple our other datasets with GIS data.

The UIUC team is continuing to summarize all the published papers that will sit on a website that will be online by the end of the 2015. This website will have fewer features than we first envisage, as collection of data on websites has a set of security challenge issues that are better handled by sharing data between teams through other mechanisms (e.g., e-mail, Dropbox, etc).

1.4 Insect biology - Sex and aggregation pheromones for pod sucking bugs

Olfactometric studies have confirmed previous observations that adult males of the coreid bug *Clavigralla tomentosicollis* produce pheromones which attract the egg parasitoid *Gryon fulviventre*. The student who carried out this research has just recently been awarded an *icipe*-ARPPIS PhD fellowship to carry out the chemical ecology part of his thesis at *icipe* in close collaboration with IITA. Also, the student will compare pheromone profiles of West, East and Southern Africa populations of *C. tomentosicollis* and possibly other congeneric *Clavigralla* species, which will be matched by population genetic studies.

Based on the evidence that female egg parasitoids *G. fulviventre* use olfactory cues emitted by adult male *C. tomentosicollis* for locating egg masses in the field, we have developed small field cages which contain the optimum number of *C. tomentosicollis* males as assessed in previous experiments. The cages have been tested in the field using sentinel egg masses of *C. tomentosicollis*, which were indeed parasitized by the parasitoid *G. fulviventre* after an exposure time of 48h. This experiment is now being carried out at larger scale with different treatments to compare parasitism levels due to the attraction of male aggregation pheromones, with the naturally occurring parasitism levels if no pheromones are present. The experiment just started in the second cropping season and will be harvested mid-November.

Objective 2. Appropriate solutions. We have developed a biocontrol and biopesticide pipeline, in order to develop a series of environmentally and economically appropriate pest control solutions.

2.1. Novel *Maruca* parasitoids available for screening

Upon the delivery of an official release permit by the Minister of Agriculture, we started to carry out experimental releases of the pod borer parasitoid *Therophilus javanus* as part of an MSc study (female student) looking into the details of the host finding behavior of the parasitoid. We successfully recovered parasitoid pupae both from *Sesbania cannabina* and cowpea in confined cages in the screenhouse at IITA-Benin. Confined field cage releases have been established during the second cropping season and will be inoculated with different densities of the parasitoid at the end of October on experimental fields at the IITA-Benin station as planned.

At the same time, a PhD study has started looking at maternal factors responsible for the parasitization success in *T. javanus*. First observations were targeting the specific organs of the female genital tract of *T. javanus*, and particularly the venom gland whose ultrastructure indicates it is of type 2 as observed in Braconidae. Also, there was no sign

of virus or virus-like particles (VLP) in the ovaries of this parasitoid, as opposed to the previously studied *Apanteles taragamae*.

This parasitoid is able to discriminate already parasitized larvae and there is a high probability that the Doufour's gland might be involved in secreting marking volatiles. Also, the study confirmed previous preliminary observations that *T. javanus* females prefer 2 and 3 day old *M. vitrata* larvae for oviposition.

Two further MSc studies have been initiated, one looking into intra-specific competition between *T. javanus* and the other parasitoid *Phanerotoma syleptae*, and the other one assessing the detection of the parasitoid *T. javanus* inside *M. vitrata* larvae by the use of molecular techniques (qPCR).

2.3 PCR techniques for detecting endophytic strains of *Beauveria bassiana* available

Three PCR primers available for the detection of *Beauveria bassiana* (Castrillo et al., 2003) were tested: SCA14₄₄₅ (F 5'TCTGTGCTGG CCCTT ATCG 3' R 5' GTACTGACGTG TCTGTGCTGG 3'); SCA15₄₄₁ (F 5' TTCCGAACCC GGTAAAGAGAC 3' R 5' TTCCGAACCC ATCATCCTGC 3') et SCB9₆₇₇ (F 5' TGGGGGACTC GC AAA CAG 3' R 5' TGGGGGACTCAC TCC ACG 3'). SCB9₆₇₇ revealed to be the best one for our *Beauveria bassiana* Bb115 strain, following the standard methodology of incubating the culture broth with conidia, and extracting the DNA from the mycelium. This was done both for the original culture and then for the re-isolated one from the plant tissue after the endophytic inoculation. However, attempts to re-isolate *Beauveria bassiana* mycelium directly from plant tissue has proven to be difficult and unreliable so far, but efforts are continuing in this direction, e.g. by designing more robust and Bb115-specific SCAR primers.

2.3 Genetic improvement of cowpea to overcome biotic constraints to grain productivity (in collaboration with the UCR cowpea breeding team):

This activity has taken place in Burkina Faso with the INERA team and in Niger with the INRAN team. Details of the activities are outlined as follows. Screening for resistance or tolerance to *Clavigralla tomentosicollis* occurred, as did screening for aphid attack. Aphids were collected in three agroecological: Sahelian zone (< 600 mm), Sudano-sahelian zone (600-900 mm), Sudanian zone (> 900 mm), to screen 10 cowpea varieties from Botswana (B 301), Burkina (KN-1, NS-1, NS-Farako-bâ and K VX 295-2-124-99), Cameroon (N°2300), Ghana (SARC1-91-1 and SARC1-57-2), Nigeria (IT97K-556-6), USA (CB27). From all of these varieties (IT97K-556-6) was recorded resistant or tolerant to aphid (from all of agroecological zone) attack. This study also showed the existence of two strains of aphids in Burkina Faso. So, their molecular characterization is needed. F1's from the cross between susceptible plant (tiligre) x K VX 299-2-124-99 are ready to screen. The INRAN team in Niger screened over 10 varieties of cowpeas thought to have some level of insect tolerance to *Clavigralla tomentosicollis*, *Maruca vitrata* and aphid.

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: (3.1) direct release into the environment and natural establishment; (3.2) educational solutions; and (3.3) private sector and NGO involvement.

3.1.1. *Maruca* parasitoids (IITA)

With regard to scaling out *M. vitrata* parasitoids, we are on track with establishing rearing colonies both for *T. javanus* and *P. syleptae* at the INERA labs in Bobo Dioulasso in Burkina Faso. Experimental releases of both natural enemies are being prepared using satellite pictures/GIS and ecological information with regard to suitable host plant habitats. They are planned as scheduled to be carried out at the onset of the dry season starting November this year, on patches of natural vegetation close to the survey villages used for the socio-economic survey carried out by Dr. Maredia. At the same time, official import permits are being processed for the establishments of similar founding colonies both in Niger and Ghana, which should allow experimental releases to be carried out during the long dry season.

3.1.2. Thrips parasitoid available for scaling up (IITA, INERA and INRAN)

According to schedule, pupae of the thrips parasitoids *Ceranisus femoratus* were collected on patches of *Pterocarpus santalinoides* and *Lonchocarpus sericeus* in Southern Benin and hand-carried to the INERA labs at Farokoba, Burkina Faso, where adult parasitoids were subsequently released on *Tephrosia candida* and other host plants bearing populations of flower thrips. Re-capture surveys to assess establishment are planned with the onset of the dry season starting at the end of November.

3.1.3. Feasibility of storing *Maruca* virus both as liquid and solid substrate (IITA)

The viral solutions kept for six months both in the deep freezer at -18°C and in a normal fridge at 4°C were also evaluated in the experimental fields at the IITA station. As already observed for the lab studies, the field evaluation indicated no significant differences in their activity, with a 63.2% and 48.8% reduction of the *M. vitrata* larval population for 4°C and -18°C treatments, respectively, as compared to the unsprayed control. Unfortunately, the experiments using the industrial-grade dry freezer at the IITA-Benin station had to be stopped due to a malfunctioning of the vacuum pump, which had become unreliable. Attempts to repair the pump locally in Benin were not successful, so the pump had to be dismantled and sent to our HQ in Ibadan for further repairs.

3.1.4 Scaling of the neem plus virus control strategies (IITA, INRAN and INERA)

In Benin, we have established some 54 demonstration plots in farmers' fields covering the whole country, and reaching out to a conservative estimate of 10,000 farmers. We expect to report on impact numbers in the next FY. Treatments consisted not only the targeted MaviMNPV + emulsifiable neem oil mixture, but also neem oil alone, conventional pesticides, an unsprayed control plot, the local concoction of macerated neem leaves, and a combination of the fungal entomopathogen *Beauveria bassiana* Bb115 strain (with endophytic properties) + emulsifiable neem oil. The demonstration plots were also used as experimental fields to assess the presence of different cowpea pests as influenced by the various control approaches, as well as their impact on yield. This is the first time we are able to carry out such an important and country-wide study on the use and impact of bio-pesticides, which was only possible through co-funding by the BMGF-funded precision-IPM project under the choice experiment scheme. Result from the demonstration plots will be available later in the year. Most notably, the INRAN team has continued to work with neem seed oil and virus sprays in villages in the region of Maradi and Zinder. The intent of this activity is to test the effectiveness of this approach in the hands of farmers.

3.1.5 Portable neem oil extraction system (CRI and SARI)

The CRI and SARI teams have and are continuing to explore the development of a low-cost portable neem oil extraction system for use at the village level. SARI has also explored the establishment of larger neem oil extractor with a Ghana-based entrepreneur, however, the movement of this device has not yet occurred.

3.1.5 Studies on the potential for use of biopesticides in the pest control market in Benin (IITA, MSU-Maredia, INRAB, and UIUC)

The INRAB and IITA teams are continuing to work closely with Dr. Maredia of MSU to perform survey studies to understand the potential for biopesticides in the pest control market in Benin. Data acquired during the survey last year were analyzed as scheduled. In Aplahoué et Klouékanmey in Southern Benin, a total of 120 cowpea producers were interviewed in 4 distinct villages. We particularly wanted to assess the farmer willingness to pay for alternative crop protection products as compared to chemical pesticides. The results show that some 5.8% of the farmers strongly favor the use of bio-pesticides, which can cost up to 250 CFA more per treatment, even if they do not significantly increase their monetary revenue, while 10% of the interviewed farmers strongly disapproved the same scenario. Some 50% of the interviewed farmers are ready to pay up to 300 CFA more per treatment with bio-pesticides if their yield is also increased.

With regard to the general perception of bio-pesticides based on neem-leaf extracts (the only ones available at the time of the survey), farmers indicated that they are less toxic, less expensive but difficult if they have to prepare them by themselves, their mode of action is slower and the yields are lower than using synthetic pesticides. They also recognize that chemical pesticides are more efficient, faster in their action, give a good yield but they are well aware of their toxicity and they have given ample examples of poisoning symptoms. They also mentioned that they would be willing to try out new bio-pesticides which can be sold over the counter, and which are more efficient than aqueous extracts.

IITA is also continuing to work with SENS-Benin, a Benin-based social enterprise that is extracting neem oil for sale. They purchase neem seeds from hundreds of local women, process the neem oil and sell it regionally in Benin, targeting cowpea and vegetable farmers. IITA has been invited to participate at their meetings and workshops, and we are in discussions with them on how to diversify their bio-pesticide supply (e.g. by including the viral bio-pesticide MaviMNPV and the fungal entomopathogen *B. bassiana*) through their network of bio-pesticide retailers.

3.2 Educational Solutions

As part of our “Educational Solutions” we have developed 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 we have been testing pathways to deploy videos. We have also been exploring pass-off of our educational materials to NGOs and government agencies for scaling. Over the past 18-months all of these have occurred. Due to the Scientific Animations Without Borders (SAWBO) program we now have a significant amount of the required educational materials needed for educating farmers on cultural techniques

that they can perform to reduce problems with insect attack. Our team is continuing to make more content and more language variants, so more groups in our target countries can be impacted by these educational materials.

We have ICT training packages and interfaces in development and ready for release to make our materials easily available to outside groups. An ICT training session occurred in Ghana in FY15 and was funded by an outside source with no costs to the Legumes Innovations Lab (funded by the Chancellor's office at UIUC) (ca. 30 participants), two ICT training sessions have occurred online through Skype with local NGO groups in Ghana (ca. 100 individuals) as well and the SAWBO team has done ICT training sessions in Burkina Faso (under the LIL program) and in Ethiopia (under another grant). Over 3000 "Extension Systems in Your Wallet" (over the past three years) have been created and distributed to educators, government officials, and NGOs globally (with about 700+ of these going out to groups in the four main countries we work in for our Legumes Innovations Lab program). The "Extension Systems in Your Wallet" is a credit card style USB card that holds SAWBO materials. Users can keep the USB drive in their wallet (save some of their own materials on it) and then share our educational materials with others when and where they see fit. Pass off has occurred to country extension programs, FARA, other West African inter-country institutions and many other organizations.

We have created and released "Apps" for cell phones that allow for easy distribution of the SAWBO animations. Over FY14 we spent a great deal of time with the UIUC legal team to make sure all data that we keep track of with the Apps adheres to international standards and does not violate the privacy of those that are using the App. The necessary supporting legal documentation were created and integrated into the Apps. The Apple version of the App has been tested by multiple groups and the supporting instructional video on the App was finalized and released in FY15. The Android version can be downloaded from Google Play at the following website: <https://play.google.com/store/apps/details?id=edu.uiuc.sawbo&hl=en>. The Apple (iOS version) was also released this past year on iTunes (<https://itunes.apple.com/us/app/id949627456>).

The App is linked to a database where we can keep track of how many people download the videos and the place in the world where they download them (down to country or city). We do not keep track of any personal data from those using the App and we will purposely not pinpoint where they are using it in terms of the location.

This App allows people to choose the country, the language and the topic of educational materials that they need. If available they can download the needed animation into the App on their cell phone or their tablets when they are connected to WiFi. They can then take the cell phone or tablet out to the target audience (away from WiFi or Internet access) and show the video and in the case of the Android App animations can be transferred, by Bluetooth®, onto other's cell phones. In the case of the Apple App, Apple restricts Bluetooth® transfers to non-Apple products, so transfer can only be to other Apple products. However, Apple products can still be used as rapid download and portable screens for showing people the content. However, Android phones are far more common in the target countries, so we will focus on the testing and promotion of this App in the countries we are working in.

The fundamental point of these Apps will be to make SAWBO educational

content easily available to the end users who can easily access and use these materials in educational programs and in the case of the Android App – easy to take content from our server onto their devices and then easy to share once one reaches the village. The Apps will also provide us with basic information on the use of the Apps and the content in a systematic manner. In FY16 we expect to release a video explaining how outside groups can use these materials.

Interestingly, a significant amount of SAWBO materials have also been used by NGOs and government organizations outside our target countries. For example, animations funded by the ADM Institute for the Prevention of Postharvest loss resulted in animations for the Ethiopian Agricultural Transformation Agency (ATA). ATA purchased 640 tablet computers that were distributed to Extension agents across Ethiopia – with an estimated coverage of 168,000 Teff growers (http://news.illinois.edu/news/14/0519sawbo_BarryPittendrigh.html). Other SAWBO animations have also been used in documentaries on TV (e.g., in the Republic of Georgia - <http://www.youtube.com/watch?v=Gh2EhCZOIV8>). Of greatest interest is that SAWBO materials, including our cowpea neem animation, are being used on a Hausa speaking TV station (AREWA24) based out of Kano in Nigeria (<http://us9.campaign-archive1.com/?u=a2b1b23a8f7e117aa0402399c&id=a7349aa0fa>). The animations are played between TV shows and the viewership of the TV station might be as high as in the multiple millions. Within the four target counties we work in we estimate the numbers of people that viewed the animations in thousands to tens of thousands during this past year, based on the use by host country scientists in their educational programs and NGOs that have used these tools. Additionally, an early draft of hermetic sealing animation was used in Mozambique in experiments to understand learning gains from the animations. Under Dr. Mazur's ISU project, Pittendrigh and Bello-Bravo both traveled to Mozambique to partake in learning gain experiments – representing an example of cross-collaboration between programs.

This past year a manuscript was submitted on an experiment performed by the MSU-Marela, INRAN and UIUC team investigating the potential use of these animations in promoting R4D innovations in rural Burkina Faso.

Our team has continued to explore the use of collaborating with and training of NGOs and other groups to perform farmer field flora. Both INERA and INRAN have used these strategies as a way to scale their technologies. For example, this past year INRAN was able to hold over 16 FFF through this approach.

Objective 4. Capacity building

Our capacity building efforts fall into the following categories: (1) undergraduate and graduate student training, (2) technician training, (3) cross-institutional capacity building for biocontrol agents, and (4) systems to easily pass of our outcomes to other groups that can scale the pest control strategies.

4.1 Undergraduate and Graduate student training

Each of our teams continues to play active role in undergraduate and graduate training programs. The complete list of training efforts is given under degree training.

4.2 Technician Training

Online cross-training has occurred (via e-mail, Skype and video exchanges based on videos made by IITA) to share skill sets between technical staff at INERA, INRAN,

and IITA and to build upon previous exchange programs of technicians.

4.3 Cross-Institutional Capacity Building for Biocontrol Agents

IITA, INERA and INRAN, due to ongoing collaborative efforts are all well-positioned to rear and deploy biocontrol agents on a scale that we expect will significantly impact target pest populations in each of these countries. Additionally, all are also in a position to test, train, and scale the neem plus virus strategy for pest control. We have begun the process of transfer of this knowledge to our new partners in Ghana at CRI and SARI.

4.4 Systems to easily pass of our outcomes to other groups that can scale the pest control strategies

Our team has continued to build the necessary sets of networks (e.g., NGOs, companies, FFF organizations, women's organizations, etc.) with whom we can pass off (1) educational materials regarding pest control strategies (through a variety of online and offline systems), (2) neem or neem and virus control strategies, (3) direct deployment of biocontrol agents and (4) FFF training approaches.

IV. Major Achievements

1. Development of bio-control agents useful for scaling for management of cowpea pests.
2. Detailed studies on insect behavior, ecology and biology to maximize the impact of biocontrol agents in the field.
3. Neem and viral spray strategy brought forward into country-wide, large scale field-testing with farmers.
4. Experimental analyses of field data has shown animated educational approach to be as effectively as use of extension agent presentations. This strategy allows us the ability to significantly scale our educational content.
5. SAWBO has been able to demonstrate the potential for other organizations to scale their materials. We have released an App that has the potential to make all of the SAWBO materials highly accessible and the use of the system highly scalable. SAWBO received the Award for Entrepreneurial Excellence: Social Venture. Champaign County Economic Development Corporation, 2015.

V. Research Capacity Strengthening

In FY14-15, CRI and INRAN both received capacity building awards. The CRI project specifically revolved around improvement of laboratory facilities, training of staff and establishing the ability to rear pests and biocontrol agents/biopesticides. The CRI team has reported that the activities have occurred and equipment has been ordered or received. The INRAN project involved the establishment of a medium scale facility for the production of a neem/MaviMNPV virus biopesticide. Training of staff has occurred and in FY15-16 the INRAN team has been working with their administration on equipment orders. INRAN and INERA also received an award for this upcoming funding cycle (end date 9/30/16), contracts are in progress (waiting signatures from INRAN), and funding transfer issues are in progress for INERA.

VI. Human Resource and Institution Capacity Development

1. Short-Term Training

- i. Purpose of Training – Training of NGOs in the use of SAWBO materials
 - ii. Type of Training - ICT training sessions
 - iii. Country Benefiting - Ghana
 - iv. Location and dates of training – Accra, spring 2015
 - v. Number receiving training (by gender): ca. 75 males and 75 females (training other groups on the use of SAWBO materials)
 - vi. Home institution(s) Funded by NGO (CLCD)
 - vii. Institution providing training or mechanism: UIUC
-
- i. Purpose of Training – general use of SAWBO materials
 - ii. Type of Training – use of animations
 - iii. Country Benefiting – Ghana, Niger, Burkina Faso, Benin (and Nigeria) as well as online global use
 - iv. Location and dates of training – Ongoing across the above countries
 - v. Number receiving training (by gender): ca. 2600 males and 2600 females
 - vi. Home institution: UIUC
 - vii. Institution providing training or mechanism: The SAWBO materials have been passed off to NGOs and TV stations in West Africa. A low estimate of number of people being impacted is 2600 males and 2600 females (which is what we are reporting), however, with the TV station in Nigeria alone, these number are definitely much higher by one to two orders of magnitude. However, we are in the process of working with a group on the UIUC campus that is working on getting more accurate estimates of the number of people who have viewed these animations. Additionally, other downloads and online viewing of SAWBOs animations are in excess of the above reported numbers.
-
- i. Purpose of Training – Train farmers in IPM
 - ii. Type of Training - FFF
 - iii. Country Benefiting – Burkina Faso and Niger
 - iv. Location and dates of training – Multiple locations in Burkina Faso and locations in Niger – various dates on FY14
 - v. Number receiving training (by gender) 68 males and 52 females in Burkina Faso and 165 persons including 50 males and 115 females in Niger
 - vi. Home institution(s) (if applicable) – INERA and INRAN
 - vii. Institution providing training or mechanism - INERA and INRAN
-
- i. Purpose of Training – Training of grad student from Iowa State University
 - ii. Type of Training – 1 week at UIUC
 - iii. Country Benefiting - Mozambique
 - iv. Location and dates of training – UIUC, spring 2015
 - v. Number receiving training (by gender): ca. 1 male
 - vi. Home institution(s) Funded by ISA
 - vii. Institution providing training or mechanism: UIUC

Examples of Training Performed by Outside Groups as a Collaboration with INRAN

- 1) Training in collaboration with MercyCorps NGO working in Maradi and Zinder area and implemented 35 FFS related cowpea production 31 extension agents were trained – Estimated impact of 500 or more farmers with an approximate 50:50 split of women and men.
- 2) Training in collaboration with the INRAN World bank project on Biopesticide working in Maradi and Zinder area and implemented 66 Demonstration field related cowpea pest control – Estimated impact of 1980 or more farmers.
- 3) 120 farmers including 40 female farmers were trained related to pest control using bio control methods with Sahel Bio and HEKS.EPER a Swiss land NGO from 01-02 September 2015.

2. Degree Training

- i. Name of trainee (First and Last Name): Laura Steele (this student is not funded in any way from LIL, however, she is contributing to the goals of the project as part of her degree training both on helping with the molecular aspects of the project and in relation to SAWBO)
- ii. Country of Citizenship: USA
- iii. Gender: Female
- iv. Host Country Institution Benefitting from Training: IITA (through collaborations)
- v. Institution providing training: UIUC
- vi. Supervising CRSP PI: Dr. Barry Pittendrigh
- vii. Degree Program: PhD
- viii. Field or Discipline: Entomology
- ix. Research Project Title (if applicable): A Genomic Analysis of the Insect Pest Populations of Cowpea in West Africa
- x. Start Date: 2009
- xi. Projected Completion Date: 2016
- xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
- xiii. Training status? Active
- i. Name of trainee: Fuseini Abdulai
- ii. Country of Citizenship: Ghana
- iii. Gender: Male
- iv. Host Country Institution Benefitting from Training: Ghana
- v. Institution providing training: University for Development Studies, Tamale, Ghana
- vi. Supervising CRSP PI: Stephen Asante
- vii. Degree Program: Undergraduate
- viii. Field or Discipline: Entomology
- ix. Research Project Title: Field evaluation of neem seed extracts from different ecological zones of Ghana in the control of cowpea pests
- x. Start Date: September 2014
- xi. Projected Completion Date: July 2015
- xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
- xiii. Training status: Completed
- i. Name of trainee: Deborah Anobil AMOSAH

- ii. Country of Citizenship: Ghanaian
 - iii. Gender: Female
 - iv. Host Country Institution Benefitting from Training: Ghana
 - v. Institution providing training: Faculty of Agriculture, Kwame Nkrumah University of Science and Technology, Kumasi
 - vi. Supervising CRSP PI: Haruna Braimah
 - vii. Degree Program: Undergraduate
 - viii. Field or Discipline: Agriculture
 - ix. Research Project Title: Neem control strategies on the pests of cowpea in Northern Ghana
 - x. Start Date: October 2013
 - xi. Projected Completion Date: September 2015
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Completed
- i. Name of trainee: Apolline SANOU
 - ii. Country of Citizenship: Burkina Faso
 - iii. Gender: Female
 - iv. Host Country Institution Benefitting from Training: INERA
 - v. Institution providing training: INERA and University of Ouagadougou
 - vi. Supervising CRSP PI: Dr. Clementine Dabire
 - vii. Degree Program: PhD
 - viii. Field or Discipline: Entomology
 - ix. Research Project Title: Biological control of cowpea pod sucking bug *Clavigralla tomentosicollis* Stål.
 - x. Start Date: 2011
 - xi. Projected Completion Date: 2015
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Completed
- i. Name of trainee: DRABO Edouard
 - ii. Country of Citizenship: Burkina Faso
 - iii. Gender: Male
 - iv. Host Country Institution Benefitting from Training: INERA
 - v. Institution providing training: INERA and University of Ouagadougou
 - vi. Supervising CRSP PI: Dr. Clementine Dabire
 - vii. Degree Program: MSc
 - viii. Field or Discipline: Entomology
 - ix. Research Project Title: Botanical extracts use for the management of cowpea pests at Soudan-sahelian and soudanian zones at Kamboinsé and Farako-ba stations
 - x. Start Date: 2015
 - xi. Projected Completion Date: 2017
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Active
- i. Name of trainee: Mariam DERA

- ii. Country of Citizenship: Burkina Faso
 - iii. Gender: Female
 - iv. Host Country Institution Benefitting from Training: INERA
 - v. Institution providing training: INERA and University of Ouagadougou
 - vi. Supervising CRSP PI: Dr. Clementine Dabire
 - vii. Degree Program: PhD
 - viii. Field or Discipline: Entomology
 - ix. Research Project Title: New pests occurring in dry season on cowpea seed production plots
 - x. Start Date: 2014
 - xi. Projected Completion Date: 2018
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Active
- i. Name of trainee: Élisée DABRÉ
 - ii. Country of Citizenship: Burkina Faso
 - iii. Gender: Female
 - iv. Host Country Institution Benefitting from Training: INERA
 - v. Institution providing training: INERA and University of Ouagadougou
 - vi. Supervising CRSP PI: Dr. Clementine Dabire
 - vii. Degree Program: PhD
 - viii. Field or Discipline: Entomology
 - ix. Research Project Title: To be determined
 - x. Start Date: 2015
 - xi. Projected Completion Date: 2019
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Pending
- i. Name of trainee: Joelle Toffa
 - ii. Citizenship: Benin
 - iii. Gender: Female
 - iv. Host Country Institution Benefitting from Training: IITA, Benin
 - v. Institution providing training: IITA
 - vi. Supervising CRSP PI: Tamò
 - vii. Degree Program for training: PhD in Entomology
 - viii. Program Areas or Discipline: Entomology
 - ix. Thesis Title/Research Area: Fungal entomopathogens as bio-pesticides against the pod borer *Maruca vitrata*
 - x. Start Date: 2010
 - xi. Projected Completion Date: 2015
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Completed
- i. Name of trainee: Djibril Aboubakar Souna
 - ii. Citizenship: Benin
 - iii. Gender: Male
 - iv. Host Country Institution Benefitting from Training: IITA, Benin
 - v. Institution providing training: IITA

- vi. Supervising CRSP PI: Tamò
 - vii. Degree Program for training: PhD in Entomology
 - viii. Program Areas or Discipline: Entomology
 - ix. Thesis Title/Research Area: Bio-ecology of *Therophilus javanus*, a promising biocontrol candidate against *Maruca vitrata*
 - x. Start Date: 2014
 - xi. Projected Completion Date: 2018
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Active
- i. Name of trainee: Hilaire Kpongbe
 - ii. Citizenship: Benin
 - iii. Gender: Male
 - iv. Host Country Institution Benefitting from Training: IITA, Benin
 - v. Training Institution: IITA
 - vi. Supervising CRSP PI: Tamò
 - vii. Degree Program for training: PhD in Chemical Ecology
 - viii. Program Areas or Discipline: Entomology
 - ix. Thesis Title/Research Area: Population genetics of pod sucking bugs *Clavigralla* spp. and comparison of aggregation pheromone profiles
 - x. Start Date: 2015
 - xi. Projected Completion Date: 2018
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Active
- i. Name of trainee: Judith Honfonga
 - ii. Citizenship: Benin
 - iii. Gender: Female
 - iv. Host Country Institution to Benefit from Training: IITA, Benin
 - v. Training Institution: IITA
 - vi. Supervising CRSP PI: Tamò
 - vii. Degree Program for training: MSc in Entomology
 - viii. Program Areas or Discipline: Entomology
 - ix. Thesis Title/Research Area: Detection and quantification of *Therophilus javaus* parasitism in *Maruca vitrata* larvae using species-specific qPCR primers.
 - x. Start Date: 2014
 - xi. Projected Completion Date: 2016
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Active
- i. Name of trainee: Ruth Afora
 - ii. Citizenship: Benin
 - iii. Gender: Female
 - iv. Host Country Institution to Benefit from Training: IITA, Benin
 - v. Training Institution: IITA
 - vi. Supervising CRSP PI: Tamò
 - vii. Degree Program for training: MSc

- viii. Program Areas or Discipline: Entomology
- ix. Thesis Title/Research Area: Testing dosage of biopesticide cashew apple oil (*Anacardium occidentale*) against cowpea pests
- x. Start Date: 2014
- xi. Projected Completion Date: 2015
- xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
- xiii. Training status: Completed
 - i. Name of trainee: Cossi Roland Maximilien Belogoun
 - ii. Citizenship: Benin
 - iii. Gender: Male
 - iv. Host Country Institution to Benefit from Training: IITA, Benin
 - v. Training Institution: IITA
 - vi. Supervising CRSP PI: Tamò
 - vii. Degree Program for training: MSc in Entomology
- viii. Program Areas or Discipline: Entomology
- ix. Thesis Title/Research Area: Biology and competitiveness of *Phanerotoma syleptae*, a novel parasitoid of the pod borer *Maruca vitrata*
- x. Start Date: 2013
- xi. Projected Completion Date: 2015
- xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
- xiii. Training status: Completed
 - i. Name of trainee: Nicolette Montcho
 - ii. Citizenship: Benin
 - iii. Gender: Female
 - iv. Host Country Institution to Benefit from Training: IITA, Benin
 - v. Training Institution: IITA
 - vi. Supervising CRSP PI: Tamò
 - vii. Degree Program for training: MSc
- viii. Program Areas or Discipline: Entomology
- ix. Thesis Title/Research Area: Host finding behavior of *Therophilus javanus*, a novel parasitoid of the pod borer *Maruca vitrata*
- x. Start Date: 2015
- xi. Projected Completion Date: 2016
- xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
- xiv. Training status: Active
 - i. Name of trainee: Arnaud HOUNHOU-GAN
 - ii. Citizenship: Benin
 - iii. Gender: Male
 - iv. Host Country Institution to Benefit from Training: IITA, Benin
 - v. Training Institution: IITA
 - vi. Supervising CRSP PI: Tamò
 - vii. Degree Program for training: MSc
- viii. Program Areas or Discipline: Entomology
- ix. Thesis Title/Research Area: Testing of dosage and combinations of MaviNPV and biopesticide neem oil and their residual effects

- x. Start Date: 2014
- xi. Projected Completion Date: 2015
- xiii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
- xv. Training status: Completed
- i. Name of trainee: Fiacre Agbaka
- ii. Citizenship: Benin
- iii. Gender: Male
- iv. Host Country Institution to Benefit from Training: IITA, Benin
- v. Training Institution: IITA
- vi. Supervising CRSP PI: Tamò
- vii. Degree Program for training: MSc in Entomology
- viii. Program Areas or Discipline: Entomology
- ix. Thesis Title/Research Area: Interactions between *Phanerotoma syleptae* and *Therophilus javanus*
- x. Start Date: 2015
- xi. Projected Completion Date: 2016
- xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
- xii. Training status: Active
- i. Name of trainee: Carmel TOSSOU
- ii. Citizenship: Benin
- iii. Gender: Male
- iv. Host Country Institution to Benefit from Training: IITA, Benin
- v. Training Institution: IITA
- vi. Supervising CRSP PI: Tamò
- vii. Degree Program for training: MSc
- viii. Program Areas or Discipline: Entomology
- ix. Thesis Title/Research Area: Host finding behavior of *Therophilus javanus* on selected host plants
- x. Start Date: 2015
- xi. Projected Completion Date: 2016
- xv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
- xiii. Training status: Active
- i. Name of trainee: Mesmin Alizanon
- ii. Citizenship: Benin
- iii. Gender: Male
- iv. Host Country Institution to Benefit from Training: IITA, Benin
- v. Training Institution: IITA
- vi. Supervising CRSP PI: Tamò
- vii. Degree Program for training: MSc
- viii. Program Areas or Discipline: Entomology
- ix. Thesis Title/Research Area: Life table studies of *Therophilus javanus* on artificial and natural substrates
- x. Start Date: 2015
- xi. Projected Completion Date: 2016
- xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No

- xiii. Training status: Active
 - i. Name of trainee: Laurent AHONGBONON
 - ii. Citizenship: Benin
 - iii. Gender: Male
 - iv. Host Country Institution to Benefit from Training: IITA, Benin
 - v. Training Institution: IITA
 - vi. Supervising CRSP PI: Tamò
 - vii. Degree Program for training: MSc
 - viii. Program Areas or Discipline: Entomology
 - ix. Thesis Title/Research Area: Life table studies of *Phanerotoma syleptae* on artificial and natural substrates
 - x. Start Date: 2015
 - xi. Projected Completion Date: 2016
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Active
 - i. Name of trainee: Firmine Aizan
 - ii. Citizenship: Benin
 - iii. Gender: Female
 - iv. Host Country Institution to Benefit from Training: IITA, Benin
 - v. Training Institution: IITA
 - vi. Supervising CRSP PI: Tamò
 - vii. Degree Program for training: BSc
 - viii. Program Areas or Discipline: Entomology
 - ix. Thesis Title/Research Area: Competition between *Phanerotoma syleptae* and *Therophilus javanus* under screenhouse conditions
 - x. Start Date: 2015
 - xi. Projected Completion Date: 2015
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Active
 - i. Name of trainee: Débora Adjayi
 - ii. Citizenship: Benin
 - iii. Gender: Female
 - iv. Host Country Institution to Benefit from Training: IITA, Benin
 - v. Training Institution: IITA
 - vi. Supervising CRSP PI: Tamò
 - vii. Degree Program for training: BSc
 - viii. Program Areas or Discipline: Entomology
 - ix. Thesis Title/Research Area: Effect of different *M. vitrata* larval densities on parasitisation success by *Therophilus javanus* under screenhouse conditions
 - x. Start Date: 2015
 - xi. Projected Completion Date: 2015
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Active
 - i. Name of trainee: Aude GBAGUIDI

- ii. Citizenship: Benin
 - iii. Gender: Female
 - iv. Host Country Institution to Benefit from Training: IITA, Benin
 - v. Training Institution: IITA
 - vi. Supervising CRSP PI: Tamò
 - vii. Degree Program for training: BSc
 - viii. Program Areas or Discipline: Entomology
 - ix. Thesis Title/Research Area: Effect of different *Therophilus javanus* densities on parasitisation rates of *M. vitrata* under screenhouse conditions
 - x. Start Date: 2015
 - xi. Projected Completion Date: 2015
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Active
-
- i. Name of trainee: Maimouna Abdourahmane
 - ii. Citizenship: Niger
 - iii. Gender: Female
 - iv. Host Country Institution to Benefit from Training: INRAN
 - v. Training Institution: INRAN / University of Maradi
 - vi. Supervising CRSP PI: Baoua / Amadou (academic supervisor Prof Saadou Mahamane, University of Maradi)
 - vii. Degree Program for training: PhD in Entomology
 - viii. Program Areas or Discipline: Entomology
 - ix. Thesis Title/Research Area: study on the incidence of *Clavigralla tomentosicollis* on cowpea yield and dissemination of one biopesticide for effective control of the pest in the region of Zinder et Maradi
 - x. Start Date: 2014
 - xi. Projected Completion Date: 2018
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Active
-
- i. Name of trainee: Ousseina Abdoulaye
 - ii. Citizenship: Niger
 - iii. Gender: Female
 - iv. Training Institution: INRAN / University of Maradi
 - v. Host Country Institution to Benefit from Training: INRAN
 - vi. Supervising CRSP PI: Baoua / Amadou (academic supervisor Prof Saadou Mahamane, University of Maradi)
 - vii. Degree Program for training: PhD in Entomology
 - viii. Program Areas or Discipline: Entomology
 - ix. Thesis Title/Research Area: study on the incidence of *Maruca vitrata* on cowpea yield and dissemination of biopesticide (neem seed extract and NPV Mavi virus) for effective control of the pest in the region of Zinder et Maradi
 - x. Start Date: 2014
 - xi. Projected Completion Date: 2018
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Active

- i. Name of trainee: Rahina Souley Mayaki
 - ii. Citizenship: Niger
 - iii. Gender: Female
 - iv. Training Institution: INRAN / University of Maradi
 - v. Host Country Institution to Benefit from Training: INRAN
 - vi. Supervising CRSP PI: Ibrahim Baoua/Amadou
 - vii. Degree Program for training: Bsc in Entomology
 - viii. Program Areas or Discipline: Entomology
 - ix. 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
 - x. Start Date: 2012
 - xi. Projected Completion Date: 2016
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Active
-
- i. Name of trainee: Soumaila Abdou Issa
 - ii. Citizenship: Niger
 - iii. Gender: male
 - iv. Training Institution: INRAN / University of Maradi
 - v. Host Country Institution to Benefit from Training: INRAN
 - vi. Supervising CRSP PI: Ibrahim Baoua/Amadou
 - vii. Degree Program for training: BSc in Entomology
 - viii. Program Areas or Discipline: Entomology
 - ix. 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
 - x. Start Date: 2012
 - xi. Projected Completion Date: 2016
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Active
-
- i. Name of trainee: Nafissatou Illa Boube
 - ii. Citizenship: Niger
 - iii. Gender: Female
 - iv. Training Institution: INRAN / University of Maradi
 - xiv. Host Country Institution to Benefit from Training: INRAN
 - v. Supervising CRSP PI: Ibrahim Baoua/Amadou
 - vi. Degree Program for training: BSc in Entomology
 - vii. Program Areas or Discipline: Entomology
 - viii. If enrolled at a US university, will Trainee be a “Participant Trainee” as defined by USAID?
 - ix. Thesis Title/Research Area: Study of the population dynamics of *Maruca vitrata* on station.
 - x. Start Date: 2011
 - xi. Projected Completion Date: 2016
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Active

- i. Name of trainee: Rakia Gonda
 - ii. Citizenship: Niger
 - iii. Gender: Female
 - iv. Training Institution: INRAN / University of Maradi
 - v. Host Country Institution to Benefit from Training: INRAN
 - vi. Supervising CRSP PI: Ibrahim Baoua/Amadou
 - vii. Degree Program for training: Bsc. in Entomology
 - viii. Program Areas or Discipline: Entomology
 - ix. Thesis Title/Research Area: Study of the biology of *Clavigralla tomentosicollis* in laboratory
 - x. Start Date: 2012
 - xi. Projected Completion Date: 2016
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Active
-
- i. Name of trainee: Kader Djibo Amadou
 - ii. Citizenship: Niger
 - iii. Gender: Male
 - iv. Training Institution: INRAN / University of Maradi
 - v. Host Country Institution to Benefit from Training: INRAN
 - vi. Supervising CRSP PI: Ibrahim Baoua/Amadou
 - vii. Degree Program for training: Bsc in Entomology
 - viii. Program Areas or Discipline: Entomology
 - ix. Thesis Title/Research Area: Study of the development cycle of *Clavigralla tomentosicollis* in laboratory conditions
 - x. Start Date: 2012
 - xi. Projected Completion Date: 2016
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Active
-
- i. Name of trainee: Haouaou Issaka
 - ii. Citizenship: Niger
 - iii. Gender: Female
 - iv. Training Institution: INRAN / University of Maradi
 - v. Host Country Institution to Benefit from Training: INRAN
 - vi. Supervising CRSP PI: Ibrahim Baoua/Amadou
 - vii. Degree Program for training: Msc in Entomology
 - viii. Program Areas or Discipline: Entomology
 - ix. Thesis Title/Research Area: Effect of biopesticide neem seeds extract for the control cowpea pods pest (*Maruca vitrata* and *Clavigralla tomentosicollis*) on station
 - x. Start Date: 2015
 - xi. Projected Completion Date: 2016
 - xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
 - xiii. Training status: Active
-
- i. Name of trainee: Eustache Biaou

- ii. Citizenship: Benin
- iii. Gender: Male
- iv. Training Institution: INRAB / University of Benin
- v. Supervising CRSP PI: Dr. Adegbola/Dr. Tamo
- vi. Host Country Institution to Benefit from Training: INRAB/IITA
- vii. Degree Program for training: MSc
- viii. Program Areas or Discipline: Social Sciences
- ix. Thesis Title/Research Area: TBD
- x. Start Date: 2015
- xi. Projected Completion Date: TBD
- xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
- xiii. Training status: Active

VII. Achievement of Gender Equity Goals

Throughout all aspects of our efforts we attempt to meet gender equity goals, from undergraduate, graduate student and technician training to field training of female farmers.

VIII. Progress in Implementing Impact Pathway Action Plan

Objective 1

In terms of “Program Logic” also worked on Step 4.2 - 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 were genotyped at UIUC to determine pest movement patterns within regions (on cowpeas and alternative host plants). We also worked on developing interfaces to summarize our findings and present our educational steps for implementation in a visual format (ongoing).

Objective 2

In terms of “Program Logic” we worked on Step 4.2 for this section: (a) new knowledge about novel parasitoids; b) thrips parasitoid available for releases c) new knowledge about sex and aggregation pheromones of pod bugs; d) endophytic strains of *Beauveria bassiana* available for testing; e) liquid and/or solid *Maruca* virus substrate available for farmer participatory trials.

Objective 3

In terms of Program Logic, step 4.2 we: 1) developed everything necessary for the releases of biocontrol agents to be 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. The potential pathways for deployment of educational videos were explored, and begin testing of pathways to deploy videos; and, 3) private sector/NGO involvement.

IX. Explanation for Changes - There were no major changes in our work plan.

X. Self-Evaluation and Lessons-Learned

One fundamental issue that we have observed is there is a considerable amount of potential for cross-collaboration between projects. We have passed educational content on to other projects for use in other countries and we have successfully worked with other Legumes Innovation Lab projects on both research and social science assessment. We feel there is considerable opportunity in the coming year to build upon our educational deployment strategies and work with the Iowa State team.

XI. Scholarly Accomplishments

Theses

- Agunbiade, T. 2014. A Genomic Analysis of the Insect Pest Populations of Cowpea in West Africa. PhD Thesis, University of Illinois at Urbana-Champaign.
- Dandjinou, G. V., 2014. Testing biopesticides: Neem oil dosage and combinations of MaviMNPV: 1st planting season 2014, BSc thesis, Agronomy Faculty/ University of Parakou, FA/UPA, Parakou, Benin.
- Akogninou, L., 2014. Behavior of *Therophilus javanus* Bhat & Gupta on larvae from eggs of *Maruca vitrata* (Fabricius) parasited by *Phanerotoma syleptae* Zettel, BSc thesis, Agronomy Faculty/ University of Parakou, FA/UPA, Parakou, Benin.
- Laleye, F., 2014. Determining the host range for the exotic parasitoids *Therophilus javanus* (Hymenoptera: Braconidae), BSc thesis, Agronomy Faculty/ University of Parakou, FA/UPA, Parakou, Benin.
- Agli, C. A. & AGO. D, 2014. Effectiveness of parasitism of *Apanteles taragamae* and *Therophilus javanus* on *Maruca vitrata* pest of cowpea, BSc thesis, Polytechnic School of Abomey-Calavi/ University of Abomey-Calavi, EPAC/UAC, Cotonou, Benin.
- Boni fofana, R. & Ahouantchede, H. S., 2014: Effectiveness of *Apanteles taragamae* and *Therophilus javanus* to control *Maruca vitrata* pest of cowpea, BSc thesis, Polytechnic School of Abomey-Calavi/ University of Abomey-Calavi, EPAC/UAC, Cotonou, Benin.
- Sagbo, R., 2015. Evaluation of continuous multiplication of its host *Trichogrammatoidea eldanae* substitution of *Corcyra Cephalonica* in a release device, MSc thesis, Faculty of Agronomic Sciences / University of Abomey-Calavi, EPAC/UAC, Cotonou, Benin.
- Zanzana, K., 2015. Evaluation of the colonization of the various organs of the cowpea by endophytic *B. bassiana* (Ascomycota : Hypodreales), MSc thesis, Faculty of Technic Sciences/University of Abomey-Calavi, FAST/UAC, Cotonou, Benin.
- Menhinto Toffa, J., 2015. Contribution to sustainable management strategies of *Maruca vitrata* Fabricius (Lepidoptera: Crambidae) of *Vigna unguiculata* L. Walp by using entomopathogenic products in Benin, PhD Thesis, Faculty of Letters, Arts and Humanities Sciences /University of Abomey-Calavi, FLASH/UAC, Cotonou, Benin.
- Fuseini Abdulai, 2015. Field evaluation of neem seed extracts from different ecological zones of Ghana in the control of cowpea pests. BSc Thesis, University for Development Studies, Tamale, Ghana

Selected Presentations

- Bello-Bravo, J. 2015. Scientific Animations Without Borders: LX PCCMCA (Generación de tecnología para la innovación de la agricultura intensiva sostenible), Ciudad de Guatemala, Guatemala, May 4-8, 2015.

- Bello-Bravo, J. 2014. Scientific Animations Without Borders. *Expert Consultation on Facilitating the Convergence of ICT*, Rhenen, The Netherlands, October 29-31, 2014.
- Belogoun, C. R., Tamò, M., Gbedjissi G., Datinon B. and Dannon E. 2015. Etude de quelques paramètres biologiques et évaluation de capacité compétitive de *Phanerotoma syleptae* Zettel (Hymenoptera: Braconidae), parasitoïde ovo-larvaire de *Maruca vitrata* Fabricius (Lepidoptera : Pyralidea). 21th conference of the African Association of Insect Scientists Oct 19-23, 2015 Cotonou, Benin.
- Kpongbe H., Tamò M., Datinon B. and Dannon E. 2015. Evaluation de l'effet des phéromones d'agregation de *Clavigralla tomentosicollis* et des substances volatiles produites par le niébe sur la capacité de recherche d'hôte par les femelles du parasitoïde oophage *Gryon fulviventrif* et la nature de cette phéromone. 21th conference of the African Association of Insect Scientists Oct 19-23, 2015 Cotonou, Benin.
- Tamò, M. 2015. Climate change challenges for insect science in Africa. Plenary inaugural keynote presentation. 21th conference of the African Association of Insect Scientists Oct 19-23, 2015 Cotonou, Benin.
- Tamò, M. 2015. Biological control, a pillar of sustainable agriculture in Africa. International workshop "Visions for a Sustainable Agriculture" May 4-7, 2015 Neuchatel, Switzerland.
- Tamò, M. 2015. Free-air CO₂ enrichment (FACE) for research on sustainable pest management in Africa. RIPE/FACE workshop, July 10-13, 2015, Urbana-Champaign, USA.
- Tamò M., Onstad D., Pittendrigh B. and Agunbiade T. 2015. Resistance management prospects for the control of legume pod borer. Cowpea Project Annual Review and Planning Meeting. Jan 29 – Feb 4, 2015, Kampala, Uganda.
- Tamò M., Datinon B., Dannon E., Srinivasan R., Pittendrigh B., Dabire C., Baoua, I., Braimah H. and Asante S. 2015. Challenges and opportunities for biological control of cowpea pests in Africa. XVIII International Plant Protection Congress, Oct 24-27, Berlin, Germany.

Publications

- Agunbiade, T.A., B.S. Coates, B. Datinon, R. Djouaka, M.-R. Tsai, W. Sun, M. Tamò, and B. R. Pittendrigh. 2014. Genetic differentiation among *Maruca vitrata* F. (Lepidoptera: Crambidae) populations on cultivated cowpea and wild host plants: Implications for insect resistance management and biological control strategies. PLoS ONE 9(3): e92072.
- Agunbiade, T.A., B.S. Coates, W. Sun, M.-R. Tsai, M.C. Valero, and B.R. Pittendrigh. Defining the species complex of the legume pod borer, *Maruca vitrata* (Lepidoptera: Crambidae), by comparative mitochondrial phylogenomics. Submitted.
- Bello-Bravo, J., and B.R. Pittendrigh. 2014. Scientific Animations Without Borders: Entomological origins and cross-discipline impact. *Entomology Society of Canada Bulletin*, 46(1): 31-36.
- Ihm, J., M. Pena-Y-Lillo, K. Cooper, Y. Atouba, M. Shumate, J. Bello-Bravo, M. Ba, C. Dabire-Binso, and B. Pittendrigh. 2015. The case for a two-step approach to agricultural campaign design. *Journal of Agricultural & Food Information*, 16: 203-220.
- Ihm, J., M. Shumate, J. Bello-Bravo, N. Ba, C. Dabire-Binso, and B. Pittendrigh. 2014. Variance of cognitive social structures between farmers and extension agents in Burkina Faso. *VOLUNTAS: International Journal of Voluntary and Nonprofit Organizations*,

- 25(5). Digital Object Identifier (DOI) 10.1007/s11266-014-9515-5
- Sokame, B. M., A. K. Tounou, B. Datinon, E. A. Dannon Elie, C. Agboton, S. Ramasamy, B.R. Pittendrigh, and M. Tamò. 2015. Combined activity of the *Maruca* multi-nucleopolyhedrovirus, *MaviMNPV* and oil from neem, *Azadirachta indica* Juss and *Jatropha curcas* L., for the control of cowpea pests. *Crop Protection* 72: 150-157
- Toffa Mehinto, J., Atachi, P., Elegbede, M., Douro, K., Tamò, M. 2015. Efficacité comparée des insecticides de natures différentes dans la gestion des insectes ravageurs du niébé au Centre du Bénin. *J. Appl. Biosci.* 84:7695– 7706.
- Traore, F., C.L. Dabire-Binso, N.M. Ba, A. Sanon and B.R. Pittendrigh. 2014. Annual cycles of the legume pod borer *Maruca vitrata* Fabricius (Lepidoptera: Crambidae) populations in southwestern Burkina Faso: Host-plants and natural enemies. *Arthropod-Plant Interactions*, 8(2): 155-162

XII. Data Management

We are currently amassing a list of all published and unpublished work that will need to fit under this category and laying out an action plan to make sure all is in order with data sharing. We have already made all genomics data, associated with genomics-oriented publications, available through online databases as required by each journal and the respective repository number are given in respective papers.

ANNEXES

Annex 1. Tables, Figures, and Photos Cited in the Report

N/A

Annex 2. Literature Cited

N/A