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

FY 16-17 Annual Project Technical Progress Report
(October 1, 2016 – September 30, 2017)

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

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I. Abstract of Research and Capacity Strengthening Achievements

Over the past year we have continued to push forward our understanding of and solutions for the major pests of cowpeas in four West African countries: Benin, Niger, Burkina Faso, and Ghana. Specifically, we have characterized pest populations through molecular tools, with a specific focus on mitochondrial polymorphisms. Solutions to these pest problems have been developed and pushed forward. These include across-country releases of biocontrol agents and a larger scale testing of neem and *Maruca*-specific viral combined sprays. We have also continued to 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 feedback on our Android App allowing collaborating organizations to easily access and use these materials in their educational programs. We have 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 several USD per day. 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* Stäl 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) developing strategies for 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 have and 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. These efforts are already being realized with local neem production businesses in Benin. We have continued to investigate biological control agents in our biocontrol pipeline and promising candidates have been released in the field, through approaches we have developed 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, (2) we have experimental data showing people learn the same or more from the animations than from traditional extension presentations, and (3) we have explored 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 communities for pass off of our 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. However, it is critical to note that our project has moved to the point where implementation has become a greater focus. 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 objectives 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 have actualized 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, and 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 efforts to understand pest populations during the cowpea cropping cycles and outside of these cycles. Insects found on diverse alternative host plants are stored in RNA later or 70% ethanol to be sent to UIUC for molecular analyses. Additionally, the INERA team has continued their experiments on understanding 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.

1.2 Molecular Analyses of pest populations

From IITA, UIUC/MSU has continued to receive pest populations for molecular analysis of insects that 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^{o}C and the DNA extracts have been shipped to UIUC/MSU 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) have continued at UIUC and are now continuing at MSU. 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 the future. One additional series of experiments include populations of aphids collected by the UC-Riverside team (Dr. Phil Roberts) on different lines of cowpeas. We published the paper in 2017 on these collaborative efforts with Dr. Phil Roberts and his research team.

1.3 Computational Modeling, GIS systems and Online System

The UIUC/MSU 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/MSU teams are continuing to explore the use of GIS systems to couple our other datasets with GIS data.

The UIUU/MSU has focused on making sure all educational output from the SAWBO animations are readily available for online download from the SAWBO system.

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

IITA has continued collaborating with *icipe*, Nairobi, Kenya (Baldwyn Torto) and Nort-West University, Potchefstroom, South Africa (Johnnie van der Berg) to elucidate putative male aggregation pheromones of the coreid bug *Clavigralla tomentosicollis* and its interactions with the egg parasitoids *Gryon fulviventre*, as part of a PhD study carried out by a student who has been awarded an *icipe*-ARPPIS PhD fellowship to investigate the chemical ecology of this pest group (including *Clavigralla* spp. from West and East Africa).

In 2017, major breakthroughs were the identification of both aggregation and sex pheromones emitted by both sexes of *C. tomentosicollis*, with strongest activity of aggregation pheromones being produced in the thorax of males. Draft chemical formulas of the aggregation pheromone compounds have been identified and are being further characterized. Right now, the student is assaying these compounds on the attractiveness of foraging female egg parasitoids *G. fulviventre* using olfactometric testing.

He has also started identifying different *Clavigralla* spp. in West and East Africa, inferring the population genetic variability of the most dominant *Clavigralla* spp., as well as comparing genetic data (PCR amplification using COI & ITS2) with pheromone profiles.

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

As part of a joint PhD fellowship with the University of Montpellier, France, (Anne-Nathalie Volkoff, UMR DGIMI) and the University of Abomey Calavi, Benin, (Aime Bokonon-Ganta, UAC-FSA), we have continued investigating maternal factors responsible for the parasitization success in *T. javanus*, one of the best biocontrol candidates against the pod borer *M. vitrata*.

Major highlights in 2017 were the investigation of ovary morphology and anatomy, oogenesis, potential fecundity and egg load in *T. javanus*, as well as the effect on egg load of factors as age of the female parasitoid/host size at oviposition. The reproductive tract of *T. javanus* females presented a classical basic morphological organization, with ovarioles from the polytrophic meroistic type, similar to what has been described in other Braconids.

The study also showed that *T. javanus* is synovigenic, *i.e.*, that teneral females emerge with comparatively few mature eggs and continue to produce eggs throughout the adult stage. In addition, oocytes at different development stages were observed in the ovarioles of females of various ages, suggesting that *T. javanus* may be able to regulate egg load depending on host availability. The number of ovarioles was found variable and significantly influenced by the age/size of the *M. vitrata* host when parasitized. Egg load also was strongly influenced by both the instar of *M. vitrata* caterpillar at the moment of parasitism as well as wasp age. These findings have practical implications for improving the mass rearing methodology for *T. javanus* and were published in a peer reviewed journal article (see publication list).

We have also investigated how volatiles from different cultivated and wild-occurring host plants used by *M. vitrata* can influence olfactory responses of foraging female parasitoids *T. javanus*. First, we used an observation arena monitored by a high sensitivity digital camera, and recorded videos were analyzed using dedicated Noldus Observer software. Also, the response of foraging *T. javanus* females to volatiles produced by flowers and/or pods of *V. unguiculata*, *L. sericeus*, *S. rostrata* and *T. platycarpa* was tested using a glass Y-tube olfactometer. Results are currently being summarized and a draft paper is in preparation.

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

We have continued investigating different techniques and methodologies for detecting entophytic *Beauveria bassiana* in cowpea vascular tissue.

A new study was carried out in 2017, comparing more recently collected (from Benin) lepidopteran-active isolates of *B. bassiana* to the standard Bb115 (of Malagasy origin) we have been using so far. This study confirmed earlier results with Bb115, but also demonstrated much higher colonization rates of cowpea flowers after leaf inoculations, particularly with Bb7. The high level of colonization observed in these two tissues (leaves and flowers) could be an asset in the development of cowpea pest control mechanism.

Table 1: Percentage colonization of cowpea organs by endophytic isolates of *Beauveria bassiana* using foliar and seed inoculation

Inoculation method	Organ	*Beauveria bassiana* isolate						
		Bb2	Bb7	Bb11	Bb12	Bb13	Bb14	Bb115
Foliar	Root	4±4 ab	8±4,89a	28±18,54a	0a	12±8a	0a	4±4a
	Stem	8±4,89b	8±8a	12±8a	0a	0a	4±4a	12±8a
	Leaf	8±4,89b	12±4,89a	4±4 a	4±4a	0a	12±8a	16±4a
	Flower	0 a	44±19,39b	4±4a	8±8a	4±4a	0a	12±8a
Seed	Root	8±4,89a	0a	8±4,89a	0a	0a	16±9,79a	0a
	Stem	4±4a	0a	16±7,48a	0a	0a	8±8a	0a
	Leaf	4±4a	4±4a	8±8a	4±4a	4±4a	16±9,79a	16±11,66a
	Flower	4±4a	24±14,69a	12±8a	0a	4±4a	4±4a	4±4a

Using PCR protocol and DNA extracted from surface-sterilized leaf, root and stem sections of cowpea plants inoculated with *B. bassiana* conidia both using seed and foliar inoculation, we were able to observe clear fingerprints of the endophyte after

electrophoresis on gel agarose. All samples that were subjected to the PCR test were positive and the amplicon obtained from the different tissues showed the same molecular weights at 2kb.

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

A manuscript is current being prepared between the UIUC/MSU and URC regarding biotype differences between cowpea aphids. We expect to submit the manuscript in the spring of 2017.

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)

After last years' massive releases of 32,000 *Therophilus javanus* and 17,600 *Phanerotoma syleptae* in Benin and 16,200 *T. javanus* and 10,500 *P. syleptae* in Burkina Faso, in 2017 we concentrated our efforts in documenting establishment of both parasitoids on wild alternative host plants and cowpea crops. In Benin, some 397 samples from 42 different localities were collected from major host plant such as *Pterocarpus santalinoides, Millettia thonningii, Lonchocarpus sericeus, L. cyanescens, Tephrosia* spp. and *Sesbania* spp., in addition to cowpea crops.

By and large, both parasitoids were recovered throughout the release areas in Benin, at distances up to 23 km from the original release sites, less than one year after the release. In fact, surveys carried out in Benin in February–April 2017 indicated with certitude and unambiguously that both species have successfully survived the long dry season (particularly harsh this year) on alternative host plants in the absence of cowpea, nearly one year after initial experimental releases. While it is too early to be able to give a proper quantitative assessment of the impact of the released parasitoids on *M. vitrata* populations, it is noteworthy that during the recent post-dry season surveys we were able to recover parasitized *M. vitrata* larvae from very low pod borer populations, indicating a good ecological adaptation of both parasitoids, and maybe also an early sign of parasitoid efficacy.

A few more releases were carried out in Benin and Burkina Faso (total of 9,600 and 6,800 *T. javanus,* and 18,700 and 8,000 *P. syleptae,* respectively), and new releases were also carried out with INRAN at Maradi, Niger (3,000 *Therophilus javanus* and 1,500 *Phanerotoma syleptae*)

These preliminary data have allowed us to refine our strategy for releasing parasitoids of *M. vitrata*. It relies on 5 pillars:

1. *Participatory releases with communities, regulatory authority and policy makers*

Many biological control campaigns are just focusing on releases of natural enemies without involving local populations who will be affected by the measure. It is therefore important to carry out the releases in participatory manner, in concomitance or shortly

after a sensitization campaign (see below). IITA, CRI, SARI, and INRAB used part or a majority of their non-degree training resources for these efforts, however, interactions with individual groups/people were less than one day (per person interaction) and therefore do not fall under short-term training. INRAN and INERA also use part of their funding, of non-degree training resources, for these same types of efforts respectively in Niger and Burkina Faso. Equally important and also to respect current regulations, at each new site we have invited the regulatory authorities of the national plant protection and quarantine office, whenever possible together with the local (chef de village, chef d'arrondissement, maire) and traditional (chiefs and kings) authorities, and collaborators from the national agricultural research institutes (INRAB, universities).

2. *Sensitization campaigns prior or during releases*

A biological control campaign is the best opportunity to showcase the natural enemies and to explain to communities, in their local language. Using both SAWBO animations and 'wooden powerpoint slides' (using the visuals from the animations) on plywood boards, which explain in very simple terms a) the cowpea pest problem; b) the issue of pesticide use; c) basic biology of the pod borer; d) basic notions of biological control using the biology of the released hymenopteran parasitoids; and, e) the importance of alternative host plants for the survival of the natural enemies in the environment in the absence of cultivated cowpea during the off-season. Sensitization campaigns have been carried out at each of the release sites, in their local language, with close assistance by the local authorities.

3. *Targeting of season, agro-ecology and host plants: importance of Google Earth*

One of the most strategic issues in biological control is the appropriate choice of release sites. Prior to releases, Google Earth has proved to be a very useful tool for identifying hygromorphic areas suitable to harbor alternative host plants flowering during the long dry season, such as *Pterocarpus santalinoides, Lonchocarpus sericeus* and *Millettia thonningii*. All these plants are host for the pod borer during the off-season and will also serve as a dry-season reservoir for the released parasitoids.

4. *Fast releases using newly designed collapsible cages and pupae in bottles*

Another innovation how to be able to release high numbers of parasitoids in short time is the collapsible release cage. The cage can be opened on all sides thus allowing parasitoids to fly away immediately and reducing the release time for each cage from 30+ minutes to a few minutes. Hence, releasing 3,000-5,000 parasitoids can take less than one hour, compared to half a day before.

5. *Choice of recapture sites to determine establishment*

Here again we use data about the presence of alternative host plants during the dry season supported by satellite images from Google Earth. During the cowpea season,

cowpea field are inspected in major cowpea cropping areas, taking care of avoiding crops heavily sprayed with synthetic pesticides.

These achievements were rendered possible by leveraging research funds from a separate grant by the Bill and Melinda Gates Foundation, for investigating a proof-of-concept of precision-IPM in cowpea.

We expect these parasitoids to establish on patches of wild vegetation where they were released, and produce several generations thereby increasing the population size and colonizing neighboring patches where host plants for *M. vitrata* are present. With the onset of the rainy season and the beginning of the cowpea cropping seasons, the parasitoids will follow the *M. vitrata* populations migrating to the cowpea fields. We anticipate an overall reduction of the *M. vitrata* damage in a range of 30–50% depending on prevailing local conditions (such as, e.g., rainfall pattern, planting dates, and cowpea varieties planted). This effort is part of an overall IPM strategy for controlling cowpea pests which includes the use of resistant varieties and the safe and judicious use of pesticides (which we are planning to substitute with locally produced bio-pesticides in the longer term), combined with modern ICT approaches to empower low-literacy farmers to make informed decisions about pest control options.

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

Also, this year we continued to supply adult individuals and pupae of the thrips parasitoids *Ceranisus femoratus* collected in Southern Benin on patches of leguminous trees in hygromorphic areas, which were subsequently hand-carried to the INERA labs at Farokoba, Burkina Faso, and released on host plants bearing high populations of flower thrips.

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

After some negotiations, IITA has agreed to include the new pump of the freeze-dryer (9,000 USD) on the 2018 capital budget.

In the interim of having the powder form for the virus, in 2017 we made progress in having the first batches of the raw viral product (cadavers of virus-infected *M. vitrata* larvae produced by the women groups) sold to our labs for conditioning in order to be used for extensive field trials. The price of treating 1 ha with MaviMNPV has now been finalized with our partners, National University of Agriculture of Porto Novo and the social enterprise SENS-Benin, and it is close to 3 UDS/ha/treatment, which makes it very competitive compared to synthetic pesticides (ranging from 7 USD/ha for the cheapest and possibly unsuitable pesticides to over 15 USD/ha for the recommended insecticides).

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

A pest control strategy which includes biological control as one of its pillars cannot be based on the indiscriminate application of synthetic pesticides as the forefront. In Benin, we have conducted demonstration trials with different biopesticides (neem, pod borer-specific virus and fungal biopesticide), and combinations thereof, which have resulted in the following information: a) against aphids and thrips we spray emulsifiable formulations of neem oil; b) against pod borers, in case of high infestation (*e.g.*, in areas

not already colonized by the parasitoids) we spray either the virus or the fungal biopesticides, or their combination with emulsifiable neem oil; c) against pod sucking bugs, we spray emulsifiable neem oil or neem seed powder extract. Data in Benin shows evidence that *Maruca* populations have been substantially reduced in regions include a minimum of 17,000 farming cowpea households.

Similar scaling field trials have also taken place in Niger, with the virus demonstration at the farmers' level involving 2498+ cowpea's producers in 100+ villages (225+ sites) from 2014-2017, which has allowed the farmers to test (MaviMNPV) + emulsifiable neem oil mixture on around 13,500 m^2. Similar efforts have occurred in Burkina Faso. In Burkina Faso, we have widely assessed several spraying dates with local neem oils in the central part (Pabré village) and southern part (Farako-Ba) of the country in multiple sites per area. This on-farm trial was scaled in two regions, at multiple sites (within those regions) involving a minimum of 50 persons per site.

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

In Benin, we carried out two follow-up training sessions on the production of the MaviMNPV virus by the women's groups at two localities in Benin (Dassa and Glazoue), with the aim of optimizing the workflow and assuring quality control. The sessions took place July 29 to August 12 in Dassa with 15 participants in total (9 for clean *M. vitrata* production and 6 for the virus production), and July 15 to 27 in Glazoue, with 8 participants (4 each for clean *M. vitrata* production and 6 for the virus production. New 'village rearing labs' were established for this purpose in each of the localities, for separating the virus production from the production of healthy pod borer larvae. A technical staff from the Ministry of Agriculture (in charge of regulatory services and bio-pesticides) actively participated as a resource person throughout the sessions.

In a separate ongoing study, some 120 cowpea value chain actors including producers, market retailers and consumers in the Departments of Couffo, Littoral and Plateau were interviewed about their actual use of pesticides along the value chain. Among the producers, 77% responded they were using chemical pesticides for spraying their cowpea crops, while 23% were using home-made aqueous extracts prepared from neem leaves to protect their fields. Additionally, 65% of the market retailers were using non-chemical approaches to protect their stored cowpea grains, such as hermetic drums, solar drying and PICS bags, while 25% were still using chemical pesticides to protect their cowpea grains in storage. Consumers were largely (98%) aware of pesticide-related issues and were not using any chemicals for their own storage after buying from the market.

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 continued to explore pass-off of our educational materials to NGOs and government agencies for scaling. Over the past year all of these aforementioned activities have occurred. The INRAN team has used the neem and biocontrol animations in scaling sensitization projects. Through a

separate funding stream, UIUC/MSU and IITA have also performed a project testing a diversity of animations (two on health and one on agriculture) in terms of learning gains, as compared to traditional extension approaches. In all three cases, the animations outperformed the traditional extension talks, in terms of learning gains of the participants. Learning gains efforts with farmers in Niger revealed the animations (for biocontrol and neem sprays) were highly effective in transmitting knowledge to farmers. 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. We have been and will continue to pass these materials to other groups that can integrate them into their educational programs.

We have ICT training packages and interfaces released to make our materials easily available to outside groups. An ICT training session occurred in Ghana in FY17 and was funded by an outside source with no costs to the Legumes Innovations Lab (funded a grant from QED) (ca. 60 participants), five ICT training sessions have occurred online through Skype with local NGO groups in Ghana (ca. 120 individuals). Over 5000 "Extension Systems in Your Wallet" (over the past three years) have been created and distributed to educators, government officials, and NGOs globally (with many 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 of these USB cards has continued to occur to country extension programs, FARA, other West African inter-country institutions and many other organizations.

In August 16, 2016, SAWBO and all supporting materials and systems has been legally transferred to Michigan State University. With the move of the SAWBO team to MSU, the system to support the App has been moved and we will be releasing an updated version of the App (1.1.1), with improved functions, in the spring of 2017. We also expect to release a 2.0 version, with more functions available for users, however, this is still in progress. The 1.0, 1.1.1 and 2.0 have all been and will be supported through startup and endowment funds to Dr. Pittendrigh.

This past year a manuscript was published on an experiment performed by the MSU, INRAN and UIUC/MSU 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.

4.1 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

As in past years, 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. Previous years' training has set the stage for the current status of the project, such that we can now produce and release in larger-scale biological control strategies. Cross-training in this past year revolved around these scaling and deployment strategies.

4.3 Cross-Institutional Capacity Building for Biocontrol Agents

IITA, INERA and INRAN, due to ongoing collaborative efforts are all well-positioned to continue 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 continue to test, train, and scale the neem plus virus strategy for pest control beyond the scope of this grant. Most importantly, we have evidence that the release of the biocontrol agents in Benin, Niger and Burkina Faso has potential for long-term impact beyond this program and all three countries have significant capacity for future work on biocontrol approaches for both cowpea and other cropping systems.

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 analysis 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 and tested an App that has the potential to make all of the SAWBO materials highly accessible and the use of the system highly scalable. This will serve at the basis for the development of the 2.0 version that we expect to release before the end of the project.

V. Research Capacity Strengthening

In FY16-17, INERA and INRAN both received capacity building awards. The projects were for refurbishing biocontrol rearing room facilities at INERA and rearing equipment and facilities s at INRAN. All facilities have been refurbished and equipment has been purchased. For example, INERA has rehabilitated the rooms for insects' rearing and purchased equipment allowing them to continuously rear three species of insects: thrips, pod sucking bugs, and *Maruca*. These populations also allow for the continuous maintenance of biocontrol agents for these pests.

VI. Human Resource and Institution Capacity Development

1. Short-Term Training

i. Purpose of Training – Train farmers in IPM
ii. Type of Training - FFF
iii. Country Benefiting – Burkina Faso
iv. Estimated USAID funding for activity
   a. US for Instruction - $2000
   b. N/A
   c. N/A
v. Location and dates of training – Multiple villages in Burkina Faso – July 2017
vi. Number receiving training (by gender) 70 males and 75 females in Burkina Faso
vii. Home institution(s) (if applicable) – INERA
viii. Institution providing training or mechanism - INERA

ix. Purpose of Training – Train farmers in IPM
x. Type of Training - FFF
xi. Country Benefiting –Niger
xii. Estimated USAID funding for activity
   a. US for Instruction - $2000
   b. N/A
   c. N/A
xiii. Location and dates of training – Multiple villages in in Niger near Maradi – July to August 2017
xiv. Number receiving training (by gender) 175 persons including 55 males and 120 females
xv. Home institution(s) (if applicable) –INRAN
xvi. Institution providing training or mechanism - INRAN

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 36 FFS related cowpea production 32 extension agents were trained – Estimated impact of 600 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 68 demonstration fields related to cowpea pest control – Estimated impact of 2000 or more farmers impacted.
3) 600 bio-pesticide neem bags of 250 g were sprayed by 600 cowpea's growers in 60 villages in Niger in 2017.

2. Degree Training

i. Name of trainee: Djibril Aboubakar Souna
ii. Country of Citizenship: Benin
iii. Gender: Male
iv. Host Country Institution Benefiting from Training: IITA
v. Institution providing training:
vi. Supervising CRSP PI: Dr. Manuele Tamò
vii. Degree Program: PhD
viii. Field of Discipline: Entomology
ix. Research Project Title: Bio-ecology of *Therophilus javanus*, a promising biocontrol candidate against *Maruca vitrata*
x. Estimated USAID funding for activity if not conducted in US
   a. US$ for instruction: 4,000
   b. US$ for participants: 0
   c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
   a. Provider of funds: BMGF, French Embassy
   b. US$ for instruction: 12'000
   c. US$ for participants: 0
   d. US$ for travel: 3000
xii. Start Date: 2014
xiii. Project Completion Date: 2018
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Active
xvi. Type of CRSP Support: Partial

i. Name of trainee: Hilaire Kpongbe
ii. Country of Citizenship: Benin
iii. Gender: Male
iv. Host Country Institution Benefiting from Training: IITA
v. Institution providing training: IITA
vi. Supervising CRSP PI: Dr. Manuele Tamò
vii. Degree Program: PhD

viii. Field of Discipline: Entomology
ix. Research Project Title: Population genetics of pod sucking bugs *Clavigralla* spp. and comparison of aggregation pheromone profiles.
x. Estimated USAID funding for activity if not conducted in US
    a. US$ for instruction: 4,000
    b. US$ for participants: 0
    c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
    a. Provider of funds: ARPPIS
    b. US$ for instruction: 14,000
    c. US$ for participants
    d. US$ for travel: 3,500
xii. Start Date: 2015
xiii. Project Completion Date: 2018
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Active
xvi. Type of CRSP Support: Partial

i. Name of trainee: Judith Honfoga
ii. Country of Citizenship: Benin
iii. Gender: Female
iv. Host Country Institution Benefiting from Training: IITA
v. Institution providing training: IITA
vi. Supervising CRSP PI: Dr. Manuele Tamò
vii. Degree Program: MSc
viii. Field of Discipline: Entomology
ix. Research Project Title: Detection and quantification of *Therophilus javaus* parasitism in *Maruca vitrata* larvae using species-specific qPCR primers
x. Estimated USAID funding for activity if not conducted in US
    a. US$ for instruction: 2,000
    b. US$ for participants: 0
    c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
    a. Provider of funds: self
    b. US$ for instruction: 2,000
    c. US$ for participants: 0
    d. US$ for travel: 0
xii. Start Date: 2014
xiii. Project Completion Date: 2017
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Completed
xvi. Type of CRSP Support: Partial

i. Name of trainee: Nazyath IMOROU
ii. Country of Citizenship: Benin
iii. Gender: Female

iv. Host Country Institution Benefiting from Training: IITA
v. Institution providing training: IITA
vi. Supervising CRSP PI: Dr. Manuele Tamò
vii. Degree Program: MSc
viii. Field of Discipline: Entomology
ix. Research Project Title: Olfactory responses of T. javanus to frass of M. vitrata.
x. Estimated USAID funding for activity if not conducted in US
    a. US$ for instruction: 2,000
    b. US$ for participants: 0
    c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
    a. Provider of funds: self
    b. US$ for instruction: 2,000
    c. US$ for participants: 0
    d. US$ for travel: 0
xii. Start Date: 2015
xiii. Project Completion Date: 2017
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Active
xvi. Type of CRSP Support: Partial

i. Name of trainee: Nicolette Montcho
ii. Country of Citizenship: Benin
iii. Gender: Female
iv. Host Country Institution Benefiting from Training: IITA
v. Institution providing training: IITA
vi. Supervising CRSP PI: Dr. Manuele Tamò
vii. Degree Program: MSc
viii. Field of Discipline: Entomology
ix. Research Project Title: Host finding behavior of *Therophilus javanus*, a novel parasitoid of the pod borer *Maruca vitrata*
x. Estimated USAID funding for activity if not conducted in US
    a. US$ for instruction: 2,000
    b. US$ for participants: 0
    c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
    a. Provider of funds: self
    b. US$ for instruction: 2,000
    c. US$ for participants: 0
    d. US$ for travel: 0
xii. Start Date: 2015
xiii. Project Completion Date: 2017
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Completed
xvi. Type of CRSP Support: Partial

i. Name of trainee: Sènan Ange Brinette
ii. Country of Citizenship: Benin
iii. Gender: Female
iv. Host Country Institution Benefiting from Training: IITA
v. Institution providing training: IITA
vi. Supervising CRSP PI: Dr. Manuele Tamò
vii. Degree Program: MSc
viii. Field of Discipline: Entomology
ix. Research Project Title: Screening of Benin local isolates of *B. bassiana* against *Maruca vitrata*
x. Estimated USAID funding for activity if not conducted in US
    a. US$ for instruction: 2,000
    b. US$ for participants: 0
    c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
    a. Provider of funds: self
    b. US$ for instruction: 2,000
    c. US$ for participants: 0
    d. US$ for travel: 0
xii. Start Date: 2016
xiii. Project Completion Date: 2017
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Completed
xvi. Type of CRSP Support: Partial

i. Name of trainee: Enock AZOKPOTA
ii. Country of Citizenship: Benin
iii. Gender: Male
iv. Host Country Institution Benefiting from Training: IITA
v. Institution providing training: IITA
vi. Supervising CRSP PI: Dr. Manuele Tamò
vii. Degree Program: MSc
viii. Field of Discipline: Entomology
ix. Research Project Title: Effect of different sugar sources (honey, sucrose solution, extrafloral nectaries of cowpea varieties, Sesbania, Tehrosia) on fecundity and longevity of *Therophilus javanus and Phanerotoma syleptae* adults
x. Estimated USAID funding for activity if not conducted in US
    a. US$ for instruction: 2,000
    b. US$ for participants: 0
    c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
    a. Provider of funds: self
    b. US$ for instruction: 2,000
    c. US$ for participants: 0

d. US$ for travel: 0

xii. Start Date: 2017
xiii. Project Completion Date: 2017
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Active
xvi. Type of CRSP Support: None

i. Name of trainee: Naasir Abdul NONDICHAO
ii. Country of Citizenship: Benin
iii. Gender: Male
iv. Host Country Institution Benefiting from Training: IITA
v. Institution providing training: IITA
vi. Supervising CRSP PI: Dr. Manuele Tamò
vii. Degree Program: MSc
viii. Field of Discipline: Entomology
ix. Research Project Title: Evaluation of the effects of different dosage formulations and biopesticides combination to control the main pests of cowpea
x. Estimated USAID funding for activity if not conducted in US
   a. US$ for instruction: 2,000
   b. US$ for participants: 0
   c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
   a. Provider of funds: self
   b. US$ for instruction: 2,000
   c. US$ for participants: 0
   d. US$ for travel: 0
xii. Start Date: 2017
xiii. Project Completion Date: 2017
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Active
xvi. Type of CRSP Support: None

i. Name of trainee: DRABO Edouard
ii. Country of Citizenship: Burkina Faso
iii. Gender: Male
iv. Host Country Institution Benefiting from Training: INERA
v. Institution providing training: INERA and University Ouagadougou I Pr Joseph KI-ZERBO
vi. Supervising CRSP PI: Dr Fousséni TRAORE
vii. Degree Program: MSc
viii. Field of Discipline: Entomology
ix. Research Project Title: Botanical extract use for cowpea pest management in Sudanian zones at Kamboinse
x. Estimated USAID funding for activity if not conducted in US
   a. US$ for instruction: 500

b. US$ for participants: 0
c. US$ for travel: 0

xi. Estimated funding from other sources for activity if not conducted in US
a. Provider of funds: self
b. US$ for instruction: 1000
c. US$ for participants: 0
d. US$ for travel: 0

xii. Start Date: 2015
xiii. Project Completion Date: 2017
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Completed
xvi. Type of CRSP Support: Partial

i. Name of trainee: Théodore Y. OUEDRAOGO
ii. Country of Citizenship: Burkina Faso
iii. Gender: Male
iv. Host Country Institution Benefiting from Training: INERA
v. Institution providing training: INERA and University Ouagadougou I Pr Joseph KI-ZERBO
vi. Supervising CRSP PI: Dr Fousséni TRAORE
vii. Degree Program: MSc
viii. Field of Discipline: Entomology
ix. Research Project Title: Assessment of neem oil application periods for more efficiency in farmer fields.
x. Estimated USAID funding for activity if not conducted in US
a. US$ for instruction: 500
b. US$ for participants: 0
c. US$ for travel: 0

xi. Estimated funding from other sources for activity if not conducted in US
a. Provider of funds: self
b. US$ for instruction: 1000
c. US$ for participants: 0
d. US$ for travel: 0

xii. Start Date: 2015
xiii. Project Completion Date: 2017
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Completed
xvi. Type of CRSP Support: Partial

i. Name of trainee: Mariam DERA
ii. Country of Citizenship: Burkina Faso
iii. Gender: Female
iv. Host Country Institution Benefiting from Training: INERA
v. Institution providing training: INERA and University Ouagadougou I Pr Joseph KI-ZERBO
vi. Supervising CRSP PI: Dr Clémentine DABIRE

vii. Degree Program: PhD
viii. Field of Discipline: Entomology
ix. Research Project Title: New pests occurring in dry season on cowpea seed production plots.
x. Estimated USAID funding for activity if not conducted in US
    a. US$ for instruction: 1000
    b. US$ for participants: 0
    c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
    a. Provider of funds: self
    b. US$ for instruction: 1500
    c. US$ for participants: 0
    d. US$ for travel: 0
xii. Start Date: 2014
xiii. Project Completion Date: 2018
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Delayed
xvi. Type of CRSP Support: Partial

i. Name of trainee: Apolline SANON
ii. Country of Citizenship: Burkina Faso
iii. Gender: Female
iv. Host Country Institution Benefiting from Training: INERA
v. Institution providing training: INERA and University Ouagadougou I Pr Joseph KI-ZERBO
vi. Supervising CRSP PI: Dr Clémentine DABIRE
vii. Degree Program: PhD
viii. Field of Discipline: Entomology
ix. Research Project Title: Effectiveness of *Gryon fulviventre* for pod sucking bug biocontrol in cowpea field
x. Estimated USAID funding for activity if not conducted in US
    a. US$ for instruction: 1000
    b. US$ for participants: 0
    c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
    a. Provider of funds: self
    b. US$ for instruction: 1500
    c. US$ for participants: 0
    d. US$ for travel: 0
xii. Start Date: 2011
xiii. Project Completion Date: 2015
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Delayed
xvi. Type of CRSP Support: Partial

i. Name of trainee: Bintou Nambe

ii. Country of Citizenship: Burkina Faso
iii. Gender: Female
iv. Host Country Institution Benefiting from Training: Ministry of Agriculture
v. Institution providing training: INERA and CAP/Matourkou
vi. Supervising CRSP PI: Dr Clémentine DABIRE
vii. Degree Program: PhD
viii. Field of Discipline: Entomology
ix. Research Project Title: TBD
x. Estimated USAID funding for activity if not conducted in US
    a. US$ for instruction: 1000
    b. US$ for participants: 0
    c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
    a. Provider of funds: self
    b. US$ for instruction: 1500
    c. US$ for participants: 0
    d. US$ for travel: 0
xii. Start Date: 2017
xiii. Project Completion Date: 2017
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Discontinued
xvi. Type of CRSP Support: Partial

i. Name of trainee: P. Carine Ouedraogo
ii. Country of Citizenship: Burkina Faso
iii. Gender: Female
iv. Host Country Institution Benefiting from Training: INERA
v. Institution providing training: INERA and University BOBO
vi. Supervising CRSP PI: Dr Clémentine DABIRE
vii. Degree Program: PhD
viii. Field of Discipline: Entomology
ix. Research Project Title: TBD
x. Estimated USAID funding for activity if not conducted in US
    a. US$ for instruction: 1000
    b. US$ for participants: 0
    c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
    a. Provider of funds: self
    b. US$ for instruction: 1500
    c. US$ for participants: 0
    d. US$ for travel: 0
xii. Start Date: 2017
xiii. Project Completion Date: 2017
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Discontinued
xvi. Type of CRSP Support: Partial

i. Name of trainee: Maimouna Abdourahmane
ii. Country of Citizenship: Niger
iii. Gender: Female
iv. Host Country Institution Benefiting from Training: INRAN
v. Institution providing training: INRAN / University of Maradi
vi. Supervising CRSP PI: Dr. Ibrahim Baoua and Dr. Amadou Laouali
vii. Degree Program: PhD
viii. Field of Discipline: Entomology
ix. Research Project Title: 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. Estimated USAID funding for activity if not conducted in US
   a. US$ for instruction: 1500
   b. US$ for participants: 0
   c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
   a. Provider of funds: self
   b. US$ for instruction: 1500
   c. US$ for participants: 0
   d. US$ for travel: 0
xii. Start Date: 2014
xiii. Project Completion Date: 2018
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Active
xvi. Type of CRSP Support: Partial

i. Name of trainee: Ousseina Abdoulaye
ii. Country of Citizenship: Niger
iii. Gender: Female
iv. Host Country Institution Benefiting from Training: INRAN
v. Institution providing training: INRAN / University of Maradi
vi. Supervising CRSP PI: Dr. Ibrahim Baoua and Dr. Amadou Laouali
vii. Degree Program: PhD
viii. Field of Discipline: Entomology
ix. Research Project Title: 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. Estimated USAID funding for activity if not conducted in US
   a. US$ for instruction: 1450
   b. US$ for participants: 0
   c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
   a. Provider of funds: self
   b. US$ for instruction: 1500

c. US$ for participants: 0
d. US$ for travel: 0

xii. Start Date: 2014
xiii. Project Completion Date: 2018
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Active
xvi. Type of CRSP Support: Partial

i. Name of trainee: Rahina Souley Mayaki
ii. Country of Citizenship: Niger
iii. Gender: Female
iv. Host Country Institution Benefiting from Training: INRAN
v. Institution providing training: INRAN / University of Maradi
vi. Supervising CRSP PI: Dr. Ibrahim Baoua and Dr. Amadou Laouali
vii. Degree Program: BSc
viii. Field of Discipline: Entomology
ix. Research Project Title: The effects of Neem grain-based biopesticide on the development of *Clavigralla tomentosicollis* at rural level in the region of Maradi
x. Estimated USAID funding for activity if not conducted in US
a. US$ for instruction: 0
b. US$ for participants: 0
c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
a. Provider of funds:
b. US$ for instruction: 0
c. US$ for participants: 0
d. US$ for travel: 0
xii. Start Date: 2012
xiii. Project Completion Date: 2016
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Completed
xvi. Type of CRSP Support: Partial

i. Name of trainee: Soumaila Abdou Issa
ii. Country of Citizenship: Niger
iii. Gender: Male
iv. Host Country Institution Benefiting from Training: INRAN
v. Institution providing training: INRAN / University of Maradi
vi. Supervising CRSP PI: Dr. Ibrahim Baoua and Dr. Amadou Laouali
vii. Degree Program: BSc
viii. Field of Discipline: Entomology
ix. Research Project Title: The effects of Neem grain-based biopesticide on the development of *Clavigralla tomentosicollis* at rural level in the region of Maradi
x. Estimated USAID funding for activity if not conducted in US

a. US$ for instruction: 0
b. US$ for participants: 0
c. US$ for travel: 0

xi. Estimated funding from other sources for activity if not conducted in US
a. Provider of funds:
b. US$ for instruction: 0
c. US$ for participants: 0
d. US$ for travel: 0

xii. Start Date: 2012
xiii. Project Completion Date: 2016
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Completed
xvi. Type of CRSP Support: Partial

i. Name of trainee: Nafissatou Illa Boube
ii. Country of Citizenship: Niger
iii. Gender: Female
iv. Host Country Institution Benefiting from Training: INRAN
v. Institution providing training: INRAN / University of Maradi
vi. Supervising CRSP PI: Dr. Ibrahim Baoua and Dr. Amadou Laouali
vii. Degree Program: BSc
viii. Field of Discipline: Entomology
ix. Research Project Title: Study of the population dynamics of *Maruca vitrata* on station
x. Estimated USAID funding for activity if not conducted in US
a. US$ for instruction: 0
b. US$ for participants: 0
c. US$ for travel: 0

xi. Estimated funding from other sources for activity if not conducted in US
a. Provider of funds:
b. US$ for instruction: 0
c. US$ for participants: 0
d. US$ for travel: 0

xii. Start Date: 2011
xiii. Project Completion Date: 2016
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Completed
xvi. Type of CRSP Support: Partial

i. Name of trainee: Kader Djibo Amadou
ii. Country of Citizenship: Niger
iii. Gender: Male
iv. Host Country Institution Benefiting from Training: INRAN
v. Institution providing training: INRAN / University of Maradi
vi. Supervising CRSP PI: Dr. Ibrahim Baoua and Dr. Amadou Laouali
vii. Degree Program: BSc

viii. Field of Discipline: Entomology
ix. Research Project Title: Study of the development cycle of *Clavigralla tomentosicollis* in laboratory conditions
x. Estimated USAID funding for activity if not conducted in US
    a. US$ for instruction: 0
    b. US$ for participants: 0
    c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
    a. Provider of funds:
    b. US$ for instruction: 0
    c. US$ for participants: 0
    d. US$ for travel: 0
xii. Start Date: 2012
xiii. Project Completion Date: 2016
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Completed
xvi. Type of CRSP Support: Partial

i. Name of trainee: Eustache Biaou
ii. Country of Citizenship: Benin
iii. Gender: Male
iv. Host Country Institution Benefiting from Training: INRAB/IITA
v. Institution providing training: INRAB / University of Benin
vi. Supervising CRSP PI: Dr. Adegbola/Dr. Manu Tamo
vii. Degree Program: MSc
viii. Field of Discipline: Social Sciences
ix. Research Project Title: Research Project Title: Biological fight against the devastating of cowpea in Benin: Logic paysannes around the use of bios pesticides in department of Couffo
x. Estimated USAID funding for activity if not conducted in US
    a. US$ for instruction: 0
    b. US$ for participants: 0
    c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
    a. Provider of funds:
    b. US$ for instruction: 0
    c. US$ for participants: 0
    d. US$ for travel: 0
xii. Start Date: 2015
xiii. Project Completion Date: TBD
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Active
xvi. Type of CRSP Support: Partial

i. Name of trainee: Deborah Anobil AMOSAH
ii. Country of Citizenship: Ghana

iii. Gender: Female
iv. Host Country Institution Benefiting from Training: CSRI/CRI
v. Institution providing training: Faculty of Agriculture, Kwame Nkrumah University of Science and Technology, Kumasi
vi. Supervising CRSP PI: Dr. Haruna Braimah
vii. Degree Program: BSc
viii. Field of Discipline: Agriculture
ix. Research Project Title: Neem control strategies on the pests of cowpea in Northern Ghana
x. Estimated USAID funding for activity if not conducted in US
    a. US$ for instruction: 1500
    b. US$ for participants: 0
    c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
    a. Provider of funds: self
    b. US$ for instruction: 500
    c. US$ for participants: 0
    d. US$ for travel: 0
xii. Start Date: 2013
xiii. Project Completion Date: 2016
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Active
xvi. Type of CRSP Support: Partial

i. Name of trainee: Samuel Abekah Kwesi
ii. Country of Citizenship: Ghana
iii. Gender: Male
iv. Host Country Institution Benefiting from Training: SARI
v. Institution providing training: University for Development Studies, Tamale, Ghana
vi. Supervising CRSP PI: Dr. Stephen Asante
vii. Degree Program: BSc
viii. Field of Discipline: Entomology
ix. Research Project Title: Evaluation of different storage methods for preserving cowpea grains against *Callosobruchus maculatus Fab.*
x. Estimated USAID funding for activity if not conducted in US
    a. US$ for instruction: 750
    b. US$ for participants: 0
    c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
    a. Provider of funds: self
    b. US$ for instruction: 500
    c. US$ for participants: 0
    d. US$ for travel: 0
xii. Start Date: 2016
xiii. Project Completion Date: 2017

xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Active
xvi. Type of CRSP Support: Partial

i. Name of trainee: Akosua Addai Asare
ii. Country of Citizenship: Ghana
iii. Gender: Female
iv. Host Country Institution Benefiting from Training: SARI
v. Institution providing training: University for Development Studies, Tamale, Ghana
vi. Supervising CRSP PI: Dr. Stephen Asante and Dr. Braimah
vii. Degree Program: BSc
viii. Field of Discipline: Entomology
ix. Research Project Title:
x. Estimated USAID funding for activity if not conducted in US
   a. US$ for instruction: 750
   b. US$ for participants: 0
   c. US$ for travel: 0
xi. Estimated funding from other sources for activity if not conducted in US
   a. Provider of funds: self
   b. US$ for instruction: 500
   c. US$ for participants: 0
   d. US$ for travel: 0
xii. Start Date: 2015
xiii. Project Completion Date: 2016
xiv. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xv. Training status: Active
xvi. Type of CRSP Support: Partial

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. In regards to gender issues, we performed a cross-collaborative effort with the Iowa State University team, they have tested (in Mozambique) the learning gains in female farmers (as compared to male farmers), as well as a 2-year later adoption study, and the data supports that the animations were effective in both groups, however, women experienced greater learning gains with the animations than with traditional extension talks. High adoption rates of the given technology were also observed 2-years post-intervention.

VIII. Implementation of Data Management Plan

The data for published cowpea pest studies within the last two years and the associated publications were uploaded to USAID database (https://mft.usaid.gov/courier/web/1000@/wmLogin.html). The name of the data file is **244-10 Genomics Data for Cowpea Pests in Africa**. As of Oct 25, 2017, Kim Marshall from opendata@usaid.gov has confirmed receiving publication files and the readme files associated with each publication. Our team is continuing to make sure any remaining datasets, with host country partners, will be loaded into the system by the end of November 2017.

IX. Scholarly Accomplishments

Theses

Agbaka Fiacre, 2016. Etude des interactions entre *Phanerotma syleptae* et *Therophilus javanus, (*Bhat & Gupa) (Hymenoptera: Braconidae) deux parasitoïdes du lépidoptère *Maruca vitrata* Fabricius (Lepidoptera: Crambidae) ravageur du niébé au laboratoire. FAST/UAC, 38p

Ahongbonon Laurent, 2016. Etude de la table de vie de *Phanerotoma syleptae* (Hymenoptera: Braconidae), parasitoide ovo-larvaire de *Maruca vitrata* (Lepidoptera: Braconidae), ravageur du niébé, *Vigna unguiculata* (L.) Walp.. FAST/UAC, 31p

Alizanon Mesmin, 2016. Etude de la table de *Therophilus javanus* sur milieux naturel et artificiel. FAST/UAC, 36p

Tossou Carmelle, 2016. Test d'efficacité de *Therophilus javanus '(*Bhat & Gupa) (Hymenoptera: Braconidae) sur *Maruca vitrata* (Lepidoptera: Crambidae. FAST/UAC, 36p

Selected Presentations

Tamò, M., E. Dannon, B. Datinon, C. Dabiré, F Traoré, B. Pittendrigh, and R. Srinivasan. 2017. Science-driven pest management saves cowpea farms from insect pests. Lead paper. The Feed the Future Legume Innovation Lab, Grain Legume Research Conference, Ouagadougou, Burkina Faso, August 13 to 18.

Pittendrigh, B., C. Dabire-Binso, I. Baoua, F. Traore, A. Laouali, S. Asante, H. Braimah, M. Mochaih, B. Datinon, E. Biaou, J. Bello-Bravo, and M. Tamò. 2017. Integrated Pest Management (IPM) in cowpea cropping systems in West Africa: From genomics to biocontrol agents, biopesticides, and extension. Invited paper. The Feed the Future Legume Innovation Lab, Grain Legume Research Conference, Ouagadougou, Burkina Faso, August 13 to 18.

Zakari, O., A., I. Baoua, S. Boureima, L. Amadou, M. Tamò, S. Mahamane S, and B. R. Pittendrigh. 2017. Biopesticide test of neem seed (*Azadirachta indica* A. Juss.) extract and MaviNPV Virus for the control of main insect pests of cowpea (*Vigna*

unguiculata L. Walp.) in Niger. The Feed the Future Legume Innovation Lab, Grain Legume Research Conference, Ouagadougou, Burkina Faso, August 13 to 18.

Abdourahmane, M., I. Baoua, L. Amadou, S. Mahamane, M. Tamò, and B. R. Pittendrigh. 2017. Farmer field test of neem-based (*Azadirachta indica*) and entomopathogenic MaviNPV virus formulations on the main insect pests of cowpea in Niger. The Feed the Future Legume Innovation Lab, Grain Legume Research Conference, Ouagadougou, Burkina Faso, August 13 to 18.

Bello-Bravo, J., E. A. Dannon, O. A. Zakari, A. Laouali, I. Baoua, M. Tamò, and B. R. Pittendrigh. 2017. An assessment of localized animated educational videos (LAV) versus traditional extension presentations or LAV followed by extension agent discussions among farmers in Benin and Niger. The Feed the Future Legume Innovation Lab, Grain Legume Research Conference, Ouagadougou, Burkina Faso, August 13 to 18.

Posters

Abdourahmane, M., I. Baoua, L. Amadou., M. Tamò, B. R. Pittendrigh, and S. Mahamane. 2017. Life Cycle of *Clavigralla tomentosicollis* (Stal.) and its Impact on Crop Yields of Cowpea (*Vigna unguiculata* L. Walp.) in Niger. The Feed the Future Legume Innovation Lab, Grain Legume Research Conference, Ouagadougou, Burkina Faso, August 13 to 18.

Toffa Mehinto, J., E. Dannon, O. Kobi, D. Kpindou, and M. Tamò. 2017. Comparative efficacy of Biopesticides for Controlling the Legume Pod Borer, *Maruca Vitrata* Fabricius (Lepidoptera: Crambidae) Under Field Conditions in Benin. The Feed the Future Legume Innovation Lab, Grain Legume Research Conference, Ouagadougou, Burkina Faso, August 13 to 18.

Agyekum, M., C. Donovan, M. Tamò, B. Pittendrigh, and E. Biaou. 2017. Precision Pest Management Technology Delivers Financial and Health Benefits for Farmers in West Africa. The Feed the Future Legume Innovation Lab, Grain Legume Research Conference, Ouagadougou, Burkina Faso, August 13 to 18.

Publications

Souna, D.A., A. Bokonon-Ganta, M. Ravallec, A. Cusumano, B, R. Pittendrigh, A.-N. Volkoff, and M. Tamò. 2017. An insight in the reproductive biology of *Therophilus javanus* (Hymenoptera, Braconidae, Agathidinae), a potential biological control agent against the legume pod borer, (Lepidoptera, Crambidae). *Psyche,* Article ID 3156534, 8 pages, doi:10.1155/2017/3156534.

Tamò, M., Datinon, B., Dannon, E., Traore, F., Dabire, C., Pittendrigh, B. R. and R. Srinivasan. 2017. Towards successful establishment of exotic parasitoids

attacking the pod borer *Maruca vitrata* in west Africa. *Biocontrol News and Information*. **38**(2): 12-13.

Bello-Bravo, J., Tamò, M., Dannon, E. A. and B. R. Pittendrigh. 2017. An assessment of learning gains from educational animated videos versus traditional extension presentations among farmers in Benin. *Information Technology for Development*, 1-21, doi:10.1080/02681102.2017.1298077 (Not directly funded from LIL).

Agunbiade, T. A., B. S. Coates, W. L. Sun, M. R. Tsai, M. C. Valero, M. Tamo and B. R. Pittendrigh. 2017. Comparison of the mitochondrial genomes of the Old and New World strains of the legume pod borer, *Maruca vitrata* (Lepidoptera: Crambidae). *International Journal of Tropical Insect Science* **37**(3): 125-136.

Sun, W., B.-L. Huynh, J. A. Ojo, B. S.Coates, F. Kusi, P. A.Roberts and B. R. Pittendrigh. 2017. Comparison of complete mitochondrial DNA sequences between old and new world strains of the cowpea aphid, *Aphis craccivora* (Hemiptera: Aphididae) *Agri Gene* **4**: 23-29.

Steele, L. D., W. Sun, M. C. Valeroa, J. A. Ojo, K. M. Seong, B. S. Coates, V. M. Margam, M. Tamò and B. R. Pittendrigh. 2017. The mitogenome of the brown pod-sucking bug *Clavigralla tomentosicollis* Stäl (Hemiptera: Coreidae). *Agri Gene* **5**: 27-36.

Valero, M. C., J. A. Ojo, W. Sun, M. Tamò, B. S. Coates and B. R. Pittendrigh. 2017. The complete mitochondrial genome of *Anoplocnemis curvipes* F. (Coreinea, Coreidae, Heteroptera), a pest of fresh cowpea pods. *Mitochondrial DNA Part B* **2**(2): 421-423.

Maredia, M. K., Reyes, B., Ba, M. N., Dabire, C. L., Pittendrigh, B. R., & Bello-Bravo, J. (2017). Can mobile phone-based animated videos induce learning and technology adoption among low literate farmers? A field experiment in Burkina Faso. *Information Technology for Development*. doi:10.1080/02681102.2017.1312245.

X. Achievement of Impact Pathway Action Plan

Objective 1

In terms of "Program Logic" we have completed all steps (up to and including Step 4.5) for this section. We feel that we were able to achieve all goals set forth at the beginning of the project and this impact pathway action plan document was an important for us to keep track of where we stood regarding our goals, as they were originally outlined.

Objective 2

In terms of "Program Logic" we have completed all steps (up to and including Step 4.5) for this section.

Objective 3

In terms of "Program Logic" we have completed all steps (up to and including Step 4.5) for this section.

ANNEXES

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

N/A

Annex 2. Literature Cited

N/A