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

FY 2015–2016 Annual Project Technical Progress Report
(October 1, 2015 – September 30, 2016)

Template

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 people learn the same or more from the animations than from traditional extension presetnations 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 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 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, 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 have been comparing these populations of aphids to determine if they are distinct biotypes. We are nearing completion of a manuscript around these topics with the intent to submit it to a peer-review journal in the spring of 2017.

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 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 project. 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

IITA has continued olfactometric studies involving the egg parasitoid *Gryon fulviventre* as attracted by putative male aggregation pheromones of the coreid bug *Clavigralla tomentosicollis*. This study was carried out by Dr. Tamo's PhD student who was awarded an *icipe*-ARPPIS Ph.D fellowship late last year, to investigate the chemical ecology of this pest group (including *Clavigralla* spp. from West and East Africa). After having spent considerable time setting up separate rearing colonies for the different species, the student was able to report a first breakthrough in identifying some of the key components. The headspace volatile of both male and female *Clavigralla* spp. were collected without food and analysed, which allowed determining chemical profile (different components) for the three species (*C. tomentosicollis, C. shadabi* and *C. elongata*). For each sex, headspace volatiles were collected over five times and analysed separately. After comparison of both male and female of each species, specific male-components were identified and are currently being characterized. Also, the student has started collecting and processing samples of these species in order to elucidate their population genetics.

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

We have continued investigating maternal factors responsible for the parasitization success in *T. javanus*, one of the best biocontrol candidates against the pod borer *Maruca vitrata*. This work is part of a joint Ph.D fellowship with the University of Montpellier (Anne-Nathalie Volkoff, UMR DGIMI). After a series of observations targeting the specific organs of the female genital tract of *T. javanus* (particularly the venom gland whose ultrastructure indicates it is of type 2 as observed in Braconidae), the study focused on phenotyping the parasitized larvae, and to investigate live stages of the parasitoid larva inside the body of the pod borer larva. This study yielded spectacular pictures of the different live stages which are given in the annexes.

Further studies confirmed the ability of the parasitoid to discriminate already parasitized larvae and there is a high probability that the Doufour's gland might be involved in secreting marking volatiles.

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

After the initial success using three PCR primers available for the detection of *Beauveria bassiana* of which $SCB9_{677}$ revealed to be the best one for our *B. bassiana* Bb115 strain (which is the most virulent, so far, against the legume pod borer *Maruca vitrata*), we were confronted with technical issues when attempting to detect *B. bassiana* mycelium directly form plant tissue, which have been reported in literature with other strains on cereals. Hence, we have initiated new collaborative links with a specialized institute in Germany (Hochschule Geisenheim) in the hope to overcome this barrier.

At the same time, we have continued to investigate possible interactions between

B. bassiana and the parasitoid *T. javanus*, in order to assess if there is any negative impact when using both in the field. Adult parasitoids treated with the entomopathogenic fungus *B. bassiana* under laboratory conditions were not negatively impacted in terms of longevity and fecundity. However, dead adult parasitoids sporulated with conidia of *B. bassiana*, indicating a possible synergistic effect in the field, as the conidia will be available during the cropping season for infecting the main target pest, the pod borer *M. vitrata*. These experiments hold out the hope that an entomopathogenic fungus might be combined with a biocontrol agent to have synergistic impact on a pest population.

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)

In Benin, we released close to 50'000 adult parasitic wasp (32'000 *Therophilus javanus* and 17'000 *Phanerotoma syleptae*) which work in synergy by having two different modes of action, one being an ovo-larval parasitoid, and the other being a sturdier larval parasitoid which can detect the presence of caterpillars of *M. vitrata* inside flowers and pods of cowpea. The parasitoids were released with the participation of local communities, in 6 regions of Western Benin, on patches of wild alternative host for the pod borer, where the pest is feeding and reproducing during the off season, ready to invade cowpea fields with the onset of the cropping season.

Preliminary field data indicated a good establishment by both biocontrol agents/organisms already a few months after their initial releases.

In conjunction with the releases, together with field staff of the Ministry of Agriculture and INRAB, Benin, we have carried out practical training sessions in conducting releases of pod borer parasitoids, and also monitoring their establishment. At the same time, we have also carried out sensitization campaigns involving farming communities to explain, in very simple terms and using their own language, basic principles and rules of biological control and the releases campaigns being carried out in their communities. In particular, farmers were sensitized about the need to refrain from inappropriate use of chemical pesticides in order to preserve the just-released natural enemies.

We also initiated the same type of releases with INERA in Burkina Faso at several locations being part of a socio-economic study being carried out by Prof Mywish Maredia at MSU. A total of 11,000 *T. javanus* and 5000 *P. syleptae* individuals, were released both on natural vegetation and cowpea fields. Similar to the releases in Benin, we also carried out similar training and sensitization sessions with INERA technical staff

and farming communities.

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 and 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)

Unfortunately, after a series of attempts to repair the pump of the freeze-dryer which was sent to our HQ in Ibadan, it became clear that the pump had been damaged beyond repairs by previous attempts to fix it locally in Benin. It has therefore become necessary to order a new pump, which has been outsourced by our supply chain. The cost of it is not negligible (over 7000 USD including shipping) so we are negotiating with IITA about the purchase of this equipment through other funding mechanisms.

In the meantime, we have initiated talks with the Agricultural University of Ketou (just being renamed National University of Agriculture) for moving all activities related to the processing of the raw viral product (cadavers of virus-infected *M. vitrata* larvae produced by the women groups), which will include purification and processing into a commercial product, to their Agri-business School involving youth agri-preneurs. They have already had preliminary discussions with our main partner on the ground, the social enterprise SENS-Benin, and we hope to be able to get their full involvement in FY17.

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

Also this year, we have established demonstration plots in farmers' fields, targeting areas with high pest pressure as identified by last year's demonstration plots covering the whole country of Benin, which reached out to over 10,000 farmers. Results from last year's demonstration plots, which could not be reported in the last report because they only became available towards the end of the year, indicate quite some variability across regions, particularly because of different rainfall pattern, vegetation cover and preferred cowpea varieties used by the participating farmers. Data analysis is being finalize and a draft paper is being prepared. Overall, we can however confirm the

good performance of the combination of the pod borer specific virus (MaviMNPV) + emulsifiable neem oil mixture, which has also been confirmed by IITA trials in Kano, Northern Nigeria, under very high pod borer population pressure. Similar scaling field trials have also taken place in Niger, with the the virus demonstration at the farmers level involving 2236 cowpea's producers in 75 villages (225 sites) from 2014-2016, which has allowt the farmers to test (MaviMNPV) + emulsifiable neem oil mixture on 13,500 m^2. Similar efforts have occurred in Burkina Faso.

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 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 are well-positioned to pass these materials to other groups that can integrate them into their educational programs.

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 FY16 and was funded by an outside source with no costs to the Legumes Innovations Lab (funded a grant from QED) (ca. 30 participants), four 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 5000 "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 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), with improved functions, in the fall of 2016. We also expect to release a 2.0 version, with more functions available for users.

This past year a manuscript was submitted on an experiment performed by the MSU-Maredia, 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.

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 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. Most importantly, we have moved to scaling the release of the biocontrol agents in Benin, Niger and Burkina Faso.

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. 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 ofaneem/MaviMNPV virus biopesticide and purchase equipment for parasitoids' multiplications. Training of staff has occurred in FY15-16 .Five INRAN staff including two PhD students attended short term training at Entomology laboratory in

IITA Benin.. INRAN and INERA also received an award for this upcoming funding cycle (end date 9/30/16) 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 and Cape Coast, spring/summer 2016
v. Number receiving training (by gender): ca. 300 males and 300 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

Purpose of Training – general use of SAWBO materials
i. Type of Training – use of animations
ii. Country Benefiting – Ghana, Niger, Burkina Faso, Benin (and Nigeria) as well as online global use
iii. Location and dates of training – Ongoing across the above countries
iv. Number receiving training (by gender): ca. 500,000 males and 500,00 females
v. Home institution: UIUC
vi. 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 500,000 males and 500,00 females (which is what we are reporting), primarily through a TV station that broadcasts the SAWBO animations in Hausa to approximately 1-5 million viewers. 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

<u>Examples of Training Performed by Outside Groups as a Collaboration with INRAN</u>

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 fields related cowpea pest control – Estimated impact of 1980 or more farmers impacted.

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: 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. Manu 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. Start Date: 2014
xi. Project Completion Date: 2018
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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. Manu 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. Start Date: 2015
xi. Project Completion Date: 2018
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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. Manu 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. Start Date: 2014
xi. Project Completion Date: 2016
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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. Manu 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. Start Date: 2015
xi. Project Completion Date: 2017
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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. Manu 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. Start Date: 2015
xi. Project Completion Date: 2017
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. Type of CRSP Support: Partial

i. Name of trainee: Fiacre Agbaka
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. Manu Tamò
vii. Degree Program: MSc
viii. Field of Discipline: Entomology
ix. Research Project Title: Interactions between *Phanerotoma syleptae* and *Therophilus javanus.*
x. Start Date: 2015
xi. Project Completion Date: 2016
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Completed
xiv. Type of CRSP Support: None

i. Name of trainee: Carmel TOSSOU
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. Manu Tamò
vii. Degree Program: MSc
viii. Field of Discipline: Entomology
ix. Research Project Title: Host finding behavior of *Therophilus javanus* on selected host plants
x. Start Date: 2015
xi. Project Completion Date: 2016
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Completed
xiv. Type of CRSP Support: None

i. Name of trainee: Mesmin ALIZANON
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. Manu Tamò
vii. Degree Program: MSc
viii. Field of Discipline: Entomology
ix. Research Project Title: Life table studies of *Therophilus javanus* on artificial and natural substrates
x. Start Date: 2015
xi. Project Completion Date: 2016
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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. Manu 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. Start Date: 2016
xi. Project Completion Date: 2017
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. Type of CRSP Support: Partial

i. Name of trainee: Firmine AIZAN
ii. Country of Citizenship: Benin
iii. Gender: Femail
iv. Host Country Institution Benefiting from Training: IITA
v. Institution providing training: IITA
vi. Supervising CRSP PI: Dr. Manu Tamò
vii. Degree Program: BSc
viii. Field of Discipline: Entomology
ix. Research Project Title: Competition between *Phanerotoma syleptae* and *Therophilus javanus* under screenhouse conditions
x. Start Date: 2015
xi. Project Completion Date: 2016
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Completed
xiv. Type of CRSP Support: None

i. Name of trainee: Débora ADJAYI
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. Manu Tamò
vii. Degree Program: BSc
viii. Field of Discipline: Entomology
ix. Research Project Title: Effect of different *M. vitrata* larval densities on parasitisation success by *Therophilus javanus* under screenhouse conditions
x. Start Date: 2015
xi. Project Completion Date: 2015
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Completed

xiv. Type of CRSP Support: None

i. Name of trainee: Aude GBAGUIDI
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. Manu Tamò
vii. Degree Program: BSc
viii. Field of Discipline: Entomology
ix. Research Project Title: Effect of different *Therophilus javanus* densities on parasitisation rates of *M. vitrata* under screenhouse conditions
x. Start Date: 2015
xi. Project Completion Date: 2015
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Completed
xiv. 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. Start Date: 2015
xi. Project Completion Date: 2017
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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. Start Date: 2015
xi. Project Completion Date: 2017
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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. Start Date: 2014
xi. Project Completion Date: 2018
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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. Start Date: 2011
xi. Project Completion Date: 2015
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Delayed
xiv. Type of CRSP Support: Partial

i. Name of trainee: Élisée DABRÉ
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
vi. Supervising CRSP PI: Dr Clémentine DABIRE

vii. Degree Program: PhD
viii. Field of Discipline: Entomology
ix. Research Project Title: TBD
x. Start Date: 2011
xi. Project Completion Date: 2019
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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. Start Date: 2014
xi. Project Completion Date: 2018
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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. Start Date: 2014
xi. Project Completion Date: 2018
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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. Start Date: 2012
xi. Project Completion Date: 2016
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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. Start Date: 2012
xi. Project Completion Date: 2016
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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. Start Date: 2011
xi. Project Completion Date: 2016
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active

xiv. Type of CRSP Support: Partial

i. Name of trainee: Rakia Gonda
ii. Country of Citizenship: Niger
iii. Gender: Female
iv. Host Country Institution Benefiting from Training: INRAN
xv. Institution providing training: INRAN / University of Maradi
v. Supervising CRSP PI: Dr. Ibrahim Baoua and Dr. Amadou Laouali
vi. Degree Program: BSc
vii. Field of Discipline: Entomology
viii. Research Project Title: Study of the biology of *Clavigralla tomentosicollis* in laboratory
ix. Start Date: 2012
x. Project Completion Date: 2016
xi. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xii. Training status: Active
xiii. 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. Start Date: 2012
xi. Project Completion Date: 2016
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. Type of CRSP Support: Partial

i. Name of trainee: Haouaou Issaka
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: MSc
viii. Field of Discipline: Entomology
ix. Research Project Title: Effect of biopesticide neem seeds extract for the control cowpea pods pest (*Maruca vitrata and Clavigralla tomentosicollis)* on station
x. Start Date: 2015

xi. Project Completion Date: 2016
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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: TBD
x. Start Date: 2015
xi. Project Completion Date: TBD
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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. Start Date: 2013
xi. Project Completion Date: 2016
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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. Start Date: 2016
xi. Project Completion Date: 2017
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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. Start Date: 2015
xi. Project Completion Date: 2016
xii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiii. Training status: Active
xiv. 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. As 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) 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.

IX. Explanation for Changes - There were no changes in our work plan over this past year.

IX. Self-Evaluation and Lessons-Learned

We have continued to recognize that there is a considerable amount of potential for cross-collaboration between projects, with other Innovations Labs and with other outside entities. As we head into the final year of this project, we will be continuing to place a heavy emphasis on research supporting pass-off strategies thereby increasing impact of the overall project.

X. 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., B.R. Pittendrigh, S. Miresmailli, V. Font, B. Blalock, , E. Dannon, B. Datinon, M. Agyekum, C. Donovan, and E. Biaou. 2016. From biocontrol to precision-IPM in Africa: Challenges and opportunities. Keynote paper, International Congress of Entomology, Orlando, Florida, 24–28 Sept, 2016. Abstract 0644: doi: 10.1603/ICE.2016.95128

Dannon, E., B. Datinon, R. Srinivasan, J. Toffa, D. Arodokoun, B.R. Pittendrigh, and M. Tamò. 2016. Biological control: anon-obvious option for managing insect pests in cowpea. Invited Paper, International Congress of Entomology, Orlando, Florida, 24–28 Sept 2016. Abstract 0774: doi: 10.1603/ICE.2016.106004.

Pittendrigh, B.R., M. Tamò, J. Bello-Bravo, E. Dannon, I. Baoua, H. Braimah, S. Asante, C. Dabire, E. Biaou, and A. Laouali. 2016. West Africa Integrated Pest Management (IPM) Cowpea Program: Discovery pipeline to scaling. Invited paper, The World Food Price, USDA-USAID 2016 International Food Assistance and Security Conference, Des Moines, 11 Oct 2016.

Tamò, M. et al., 2016. Biological control of cowpea insect pests: progress, challenges and opportunities. Keynote presentation. Pan-African Grain Legume & World Cowpea Conference, Livingstone, Zambia, 28 February – 4 March, 2016. Paper Number: 1299.

Agunbiade, T.A., B.S. Coates, W. Sun, M. Ba, I. Baoua, M. Tamò, and B.R. Pittendrigh. 2016. IPM-Omics: From Genomics to Extension for Integrated Pest Management of Cowpea. Pan-African Grain Legume & World Cowpea Conference, Livingstone, Zambia, 28 February – 4 March, 2016. Poster Number 332.

Apkoffo, M.A.Y., M. Tamò, B. Datinon, A. Djihinto, and E. Dannon. 2016. Evaluation

de quelques paramètres biologiques et de l'efficacité de *Therophilus javanus* Bhat et Gupta (Hymenoptera : Braconidae), parasitoïde larvaire de *Maruca vitrata* Fabricius, (Lepidoptera: Crambidae), foreuse des fleurs et des gousses du niébé (*Vigna unguiculata*). Pan-African Grain Legume & World Cowpea Conference, Livingstone, Zambia, 28 February – 4 March, 2016. Poster Number 334.

Publications

Agunbiade, T.A., B. R. Pittendrigh, M. Tamò, W. Sun, B. S. Coates, F. Traore, J. A. Ojo, A. N. Lutomia, J. B. Bravo, S. Miresmailli. Cowpea Field Insect Pests and Integrated Pest Management Techniques for Cowpea Cultivation in West Africa. Francis Dodds ed, legume book chapter (submitted)

Bello-Bravo et al., An Assessment of Learning Gains from Educational Animations versus Traditional Extension Presentations among Farmers in Benin, submitted.

Oigiangbe, O.N., Tamò, M., Igbinosa, I.B. 2016. Bioactivity of Alstonia boonei De Wild leaf alkaloid on the growth and development of Maruca vitrata Fabricius pp. 117-122 In: Sahayaraj and Selvaraj (eds.). Biopestides: Innovations and Practices. Smith and Franklin Academic Publishing Corporation, Ash Vale, UK.

Rabé Moctar et al., Champ école paysan un processus participatif pour l'amélioration de rendement du niébé : résultats des expériences pilotes conduites dans les régions de Maradi and Zinder. Submitted to Agronomie Tropicale.

Sokame, B. M., A. K. Tounou, B. Datinon, E. A. Dannon, C. Agboton, R. Srinivasan, B. R. Pittendrigh and M. Tamò (2015). "Combined activity of Maruca vitrata 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.

Ihm, J., M. Shumate, J. Bello-Bravo, Y. Atouba, N. M. Ba, C. L. Dabire-Binso and B. R. Pittendrigh (2015). "How do Service Providers and Clients Perceive Interorganizational Networks?" VOLUNTAS: International Journal of Voluntary and Nonprofit Organizations 26(5): 1769-1785.

Ihm, J., M. Pena-Y-Lillo, K. R. Cooper, Y. Atouba, M. Shumate, J. Bello-Bravo, N. M. Ba, C. L. Dabire-Binso and B. R. Pittendrigh (2015). "The Case for a Two-Step Approach to Agricultural Campaign Design." Journal of Agricultural & Food Information 16(3): 203-220.

XI. Progress in Implementing Impact Pathway Action Plan

Objective 1

In terms of "Program Logic" we worked on Step 4.3 for this section.

Objective 2

In terms of "Program Logic" we worked on Step 4.3 for this section.

Objective 3

In terms of Program Logic, step 4.3. As reported on our performance indicator pathway we documented 10,000+ people receiving the educational content, however, this is inclusive of other groups using our materials in their educational programs.

ANNEXES

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

N/A

Annex 2. Literature Cited

N/A