Dry Grain Pulses CRSP Proposal

COVER PAGE (must print on one page)

Title of Proposal: **Biological Foundations for Management of Field Insect Pests of Cowpea in West Africa**

Name(s), institutional affiliation and contact information of Lead U.S. Principal Investigator(s) submitting this proposal:

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Proposed Project Period: (30 months maximum, between April 1, 2008 – September 30, 2010)	Total federal funds requested	Total non-federal cost share commitment by U.S. institution(s)
April 1, 2008 -September 20, 2010	**$427,715**	**$113,854**

Proposed HCs where project activities will be implemented:	Proposed HC institutions to be sub-contracted (abbreviated name):	Proposed budget for a sub-contract to a HC institution	Are you requesting the ME (MSU) to manage the Fixed-Price sub-contract for this HC Institution? (Yes/No)
Nigeria	**INRAN**	**$64,000**	**Yes**
Niger	**INERA**	**$61,500**	**Yes**
Burkina Faso	**IAR**	**$61,500**	**Yes**

Authorized lead U.S. institutional representative (type name, phone number and e-mail):_______

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Signature: Walter K. Knorr **Date:** 11/29/07

Walter K. Knorr, Comptroller

The Board of Trustees of the
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Dry Grain Pulses CRSP Proposal
SUMMARY PAGE

Title of Proposal: Biological Foundations for Management of Field Insect Pests of Cowpea in West Africa

Name and Institutional Affiliation of the U.S. Principal Investigator:

Dr. Barry Robert Pittendrigh, University of Illinois at Urbana-Champaign

Abstract **(Limit: 1800 characters including spaces—about 200-250 words):**

Cowpea is an important food and protein source for about 200 million people in Africa, with 80% of the world's cowpea production occurring in West Africa. The three top producers of cowpea in West Africa include Niger, Nigeria, and Burkina Faso. However, insect pests limit the potential of cowpea cultivation and production in these areas. The major field pests of cowpea include the legume pod borer, coreid pod-bugs, groundnut aphids, and thrips. Beyond insecticide sprays, few solutions exist for the control of the insect pests of cowpea. Developing alternatives to pesticide sprays requires a fundamental understanding of life-history of these pest insects. A solution for the control of legume pod borer in West Africa now exists: transgenic *Bt*-cowpea expressing the Cry1Ab protein. Although *Bt*-cowpea is now ready for field-testing, its release in West Africa requires that an Insect Resistance Management (IRM) plan is developed for the legume pod borer. IRM plans prevent or slow the rate at which the insect population becomes resistant to the transgenic plant. In the following project we will develop an IRM plan for *Bt*-cowpea useful in the control of the legume pod borer. Concurrently, we will also perform life-history studies on the other pest species of cowpea, to lay the foundation for environmentally benign pest control strategies. We will also develop an Internet-based outreach program for the dissemination of CRSP outcomes and technologies.

Pulse Crop of Focus *(select at least one between beans and cowpeas)*

Beans ☐ **Cowpeas** ☒ **Other (specify):** ☐

Topical Areas to be Addressed By this Project

Select one or more under Global Themes A-C:

A. To reduce bean and cowpea production costs and risks for enhanced profitability and competitiveness.

- ☒ 1. Genetic Improvement
- ☒ 2. Integrated Crop Management
- ☐ 3. Mitigating Effects of Low Soil Fertility/Drought
- ☐ 4. Grain Quality
- ☐ 5. Sustainable Seed Systems

B. To increase the utilization of bean and cowpea grain, food products and ingredients so as to expand market opportunities and improve community health and nutrition.

- ☐ 1. Health and Nutritional Attributes
- ☐ 2. Consumer Attitudes and Preferences
- ☒ 3. Influencing Decision Makers
- ☐ 4. Urban Consumer Access to Value-added Pulse Foods

C. To improve the performance and sustainability of bean and cowpea value-chains, especially for the benefit of women.

- ☐ 1. Understanding constraints to smallholder pulse farmer participation in markets and trade
- ☐ 2. Identifying "weak links"/constraints in the functionality of dry grain pulse value-chains
- ☐ 3. Identifying strategic public sector interventions to alleviate constraints or market failures.

Select at least one from Global Theme D; If none selected from A-C, then select at least two:

D. To increase the capacity, effectiveness and sustainability of agriculture research institutions

- ☐ 1. Building and promoting partnerships with key stakeholders
- ☒ 2. Strengthening regional dry grain pulse commodity research networks
- ☒ 3. Training young scientists in the use of modern tools for research, management and outreach

Summary Checklist *(select as many as appropriate)*

- ☒ Project addresses IEHA objectives (give anticipated level of effort as % of total budget requested): 32%
- ☒ Project devotes at least 30% of project funds on HC capacity building activities (Global Theme D) (give total % budgeted): 58%
- ☒ Project involves research on biotechnology as defined in the RFP (give % effort on biotechnology) 10%
- ☐ Project involves the use or generation of genetically modified organisms (GMOs)
- ☐ Project involves human subject approval
- ☐ Project involves animal use approval
- ☐ Project involves M.S. or Ph.D. degree training of HC personnel (how many?)_____

The University of Illinois
at Urbana-Champaign

Revised Proposal Entitled:
"Biological Foundations of Management of Field Insect Pests of Cowpea in West Africa"

University of Illinois Principal Investigator
Dr. Barry Pittendrigh

Submitted by and make contract to:
THE BOARD OF TRUSTEES OF THE
UNIVERSITY OF ILLINOIS
c/o Office of Sponsored Programs and Research Administration
1901 South First Street, Suite A
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Authorizing Official

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Title: **Chair, Research Board**

Signature: Charles F. Zukoski

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Chartered 1867

4. Technical Component of Project (Revised)

4.1 Problem Statement and Justification

Cowpea (*Vigna uguiculata* [L.] Walp.) is an important food and protein source for about 200 million people in Africa. Cowpea is cultivated in approximately 9.27 million hectares in West Africa alone, accounting for greater than 80% of the world's cowpea production [1, 2]. Low-income farmers are the major contributors to cowpea production in Africa [3]. Cowpea cultivation, apart from being a major source of dietary protein, has multiple advantages such as (i) it is an ideal crop for legume-cereal based cropping systems since it can replenish the soil-nitrogen content used by cereal crops [4, 5]; (ii) cowpea is one of the key components of sustainable agricultural systems like crop-livestock systems in sub-Saharan Africa, serving dual purposes as both food and fodder [6]; and, (iii) cowpea cultivation does not require external inputs like fertilizers [4-6]. These factors make cowpea a relatively environmentally friendly crop that is highly beneficial for low-income farmers. However, numerous factors, including biotic and abiotic stresses, limit the potential of cowpea cultivation and production [7, 8].

Field and storage insect pests are the most severe biotic constraints for cowpea production [7, 8]. Insect-resistant cultivars have the potential to resolve some of the pest problems like root-knot nematode, but the lack of cultivars that resist major insect pests like legume pod borer, bruchids, pod bugs, and pod sucking bugs cannot be filled by conventional breeding because attempts to find genes conferring resistance in the cowpea genome to these pests have failed so far [7]. Recent work by Dr. J. Ehlers has identified thrip resistance in cowpeas, but field testing of these plants in places like Burkina Faso, and Niger still needs to be done (see letter of support), before these plants make their way into the hands of growers. ***Thus, farmers often resort to use (and misuse) of neurotoxic pesticides to control cowpea insect pests with, in some unfortunate cases, dire consequences to their health, the health of their families, and the end users of those who purchase the cowpeas*** [9]. Thus, there is a need to develop alternative strategies for control of insect pests of cowpea, in order to reduce the levels of pesticides used on cowpea crops.

Several major strategies have been taken in the developed world to reduce the use of neurotoxic pesticide sprays in the field and on the stored seeds. First, biotechnology has offered us new tools to produce transgenic plants [10] carrying insect resistance traits. Insecticidal proteins like those produced by *Bacillus thuringiensis (Bt)* specifically target the insect pests that actually feed on the plant. Second, Integrated Pest Management (IPM) plans have been developed to control insect pests using alternative control methodologies, including, but not limited to, host-plant resistance traits, cultural practices, and biological control agents. However, regardless of which strategy prevails for insect control, all of these strategies require an in-depth understanding of the biology of the pest insects and how they interact with their environment.

The major pests of cowpea in the field in northern Nigeria, Niger, and Burkina Faso include: (i) the legume pod borer, *Maruca vitrata* Fabricius; (ii-iii) the coreid pod-bugs, *Clavigralla tomentosicollis* Stal and *Anoplocnemis curvipes* (F.); (iv) the groundnut aphid, *Aphis craccivora* Koch; and, (v-vi) thrips, *Megalurothrips sjostedti* Trybom and *Sericothrips occipitalis* Hood [11-56]. A significant amount of work has been done on the pests of cowpea in southern Benin; however, little has been done to understand these insect pests in the areas we propose to work. Also, there are few alternatives to pesticide sprays for many of these pest species. Two notable exceptions to this situation exist. The first is *M. vitrata,* where a potential biotechnology-based pest control solution exists. Transgenic cowpea expressing the *Bt*-protein Cry1Ab, effective against *M. vitrata* already exists, however, these plants are unlikely to be available for use by

African farmers during the current CRSP funding cycle. However, before transgenic *Bt*-cowpea can be released there will be a need for an insect resistance management (IRM) plan. Although not the primary focus of the current project, our studies may ultimately provide the necessary data for the eventual development of an IRM plan for *Bt*-cowpea. We do not rule out the possibility of participating the development of such an IRM plan as a consequence of the below proposed work. The second pest of cowpea, where a potentially new strategy for insect control exists, are thrip-resistant cultivars that have been created by Drs. Phillip Roberts and Jeff Ehlers of University of California at Riverside. Thrip-resistant cowpeas are ready for field-testing in Africa. We will work with Drs. Roberts and Ehlers to investigate the interactions between thrip-resistant cowpeas and trips in field experiments in Northern Nigeria, Niger, and Burkina Faso.

Although transgenic plants, and traditional plant breeding for insect resistant varieties are potentially effective methods for controlling at least two pests of cowpeas, a better understanding of pest populations is needed in order to integrate these, and other, pest control options into an overall IPM plan to maximize cowpea production in the field. IPM refers to a pest control strategy where a variety of complementary approaches are used to minimize the negative effects of pests on a given crop or cropping system. Such approaches may use, but are not limited to, natural parasites and predators, pest-resistant varieties, biological controls, cultural practices, physical techniques, and in some cases the strategic use of pesticides. However, IPM is an approach that relies on a solid understanding of the ecology of the crops and their pests, in order to reduce or eliminate the use of pesticides.

Before we begin to develop IPM strategies for the pests of cowpea, we must first understand many of the life-history parameters of these pest insects in relationship to their environment. Critical life-history parameters include, but are not limited to, the following. First, when and where do the pest insects occur? For example, are they migratory or do they occur in these areas all year long? If they migrate, where do they come from? If they are endemic, where do they live in the dry season? Second, what do the pest insects live on beyond just cultivated cowpeas? Third, are their varieties of cowpea that remain productive in spite of the presence of these pest insects? Fourth, what organisms (*e.g.*, predators or parasites) regulate the populations of the insects that attack cowpea? If so, what can be done to encourage the populations of these predators or parasites? Fifth, are there parameters in the field that can be altered that will reduce the negative impacts that these insect pests have on cowpea? Sixth, where sprayed pesticides are the only option, or a necessary component of an IPM program, how can their use be minimized while still achieving effective pest control?

Regardless if biological control, insect resistant varieties, or transgenic plants, limited pesticide sprays, or a combination of these approaches are ultimately used, we will need a fundamental understanding of the insect pest populations in order to determine which of these will be viable control strategies for the pests of cowpeas in the field. ***Therefore, in this project, we will develop a better understanding of the biology of the pests of cowpea in northern Nigeria, Niger, and Burkina Faso***. At the end of this 30-month project we expect to have data to provide for the development of IPM plans for the control of cowpea pests in northern Nigeria, Niger, and Burkina Faso.

We have already begun the process of investigating the basic biology of all of these pest species, with much of our work in the past CRSP being focused on *M. vitrata*. For example, the migration patterns, including distances traveled by *M. vitrata* adults, will have a major bearing on when and where *M. vitrata* populations will occur. Such population dynamics may ultimately have an impact on the deployment of transgenic *Bt* cowpea, beyond the scope of this CRSP project. Additionally, the fact that multiple wild host plant species serve as a host for *M. vitrata* will also impact an insect resistance management plan for *Bt*-cowpea or may even serve as trap crops for cowpea varieties currently in cultivation.

Our first complete large-scale field season of data suggests that *M. vitrata* (i) lives year round in the Sudanian zone in Farako-ba, and (ii) dies out (or is at extremely low population levels) in northerly areas when cultivated cowpeas are not available (Figures 1-2). Light trapping data (not shown) from Niger and Nigeria are in keeping with these observations. Microsatellite data is currently being analyzed to determine if *M. vitrata* from these locations are (i) endogenous populations, (ii) coincides with potential migration patterns based on the known wind directions in the region, or (iii) a combination of i-ii. A minimum of three seasons of fieldwork is necessary for such ecological studies, especially when the work needs to withstand the rigor of review by a regulatory agency.

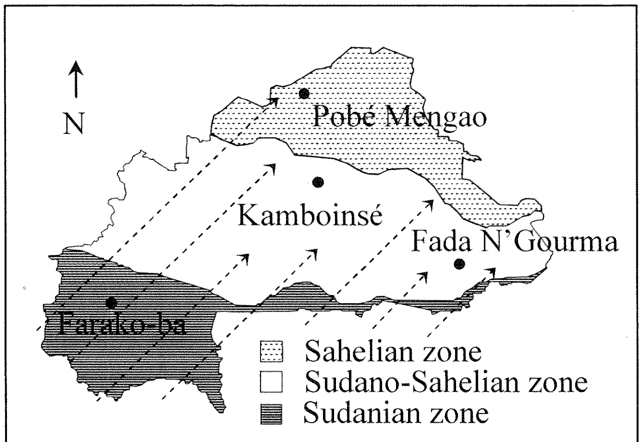
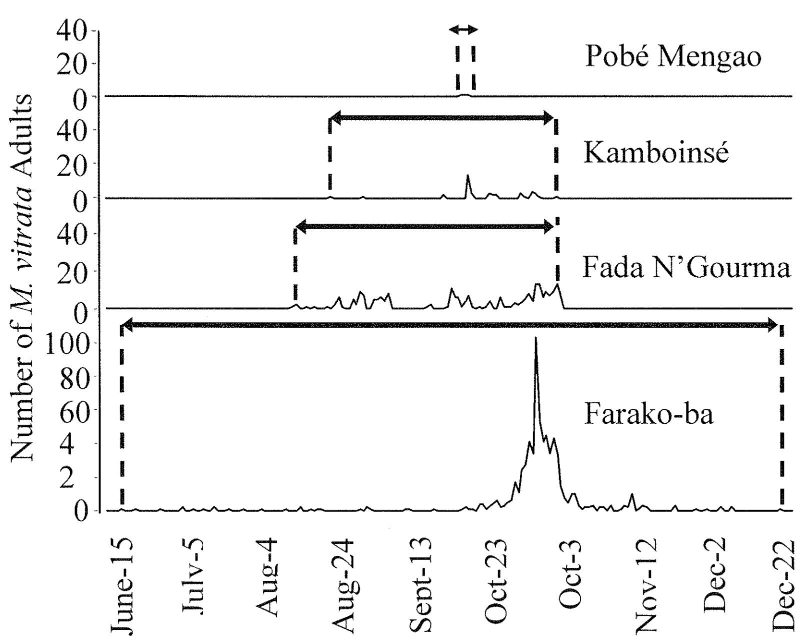


Figure 1. Current locations of light traps (Burkina Faso) for monitoring of *M. vitrata* adult populations (traps in Niger and Nigeria not shown). Also given are dashed lines showing the direction of the monsoon winds during cowpea growing season (August-October) [2].

Figure 2. Adult *Maruca vitrata* catches in the light traps at Farako-ba, Fada N'Gourma, Kamboinsé, and Pobé Mengao in 2006. Horizontal lines show the starting and ending intervals of adult catches at each location for the year. Adults were not observed in light traps before or after these intervals. **Conclusions** -- These data demonstrate that at Farako-ba (Sudanian zone) *M. vitrata* adults occurred before and after cultivated cowpea flowering times. However, in the light trap locations (in the Sudano-Sahelian and Sahelian zones) the adult *M. vitrata* populations were low in abundance, coinciding with (i) cowpea growing season and (ii) the southeast monsoon winds of August - October (presumably pushing the insects from the Sudanian zone into the Sudano-Sahelian and Sahelian zones).



In keeping with the migratory hypothesis, *M. vitrata* were observed on alternative hosts plants only in Farako-ba when cultivated cowpeas were not being grown (January-May); extensive scouting revealed that *M. vitrata* did not occur in Fada N'Gourma, Kamboinsé, or Pobé Mengao outside of the cowpea growing season (November-July). These data support the hypotheses that *M. vitrata* (i) is endogenous in Farako-ba and (ii) are potentially migrants into Fada N'Gourma, Kamboinsé, and Pobé Mengao during the cowpea growing season. In keeping with this hypothesis, as given in Figure 1, the August-October winds are known to influence insect migration from the southwest to the northeast of Burkina Faso [2]. Additionally, our data shows that *M. vitrata* may not be an important pest of cowpea in the Pobé Menago region. If this holds true throughout multiple cropping seasons, then an IPM strategy in the Pobé Menago region may not need to involve the control of *M. vitrata*. Thus, in our project we will identify which pests are of primary importance in each of the given regions where we will be working in, such that IPM program for each of these regions will be focused on dealing with the most critical pest problems.

We also have had one full field season of studying wild alternative host plants of *M. vitrata*. An exciting possibility as a putative trap crop for cowpea for *M. vitrata* has already emerged from our work. An economically important weedy species, *Sesbania pachycarpa* grows near many cowpea fields in Niger (Baoua and Pittendrigh, unpublished results), as well as Burkina Faso, and northern Nigeria. In Niger, *S. pachycarpa* appears to be a preferential host for *M. vitrata*. Stalks of *S. pachycarpa* are used for a diverse set of economic and social activities in Niger (*e.g.*, roofs, fences, mats, medicines, arrows, and it is burnt instead of wood in heavily deforested areas), making it a potentially ideal trap crop (with other benefits to the farmer) or a refuge for cowpea (to maintain susceptibility in the insect population in cases where resistant varieties of cowpeas are ultimately released). Thus, we propose to perform further studies to understand the role of *S. pachycarpa* in *M. vitrata* populations in Burkina Faso, Niger, and in northern Nigeria (near Zaria). We will gain estimates of the numbers of *M. vitrata* larvae on the *S. pachycarpa* plants and on the cultivated cowpeas to determine if *S. pachycarpa* can be used either as a (i) trap crop or (ii) as a refuge in cases where resistant varieties of cowpea are deployed (*e.g.*, transgenic *Bt* cowpea) beyond the scope of this project.

Thus, in the following project, we propose to perform life-history studies on the other major cowpea pests at selected locations in Burkina Faso, Niger, and Nigeria: (i) *C. tomentosicollis*, (ii) *A. curvipes*, (iii) *A. craccivora*, and (iv) thrips (*M. sjostedti* and *S. occipitalis*). Dr. Clémentine Dabiré has already collected about ten years of data on *C. tomentosicollis*, its biology, life cycle, and alternative host plants in the Sahelian environment. Our North American co-operator Dr. McNeil (who is also world-renowned insect ecologist and specialist in insect migration) has made a career of developing novel insect control strategies by "eavesdropping on mother nature" and will participate in the design and analysis of the life-history studies for the aforementioned pests (http://www.mcmaster.ca/research/sciencecity/mcneilgg.htm). Dr. David Onstad, our second North American co-operator is a leader in the development of practical control strategies for insect pests through computational modeling of the datasets [67] that emerge from "mother natures conversations" and he is also an expert in development of pest management plans for insect pests on the type of parameters that we have and will collect in the field experiments in Burkina Faso, Niger, and Nigeria. Drs. Onstad and Pittendrigh have already worked together on computational modeling for novel resistance management strategies [68].

IPM is both about (i) developing ecologically sound strategies of pest control and (ii) bringing together networks of people to accomplish these tasks. Such IPM strategies can best be developed through the networking of scientists and farmers in these regions for the long-term goal of (i) understanding pest problems and (ii) developing appropriate responses to these problems. Farmer field schools have been used in the past by both CRSP and non-CRSP projects to deploy IPM strategies for pest control. For example our African team members, Drs. Baoua, Dabire, and Ba have extensive experience with the development of biological control strategies for the discovery and deployment of parasitoid wasps for the control of pests that live on crops in Niger and Burkina Faso. In fact, they have recently completed a McKnight Foundation grant to discover and deploy parasitic hymenoptera for the control of pests of millet. Although these parasites were found natively in West Africa, the McKnight Foundation funded project focused on training farmers how to increase the numbers of parasitoid wasps in their environment (in farmer field schools), such that the pests of millet could better be controlled. Drs. Baoua, Dabire, and Ba have successfully used the farmer field school strategy to train farmers to rear and release these parasites for the control of the pests of millet. Dr. Ishiyaku has also had extensive experience with farmer field schools relating to cowpea production. Thus, we will also attempt to identify, where possible, parasitoid wasps for the control of pests of cowpea that may ultimately be used for deployment in a farmer field school IPM program.

The farmer field schools are not just about scientists passing new knowledge to farmers. Farmer field schools are also about farmers sharing their knowledge and insights with the scientists, their peers, and ultimately with their communities. This multi-dimensional flow of knowledge, ideas, and experience can be used to provide our project with data on the pest populations and with the potential insights on how to control these pests. As the next 30-months of this project will focus on understanding pest systems of cowpea we will employ farmer field schools as a mechanism to (i) establish a network of farmers (including 50% mix of women) interested in controlling pests of cowpeas, (ii) train these farmers how to identify these pests, (iii) have the farmers keep track of their general pest problems on cowpea and how they deal with these concerns (data that will be helpful to the scientists), and (iv) relay ideas back to the group on how to control these pests in a culturally and economically acceptable manner. Thus, beyond the scope of this current 30-month project we expect to have a network in place were we (i) have farmers that are knowledgeable about these pest systems and (ii) will be able to employ IPM strategies that may emerge out of our work.

Additionally, as we have a network of scientists who have a good base knowledge of these insect systems, we are also in a position to expand out network of scientists out to other countries. As many other countries across Africa face similar insect pest problems our team is positioned to include other countries in our program. The aims we are proposing for the current project can be expanded to these other countries, to provide for (i) pest information networking across African research institutions, (ii) perform experiments in these other countries (with host country scientists) to understand the pest problems of cowpea, and (iii) develop the knowledge needed to develop IPM programs for pests of cowpeas in these countries. Where time and resources permit we are interested in expanding our efforts into other countries that are high priority for this CRSP, including (but not limited to) Mali, Angola, Namibia, and Zambia.

4.2 Objectives (Revised)

***Thus, in the following CRSP project we will*:**

1) Determine basic life-history parameters of the major insect pests living on cultivated cowpeas in Burkina Faso, Niger, and northern Nigeria.
2) Determine when and where these insects cause significant negative impacts on the cowpea crops in Burkina Faso, Niger, and northern Nigeria.
3) Identify or perform testing, or both, on putative control agents for pests of cowpea (*e.g.*, parasites, predators, and resistant lines of cowpeas).
4) Facilitate the long-term development and deployment of control strategies for the pests of cowpeas.
5) Establish regional training networks between African scientists and farmer field schools for the development of networks of people to be involved in the deployment of IPM strategies for the control of cowpea pests.

4.3 Approaches and Methods (Revised)

Light trapping and microsatellite analysis of *M. vitrata*

We will continue to run the light traps at (i) the four previously mentioned sites in Burkina Faso, (ii) the two current sites (Maradi and Niamey) and one new site (Zinder) in Niger, and (iii) one current (Zaria) and two new sites in Nigeria (Kano and Kaduna). As in the previous project, the light traps will be run every night and adult *M. vitrata* numbers will be counted in the morning. *M. vitrata* will be placed in vials with ethanol and shipped to the University of Illinois at Urbana Champaign (UIUC) for microsatellite analysis. Genomic DNA will be isolated from the insects following a modified CTAB, phenol-chloroform isolation method. We will use at least eight microsatellite loci to test for polymorphic differences. Allelic diversity, observed (H_O), and expected (H_E) heterozygosities will be assessed for each locus. H_E will be calculated using an unbiased estimate [69]. Linkage disequilibrium will be tested between all pairs of loci at all locations using the program fstat (version 2.9.3) [70]. Departures from Hardy–Weinberg (HW) equilibrium will be tested by the inbreeding coefficient F_{IS} [71] and by HW exact tests using the Markov chain randomization method [72] if more than four alleles are detected per locus. Genepop version 3.4 will be used to determine estimations [73]. The results that will emerge from this work will help us to address the questions of when and where do these *M. vitrata* populations come from and go to. The outcome of these results will determine the need for an insect resistance management plan for *Bt*-cowpea useful in the control of *M. vitrata* beyond the scope of this project.

Scouting for insects when cowpea is not in cultivation

We will continue to perform year-round scouting for *M. vitrata* larvae, and other aforementioned pests of cowpeas, on alternative host plants within 10 km of the light trapping locations. The scouting trips will be performed once a month. Each African collaborator has a list of wild alternative host plants for *M. vitrata*, for their given region; they have been using the list for such studies in the last CRSP project. We will also assemble a list of putative wild alternative host plants for the other aforementioned pests of cowpeas. A subgroup of the *M. vitrata* larvae observed in the field, and where necessary the immature stage of the other pest species, will be collected and reared out to adulthood in the laboratory to verify these are indeed the pests of interest. We have done this in the past, and found that the larvae were properly identified as *M. vitrata*.

Insect pests on cultivated cowpeas

At the field stations in INERA (Kamboinsé, Burkina Faso), INRAN (Maradi, Niger) and IAR (Zaria, Nigeria) we will perform field experiments in which we monitor the insect pests on cultivated cowpeas (field plots) and wild alternative host plant (scouting) during the cowpea growing season. Briefly, we will plant a minimum of three varieties of cowpeas in a field plot at each of these aforementioned locations (*e.g.*, early, medium, and late flowering plants). We will also plant wild cowpeas and *S. pachycarpa.* We will also test the potential use of *S. pachycarpa* as a trap crop for cowpea. ***Once Dr. J. Ehlers (U. of California at Riverside) has varieties that need to be tested in the field for insect resistance we will include these in the experiments.*** Each variety will be planted in a 4.8 X 4.8 m plot (per replicate per treatment) in a completely randomized blocked design (with five blocks) in the field. During the cowpea growing season the plots will be monitored daily for the numbers of and species of insects on twenty plants selected randomly in each plot. All data will be analyzed using ANOVA and a protected LSD test. ***We have already collected one field-season of data on M. vitrata, C. tomentosicollis, A. curvipes, and A. craccivora population dynamics (no thrips were present in the experiment) in cowpea fields in Maradi (Niger) using this exact experimental design***. Also, in areas where the only known methodology of control of the pest insects is through the use of insecticides, we do not rule out the possibility that we may need to determine the minimum amount of pesticide necessary to achieve effective control. However, our overall goal will be to eliminate or minimize the use of pesticides. These experiments will be performed in the summers of 2008-2010.

Estimations of the impact of *Sesbania pachycarpa on M. vitrata* populations

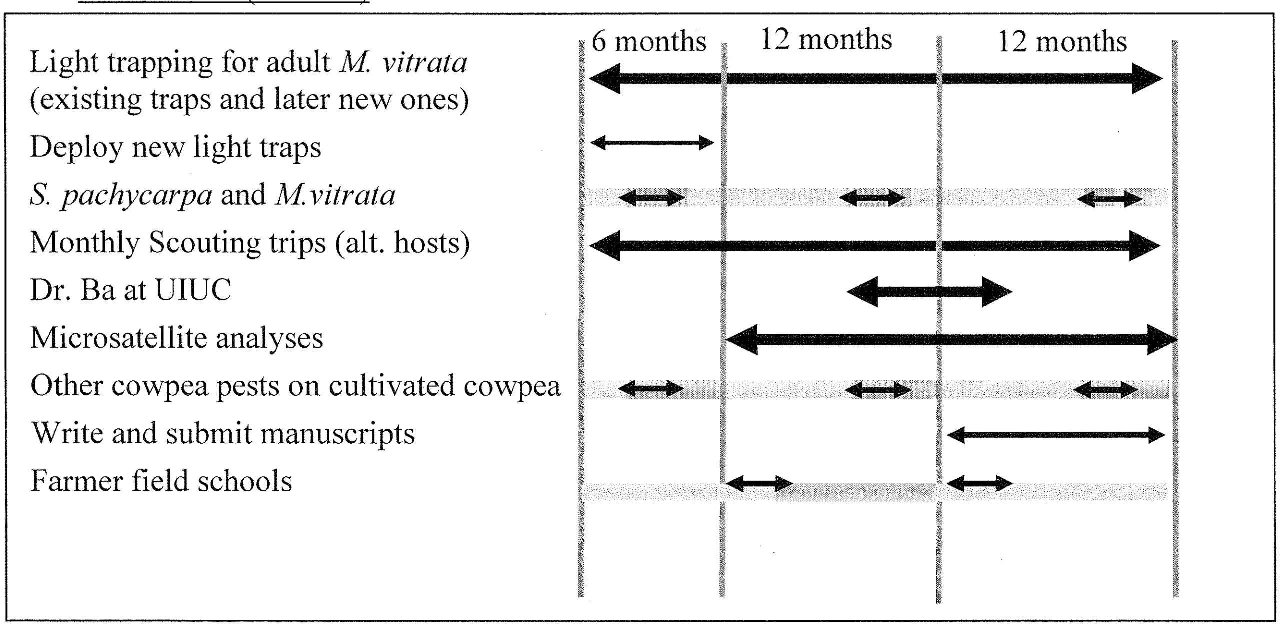
During peak cowpea growing season, specifically flower times, we will scout farmers' fields for the presence of *S. pachycarpa,* and, where present, determine estimates of numbers of *M. vitrata* larvae on the *S. pachycarpa* versus nearby cultivated cowpeas. Each farmer's field will be estimated for (i) size, using a Global Positioning System (GPS) device, (ii) the numbers of cowpea plants and (iii) numbers of flowers with *M. vitrata* will be determined (with a minimum of 50 plants sampled per field). The location and numbers of flowers with and without *M. vitrata* on *S. pachycarpa* both within the field and 100 m from the field will be estimated. We will perform these studies in the fields of a minimum of twenty farmers in each country (and where possible in multiple ecological zones).

4.4 Collaboration with Host Country Institutions

Dr. Pittendrigh has performed ongoing collaborative research with Drs. Clémentine Dabiré and Malick Ba (INERA), Ibrahim Baoua (INRAN), and Mohammad Ishiyaku (IAR). This work was initiated in the previous Bean/Cowpea (B/C) CRSP project. This group has performed all of the experimental protocols, proposed in this current project, during the previous Bean Cowpea CRSP grant. Dr. Pittendrigh has (i) traveled to each of these institutions in the summers of 2006 and 2007 to plan research activities; (ii) assist in analysis of the data; (iii) write manuscripts with all aforementioned collaborators (four manuscripts in progress); and, (iv) in Niger he was also actively involved in performing fieldwork regarding *S. pachycarpa* (summer of 2007). The termination of the B/C CRSP at the end of September of 2007 prevented us from collecting a complete second season of data. Drs. Pittendrigh and McNeil will travel to Africa in years one and three of the project (and Dr. McNeil will also travel to these sites in the fall of 2008 to assist in ecological observations) to continue this pattern of work: (i) plan research activities; (ii) observe and participate in field observations; (iii) assist in analysis of the data; and, (iv) write manuscripts.

Field experiments will be planned in collaboration with the African P.I.s, and Drs. Pittendrigh, Murdock, and McNeil. A statistician will be consulted prior to and during the performing of the experiments and data analysis (Dr. William Muir of Purdue University, see letter of support). Host countries will be responsible for all the aforementioned fieldwork experiments and they will ship *M. vitrata* samples (in ethanol) materials to UIUC for microsatellite analysis in Dr. Pittendrigh's laboratory. All APHIS provisions for shipping these samples into the U.S. have been dealt with and Dr. Pittendrigh has been receiving such samples routinely in the past. The African P.I.'s will report directly to Dr. Pittendrigh with yearly reports on progress and data. Dr. Pittendrigh will also host Dr. Malick Ba (from INERA) in his laboratory for six months in order for Dr. Ba to develop skills in (i) molecular entomology (microsatellite analysis) and (ii) pest management modeling and planning (co-supervision with Dr. Onstad at UIUC). Dr. Pittendrigh will have one of his technicians continue the microsatellite analysis on the *M. vitrata* populations. This technician will train Dr. Ba during his stay at UIUC in molecular techniques associate with microsatellite analysis. Dr. Pittendrigh will train an M.S. or Ph.D. student from Africa on the microsatellite analysis on the *M. vitrata* populations. Dr. Pittendrigh will use funds from his endowed chair position to fund this student for the duration of her/his studies at UIUC (costs sharing).

4.5 Benchmarks (Revised)



5. HC Institutional Capacity Building (Revised)

5.1 Short-Term Training

Three forms of short-term training will occur in this project:

1. Dr. McNeil who is an expert insect ecologist (in the areas of plant-insect interactions as well as insect ecology and migration) will spend time in each of the three countries (in the first summer of the project) interacting with the collaborators on issues of insect ecology. As Drs. Dabiré, Ba, and Baoua all have a great deal of experience in fieldwork on the insect pests we will be working on, this will provide for an excellent opportunity to exchange ideas between a series of top notch insect ecologists.
2. Dr. Baoua will also travel to Burkina Faso and Nigeria, along with Drs. McNeil and Pittendrigh, to work with the other collaborators to standardize how all the experiments, with the ecology of the pest insects of cowpeas, will be performed. Drs. Dabiré, Ba, Baoua, and Ishiyaku all have considerable field experience with all of the pests we will be studying. However, Dr. Baoua's central geographical location between Burkina Faso and Nigeria means that he can travel to both locations to work with both groups (or they travel to meet with him in Niger) to help make sure our experimental protocols are standardized across the three countries.
3. The budgets for each of the host countries include money to run farmer field schools (with two meetings during the project). Each farmer field school will consist of a minimum of twenty farmers with 50% of these being women.
4. During his six-month stay at UIUC, Dr. Ba will travel to Monsanto Company in St. Louis in order to interact with Drs. Joseph Huesing and Graham Head regarding regulatory issues associated IRM plans for transgenic plants.

5.2 Long-Term Training

1. Dr. Pittendrigh will train a M.S. or Ph.D. student at UIUC using funds provided either from (i) resources provided to him from his *C.W. Kerns, C.L. Metcalf and W.P. Flint Endowed Chair* in Entomology or (ii) from start-up funds he will be receiving from UIUC, or a combinations of these sources of funding. Thus, Dr. Pittendrigh will cost-share the expenses of a graduate student for this project.
2. Dr. Ba will visit Dr. Pittendrigh's laboratory for six months to further develop his knowledge in the areas of molecular biology and understanding of insect resistance and pest management plans.

5.3 Infrastructure

1. The training of Dr. Ba at UIUC will also allow him to take maximal advantage of existing infrastructure at INERA. The INERA station in Kamboinsé already has a molecular biology laboratory that Dr. Ba could continue to perform microsatellite work in upon returning to INERA. However, his six-month stay at UIUC will allow

him to develop the necessary molecular tools to better use resources that exist at Kamboinsé (INERA).

2. Establishment of one new light trap in Niger (Zinder) and two new light traps in Nigeria (Kano and Kaduna) for long-term monitoring of pest populations. These steel and metal mesh light traps will be used for the duration of this project and can be used long after the termination of this project to study the population levels of the adults of other nocturnal insect pest species.

6. Contribution to USAID Objective and Initiatives (Revised)

We will also, ***"conduct research in a manner that creates sustainable capacity for research and outreach through genuine collaboration with host country scientists, training of a new generation of scientists, partnership in the leveraging of new funds, and promoting linkages with stakeholder groups."*** The overall research program will provide foundational information for (i) an IPM plan for cowpea and this information can also be used for the development of an IRM plan for *Bt*-cowpea, (ii) train an INERA scientist in the development of an IPM and IRM plans (Dr. Ba), (iii) train the same INERA scientist (Dr. Ba) in the use of modern molecular biology tools to study insect pests, and (iv) facilitate a network across Burkina Faso, Niger, and Nigeria for the long-term study of insect pests of cowpea. As is evidenced by our data shown in Figure 2, as well as a series of manuscripts in progress, strong collaborative links exist between Drs. Pittendrigh, Murdock, Dabiré, Ba, Baoua, and Ishiyaku.

The proposed project will build on these existing collaborative links to engage new researchers (Drs. Onstad and McNeil) that can help bring new skill-sets into the project. Dr. Onstad will work directly with Dr. Ba for six months on pest managements (at UIUC), such that Dr. Ba (i) could be involved in the creation of the IRM plan for *Bt*-cowpea (beyond the scope of this project) and (ii) have expertise for the development of IRM plans for other transgenic plant for release in West Africa (beyond the scope of this project). Upon returning to INERA, Dr. Ba will have the skill-sets to play an important long-term role in the development and deployment of IPM and IRM plans that will be important for the release of both cowpea and other species of transgenic plants in both Burkina Faso, and the rest of West Africa. Thus, this project will be critical to training ***a young scientist in modern molecular tools (microsatellite analysis of M. vitrata) and in insect management plans***. The datasets generated in this project will be critical to ***influence decision makers*** (*i.e.*, government regulatory agencies) in regards to such insect control strategies as IPM plans and even in the potential release of transgenic *Bt*-cowpea, such that they can help implement a program of ***long-term increased productivity and yield stability of cowpea***.

Thus, under the four strategic themes of USAID's agricultural development focus, our work will (i) ***allow for mobilization of science and technology capacity for innovation***, and (ii) ***assist in the formulation of science policies***. Our efforts will support, in an indirect way, the applications of technologies that already exist (*i.e.*, transgenic *Bt*-cowpea), as well as directly laying the foundation for IPM plans for pests of cowpeas in Burkina Faso, Niger, and Nigeria. Additionally, our farmer field school activities will help to facilitate (i) ***collaborative networks of specialists***, and (ii) ***foster innovation within and among developing countries so that they can generate, utilize, and direct new technologies in***

locally appropriate directions. These activities will also assist in facilitating the Presidential Initiative to End Hunger in Africa initiative, by "***developing science and technology applications and support services that harness the power of new technology***." We will ***strengthen agricultural training and education, outreach, and adaptive research through***: (i) a training program with Dr. Ba (at UIUC); (ii) exchanges between North American and African collaborators; (iii) interactions between African collaborators; and, (iv) farmer field schools. Additionally, the development of IPM strategies for pests of cowpeas is likely to result (i) in increased production of cowpeas (due to reduced losses by insect attack) and (ii) reduce the need for pesticide sprays.

As women are often the primary producers of cowpeas in Burkina Faso, Niger, and Nigeria, our project has the potential to have direct impact on women, both in terms of health due to long-term reductions in the use of pesticides on cowpea and due to increases in productivity due to the introduction of new cowpea varieties with resistance traits to insect pests. Our collaborator, and Primary Investigator in Burkina Faso, ***Dr. Madame Clémentine Dabiré*** (a female scientist) has made, and will continue to make, efforts to develop extension materials appropriate for involvement of women in new technologies useful in the minimization of pesticides on cowpeas (*e.g.,* triple bagging to prevent cowpea weevil infestations). Additionally, if *S. pachycarpa* makes a good refuge for the management of resistance in *M. vitrata* to *Bt*-cowpea, then the stocks of these plants may serve as starting materials for products made by women in the villages (*e.g.*, bedding, roofs, and baskets). The use of a refuge, which also provides social or economic (or both) benefits for women in villages, could be explored beyond the scope of this project in conjunction with economists, or social scientists, or both.

If funded, we will work with the Dry Grain Pulses CRSP management office to interact with the relevant missions associated with cowpea growing countries in West Africa. Where appropriate we will attempt to garner further resources from the missions to expand out studies within the countries we are proposing to work in or to add additional collaborators in other countries where (i) we can help build the capacity of their respective research institutions (*e.g.*, research exchanges, short-term or long-term training of students or staff, or physical structures such as light traps), and (ii) expand our studies to lay the groundwork for pest control strategies for insects that attack cowpeas in these other countries.

7. Strategy for Achieving Developmental Impacts (Revised)

Farmer field schools will be established in each of the countries for the development of a network of farmers that will initially help us define the pest problems, current control strategies, and novel opportunities for the control of pests of cowpea [74-79]. Ultimately, beyond the scope of this 30-month project these same farmers will participate in the deployment of IPM programs in their villages. These schools will be made up of an equal mix of women and men chosen from a series of different villages where cowpeas are an important crop. The farmers will (i) learn how to identify important insect pests, (ii) share experiences regarding these pests and their control, and (iii) will ultimately provide data to the group on the specific pest problems in their villages.