DRY GRAIN PULSES CRSP WORKPLAN FORMAT
(FY 12 – All Partners)
Planned Project Activities for the Period October 1, 2011 to September 28, 2012
As revised May 26

Project Title: Enhancing biological nitrogen fixation (BNF) of leguminous crops grown on degraded soils in Uganda, Rwanda, and Tanzania

Lead U.S. Principal Investigator and University:

Mark E. Westgate
Director, Center for Sustainable Rural Livelihoods
Iowa State University
110 Curtiss Hall
Ames, IA 50011
515-294-9106
westgate@iastate.edu

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

John Steven Tenywa: Makerere University, Department of Soil Science. P.O. Box 7062, Kampala, Uganda. ph: +256-414-540-707, Cell: +256-772-487-404. jstenywa@agric.mak.ac.ug.

Lynne Carpenter-Boggs: Washington State University, BioAg Research Leader, Center for Sustaining Agriculture and Natural Resources, Dept. Crop and Soil Sciences, (509) 335-1553. lcboggs@wsu.edu

Karen Cichy: USDA-ARS, Sugarbeet and Bean Research Unit, East Lansing, MI, 48824-1325 ph: 517- 353-9262 ext. 4, Fax: 517- 337-6782, karen.cichy@ars.usda.gov

James D. Kelly: Michigan State University, Department of Crop & Soil Sciences, East Lansing, MI 48824-13254. Ph: 517-355-0271 x 1181, Fax: 517-353-5174. kellyj@msu.edu

Phillip Miklas: USDA-ARS, Vegetable and Forage Crop Research, Prosser, WA 99350. ph: 509-786-9258; cell: 509-786-8492; Fax: 509-786-9277; phil.miklas@ars.usda.gov

Henry Kizito Musoke: Volunteer Efforts for Developmental Concerns, Kampala, Uganda. ph: +256-414-270-598, henrykizito@vedco.or.ug

Susan Nchimbi-Msolla: Crop Science and Production, Sokoine University of Agriculture, Morogoro, Tanzania, nchimbi@giant.suanet.ac.tz

Ernest Semu: Department of Soil Science, Sokoine Unversity of Agriculture. P.O. Box 3008, Chuo Kikuu, Morogoro, Tanzania. Ph: +255-23-260-3999, FAX: +255-23-260-3259, Cell: +255-754-565-808.

Augustine Musoni: Institit des Sciences Agronomiques du Rwanda (ISAR), Nygatare Research Station, fmusoni@yahoo.com

Michael Ugen: National Crops Research Institute, Namulonge, Uganda. ph: +256-414-573-016, Fax: +256-752-726-554, michaelugen@yahoo.com

Daniel Krohn: (collaborator) Becker Underwood, Inc. 801 Dayton Avenue, Ames, IA. 50010. Ph: 515-956-2351, Cell: 515-509-1047. daniel.krohn@beckerunderwood.com.

Peg Armstrong-Gustafson: (collaborator) amson technology l.c., 4010 University Avenue, Des Moines, IA 50311. Ph: 515-279-7767, Fax: 515-255-6101, peg@tmgmanagement.com

I. Project Problem Statement and Justification:

Common beans are the most important legume crop in Uganda, Rwanda and Tanzania occupying a very large proportion of land devoted to legumes. For example, over 45% of the protein intake by Ugandans comes from beans providing 25% of dietary calories. Likewise, over 75% of rural households in Tanzania depend on beans for daily subsistence. Common bean is an important source of protein for low-income families in rural and urban areas providing about 38% of utilizable protein and 12-16% of daily caloric requirements. Improved bean production in Uganda, Rwanda, and Tanzania offers a unique opportunity to address the deteriorating food security situation there and elsewhere in sub-Saharan Africa.

Loss of soil fertility is recognized as the most important constraint to food security in sub-Saharan Africa. Low levels of nitrogen and phosphorous are the primary fertility constraints. Because soils are increasingly becoming degraded, an affordable means of improving soil fertility and productivity of nitrogen-accumulating crops is critical. Properly nodulated legumes can leave up to 350 kg nitrogen per hectare in the soil, depending on effectiveness of the nitrogen fixation process, type of legume, length of time the legume is grown, soil nutrient levels and nitrogen already available. Because inoculum is much cheaper than inorganic fertilizer, use of inoculants can provide an affordable and sustainable way to improve production of nitrogen fixing legumes.

Numerous studies have shown the potential of improving legume productivity by enhancing nodulation through proper use of a biological inoculant. Yet field trials in sub-Saharan Africa have provided mixed results. Likely causes for variable response include poor quality control of inoculant formulation, failure to compete with local rhizobia, inhibition by indigenous microbial flora, or failure of the inoculant species to survive in low pH and/or droughty soils. Modern inoculant formulations designed to deliver a synergistic suite of biological and chemical enhancements for biological nitrogen fixation under stressful soil conditions have
been made available to our collaborative research project by Becker Underwood, Inc. Becker Underwood's **BioStacked®** inoculant technologies for legume crops consist of well stabilized *Rhizobium* bacteria, a biological fungicide, plant growth promoting rhizobacteria, and other biologically derived proprietary biostimulant technologies which promote plant growth and overall plant health. These stacked inoculants have been shown to decrease chemical fertilizer use in crop rotations, increase legume yields, suppress root diseases, and improve rhizosphere conditions for root growth. We anticipate they will be particularly effective under degraded soil conditions encountered on small-landholder farms in Uganda, Rwanda, and Tanzania.

To optimize BNF, it also is essential to identify germplasm with greatest capacity for this trait. Although common bean has the potential for BNF, it is reported to have the lowest percent N_2 derived from N fixation among legumes. Genetic variation for BNF has been reported within the primary gene pool, and lines with superior BNF have been identified. Superior BNF lines such as Puebla 152 and BAT 477 have been used as parents in crosses to generate populations for genetic studies and to examine selection and breeding for improved BNF. Few breeding lines with improved BNF, however, have been developed. The optimal selection environment for BNF is under low soil N since application of nitrogen fertilizer reduces N fixation capacity. Marker-assisted selection (MAS) under such conditions is highly sought after as a means to facilitate breeding for traits like BNF with low to moderate heritability. Molecular mapping in combination with germplasm screening and MAS would be a powerful way to improve locally adapted germplasm for BNF in a host country. Recombinant inbred populations currently available are ideal for tagging and mapping genes that influence quantitative traits (QTLs). Few QTLs associated with BNF, however, have been identified to date, and those identified have not been validated. Identifying and validating QTL-conditioning enhanced BNF would be a major contribution to the scientific community, and represent a major step toward effective marker-assisted selection for BNF.

Our BNF-CRSP program objectives address the need to identify production systems that enhance BNF, develop germplasm that benefits most from symbiotic inoculation, and aggressively share this new information with small landholder farmers in sub-Saharan Africa whose health and well being depend heavily on legume production.

II. Planned Project Activities in the Workplan Period (October 1, 2011 to September 28, 2012)

Objective 1:

The ***first strategic aim*** is to improve BNF and seed yields of common beans significantly using superior seed inoculants such as Becker Underwood's BioStacked® inoculant through farmer-based experimentation and adoption of innovative production techniques.

Sub-Objective1a: *To evaluate effectiveness of biologically stacked inoculants on local and improved germplasm.*

We expect to:

1. Establish Field Trial 2 at HC field locations (NaCCRI, SUA, ISAR)
2. Test common bean varieties along with non-nodulating controls and high/low-N treatments at all HC trial locations (NaCCRI, ISAR, SUA)
3. Quantify yield advantage of inoculation for second cropping season (NaCCRI, SUA, ISAR)
4. Hold workshop for graduate students to share outcomes of research/training prior to 2012 CRSP meeting.
5. Attend Bean Improvement Cooperative Meeting in November 2011.

Sub-Objective 1b: *To quantify genotype by environment interactions and constraints to enhancing BNF of inoculated plants.*

We expect to:

6. Complete analysis of plant/soil/weather data (ISU, Makerere, NaCCRI, SUA, ISAR)
    a. Intitate modeling studies of seasonal soil moisture profiles and bean yield
7. Confirm phenotype and yield response to inoculant x genotype x environment (ISU, Makerere, MSU, WSU, NaCCRI, SUA, ISAR)
    a. Incorporate new inoculants from Becker Underwood and local companies in field trials
    b. Quantify plant N, biomass, nodule classes, ureide levels prior to pod fill.
    c. Quantify yield, yield components, NUE, NHI.
    d. Quantify nodule classes and occupancy
8. Confirm indigenous rhizobia levels and relate to local environmental conditions (ISU, WSU, MSU, Makerere)
9. Confirm soil rhizobia soil populations and strain diversity at field sites
    a. Collect nodules, soil samples at field sites, store for analysis
10. Initiate root/nodulation study in greenhouse on selected lines (ISU, MSU, WSU)
11. Complete initial studies on strain x host interactions for BNF (WSU)
12. Identify most effective genotype-inoculant combinations for each eco-zone tested in HC (Makerere, NaCCRI, SUA, ISAR)
13. Calculate economic return for inoculation treatments for season 1 and 2 field trials (NaCCRI, SUA, ISAR)

Collaborators:

Becker Underwood, Inc. (BU) is an international developer of bio-agronomic and specialty products. The company is the leading global producer of inoculants, beneficial nematodes, and a wide range of agricultural and horticultural products. BU will produce the **Bio-stacked**® legume inoculants (see http://www.beckerunderwood.com/en/newsreleases/100104) for distribution to HC and US researchers in this CRSP project. BU has worked with numerous universities around the world and has implemented quality assurance programs and technical support to ensure proper formulation and field application.

Approaches and Methods:

In Rwanda, Tanzania, and Uganda multiple sites will be used to evaluate popular cultivars of both determinate bush and indeterminate vine growth habit types for response to different rhizobia-inoculum treatments. Site selection will be defined by where beans are already grown and consumed, and will encompass the range of soil types and weather conditions documented at each site (1c). Four cultivars will be chosen representing different market types, evolutionary origin, in addition to the different plant types. For example in Tanzania popular cultivars (genotypes) representing the major speckled purple-Kablanketi (Type III, Andean), yellow-Njano (Type I, Andean), Red Kidney (Type I, Andean), and Carioca (Type II, MA) market types would be tested. Adapted non-nodulating genotype(s) (~BAT477, DOR364 from CIAT) will be useful for this and subsequent BNF trials as checks. Rhizobia inoculum treatments will include **Bio-stacked**®, other commercially available inoculants (e.g. Bio-N-Fix), and no inoculum. The **Bio-stacked**® inoculum from Becker-Underwood, Inc. is formulated for enhanced BNF under stressful soil conditions (see product note from Becker Underwood, Inc.). A RCBD with four replications, and moderately large plot size will be used (4 to 6 rows wide by 5 to 7 m length), Established research station sites will be used initially and expanded to on farm and community co-op trials using select genotypes which exhibit greatest BNF response. It is envisioned by year 2 that HC Extension personnel, NGO, or other business partners will be identified to help develop and implement strategies for technology dissemination to numerous farmers (Strategic Aim 3). A low N treatment will be targeted the first few years and expanded to include low and high N in subsequent years as HC and US project participants gain training and experience with experimental protocols and procedures.

Standard agronomic practices will be employed in the controlled location studies (Opio et al 2001). Incidence and severity of disease and pest damage will be recorded to determine their indirect impact on N-fixation, plant performance and response to inoculant treatments. Agronomic data collected for each treatment includes: soil analysis, final plant stand (pl/m), seed yield (kg/ha), disease and insect pest ratings (mid-season for leaves), days to physiological maturity, pods per plant, seed quality (color, % not mature, % mottled, and economic return on investment in the inoculant technology. The latter will be assessed by careful record keeping of agronomic input costs and grain sales. Thermometers, rain gauges, and soil moisture sensors will be positioned on site for recording local weather conditions. Plant biomass, total plant N, petiole ureide levels prior to podfill, seed yield, seed N, and biomass at harvest maturity on a plot basis will be used to measure BNF response of the different genotypes and treatments. These measurements are the most affordable in terms of cost and labor and correlate well with seasonal BNF. Select genotypes or treatments with large or interesting BNF responses, could be further characterized by evaluation of root biomass, nodulation number and mass, isotope assays, or post crop response. Data collection will be coordinated by HC scientists and students.

Objective 2:

The ***second strategic aim*** is to examine the inheritance of genetic and environmental variation in BNF in common bean, and to identify molecular markers associated with QTL conditioning for enhanced BNF.

Sub-Objective 2a: *To identify parental materials for inheritance studies of BNF*.

We expect to:

14. Increase seed of BNF diversity panel lines in winter nursery.
15. Complete initial greenhouse screening on 50 selected lines for BNF response (WSU)
16. Evaluate correlative responses of BNF phenotypic characteristis in field and GH trials (ISU, MSU, WSU, NaCCRI, SUA, ISAR)
17. Confirm nodule rhizobia occupancy on selected lines from US and HC trials (WSU, SUA)
18. Test subset of BNF DP lines on low soil N +/- inoculants in HC field trials (MSU, WSU, NaCCRI, SUA, ISAR)
    a. Include high N treatment, non-nodulation lines for comparison

Sub-Objective 2b: *To phenotype existing mapping populations for BNF response, populate with molecular markers, and conduct QTL analysis.*

We expect to:

19. Characterize soil rhizobia soil populations and strain diversity at field sites
    a. Establish nodule rhizobia occupancy established on selected lines (WSU)
20. Confirm season 1 BNF phenotyping of selected populations [Bean CAP and South American Core]
    a. biomass, plant N, ureide levels prior to pod fill.
21. Conduct SNP analysis (SNP chip) on bean CAP and SA Core collection for association mapping with phenotype data (WSU, MSU).
22. Complete initial list of candidate genes associated with BNF for SNP associations (WSU, MSU).
23. Advance selected RILs to F3 (MSU,WSU)

Collaborators:

Host country field managers at NaCRRI, ISAR, and SUA and experiment station managers at ISU, MSU, and WSU in the US.

Approaches and Methods:

We will increase seed of the BNF diversity panel (DP) consisting of 300+ Andean bean lines for evaluation. This panel will include lines from the current Bean CAP and South American Core collections, representative commercial market types and advanced breeding lines from host countries Rwanda, Uganda, Tanzania and the US; lines known to differ for BNF (BAT 477, Pueblo 152, CAL 143,

RIZ lines, etc.); super-nodulating and non-nodulating; and select parents of existing mapping populations. A subset of these materials will be tested for BNF response under low N conditions in the field (single locations in Rwanda, Tanzania, and Uganda) and greenhouse (US-WSU).

Initial screening of selected lines will begin in the greenhouse in the US (WSU and ISU). Single plants will be sown in 1 liter pots containing 50% sand/potting soil mixture, N-deficient fertilizer solution, and arranged in RCBD with 5 replications, and at least two treatments – non-inoculated and inoculated (with mixture of rhizobia strains). The materials will be similarly grouped (20 to 30 materials each group) for the GH experiments conducted over a period of two years. BNF response will be measured by plant N (multiple subsamples per plot), seed N (multiple subsamples per plot), biomass, and seed yield at harvest maturity for field studies. For greenhouse studies, plant biomass on shoot/root basis, nodulation score, and plant N concentration at 12 wks after planting will be used to measure BNF response.

Initial phenotyping will focus on selected populations [Bean CAP and South American Core] for BNF response in US field sites. Data collected on each line/location will include biomass, plant N, ureide levels prior to pod fill. Ureide samples collected in the US will be analyzed at ISU. Samples collected in HC countries will be analyzed at NaCCRI. A mechanism will be established to correlate the phenotyping results of field and greenhouse trials.

The process of identifying genes associated with BNF response to inoculant will begin by collecting tissue samples from bean CAP and SA Core collections grown at WSU and/or MSU for SNP analysis (SNP chip). This approach will leverage SNP analyses currently being conducted by the bean CAP program. The primary constraint for utilizing these molecular markers effectively is collecting appropriate phenotype data to associate with the observed genetic variation. The phenotyping being conducted under this objective addresses this issue. Ultimately, phenotype data will be utilized for gene identification via association mapping as the gene sequence for *Phaseolus* becomes available in the near future.

Given the three year time frame necessary to generate new mapping populations, existing mapping populations with promise for mapping QTL conditioning BNF response will be tested in HC and US. We will continue to advance existing RIL populations for phenotyping BNF response (EP=Eagle/Pueblo 158, 78 F8 RILs, 357 markers; RC=Rojo/CAL 143, 147 F5 RILs, no markers). Seed of the RILs will be increased (January-May, Year 1, EP by ARS, East Lansing and RC by ARS-Prosser). The parents for EP, RC, and a few other bi-parental populations will be tested in the GH to confirm divergent phenotypic response for BNF. Given divergent response for the parents the EP population will be tested at two sites (ARS-Prosser and -East Lansing) under low N.

Objective 3:

The ***third strategic aim*** is to improve the productivity, profitability, and sustainability of agricultural systems on degraded soils through effective dissemination of new information and technologies to small-landholder farmers.

Sub-objective 3a: *To improve farmer awareness of inoculation technologies*

We expect to:

24. Establish format for field demonstrations at HC research stations (ISU, MSU, WSU, VEDCO, Makerere, NaCCRI, SUA, ISAR)
25. Include information on N2fixation and inoculation at research station/demonstration sites at (VEDCO, NaCCRI, SUA, ISAR)
26. Conduct field days in each HC to sensitize farmers and present research results (VEDCO, NaCCRI, SUA, ISAR)

Sub-objective 3b: *To conduct on-farm demonstrations comparing inoculant strategies*

We expect to:

27. Conduct on-farm trials initiated with selected farmer cooperators in all HC (VEDCO, NaCCRI, SUA, ISAR)

Sub-objective 3c: *To strengthen farmers' collective capabilities to purchase inoculants and incorporate them into a profitable and sustainable system for small landholders,*

We expect to:

28. Create training materials to disseminate through PELUM farmer network
29. Conduct information dissemination meetings on BNF with PELUM-associated farmer groups in Rwanda, Tanzania, Uganda, and Kenya (VEDCO)
30. Incorporate research results into extension training programs, farmer advocacy meetings, and PELUM network website (VEDCO)
31. Determine potential for engaging international funding agencies to expand current technology transfer efforts (ISU, Makerere, VEDCO, NaCCRI, SUA, ISAR)
32. Conduct advocacy meetings with farmer groups and agribusiness interests (VEDCO)

Collaborators:

PELUM (Participatory Ecological Land Use Management Association) is an a network of 207 civil society organizations in Eastern, Central and Southern Africa working towards poverty eradication, food security, and sustainable community development (see http://www.pelumrd.org/).

Approaches and Methods:

Ultimately our outreach activities will include training field staff on the use and potential benefits of inoculation technology, selecting farmers to participate in on-farm trials, sensitizing farmers and farmer groups about inoculant technology, identify local bean varieties to include in the field trials, training farmers on proper methods for conducting on-farm trials, data management, economic returns, and supporting data collection for site characterization. This will be completed through on-farm demonstrations, mass media, field schools, and local forums that the PELUM network has established in the region.

Our approach in Year 2 and 3 will be to disseminate information about the application of inoculant technologies directly to small landholder farmers through our partner connections in PELUM. PELUM's work focuses on enhancing farmers' livelihoods through sustainable agriculture, seed and food security. PELUM has active networks in 10 countries: Botswana, Kenya Lesotho, Malawi, Rwanda, South Africa, Tanzania, Uganda, Zambia and Zimbabwe. As a network their strength lies in efficient and effective collaboration and communication.

Objective 4: *"Increase the capacity, effectiveness and sustainability of agriculture research institutions which serve the bean and cowpea sectors in developing countries"*

Capacity building in terms of degree training includes formal education for seven (7) MS level graduate students and five (5) undergraduate students from host countries. Two graduate students will be trained in the Soil Science Department at Makerere University under the direction of Dr. Mateete Bekunda, Professor of Soil Science. Two graduate students will be trained at Sokoine University of Agriculture under the direction of Dr. Susan Mchimbi, Associate Professor of Plant Breeding and Genetics. One HC graduate student will be trained at Washington State University under the co-direction of Dr. Lynn Carpenter-Boggs, Assistant Professor of Soil Microbiology and Biochemistry, and Dr. Phillip Miklas, Legume Research Geneticist with USDA-ARS. One HC graduate student will be trained at Iowa State University under the direction of the program PI, Dr. Mark Westgate, Professor of Crop Production and Physiology. And one HC graduate student will be trained at Michigan State University under the co-direction of Dr. Jim Kelly, Professor of Crop Breeding and Genetics, and Dr. Karen Cichy, Research Geneticist with USDA-ARS.

It is expected that HC students training in the US will spend some time conducting practical field work in their home country. The student enrolled at Michigan State University in Crop and Soil Sciences, for example, will conduct in depth studies on promising lines indentified in Rwanda field trials and will develop linkage maps of a recombinant inbred line population to conduct QTL analysis of BNF capacity. Once the student has completed his or her coursework at MSU, he or she will spend an estimated 4 months in Rwanda gathering data on BNF variability in the RIL population. The student will then return to MSU to complete degree requirements. It also is expected that HC students trained at US institutions will return to their home countries to engage in research in their chosen field.

Capacity building in terms of non-degree training include formal internships for five (5) undergraduate students and training of HC laboratory technicians, field agronomists and extension staff on use and agricultural benefits of seed inoculants. In the first year, three undergraduate students will be

assigned to the three field sites in Rwanda to assist in germplasm evaluation. These students will be supervised by Dr. Augustine Musoni, and interact directly with US PIs during their visits to the field sites. Two undergraduate intern will be assigned to work with VEDCO staff on information dissemination in Year 2 and 3.

Training/Capacity Building Workplan Format (January 1 to September 28, 2010)

This program includes formal training for seven MSc students and five undergraduate interns, and short-term training sessions for the entire BNF team on BNF protocols. Five graduate students and three undergraduate interns will be identified in during the first funding period. Two graduate students and two interns will begin training in year 2. Graduate students will also be encouraged to attend a workshop to share research outcomes and training activities prior to the CRSP meeting in 2012

Degree Training:

Seven host country M.Sc. graduate students

First and Other Given Names	Mercy
Last Name	Kabahuma
Citizenship	Uganda
Gender	Female
Training Institution	Iowa State University
Supervising CRSP PI	Mark Westgate
Degree Program for training	M.S.
Program Areas or Discipline	Plant Physiology
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID?	YES
Host Country Institution to Benefit from Training	
Thesis Title/Research Area	Shoot and Root Control of BNF
Start Date	Fall 2010
Projected Completion Date	Summer 2012
Training status (Active, completed, pending, discontinued or delayed)	Active
Type of CRSP Support (full, partial or indirect) for training activity	full

First and Other Given Names	Martha
Last Name	Abwate
Citizenship	Uganda
Gender	Female
Training Institution	Makerere University
Supervising CRSP PI	John Tenywa
Degree Program for training	M.S.
Program Areas or Discipline	Soil Science

If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID? YES

Host Country Institution to Benefit from Training	Makerere University
Thesis Title/Research Area	TBD
Start Date	Summer 2010
Projected Completion Date	Summer 2012
Training status (Active, completed, pending, discontinued or delayed)	Active
Type of CRSP Support (full, partial or indirect) for training activity	full

First and Other Given Names	Peter
Last Name	Ssenyonga
Citizenship	Uganda
Gender	Male
Training Institution	Makerere University
Supervising CRSP PI	John Tenywa
Degree Program for training	M.S.
Program Areas or Discipline	Soil Science

If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID? YES

Host Country Institution to Benefit from Training	Makerere University
Thesis Title/Research Area	TBD
Start Date	Summer 2010
Projected Completion Date	Summer 2012
Training status (Active, completed, pending, discontinued or delayed)	Active
Type of CRSP Support (full, partial or indirect) for training activity	full

First and Other Given Names	Kelvin
Last Name	Kamfwa
Citizenship	Rwanda
Gender	Male
Training Institution	Michigan State University
Supervising CRSP PI	Kelley, Cichy
Degree Program for training	M.S.
Program Areas or Discipline	Plant Breding/Genetics

If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID? YES

Host Country Institution to Benefit from Training	ISAR
Thesis Title/Research Area	Genetic control of BNF
Start Date	Fall 2010
Projected Completion Date	Summer 2012
Training status (Active, completed, pending, discontinued or delayed)	Active
Type of CRSP Support (full, partial or indirect) for training activity	full

First and Other Given Names	Michael
Last Name	Lege
Citizenship	US
Gender	Male
Training Institution	Washington State University
Supervising CRSP PI	Carpenter-Boggs, Miklas
Degree Program for training	M.S.
Program Areas or Discipline	Soil Microbiology/Biochemistry
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID?	YES
Host Country Institution to Benefit from Training	Sokoine University Agriculture
Thesis Title/Research Area	N2 fixation of rhizobial strains
Start Date	Fall 2010
Projected Completion Date	Summer 2012
Training status (Active, completed, pending, discontinued or delayed)	Active
Type of CRSP Support (full, partial or indirect) for training activity	full

First and Other Given Names	Beatha
Last Name	Khafa
Citizenship	Tanzania
Gender	Female
Training Institution	Sokoine University Agriculture
Supervising CRSP PI	Mchimbi, Tindwa
Degree Program for training	M.S.
Program Areas or Discipline	Breeding and Genetics
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID?	YES
Host Country Institution to Benefit from Training	Sokoine University Agriculture
Thesis Title/Research Area	Genotype evaluation for BNF
Start Date	Summer 2010
Projected Completion Date	Summer 2012
Training status (Active, completed, pending, discontinued or delayed)	Active
Type of CRSP Support (full, partial or indirect) for training activity	full

First and Other Given Names	Charles
Last Name	Komba
Citizenship	Tanzania
Gender	Male
Training Institution	Sokoine University Agriculture
Supervising CRSP PI	Mchimbi, Tindwa
Degree Program for training	M.S.
Program Areas or Discipline	Breeding and Genetics
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID?	YES
Host Country Institution to Benefit from Training	Sokoine University Agriculture
Thesis Title/Research Area	TBD
Start Date	Summer 2010
Projected Completion Date	Summer 2012

Training status (Active, completed, pending, discontinued or delayed)	Active
Type of CRSP Support (full, partial or indirect) for training activity	full

Short-term Training:

Two undergraduate internships at VEDCO

Type of training	Undergraduate Internship on inoculant technologies, management and benefits
Description of training activity	Participation in field operations
Location	Varied, depending on staff and farmer group locations
Duration	8 weeks
When will it occur?	Summer 2012
Participants/Beneficiaries of Training Activity:	Undergraduate students
Anticipated numbers of Beneficiaries (male and female)	1 male, 1 female
PI/Collaborator responsible for this training activity	VEDCO, Musoke
List other funding sources that will be sought (if any)	
Training justification	Adaptation of new technology requires user understanding of appropriate use, management, and pitfalls.

Three undergraduate internships at ISAR

Type of training	Undergraduate Internship on inoculant technologies, management and benefits
Description of training activity	Participation in field operations
Location	Varied, depending on staff and farmer group locations
Duration	8 weeks
When will it occur?	Summer 2012
Participants/Beneficiaries of Training Activity:	Undergraduate Students
Anticipated numbers of Beneficiaries (male and female)	2 female, 1 male student
PI/Collaborator responsible for this training activity	ISAR, Musoni
Training justification	Adaptation of new technology requires user understanding of appropriate use, management, and pitfalls.

VEDCO, NaCRRI, ISAR, SUA staff

Type of training	Staff and farmer education on inoculant technologies, management and benefits
Description of training activity	Formal lecture and open discussion
Location	Varied, depending on staff and farmer group locations
Duration	4 hours
When will it occur?	Fall 2011-Spring 2012
Participants/Beneficiaries of Training Activity:	Extension staff, farmer groups
Anticipated numbers of Beneficiaries (male and female)	50 male, 50 female
PI/Collaborator responsible for this training activity	VEDCO/ISAR/SUA, Musoke, Nchimba, Musoni
Training justification	Adaptation of new technology requires user understanding of appropriate use, management, and pitfalls.

III. Contribution of Project to Target USAID Performance Indicators:

Graduate and undergraduate training is central to this project. Supporting advanced education for HC students with world-class scientist and training field technicians will contribute directly to HC capacity building.

Training of farmers and farmer groups on technologies to improve bean productivity will contribute to income and food security of small landholder farmers.

Improved on-farm productivity will enhance marketing opportunities for farmer associations.

Advancing inoculant technology for legumes will promote agricultural enterprise associated with inoculant production and sales.

IV. Target Outputs:

New knowledge on bean germplasm x inoculant x environment interactions to inform ongoing variety development programs in the U.S. and host countries about specific improvements in BNF needed to realize enhanced yield, nutritional value, and marketability of dry beans and other pulses.

Seven graduate students and (at least) five undergraduate students trained in agricultural research and extension.

Methods and conditions for profitable use of superior legume inoculants determined.

V. Engagement of USAID Field Mission(s)

Work in this project is closely aligned with USAID's goals of increasing agricultural production, enhancing the sustainable use of natural resources, reduce threats to biodiversity, and improve food security. USAID assistance seeks to increase and diversify commercial agricultural production and increase Uganda's competitiveness in local and international markets. This project will contribute to USAID's mission of strengthening producer organizations by working with individual farmers and farmer groups. In particular, the CRSP project explores the benefits of modern agricultural (micro-biological) technology to increase agricultural productivity and income to small landholder farmers.

Outcomes of this CRSP program directly support the USAID Rwanda Mission program for economic growth and expanded opportunities in rural areas, increase household incomes, employment, and corresponding rural financial services for targeted communities. The central Mission goal of increasing agricultural productivity is promoted by developing sustainable production practices to increase legume yields through training and access to modern agricultural inputs. Knowledge and experiences gained through VEDCO's dissemination activities in Uganda provide an excellent model for disseminating information to farmer groups in rural communities in Rwanda.

The major objectives of the USAID Mission in Tanzania is to stabilize population growth, prevent the spread of HIV/AIDS, arrest environmental degradation and promote democracy, human rights and broad-based national and regional economic growth. CRSP activities Tanzania will contribute to USAID's mission of strengthening producer organizations by working with individual farmers and farmer groups. Through our participatory approach, this program will disseminate new knowledge about sustainable agricultural technologies and build capacity of farmer groups and associations. This program also contributes directly to the US Presidential Initiative to End Hunger In Africa, which is designed to help Africa countries reduce hunger in half by 2015.

VI. Networking Activities with Stakeholders:

We anticipate our direct interaction with these programs will expand the impact of current CRSP-funded variety development programs in the US. Dr. Phil Miklas has ongoing research activities with the bean breeding program at the Sokoine University of Agriculture. This connection will provide direct linkage between US and Tanzanian scientists using molecular genetics tools to select for improved bean germplasm. Prof. Jim Kelly at Michigan State University has ongoing germplasm development projects with colleagues at the Institit des Sciences Agronomiques du Rwanda/ISAR in Rwanda. Our research team has ongoing collaboration with bean breeders at the Rwanda through PABRA (CIAT and ECABREN) in the area of exchange of germplasm, esp. snap beans, climbing beans and root rot resistant bean lines.

Dr. Michael Ugen and colleagues at NaCRRI in Uganda work in collaboration with CIAT and ECABREN (East and Central Africa Bean Research Network) under PABRA (Pan African Bean Research Alliance) for germplasm exchange, sharing equipment and research results, trainings, support to monitoring tours, exchange of scientists, backstopping national research programs (breeding, pathology, participatory monitoring and evaluation and seed system), supervision of students, co-designing 5-year collaborative research programs.

Through VEDCOs leadership in the PELUM network, we will work with farmers groups and associations and agribusiness concerns in Rwanda, Tanzania, Uganda, and Kenya using participatory methods to understand local livelihoods, agronomic practices, their previous and current linkages with various types of institutions and service providers (governmental and non-governmental), private sector

traders, transporters, their livelihood aspirations, assets, capabilities, and strategies. Involving local leadership is a key component of this approach to mobilization of farmers and local agricultural concerns.

CSRL uses 'Learning Forums' regularly to interact with various institutions and service providers (governmental and non-governmental), private sector traders, agricultural processors and distributors etc., to gain and maintain appropriately broad perspectives on key issues in production, the value chain, benefit from their special expertise, and build new collaborative relationships for high levels of success.

VII. Leveraging of CRSP Resources:

US Institutions have committed $154,236 in 'in-kind' dollars towards the successful completion of the projects outlined in this proposal. Our industrial partner, Becker Underwood, Inc (BU) is contributing about 43% of this amount. This level of commitment from an industry partner is significant and clearly indicative of the potential for leveraging additional industry funds to expand the program. Utilization of SNP analysis from the Bean CAP program represents a significant savings to the CRSP project as these data will be directly applicable for discovery of BNF-related genes and those regulating response to inoculation.

Through its collaboration with the Lutheran World Relief, Becker Underwood is currently supporting the expansion of Inoculant Technology in Burkina Faso, Niger, Tanzania, Kenya, and Mali. This activity involves local seed companies and is designed to minimize dependence on inorganic N fertilizer. While a formal commitment of funds from the CSRL program is not possible, many of the management, development, and research activities conducted by the Center with our partners in Sub Saharan Africa Uganda support the research and development activities outlined in this proposal.

VIII. Contribution of Project to Target USAID Performance Indicators:

(At this time—leave this field blank)

IX. Project Benchmarks (semi-annual indicators of progress):

(At this time –leave this field blank)

SEMI-ANNUAL INDICATORS OF PROGRESS BY INSTITUTIONS AND TIME PERIOD

Project Title: *Enhancing biological nitrogen fixation (BNF) of leguminous crops grown on degraded soils in Uganda, Rwanda, and Tanzania*

	Abbreviated name of institutions															
	ISU		MSU		WSU		VEDCO		NaCCRI		SUA		Makerere		ISAR	
Identify Benchmark Indicators by Objectives	**4/1/12**	**9/30/12**	**4/1/12**	**9/30/12**	**4/1/12**	**9/30/12**	**4/1/12**	**9/30/12**	**4/1/12**	**9/30/12**	**4/1/12**	**9/30/12**	**4/1/12**	**9/30/12**	**4/1/12**	**9/30/12**
Objective 1																
Field Trial 2 established at HC locations									x		x				x	
Quantified yield advantage of inoculation for second HC field season										x		x				x
Analysis of soil/weather data completed		x								x		x		x		x
Confirmed phenotypic and yield responses to inoculant X Gen X Env.		x		x		x				x		x		x		x
Confirmed indigenous rhizobia levels related to environmental conditions		x		x		x								x		
Root/nodulation study initiated		x		x		x										
Confirm soil rhizobia populations and strain diversity						x										
Identified most effective genotype-inoculant combinations for each eco-zone										x		x		x		x
Determined economic return for inoculation treatments at all yield levels										x		x				x
Held BNF-CRSP team meeting	x		x		x		x		x		x		x		x	
Held workshop for graduate students on research results	x		x		x											
Attend Bean Improvement Cooperative Workshop	x		x		x											
Objective 2																
Tested subset of BNF panel lines in low N soil +/- inoculants in HC				x		x				x		x				x
Increased seed of BNF diversity panel lines			x		x											
Completed initial greenhouse screening of 50 selected lines for BNF response						x										
Evaluated correlative response of BNF phenotype characteristics		x		x		x				x		x				x
Confirmed nodule rhizobia occupancy on selected lines						x						x				
Characterized soil rhizobia populations and strain diversity at field sites						x										
Confirmed season 1BNF response phenotyping for selected CAP & SA lines				x		x										
Conducted initial SNP analysis on bean CAP and SA Core collection				x		x										
Completed initial list of candidate genes for BNF response				x		x										
Advanced selected RILs to F3				x		x										
Objective 3																
Established format for field demonstrations at HC stations	x		x		x		x		x		x		x		x	
Included information on N2Fixation and inoculation at demonstration sites							x		x		x				x	
Conducted field days in each HC to sensitize farmer on BNF								x		x		x				x
Conducted on-farm trials with selected farmer cooperators								x		x		x				x
Created training materials to disseminate through PELUM network		x						x		x		x		x		x
Incorporated research results into extension training programs, farmer advocacy meetings, and PELUM network website								x		x		x		x		x
Determined potential for engaging international funding agencies to expand current technology transfer efforts		x						x		x		x		x		x
Conducted advocacy meetings with farmer groups and agribusiness interests								x								
Objective 4																
Graduate students identified		x		x		x						x		x		
Graduate research programs initiated		x		x		x						x		x		
Undergraduate student interns identified								x								x
Undergraduate student projects intiated								x								x
Name of the PI responsible for reporting on benchmarks	Westgate		Cichy		Miklas		Musoke		Ugen		Mchimbi		Bekunda		Musoni	
Signature/Initials:																
Date:																

Dry Grain Pulses CRSP
PERFORMANCE INDICATORS/TARGETS for FY 12
(October 1, 2011 -- September 30, 2012)

	PIII-ISU-2	
	2012 Target	2012 Actual
Output Indicators	(Oct 1 2011-Sept 30, 2012)	
Degree Training: Number of individuals who have received degree training		
Number of women	4	
Number of men	3	
Short-term Training: Number of individuals who have received short-term training		
Number of women	50	
Number of men	50	
Technologies and Policies		
Number of technologies and management practices under research	1	
Number of technologies and management practices under field testing	1	
Number of technologies and management practices made available for transfer	1	
Number of policy studies undertaken		
Beneficiaries:		
Number of rural households benefiting directly from CRSP interventions - Female Headed households	300	
Number of rural households benefiting directly from CRSP interventions - Male Headed households	200	
Number of agriculture-related firms benefitting from CRSP supported interventions	3	
Number of producer organizations receiving technical assistance	3	
Number of trade and business associations receiving technical assistance	3	
Number of community-based organizations receiving technical assistance	3	
Number of women organizations receiving CRSP technical assistance	3	

Dry Grain Pulses CRSP
PERFORMANCE INDICATORS/TARGETS for FY 12
(October 1, 2011 -- September 30, 2012)

Number of public-private partnerships formed as a result of CRSP assistance	3	
Number of HC partner organizations/institutions benefiting	3	
Developmental outcomes:		
Number of additional hectares under improved technologies or management practices	500	