

Soil Management Collaborative Research Support Program

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Executive Summary

The Soil Management Collaborative Research Support Program (SM CRSP) aims to eliminate soil-related bottlenecks that stand in the way of sustainable development. It makes the critical assumption that perverse policies, slow rates of technology adoption and impediments to acquisition and application of scientific knowledge continue to be bottlenecks to the development process. In addition the SM CRSP concentrates on bottlenecks for which it has comparative advantage in eliminating.

This advantage resides in the participating institutions' ready access to scientific knowledge, technology inventories and their capacity to synthesize knowledge-based products that enable users to make informed decisions about policy reform and technology adoption. In this way users are allowed to exercise choice from a number of options in the way bottlenecks are eliminated or circumvented. The collaborating host-countries add to this comparative advantage by incorporating local knowledge into CRSP products, and by serving as potential customers whose role is to evaluate knowledge products for accuracy and user acceptability. The knowledge-based products developed by the Soil Management CRSP come in several forms. They can be packaged as decision aids which provide alternative ways or trade-offs to overcome or circumvent bottlenecks (University of Florida, Montana State University, North Carolina State University), as a diagnostic procedure to detect weak links that threaten the sustainability of a green revolution cropping system (Cornell University), as prescriptions for policy makers and farm households on effective ways to conserve land on densely populated steplands and protect downstream communities (Texas A&M University), and as a new formulation of an old product that renders benefits of biological nitrogen fixation affordable to low income households (NifTAL). A key characteristic of the knowledge-based products is their global applicability at the local level. They apply globally because they are based on fundamental principles that transcend political boundaries, and apply locally because local biophysical and socio-economic data are used to analyze site and user-specific situations.

In short, the SM CRSP is endeavoring to transform traditional agriculture from trial-and-error subsistence farming to knowledge-based enterprises. Traditional agriculture is not sustainable because it requires more land than in use now to produce more food for more people. Knowledge-based agriculture on the other hand, offers hope that agricultural production can keep pace with demand without expanding the current cultivated land area.

Trained people are also needed to implement knowledge-based agriculture. To this end the SM CRSP offers host country students opportunities to participate in field research and earn advanced degrees in agriculture from participating U.S. universities.

Introduction

This is the second annual report of the restructured Soil Management collaborative Research support Program (SM CRSP). Last year's report contrasted the newly restructured CRSP with the old. The old CRSP was primarily designed to generate new knowledge and technologies related to soil management. The restructured CRSP, on the other hand, operates on the premise that a large body of soil management knowledge already exist, and makes the critical assumption that the desired impact of soil management on food security and sustainable land management will occur only when there is widespread adoption of existing soil knowledge and technologies by farmers, extension agents, agribusinesses, and policy makers.

The Technology Adoption Bottleneck

The slow adoption of technology packages constitutes a major problem in many developing countries for farmers and researchers alike. The reasons for the delay in technology adoption include the following:

1. Farmers' objectives often do not coincide with those assumed by researchers and extension personnel.
2. Farmers' risks involved in adopting a new technology are not appreciated by researchers.
3. Farmers experience management problems associated with new technology which are not always anticipated by researchers.
4. Farmers may be operating within a set of constraints the extent of which is not fully appreciated by researchers; for example,

credit, gender, infrastructure, market and policy limitations may preclude widespread adoption.

There are many more reasons for the slow adoption of technology, but the list illustrates the multitude of factors farmers consider when confronted with a decision to adopt or reject a technology.

Participatory Approaches to Technology Adoption

The development community has been aware of this problem from the time of the green revolution when technologies that performed well in irrigated farms did not do so under rain-fed agriculture. The sondeos and rapid rural appraisals of the early years have now been replaced by participatory methods that involve farmers in problem identification and project design and implementation. This iterative, dynamic and self-correcting approach when properly applied guarantees a high adoption rate. But adoption only by those involved in participatory experiments is not sufficient. To be sufficient, there must be widespread adoption of a technology by user groups. The unanswered question for participatory research is how to scale up to a national or regional level what was accomplished with a few farm households. The scaling up of technology adoption from households to villages, villages to watersheds, watersheds to provinces and from provinces to nations and regions is essential for research to produce desirable results. Donor fatigue which we hear so much about is a symptom of donor disappointment with trail-and-error research on sustainable development.

What can this CRSP do to complement the on-going global agricultural research and make a difference where it counts? This CRSP has by most standards a large budget, but the amount is minuscule compared to the

annual global agricultural research budget of 3-4 billion dollars. The U.S. Department of Agriculture alone will spend 1.8 billion dollars on agricultural research this year.

To even have a chance to make a difference this CRSP must concentrate on what it can do best on a few choice topics. The CRSP has a mandate to concentrate on five such topics.

CRSP Mandate

The restructured SM CRSP is mandated to focus on five soils-related constraints identified by an independent panel of soil experts as part of the restructuring process. The constraints are as follows:

1. Soil Nitrogen management—especially technologies that improve nitrogen use efficiency.
2. Soil Phosphorus management—especially decision aids that help users make better policy, business and farm management decisions related to phosphorus.
3. Soil Acidity management—especially decision aids that foster improved practices and policies for eliminating this production constraint.
4. Management of Water Deficiencies—especially through better understanding of the interactions between nutrients and water use efficiencies.
5. Erosion and Land Degradation—especially as they relate to nutrient management.

Six projects are now engaged in collaborative research with developing country partners to address one or more constraints. Although only four projects could be funded by the allotted budget, the agency and management

entity chose to fund the fifth and sixth projects at a reduced level to enable them to seek financial support from other sources. The title, principal investigator and lead participating institution for each project are as follows:

A. Fully Funded

1. Decision aids for integrated nutrient management. T. Jot Smyth, North Carolina State University.
2. Soil management practices for sustainable production on densely populated tropical steeplands. Thomas Thurow, Texas A& University.
3. Sustainability of post-green revolution agriculture: The rice-wheat cropping system of South Asia. John Duxbury, Cornell University.
4. Tradeoffs in sustainable agriculture and the environment in the Andes; A decision support system for policy makers. John Antle, Montana State University.

B. Reducing Funding

1. Improved agricultural productivity through biological nitrogen fixation technology and legume management. Paul Singleton, NifTAL Center, University of Hawaii.
2. Gender and soil fertility. Christina Gladwin, University of Florida.

In the first year, six projects developed in isolation from each other focused their individual activities on their own specific objectives. The challenge was to find a way to concentrate project activities on a common set of program objectives. To do so the principal investigators

were asked to focus on the four properties of sustainable agroecosystems, namely, productivity, stability, resiliency, and equitability. These properties embedded in the program objectives are as follows:

1. Increase **productivity** of agroecosystems by raising yields and incomes of host country and U.S. families.
2. Increase **stability** of agroecosystems by reducing fluctuations in productivity by factoring uncontrollable production variables such as weather and climate into prescriptions for managing sustainable agroproduction systems.
3. Increase **resiliency** of agroecosystems by prescribing soil management practices and policies that enable the system to recover quickly from externally imposed stresses and perturbations.
4. Increase **equitability** by enabling individuals within and between households to share fairly in benefits derived from agroecosystems.

After two years, the project now show their strengths and weaknesses, and look for inter-project collaboration to share strengths with other projects. Common grounds for such collaboration can be identified along the lines of constraints (Figure 1), or program objectives (Figure 2).

In Figure 1, for example, the nitrogen constraint is covered by three institutions, but for very different reasons. The University of Florida is exploring ways to enable women farmers to obtain and apply fertilizer to food crops they produce, the NifTAL project is developing a liquid inoculum for Rhizobium that will reduce the cost of inoculum production, and North Carolina State University is developing a decision support system that renders expert knowledge on nitrogen use efficiency accessible to extension agents, agribusinesses, farm consultants and NGOs. These three projects have an opportunity to share knowledge, and incorporate the best into their own products.

Figure 1 also reveals that the water constraint is receiving token attention by the CRSP even though water may be the limiting constraint for raising productivity in rainfed

Figure 1. Matrix showing soil constraints covered by the participating institution.

INSTITUTION/ CONSTRAINT	CORNELL	FLORIDA	MONTANA STATE	NifTAL	NORTH CAROLINA STATE	TEXAS A&M
Nitrogen		X		X	X	
Phosphorus		X			X	
Acidity	X				X	
Water						
Degradation	X		X			X

Figure 2. Matrix showing program objectives covered by participating institutions.

INSTITUTIONS/ OBJECTIVES	CORNELL	FLORIDA	MONTANA STATE	NifTAL	NORTH CAROLINA STATE	TEXAS A&M
Productivity	X	X	X	X	X	X
Stability			X			X
Resiliency	X		X			X
Equitability		X			X	

agriculture. This apparent neglect of water stems from the belief by farmers and researchers that rainfall is an act of God and beyond human control. If we go to Figure 2, we see limited involvement in the second objective, to increase stability of agroecosystem. By stability we mean the year to year fluctuations in productivity caused by rainfall variability. The combination of stability and water supply represents the source of uncertainty that renders technology adoption so risky.

Two years ago, we could not have anticipated the limited research activity in the water constraint and agroecosystem stability objective. One way to correct this deficiency is to join forces with agencies and organizations involved in weather forecasting. In the U.S., companies and consultants market short-range weather forecasting information to farmers. Farmers, can then adjust their management strategies and operations to take full advantage of the anticipated weather, including rainfall. Recent work with El Nino shows that in some regions weather conditions for the next growing season can be reliably forecast. With such forecasts, farmers can adjust their management inputs to match the forecasted rainfall. In the absence of weather forecasts, farmers' inputs are typically matched for average rainfall. In highly variable rainfall areas, dependence on averages to determine fertilizer rates is too risky economically and environmentally. Use of average rainfall results in excessive application in dry years and insufficient application in wet years. Weather forecasting, water supply and soil management are high priority topics that this CRSP can and should explore.

Comparative Advantage

This CRSP is aimed at eliminating soils-related bottlenecks that delay sustainable agri-

cultural development for which it has a comparative advantage over other research groups. It has identified policy reform at the national and regional levels and technology transfer and adoption at the farm and household levels as key bottlenecks. We also make the critical assumption that the bottlenecks continue to exist not because there is a shortage of knowledge but because existing knowledge is not effectively utilized by policy makers, agribusinesses and farm households.

In both developed and developing countries effective application of knowledge is constrained by inaccessibility and the fragmented nature of knowledge.

The comparative advantage of the participating SM CRSP institutions is their easy access relative to documented knowledge, and therefore, the opportunity to synthesize knowledge-based products that serve as decision support for policy reform, business transactions and technology adoption.

For this CRSP, the knowledge products come in several forms. They are packaged as decision trees (University of Florida) or decision aids (North Carolina State University and Montana State University) used to support decision making by policy maker, agribusinesses and farmers; as a diagnostic procedure for detecting weak links that threaten the sustainability of a green revolution-based cropping system (Cornell University); as prescriptions to enable farm households occupying densely populated steplands and policymakers to save upstream resources and protect downstream communities (Texas A&M); and as a new formulation of an old product that renders the benefits of biological nitrogen fixation affordable to low income households (NIFTAL).

But knowledge-based products, no matter how powerful, serve no useful purpose if they are rejected by their intended customers. For this reason the role of the host-country collaborators is crucial. It is with these partners

that user participation and incorporation of local knowledge take place. The comparative advantage shifts from participating U.S. institutions to host country collaborators when potential customers participate in the design and evaluation of knowledge products.

Striving for a Locally Applicable Global Plan

What makes a CRSP global is the global dimension of the problems it addresses and the global applicability of its products. To be globally applicable, a knowledge-based product must be based on fundamental, natural processes that transcend political boundaries. Processes involved in soil erosion or photosynthesis, for example, are the same everywhere. But if processes are global, the end result is local and site-specific. Soil loss, for example, depends on local rainfall, plant cover and the length and steepness of slopes, whereas photosynthesis and crop performance depends on local water supply, nutrient availability and weather that vary over space and time.

This means that the inferencing capability of knowledge-based tools can only be as good as the site-specific data that fuels the inference engine. What is different today is that such site-specific data can be georeferenced and retrieved as many times as needed to diagnose and prescribe alternative solutions to problems. The power of information technology enables national agricultural research and extension personnel to respond to customer request for services in a timely and cost-effective manner. Knowledge-based tools do this by allowing customers to ask “what if” questions. This capacity of information technologies to be interrogated by users ranging from extension agents to government officials dramatically changes the way knowledge is made accessible to users. With the new information technology customers specify which

knowledge is needed by asking “what if” questions. In enabling customers to ask “what if” questions, they are being offered choices in how problems are solved. Theodore Shultz, in his award winning book “Transforming Traditional Agriculture” encouraged the development community to invest in research that enables farmers to exercise choice. Armatya Sen, this year, reiterated Shultz’s views on choice.

But choice implies the existence of options from which to choose. If, for example, a farm is rendered unproductive because of nitrogen shortages, there are numerous options from which the farmer can choose. What if the farmer were to grow a nitrogen fixing crop? What if she were to purchase nitrogen fertilizer? What if the fertilizer were entirely applied at planting time, split in three applications, or broadcast on the surface or buried below the surface. Not only must the farmer know the options, but she must be able to visualize the outcome of each option. Prediction and visualization of outcomes are the bases for choosing. Resource poor farmers will most likely make choices on the basis of economic benefits, whereas, farmers in industrialized countries, criticized for harming the environment, may choose strategies that are simultaneously profitable and ecologically sound.

In this way the global plan operates not only on a site-specific, but on a customer-specific basis.

Project Summaries

Project Title: Decision Aids For Integrated Soil Nutrient Management

Principal Investigator: T. Jot Smyth, North Carolina State University

Summary:

The goal of this project is to integrate and disseminate decision aid tools that will reduce soil acidity, N and P nutrient limitations to food production and quality. The tools will facilitate the diagnosis of soil nutrient constraints and help the user to select appropriate management practices for location-specific conditions.

The 5-year plan for project tasks are organized into two major categories: *developmental research* and *outreach activities*.

Developmental research includes tasks to do the following:

- merge the single-constraint decision support systems (DSS) for acidity, N and P into an integrated nutrient management system (IntDSS);
- synthesize, analyze and assemble knowledge required to overcome recognized information gaps in the existing information base for acidity, N and P;
- test and refine IntDSS; and
- develop auxiliary tools to facilitate use of the integrated knowledge base by a variety of users.

Outreach activities involve two major types of collaborative effort: *intensive testing areas* and an *extensive evaluation network*. Intensive testing areas are a representative region in each of three agroecological zones (semi-arid, wet-dry and humid tropics) where there is significant potential for tools developed by this project to alleviate soil acidity, N and P management problems. These three regions provide real life situations where all

developmental research by the multi-disciplinary team of 16 scientists from four U.S. universities (Cornell, Hawaii, N.C. State and Texas A&M) is conducted jointly with national and international institute collaborators. The extensive evaluation network focuses on the evaluation of products under a variety of user conditions, once suitable performance is achieved at the intensive testing areas. Although major efforts in product evaluation will occur towards the end of the 5-year project, early and continued contact with network collaborators will help ensure global relevance in product design and knowledge assembly.

The targeted audience for IntDSS are agriculturalists in NARES, IARCS, NGOs, PVOs, agribusiness and other CRSP projects.

Our comparative advantage towards development and widespread distribution of an integrated soil nutrient management decision support system lies in the project investigators' (a) long-term participation and experiences in international efforts to develop soil nutrient management information, (b) successes achieved among targeted users with prior development of decision support systems for single-nutrient problems, and (c) an extensive global network of collaborators willing to contribute pertinent knowledge and test IntDSS under a variety of location specific conditions.

During this second year of the project a series of field, laboratory and greenhouse investigations were implemented at intensive testing sites in Costa Rica, Mali and Philippines to acquire critical information related to soil nutrient management. Seven project-sponsored travel events by U.S. team members focused on visits to assist collaborators at testing sites in development of experimental designs, research protocols and to monitor progress. Baseline surveys were completed for each site, providing a detailed characterization of socio-economic settings and decision-

making processes used by farmers in each region. Comparisons of baseline data with surveys in project years 3 and 5 will provide measures of changes and impact assessment. We expect that the IntDSS software, when fully implemented, will help users increase agricultural productivity, income, and, thus, provide more options to limited-resource farmers. An improved soil nutrient status and management will enhance the natural resource base by increasing choices of plant materials to control erosion and minimizing off-site nutrient transport.

Investigations on information gaps at testing sites were complemented by continued searches, analyses and interpretations of pertinent data in published and gray literature. Estimates of Ca and Mg movement, for example, highlighted the importance of understanding and predicting processes governing soil bicarbonate and nitrate levels. Protocols were developed for assembling and interpreting existing available data on N response by key crops to various sources of applied N. Existing information on the diagnosis of P deficiency/sufficiency in tree crops was evaluated and, based on a comprehensive review, methods were identified that merit further development. During the year U.S. and overseas collaborators published or presented at meetings 44 papers related to knowledge assembly and information gaps in soil acidity, N and P management.

Programming of the integrated nutrient decision support system (IntDSS) continued under the Delphi platform with the conversion of ADSS and PDSS from other operating systems, and programming of the New York-based NDSS to fit the management needs of tropical regions. All single-thread nutrient software conversions and developments were made to a fit a common interface shell and database structure with *Diagnostic*, *Prediction* and *Guidance* modules. Compatibility with this common interface

structure will facilitate future planned revisions of IntDSS software.

Activities with the external evaluation network intensified this year with four project-sponsored travel events and numerous contacts via correspondence and email. Primary contacts and specific interests were identified for various network groups. Many of these collaborators began to contribute to the project by providing unpublished field research data from their respective locations.

Project Title: Soil Management Practices For Sustainable Production On Densely Populated Tropical Steeplands

Principal Investigator: Thomas Thurow, Texas A&M University

Summary:

A watershed planning unit internalizes the costs and benefits of upland soil and water conservation activities with the additional benefits to downstream interests, thereby influencing the scope and assessment of the investment decisions. Simply put, investment in steepland soil and water conservation is much more attractive from an economic, environmental and policy perspective if the benefits to downstream interests are considered in addition to benefits to sustainable production on the upland fields themselves. Documenting these interrelationships can help to build coalitions between upland and downstream interests that have previously been behaving as if they were environmentally and socioeconomically disconnected.

Three countries, Honduras, Nicaragua, Haiti, are the focus of our research activities. Each was selected because of the contrasts they provide in their environmental, economic, social and institutional characteristics. Other factors influencing their selection were (1) the logistic/cost benefits associated with

the close proximity, geographically, of these countries relative to the U.S. (hence more time and money can be spent on research instead of travel) and (2) existing working relationships between scientists at the lead institution and at host country institutions (hence start-up time was fast and the projects can access data collected on some of the study sites that were already operating).

The central hypothesis of this project is that a watershed is an appropriate scale of resolution for implementing a sustainable steepland soil and water conservation program. The drainage patterns of a watershed form the framework of important energy and nutrient cycles that occur on the landscape. If planning does not occur at this level, activities on a smaller planning unit will be susceptible to being undercut by events outside the project control which disrupt these energy and nutrient flow patterns. These flow patterns also are central to the benefits and costs of many types of socioeconomic decisions.

- During PY-2, a Ph.D. dissertation and 6 scientific articles were published and 9 presentations were made at scientific meetings or development workshops. Over the 2 years of this project, 2 M.S. theses, 1 Ph.D. dissertation, and 9 scientific articles have been published and 14 presentations have been made at scientific meetings or development workshops. Four of these presentations were invited by organizations seeking to incorporate our experience/research results in development activities. The reconstruction activities associated with Hurricanes Georges and Mitch have resulted in literally hundreds of e-mail and telephone requests for information on what we have learned from our research. Examples of organizations requesting information were the USAID missions, speech-writers for USAID, USDA, IDB senior officials,

various ministries of the governments in the affected countries, and a host of other development organizations (e.g., InterAmerican Development Bank, World Bank, organizations sponsored by European governments and *many* non-government organizations).

It was gratifying that preliminary data from this SM CRSP project have had a tangible influence in shaping the dialog and strategies of donor, lending and action organizations engaged in reconstruction activities following Hurricane Mitch. For example, the USAID mission in Honduras has used our information to support their plan for an US\$ 8 million soil and water conservation project to begin in FY-2000. The USAID mission and the Ministry of Agriculture in Nicaragua have been working closely with Texas A&M University to develop GIS tools that can help guide reconstruction efforts. The InterAmerican Development Bank excerpted text from several of our documents to craft their loan/reconstruction/transformation strategy (e.g., sectoral development activities must be coordinated—downstream investments must consider vulnerability associated with upland use patterns).

An example of the type of data generated from our ongoing research is illustrated by the catchment studies underway in southern Honduras since 1993. The two wet years (1995 & 1996) of our data set (prior to the exceptional 1998 year in which Hurricane Mitch occurred) averaged 92 tons/ha/yr soil loss on traditional slash and burn sites, 43 tons/ha/yr soil loss on the mulched sites (i.e., no burning but no investments to tie the soil into the hillside), 0.9 tons/ha/yr on the vetiver grass contours sites (without the vetiver strips this site would have been expected to lose 73 tons/ha/yr if mulched only, as determined using EPA paired plot calibration

techniques) and 0.7 tons/ha/yr on previously cropped land being reclaimed using a nitrogen-fixing tree fallow).

Throughout the region, cropped sites with vegetation contours, rock walls and tree fallows withstood Hurricane Mitch quite well, but the sites that did not have these investments were devastated by massive landslides. Our storm intensity data from Hurricane Mitch is the only source of this type of information for a region extending the southern half of Honduras and northern Nicaragua (to be published in the scientific journal *Nature* in late May 1999). GIS analysis of land use changes since the mid-1950s, and the implications of those changes for runoff and erosion, provide an understanding of the magnitude of increased risk and vulnerability to tropical storms like Hurricane Mitch.

Research is targeted at understanding the various facets germane to the issues of accounting for soil conservation costs and benefits when analyzed at a field and watershed scale of resolution. Examples of some of the current research feeding into the policy relevant analyses of land use practices and soil and water conservation investment options include:

- the magnitude of preservation of carbon sequestration on sites with soil conservation investments,
 - the socioeconomic linkages between upstream land use and downstream environmental and economic interests,
 - long-term impacts of soil conservation investments on total production and the production variation (e.g., risk reduction associated with production in dry years),
 - refinement and validation of sustainable farming system options compatible with the farmers economic and social constraints,
 - refinement and validation of GIS analysis and simulation models needed to estimate the overland loss of water, soil and nutrients on representative steepland sites as influenced by land management practices and inherent soil characteristics.
- All field research requiring multiple years of data collection were initiated. Progress of the project is on track or advanced/enhanced relative to what was outlined in the initial project proposal. Collaborative research projects involve 22 scientists with 9 organizations in Honduras, Haiti and Nicaragua. These host-country professionals are academically-linked with the 6 principal investigators or lead scientists and 8 collaborating scientists from Texas A&M University, Auburn University and North Carolina State University. The host country organizations provide tangible in-kind support (personnel, vehicles, etc.) for the research projects valued at approximately \$130,000/yr. Our project also benefited from the unique opportunities that arose from Hurricane Mitch, especially in terms of accessing satellite imagery and detailed aerial photos which is very complimentary with our ongoing GIS and simulation modeling analyses.
 - Eight graduate students (2 from Honduras, 2 from Nicaragua, 2 from Haiti and 2 from the U.S.) were supported in their programs during this project year. Five of the 6 host-country students were selected based on merit from the ranks of collaborating host-country national organizations. These organizations use their collaboration with the CRSP to improve their institutional scientific capabilities and to strengthen linkages to U.S. universities. In addition, 2 students (1 from Bolivia and 1 from India) are conducting

research in support of the project while being supported from sources external to the SM CRSP (i.e., Fulbright Scholar and TAMU Experiment Station). Two students graduated during the first year of this project. Therefore, a total of 12 graduate students have been or are part of this project. Partial funding for 1 undergraduate thesis at the PanAmerican University, Honduras and 3 undergraduate theses at the National Agriculture University, Nicaragua are provided by the SM CRSP project to support the research of these students which are designed to dovetail in support of on-going research directed by the project principal investigator and each respective lead scientist.

Project Title: Sustainability of Post-Green Revolution Agriculture: The Rice-Wheat Cropping Systems of South Asia.

Principal Investigator: John Duxbury, Cornell University

Summary:

The Cornell program has two linked projects; one concerned with the sustainability of the rice-wheat cropping system in the Indo-Gangetic Plains and the second with developing food systems approaches to preventing Ca deficiency rickets in Chakaria thanna (Cox's Bazaar district), Bangladesh. The rice-wheat project is a component of the core SM-CRSP program and the rickets project is supported by funds transferred from the Bangladesh AID mission to Cornell via the SM-CRSP. Activities in the rice-wheat project have been geographically constrained to Bangladesh and Nepal due to sanctions by the U.S. government against the governments of both India and Pakistan.

Constraint 1: Nutrient Deficiencies in Crops and Soils

Activities in this area are aimed at characterizing and overcoming widespread macro- and micro-nutrient deficiencies of soils in the rice-wheat regions of Bangladesh and Nepal. Strategies to cope with inadequate nutrient supply include fertilization with inorganic and/or organic nutrient sources; development of cultivars of crops that have nutrient efficiency traits; designing cropping systems so that nutrients can be recycled through crop residues or (legume) green manures; and enriching seeds with nutrients. Key results to date are:

- Diagnostic surveys of soil fertility and results of on-farm research experiments have shown that both macro-(N, P, K, and S) and micro-(Zn, B, and Mo) nutrient deficiencies are widespread in Nepal and Bangladesh.
- Screening trials in Bangladesh for P efficiency in wheat have identified several lines that appear to be more P efficient and/or responsive to P addition than current varieties.
- B deficiency was demonstrated to be the sole cause for the high incidence of sterility in wheat at Sipaghat, a mid-hills rice-wheat area in Nepal. In Bangladesh, a shading experiment to simulate foggy days induced sterility in wheat that was not corrected by B fertilization, indicating that there is a strong interaction between shading and B availability. These results are being incorporated into plant breeding programs to screen lines for resistance to B deficiency.

- Evaluation of micronutrient-enriched wheat seed (generated by foliar applications of micronutrients) showed improved germination and plant growth compared to unenriched seed and farmer seed and gave an average yield response of 0.62 t/ha (20% yield increase) on 6 of 15 farms in Dinajpur district, Bangladesh.
- Micronutrient enrichment of BR-32 seed, a newly released monsoon season rice variety in Bangladesh that is susceptible to Zn and Mo deficiency, gave the same yield response (1.1 t/ha; 37%) as soil or foliar fertilization with micronutrients. Yield responses (0.7 and 1.4 t/ha; 25 and 50%) to foliar fertilization of BR-32 with micronutrients were observed in 2 of 4 on-farm trials in Dinajpur district, Bangladesh.
- Various grain and green manure legume species exhibited different nutrient acquisition/recycling capacities, and different effects on root health and populations of parasitic nematodes in a following rice crop.

Constraint 2: Nutrient Deficiencies in Humans

Rickets has been identified as a major cause of physical disability in children of Chakaria thanna, Cox's Bazaar district, in southeastern Bangladesh. The underlying cause of rickets is insufficient calcium for proper bone formation and this is most often caused by a lack of vitamin D which is needed for calcium utilization. However, biochemical analysis of blood of rickets patients indicates that calcium deficiency itself is the cause of rickets in Chakaria. Cornell has formed and leads a consortium to tackle this problem using a food systems approach to increase dietary intake of Ca and other nutrients.

Consortium members include the USDA Nutrition Laboratory, Ithaca NY; UNICEF Bangladesh; SARPV (a Bangladesh NGO); AEM (a French NGO); CIMMYT; the Institute of Child and Mother Health, Dhaka; Dr P. Fisher, Mayo Clinic, an expert on Ca deficiency rickets; Dr N. Hassan, Professor of Nutrition, University of Dhaka; and the Memorial Christian Hospital, an American missionary hospital in Chakaria thanna.

The consortium has developed a program aimed at rickets prevention. Principal components of the program are:

1. Determination of the prevalence of rickets in Chakaria and other parts of Bangladesh.
2. Determination of the efficacy of treatment with Ca and benefits associated with other nutrients that are commonly deficient in the diet.
3. Analysis of the food system in Chakaria through household surveys.
4. The design of agricultural systems to increase the supply of Ca and other nutrients.
5. The development of medical protocols and implementation of a treatment program for children with brachitic deformities.

The prevalence studies are being financially supported by UNICEF, the food systems components by the Bangladesh AID mission, and the medical treatment of rachitic afflicted children is not currently funded.

A prevalence survey (900 randomly selected children from 30 villages) in Chakaria thanna found that 8.6% of the children had clinical symptoms of rickets. Of this group, 25% had

blood biochemistry consistent with rickets and 10% had active rickets confirmed by radiology. Among 111 “control” children selected from the group without clinical symptoms, 20% showed biochemical evidence for rickets. The survey showed that rickets is a major public health problem in Chakaria thana, that a large fraction of the rachitic children no longer had active rickets, and it found disturbing evidence for rickets in the control group. The prevalence survey is being extended to other parts of Bangladesh in collaboration with the Bangladesh Rural Advancement Committee (BRAC), the major NGO in Bangladesh.

Food system activities initiated include development of a “food system” survey instrument and formation of a team to carry out surveys during different cropping seasons in Chakaria; development of a 7 acre SARPV owned farm in Chakaria to evaluate potential agricultural/food system interventions; and establishment of linkages with NGO’s (Helen Keller and CARE), who have home gardening projects in the Chakaria or Chittagong areas.

Nutrition and health of farm families in rice-wheat areas of Bangladesh are being coupled to the rickets project by using the same food systems survey instrument. This will provide the basis for design of agricultural interventions in both projects as well as useful agricultural and human nutrition contrasts between different regions of the country that have acid soils. A Ph.D. economics student is developing a “rice-wheat household agricultural model” that will be used to explore the implications of household decision making on food security, nutrition and health of the family, and income. The “household agricultural model” will also be used in the rickets project.

The food systems approach explicitly links agriculture to human nutrition and health and will provide a widely transferable model for addressing health problems caused by malnutrition.

Constraint 3: Soil Degradation

A. Physical. Puddling of soils destroys soil aggregates and creates pans that can restrict root penetration. Although puddling is generally considered beneficial for rice, the poor soil structure that it creates interferes with the timely establishment of wheat and often leads to poor crop stands and growth. There is also interest in direct seeding of rice because of labor shortages for transplanting. To address these constraints, a series of experiments that compare tillage (deep, conventional, and no-tillage), crop establishment (direct seeding and transplanting for rice; and surface seeding with no land preparation and Chinese seed drill for wheat), and residue management (straw removal, incorporation, and use as a mulch) have been implemented at several locations in Bangladesh and Nepal. Initial results from these experiments include:

- Surface seeding of wheat increased wheat yields from 2.4 to 4.3 t/ha (80%) in the terai of Nepal due to more timely planting.
- Direct seeding of rice gave the same yields as transplanting in the terai of Nepal (6 t/ha) but lower yields in Bangladesh, probably due to inappropriate N management in the latter case.
- No significant effects of deep tillage prior to rice on rice or wheat yields have been observed to date.
- Incorporation or application of wheat straw as a mulch increased rice yields by 0.5 and 1 t/ha (13 and 27%), respectively in the terai of Nepal. A similar result was obtained with straw incorporation in northwest Bangladesh. The hypothesis that the straw treatments increase the efficiency of fertilizer N use is being evaluated.

- Rice yields were reduced from 5.3 to 3.7 t/ha (30%) when soils were not puddled following normal tillage at a mid-hills site in Nepal, but deep tillage without puddling restored rice yield to the that obtained with puddling.

B. Biological. Solarization of soil (heating to 50C by covering with clear plastic) is being used as a diagnostic tool to evaluate the constraints to crop yields caused by soil borne pathogens. The technique is not completely definitive for pathogens because it also alters nutrient availability. Solarization is most effective when carried out during the dry summer months, i.e. prior to rice.

Of 23 studies carried out with rice, 13 showed yield increases with solarization. The mean yield increase was 1.5 t/ha (41%). Yield increases with wheat averaging 0.6 t/ha (17%) were observed in 3 of 6 trials. Positive effects of solarization on crop growth were observed in all studies, but these did not always translate into yield increases as crops in solarized plots attracted considerably greater insect pressure and were more susceptible to lodging and loss of grain to rats.

A simple scoring system showed that root health was improved by solarization and populations of parasitic nematodes were considerably reduced. Preliminary studies of the effect of solarization on nutrient availability showed increased availability of N and Mn.

The solarization results indicate that there is substantial scope for increasing crop yields through improved management of soil borne pathogens and possibly also nutrients.

Project Title: Tradeoffs in Sustainable Agriculture and the Environment in the Andes: Decision Support Systems for Policy Makers.

Principal Investigator: John Antle, Montana State University

Summary:

A preliminary version of The Tradeoff Model, a decision support system for policy makers, was completed. This software integrates field-scale GIS-based soils and climate data with the DSSAT suite of crop growth simulation models, econometric-based economic simulation models of land use and management decisions, and environmental process models (leaching, runoff and erosion). The software provides the basis to draw a statistically representative sample of fields in a region such as a watershed, conduct integrated analysis, and statistically aggregate the results to a scale relevant to policy decision making. The software displays tradeoffs between competing or complementary policy objectives in simple two-dimensional graphs, and shows how these tradeoffs change under alternative policy and technology scenarios. A long-term objective of the project is to make this model general so that it can be applied to analysis of tradeoffs in any agro-ecosystem. A related long-term objective is to develop the software and documentation for distribution and use by analysts world-wide.

The Tradeoff Model provides the framework in which the Soil Management CRSP constraints will be assessed in this project. Tradeoff indicators include value of crop and livestock production, soil productivity and water quality, and human health. Constraints addressed in this project include reductions in soil productivity associated with mechanical and water erosion and soil compaction, losses in nutrients, impacts of management practices (erosion and chemical use) on water

quality, and impacts of pesticide use on human health. Scenarios for enhancing the long-term sustainability of Andean production systems include improved soil management and conservation practices, pest management practices and IPM, improved crop varieties (specifically, adoption of late-blight resistant varieties), pasture management, and farmer training to improve the safety of pesticide use and farm machinery practices.

The Tradeoff Model provides a framework in which to structure input from stakeholders, such as farmers, research administrators, and local and national policy makers. This information is used to define the indicators that are quantified as tradeoffs, and to define policy and technology scenarios to be evaluated.

The expected impact of this policy decision support tool will be realized as it is adopted and used to support more informed policy decisions that impact agricultural production and related soil and natural resources. For example, in the Andean region, widespread adoption and subsequent applications of the tools are anticipated to lead to a better understanding by farmers and policy decision makers of the potential long-term impacts of current land use and management practices, and how economic conditions and technological innovations could favorably or adversely impact agricultural sustainability.

Much of the research activity during this year was related to development of data and models to be used in the Tradeoff Model, and to collection of data needed to parameterize scenarios. Highlights of this work are as follows:

- Farm-level survey data collection continued at the Cajamarca site in Peru. The first year of collection of data from some 600 fields was completed. Data were computerized and prepared for analysis.
- Parameterization and validation of crop and livestock (LINTUL, SUBSTOR and pasture/milk) and environmental process (LEACHP, WEPP) models to address the SM-CRSP priority constraints in the Andean region.
- Adaptation of econometric production models and the related economic simulation models for linkage with spatially referenced crop, livestock, and environmental process models. Modification of economic models to test effects of alternative model and data structures for up-scaling and extrapolation.
- Analysis of land use history and erosion. Data was collected from farmer interviews and field surveys to quantify the effects of mechanical erosion. This work will lead to a model describing the process of mechanical erosion (i.e., the mechanical displacement of soil down slope on steeply sloped hillsides) as a function of land management. The downscaling methodology for soils developed for the Carchi, Ecuador, site was applied and tested for the Cajamarca, Peru, site. This provides field-scale soil data for use in the bio-physical simulation models.
- A methodology was developed to interpolate climatic data from weather stations to the field level and will be applied in Carchi and Cajamarca sites.
- Automatic weather stations were installed in Peru.
- Erosion runoff plots in Ecuador were rehabilitated and managed.
- Field experiments on response of potato varieties to nitrogen and to late blight were conducted in Ecuador and Peru.
- Project research reports were prepared, and presentations were made at international scientific conferences.
- A collaborative agreement was prepared with the IPM CRSP. A successful proposal for funding of a complementary project by IDRC was prepared.

- A 3-day project meeting for project researchers, collaborators, and stakeholders was held. Presentations from the meeting were posted on the project's web site.

Project Title: Improved Agricultural Productivity Through Biological Nitrogen Fixation And Legume Management

Principal Investigator: Paul Singleton, NifTAL Center, University of Hawaii

Summary:

Global Problem Addressed. Nitrogen is an essential element in the proteins of all plant and animal life. Protein in crop plants is derived, in large part, from nitrogen fertilizer which is the most widely used production input in agriculture. The world's farmers now consume 80 million metric tons of nitrogen fertilizer per year and the rate may more than double in the next 40 years if projected global food demand is to be met. The economic and environmental consequences of increased use of nitrogen fertilizers are significant. Even in well managed systems, most nitrogen fertilizer used in agriculture is lost to the atmosphere as potent, long-lived greenhouse gases or become contaminants of marine and groundwater systems. In the future, the problem will be exacerbated by the need to dramatically increase nitrogen fertilizer applications to enhance crop yields. With more intense fertilizer application the relative and total loss of nitrogen from the agricultural system increases rapidly.

While other programs of the SM-CRSP seek to improve the efficiency nitrogen fertilizer use, this program aims to increase the farmers' acquisition of organic sources of nitrogen through biological nitrogen fixation (BNF). In the BNF process leguminous crops

such as beans, peas and soybeans capture nitrogen gas from the atmosphere through a symbiosis with a bacterium, *Rhizobium* and *Bradyrhizobium* and convert the gaseous nitrogen into protein for human and animal consumption. The nitrogen and protein farmers acquire through BNF is nearly cost free and without the environmental costs associated with the production, distribution and use of manufactured nitrogen fertilizers. BNF accounts for more than 35 million metric tons of the nitrogen found in the world's agricultural crops.

To ensure legume crops capture the maximum amount of gaseous nitrogen, farmers can inoculate the crop with selected, superior strains of the bacterium. This practice has given rise to private and public sector inoculant production facilities in many countries.

Project Goal and Objectives. Our goal is to raise farm and national income and increase consumer access to protein in LDCs through improved performance and increased reliance on legume BNF technology.

The program's objectives are; 1) Improve legume inoculant performance, 2) facilitate production of quality inoculant products, 3) increase market awareness for inoculant products, 4) increase legume yield and BNF through crop management and, 5) improve capacity in LDCs to implement BNF programs. Budget restrictions in project year two limited activities to objective 1.

Summary of Project Year Two Research Accomplishments. We developed a new liquid inoculant formulation that improved the performance of *Bradyrhizobium japonicum* (the microorganism that performs the BNF process with soybean) at 65% of the materials cost of earlier generations and less than half the cost of conventional products. Most conventional inoculant products are based on solid carriers composed of peat mined from wetlands or from processed agricultural

wastes. Maintaining performance consistency of these solid carriers is difficult without rigorous quality control procedures that are beyond the reach of most LDC inoculant producers.

Our new formulations are liquid mixtures of commonly available chemicals. Our approach with liquid formulations offers inoculant producers and farmers in LDC and developed countries several advantages that will increase the likelihood they will adopt and benefit from the technology. These advantages include lower cost, ease of application, compatibility of product with advanced planting machines, uniform performance between production runs, and lower capital costs for production facility setup.

Unsolicited feedback from 14 inoculant producers in 12 countries (including Australia, Austria, Bangladesh, Bhutan, China, Ghana, India, Nepal, Sri Lanka, the UK, and the U.S.) indicate that our goals and progress will benefit their operations. (see Table 6 of complete annual report). Details of the research process and results are also contained in the complete Project Year Two Annual Report.

Transferring Research Results to Clients.

We developed a global network with the aim to field test our products in cooperation with inoculant producers (about half are private sector entities), obtain their feedback on product effectiveness, identify their future needs and familiarize prospective end users with the potentials of our new formulations.

We developed a two-tiered database of inoculant producers, researchers and policy makers with interest in the subject. The objective for the first tier is to provide technical information on our goals, rationale and research results. This year we communicated our research results to 102 individuals in 36 countries.

The second, smaller database is composed of collaborators for field evaluation of our formulations and quality control methods.

After reading our research results several inoculant producers asked to participate in field evaluation. We have formed a network of 24 inoculant producers and scientists in 16 countries that are beginning to evaluate our product against locally available products. Countries listed include Bangladesh, China, Honduras, India, Kenya, Nicaragua, Philippines, Rwanda, South Africa, Tanzania, Thailand, Uganda, Uruguay, Vietnam, and Zimbabwe. We have provided each collaborator with a simple protocol, standard materials, strains, quality assurance materials and protocols and technical assistance. We are conducting laboratory bioassays on their local inoculant products to assess the potential of predicting inoculant performance in the field with a simple lab procedure, providing them with tissue analysis of test crops and feedback on quality control analysis of local inoculant products.

Project Impact. There is a high probability clients will adopt some of our improved inoculant formulations and quality control technologies when they are proven effective in the field. Some have already adopted quality control technologies; others want to adopt liquid inoculant formulations as soon as its efficacy in the field is demonstrated (see Table 6 of Complete Annual Report). A U.S. inoculant producer commented “this type of work is important to us.” A producer from India commented Awe are working on the feasibility and market acceptance of the same (liquid inoculants).

Although producers keep their production and sales figures confidential, we believe, based on the comments we received, that up to half the world’s producers are interested in adopting liquid inoculant formulations. This could result in application of these products to more than 20 million hectare. Given that improved, high quality inoculant products can improve yield of many legume crops 50-75% of the time, the long run impact on

aggregate farm and national income can be large.

Project Title: Gender and Soil Fertility
Principal Investigator: Dr. Christina Gladwin, University of Florida

There are two phenomena motivating the University of Florida project, "Gender and Soil Fertility in Africa." First, African women on small rainfed farms produce up to 70-80% of the domestic food supply in most sub-Saharan African societies. On average, they also provide 46% of the agricultural labor. Second, soil fertility is the number-one natural resource in Africa that is being depleted. Soil fertility depletion on smallholder farms is the biophysical root cause of declining per-capita food production in Africa (Sanchez et al. 1997). Yet women lack access to soil-replenishment inputs such as chemical fertilizers and animal manure (Gladwin 1989). This is not due to their lack of belief in chemical fertilizers or a commitment to organic farming. It is mainly due to their lack of cash or credit to acquire both chemical fertilizers and animal manure, and lack of knowledge, land, and labor required by new agroforestry and legume technologies. As a result, this project addresses all the constraints (lack of nitrogen, phosphorus, and water and land degradation) that the USAID Soils CRSP (collaborative research support project) addresses.

Project purpose. If government's aim is to increase food production, then it should improve the soil fertility on fields of food producers, who in Africa happen to be women farmers. How to do this? The purpose of the UF project is to answer this question. There are problems targeting women farmers with yield-increasing inputs of production, given (1) women farmers' severe cash and credit constraints; (2) recent increases in fertilizer prices due to currency devaluations;

and (3) women farmers' focus on subsistence versus cash crops. Because these problems tend to be shared across sub-Saharan Africa, the results of this study are also expected to be of relevance to not only the specific study site, but Africa in general.

In 1998/99, the UF project sought solutions to these formidable problems via research with farmers in several African countries (Ethiopia, Ghana, Malawi, Mali, Senegal, Uganda, and Zambia) working with Ministries of Agriculture and collaborators in international centers (CIAT, CIMMYT, ICRAF, ICRISAT), and African universities (Bunda College in Malawi, Makerere University in Uganda, Awassa Agricultural Research Center in Ethiopia, and University of Ghana). With funding from the USAID Soils CRSP, we monitored, tested, and compared the many different ways African governments, NGOs, PVOs, and agricultural research/extension centers (both CGIARs and NARs) are trying to replenish the soil fertility on women farmers' fields devoted to their food crops. Results from all these countries can be seen in the research and travel reports printed on our webpage at www.fred.ifas.ufl.edu/CRSP. The following is a brief summary of the highlights of those reports.

Ethiopia. During their trip to Awassa Research Center in Ethiopia, Clif Hiebsch and Michael Dougherty worked on a soil fertility needs assessment associated with the production of enset (*Ensete ventricosum*) or fake banana in southern Ethiopia. Due in part to the success of enset-based systems, population density in some areas is exceeding the carrying capacity provided by indigenous practices. The cause is a reduction in ruminant animals per human capita as grazing land is plowed for crop production. This causes a decline in both animal food products needed to supplement the low-protein content of enset, and manure used extensively to maintain soil fer-

tility. Because women have the major role in manuring of crop land as well as responsibility for what the family eats, they are impacted by these changes to the onset-based system.

Malawi. Political scientist Robert Uttaro returned to Malawi for a second trip to study the political ramifications of the recent democratization of Malawi (and collapse of the Banda regime). He hypothesized that the democratic changes should have empowered farmers, enabling government to respond better to farmers' needs. However, democratization processes were accompanied by economic crises following several substantial devaluations of the Kwacha (and subsequent increases in fertilizer, credit, and maize prices) as the economy was opened up to global financial markets during Malawi's market liberalization process. Uttaro thus found peoples' faith in the Malawi government to be in a downward spiral, with 92% of them believing government was not doing all it could to help them solve their important problems, one of which was lack of access to chemical fertilizer. Fertilizer use in 1997/98 was not profitable for maize production (grown by women). Both women and men had trouble repaying credit. Nitrogen nutrients were not being supplied by legumes as green manure, because women farmers did not plant legumes like pigeon peas to undersow them green, but to consume them for food or feed. Nitrogen was not being supplied by agroforestry innovations, either because women farmers did not know about them or lacked the land to plant them. Indeed, the only feasible way to encourage women to use fertilizer on food crops in 1998 was to give them credit for fertilizer for cash crops such as burley tobacco.

Andrea Snyder showed similar results after interviewing both FHHs and MHHs in Malusa, Malawi, and building linear programming (LP) models of household livelihood strategies. Using information on labor, price, yield, and caloric requirements, as well as

household composition data, she was able to create a model of each household farm that predicted the choice of technology the household was using at the time. Then she asked "what-if" questions to show how an individual household might adapt to future changes, such as the August 1998 devaluation of the Kwacha as well as the introduction of a maize or fertilizer "safety net"—a program for the poor who are falling through the cracks of Malawi's market liberalization process.

Christina Gladwin returned to Malawi in January 1999 to look specifically at safety net design issues. Due to recent increases in maize and fertilizer prices, rural and urban poor were suffering from so much hunger from November, 1998, to March, 1999, that both the government and donors were recognizing the need for a safety net. However, they did not want to design and implement formal safety nets that would compete with and replace the informal safety nets, adaptive strategies, and coping mechanisms already being successfully used by the poor to alleviate hunger and poverty. Therefore, Gladwin and colleagues Stephen Devereux of IDS Sussex, Maxton Tsoka and Peter Mvula of the Center for Social Research (CSR), Zomba, designed surveys of both rural and urban poor populations that were administered by CSR in Zomba. Their results showed that due to the almost-doubling of maize prices following the 60% devaluation of the Kwacha in August, 1998, informal safety nets and rural-urban linkages had broken down in both rural and urban areas of Zomba.

Recommendations suggested an expansion of existing safety-net programs and a new emphasis on "PES nets" (productivity-enhancing safety nets) which would increase productivity as well as reduce poverty and could be in the form of "fertilizer-for-work" programs or "fertilizer-for-improved fallow plots" in rural areas, and "medicines-for-community work" in urban areas.

Because fertilizer prices have increased so much in Malawi, Paul Thangata asked whether fertilizer can even be considered a sustainable solution for poor farmers. In a trip to kick off his Ph.D. research to assess agroforestry policy and institutions in Malawi, he took a detailed look at: MAFEP, the Malawi Agroforestry Extension Project, a USAID funded project to design and extend agroforestry innovations, SADP, the Smallholder Agribusiness Development Program funded by USAID, and ICRAF's Makoka Research Station in Zomba.

Mali. Agro-forester PK Nair visited Bocary Kaya at his research sites in the Sikasso region of southern Mali. They worked with the Sikasso Farming System Research Team (ESPBRN) to identify soil degradation and recommend agroforestry approaches to address the problem. In addition to examining ways to incorporate the soil-improving trees and shrubs as short-rotation fallow species in local farming systems, Kaya is conducting socioeconomic investigations involving rapid rural appraisal and linear programming techniques to also understand the viability and adoption of the technology for both male and female headed households.

Senegal. Amy Sullivan, aided by Rick Rudd, examined different farming systems, soil fertility practices, and different household composition patterns in two neighboring communities of different ethnic origin (Mandinka and Fulani) in the Casamance region of southern Senegal. She found that neither farming system relies very heavily on cash inputs and what little cash is produced is controlled by male family members. Women in both villages engage in rainfed rice production—with no chemical fertilizer or manure—as their primary productive contribution to the household. Mandinka women, however, tend to have more discretionary income than Fulani women, partly due to their market access and production of garden

vegetables for sale during the dry season. While both women and men face constraints of low soil fertility in both villages, the more diverse Mandinka livelihood system is more apt to initiate use of chemical fertilizer on rice in the future.

Ghana. In February-March, 1999, Peter Nkedi-Kizza and Kafui Awuma assessed fertility levels of soils in both Uganda and Ghana, and tested the null hypothesis of no difference in soil fertility on men's and women's fields in several agro-ecological zones in these countries. In each agro-ecological zone in each country, soil samples were taken from five participating women farmers and their male match. Soil pedons were examined for each male-female pair of farmers. Statistical analysis of soil fertility data is still being performed.

Uganda. In July through November 1998, Kathleen Heldenbrand and Abe Goldman studied the farming systems of four villages in Mbale District, one of the three most densely populated rural districts in Uganda. Household landholdings are extremely small in Mbale, both in the lower and higher altitude villages and among all demographic groups. The average farm size across the total sample is 2.2 acres or about 0.9 hectares. Farmers were asked to compare current agricultural output for their main crops with that 10 years ago (or when they began farming if that were more recent). The majority of farmers reported substantial declines for most or all of their main food and income crops. Roughly four out five households reported declines in production of the four main food and income crops: maize, matoke, beans, and coffee. The extent of reported declines in output was dramatic: Farmers reported mean production declines of 39% for maize, 44% for bananas, 48% for beans, and 46% for coffee in comparing current output with output on their farms 10 years ago. If these comparative estimates are even roughly accurate, the agricultural system of this region is undergo-

ing a profound production crisis, whose reversal is not in sight.

There has been little or no use of fertilizers in most of Uganda for the past 30 years, in contrast to much of Kenya and (to a lesser degree) Tanzania (FAO data). A small number of farmers in Mbale have recently begun to use fertilizers to address declines in soil fertility, but it seems that this trend has been arrested or reversed by sharply rising prices. Seventy five percent of the respondents say they never use fertilizers. Only eight farmers—five women and three men—were using fertilizers at the time of the survey. In sharp contrast to fertilizers, hybrid maize varieties are now widely grown in all four villages, with almost 70% of the total sample and over 80% of those who grew maize used some hybrid seed. About two thirds of the respondents use at least some animal manure, usually on plots close to the homestead. None of the respondents purchases manure, and of those who use manure, 80% say they do not have enough for their plots. One positive finding of the survey is the apparent emergence of a category of younger married households of those under 35 in which women's traditional roles have begun to expand and new techniques are being more widely adopted. Survey responses indicate that within this group, women have begun to own more cash crops, learn newer farming techniques, have greater control over their earnings, and become more involved in farming.

Zambia. In Eastern Zambia, Christina Gladwin and agronomist Jennifer Scheffee Peterson worked with Steve Franzel, Param Mfongoya, and ICRAF scientists at Msekera Research Station to elicit from women farmers the constraints limiting their adoption of new *sesbania Sesban* improved fallow systems (IF). Together, they modeled those constraints and criteria in decision trees, in order to predict whether or not women and men farmers would participate in an on-farm trial of the

IF-plot technology; and given that, go on to plant another IF plot in a following year. Jennifer Scheffee Peterson then interviewed 120 farmers in four villages in which ICRAF had worked to diffuse the technology. Results show that men are twice as likely to be classified as well off as women, and well off farmers tend to try IF plots—and poor farmers do not, but more very poor women (than very poor men) who test the technology tend to adopt it. Factors which motivate farmers to try IF plots include: recognition of low soil fertility as a crop production constraint, the high price of fertilizer and farmers' lack of access to cash to buy it, and visual verification of the benefits of the technology. Limiting factors include: failure of the first IF plot, sickness/poor health of the farmer, and the farmer's lack of belief in the benefits of IF plots, lack of access to seeds or seedlings, and change in access to land. Women's lack of knowledge about IF plots was not a constraint in this sample due to ICRAF's intensive work in these four villages. The UF team then decided to join forces with World Vision and try to extend the IF technology to 12,000 farmers in the Eastern Zambian district.

Project Management

Management Entity (ME)

The University of Hawaii is the Management Entity for the Soil Management CRSP and, in that capacity, receives and administers grant funds under Grant No. LAG-G-00-97-00002-00 from the AID Procurement Office on behalf of the Soil Management CRSP. The ME is responsible for implementation of the research program and for coordinating program activities relative to annual workplans and budgets. It is responsible for the program and accountable to AID for all expenditures. The ME reports on the program and represents the SM CRSP in negotiating with AID/Washington, in meetings of the CRSP Council (composed of all CRSP Directors), and related meetings nationally and internationally.

Participating institutions in the Soil Management CRSP include Cornell University, Montana State University, North Carolina State University, Texas A&M University, University of Florida and the NifTAL Center at the University of Hawaii. Except for the NifTAL Center, each of the participating institutions has entered into a subagreement with the Research Corporation of the University of Hawaii (RCUH). The RCUH is a State agency, established by the Legislature in 1965, and is attached to the University of Hawaii for administrative purposes. The fundamental mission of RCUH is to support the research and training programs of the University of Hawaii and to enhance research, development, and training generally in Hawaii.

The ME, through its subagreements with participating institutions, hold each responsible for programs and accountable for expenditure of project funds. In accordance with OMB Circular A-21, a system of reporting cost sharing or matching of federal funds up

to 25% of non-exempt project funds from non-Federal sources is written into each of the subagreements.

The ME has a governance system, based on the CRSP Guidelines established in 1985, in place and is designed to ensure that the ME performs in accordance with those guidelines. The scope and level of effort are modified annually by principal investigators from each of the participating institutions to reflect progress achieved toward each project objectives as reported in annual progress reports and annual workplans. The governance system of the SM CRSP consists of (1) the Board of Directors (BOD); (2) the Technical Committee (TC); and (3) the External Evaluation Panel (EEP).

A description of the composition and governance role of each body as stated in the CRSP Guidelines follows.

The Board of Directors (BOD)

“The Board consists of representatives from some or all of the participating institutions and may include individuals from other organizations and host country institutions. The AID Program Officer and the ME Director serve as ex-officio members. The institution, which serves as the ME, will have a permanent member on the Board. Board members are selected by their participating institutions on the basis of their administrative responsibilities and relevant expertise. They should not be chosen solely to represent their respective institutions or projects, but to function in the objective interest of the CRSP. The Board operates under a defined charter to deal with policy issues, to review and pass on plans and proposed budgets, to assess progress, and to advise the ME on these and other matters. While the ME institution has the authority to make final decisions relative to program assignments, budget allocations and authorizations, the ME must, in the

collaborative spirit, carefully consider the advice and guidance of the Board and other CRSP advisory groups. Any departure from the Board's recommendations should be justified, recorded in minutes of the meeting, and reported in writing by the ME."

The second meeting of the Board of Directors was held in Baltimore, Maryland in November 1998. Also present were Dr. Richard Frankel, chief of the Food Policy Division in the Office of Agriculture and Food Security and Dr. John Duxbury, principal investigator of Cornell University's project in the SM CRSP. Members and officers of the Board of Directors include:

Dr. Richard Guthrie, Auburn University,
Chair
Dr. Michael Walter, Cornell University,
Vice-Chair
Dr. John Havlin, North Carolina State
University
Dr. Charles Laughlin, University of Hawaii
Dr. Thomas McCoy, Montana State
University
Dr. Philip Thornton, ILRI, Nairobi, Kenya.

Special emphasis on this year's meeting was on the handling of buy-ins or field support funds to the University of Florida from the Office of Disaster Relief and to Cornell University from the USAID mission in Dhaka, Bangladesh. The former increased the funding level of the core grant by \$200,000 and the latter by \$1,000,000. Principal investigators at both institutions questioned the administrative fees imposed by the ME. Members of the Board concurred with actions taken by the ME, a 16% direct cost charge. The Board also recommended, on a case by case basis, to negotiate that direct cost charge. These recommendations were made after noting the absence of such language in the CRSP Guidelines (1985).

Minutes of the meeting are available by accessing the SM CRSP web site at the follow-

ing URL, <http://agrss.sherman.hawaii.edu/sm-crsp>.

The Technical Committee (TC)

"The TC is established with membership drawn primarily from the principal scientists engaged in CRSP activities, known as Principal Investigators (Pi's), and host country scientists involved in CRSP or IARC activities. The ME Director and the AID Program Officer serve as ex-officio members. The TC meets from time to time to review work plans and budgets, program performance, to propose modifications in the technical approach to achieve program objectives, and to recommend allocation of funds. The TC reports its findings in writing to the ME who will share them with the BOD."

The first meeting of the Technical Committee was held in Irving, Texas in April 1998 followed by a second meeting in Las Vegas, Nevada, in January 1999.

Members of the Technical Committee include the following:

Dr. E. B. (Ron) Knapp, CIAT, Cali,
Colombia
Dr. T. Jot Smyth, North Carolina State
University, Chair
Dr. Thomas Thurow, Texas A&M
University
Dr. Thomas Walker, CIP, Lima, Peru.

The Technical Committee reviewed and approved workplans and budgets received by the ME prior to the meeting date. Workplans and budgets were not received from the University of Florida. An extension of the deadline for Florida was agreed upon members present.

Once again, the task of the Committee was constrained by the lower level of funding provided for research efforts in PY2 and with an anticipated lower level in PY3, these efforts will need to be reduced correspondingly. At

issue is the non-correspondence of the project start date with the incremental funding period, workplans and budgets are prepared annually but the information appear to be inconsequential as the cost of the proposed efforts do not match up with the level of funding provided.

The External Evaluation Panel (EEP)

“The EEP is established with membership drawn from the scientific community to evaluate the status, funding progress, plans and prospects of the CRSP and to make recommendations thereon. In accordance with the CRSP guidelines, At the panel shall consist of an adequate number of scientists to represent the major disciplines involved in the CRSP, normally no more than five members. This number will vary with program size and cost-effectiveness. The term of office shall be long-term to retain program memory. A five-year term is recommended for the initial panel and subsequently rotated off on a staggered time base. Provisions should be made for replacements for low attendance, for resignations or for other reasons. In instances where a minor discipline is not represented on the EEP, the Chairman may request the assistance of an external consultant from the ME.

Panel members will be internationally recognized scientists and selected for the in-depth knowledge of a research discipline of the CRSP and experience in systems research and/or research administration. International research experience and knowledge of problems and conditions in developing countries of some members are essential. The members are selected so that collectively they will cover the disciplinary range of the CRSP, including socio-economic components that can influence research and technology adoption. Panel members should be drawn from the United States (some with experience in agricultural research and knowledge of the Land Grant

University system) and the international community and should include at least one scientist from a developing host country. Availability to devote considerable time to EEP activities is an important criterion for membership.”

Nomination of candidates was solicited by AID from the principal investigators and the ME. A five-member panel was appointed. Members of the External Evaluation Panel include the following individuals:

Dr. Will Blackburn, Area Director,
ARS/USDA, Ft. Collins, Colorado
Dr. Eric Craswell, Director-General,
IBSRAM, Bangkok, Thailand
Dr. Jean Kearns, Executive Director, CID,
Phoenix, Arizona
Dr. David MacKenzie, Director, NERC/
CREES/USDA, College Park, Maryland
Dr. Amit Roy, President and CEO, IFDC,
Muscle Shoals, Alabama.

The first meeting of the EEP was being planned for April or May 1999 with on-site mid-term evaluation of project activities as the principal topic of that initial meeting.

Panel members will be invited to attend important meetings of the Pi's and CRSP organizations in order to keep abreast of progress and be familiar with problems and issues. Evaluations should include periodic site visits, made on a rotational basis to each university and each participating country, particularly to prime country sites. These visits can be divided up amongst the members, permitting at least two members to work together on each site visit. There also should be adequate opportunities for interaction of the TC and Board with the EEP.

The EEP recommendations may serve as the basis for bringing about statutory changes in CRSPs through adjustments in projects and other changes. In the extreme, it may be necessary to change institutions. The EEP's recommendations could serve as the basis for

such changes where necessary. A decision to take such action without the EEP's recommendation would not constitute appropriate use of the EEP. However, more often it would be expected that the EEP would find solutions to problems through changes in projects and components of projects. The Board or ME might disagree with an EEP's recommendation. In such cases, the rationale for such disagreement should be stated in minutes, and a report made by the ME to AID, justifying the disagreement.

CRSP Council

The Director of the ME represents this CRSP in the CRSP Council composed of directors of 9 other CRSPs.

During project year 2, there were two face-to-face meetings of members of the CRSP Council. One was held in Washington, D.C. and the second in Davis, California, hosted by the Small Ruminant CRSP at the University of California, Davis.

Conference calls involving all directors and program officers from USAID were coordinated by the chair of the CRSP Council, Dr. John Yohe of the INTSORMIL CRSP at the University of Nebraska. These calls are organized to allow the CRSP to receive first hand information from the Office of Agriculture and Food Security of AID and as a forum to openly discuss issues of concerns to the CRSP and to AID. These calls are 2 hours in length and are generally conducted at intervals of 2 months.

The SM CRSP participated in 2 programs organized designed to improve the visibility and information dissemination of the CRSP. The first was an international symposium at the annual meetings of the American Society of Agronomy (Baltimore, Maryland) in November 1998. The second was a photographic gallery presentation in the exhibition area of the newly inaugurated Ronald Reagan Building in Washington, D.C. The gallery was on display for 3 months starting in October 1998.

Financial Summary

Incremental core funding of the SM CRSP continued at a level of \$2.5 million for a period of 12 months ending on April 30, 1999. Project year 2 ended on February 10, 1999. Incremental funding awards or modifications to the grant do not follow any regular cycle. There is no coincidence of the project year with the period or dates of each modification. Table 1 shows the relative temporal difference between the grant award period and the incremental funding period.

Funds derived from field support or AID buyins were received in Project Year 2 and added to core funds during this reporting period and are reported as part of modification no. 2 and all of modification no. 3.

Mod #2 extended the grant award period to April 30, 1999 (into Project Year 3) and increased cumulative grant total by \$2.7 million. Of that total, \$200,000 was "earmarked" to the University of Florida by the Office of Disaster Relief, USAID as field support funds (also previously referred to as buy-ins). The base core total of \$2.5 million for 12 months represented a reduction from the level of nearly \$360,000 or 9% from the first 15 months of the grant. Funding for the previous 15 month period amounted to \$3.58 million.

Mod #3, received in Project Year 3, amounted to \$1 million as field support funds

from the mission in Bangladesh. This modification is reported here as a request to enter into an agreement with Cornell University and the SM CRSP was received in Project Year 2. Further, preliminary activities in anticipation of receiving funding through field support in Project Year 2.

These funds were intended only for Cornell University in support of research related to a link between soil fertility constraints and crop management with the relatively high incidence of rickets among young children in Chakaria, Bangladesh.

A complicating factor with Mod #3 was the extension of the grant period by 3 months to July 31, 1999 without additional funding for the 6 core projects and the ME. Since the award was for Cornell University only for the added effort, that meant the remaining projects and the ME would have no additional funds for 3 additional months. Email communications and a personal visit by the ME Director to the Procurement Office of USAID failed to have the funding date restored to April 30, 1999.

Field Support and CRSP Guidelines

Further complications included the withholding of administrative costs by the ME on the field support award. Without specific

Table 1. Project year and incremental award periods

Start Date	February 11, 1997	
Project Year 1:	February 11, 1997 to February 10, 1998	
Initial grant award:	\$2,467,975	Period: February 11, 1997 to September 30, 1997
Modification no. 1:	1,131,025	Period: October 1, 1997 to April 30, 1998
Project Year 2:	February 11, 1998 to February 10, 1999	
Modification no. 2	2,700,000	Period: May 1, 1998 to April 30, 1999
Modification no. 3	1,000,000	Period: May 1, 1999 to July 31, 1999

mention of field support or buyins in the CRSP Guidelines, the ME consulted with other CRSPs that have handled similar support resulted in the ME's decision to withhold 16% of each award rather than a maximum allowable of 20%. The 16% figure was derived from the percentage of the ME's budget relative to the entire CRSP budget submitted in its initial proposal to AID. Through actions taken by the CRSP Council, a communication related to changes in the CRSP Guidelines was submitted to the BIFAD committee handling revisions to the CRSP Guidelines.

In the absence of articles pertaining to the administration of field support funds and to resolve issues related to field support awards impacting on the Soil Management CRSP, the second meeting of the Board of Directors focused on issues concerning the administrative fees imposed by the ME. The principal investigators affected, C. Gladwin of the University of Florida and J. Duxbury of Cornell University were invited to participate in the 2nd meeting of the Board of Directors in Baltimore, Maryland.

Due to teaching responsibilities, Gladwin met with the Board Chair, the ME, and the chair from the Soil Science Department of the University of Florida a day prior to the meeting of the Board members.

Actions by the SM CRSP Board of Directors

1. The Board determined the ME met its responsibilities in withholding direct cost funds as administrative costs. Since the CRSP guidelines is not specific on this topic, the AID program officer advised the Board that the use of a "rule-of-thumb" 20% figure for administrative costs for the CRSPs is an acceptable level as determined by AID. The Board concurred with the application of a 16% figure. These costs, as emphasized by the Board, should not be construed as indirect costs but direct costs.
2. Further, the Board asked the ME to use its best judgement on a case by case basis in determining the level of administrative costs for field support funds. And, the Board agreed to draft a letter to the BIFAD to address this topic in their deliberations on revisions to the CRSP Guidelines (1985).

Financial Summary

Table 2 shows the summary expenditures for PY (project year) 2, cost sharing totals for PY2 and cumulative awards to the SM CRSP from its initial award to incremental funding awards, Mod#1, #2, and #3.

Table 2. Financial summary statement (\$'000)

Summary of Expenditures (February 11, 1998 to February 10, 1999)								
	MSU	NCSU	CU	TAMU	NifTAL	UFL	ME	TOTAL
Direct costs	165	1028	593	303	152	136	245	2622
Indirect costs	-6	184	188	52	30	29	85	562
Total	159	1212	781	355	182	165	330	3184
Cost Sharing (February 11, 1998 to February 10, 1999)								
	98	309	193	140	45	46	0	831
Summary of Funding (February 11, 1997 to July 31, 1999)								
Initial Grant Award	202	917	555	291	191	95	228	2479
Modifications								
#1 (to 4/30/98)	74	312	189	99	65	33	359	1131
#2 (to 4/30/99)	194	1000	483	361	190	226	246	2700
#3 (to 7/31/99)	39	173	604	57	36	18	73	1000
Total	509	2402	1831	808	482	372	906	7310

Participating and Collaborating Scientists and Institutions/Organizations

National Agricultural Research
Systems (NARS)

Australia

University of New England
Paul Winters

Bangladesh

*Bangladesh Agricultural Research
Institute (BARI)*

M.A. Razzaque
Md. Bodruzzaman
Md. Elahi Baksh
Md. A. Mannan.
A.K. Maqubul Hossain
S. Parvin Banu
M.A. Rahman
A. Shaheed

Bangladesh Rice Research Institute (BRRI)

H. Ahmend
T. Das
N. E-Elahi
S.M.R. Karim
B.A.A. Mustafi
N. Nahar
M.D. Nurul Islam.
G.M. Panaullah

*Bangladesh Institute for Nuclear
Agriculture (BINA)*

M. Sattar

MCC-Bangladesh

A. Entz

Bolivia

IBTA

Brazil

Amazonia National Research Institute
Charles Clement

Newton Falcao
Yukio Yuyama

EMBRAPA

Lafayette Sobral

Federal University of Ceara

Bonerges Aquino

University of Vicosa

Canada

McMaster University

Donald Cole

S. Ibrahim

China, People's Republic of

Oil Crops Research Institute

Colombia

CIP/CIAT-Cali

Ruben Dario Estrada

PATH

Peter Berti

Costa Rica

*University of Costa Rica, Center for
Agricultural Research*

Alfredo Alvarado

Rafael Salas

Eloy Molina

Lidieth Uribe

Gabriela Soto

Organization of Tropical Studies

Eugenio Gonzales

Orlando Vargas

Ecuador

INIAP-EE St. Catalina

Victor Barrera

Juan Cordova
Manuel Pumisacho
Flor Maria Cardenas
Jovanny Suquillo

INIAP-UVTT Carchi
Jovanny Suquillo

Pontifica U. Catolica Ecuador
Ramiro Merino

Fundacion Pastaza Ambato
Fabian Valencia
Wilson Perez

U. Central- Quito
Marcelo Calvache

EcoCiencia-Quito

Ethiopia
Awassa Agricultural Research Center

Ghana
Ministry of Agriculture-Crops Services Division
Francis Ofori

Kenya
University of Nairobi

Haiti
*Centre de Recherche et de Documentation
Agricoles (CRDA)*
*Ministère de l'Agriculture, des Ressources
Naturelles et du Développement Rural*
Jackson Donis
Jean René Bossa
Christian Roche,

*South-East Consortium for International
Development (SECID)*
J.D.Z. Lea
Carine Bernard
Jean Pierre Roswald Villefranche

*Pan American Development
Foundation (PADF)*
Michael Bannister
Gaspard Brice
Etzer Fanfan

ASSET Project
Winrock International
Ed Scott

USAID Haiti Mission Liaison
Felipe Manteiga

Honduras
*Ministry of Natural Resources—Land Use
Productivity Enhancement Project (LUPE)*
Olman Rivera
Miguel Sanchez
Mario Pinto

Ministry of Environment
Jesus Salas

PanAmerican University (EAP)
Carlos Rosas
Margoth Andrews
Hector Sierra

Honduras National Association of Aquaculture
John Wainwright

USAID Honduras Mission Liaison
Peter Hearne

Escuela Agricola Panamericana
Juan Carlos Rosas

India
Indian Agricultural Research Council
R.K. Gupta
I.P. Abrol

Punjab Agricultural University
C.L. Arora
S. Beedi
M.R. Chaundhary

P.R. Gajri
N. Jead
P.P.S. Pannu
Bijay Singhadvinder Singh

G.B. Pantnagar Univ.
Y. Singh, Agronomy

Gujarat State Fertilisers & Chemicals, Ltd.

MAHYCO, Ltd.

Malawi
Zomba Redevelopment Project

Mali
Institut d' Economie Rurale
Mamadou Dombia
Aminata Sidibe
Adama Coulibaly
Zoumana Kouyate
Oumar Coulibaly

The Netherlands
Wageningen Agricultural U.
Jetse Stoorvogel
Johan Bouma

AB-DLO
Anton Haverkort
Robert van Haren
Paula Westerman

Nepal
Nepal Agricultural Research Council
M. Mishra
T. Pokharel
C. Adhikari
S. Bhattarai
D.B. Garti
M. Ghimire
G.S. Giri
C.B. Karki
D. Joshi
M. Maskey
S.P. Pandey

N.K. Rajbhandari
J.D. Ranjit
R.P. Sapkota
S. Sharma
R. Shrestha
H.K. Upreti

Inst. Agric. & An. Sci. Rampur
R.R. Pokharel
S.M. Shrestha

Nicaragua
National Agriculture University (UNA)
Georgina Orozco
Matilde Somarriba
Domingo Rivas
Bismark Mendoza

USAID Nicaragua Mission Liaison
Margaret Harritt
Paul Crawford
Fernando Rodriguez
Jennifer Swenson

Inst. Ec. De Seguro Social
Hipatia Viteri de Almieda

Escuela Politenica de Chimborazo (ESPOCH)
Hernan Negrete

ESPOCH-Riobamba
Niedy Clavijo
Hernan Uvidia

GRAINCO
Jorge Salazar

Pakistan
PARC
Md. Salim

Peru
INIA-Banos del Inca
M. Sc. Hector Cabrera H.
Rocio Sanchez M.

U. Nacional Cajamarca

Peter Muck
Edelvaly de la Pena

ADEFOR-Cajamarca

Flavio Flores

ASPADERUC-Cajamarca

Pablo Sanchez

CIP/IFDC-Lima

Walter Bowen

CIP/ILRI-Lima

Carlos Leon Velarde

CIP/CONDESAN-Lima

Mario Tapia

Rwanda

ISAR, Butare

Philippines

Philippines Rice Research Institute, Maligaya

Jocelyn Bajita
Theodula Corton
Santiago Obien

Mariano Marcos State University, Ilocos Norte
Sixto Pascua

Senegal

ISRA, Dakar
Badiane

Peace Corps-Senegal

Winrock International

South Africa, Republic of

Soygro, Ltd., Potchefstroom

Sri Lanka

Institute of Fundamental Studies, Kandy

Tanzania

Selian Research Institute, Arusha

Thailand

Suranaree University of Tech., Nakhon Ratchasima
Nantakorn Boonkerd

Uganda

Makerere University, Kampala
J. Anileu, Soil Science Dep.

IDEA Project

M. Wood
M. Maleaby

United Kingdom

CABI Bioscience
M. Halderness

Rothamsted Exp. Station

J. Gaunt

United States

Auburn University
Dennis Shannon
Curtis Jolly
Greg Mullins
C. Wood
Richard Guthrie
J. Shaw
Kyung Yoo
Glenn Howse
David Coddington (Pond Dynamics CRSP)
Bart Green (Pond Dynamics CRSP)

Cornell University

George Abawi
Robin Bellinder
Gary Bergstrom
Philippe Baveye
Dave Bouldin
Gerald Combs
John Duxbury
Stephen DeGloria
Shelley Feldman

Steven Kyle
Julie Lauren
David Lee
Ralph Obendorf
Shaw Reid
Susan Riha
Norman Uphoff
Timothy Widmer
P.K. Katakai (Cornell On-Site Coordinator,
New Delhi, India)
C.A. Meisner (Cornell On-site coordinator,
Dhaka, B'desh)

Michigan State University
Joe T. Ritchie

Montana State University
John Antle

North Carolina State University
Keith Cassell
Fred Cox
Daniel Israel
Pedro Luna
Deanna Osmond
T. Jot Smyth
Michael Wagger

Texas A & M University
Tom Thurow
Amy Thurow
Larry Wilding
Tony Juo
Richard Drees
Gary Peterson (INTSORMIL CRSP)
Lloyd Hossner
Frank Hons
Rick Wesch
Sharry Blanton-Knewton
Yuji Nino

Understanding Systems, Inc.
Steve Pratt
Will Branch

US Plant Soil Nutr. Lab
Ross Welch

University of Florida
Christina H. Gladwin
Ken L. Buhr
Edwin "Tito" French
Abraham Goldman
Clifton Hiebsch
Peter E. Hildebrand
Gerald "Jerry" Kidder
Max Langham
Donna Lee
P.K. Nair
Peter Nkedi-Kizza
Clyde Kiker
Andrew Schmitz

University of Hawaii
Adrian Ares
Nguyen Hue
Thomas George (IRRI)
Richard Kablan
Harold Keyser
Paul Singleton
Xinmin Wang
Russell Yost

University of Minnesota
M. Sadowsky
T. Wacek

University of the South (Sewanee, Tennessee)
D. MacGrath

Virginia Polytechnic and State U.
George Norton
Sarah Hamilton

Uruguay
Ministerio de Ganaderia Ag. Y. Pesca
Carlos Labandera

Vietnam
*Oil Plant Institute of Vietnam, Ho Chi Minh
City*

Vietnam National University, Hanoi

Zambia

University of Zambia, Lusaka

Vernon Chinene

Ministry of Agriculture, Food, and Fisheries

Zimbabwe

Grasslands Research Institute, Marondera

International Agricultural Research Centers

CIP

Aart Osman (Cajamarca)

Ing. Luis Escudero (UVTT Carchi)

Lic. Lilian Basantes (UVTT Carchi)

Enfermera Mariana Perez (UVTT Carchi)

M. Sc. Steve Sherwood (Quito)

M. Sc. Patricio Espinosa (Quito)

Lic. Fabian Munoz (Quito)

Greg Forbes (Quito)

Charles Crissman (Quito)

Robert Hijmans (Lima)

Ing. Estuardo Regalado (La Encanada)

Tec. Alcides Rosas (La Encanada)

Tec. Lucinda Chavez (La Encanada)

Sra. Noemi Cabanillas (La Encanada)

Tec. Nicolas Tasilla (La Encanada)

CIMMYT

Elio Duron (Nicaragua)

E. Duveiller (Nepal)

P.R. Hobbs (Nepal)

M. Ortiz-Ferrera (Nepal)

L. Harrington (Mexico)

J. White (Mexico)

Regional Maize Program (Central America)

IBSRAM

Steepland Network (Asia)

ICRAF (Malawi)

ICRAF (Peru)

ICRAF (Zambia)

ICRISAT

C. Johansen

IFPRI-Washington, D.C.

Phillip Pardey

Stanley Wood

IITA

G. Tiau (Nigeria)

IRRI

J.K. Ladha

Thomas George

Bruce Lindquist

Rice Consortium (Asia)

Training

The SM CRSP provides support for both undergraduate and graduate training for academic degrees from participating U.S. institutions. Students from countries where field activities are on-going and the United States and selected third-country nationals fully or partially supported by the SM CRSP. Students enrolled in academic degree programs in host-country institutions are supported by the SM CRSP through their involvement with in-country research activities. Undergraduate and graduate students are included in the list of students

List of Students

<i>Auburn</i>	<i>Home Country</i>	<i>Texas A&M</i>	
Lionel Isaac	Haiti	James Smith	United States
Budry Bayard	Haiti	Matilde Somarriba	Nicaragua
		Robert Schwartz	United States
<i>Cornell</i>		Marcela Samayoa	Honduras
Kaafee Billah	Bangladesh	Hector Santos	Honduras
Medha Devare	India	Brad Driessen	United States
Anna Marie Mayer	England	Domingo Rivas	Nicaragua
Andy McDonald	United States	Bismark Mendoza	Nicaragua
Jon Padgham	United States	Humberto Perotto	Bolivia
Shabnam Qureshi	Pakistan	Ramesh Sivanpillai	India
<i>Esc. Pol. De Chimborazo</i>		<i>U. Nac. De Cajamarca</i>	
José Negrete	Ecuador	Genaro Carrión	Peru
Hernán Uvidia	Ecuador	Sara García	Peru
Neidy Clavijo	Ecuador	Ernesto Rodriguez	Peru
		Mario Cáceres	Peru
<i>Montana State Univ.</i>		<i>Univ. Central, Quito</i>	
Mykel Mathews	United States	Miguel Flores	Ecuador
Roberto Valdivia	Peru	Roque Tapia	Ecuador
<i>National Agri. Univ</i>		<i>Univ. of Florida</i>	
Benigno Montez	Nicaragua	Bocary Kaya	Mali
Roberto Marachel	Nicaragua	Janet Puhalla	United States
Felix Ortega	Nicaragua	Jen Scheffee Peterson	United States
		Amy Sullivan	United States
<i>Pan American Univ.</i>		Andrea Snyder	United States
Claudia Gomez	Honduras	Robert Uttaro	United States

University of Hawaii
Jocelyn Bajita Philippines
Xiufu Shuai China

Utah State University
Cecilia Ortiz Ecuador

Wageningen Agr. Univ.
Ramiro Merino Ecuador
Guillermo Baigorria Peru

Raul Jarrimillo Ecuador
Magedelena Lopez Ecuador
David Meerbach, Netherlands
Francien van Soest Netherlands
Erik Meyles Netherlands
Lammert Kooistra Netherlands
Martijn Veen Netherlands
Koen Overmars Netherlands
Gerben de Vries Netherlands

Field Support, Leveraging, and Cost Sharing

Field support, also commonly referred to as buyins, are resources provided by AID either through mission or regional offices. Leveraging refers to the ability of the project to generate interest and support which results in added contributions of both human and fiscal resources to the project. Cost sharing refers to either or both in-kind support and wages/salaries of individuals assigned to SM CRSP activities of participating and collaborating organizations. During PY2, funding from field support amounted to \$1,231,000 and an estimated \$1,208,053 from leveraging activities and from cost sharing from developing country collaborators.

Africa

Office of Disaster Relief. Two hundred thousand dollars were added to modification no. 2 of the SM CRSP grant by AID's Office of Disaster Relief (ODR) for disbursement by the ME to the University of Florida's Gender and Soil Fertility project. The additional funds allowed expansion of project activities from Malawi to Uganda, Kenya, and Ghana.

A direct grant to the NifTAL project of \$31,000 was made by ODR in PY1 and completed in PY2. USAID provided support for the Rhizobium Ecology Network for East and Southern Africa at the University of Nairobi, Kenya. The goal of this grant was to test NifTAL's liquid inoculant formulas in E. and S. Africa.

Institut Economique Rurale (IER), Mali. Personnel costs, in-country travel costs, and other expenses to design and implement field trials. (\$100,000)

Asia

USAID/Dhaka (Bangladesh). A request for field support from the AID mission in Bangladesh was received by Cornell University's Rice-Wheat program to undertake research related to soil fertility and the lack of calcium in the nutritional diet of children and adults in the Chakaria region of Bangladesh. Funds from the mission were channeled through to the Office of Agriculture and Food Security (AFS) and to the SM CRSP. The mission provided \$1 million for disbursement to Cornell University over a period of 2 years.

World Bank/Tamil Nadu Agricultural University provided a research scientist to work on quality control methods. Specifically he developed recovery methods of bradyrhizobia form peat carriers for direct enumeration of viable cells by microscopy. This project is a continuation from PY1. \$23,400.

Philippine Rice Research Institute (PhilRice). Personnel costs in the establishment and maintenance of core experiments, for baseline participatory survey, maintenance/monitoring of core and on-farm experiments. (\$50,000)

PhilRice and Philippine National Soil Survey. Personnel and laboratory support services to classify the soil pedon from the experimental site in Illagan. \$25,000.

CGIAR

ISNAR/Ecoregional Fund. Two projects, one in Ecuador and one in Peru, are in their second year of a three year program. Total funding for each project was \$500,000.

International Rice Research Institute (IRRI). Collaboration with IRRI resulted in significant leverage for the NifTAL project and the Phosphorus and Nitrogen decision support

system (PDSS and NDSS, respectively) components of the Decision Aids project of the SM CRSP. NIFTAL cost shared approximately 15% of a research scientist position with IRRI (the Decision Aids project provided 85% of the support) and received a package of research support from IRRI (lab services, technical and logistical support, housing, transportation, regional travel, greenhouse and field support, post doctoral research staff). The opportunity costs of this support are \$120,000 for the CRSP.

Americas

IDRC. A new project, “Human Health and Changes in Potato Production Technology in the Highland Ecuadorian Agro-Ecosystem” was approved for funding for three years by IDRC. This project will complement the SM CRSP core project by making it possible to include important new data on human health scenarios in the analysis of pest and soil management scenarios in the Carchi study. This activity will validate earlier scenarios on health and pesticides, investigate accident risks associated with mechanization, and support analysis of the adoption of IPM practices.

INIAP, Ecuador. Personnel and staff involved in research activities, facilities and communications costs. (\$13,600)

INIA, Peru. Staff time and facilities. (\$ 5,000)

Peruvian Soil Science Society. Travel for Jot Smyth to Peru to participate as an invited speaker at a national symposium. (\$1083)

Amazonian National Research Institute. Dr. Charles Clement provided time and data/information gathering (gray literature) on tree crops relative to soil properties.

Ministry of Natural Resources—Land Use Productivity Enhancement Project (LUPE), Honduras. Provided personnel and transportation to collect data at the field sites. Provide vehicles and cost of living (room and board per diem) for graduate students collecting research on the LUPE project sites. This in-kind contribution is a value of about \$30,000/year.

Ministry of Environment, Honduras. Provided in-country aid regarding geographic information system analysis and access to data.

PanAmerican University (EAP) , Honduras. Costs of Hector Sierra’s salary and of a vehicle are provided through a combination of INTSORMIL/PanAmerican University funding. This in-kind contribution is a value of about \$30,000/yr.

Honduras National Association of Aquaculture. Provided access to data on environmental impacts of shrimp farming

University of Costa/Centro Investigaciones Agricola (UCR/CIA), Costa Rica. Personnel costs to collect samples and analytical support services and facilities and administrative services. (\$53,000)

DEMASA, Costa Rica. Provided personnel, experiment maintenance, supplies and materials: \$33,000.

USAID Honduras Mission Liaison. Provided great support in helping with logistics (such as setting up meetings, helping to clear equipment from port, helping to interview and process prospective Honduras students for graduate research) and encouraged collaboration with the USAID-funded LUPE program within the Ministry of Natural Resources.

National Agriculture University (UNA), Nicaragua. Provided personnel and vehicles necessary to conducting field research. This in-kind contribution is equivalent to about \$20,000/yr.

SECID/PLUS, Haiti. Administrative and logistical support were provided to the Soil Management CRSP Steeplands Project by the USAID/Haiti Mission through the South-East Consortium for International Development (SECID), a contractor in the Productive Land Use Systems Project (PLUS). SECID, at no cost to the Soil Management CRSP, handled all financial transactions related to the operation of SM CRSP activities in Haiti including transferring funds to Haiti, maintaining Dollar and Gourde bank accounts in Haiti, making all disbursements and reporting back to Auburn University. SECID shared office space, computers and vehicles for two technicians employed with SM CRSP to supervise research activities. In addition, faculty from U.S. Universities travelling for SM CRSP receive in-country support from SECID. Value of assistance: \$40,000

PADF/PLUS, Haiti. The Pan American Development Foundation, a Grantee of the PLUS project conducts agricultural extension activities in the South of Haiti. They have been instrumental in helping the Steeplands project identify collaborating farmers in Ga•ta and Bannate for on-farm trials. PADF also assigned a technician to assist with follow-up of the trials and collecting some data. Value of assistance: \$5,000.

ASSET Project, Haiti. During most of PY2, SECID did not have its own office and was housed with the ASSET Project of USAID/Haiti. SECID and SM CRSP used ASSET's phone lines, utilities, etc. Value of assistance: \$20,000

Centre de Recherche et de Documentation Agricole (CRDA), Haiti. The research arm of the Ministry of Agriculture, Natural Resources and Rural Development (MARN-DR) is our principal institutional collaborator. It provides personnel and use of one vehicle for SM CRSP activities.

J.R. Bossa @ 3/4 time:	\$11,000
4 technicians 1/4 time:	\$ 6,000
Use of vehicle	\$ 5,000
Total:	\$22,000

CRSP

IPM CRSP. An important new collaborative arrangement was initiated during the year with the IPM CRSP activity in Ecuador. This collaboration will make it possible to investigate the accuracy of the ex ante IPM technology scenarios simulated in earlier work done with the previous version of the Tradeoffs Model. Important new data on pesticide use and the efficacy of IPM training programs will be collected and utilized to parameterize scenarios for analysis in the Tradeoff Model. Also, the Tradeoff Model will be linked with analysis of IPM impacts being conducted by the IPM-CRSP research team. This linkage will facilitate the generalization of the Carchi region's analysis to other regions of Ecuador.

INTSORMIL CRSP. Contribution: Provided the vehicle and part of the salary of a research associate at the PanAmerican University, we provide operation expenses for field research designed to test the impact of soil conservation activities on sorghum production.

Pond Dynamics CRSP. Contribution: Provides access to their water quality lab at La Lahosa, Honduras which we use to analyze some aspects of water quality (e.g., TSS) and use their freezers to store water samples for transport to the US for water quality analysis.

Europe

University of Surrey, UK. University of Surrey provided support to work with them to define organic matter decomposition characteristics of waste materials and identify organism with superior decomposition capability. \$5000

Global

National programs. Field experiments conducted by NifTAL collaborators have opportunity costs of approximately \$5000 each. The cost sharing value received from 24 collaborators would be \$120,000 less the \$17,500 of direct financial support provided with SM CRSP funds for a net cost share of \$102,500.

Publications, Reports, and Presentations

Information from the SM CRSP are disseminated through both the electronic and print media. An internet site has been established at the URL, [Through this site](#), access is available to similar sites of participating institutions of the SM CRSP and to USAID.

The following is a listing of technical publications, reports and oral/poster presentations by participants and collaborators of the SM CRSP. Those publications appearing in journal series publications are peer reviewed.

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Acronyms

AB-DLO	Research Institute for Agrobiolgy and Soil Fertility, Wageningen Agricultural University
ADEFOR	Asociación Civil para la Investigación y Desarrollo Forestal
ADSS	Acidity Decision Support System
AFS	Agricultural and Food Security Office, USAID
ARS	Agricultural Research Service
ATI	Appropriate Technology International
BARI	Bangladesh Agriculture Research Institute
BINA	Bangladesh Institute for Nuclear Agriculture
BNF	Biological Nitrogen Fixation
BOD	Board of Directors
BRAC	Bangladesh Rural Advancement Committee
BRRRI	Bangladesh Rice Research Institute
CARE	Cooperative for American Relief Everywhere
CGIAR	Consultative Group for International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIDA	Canadian International Development Agency
CID	Consortium for International Development
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo
CIP	Centro Internacional de la Papa
CONDESAN	Consortium for the Sustainable Development of the Andean Ecoregion
CRDA	Centre de Recherche et de Documentation Agricoles
CREES	Cooperative State Research, Education, and Extension Service
CSR	Center for Social Research
CU	Cornell University
DSS	Decision Support System
EEP	External Evaluation Panel
EGAD	Economic Growth and Agricultural Development
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária Vinculada Ao Ministério de Agricultura
EPA	Environmental Protection Agency, U.S.
ESPOCH	Escuela Politécnica de Chimborazo
FAO	Food and Agriculture Organization
FHH	Female Head of Household
GIS	Geographic Information System
IARC	International Agricultural Research Centers
IBSRAM	International Board for Soils Research and Management
ICAR	Indian Council of Agricultural Research
ICRAF	International Center for Research in Agro-Forestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDB	Inter-American Development Bank
IDRC	International Development Research Council, Canada
IER	L'Institut d'Economie Rurale
IFDC	International Fertilizer Developmental Center
IF	Improved Fallow
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INIA	Instituto Nacional de Investigación Agropecuaria
INIAP	Instituto Nacional de Investigaciones Agro-Pecuarias
IntDSS	Integrated nutrient management Decision Support System
INTSORMIL	International Sorghum and Millet CRSP
IPM	Integrated Pest Management

IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
ISRA	L'Institut Senegalais de Recherche Agricole
LDC	Lesser Developed Country
LUPE	Land Use Productivity Enhancement project
MAFEP	Malawi Agroforestry Extension Project
ME	Management Entity
MERC	Middle East Research Cooperation
MHH	Male Head of Household
MSU	Montana State University
NARC	Nepal Agricultural Research Council
NARES	National Agricultural Research and Extension Systems
NARS	National Agricultural Research Systems
NCSU	North Carolina State University
NDSS	Nitrogen Decision Support System
NERC	North East Regional Center
NGO	Non-Governmental Organizations
NifTAL	Nitrogen Fixation of Tropical Agricultural Legumes
OMB	Office of Management Budget
PADF	Pan American Development Foundation
PARC	Pakistan Agricultural Research Council
PAU	Punjab Agricultural University, Ludihana, India
PDSS	Phosphorus Decision Support System
PES nets	Productivity-Enhancing Safety nets
PhilRice	Philippine Rice Research Institute
PI	Principal Investigator
PVO	Private Voluntary Organization
PY	Project Year
RCUH	Research Corporation of the University of Hawaii
SADP	Smallholder Agribusiness Development Program
SARPV	Social Assistance and Rehabilitation for the Physically Vulnerable
SECID	South-East Consortium for International Development
SM CRSP	Soil Management Collaborative Research Support Program
SUBSTOR	Subterranean Storage crop model
TAMU	Texas A&M University
TC	Technical Committee
UF	University of Florida
UNA	Universidad Nacional Agraria
UNC	Universidad Nacional de Cajamarca
UNICEF	United Nations International Children's Emergency Fund
URL	Universal Resource Locator
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WAU	Wageningen Agricultural University

