Soil Management
Collaborative Research Support Program

Annual Report
1997

Cornell University
Montana State University
North Carolina State University
Texas A&M University
University of Florida
University of Hawaii, NifTAL Center

Goro Uehara
Director
University of Hawaii

This publication was made possible through the support provided by the U.S. Agency for International Development, under the terms and conditions of Grant No. LAG-G-00-97-00002-00. The opinions expressed herein are those of the author(s) and do not necessarily reflect the views of the U.S. Agency for International Development.

Table of Contents

Executive Summary

This is the first annual report of the restructured Soil Management Collaborative Research Support Program (SM CRSP). Unlike the previous SM CRSP (commonly referred to as TropSoils), which concentrated on improving soil management practices, the restructured SM CRSP is designed to enable its customers to adopt and implement wiser soils-related agronomic, economic and environmental decisions.

The restructuring process began in 1995, when the Office of Agriculture and Food Security of USAID initiated a plan to refocus this CRSP's research capability to "Integrated Nutrient Management." An independent panel of experts was appointed to identify key constraints related to the new focus. The panel identified the following constraints.

1. Soil Nitrogen Management—especially technologies that improve nitrogen use efficiency.
2. Soil Phosphorus Management—especially decision aids that help users maker 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 nutrient and water use efficiencies.
5. Erosion and Land Degradation—especially as they relate to nutrient management.

A request for preproposals to address one or more of the five constraints resulted in 54 submissions of which 19 were selected for development into full proposals. A second independent panel of reviewers ranked and recommended that seven of the 19 proposals be funded. In the end the top four projects were fully funded, two were funded at reduced levels, and one sought funding from another source.

The seven project titles, principal investigators, and the lead participating institution of the restructured SM CRSP 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&M 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. Reduced 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.
3. *Ecological soil management in Israel and Palestine*. Frederick Magdoff, University of Vermont.

Shortly after the announcement of the selected projects, a meeting of the seven principal investigators was held in Raleigh, North Carolina to enable the PIs to hear, for the first time, the purpose and content of the other projects.

Prior to this meeting the Management Entity (ME) of the original SM CRSP at North Carolina State University circulated an announcement

requesting other institutions to apply for the ME of the restructured SM CRSP. Three universities, including Hawaii, North Carolina State, and Texas A&M expressed interest in serving as the ME. Representatives from these institutions presented their vision of what the restructured CRSP should look like. By a vote of 5 to 2, the University of Hawaii was selected to be the new Management Entity.

Shortly after the Raleigh meeting, AID announced the budget for the SM CRSP. The agency was able to allot $2.6 million of the $4.1 million recommended by the review panel. But the panel, in anticipation of a lower than recommended budget, prioritized funding levels for the project. On the basis of this prioritization, the Cornell, Montana State, North Carolina State, and Texas A&M projects were fully funded and the Florida and NifTAL projects were allotted a small fraction of their budgets to await increases in next year's budget and to enable them to seek support from other sources. The Vermont project was asked by AID to seek support from the Middle East Research Cooperation (MERC) and therefore dissolved its relationship with the SM CRSP.

The global plan of the restructured SM CRSP is based on developing portable decision aids that offer site-specific recommendations anywhere in the world where input data to operate the decision aid are available. Unlike traditional methods for transferring technology, which depend on offering technologies to users, the SM CRSP's decision aids are designed to help potential users visualize the consequences of adopting the technology and to offer alternative ways to attain the desired outcome. This new paradigm enables SM CRSP customers to exercise choice and transforms developmental research from a supply-driven process to one that is demand-driven.

Much of the first year was spent readying the projects for full implementation in Africa, Latin America, and Asia. Highlights of accomplishments include the following:

- improving performance of a Rhizobium inoculum production system by privatizing a government operated program (NifTAL);
- development of a prototype decision support system for diagnosing soil nutrient problems and prescribing alternative ways to correct them (North Carolina State);
- development and testing of a decision support system to evaluate tradeoffs between productivity and sustainability of agroecosystems (Montana State);
- coastal shrimp producers negatively affected by sediment in river waters pay upstream farmers to install soil conservation measures (Texas A&M);
- high cost of fertilizer and low value of food crops make fertilizer use unlikely unless African women are allowed to keep earnings from cash crops to pay for fertilizing food crops (Florida);
- in South Asia where the green revolution has come to a standstill, increases in wheat yields averaging 40% were obtained by simply treating seeds with micronutrients (Cornell).

The six projects cover all constraints identified by the review panel. Three projects operate at the field and farm levels and three others at the watershed and regional levels. Projects operating at the lower level concentrate on adoption and implementation of agricultural practices, and projects operating at the higher levels are designed to improve decision making by policy makers.

History and Accomplishments

In 1981, the Soil Management CRSP was established as a collaborative effort among USAID, four U.S. universities, and developing countries. The universities included Cornell University, the University of Hawaii, North Carolina State University, and Texas A&M University. This collaborative effort known as TropSoils concentrated its efforts on three agro-ecological zones which included the humid tropics of Peru and Indonesia, the semi-arid tropics of Niger and Mali and the acid savannas of Brazil. TropSoils' major accomplishments during the first decade were as follows:

- developing local capacity for making and interpreting soil surveys;
- predicting outcomes of alternative soil fertility recommendations;
- developing local capacity to produce, distribute and benefit from biological nitrogen fixation technologies;
- improving technology for soil water conservation and use; and
- improving methods for restoring degraded land for food production.

Because of TropSoils' collaborative efforts, large areas of land in Latin America, Sahelian Africa and South-East Asia, considered to be mantled with "problem soils" are slowly being transformed into productive agricultural lands. In addition, 115 individuals from developing countries obtained advanced degrees from the four U.S. institutions. These graduates form a rich source of talent for their home countries and will play a key role in the future work of this CRSP.

In 1990, three large AID-funded projects were administratively merged with the original CRSP partners. The new members included the NifTAL (Nitrogen Fixation for Tropical Agricultural Legumes) project at the University of Hawaii and the USDA's Soil Management Support Services project and the Technology of Soil Moisture Management project. The program merger added to the problem of achieving the required integration of effort among the four institutions and the three new partners. Although the Soil Management CRSP continued to receive high praise for its technical achievements from their peers, the signals from USAID contained reminders to restructure the SM CRSP so that it would be more results-oriented.

SM CRSP

Restructuring of the Soil Management CRSP

In March 1995, USAID requested North Carolina State University, then serving as ME, to implement a restructuring plan to revitalize CRSP, which had been operating for 15 years. The agency requested that North Carolina State University convene an advisory panel of 9 to 13 members to identify and prioritize the major constraints blocking the adoption and application of integrated nutrient and soil management in the tropics.

The panel identified five constraints: nitrogen deficiency; phosphorus deficiency; soil acidity; water deficiency; and soil erosion and degradation.

Shortly thereafter North Carolina State University requested preproposals from qualified U.S. universities and both U.S. and non-U.S. research organizations to address the five constraints.

An external panel was convened to evaluate and rank the 54 preproposals that were submitted. Nineteen preproposals were considered worthy of resubmission as full proposals. The panel recommended that five preproposals be combined into a single proposal. Seven of the 14 full proposals were then selected for funding under the restructured SM CRSP. The principal investigators, institutions, and proposal titles were as follows.

- John M. Duxbury, Cornell University, *Sustainability of Post-Green Revolution Agriculture: The Rice-Wheat Cropping System of South Asia*
- Christina H. Gladwin, University of Florida, *Gender and Soil Fertility: A Proposal to the Soil Management CRSP*
- Paul Singleton, University of Hawaii, NifTAL Center, *Improved Agricultural Productivity through Biological Nitrogen Fixation Technology and Legume Management*
- John M. Antle, Montana State University, *Tradeoffs in Sustainable Agriculture and the Environment in the Andes: A Decision Support System for Policy Makers*
- T. Jot Smyth, North Carolina State University, *Decision Aids for Integrated Soil Nutrient Management*
- Thomas L. Thurow, Texas A&M University, *Soil Management Practices for Sustainable Production on Densely Populated Tropical Steeplands*
- Frederick R. Magdoff, University of Vermont, *Ecological Soil Management in Israel and Palestine*

Shortly after the announcement of the selected projects, a meeting of the seven principal investigators was held in Raleigh, North Carolina to enable the PIs to hear, for the first time, the purpose and content of the other projects.

Prior to this, the ME circulated an announcement requesting interested institutions to take on the duties of the ME. Three universities, Hawaii, North Carolina, and Texas A&M expressed interest in serving as the ME. Representatives from these institutions presented their vision of what the restructured CRSP should look like. The PIs elected Hawaii to be the new ME by a vote of 5 to 2.

Owing to budgetary uncertainties, the independent panel appointed by USAID recommended three funding scenarios. First, that a minimum, viable CRSP would consist of the projects proposed by Cornell University, Montana State University, North Carolina State University and Texas A&M University. As a second scenario, the panel recommended that the University of Hawaii's NifTAL project be added to the CRSP if funding were increased. Finally, it recommended that the projects of the University of Florida and the University of Vermont be included in a third scenario. In the end, the Cornell, Montana State, North Carolina State, and Texas A&M projects were fully funded. The Florida and NifTAL projects were allotted a small fraction of their budgets to await possible increases in next year's budget and to enable them to seek support from other sources. The Vermont project was asked by AID to seek support from the MERC.

SM CRSP

Global Plan

The restructured Soil Management CRSP operates on the premise that a large body of knowledge on soil management already exists. While new knowledge is desirable and needed, we believe soil management research must focus on customer adoption of proven technologies. We also assume that knowledge from a single discipline is rarely sufficient to address customer needs. This means that researchers from other disciplines must contribute to the understanding of cultural and economic factors that affect technology adoption. For the first time, two of the six principal investigators come from disciplines other than soil science. One is an economist and the other an anthropologist/economist.

Product-Oriented CRSP

Unlike the previous Soil Management CRSP, the new CRSP has projects whose success depends on developing globally applicable knowledge products and technologies. The knowledge products or decision aids on decision support systems are assembled by interdisciplinary teams that capture, condense and organize knowledge from relevant disciplines with the singular aim of making knowledge accessible to CRSP customers. These products are portable and transferable to NGO's, extension agencies, U. S. farmers, National Agricultural Research Systems (NARS) policy makers, regulatory agencies, banks, and businesses. These products are designed to answer "what if" questions posed by the user. For example, the NGO representative or extension personnel can use a decision aid to answer a farmer's question such as, "What if I were to apply zero, 5, 10, 50, or 100 kg of nitrogen on a particular field of the farm?" The farmer can raise "what if" questions related to anticipated profits given projected fertilizer prices and market prices for the farm produce. A U. S. farmer may ask "what if" questions related to fertilizer use and ground water contamination. The knowledge products planned for development and distribution by this CRSP are designed to operate globally and site-specifically. They can operate globally because they are process-based, i.e., they are based on universal processes and principles that apply everywhere. These globally applicable decision aids are also used to diagnose and prescribe site-specific solutions to soil management problems by inputting site-specific socioeconomic and biophysical data into them.

Application of a Systems Approach to Development

A systems approach assumes that it is often more convenient to study a system using models than conducting experiments on the system itself. This is not to say that experiments are unnecessary or unimportant. It does imply that experiments are too costly and too valuable to solve every-day problems of people who depend on system performance for their livelihood. Field experiments should be reserved for uncovering principles and processes that determine systems behavior and performance. The manner in which the system as a whole behaves and performs often depends more on factors such as weather and prices than on management practices. For example, farmers may add nitrogen to their soil with the expectation that their nitrogen deficient soil will produce a more profitable crop. And yet the farmer may experience no benefit from nitrogen because of drought or nitrogen loss from heavy rains. In the systems approach the customer is given a probability distribution of the promised outcome. For many farmers, risks that reside in the tail of probability distribution are more important than the average outcome.

Framework for Achieving Results

A customer-oriented approach assumes that customers will make decisions based on options presented to them. The promised (predicted) results are generated by the knowledge products

assembled by SM CRSP teams. But a knowledge product that cannot deliver on its promise will do more harm than good. For this reason, their reliability must be field-tested before they are released to the public. The role of NGO, host country collaborators, and IARC is crucial to the testing phase because they have direct contact with end-users and are in the best position to objectively evaluate SM CRSP products.

Timeliness and Cost-Effectiveness

A key element of the global plan is to enable the largest number of customers to implement sound, integrated nutrient management practices and policies in a timely and cost-effective manner, anywhere in the world, during the life of this SM CRSP and especially after this SM CRSP has ended. The product-oriented approach taken by the SM CRSP is based on the premise that it is impossible to find answers to the large number of "what if" questions farmers, policy makers, and agribusinesses might ask using field experimentation or through consultation with human experts. There are insufficient monies and trained people to conduct the countless number of field trials needed to find appropriate ways to raise agricultural performance worldwide andconsultants are too expensive for most CRSP customers. And yet for this or any CRSP to produce dramatic improvements in agroecosystems performance, millions of farmers must be influenced by this SM CRSP now and in the future. Probably the only way to do this is to collect the rules, experience, and knowledge experts use to diagnose and solve problems and make them available to SM CRSP customers. By doing so the SM CRSP empowers its customers by enabling them to exercise choice over when and how changes will be made.

Customer Participation

A knowledge product no matter how powerful and accurate serves no useful purpose unless it is adopted by users for which it was intended. This means that the intended customers must be identified and invited to participate in product design and development. The involvement of customers is critical for two reasons. First, customer participation is necessary to ensure that the final product is acceptable to them, and second, customers generally have specialized knowledge which is unknown or overlooked by scientists. Inclusion of customer knowledge can enhance product performance and customer acceptance of the product.

A network of testing sites has been identified to test the reliability of the products and to evaluate customer reaction to updated versions. The testing procedure is driven by customer feedback and will be iterative, dynamic, and self-correcting.

The ultimate customers of this CRSP are farmers, policy makers and bankers and agribusinesses. The products are not designed for direct application by farmers but are intended for use by NGO, extension agents and consultants. Even for policy makers, bankers, and businesses, the CRSP products will be generally used by staff hired to evaluate outcomes of alternative practices and policies for the benefit of policy makers and executives. This CRSP will work directly with customers using the products, and must depend on them to connect with farmers, policy makers, and executives.

Monitoring Performance

A result-oriented program does not happen by chance. It must be monitored and managed for results. In order to manage the SM CRSP for results, all CRSP activities will be based on annual work plans jointly developed by the PIs. The work plan will be reviewed by the Technical Committee (TC) for technical soundness, attainability, and cost-effectiveness. The BOD will react to the TC's findings and add its own recommendations, particularly in the area of missed opportunities and new sources of funding.

Information from customer feedback, progress reports and oral presentations by PIs will be used

to monitor and evaluate performance. Decisions on resource allocations will be guided by performance. Revisions and new strategies for achieving results will be implemented for failed or ineffective thrusts.

A program focused on results and not on activities can be sustained by a common vision shared by all stakeholders. An appropriate vision for this CRSP is a world in which CRSP customers are empowered with information to make economically and environmentally sound soil management decisions. This CRSP is accountable to its customers.

End-of-Program Status

What happens to this SM CRSP after it ends may be more important than its accomplishments during the program period. This program is designed to carry the momentum generated during its life into the indefinite future. This momentum resides in the SM CRSP products, customer networks, and collaborating scientists.

The products represent the institutional memory of all that was learned in this SM CRSP. Future projects do not need to rediscover what is already known or to repeat what has already been done. New efforts in soil and nutrient management can build on the accomplishments of this SM CRSP. It is important to keep this in mind because the law of the minimum virtually guarantees that when the five soil constraints are removed, others now overshadowed by the dominant constraints will emerge to replace them. As new constraints appear, they should be easily coupled to SM CRSP products. This can be achieved by designing SM CRSP products to be modular in structure.

The product-development teams and customer networks also represent an end-of-program product. In the current information age, their continued existence is highly likely owing to the ease of electronic communication. But what will sustain the networks is the mutual benefit scientists and customers gain by belonging to such a network. Each member benefits from the full intellectual capital of the network in exchange for a single member's contribution.

Impact Analysis

Much of the first year was spent readying the projects for action. Even so all projects had achievements beyond start-up activities to report.

NifTAL

The NifTAL project exemplifies the benefits CRSPs can gain by joining forces with the private sector. NifTAL's major accomplishment for last year is summarized below.

The NifTAL Project helped privatize the legume inoculant production industry in Nicaragua. USAID-Nicaragua sponsored the technical assistance to GRAINCO Company through a sub-agreement with NifTAL. NifTAL provided assistance in facility design, equipment procurement and installation, training staff in inoculant production, and quality control techniques. The facility design and production protocols followed NifTAL's broth dilution method for producing inoculant in sterilized carrier. During the technical assistance contract, GRAINCO produced 45,000 bags of inoculant in the first year of operation compared to 25,000 produced in previous years by the government facility, which had ceased operations. GRAINCO's product inoculated 32,000 ha. in the first year. The facility NifTAL specified has a capacity several times the first year production. GRAINCO has recently ordered peat carrier sufficient to produce more than 100,000 bags in 1998. Field research on inoculant response in this region indicate a yield increase ranging from 15%–172% could be expected depending on site. Given average yields of 1600 kg ha^{-1} and prices, at minimum, the aggregate yield increase from inoculation would have exceeded 7,680 metric tonnes which is worth more than $2.3 million U.S. (FAO, 1992 Production Yearbook data).

Next year NifTAL plans to field test a new method for inoculating seeds with a nitrogen fixing micro-organism. Unlike the product based on a plot carrier, the new method employs a liquid inoculum which is especially needed in Sub-Saharan countries where peat needed to serve as carrier of the inoculum is unavailable or too expensive.

Montana State University

The Montana State project entitled "Tradeoffs in Sustainable Agriculture and the Environment in the Andes" is specifically designed to enable NARS to provide decision makers with information they need to formulate sound policies.

One of the principal goals of the SM CRSP work in Ecuador and Peru is to develop a decision support system for assessing tradeoffs between agricultural production and the environmental impacts of agriculture. This decision support system will allow quantitative analysis of tradeoffs associated with various economic, agricultural and environmental policies, and agricultural research. The decision support system is being developed and tested in the potato/pasture production system of the Andean region. This decision support system has the following key features.

- Provides policy makers with information on tradeoffs between key sustainability indicators under alternative policy and technology scenarios.
- Links disciplinary data and models in a GIS framework.
- Utilizes minimum data necessary for decision support and policy analysis.
- Generalizes results that can be extrapolated to larger geographic regions in a GIS framework.
- Adapts and transports the generic structure of the system to other geographic settings and applications.

The SM CRSP project, the International Potato Center, the International Consortium for Agricultural Systems Applications, and the C.T. de Wit Graduate School for Production Ecology

Wageningen Agricultural University sponsored a workshop on information technology as a tool to assess land use options. Twenty-five researchers from 11 countries participated in a workshop in which eight models were presented for hands-on testing and criticism. Included in the workshop was the decision support system for policy tradeoff analysis being developed by the SM CRSP project in Ecuador and Peru. The course proceedings were published in *Quantitative Approaches in Systems Analysis,* January 1998.

Reorientation of Soil Sciences in a NARS. In many developing country NARS, soil science is stuck in the chemical analysis-fertilizer recommendation rut. Through its activities in Ecuador, the SM CRSP is assisting the soil and water management department of the national agricultural research institute (INIAP) to think strategically, broaden its skills, and become a more relevant partner in the shifting mandate of the institution. Through a brainstorming session, an innovative training course that focused on practical pragmatic training in physical and hydraulic measurement procedures, and the installation of basic laboratory equipment and collaboration in field research, the department is changing direction. The soil and water department should develop as a respected institution within Ecuador in the near future. It should provide answers for policy makers in terms of regional planning exercises and the determination of high risk areas. It should also be able to properly advise farmers and local producers. This can only be accomplished through training of INIAP staff in modern quantitative methodologies and the establishment of a national soils database. The SM CRSP allows INIAP staff to carry out these kinds of activities together with international scientists.

Downscaling Soils Information. In many developing countries, spatial soil information consists of soil surveys done, at best, at scales of 1:50,000. Despite the enormous cost and effort of producing a soil survey, information at scales of 1:50,000 or higher is of little use for studies at the farm level and in tropical mountainous environments where spatial heterogeneity is extreme. With the shift in analytical paradigm from experimental to modeling approaches to research being supported by the SM CRSP, new methods are required to make effective use of the heritage of decades of soil survey. In Ecuador, first steps are being made in this direction with the successful implementation of a low cost sampling-based procedure that produces distributions of functional soil horizons. By opting for a limited sampling approach and using detailed digital elevation maps, the existing exploratory soil survey map is downscaled to a 1:10,000 scale level. Compared to creating a new detailed soil survey using traditional soil survey methods, costs are reduced by 80%. The downscaling procedure enhances the value of the enormous investment in soil survey and makes it possible to engage this important component in modern model-based research techniques.

An unappreciated aspect of the CRSP work in the Andes is its transferability to other regions in the world. The Decision Support Systems developed by the SM CRSP partners is portable and can be applied to any site where the minimum set of input data to operate it exists.

North Carolina State University

The difference between a wealthy farmer and a poor one is one of having choices. The rich farmer has many more options from which to choose than the poor farmer. Sound economic policies and well-developed infrastructure generate options for everyone, but in their absence, the CRSPs must invest in research that enables its customers to evaluate and choose alternative ways of achieving customer-specified objectives.

The North Carolina State University and University of Florida projects are designed to give CRSP customers the opportunity to make choices.

The former, referred to as the IntDSS project, consists of three parts. The first part diagnoses nutrient related problems. On the basis of the diagnosis, the second part prescribes alternative strategies for solving the problem, and third, an economic module is fed cost-return information to enable customers to compare the economic advantage of each option. The following is a summary of the intent and early accomplishment of the project.

The strategy of IntDSS is to develop globally applicable, largely computer-assisted, integrated decision aids that will both diagnose nutrient constraints to food production and quality and prescribe appropriate solutions to the constraints. A range of decision aids, varying from guides to assist in nutrient management at a regional level to those that provide site-specific nutrient diagnoses and prescriptions will be available for users to select as applicable to their local conditions. Prior to final release, the capability of these integrated decision aids will be tested, refined, and retested with the assistance of user groups. Users will apply the decision aids, usually the electronic integrated nutrient management system, to diagnose and prescribe management solutions to identified nutritional constraints.

Project activities will be conducted by a multidisciplinary team of 16 scientists from four U.S. universities in close collaboration with overseas investigators from national agricultural research and extension systems (NARES), international agricultural research centers (IARCs), and selected members of private volunteer organizations (PVOs), nongovernmental organizations (NGOs), agribusiness and other CRSP projects. Project activities are distributed among two levels of collaborative effort: *intensive testing areas* and an *extensive evaluation network*.

Intensive testing areas are a selected representative region in each of three agroecological zones (semi-arid, wet-dry, and humid tropical) where there is significant potential for products developed by this project to alleviate soil acidity, N and P constraints to food production and to promote environmental security. Each area should be large enough to constitute a political entity. It can be as small as a farming community but not exceeding a county or province. Testing areas provide real life situations where all developmental research by U.S. team scientists will be conducted in conjunction with collaborators in each area. Testing area activities will begin with a baseline assessment of social, economic and cultural conditions, infrastructure, and nutrient needs. This initial assessment will be conducted by multi-disciplinary teams of U.S. scientists and local collaborators. It will include extensive contacts with farmers, extension agents, planners and decision-makers. Based on the team's determination of potential remedial actions and approaches, subsequent activities in developmental research and outreach will be tailored to address the needs of the testing area. Products developed by the project will be tested in these areas and refined to provide satisfactory performance. Similar assessments in the third and fifth years will be used to document project impact.

The second type of collaborative effort, *extensive evaluation*, will focus on a network of collaborators to evaluate refined products under a variety of conditions on a global scale. Although extensive evaluation will be concentrated towards the end of the 5-year project, a modest level of interaction with collaborators in this effort is also planned for the initial years of the project. Early and continued contact with these collaborators will help clarify the global extent of knowledge gaps and potential adjustments needed for application of products beyond the testing areas.

The integrated nutrient management decision support system is the core knowledge base from which information is extracted to build auxiliary tools that facilitate use of this knowledge for different purposes and/or groups. We perceive the process of developing the integrated nutrient management decision support system

and its auxiliary tools as a continuous feedback loop among developmental research and outreach activities. Upon the synthesis of existing knowledge the team will gather to formulate options and refine developmental research needs. Prototypes will be assembled and tested, and the team of U.S. scientists and collaborators will critique/discuss/improve the prototypes. With each repetition of this cycle the product approaches desirable performance.

During the first year, the first prototype of an integrated nutrient decision support system was produced. In coming years the prototype decision support system will be field tested in a network of sites in Asia, Latin America, and Africa.

University of Florida

The University of Florida projects focuses on gender-based options. Women who produce the bulk of food for family consumption lack the financial means to adopt new products and practices such as seeds of high performance crops and use of chemical fertilizers. Men, on the other hand, who grow cash crops such as cotton and tobacco can afford to use fertilizers. This project is about giving women farmers options for breaking from the traditional way of sharing the income derived from farming. A brief account of the first years activities is given below.

Decision criteria were elicited from interviews with 60 women farmers and decision tree models were developed to predict women's use or non-use of chemical fertilizers vs. manure, women's participation in a credit club, and women's decision to buy fertilizers in small bags, big bags, or not at all. In addition, decision tree models were developed in the field which represents women's decision processes to use undersowed legumes and leguminous tree crops to improve soil fertility. In a collaborative study with ICRAF, women in Western Kenya chose not to use hedgerow intercropping, improved fallow systems, or biomass transfers to fields reserved for growing food crops. In Uganda, a SM CRSP-CIAT collaborative effort shows that no chemical fertilizer is used by men and women farmers, but household waste and manure in combination with fallow, local knowledge of soils, and crop residues are traditionally used.

Preliminary research results show that only small amounts of chemical fertilizer (e.g., 18 kg N/ha or 40 kg urea/ha) on food crops are now profitable at current price ratios of fertilizer to food crops. Therefore, some African countries are revising their recommended use of fertilizer downwards. Many women farmers will not be able to afford to adopt agroforestry innovations such as hedgerow intercropping, improved fallow systems, or biomass transfers for use on their food crops, because they often lack the land and labor necessary for adoption in areas of high population density in countries such as Malawi and Kenya. Undersowing of food grains with BNF legumes was also considered a "non-answer" in southern Malawi because women plant legumes (pigeon pea, soya) for food and thus do not plow them under when green. Small bags of fertilizer and microcredit programs at current interest rates for food crops were also seen as problematic for female heads of family and used more by male heads of family because the female heads of family could not afford them. Ironically, the only sustainable solution we found was for women farmers to switch a small part of their land (e.g., 1/10 ha) out of the subsistence crop (maize in Malawi and Kenya) and plant a very profitable cash crop (e.g., tobacco in Malawi, tomatoes in W. Kenya, coffee in Uganda), so that they could repay fertilizer loans with the proceeds from the cash crop.

In its first year of operation, the University of Florida project was promised additional funds from the Division of Disaster Relief of USAID to expand its work in Africa.

Cornell University

The Cornell University project entitled "Sustainability of Post-Green Revolution Agriculture: The rice-wheat cropping system of South Asia" returns to the land of the origin of the green revolution. India, Pakistan, Bangladesh

and Nepal benefited greatly from the green revolution when farmers adopted short-strawed, high yielding rice and wheat varieties that responded to chemical fertilizers. Today, the rapid increases in productivity experienced in the past has virtually come to a standstill. If current trends hold, population expansion will overtake productivity increases. This project operates within the framework of the NARS to search for factors that can rejuvenate a revolution that has run out of fresh ideas. A summary of observations and accomplishments for the first year is given below.

- Surveys of farm households with NARS scientists in Bangladesh and Nepal confirmed that although soil fertility is considered a major constraint, cost of fertilizer limits inputs to less than recommended rates. In recognition of this situation, plant breeders in Bangladesh and Nepal are screening for crop performance under reduced nutrient inputs, especially N. Whether this is a good strategy needs to be evaluated. In Bangladesh, BR-32, a shorter duration rice variety selected specifically for the rice-wheat rotation under reduced N inputs (80 kg N/ha), out-yielded BR-11 (4.59 compared to 4.08 t/ha), the standard longer duration variety, at an N input rate of 120 kg N/ha (the standard recommendation) when micronutrients were also supplied. However, BR-32 was found to be susceptible to Zn and Mo deficiency, which was not a known characteristic of the variety. With appropriate fertility management (and based on one trial), BR-32 may have the potential to increase total grain output of the rice-wheat system by at least 1 t/ha (15+%); 0.5 t/ha through a direct increase in rice yield and an estimated 0.5 t/ha increase in wheat yield because the shorter growth duration of BR-32 (130 days compared to 145-150 days for BR-11) will allow more timely planting of wheat to reduce yield depressions caused by heat during grain fill.
- Increases in wheat yield averaging 40% or 0.84 t/ha, were found at 6 of 14 sites in an on-farm evaluation of micronutrient enriched seed in Dinajpur district in north-west Bangladesh. Analysis of yield data with seeds differentially enriched with micronutrients suggested that the response to micronutrient enrichment was caused by Zn at 4 sites, by Mo at 1 site, and both Mo and Zn at 1 site. A better understanding of micronutrient deficiencies, in rice-wheat cropping systems is needed in Bangladesh. Results of this study demonstrate that micronutrient deficiencies are probably a serious constraint to wheat production in Bangladesh.
- P deficiency in wheat is widespread in the rice-wheat rotation; it is commonly associated with wheat rather than rice because flooding soil increases P availability. Evaluating wheat cultivars for P efficiency was introduced into the wheat breeding program in Bangladesh; an initial screening trial showed substantial differences in P efficiency amongst cultivars and this will be incorporated into the breeding program.
- Screening of legume and a few non-legume green manure species for nutrient acquisition at Ludhiana, India demonstrated distinctly different acquisition patterns for macro- and micro-nutrients. These results suggest that much potential exists for selecting green manures to correct specific nutrient deficiencies or imbalances. For example, crotalaria or pearl millet green manures, which were found to be the best at acquiring potassium, could be more useful than other species in the Terai of Nepal where K deficiency is found. Cowpea, with high Mn content, was found to suppress nematodes of rice and wheat (Hirschmanella and Tylenchorynchos) and could be advantageous where these pests cause significant yield losses. The results indicate that use of legume green manures could be more attractive if they are targeted to overcoming site-specific nutrient and pest problems in addition to supplying N.

- A study of government pricing policies in India showed that incentives encourage wheat and mustard production at the expense of chickpea. Such policies, while ensuring calorie security, are in direct conflict with human health and nutrition goals to include more micronutrient rich foods in Indian diets.

As of this writing, the USAID mission in Bangladesh has offered to provide additional funds to this project to work on the relationship between calcium deficiency in soils and rickets in children.

Texas A&M University

Some of the most devastating land degradation is currently taking place in Central America. Population pressure has forced farmers to cultivate fragile steeplands. Aerial photos taken over the past 15 years show an acceleration of land degradation in the region.

An SM CRSP project titled "Soil Management Practices for Sustainable Production on Densely Populated Tropical Steeplands" from Texas A&M University addresses their problem. A summary of their activities and anticipated results is given below.

The environmental and socioeconomic interdependencies associated with peasants' decisions to cultivate steeplands are complex. A systems orientation to understanding peasants' immediate motives and constraints—as well as how their decision-making is linked with downstream effects and downstream users, and with the resource endowment passed on to their children and grandchildren—is the key to linking the results of an aggressive soil management research program with on-the-ground changes in peasants' cultivation practices.

Farmers tilling steeplands for subsistence face declining yields over time due to soil erosion. To make up for gradually diminishing production, they clear more forest to expand the area under cultivation. Though these decisions are rational and even necessary in accord with their short-run subsistence goals, there are adverse long-run consequences such as flooding, siltation of hydroelectric facilities and degradation of coastal aquatic ecosystems. Thus, although the sustainable use of steeplands depends on sound soil management, the factors which affect national planners and peasant farmers' decisions regarding use of steeplands involve a variety of environmental, economic, social and cultural considerations. To manage these multifaceted and inter-connected issues will require synchronization of the five goals of this project.

1. Improve farmer-acceptable erosion-control and nutrient management technologies that will increase the implementation of practices required to enhance sustainable production and thereby improve living standards in densely populated tropical steeplands.
2. Improve understanding of the technology adoption process used by the peasant farmers who typify steepland farm enterprises.
3. Improve socioeconomic information and economic valuation techniques needed to aid the design and implementation of policies aimed at balancing current subsistence food production goals versus future-oriented environmental protection and resource conservation goals.
4. Improve education/extension techniques/materials to foster the adoption and diffusion of appropriate technologies.
5. Improve integration of farm-level and landscape-level conservation/production options using systems research methods to equip stakeholders to participate in choices among economic and policy alternatives.

The project sites are built on strong existing relationships with collaborators in Haiti, Honduras and Nicaragua. Substantial baseline work has already been done at these sites by the project

collaborators, thereby leveraging SM CRSP investments. Efforts to achieve project objectives will result in the following impacts:

- Develop soil conservation methodologies that are transferable to other densely populated steeplands elsewhere in the world.
- Reduced soil degradation and erosion enhancing the sustainability of production on the sites.
- Reduced conflict between upstream farmers and downstream aquaculturists.
- Greater crop yields as a result of enhanced nutrient and moisture status of the soils.
- Improved survival and production of livestock.
- Reduced risk and greater economic returns to the farmers.
- More effective economic assessment tools than can be used by policy makers to assess the costs: benefits of soil and water conservation and farming system technologies.

One outcome of this project is the payment by downstream shrimp producers to upstream farmers to adopt and practice soil conservation measures. This is clearly a case where soil erosion impacts on downstream industries as much as on upstream agriculture.

SM CRSP

Project Integration

All six projects currently funded by the SM CRSP were designed in isolation of the other projects. They shared only one thing in common and that was to address one or more constraints identified by an external panel. The institution by constraint matrix shown below links institutions to constraints. We assume that institutions working on a common constraint have the greatest opportunity for mutually beneficial, intra-CRSP collaboration.

One characteristic of agriculture that complicates integration of effort is that agriculture is hierarchically organized and can be studied at a number of levels. The matrix below shows that three projects operate at the field (farmer) and farm (household) level and another three projects at the watershed (villages) and region (provincial) level. Projects that focus on field-farm are designed to improve decision making in farm management practices, whereas projects operating at the higher levels are primarily aimed at improving decision making at the policy level.

SM CRSP

Constraints/ Projects	Nitrogen	Phosphorus	Acidity	Water	Soil Degradation
N. C. State	X	X	X		
Texas A&M				X	X
Montana State				X	X
Cornell	X	X	X	X	
NifTAL	X				
Florida	X	X			

Hierarchical Level/ Project	Field/ (Farmer)	Farm/ (Household)	Watershed/ (Villages)	Region/ (Nations)
N.C. State	X	X		
Texas A&M			X	X
Montana State			X	X
Cornell			X	X
NifTAL	X	X		
Florida	X	X		

Project Management

The Management Entity (ME)

At the March 12, 1996 meeting in Raleigh, North Carolina of the seven participating Universities, representatives from three participating institutions presented their case for becoming the Management Entity (ME) of the restructured SM CRSP. The institutions expressing interest in the ME were the University of Hawaii, North Carolina State University and Texas A&M University. The University of Hawaii received five of the seven votes and was selected to be the ME on a provisional basis. The elected institution became recognized as the ME upon submission of a proposal containing a management plan and budget acceptable to the participating institutions and to USAID. In the following sections, a description of the structure, function and responsibilities of the ME is presented.

As the ME institution, the University of Hawaii receives and administers the AID grant funds for the SM CRSP and enters into subgrant agreements with participating U.S. and host country institutions for their respective projects. The ME is responsible for implementation of the program and for coordinating and leading the development of annual work plans and budgets. It is responsible for the program and accountable to AID for all expenditures. The ME establishes a system to facilitate and manage international travel. It reports on the program and represents the SM CRSP in negotiating with AID/Washington in meetings of the CRSP council and related meetings nationally and internationally. The ME, through its subagreements with participating institutions, holds them responsible for programs and accountable for expenditure of project funds. A system for reporting effective matching of resources contributed by participating institutions was established between the ME and participating institutions.

The ME will have a governance system designed to ensure that the ME performs in accordance with the overall plan and budget contained in the grant document, and that project objectives of the grant are achieved. The governance system of the SM CRSP will consist 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 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 first meeting of the Board of Directors was held in Washington, D.C. in November 1997. Members and elected 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, International Livestock Research Institute, Nairobi, Kenya.

The Technical Committee (TC). The TC was established with membership drawn from the principal scientists engaged in CRSP activities, known as Principal Investigators (PIs), 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, 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 shares them with the BOD.

Members of the Technical Committee include the following:

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

The External Evaluation Panel (EEP). The EEP will be 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, 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 bases. 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 will be 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 will 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 lease one scientist from a developing host country. Availability to devote considerable time to EEP activities is an important criterion for membership.

Names of prospective members of the EEP were forwarded to the Office of Agriculture and Food Security by the ME in consultation with the AID program officer. After an EEP is established, replacements for the panel will be made through direct consultation between panel members, the ME Director, the BOD, and the AID Program Officer. The final appointments are made by the ME.

Evaluations should be scheduled over a five-year period with an annual evaluation of varying depths. An in-depth evaluation should be made once every three years, with visits to overseas sites as necessary. This should coincide with AID's Triennial Review. The EEP will submit its reports to the AID Program Officer with copies to the ME and BOD for wider distribution.

The EEP must play a strong role in judging the balance of a CRSP and relevance of each project to the program goals. It should evaluate

the performance and the productivity of each institution on each project annually, and assess the appropriateness of the projected resource allocations.

The objective views and expertise of this external group are necessary to balance the sometimes conflicting but natural institutional biases that may exist in a CRSP. It is important that the ME make full use of the EEP and its recommendations. Panel members should be invited to attend important meetings of the PIs 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.

SM CRSP

Financial Statement

A Chronology of Events to Initiate the Grant

Principal investigators of the seven projects selected to form the restructured Soil Management CRSP and principals from the Management Entity met in Washington, D.C. in April 1996 with the Director and program officers of the Office of Agriculture and Food Security(AFS), Center for Economic Growth (now Center for Economic Growth and Agricultural Development, EGAD), USAID to set strategic priorities for research activities based on different budget scenarios. Soon after this meeting, the projected budgetary amounts allocated to the AFS office for 9 of the 10 CRSP programs, the ME was informed by USAID of the probable level of funding for year 1 of the grant. That amount, $2,647,975, was well short of the $4,135,101 proposed amount. Based on budget scenarios developed by the review panel, Projects 5, 6 and 7 were now in jeopardy of being dropped from the SM CRSP.

The total award was adequate for only 4 of the 7 projects. However, at the recommendation of the Office of Agriculture and Food Security, Projects 5 and 6 were retained and Project 7 from the University of Vermont was invited to remain a member of the SM CRSP but to seek resources from an AID-supported program referred to as MERC. The six remaining projects would now be supported by reducing the period of the first project year to 11 months. With the total award fixed at $2,647,975, a reduction of the award period by a month, allowed the inclusion of Projects 5 and 6, the NifTAL program at the University of Hawaii and that of the University of Florida. The difference between the total award and the total projected monthly expenditure rate of the 4 projects for 11 months would then be used to partially support Projects 5 and 6. This amounted to slightly more than $285,000 with two-thirds going to Project 5 and one third to Project 6.

The full proposal was submitted to AID in July 1996 with an anticipated start date of October 1, 1996. However, grant officers at AID procurement advised the ME that because of their existing work load, negotiations for the Soil Management CRSP grant would not start until after the end of the federal fiscal year, September 30, 1996. Negotiations between the ME and the AID procurement office did not begin until November 1996 and were finalized at the end of December 1996. The start date was February 11, 1997, nearly 4 months later than anticipated.

The Office of Research Service at the University of Hawaii, in turn, required additional time to review the grant documents before accepting

Table 1. Summary of PY 1 Award and Modification 1 for the Period Feb 11 97 to Apr 30 98

	MSU	NCSU	CU	TAMU	NifTAL	UFL	ME	TOTAL
Salaries	39	417	261	107	125	0	208	1,157
Fringe Benefits	3	111	80	26	28	1	54	303
Consultants	0	25	0	0	0	0	0	25
Equipment	66	51	60	70	5	10	4	266
Supplies/Service	42	87	102	39	19	4	70	363
Travel	19	122	85	48	7	50	79	410
Training	52	0	0	0	28	40	0	120
Direct Costs	221	813	588	290	212	105	415	2,644
Indirect Costs	55	416	156	100	44	23	145	939
Total	276	1,229	744	390	256	128	560	3,583

grant conditions in the agreement with AID. The grant document was finally executed on April 7, 1997 and returned to AID.

Subsequently, modification #1 which added $1,131,025 to the grant and extended the incremental funding period to April 30, 1998 was received in August 1997.

Fiscal Summaries

Table 1 is a summary of the budget allocation to each of the six projects. Subgrants were initiated between each of the institutions and the Research Corporation of the University of Hawaii. NifTAL, a program at the University of Hawaii, did not require such a subgrant.

Figure 1 is a graphical representation of the distribution of funds by projects. The allocation of funds associated with Modification #1, received in August 1997, was made using the same percentages as all of the projects were basically in a 'start-up' mode at that time.

Table 2 is a summary of expenditures reported up to March 31, 1998 for each of the project. In addition, a figure for an estimate of their encumbrances and expenditures up to the end of the incremental period of April 30, 1998 was requested to determine the available pipeline funds. The reported cost-sharing totals for each project are also included. At the time the annual report went to press, further information on cost-sharing was being requested from each of the subgrant. The collective commitment on cost-sharing should be 25% or more of funds expended by both participating institutions and USAID.

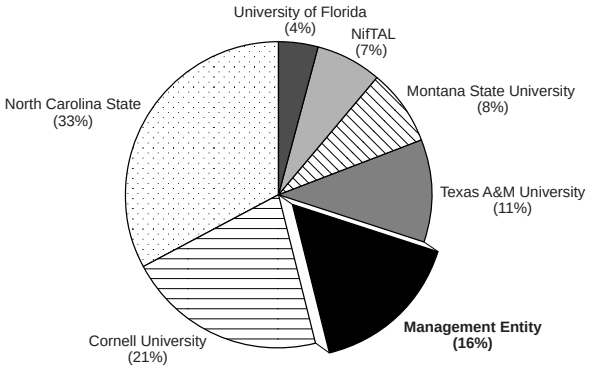

Figure 1. SM CRSP budget allocation for the period February 11, 1997 to April 30, 1998

SM CRSP

Table 2. Summary of Expenditures for PY 1 ('000)
and Modification 1 for the Period Feb 11 97 to Mar 31 98

	MSU	NCSU	CU	TAMU	NifTAL	UFL	ME	TOTAL
Salaries	5	42	70	36	141	0	161	455
Fringe Benefits	1	9	17	10	31	0	39	107
Consultants	0	0	0	49	0	0	0	49
Equipment	4	6	8	7	2	7	4	38
Supplies/Service	195	191	128	25	28	21	7	595
Travel	4	31	61	22	3	27	32	180
Training								
Degree	0	0	11	0	0	0	0	11
Non-Degree								
Direct Costs	208	280	295	149	205	55	243	1,435
Indirect Costs	9	94	77	46	43	11	110	390
Total	217	374	372	196	248	66	353	1,826
Cost Sharing	100	110	139	74	80	21	0	524

Participants and Participating Institutions

The key elements to a successful program are the individuals who carry out the many tasks involved in a collaborative research program involving a network of individuals and institutions. Personnel associated with each of the six participating institutions in the SM CRSP are listed here. This list is by no means indicative of the number of individuals involved at each of the respective campuses. Names of the principal investigator are in bold type. Each participating institution is a subgrantee of the primary grant between the Management Entity at the University of Hawaii and the Office of Agriculture and Food Security of the U.S. Agency for International Development.

SM CRSP

Participating Institutions

Cornell University
George Abawi
Phillippe Baveye
Robin Bellinder
Dave Bouldin
Gerald Combs
Stephen DeGloria
John Duxbury
Shelley Feldman
Steven Kyle
Julie Lauren
David Lee
Ralph Obendorf
Susan Riha
Norman Uphoff
Ross Welch
Timothy Widmer

Montana State University
John M. Antle

North Carolina State University
Fred Cox
Daniel Israel
Deanna Osmond
Frank Smith
T. Jot Smyth
Mike Wagger
Art Wollum

Texas A&M University
Amy Thurow
Tom Thurow
Rick Wesch
Larry Wilding

University of Hawaii
Harold H. Keyser
Eve Sande
Paul Singleton

University of Florida
Christina Gladwin
Abraham Goldman
Jerry Kidder

Collaborating Institutions

Auburn University
Glenn Howse
Curtis Jolly
Greg Mullins
Dennis Shannon
C. Wood
Kyung Yoo

Cornell University
Shaw Reid

International Potato Center
Walter Bowen, and IFDC, Alabama
Charles Crissman
Ruben Dario Estrada, and CIAT, Cali, Colombia

Michigan State University
Joe T. Ritchie

North Carolina State University
Keith Cassell

Texas A&M University
Richard Dress
Anthony Juo
Frank Hons
Lloyd Hossner

University of Hawaii
James B. Friday
James Fownes
Thomas George
Nguyen Hue
Richard Kablan
Michael Robotham
Xinmin Wang
Russell Yost

Wageningen Agricultural University
Johan Bouma
Anton Haverkort
Jetse Stoorvogel
Robert van Haren

Collaborators

Implementation of project activities in a global program such as the Soil Management CRSP requires cooperation and good will among individuals and organizations collaborating with SM CRSP institutions to undertake such an effort. Names of individuals and their respective organizations are listed in this section alphabetically by geographic regions. We apologize if we've missed names. These individuals and organizations are partners with scientists, students, and staff at associated participating institutions of the SM CRSP in managing and maintaining local research sites of a global program. In many instances, collaborators provide "in-kind" support to the SM CRSP by providing human and capital resources to implement project activities.

1. National Agricultural Research and Extension Services (NARES)

ASIA

Bangladesh

Bangladesh Rice Research Institute (BRRI), Joydebpur
H. Ahmed, Plant Pathology
T. Das, Plant Breeding
N. E-Elahi, Agronomy
R. Karim, Entomology, National Rice-Wheat Coordinator
S.M.R. Karim, Agr. Economics
B.A.A. Mustafi, Agr. Economics
M.D. Nurul Islam, Irrigation & Water Management
G.M. Panaullah, Soil Fertility

Bangladesh Agricultural Research Institute (BARI), Joydebpur
Md. Elahi Baksh, Agr. Economics
Md. A. Mannam, Entomology
A.K. Maqbul Hossain, Soil Chemistry
S. Parvin Banu, Plant Pathology
M.A. Razzaque, Agronomy
A. Shaheed, Plant Pathology

India

Indian Council for Agricultural Research (ICAR)
R.K. Gupta, Soil Science-National Rice-Wheat Coordinator

G.B. Pantnagar University
Y. Singh, Agronomy

Punjab Agricultural University (PAU)
C. L. Arora, Soil Chemistry
S. Beedi, Agronomy
M.R. Chaudhary, Soil Physics
N. Jead, Plant Pathology
P.P.S. Pannu, Plant Pathology
Bijay Singh, Soil Chemistry
Yadvinder Singh, Soil Chemistry

Nepal

Nepal Agricultural Research Council (NARC)
S. Bhattarai, Soil Science
H. Bimb, Plant Pathology
S.K. Gami, Agronomy
M. Ghimire, Entomology
G.S. Giri, Agronomy
D. Joshi, Soil Science-Executive Director
C.B. Karki, Plant Pathology
M. Maskey, Soil Science
S.P. Pandey, Soil Science/GIS
N.K. Rajbhandari, Agronomy
J.D. Ranjit, Weed Science
R.P. Sapkota, Agronomy-National Rice-Wheat Coordinator
R. Shrestha, Legume Agronomy
H.K. Upreti, Agronomy

Pakistan
Pakistan Agricultural Research Council (PARC)
Md. Saleem Akhtar, Soil Physics-National Rice-Wheat Coordinator

Philippines
Philippine Rice Research Institute (PhilRice)
Teodula Corton, Coordinator

AFRICA
Malawi
Chitedzi Agricultural Research Station
Alex Saka

Banda College
Vincent Saka

Mali
Institut Economique Rurale (IER)
Adama Coulibaly, Cinzana Station
Oumar Coulibaly, Cinzana Station
Mamadou Doumbia, Sotuba Station
Zoumana Kouyate, Cinzana Station
Aminata Sidibe, Sotuba Station

AMERICAS AND THE CARIBBEAN
Brazil
Federal University
Bonerges Aquino, Ceara
Roberto Novais, Viçosa

EMBRAPA
Lafayette Sobral

Costa Rica
Center for Agricultural Research/University of Costa Rica
Alfredo Alvarado
Rafael Salas

Ecuador
Instituto Nacional de Investigaciones Agro-Pecuarias (INIAP), Quito
Victor Barrera
Juan Cordova

Universidad Catolica, Quito
Ramiro Merino

Haiti
Centre de Recherche et de Documentation Agricoles (CRDA)
Ministère de l'Agriculture, des Ressources Naturelles et du Développement Rural (MARNDR)
G. Alexis
J. Roche

Honduras
Ministry of Natural Resources—Land Use Productivity Enhancement Project
Choluteca
Mario Pinto
Olman Rivera
Miguel Sanchez

Ministry of Environment
Jesus Salas

PanAmerican University
Margoth Andrews
Carlos Rosas
Hector Sierra

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

Peru
Universidad Nacional Agraria (UNA)
Guillermo Baigorria, Dept of Agrometerology, La Molina, Lima

Universidad Nacional de Cajamarca (UNC)
Edevaly de la Peña, Escuela de Post-Grados
Peter Muck, Escuela de Post-Grados

Asociacion Civil para la Investigacion y Desarrollo Forestal (ADEFOR)
Flavio Flores, Cajamarca

Instituto Nacional de Investigacion Agropecuaria (INIA)
Hector Cabrera, Cajamarca

2. International Agricultural Research Centers (IARC)

International Rice Research Institute (IRRI)
K. Bronson
S.P. Kam

Centro de Investigacion y Mejoramiento de Maiz y Trigo (CIMMYT)
E. Duveiller (Nepal)
P.R. Hobbs (Nepal)
L. Harrington (Mexico)
J. W. White (Mexico)

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
I.P. Abrol, Soil Science, Rice-Wheat Consortium Facilitator
C. Johansen

3. Private Sector and NGOs

AFRICA
East and S. Africa. Rhizobium Ecology Network of East and Southern Africa (Soil Science Department of the University of Nairobi) coordinator for Kenya, Zimbabwe, Uganda, Zambia and Rwanda

AMERICAS
Argentina, Sintesis Quimica Fabrica, Buenos Aires
Brasil, Faculdade de Cinecias Agrarias e Vet. UNESP, Jaboticabal
Brasil, Microbiological Resources Center, Porto Alegre
Canada, MicroBio RhizoGen Corp., Saskatoon
Ecuador, EcoCiencia, Quito
Honduras, Honduras National Association of Aquaculture, Choluteca
Nicaragua, GRAINCO Inc., Chinandega
Uruguay, Laboratorio Microbiolgia de Suelos Y Inoculantes, Montevideo
USA, LiphaTech, Inc., Milwaukee, Wisconsin
USA, Urbana Laboratories, St. Joseph, Missouri

ASIA
Bangladesh, Mennonite Central Committee, Dhaka
Dhaka, Mennonite Central Committee
India, Maharashtra Hybrid Seed Co., Ltd., Bombay
India, SPIC Science Foundation Center for Biotechnology, Madras
Philippines, BIOTECH Microbial Fertilizer Program, Los Banos
Thailand, Bangkok Seeds Ltd., Bangkok
Thailand, Department of Agriculture, Ministry of Agriculture Bangkok
Thailand, Suranaree University of Technology, Nakhon Ratchasima

CARIBBEAN
Haiti, ASSET Project, Winrock International, Port-au-Prince
Haiti, Pan American Development Foundation (PADF), Port-au-Prince
Haiti, South-East Consortium for International Development (SECID), Port-au-Prince

4. CRSPs

INTSORMIL CRSP collaborates with support of research associate at the PanAmerican University, Honduras. INTSORMIL provides the vehicle and part of the salary, we provide operation expenses for field research designed to test the impact of soil conservation activities on sorghum production.

Pond Dynamics CRSP collaborates by providing 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. We plan to work closer with Pond Dynamics CRSP scientists to analyze how the impact of steepland degradation on water quality/quantity influence the viability of the lucrative shrimp production

industry dependent on water from the Choluteca, Negra and Sampile rivers.

Training. Graduate training continue to play a role in the implementation of SM CRSP research activities abroad and within the U.S. Training is in the traditional classroom academic environment and in the conduct of field and survey research at overseas locations. The list below ranges from training being undertaken at participating institutions in the U.S. to campuses of collaborating institutions and of host country national or regional institutions. Students enrolled at participating institutions in the U.S. are generally supported by SM CRSP funding. Many others listed are not. The latter are participants and partners who receive hands-on training and experience in the conduct of on-site biophysical and socio-economic research techniques.

List of Graduate Students:

Auburn University

Lionel Issac	Haiti

Cornell University

Kaafee Billah	Bangladesh
Medha Devare	India
Andy McDonald	U.S.
Shabnam Qureshi	Pakistan
Krishna Rao	India

Escuela Politecnica de Chimborazo (ESPOCH)

Neidy Clavijo	Ecuador
Miguel Flores	Ecuador
José Negrete	Ecuador

Texas A&M University

Marcela Samayoa	Honduras
Hector Santos	Honduras
Robert Schwartz	U.S.A.
James Smith	U.S.A.
Matilde Somarriba	Nicaragua

Universidad Nacional de Cajamarca (UNC)

Mario Cáceres	Peru
Genaro Carrión	Peru
Sara García	Peru
Ernesto Rodriguez	Peru

University of Florida

Mike Dougherty	United States
Bocary Kaya	Mali
Janet Puhalla	United States
Jen Scheffee Peterson	United States
Amy Sullivan	United States
Andrea Synder	United States
Bob Uttaro	United States

University of Hawaii

Xiufu Shuai	People's Republic of China

Utah State University

Cecilia Ortíz

Wageningen Agricultural University (WAU), The Netherlands

Guillermo Baigorría	The Netherlands
Lammert Kooistra	The Netherlands
David Meerbach	The Netherlands
Ramiro Merino	The Netherlands
Erik Meyles	The Netherlands
Francien van Soest	The Netherlands

Leveraging and Local Cost-Sharing

In the context of jargon common to AID-supported projects, leveraging refers to the ability of the project to generate interest and support which results in added contributions of both human and fiscal resources. Leveraging of AID resources with added support tend to enhance or extend the impact of anticipated project outcomes for the benefit of customers of the SM CRSP both locally and globally. Descriptions of activities and organizations which contributed resources considered as leveraging and local cost-sharing of AID resources are presented here.

Africa

IER/Mali—senior and technical staff time, vehicle, farm, laboratory and computing facilities contributed are estimated as $10,000;

Americas

Agriculture and Agri-Food Canada. Supplied professional support to develop new identification methods for rhizobia in culture media. Results have been translated into a rapid assay for inoculant producers. $23,000

The *Brazilian government* provided full sponsorship of the three Brazilian scientists who worked on PDSS-related issues during their sabbaticals at N.C. State University. The contribution in salaries, travel, housing allowance, and medical insurance is estimated to be in excess of $180,000.

OTS/Costa Rica—senior and technical staff time, vehicle, farm, laboratory and computing facilities contributed are estimated as $6,000; Peace Corp fellowship awarded to project assistant in the amount of $25,000

Potash&Phosphate Institute Andean Program (Central-Latin America) investments into their field and laboratory research is estimated to exceed $50,000. Their willingness to share and collaborate on this information represents a direct savings to the project.

USAID/Nicaragua—Establishment of a Legume Inoculant Production Facility at GRAINCO, Chinandega, Nicaragua. A legume inoculant production facility was established at the GRAINCO company in Cinandega, Nicaragua. The activity was sponsored by USAID-Nicaragua through the Union of Agricultural and Livestock Producers of Nicaragua and a sub-agreement with NifTAL. Major activities included design assistance, equipment procurement, installation, and training of staff in inoculant production and quality control techniques during April and May, 1997. The facilities design and production protocols followed NifTAL's broth dilution method for producing inoculant in sterilized carrier. GRAINCO produced 45,000 bags of inoculant in the first year of operation compared to 25,000 produced the previous year by the government facility. Yield increases from use of this inoculant range from 15%–172% depending on site. $116,149

Asia

Appropriate Technology International. NifTAL performed a project review of ATI's CIDA funded project to develop small-scale inoculant production capability and expand inoculant markets in Sri Lanka, Philippines and India. This project facilitated the introduction of NifTAL designed inoculant production technology and quality control methods including the purchase of U.S. manufactured equipment by producers. $10,000

BNF Industries. Provided assistance in design of a new inoculant micro-production unit based on NifTAL's culture dilution method. One production unit with new design exported.

Gujarat State Fertilizer Company. Provided assistance for new inoculant culture formulation to reduce fermentor operation costs.

World Bank/Tamil Nadu Agricultural University provided a research scientist to work on quality control methods for legume inoculant for six months. The scientist initiated a project for direct and rapid enumeration of live and dead rhizobia from inoculant carriers and liquid broth media. Several client inoculant producers have identified this capability as a priority. The project is ongoing and this project has provided fundamental information on the feasibility of microscopy methods to meet the specifications of inoculant producers. $23,400

CGIAR

Ecoregional Fund (ISNAR). The International Potato Center (CIP) was awarded $500,000 each in Peru and in Ecuador for three years for research linked to the SM CRSP program at Montana State University.

IRRI. Collaboration with IRRI has resulted in significant leverage of CRSP funds. NifTAL and the PDSS grants of the CRSP cost share salary for a senior scientist stationed at IRRI who coordinates field, lab and greenhouse research in S. and SE Asia. IRRI provides housing, local and regional transportation, post doctoral research staff, laboratory and field technicians and communications and logistical support at field sites. The opportunity cost of these inputs from IRRI is $120,000/year.

Middle East

World Bank/Government of Turkey Strategic Research Initiatives in Soil Microbiology. Technical assistance was provided to the General Directorate of Rural Services through a World Bank project. The project is designed to develop a new national soil microbiology research initiative. The project is ongoing and recommendations on program development will be summarized in next year's annual report. $16,000

Publications, Reports, and Presentations

The following is a listing of publications, reports and presentations made by participants and collaborators of the SM CSRP.

anon. 1998. Las propiedades físicas del suelo en análisis de use de la tierra desde datos de estudios de suelos hasta retencion de agua y conductividad hidráulica: Curso sobre análisis de las propiedades físicas del suelo y su aplicación en análisis del uso de la tierra (Soils Physical Properties Course Manual). 9-13 February, 1998. CIP-WAU-INIAP, Quito.

Antle, J., and C. Crissman. 1998. Linking Economic and Crop Growth Models for Environmental Impact Assessment. Research Discussion Paper (in preparation).

Antle, J., J. Stoorvogel and C. Crissman. 1997. TRADEOFF: A Decision Support System for Policy Decision Makers, Version 1. September 1997.

Antle, J.M., Stoorvogel J.J. & Crissman, C.C., 1998. Tradeoff assessment as a quantitative approach to analysis of the sustainability of agricultural production systems. In: Stoorvogel, J.J., Bouma J. & Bowen, W.T., 1998. *Information technology as a tool to assess land use options in space and time. Proceedings of an international workshop Lima, September 28- October 4, 1997.* Quantitative Approaches in Systems Analysis No. 16. DLO Research Institute for Agrobiology and Soil Fertility, The C.T. de Wit Graduate School for Production Ecology. Wageningen, The Netherlands: 63-76.

Aquino, B.F., L.F. Sobral, and F.R. Cox. 1998. Properties of Ultisols and Oxisols related to Mehlich-3 phosphorus buffer coefficients. Commun. Soil Sci. Plant Anal. (in review).

Cai, T.T., T.W. Olsen, R.S. Yost, and J.A. Silva. 1997. Performance indices for tests of soil nutrient status: extractable P. Commun. Soil Sci. Plant Anal. 28:329-339.

Chen, G., R.S. Yost, Z.C. Li, X. Wang, and F.R. Cox. 1997. Uncertainty analysis for knowledge-based decision-aids: application to PDSS (Phosphorus Decision Support System) Agricultural Systems 55:461-471.

Cox, F.R. 1998. Mehlich-3 phosphorus availability indices. Presented at the 5th International Symposium on Soil and Plant Analysis. Bloomington, Minnesota, August 2-7, 1997.

Cravo, M.S. and T.J. Smyth. 1998. Soil fertility management for sustainable cropping on an Oxisol in the Central Amazon. Rev. Bras. Ci. Solo 21:607-616.

Dierolf, T.S, L.M. Arya, and R.S. Yost. 1997. Water and cation movement in an Indonesian Ultisol. Agron. J. 89:572-579.

George, T. 1998. Nutrient decision-aids for the transition to high value production systems in erosion-free Asian uplands. Trans. 16th World Congress Soil Science (in press).

George, T. 1998. Nutrient decision-aids for the transition to high value production systems in erosion-free Asian uplands. Trans. 16th World Congress Soil Science (in press).

George, T., R.J. Buresh, J.K. Ladha and G. Punzalan. 1998. Recycling *in situ* of legume-fixed and soil nitrogen in tropical lowland rice. Agron. J. (in press).

Gladwin, Christina H. 1997. Targeting women farmers to increase food production in Africa. In S. Breth (ed.) *Women, agricultural intensification, and household food security,* pp. 55-71. Mexico City: Sasakawa Africa Association.

Gladwin, Christina H., Ken L. Buhr, Abraham Goldman, Clifton Hiebsch, Peter E. Hildebrand, Gerald Kidder, Max Langham, Donna Lee, Peter Nkedi-Kizza, and Deirdre Williams. 1997. Gender and Soil Fertility in Africa. In *Replenishing Soil Fertility in Africa,*

R. Buresh and P. Sanchez, eds. SSSA Special Publication 51. Madison, WI: Soil Science Society of America (SSSA).

Gladwin, Christina, Abraham Goldman, Alan Randall, Andrew Schmitz, and G. Edward Schuh. 1997. Are There Public Benefits to Private Use of Fertilizer in Africa? Paper presented at the 1997 meetings of the American Association of Agricultural Economists, Toronto, Canada.

Gladwin, Christina, and Anne Thomson. 1997. Food vs. Cash Crops: Which is the Key to Food Security for African Women Farmers? Paper presented at the 1997 meetings of the American Anthropological Association, Washington, DC, and the International Association of Agricultural Economists, Sacramento, CA.

Hossner, L. and A. Juo. 1998. Report on trip to Costa Rica, January 11-17, 1998. USAID Grant No. LAG-G-00-97-00002-00. SM CRSP IntDSS Project. 2p.

Hunter, D.J., L.G. Yapa, and N.V. Hue. 1997. Effects of green manure and coral lime on corn growth and chemical properties of an acid Oxisol in Western Samoa. Biol. Fert. Soils 24:266-273.

Jackman, J., R.C. Jones, and R.S. Yost. 1997. Predicting P sorption by soils from Rietveld refinement of XRD measurement of soil minerals. Soil Sci. Soc. of Am. J. 61:618-625.

Jallah, J.K. and T.J. Smyth. 1998. Assessment of rhizotoxic aluminum in soil solutions by computer and chromogenic speciation. Commun. Soil Sci. Plant Anal. 29:37-50.

Juo, A.S.R. and T.L. Thurow. 1997. Technologies for use and conservation of steeplands worldwide. Invited Presentation-*Proceedings of International Workshop on Sustainable Farming Systems in Upland Regions of Asia*. Asian Productivity Organization and Food and Fertilizer Technology Center for Asia and the Pacific Region. Tokyo, Japan. (16p. in press).

Kahindi, J.H.P, P. Woomer, T. George, F.M. de Souza Moreira, N.K. Karanja and K.E. Giller. 1997. Agricultural intensification, soil biodiversity and ecosystem function in the tropics: the role of nitrogen-fixing bacteria. Appl. Soil Ecol. 6:55-76.

Kirk, G.J.D., T. George, B. Courtois and D. Senadhira. 1998. Opportunities to improve phosphorus efficiency and soil fertility in rainfed lowland and upland rice ecosystems. Field Crops Res., (in press).

Kirk, G.J.D., T. George, B. Courtois and D. Senadhira. 1998. Opportunities to improve phosphorus efficiency and soil fertility in rain-fed lowland and upland rice ecosystems. Field Crops Res., (in press).

Kooistra, L. and E.W. Meyles. 1997. AA novel method to describe spatial soil variability: A case study for a potato-pasture area in the northern Andes of Ecuador. M.Sc. Report, Wageningen Agriculture University, The Netherlands and International Potato Center, Quito, Ecuador.

Li, M.B., N.V. Hue, and S.K. Hussain. 1997. Changes of metal forms by organic amendments to Hawaii soils. Commun. Soil Sci. Plant Anal. 28:281-394.

Linquist, B.A., P.W. Singleton, R.S. Yost, and K.G. Cassman. 1997. Aggregate effects on the sorption and release of phosphorus in an Ultisol. Soil Sci. Soc. of Am. J.61:160-166.

Magbanua, R. D. and T. George. 1997. Soil aggregation as a determinant of phosphorus availability in tropical upland soils. 1997 Annual Scientific Conference of the Federation of Crop Science Societies of the Philippines held at Hotel Supreme, Baguio City, 25-29 may 1997. *Abstract in*: The Phil. J. Crop Sci. 22: Suppl. No. 1. 34.

Magbanua, R. D. and T. George. 1997. Soil aggregation as a determinant of phosphorus availability in tropical upland soils. Paper presented at the 1997 Annual Scientific

Conference of the Federation of Crop Science Societies of the Philippines held at Hotel Supreme, Baguio City, 25-29 may 1997. *Abstract in*: The Phil. J. Crop Sci. 22: Suppl. No. 1. 34.

Olsen, P.E., E.S. Sande, H.H. Keyser, P.W Singleton and W.A. Rice. 1998. A very rapid enzyme immunoassay for confirmation of rhizobial identity and estimation of cell numbers in fresh broth culture. Can. J. Microbiology (accepted 1/7/98).

Osmond, D., S. Reid, and R.S. Yost. 1997. Decision-aids for integrated nutrient management, SEARCA seminar, Los Banos, The Philippines.

Rao, K.D. 1998. Effective incentives and chickpea competitiveness in India. M.S. Thesis, Cornell Univ. 235 pp.

Reichardt, W., A. Dobermann and T. George. 1998. Intensification of rice production systems: opportunities and limits. *In*: Dowling NG, Greenfield S.A., Fischer KS (eds) Sustainability of rice in the global food system. California (USA): Pacific Basin Study Center and Manila (Philippines): International Rice Research Institute. (in press)

Reichardt, W., A. Dobermann and T. George. 1998. Intensification of rice production systems: Opportunities and limits. *In: Dowling* NG, Greenfield SA, Fischer KS, eds. 1998. Sustainability of rice in the global food system. California (USA): Pacific Basin Study Center and Manila (Philippines): International Rice Research Institute. *In press.*

Reoma, V. L., Magbanua, R. D., Quirol, B. S. and T. George. 1997. Phosphorus effects on traditional upland rice production in the Philippines. 1997 Annual Scientific Conference of the Federation of Crop Science Societies of the Philippines held at Hotel Supreme, Baguio City, 25-29 may 1997. *Abstract in*: The Phil. J. Crop Sci. 22: Suppl. No. 1. 17.

Reoma, V. L., Magbanua, R. D., Quirol, B. S. and T. George. 1997. Phosphorus effects on traditional upland rice production in the Philippines. Paper presented at the 1997 Annual Scientific Conference of the Federation of Crop Science Societies of the Philippines held at Hotel Supreme, Baguio City, 25-29 may 1997. *Abstract in*: The Phil. J. Crop Sci. 22: Suppl. No. 1. 17.

Sanchez, P., A.M. Izac, R. Buresh, K. Shepherd, M. Soule, U. Mokwunye, C. Palm, P. Woomer, and C. Nderitu. 1997. Soil Fertility Replenishment in Africa as an Investment in Natural Resource Capital. In *Replenishing Soil Fertility in Africa*, R. Buresh and P. Sanchez, eds. SSSA Special Publication 51. Madison, WI: Soil Science Society of America (SSSA).

Sanzonowicz, C., T.J. Smyth and D.W. Israel. 1998. Hydrogen and aluminum inhibition of soybean root extension from limed soil into acid subsurface solutions. J. Plant Nutr. 21:387-403.

Schwartz, R.C., A.S.R. Juo, K.J. McInnes, L.P. Wilding and C. Cervantes. 1997. Water and solute movement in a steepland, fine-textured Ultisol. *USDA-NRCS Soil Survey and Land Resource Workshop*. College Station, TX. (abstract)

Scientists' Reports from the South Asian Regional Agricultural Scientist Exchange Program. 1997. P.R. Hobbs and C.A. Meisner (eds.) Cornell Univ. and Rice-Wheat Consortium Facilitation Unit.

Singleton, P.W., N. Boonkerd and J.R. Hollyer. 1998. The biological and economic implications of nitrogen fertilizer use in legume production. Phosphate Potash Institute, in press.

Singleton, P.W. and N. Boonkerd. 1998. Potentials and limitations of microbial inoculants for improved crop nutrition. Phosphate Potash Institute. In press

Smith, J.E. 1997. Assessment of soil and water conservation methods applied to the cultivated steeplands of southern Honduras. *M.S.*

Thesis. Texas A&M University, College Station, TX.

Smyth, T.J. 1998. Summary report of the program planning workshop: decision aids for integrated soil nutrient management project. Soil Management CRSP, 1-3 December 1997, Honolulu, HI. 55p.

Sobral, L.F., B.F. Aquino, and R.F. Cox. 1998. Mehlich-3 phosphorus buffer coefficients. Commun. Soil Sci. Plant Anal. (in review).

Somarriba, M. 1997. Soil erosion and conservation as affected by land use and land tenure, El Pital Watershed, Nicaragua. *M.S. Thesis*. Texas A&M University, College Station, TX.

Stoorvogel, J.J., Bouma J. & Bowen, W.T., 1998. *Information technology as a tool to assess land use options in space and time. Proceedings of an international workshop Lima, September 28- October 4, 1997*. Quantitative Approaches in Systems Analysis No. 16. DLO Research Institute for Agrobiology and Soil Fertility, The C.T. de Wit Graduate School for Production Ecology. Wageningen, The Netherlands.

Thapa, B.B., D.K. Cassel and D.P. Garrity. 1997. Assessment of tillage erosion rates on steepland Oxisols in the humid tropics using granite rocks. *International Symposium on Tillage Translocation and Tillage Erosion*. J. Soil and Water Conserv. 52:307 (abstract)

Thapa, B.B., D.K. Cassel and D.P. Garrity. 1997. Ridge tillage and contour natural grass barrier strips reduce tillage erosion. *International Symposium on Tillage Translocation and Tillage Erosion*. J. Soil and Water Conserv. 52:305 (abstract).

Thurow, A.P., H.E. Sierra, R.M. East and T.L. Thurow. 1998. Linkages between declining crop production and deforestation on tropical steeplands in Honduras. *Annual meeting of American Society of Agriculture Economists*. Amer. J. of Ag. Economics. (abstract -in press).

Thurow, T.L. 1997. Soil management practices for sustainable agriculture on tropical steeplands. USDA-NRCS Soil Survey and Land Resource Workshop. College Station, TX. (abstract)

Toness, A.S., T.L. Thurow and H.E. Sierra. 1998. Sustainable management of tropical steeplands: An evaluation of terraces as a soil and water conservation technology. *Soil Management CRSP Technical Report 98-1*. 46p. *Publications available in either English and Spanish*.

Tubana, B. S. and T. George. 1997. Seed phosphorus effects on the early growth of soybean under low phosphorus supply. Paper presented at the 1997 Annual Scientific Conference of the Federation of Crop Science Societies of the Philippines held at Hotel Supreme, Baguio City, 25-29 may 1997. *Abstract in*: The Phil. J. Crop Sci. 22: Suppl. No. 1. 32.

Tubana, B. S. and T. George. 1997. Seed phosphorus effects on the early growth of soybean under low phosphorus supply. 1997 Annual Scientific Conference of the Federation of Crop Science Societies of the Philippines held at Hotel Supreme, Baguio City, 25-29 may 1997. *Abstract in*: The Phil. J. Crop Sci. 22: Suppl. No. 1. 32.

van Soest, Francien. 1997. A method for downscaling soil information from regional to catena level. M.Sc. Report, Wageningen Agriculture University, The Netherlands and International Potato Center. 60 p + annex.

Video. 1997. Mechanical revolution on South Asia—The growing use of the Chinese Hand Tractor. Cornell Univ. and CIMMYT-Bangladesh.

Wade, L. J., T. George, J.K. Ladha, U. Singh, S.I. Bhuiyan and S. Pandey. 1998. Opportunities to manipulate nutrient by water interactions in rain-fed lowland rice systems. Field Crops Res., (in press).

Wang, Xinmin. 1997. Phosphorus sorption, desorption, and availability in Oxisols and Ultisols as influenced by soil aggregate size. Ph.D. Dissertation, Department of Agronomy and Soil Science, University of Hawaii at Manoa, Honolulu, Hawaii.

Wang, X., J. Jackman, R.S. Yost, B. Linquist. 1997. Predicting soil phosphorus buffer coefficients with soil potential phosphorus sorption sites and aggregation. (In review).

Williams, Deirdre. 1997. Gender and Integrated Resource Management: The Case of Western Kenya." M.S. Thesis, University of Florida, Gainesville, FL.

Yost, R.S., R. Caldwell, M. Constantinides, D. Herbert, and J.F. Fownes. 1997. The sustainability of agriculture and forestry production systems on soils with low pH. (Presented at the Fourth Symposium on Plant-soil reactions on soils with low pH, Belo Horizonte, Brasil). *Plant Soil Interactions at Low pH*, A.C. Moniz, (ed.) Brazilian Soil Science Society, Printed in Brasil.

List of Acronyms

ADEFOR	Asociacion Civil para la Investigacion y Desarrollo Forestal
AFS	Agricultural and Food Security Office, USAID
ATI	Appropriate Technology International
BARI	Bangladesh Agriculture Research Institute
BNF	Biological Nitrogen Fixation
BOD	Board of Directors
BRRI	Bangladesh Rice Research Institute
CIAT	Centro Internacional de Agricultura Tropical
CIDA	Canadian International Development Agency
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CIP	Centro Internacional de la Papa
CRDA	Centre de Recherche et de Documentation Agricoles
DSS	Decision Support System
EEP	External Evaluation Panel
EGAD	Economic Growth and Agricultural Development
EMBRAPA	Empresa Brasilerira de Pesquisa Agropecuaria Vinculada Ao Ministerio da Agricultura
ESPOCH	Escuela Politecnica de Chimborazo
IARC	International Agricultural Research Centers
ICAR	Indian Council of Agricultural Research
ICRAF	International Center for Research in Agro-Forestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IER	L'Institut d'Economie Rurale
IFDC	International Fertilizer Developmental Center
INIA	Instituto Nacional de Investigacion Agropecuaria
INIAP	Instituto Nacional de Investigaciones Agro-Pecuarias
INTSORMIL	International Sorghum and Millet CRSP
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
ME	Management Entity
MERC	Middle East Research Cooperation
NARC	Nepal Agriculture Research Council
NARES	National Agricultural Research and Extension Systems
NARS	National Agricultural Research Systems
NGO	Non-Governmental Organizations
NifTAL	Nitrogen Fixation of Tropical Agricultural Legumes
PADF	Pan American Development Foundation
PAU	Punjab Agricultural University, Ludihana, India
PARC	Pakistan Agricultural Research Council
PDSS	Phosphorus Decision Support System
PhilRice	Philippine Rice Research Institute
PI	Principal Investigator
PVO	Private Voluntary Organization
SECID	South-East Consortium for International Development
SMCRSP	Soil Management Collaborative Research Support Program
TC	Technical Committee
UNA	Universidad Nacional Agraria
UNC	Universidad Nacional de Cajamarca
USAID	United States Agency for International Development
WAU	Wageningen Agricultural University