Soil Management
Collaborative Research Support Program

Grant Extension Proposal

Global Plan

Volume 1

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EXECUTIVE SUMMARY

The goal of the Soil Management CRSP is to enable the food insecure developing countries Africa, Asia and Latin America to combat hunger, poverty and land degradation without further compromising the sustainability of their natural resource base. To achieve this goal the CRSP will join forces with other groups with similar goals, and contribute to the global effort by focusing on the following objectives:

1. Enable developing country institutions to adopt and apply information technology and knowledge-based tools to increase agricultural productivity.

2. Enable developing country institutions to scale-up technology adoption from local to regional scales.

3. Strengthen human and institutional capacity to combat poverty, land degradation and food insecurity.

Over the past five years, the CRSP has developed products and practices that can be adopted by farmers and policy makers to improve performance of the agricultural sectors. The products consist of (I) a decision aid for diagnosing and prescribing remedies for soil fertility problems, (2) an integrated suite of biophysical and economic models that enable policy makers to evaluate tradeoffs between productivity and sustainability, and (3) crop simulation models of the major food crops linked to modules to simulate the effect of crop and soil management on carbon sequestration. The CRSP practices include technologies that singly can increase rice and wheat yields by 15 to 40%, and often produce additive benefits when used in combination. These include practices that reduce soil pathogen and nematode population, rectify micronutrient deficiencies, and allow greater intensification of rice production by varying plant spacing, water control and fertilizer input.

To insure that its products, practices and training capabilities are effectively utilized, the CRSP will do the following:

1. Hold annual workshops with partners to formulate training and utilization strategies for the coming year.

2. Form alliances with partners from the public and private sectors to promote market and trade-based agricultural development.

3. Join forces with USAID Missions to achieve USAID strategic objectives.

4. Develop an interactive Internet site to publicize CRSP goals and objectives, response capability, progress and results.

The CRSP realizes that to make a difference it must form quality alliances with a diverse group of partners. It can form such alliances by partnering with groups that share common goals and perform essential but different functions.

The CRSP stands ready to support Missions achieve their objectives. It can do so by matching its strengths and capabilities with Mission priorities and needs. It will publicize its readiness to support the Missions through its website, publications, cognizant technical officer and direct communication with the Missions.

HISTORY

In 1981, the Soil Management CRSP was established as a collaborative effort among four U.S. universities, developing countries and USAID. 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 including 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 of its life included (1): developing local capacity for making and interpreting soil survey, (2) predicting outcomes of alternative soil fertility recommendations, (3) developing local capacity to produce, distribute and benefit from biological nitrogen fixation technologies, (4) improving technology for soil water conservation and use, and (5) improving methods for restoring degraded land for food production. Because of TropSoils' collaborative efforts, large areas of land in Latin America and South-East Asia, considered to be mantled with "problem soils" are being transformed into productive agricultural lands.

In addition, by 1996, 115 individuals from developing countries obtained advanced degrees from the four U.S. institutions. By the end of the fall semester 2001, that number will have increased by another 50. A listing of these students is provided in volume 3 of this proposal. These graduates form a rich source of talent for their home countries and will playa key role in the future work of this CRSP.

In 1990, three large AID-funded projects were administratively merged with the original CRSP partners. These new members included the NifTAL (Nitrogen fixation for Tropical Agricultural Legumes) project, the Soil Management Support Services project and the Technology for Soil Moisture Management project. The program, merger added to the problem of achieving integration of effort among the four institution and the three new partners. Although the Soil Management CRSP continued to receive high praise for its technical achievements, the signals from USAID contained reminders to restructure the CRSP so that all partners would operate as a coherent unit on common goals and objectives.

In 1995, USAID initiated a plan to restructure the Soil Management CRSP with a new focus on "Integrated Nutrient Management" and with a new set of participating institutions. A request for pre-proposals resulted in 54 submissions of which 19 were approved for development into full proposals. An external review panel selected seven proposals for the restructured Soil Management CRSP. Subsequently, an extension of the Soil Management CRSP provided the technical and administrative basis for implementing the restructured Soil Management CRSP in 1996.

THE RESTRUCTURED SOIL MANAGEMENT CRSP

Seven participating institutions were involved in the first phase of the restructured Soil Management CRSP including, Cornell University, the University of Florida, the University of Hawaii, Montana State University, North Carolina State University, Texas A&M University, and the University of Vermont. Florida, Montana and Vermont had no prior association with this CRSP. The University of Hawaii was elected to serve as the Management Entity by the principal investigators on March 12, 1996 at a group meeting in Raleigh, North Carolina. The new Management Entity assumed responsibility for organizing the first grant proposal.

Researchers from the seven universities and their collaborating institutions and organizations proposed to do research on five soil constraints identified by an independent panel of experts. The five constraints were as follows:

1. Nitrogen management, especially technologies that improve nitrogen use efficiency;

2. Phosphorus management, especially decision aids to promote enlightened fertilization policies and technologies that increase efficiency of use of phosphorus amendments;

3. Acidity management, especially decision aids that help apply current knowledge to soil management;

4. Management of water deficiencies, especially through better understanding of the interactions between nutrient management and water use efficiency;

5. Erosion and land degradation.

The titles of the seven projects, the Principal Investigators and the lead institutions responsible for the projects are listed below to show the range of approaches proposed to deal with the constraints.

1. Decision aids for integrated nutrient management; T. Jot Smyth; North Carolina State University.

2. Sustainability of post-green revolution agriculture: The rice-wheat cropping system of South Asia; John Duxbury; Cornell University.

3. Tradeoffs in sustainable agriculture and the environment in the Andes: A decision support system for policy makers; John Antle; Montana State University.

4. Soil management practices for sustainable production on densely populated tropical steeplands; Tom Thurow; Texas A & M University.

5. Improved agricultural productivity through biological nitrogen fixation technology and legume management; Paul Singleton; NifTAL Center, University of Hawaii.

6. Gender and soil fertility; Christina Gladwin; University of Florida.

7. Ecological soil management in Israel and Palestine; Frederick Magdoff; University of Vermont.

The matrix shown in Table 1 indicates that all five constraints would receive adequate coverage in the first five years.

Table 1. Constraints by projects matrix with (**1**) Decision Aids for Integrated Soil Nutrient Management, (**2**) Soil Management Practices for Sustainable Production on Densely Populated Steeplands, (**3**) Tradeoffs between Sustainable Agriculture and the Environment in the Andes: A Decision Support System for Policy Makers, (**4**) Sustainability of Post Green Revolution Agriculture: The Rice-Wheat Cropping System of South Asia, (**5**) Improved Agricultural Productivity through Biological Nitrogen Fixation Technology and Legume Management, (**6**) Gender and Soil Fertility, and (**7**) Ecological Soil Management in Israel and Palestine.

Constraints/ Projects	Nitrogen	Phosphorus	Acidity	Water	Soil Degradation
1	X	X	X		
2	X	X	X	X	X
3	X	X		X	X
4	X			X	
5	X	X	X		X
6	X	X	X		
7	X	X		X	X

The contractual start date of the restructured Soil Management CRSP was February 11, 1997, nearly 4 months after submission of the grant proposal. The level of funding available to the SM CRSP was substantially less than that proposed for 7 projects. To address each of the constraints adequately, projects 5 and 6 received partial funding relative to their proposed budgets. In consultation with the Office of Agriculture, Project 7 was moved to another program, and Projects 1 to 4 and the ME reduced their first year budgets and work plans to accommodate the partial funding to Projects 5 and 6.

ACCOMPLISHMENTS

The following are the accomplishments by projects from 1997 to mid-2001.

MONTANA STATE UNIVERSITY

Project Title: Tradeoffs in sustainable agriculture and the environment in the Andes: A decision support system for policy makers.

The principal accomplishment of the Tradeoffs Project was the development of a policy decision support system known as Tradeoff Analysis (TOA), and corresponding software for its implementation, the Tradeoff Analysis Model. This system is designed to enhance the capability of policy decision makers to assess the impacts of changes in policy and technology on the sustainability of agricultural production systems. This software integrates disciplinary data into standard geo-referenced formats, and provides a modular capability to link existing disciplinary simulation models to support the TOA method.

Other accomplishments include:

- Application of Tradeoff Analysis in Ecuador and Peru to test its capabilities and to provide various stakeholders information in relation to critical policy issues in their respective regions.
    - Analysis in Ecuador, in collaboration with local non-governmental organizations, provincial governments, and national agricultural research institutions (INIAP) addressed long-term impacts of tillage erosion on soils and productivity, and impacts of pesticide use and improved pest management technologies on environmental quality and human health.
    - Analysis in Peru, in collaboration with local non-governmental organizations, and the national soil conservation program (PRONAMACHCS) addressed the economic and environmental impacts of terracing and agro forestry investments.
- Collection of data and development of related models and methods to support use of Tradeoff Analysis, including:
    - support of local institutions for collection of critical soils, climate, and related bio-physical data needed to assess sustainability of agricultural production systems
    - development and calibration of DSSA T crop models, pesticide leaching models, soil erosion models
    - methods for up-scaling and downscaling climate and soils data to support application of quantitative models.
- Development of a research and outreach program on environmental and human health impacts of pesticide use, through additional funding from IDRC and collaboration with the IPM CRSP. This research developed important new information about environmental fate of highly toxic pesticides in the Andean environment, and utilized collaborating

farmers in farmer field schools to develop improved methods to mitigate human health impacts of pesticide use. Two innovative new methods were:
    - the use of fluorescent tracers to demonstrate the widespread exposure of farm workers and farm family members
    - the development of funding mechanisms to help farmers acquire protective equipment.

- Training of students and scientists in Ecuador and Peru. Accomplishments include:
    - workshops to train national scientists in soil science methods
    - workshops to train national scientists and collaborators in the use of the Tradeoff Analysis methods and software
    - supported training of 6 B.S., 5 M.Sc. and 3 Ph.D. students.

NORTH CAROLINA STATE UNIVERSITY

Project Title: Decision aids for integrated nutrient management

Nutrient Management DSS Developed - the Nutrient Management Support System (NuMaSS) is a Windows 9xINT-compatible software to assist in soil acidity, nitrogen and phosphorus management decisions for crops in tropical regions of Africa, Asia and Latin America. Assistance in nutrient management decisions to grow a crop under user-specified field conditions is provided through three software modules. The *Diagnosis* module addresses the question of whether acidity, nitrogen or phosphorus problems exist based on observations provided about geographical location, climatic conditions, soil type, previous crop yield and nutrient management, nutrient deficiency symptoms and indicator plants. Soil and plant analytical data are considered, if available, but are not required. The *Prediction* module recommends lime and nutrient inputs to correct identified acidity, nitrogen and phosphorus problems that could limit achievement of the yield level specified by the user for the selected crop. Lime and fertilizer recommendations provided by NuMaSS account for differences in available nutrient sources and nutrient requirements among crop species and cultivars, but user input of a minimum soil analytical data set is required. The soil analysis data are restricted to measurements that are determined on a routine basis by soil testing laboratories. With user input of commodity prices and lime/fertilizer costs, the *Economics* module estimates net returns to applied nutrients. Users can compare different types of elemental fertilizers, available commercial blends and organic sources. For each combination of nutrient sources, NuMaSS will estimate amounts of inputs for either the best profit or the best yield. Economic estimates can also be constrained by specifying a maximum amount of fertilizers to be applied or a given amount of cash to be invested in fertilizers and application costs. For each of the various user-selected scenarios NuMaSS estimates whether there will be a surplus or deficit in applied lime, nitrogen and phosphorus.

NuMaSS Benefits to U.S. Agriculture - Agricultural issues in the State of North Carolina have benefited from development of NuMaSS. Regulations established in 1998 for the Neuse River Basin in North Carolina required that all pollution sources (point and non-point) reduce nitrogen (N) loading into the Neuse Estuary by 30%. Agriculture is believed to contribute over 50% of the total N load to the river. In order to reduce these N inputs, agricultural best management practices (BMPs) are necessary to control the delivery of N from agricultural fields to water resources. Producers were given a choice: either use standard BMPs or join a local area committee (county group) and as a county, reduce N loads by 30%. In order to track these 30% reductions by each county, an accounting and tracking tool had to be developed. This tool, Nitrogen Loss Estimation Worksheet (NLEW), was developed to track N reductions due to BMP implementation, including nutrient management. NLEW uses a modified N-balance equation that accounts for some inputs as well as N reductions from BMPs at both field- and county-scale levels. The tool is used by each county in the Neuse River Basin to determine which BMPs are needed and the farmers who must implement them.

Much of the programming structure and the N mass balance approach for NLEW were adapted from NuMaSS. Some of the program algorithms and databases for NLEW were also taken directly from NuMaSS. The time and cost for development of NLEW was minimized by the application of information in NuMaSS. Currently, NLEW is under review by agencies in several states where total maximum daily nutrient loads have been imposed on particular water resources. USDA-NRCS is also reviewing NLEW as a potential accounting tool for N.

Impacts in Africa, Asia and Latin America - project activities in collaboration with the 'Institut d'Economie Rurale' staff in the Sahel region of Mali focused on crop productivity potentials from improved nutrient management in an agricultural region were nutrient inputs are traditionally restricted to the recycling of composted mixtures of crop residues and animal manures. On-farm trials have documented increasing deficits in soil nutrient reserves with traditional farming practices and the nutrient inputs that would be required to sustain a neutral balance with annual nutrient exports and losses. Initial surveys revealed that 25% of farmers supplemented compost applications with purchased fertilizers in millet production to ensure annual household stocks of this food staple. A recent survey in the project's fifth year revealed that nearly all farmers are supplementing their traditional field applications of compost with purchased fertilizers. The primary reasons given by farmers for their increased use of fertilizers were the increased crop productivity on their limited land area, thus reducing their costs in crop establishment and management to achieve their desired household production goal.

The Philippine Rice Research Institute, in collaboration with the CRSP, has broadened their scope of public service from paddy rice production to crop production in upland regions with acid, nutrient poor soils. Interest of farmers and agricultural agents in the successful production of corn, peanut, soybean, mungbean and upland rice in the Ilagan to Isabela region of Luzon island, via NuMaSS project activities, have led PhilRice to apply similar nutrient management technologies to research and development efforts with upland farming areas on other islands in the Philippines. Recent updates in national soil survey information have also revealed that land area under acid, infertile soils are considerably larger than previously estimated, thus, increasing the potential for application of the soil nutrient management technologies and approaches developed through the CRSP project.

Peach palm is a native food tree of Latin American humid tropical regions, wherein cultivation for heart-of-palm production in over 40,000 hectares provides a viable cash crop option for smallholder farmers in response to a growing international market demand. As a non-traditional crop, there is limited information and access to the knowledge needed to diagnose soil nutrient limitations and prescribe agronomically and economically sound corrective strategies. Project collaboration with investigators in Brazil and Costa Rica has focused on development and assembly of knowledge on agronomic traits, nutrient requirements and management options for this crop. Comparison of our findings with current practices suggest that lime, nitrogen and phosphorus inputs for heart-of-palm production can be significantly reduced, thus minimizing both farmer costs and potential risks of nutrient pollution.

TEXAS A&M UNIVERSITY

Project Title: Sustainable soil management for densely populated tropical steep lands

Conversion of tropical steep lands for cropping and grazing has, in many instances, led to landslides upstream and flooding and sedimentation downstream. Major research achievements by the Soil Management CRSP in Central America and Caribbean region are summarized as follows:

1. The risk of soil erosion on sloping lands differs according to slope and soil type. The major form of soil erosion affecting Alfisols and Inceptisols derived from quartz-rich parent materials are block slumping and landslide. In collaboration with INTSORMIL and the USAID Mission supported national extension project, LUPE, SM CRSP scientists have evaluated and promoted soil conservation technologies that could help anchor the topsoil using biophysical means including terraces stabilized by Vetiver grass or fruit and fodder trees, and by rock retention walls. In Nicaragua and Haiti, the highly permeable Andisols derived from volcanic ash and Mollisols and Alfisols derived from limestone and basalts are less vulnerable to erosion. Best soil management practices on such soils in minimum tillage. Contour grass or tree barriers are recommended to prevent gradual movement of soil downhill. Benchmark watershed sites were established in Honduras and Nicaragua with the dual purposes of research and demonstration. The sites were widely used by Central American national extension and NGO workers and students as a field laboratory.

2. Because soil slumping is the primary cause of soil erosion on steep slopes, research on farmlands with slope ranging from 20 to 60 % in Honduras and Nicaragua have shown that the small USLE erosion plots (0.004 ha) are unsuited for soil erosion prediction at watershed level. Thus, large erosion plots or catchments (i.e. 0.2 ha of larger) are recommended.

    a. In Haiti, severely eroded farmlands are widespread and the most important task of soil management is rejuvenation of soil fertility. SM CRSP scientists in collaboration with NGO workers screened over 30 soil conserving tree species for alley cropping. At low altitude, *Leucaena leucocephala* and *Gliricidia sepium* are among the best N sources. One pruning of these species yielded about 70 kg of N per ha within 8 weeks of growth. *Delonix regia* is unpalatable to ruminants, which makes it advantageous in areas with free-grazing livestock during the dry season. In mid-elevation (900 - 1200 m), *Acacia angustissima* produced highest amount of biomass and N yield (40 kg N per ha in 8 weeks).

    b. Socioeconomic studies explored (i) the linkages between steepland soil erosion and downstream sedimentation and (ii) the per hectare cost of extension programming to support the adoption of three conservation technologies (rock wall, Vetiver grass barrier and mulching). The first study sought to broaden the policy justification for soil conservation by demonstrating the costs of sedimentation to one important group of downstream stakeholders, namely, the commercial shrimp producers. The accounting for downstream costs of steepland erosion makes a strong case for increased public support extension programming t support subsistence farmers to adopt soil conservation technologies. The costs per ha of promoting each of the three conservation technologies and the cost per ton of soil saved for each were estimated.

3. GIS analysis based on physical landscape attributes and remote sensing-based vegetation and landslide (associated with hurricane Mitch) data was conducted to (a) evaluate the effect of landscape-scale factors on landslide risk and (b) develop GIS-based models for predicting landslide risk. Our results showed that the likelihood of landslide was significantly influenced by slope: it was low on gentle slopes, increased sharply on moderately steep slopes, and peaked on steep slopes. The likelihood of landslide was generally high in areas under bare soil, crops, and grass fallows while low in shrub fallows and very low in forests. As slope increased, the percentage of land affected by landslides increased sharply in crop areas and bare soil areas, indicating that agricultural activity and removal of permanent vegetation increased the risk of having landslides in steep lands. Shrub fallow and forests had a low incidence of landslides. They seemed to offer a protective cover to the landscape and thus reduced the percentage of land affected by slumps. The GIS model of landslide risk is being developed based on data from the Namasigue (67.3 km^2) watershed were validated in the El Triunfo watershed (47.2 km^2).

4. A GIS model of topographical distribution of soils based on landform attributes derived from digital elevation model (DEM) is being developed based on a synthesis of the extensive fieldwork conducted by Wilding's group that revealed consistent trends in topographic distribution of soils in the steeplands in our study sites in Honduras. This model has been used with the database of the carbon storage and profiles of soils in the steep lands sites developed by Wilding's group, as well as the GIS model of landslide risk, to (1) estimate the quantity and spatial distribution of carbon sequestration in watersheds, (2) evaluate the impact of landslides on carbon sequestration, and (3) help develop spatially explicit soil conservation strategies to enhance carbon sequestration.

5. The project trained ten M.S. and Ph. D degree students and nine non-degree technicians.

6. Five SM CRSP technical publications (in English and Spanish) were distributed to a large number of users including extension workers, policy makers and researchers. Titles of the publications are: (a) Assessment of soil and water conservation methods applied to cultivated steeplands of southern Honduras, (b) Sustainable management of tropical steeplands: an assessment of terraces as a soil and water conservation technology - a review, (c) Soil erosion and conservation as affected by land use and land tenure in El Pital watershed, Nicaragua, (d) A watershed-level economic assessment of the downstream effects of steepland erosion on shrimp production in Honduras, (e). Linkage between investment extension services and farmer's adoption of soil conservation practices in southern Honduras.

7. Participating institutions: Texas A&M University, Auburn University, North Carolina State University, Pan American School of Agriculture, Honduras, National Agricultural University of Nicaragua, and Center for Agricultural Research and documentation, Haiti.

UNIVERSITY OF HAWAII-NIFTAL CENTER

Project Title: Improved agricultural productivity through biological nitrogen fixation and legume management

Accomplishments of the project include the following:

- Developed a new liquid inoculants formulation (G5) that improved the performance of *B. japonicum* at 65% of the materials cost of earlier generations and less than half the cost of conventional products.

- Developed a laboratory bioassay measuring survival of *B. japonicum* on seed as a predictor of inoculants performance in drought and heat stressed soil.

- Identified strains of *B. japonicum* with improved survival after inoculation.

- Determined that culture age had little effect on survival characteristics of *B. japonicum.*

- Developed a method to enumerate viable and dead bradyrhizobia in peat inoculants using direct microscopic evaluation, reducing the time required to evaluate inoculants quality from 5 days to several hours.

- Developed a database of inoculants producers.

- Communicated our research results to 102 inoculants producers and scientists in 36 countries.

- Developed experimental protocols to test our new inoculants and quality control technologies. Formed a network of 24 producers and agronomists in 16 countries to evaluate our formulations and quality control methods.

- Provided network participants with standard materials (media components, strains, and antisera) to conduct trials and provided six with some financial support.

- Provided technical assistance to collaborators in strain identification, quality control of local inoculants and experimental design and procedures.

- A new generation of liquid soybean inoculants (G6) reached 3 X 10^{10} cells/mL under experimental conditions that is 5-10 times that of normal YM media.

- Our two prototype liquid media (G5 and G6) support cell numbers in excess of 1 x 10^9 mL^{-1} when stored for six months at 25 C comparable to the best peat inoculants.

- With the protecting additive polyvinylpyrrolidone (PVP), the G6 media reduced the rate of cell death after application to seed by 50% compared to G5 media. The G5 and G6 with PVP media increased cell survival on seed by 100-fold compared to cells with no protecting additives.

- Results from the first network field trials of 42 experimental comparisons demonstrated the G5 formulation nodulated legumes more prolifically (freq. = 77%) and increased seed yield 68% of the time compared to local inoculant products (see Table 1. below).

- Discovered common antifoam agents used in large-scale production of rhizobia limit cell growth.

- Determined optimum airflow and agitation rates for producing liquid media.

- Preliminary evaluation of several common gums indicates some may have protective activity approaching that of PVP.

Table 1. Field Performance Summary of G5 Inoculants Formulation Compared to Uninoculated Control and Local Inoculants Products (Network Trial 1)

	Response of G5 inoculant above:			
	Control		Local Inoculant	
Response Indicators:	Relative frequency	Percentage Increase	Relative frequency	Percent Increase
		%		
Seed Yield[1]	100	92	68	7
Total Seed N	100	126	53	3
Nodule no.	100	>1000	74	21
Nodule wt.	100	>1000	68	10

- Communicated our research results in a second research report to 127 inoculant producers and scientists in 36 countries.

- Developed new experimental protocols to test our next generation (G6) liquid inoculant formulation.

- Provided technical assistance to collaborators in strain identification, quality control of local inoculants and experimental design and procedures.

- Agreements were reached with 20 collaborators in 16 countries to conduct a second network field trial to evaluate the performance of G5 and G6 liquid inoculants compared to a sterile Canadian peat based carrier. Trial data (29 comparisons of each liquid with a sterile Canadian peat-based carrier product and un-inoculated control) showed our G5 and G6 liquid products increased average seed yield by 760 kg/ha and 733 kg/ha above un-inoculated controls and 130 kg/ha and 102 kg/ha above the sterile peat carrier product (see tables 2-5 below).

- Nodulation measurements followed a similar trend as yield except the G5 inoculant produced an average of 5.1 kg nodules/ha less than the peat formulation.

- The frequency of responses to inoculation observed with the G5 and G6 formulations were 100% and 97% compared to the un-inoculated controls and 61 % and 61 % compared to the peat based product.

Table 2. Seed Yield and Nodulation Response to Inoculation with NifTAL's

Liquid Formulations (G5 & G6) and a Sterile Peat-Based Formulation (Network Trial 2)

Response Indicator	Uninoculated Control	Formulation		
		G5	G6	Peat
Seed Yield (kg/ha)	1318	2078	2050	1933
Nodule wt (kg/ha)	20.3	80.7	87.3	82.8
Nodule no. (millions/ha)	2.5	7.9	8.4	7.2

N=29 sites X strain combinations except for Peat treatment N= 28

Projected Impact:

Results *from* the network field trials show an expected yield increase of 6% above local products in the market and an increase of 90% compared to uninoculated crops. If this product is adopted in existing inoculant markets we can expect an average yield increase of98 kg/ha worth approximately $24.50 U.S. (based on 1991 yields and Rotterdam prices) compared to local inoculants. If we assume this product is adopted by 5% of inoculant producers and since soybean inoculants penetrate about 45% of the potential market then the aggregate marginal yield increases in LDC's could be as much as 68,000 metric tonnes worth $16.7 million U.S. Potential gains on other legumes could be as large.

CORNELL UNIVERSITY

Project Title: Sustainability of post-green revolution agriculture: The rice-wheat cropping system of South Asia

The overall goal of the project was to identify and address factors that threaten the sustainability of the rice-wheat cropping system, which provides staples *for* 20% of the world's population. Secondary objectives were (i) to simultaneously improve the cropping system as a source of nutrients *for* people, with emphasis on micronutrients because deficiencies of these have grown to epidemic levels with the green revolution, and (ii) to enhance the capacity of national programs to address sustainability issues in the cropping system.

The project focused on the Indo-Gangetic Plains (IGP) region of S. Asia, but was largely restricted to working in Bangladesh and Nepal due to US government sanctions against India and Pakistan. The following are generalized accomplishments relative to soil management in the rice-wheat system and project goals:

1. Rice is more vulnerable than wheat. Analysis of long-term nutrient management experiments across the IGP and district level production data from Punjab and Haryana Sates in India showed that declining yields in experiments, and stagnating and possibly declining farm productivity, were mostly associated with rice. This result is surprising because puddling of the soil for rice leaves a poor soil physical condition for wheat, especially in finer textured soils.

2. Poor soil biological health is the greatest soil constraint to productivity in the rice-wheat cropping system in South Asia. This conclusion was reached from more than seventy soil solarization diagnostic trials on farms and research stations. In this technique, moist soil is covered with clear plastic for several weeks and heated by solar radiation to temperatures that kill pathogens and nematodes. It is estimated that overcoming soil borne pathogen and nematode problems could increase crop yields by 50 % or more. Although every site that was evaluated was responsive to soil solarization, the technique is not practical for large areas of land, and alternative strategies to accomplish the same outcome need to be developed. This will likely require a long-term research effort utilizing molecular and other methods to better characterize soil microbial and nematode communities, and shifts in community structure and function in response to soil solarization and alternatives to solarization. However, the concept of producing "healthy rice seedlings" by solarization of nursery soil and/or seed treatment with fungicide is practical and proved very worthwhile. Use of healthy seedlings, without any other change in practice, increased rice yields by 20-40 % on farms in Bangladesh and resulted in new farmers asking to be taught the technology. Solarization proved to be the more important of the two technologies used. The "healthy seedling concept" is being extended in Bangladesh through NGO's; CARE for rice, and the Bangladesh Rural Advancement Committee (BRAC) for vegetable seedlings. The latter application began as a farmer initiative after dramatic responses to tomato seedling survival and growth were observed in solarization trials that had a rice-vegetable rotation.

3. Micronutrient deficiencies are prevalent in Bangladesh and Nepal, and reduce yields of rice, wheat and grain legumes. Key micronutrient deficiencies are boron, zinc and molybdenum. Most farmers do not know that Zn and Mo deficiencies are a problem because deficiency symptoms hardly exist for rice and wheat, and soil testing for these elements is not widely available. *In vivo* seed enrichment was used to combat deficiencies of Zn and Mo; this unusual approach was selected because it reduces the need for widespread application of micronutrients to soil, and it has the potential to increase seedling resistance to soil borne pathogens. Seedling emergence, vigor and root health of wheat were dramatically improved using micronutrient-enriched seeds. Without targeting micronutrient deficient areas, the seed enrichment technology was shown to increase wheat yields on farms in Bangladesh by an average of24 % (0.69 t/ha) with a frequency of one in every four trials (total of 47 carried out over four years). Similarly, yields of BR 32 rice, a newly released, short duration aman (monsoon) season variety, were increased by up to 40 % in 17 of 24 on-farm trials carried out over two years. Seed enrichment was also often found to be more effective than soil application of micronutrients.

   Boron deficiency was addressed in other ways because seed could not be enriched naturally with this element. Boron deficiency is a major cause of crop sterility and has soil, weather, and genetic components. A large percentage of soils analyzed from national rice-wheat research sites in Bangladesh and Nepal were found to be below the critical level for B. Both soil and foliar applications of B successfully overcame B deficiency at highly deficient sites. Response to B application at these sites and a shading technique to simulate fog were two approaches used to screen wheat germplasm for genetic susceptibility to sterility, and were incorporated into national breeding programs after genetic susceptibility was found in a significant number of breeder lines. Similarly, it was shown that a number of newly released varieties of both rice and wheat in Bangladesh were susceptible to Zn and Mo deficiencies and breeding for micronutrient efficiency was initiated in the national breeding programs in Bangladesh.

4. Novel approaches to rice production have great potential to improve both rice and cropping system productivity together with increased N and water use efficiencies. The latter is especially critical in the higher yielding areas of the IGP where groundwater resources are being used in a non-sustainable manner. The new techniques challenge conventional wisdom that the paddy is an optimal environment for rice production.

   The system of rice intensification (SRI) uses a single seedling at wider than conventional spacing without continuous flooding. Yields of up to 16 t/ha are claimed for this technique. In our experience, yields were increased by 15-40 % and crop lodging was eliminated, potentially allowing higher N inputs and greater yields as lodging prevents the yield potential of current varieties from being achieved. Moreover, additional yield increases can be expected as other management practices are optimized for the SRI method. Conceivably, rice yields can be doubled at a country scale while conserving resources.

   Permanent raised beds with furrow irrigation and without flooding led to increases in yields of all three crops in a rice-wheat-mungbean rotation on a heavy textured soil, and to increases in wheat and mung bean yields with similar rice yields on a light textured soil. Yield increases for the individual crops ranged from 20-40 % and system productivity was substantially enhanced. Most importantly, irrigation water use was reduced by 40-50%, higher yields were achieved at lower N inputs, and weed pressure was reduced for all crops in the rotation compared to conventional practices on flat land. Yields and input use efficiencies may be increased further as management practices are optimized.

5. The success of the green revolution with cereal production in S. Asia has been accompanied by a decline in the production and availability of grain legumes (pulses), leading to imbalances in the supply of essential amino acids and deficiencies of mineral micronutrients (principally Fe and Zn and possibly also Cu) in human diets. An analysis of declines in grain legume (chickpea) production in northwest India showed that government price support policies for cereal and oil crops coupled with high risk associated with chickpea production were the principal reasons for the large decrease in the land area used for production of this crop. Research to improve pulse productivity is beginning to show returns in the latter phases of the project, especially for mungbeans where improved short duration (60-70 days) varieties are coupled with production on raised beds to avoid excessive moisture and associated disease pressures with traditional flood irrigation on flat soils. Seed treatments with fungicides and bio-control fungi to improve stand establishment coupled with micronutrient fertilization (especially B) are also showing returns with chickpea and lentil. The best yields of pulses achieved by the project are still in the 1 to 1.5 t/ha range, but this would be a substantial improvement over average yields of around 0.5 t/ha averages, provided that yield stability can also be achieved. Continued research effort on grain legume productivity is essential if agriculture is to address negative human health outcomes associated with current food systems in the region.

6. Capacity building was addressed through a variety of conventional approaches including degree programs, short-term trainings, support of traveling seminars in different zones of the IGP, scientist exchanges within the region, participation in American Society of Agronomy and International Society meetings, annual CRSP review and planning meetings, upgrading computer and laboratory analytical capabilities, and use of newer technologies such as geographic information systems (GIS). Most importantly, emphasis was placed on multidisciplinary participation in planning and implementation of projects. Collaborations between major institutes such as BARI and BRRI in Bangladesh were

achieved and for now, at least are self sustaining. Rice scientists are making significant contributions to soil fertility issues in wheat and wheat scientists initiated the work on effects of soil biological health on rice productivity. Research programs have moved from research centers to farmer fields and farmer participatory research approaches are slowly becoming accepted. None of this has occurred without frictions and disputes, but progress has exceeded our expectations. National scientists have contributed as much as Cornell and International Center scientists to the program, which has been a true partnership.

Some specific accomplishments in relation to the soil nutrient and acidity constraints targeted in the SM-CRSP program were:

A. Nitrogen Deficiencies

Nitrogen: Technologies to improve returns to N inputs and N use efficiency in the rice wheat system were identified. Use of straw mulch in the rice paddy lowered floodwater pH and reduced N losses by ammonia volatilization. Rice yields at 60 kg with mulch were the same as those achieved at 120 kg N/ha without mulch. An identical result was obtained when wheat was grown on raised beds with furrow irrigation to reduce N leaching losses, and maximum yield was increased from 3.5 to 5 ton/ha. Adoption of these technologies will increase rice and wheat yields of resource poor farmers who use low N inputs and will reduce N inputs in high yielding areas where fertilization rates sometimes exceed recommendations, e.g. Punjab State, India. These technologies increase crop productivity, economic return and have environmental benefits.

Phosphorus: Phosphorous efficient wheat lines have been identified in Bangladesh. This breeding program is expected to lead to reduced needs for inputs of P fertilizer, which is an expensive import for Bangladesh and Nepal, is not always available or affordable for farmers and may be of questionable quality.

Potassium and Zinc: Widespread deficiencies of K and Zn, affecting both rice and wheat, were documented in the Nepal Terai. Deficiencies of these elements were related to soil texture and a GIS based strategy for targeting nutrient management programs to high return environments was developed. Similarly, K deficiency was identified in Bangladesh. Soil fertility survey data has documented the generally low fertility conditions in rice-wheat production areas in Bangladesh and Nepal, and data is being analyzed within a GIS framework.

B. Soil Acidity

Experiments have demonstrated yield responses in the range of 15-25 % to liming of acid soils in Bangladesh for both rice and wheat. Interactions between liming and Zn and B confirm concerns that liming would exacerbate micronutrient deficiencies. Nevertheless, a properly implemented liming program has high potential impact since 50 % of the soils in Bangladesh, and many areas in Nepal are acid. Liming is essentially not currently practiced in Bangladesh and Nepal.

Perhaps the most important outcome from the project is its demonstration of the need for soil management research to be more strategically developed and applied within a multidisciplinary context both within and beyond soil science. Our work on soil biological health and the more traditional areas of soil management, such as tillage and nutrient management, emphasized the need to focus on problems on identification of critical constraints to crop productivity, whether biophysical or otherwise. For example, use of deep tillage to reduce soil compaction and promote deeper rooting increased wheat yields by 15-25 %, however soil solarization increased yields by up to 65 % (from 3 to 5 tons/ha) and eliminated the tillage effect. Similarly, on-farm research showed that applying fertilizer according to a soil test based recommendations could increase farmer wheat yields up to 30 %, but greater yield increases were achieved in soil solarization trials with current nutrient management. The same research also found that high yield variability amongst farms persisted despite following the best nutrient recommendations. Addressing this issue was at least as important as improving nutrient recommendations, and involved non-soil constraints.

The project also identified a fairly large number of technologies (not all discussed here) that individually increased yields of rice and wheat in the range of 15-40 %. Combining technologies has the potential to obtain additive and synergistic interactions that could increase crop yields more dramatically. For example, the effects of soil solarization and vitavax seed treatment on the performance of "healthy rice seedlings" were additive. Many other combinations of technologies are possible. Unfortunately, too much of the soil management research being carried out on the rice-wheat system remains ineffective as it is take a single factor approach in traditional areas for small returns.

UNIVERSITY OF FLORIDA

Project Title: Gender and soil fertility

To achieve project objectives at a number of locations in Africa, the following were accomplished over the past 5 years.

A. Soil Fertility Depletion: Monitor progress of agricultural projects in Ethiopia, Kenya, Malawi, Mali, Senegal, Uganda, and Zambia to document:

1. What effects soil fertility depletion in Africa has had on farmers' yields, incomes, and quality of life in these countries; a summary report on these effects from well over 1000 interviews with farmers in their fields and homes in different geographic regions of each country is being assembled.

2. What soil fertility amendments are adoptable or adaptable by small-scale farmers, including female headed households (FHH); a report on monitoring "naturally-occurring" experiments conducted by governments and NGOs to encourage adoption and adaptation of practices related to soil fertility replenishment is planned at the end of the 5 years.

Results to date from activities in Africa indicate the following:

- African farmers are too well aware that their soils are depleted

- Nutrient-management model shows farmers are aware they are losing essential nutrients when they switch from high-protein cereals like maize to lower-protein root crops like cassava.

- Men farmers in male-headed households (MHH) do adopt and adapt but to a lesser extent;

- Female-headed households do *not.* (The *only* solutions that are now being adopted by FHH s on a significant scale are agro forestry innovations in the form of *improved fallow* (IF) developed by ICRAF).

B. Improved Fallow: In an era of dismal reports and horror stories about Africa (prevalence of AIDs, corruption, weak governments), improved fallow technologies are a true African success story. Improved fallow technologies with various tree species *(Sesbania sesban, Tephrosia vogelee, Gliricida sepium)* have been tested and evaluated at the Msekera Research Station in Eastern Zambia by ICRAF since 1988, and in 1992/93 some on-farm trials of the improved fallows (IFs) began. Improved fallow plot, ranging from 10 meters by 10 meters to 30 meters by 20 meters, are planted for two years with nitrogen-fixing tree species *(Sesbania or Gliricida* seedlings or direct-seeded *Tephrosia vogelii* or *Cajanus Cajan* (pigeon pea), and followed by two or three years of maize. By far the most promising, although it may look like a "dinky little tree", is *Sesbania sesban,* which is grown in a nursery three to six weeks before the rainy season. Results over the five year cycle showed improved fallows improve total maize production eighty-seven percent over unfertilized maize (even without any yield in years one and two).

Moreover, with the rising prices of fertilizer in Zambia, fully fertilized maize is no longer an option, and even partially fertilized maize is not an option for many farmers who have neither the cash nor the access to credit to purchase fertilizer. By 1997, over 3,000 farmers had participated in the multi-year trials of improved fallow technologies. Forty-nine percent of who were women farmers, according to ICRAF. By 2001, two years after the start of the World Vision project to extend the IF technology in the Eastern Zambia, *10,000* farmers participated in planting IFs.

Yet the question still unanswered is: *why* are improved fallows being adopted so readily in Eastern Zambia, especially by women and FHHs, when nothing else works? Results from the UF Soils CRSP show their success is due to two facts:

1. Eastern Zambia is a region of lower population density than other African regions (e.g. western Kenya or southern Malawi) so that women farmers have enough land to put some of it in fallow.

2. Adoption of improved fallows is a delayed reaction to structural adjustment policies that have raised the price of inorganic fertilizers to level so high that women farmers have finally "adjusted" by deciding to "grow their own fertilizer" and adopt a substitute soil-fertility amendment.

These results were described with use of decision tree modeling and ethnographic linear programming models. Both were complemented with political-science studies of indigenous institutions and governance structures in Eastern Zambia.

GLOBAL PLAN

The global plan is directed toward attaining the SM CRSP's goal of achieving food security in regions of the world where hunger and poverty are highest, and enabling its clients to do so without compromising the sustainability of agroenvironments. The plan gives priority to the food insecure regions of Africa, Asia, and Latin America where most of the 700 million food insecure people live.

Objectives and Premise

The SM CRSP will contribute to the on-going international effort to reduce food insecurity by focusing on the following objectives:

1. Enable developing country institutions to apply information technology and knowledge-based tools to increase agricultural productivity.

2. Enable developing country institutions to scale-up technology adoption by farmers from local to regional scales.

3. Strengthen human and institutional capacity to combat poverty, land degradation and food insecurity.

The global plan is based on the premise that much is known about sustainable natural resource management, in general, and soil management in particular, and that the problem is mainly one of low accessibility to, and non-adoption of, existing knowledge and technology. There are good reasons for the low adoption rate of technology by resource-poor households including the following:

1. Household objectives often do not coincide with those assumed by researchers and extension agents.

2. Households may be operating within a set of constraints the extent of which may not be fully appreciated by change agents; for example, market and infrastructure limitations, or unavailability of credit.

3. The technology may simply be inappropriate to household needs.

4. The risks involved in adopting a new technology are not appreciated by the change agent.

In addition to the above, soil diversity and weather variability add to the difficulty of matching technologies to land that varies spatially and temporally.

Farmers, for example, are well aware of natural and human-induced spatial variability in land quality. These differences can occur over short distances and are often marked by abrupt changes in crop performance. In addition, crop responses to inputs vary spatially within and between fields, farms, watersheds, and regions. For this reason, the one-prescription-fits-all government programs designed to spur economic growth rarely succeed.

Crop responses to inputs also vary from year to year owing to weather variability. Because crop performance depend on environmental factors over which farmers have little or no control, chance enters the decision making process, compelling farmers, however unwilling, to gamble with nature.

Traditionally, farmers have learned to cope with weather variability by choosing crops and practices by the slow and tedious process of trial-and-error. Where farming is especially risky, crops and practices are chosen not to produce high yields in the average year, but to secure adequate food or income in the below-average years. If farmers seem conservative, it is because they know from experience that there is risk associated with change. Thus to assess risk, an innovation needs to be evaluated over many years to expose hidden dangers which one or two years of on-farm trials cannot reveal. A new kind of technology is needed to help farmers, policy makers and agri-businesses cope with weather-related risk and uncertainty.

Enabling clients to apply knowledge-based tools to increase productivity

One way to circumvent socio-economic and biophysical barriers to technology transfer and adoption is to enable decision makers to exercise choice. This implies that decision makers must be presented with a cafeteria of options from which they can choose. To do so, a chooser must be able to visualize and compare outcomes of alternative strategies to achieve specified objectives. This approach should enable clients to explore the future and minimize risk in a cost-effective and timely manner. It was Theodore Schultz who, in his award-winning book "Transforming Traditional Agriculture" challenged international development agencies to invest in agricultural research that allows farmers to choose productivity increasing innovations.

Two general types of decision support, information technology have been developed or assembled by the CRSP. The first is a rule-based or expert system that mimics the step-by-step rules an expert would choose to diagnose and prescribe remedies for a problem. A rule-based system's large and virtually infallible memory is its main strength. Its principal advantage over human experts is its easy reproducibility, portability, and application by non-experts in regions lacking experts.

The second type of decision support tools the CRSP will encourage developing country institutions to adopt are process-based simulation models. These models are designed to supplement the slow and costly trial-and-error method of conducting field experiments. While field experiments are preferable to simulated results, most developing countries do not have the financial resources, trained personnel or luxury of time to screen new crops, crop varieties, products and practices for all regions of their countries. Unlike the industrialized countries that have the installed capacity for agricultural research and thus, can test a steady stream of technology to remain competitive, the developing countries must leap frog the industrialized countries' way of screening agricultural technologies by going directly from traditional agriculture to one based on knowledge and information technology.

In knowledge-based agriculture, scientific understanding of biophysical processes captured, condensed and organized in decision aids, is employed to generate information to support decision making. These decision aids, are able to operate globally because they are process-based. The site-specific soil, weather, crop and farm management input data enable the decision aids and its users to perform site-specific, multi-year simulations of genotype by environment by management interactions.

One advantage of this approach is that it enables its users to perform expensive field experiments that would require years to complete in a matter of minutes. The field experiments that need to be conducted, but are never installed owing to lack of funds and trained personnel can now be simulated. The challenge for the CRSP is to enable developing country institutions to utilize this approach to combat poverty, land degradation and food insecurity.

Two factors prevent immediate and widespread application of decision aids in developing countries. First, developing countries either lack or have yet to geo-reference and compile their soil and climate data for easy retrieval by users to generate site specific crop performance results. Second, a cadre of national agricultural and policy researchers and administrators need to be trained to use decision aids to support decision making at the production and policy levels.

The CRSP realizes that to enable developing country institutions to effectively utilize decision aids, it must partner with other groups with similar objectives. One such group is the IARCs which maintains the International Crop Information System (ICIS). This system contains the crop information needed by decision aids to simulate genotype by environment interactions of the CG Centers' genetic resources in the food insecure regions of the world.
This has important implications for the CRSP, IARCs and developing country institutions. This means that the CRSP and international centers must work together to . develop compatible input-output systems to ensure easy accessibility of crop information for input into CRSP decision aids. This also means that developing country institutions must participate in the design and development of harmonized soil and climate/weather data bases. A harmonized and geo-referenced soil and weather data base will enable developing country institutions to use decision aids to access the CG Centers' crop information system, and screen crops (varieties), products (e.g. fertilizer) and practices (e.g. no-till farming) on a site-specific, cost effective and timely basis.

This capability to evaluate alternative production strategies should be useful not only to farmers, but to policy makers. Since lack of soil and weather data prevents the application of this approach, developing country governments must be made aware of the potential benefits of removing this bottleneck.

Since current methods for making soil and weather inventories are slow and expensive, developing country institutions must be provided with faster and more cost-effective ways of producing them. New technologies that make this possible include remote sensing technology, geographic information systems, global positioning systems, and spatial statistics. The latter makes it possible to estimate soil and weather data at unsampled locations from neighboring sites.

<u>Scaling-up technology adoption</u>

One often encounters projects that successfully transfer innovations to entire villages but fail when they attempt to transfer the same innovation to villages outside the project area. One reason for such failures is the sensitivity of technology transfer and adoption to biophysical and socioeconomic factors that vary spatially and temporarily.

There are three ways to transfer technology from locations where a particular technology has been successfully adopted to new locations. The first is by trial-and error, the second by analogy, and the third through systems analysis and simulation that enable adopters to exercise choice.

The trial-and-error method is now too slow and expensive to enable food production to keep pace with population growth.

Technology transfer by analogy depends on taking innovations from one location to other similar (or analogous) agroenvironments. The successful transfer of Malaysian rubber and oil palm technology to other agroecologically similar locations exemplifies this approach. Recommendation domains and eco-regional research contain elements of transfer by analogy. Technology transfer by analogy represents a major improvement over transfer by trial-and-error, but is limited by the fact that most transfers are made to dissimilar agroenvironments.

The third method, which enables adopters to exercise choice depends on the use of systems analysis and simulation. This method assumes that every farm and farmer is different, and relies on models to simulate site-specific results for different management practices, thereby allowing adopters to choose outcomes that best suit their needs.

Technology transfer and adoption have the best chance of succeeding when all three methods are employed. The CRSP is concentrating on the third method because it is the one that is least used and has a high potential for improving the success rate of technology adoption.

Strengthening human and institutional capacity

Capacity building is an enabling exercise. The goal is to enable individuals and institutions to perform critical tasks not only during, but also after the capacity building effort has ended.

The CRSP's aim is to enable developing country institutions to adopt new practices and products including systems analysis and simulation.

Two of the three components required to apply systems analysis and simulation are in place. The two components that are in place are the CG Centers' crop information system and the CRSP's decision aids. The third and missing component is the national soil and weather data base. Most countries have soil and weather data but have not complied, organized, and geo-referenced them for easy retrieval by users.

The CRSP's capacity building efforts will, therefore, include (1) training scientists, administrators and policy makers in the use of systems analysis and simulation, (2) training researchers and administrators in new, cost-effective ways to compile, collect and organize soil and weather data, and (3) training researchers in diagnosing and prescribing alternative remedies for soil-related production problems.

Implementing the Global Plan

In the next five years, the CRSP proposes to shift emphasis from development and testing to training and utilization of CRSP products and practices. CRSP products include (1) a decision aid for diagnosing and prescribing remedies for soil fertility problems, (2) an integrated suite of biophysical and economic models that enable policy makers to evaluate tradeoffs betweens productivity and sustainability and (3) crop simulation models of the major food crops which have been combined with modules to simulate the effect of crop and soil management on carbon sequestration. CRSP practices include technologies that singly increase rice and wheat yields from 15 to 40%, and often produce additive benefits when combined. These include practices that reduce soil pathogen and nematode populations, rectify micronutrient (boron, zinc, molybdenum) deficiencies, and allow greater intensification of rice production by varying plant spacing, water control and fertilizer input.

To ensure that its products, practices and training capabilities are effectively utilized, the CRSP will do the following:

1. Hold annual meeting with partners to formulate training and utilization strategies for the coming year.

2. Form alliance with partners from the public and private sectors to promote market and trade-based agricultural development.

3. Join Forces with USAID Missions to achieve USAID strategic objectives.

4. Develop interactive Internet site to publicize CRSP goals, objectives, and response-capability, progress and results.

Annual planning workshops

A key element in the implementation of the SM CRSP global plan will be annual SM CRSP workshops. At these workshops, PIs and key collaborators from the SM CRSP projects will present and discuss their work, and plan collaborative activities for the next year. Key stakeholders and potential collaborators including USAID Mission staff, will be invited to attend these workshops. The format for the workshops will be a 2-3 day session of presentations and discussion by the entire group, followed by a 2-3 day planning session for PIs.

The purpose of these workshops is to report progress, compare progress against posted milestones, identify bottlenecks, form new alliances, set priorities for the coming year and to assess impact of CRSP activities.

Alliance for market and trade-based agricultural development

The CRSP working alone and in isolation has little chance of making an impact on food security. Its capacity to make a difference hinges on establishing quality alliances with a diversity of partners. Quality alliances are formed when partners share a common aim and perform different but essential functions.

For example, one aim of the CRSP is to enable developing country farming communities to generate income by sequestering carbon in agricultural lands and selling carbon credits to CO2 emitting industries. The added income can be used to purchase food or fertilizer. Fertilizer will not only increase crop yields but also will increase carbon accretion and improve land quality.

Unlike donor supported technical assistance programs that are subject to donor fatigue, carbon trading will be sustained by the self interests of farmers and CO_2 emitting industries. It can be an effective, financially sustainable way to win the war against poverty, land degradation and food insecurity.

But before carbon trading can become a reality, farming communities, their governments, CO_2 emitting industries, carbon traders, climate change organizations and the SM CRSP must all be ready to fulfill their respective roles.

The CRSP can play a key role in this regard by making accessible to carbon traders the means to measure, monitor, simulate and verify changes in carbon levels in large tracts of spatially variable lands. It must also provide farmers with soil management options to profitably sequester carbon. Without such a carbon accounting and management system, it is unlikely that carbon trading will occur.

Training carbon traders to use the carbon accounting system, and extension agents and agribusinesses to use decision aids to optimize crop and carbon yields may become a major CRSP activity. The CRSP is prepared for this possibility.

Joining Forces with USAID Missions to Achieve USAID Strategic Objectives

The SM CRSP will expand its capacity to respond to USAID Mission request for field support. The CRSP currently has a scientist working in the Amhara region of Ethiopia in support of Mission activities, but in the future can strengthen its response capability by involving collaborating country and private sector partners to provide market-based field support to Mission.

For example, response to Mission requests for assistance to Southeast Asian countries can involve not only U.S. personnel, but CRSP collaborators from Thailand and the Philippines who know the language and cultures of the region, along with private sector partners such as Hewlett Packard which has offices in the region. The CRSP is currently negotiating with Hewlett Packard and its Thai partners, to produce and market a hand-held version of one of its decision aids.

Another example might be the involvement of our Brazilian partners in Mission support to countries such as Angola and Mozambique. The Brazilians like the Thais are true partners. They do not receive CRSP funds but contribute to CRSP efforts by testing and providing feedbacks to improve CRSP decision aids.

The CRSP also partner with IFDC and CIP in the Andean region of South America to test and develop one of its decision aids. These partners have played key roles in helping to develop the CRSP decision aids and therefore represent an extension of the CRSP's response capability.

A fourth possibility is to provide field support to Missions in Arabic, Urdu and Farsi speaking regions. The CRSP closed its activities in Pakistan and India when sanctions were imposed on the two countries, but with the lifting of sanctions, the CRSP can renew activities there. This CRSP activity, now confined to Nepal and Bangladesh, is linked to IRRI and CIMMYT through the Rice Wheat Consortium.

Finally, the CRSP has established strong linkages with West African agricultural research institutions through an Inter-CRSP program. This year, in collaboration with Malian researchers, the SANREM and Soils CRSPs applied for, and received a NASA grant to monitor carbon accretion in cultivated and range lands in West Africa. The Malians are especially interested in measuring organic carbon in land brought under a ridge-till farming system. This practice introduced by the French many years ago, retains more water in the field and produces higher yields particularly in the dry years. Native trees and shrubs that gradually disappeared when the land was brought under cultivation are reappearing in the ridge-tilled areas. What has impressed everyone is the rapid pace at which the ridge-till system is being adopted without government assistance or encouragement. The NASA grant will allow ground truth to be collected to enable remote sensing technology to be used to monitor the spread, and delineate areas where the ridge-till system can and cannot be applied.

The CRSP and its partners have a global presence, and stand ready to support Missions achieve their objectives. How well the CRSP performs in this regard will depend on matching CRSP strengths and capabilities with Mission priorities and needs.

The CRSP will publicize its readiness to provide field support to Missions through its website, publications, Cognizant Technical Officer and direct communications with Missions.

Interactive Internet site for global alliance

A critical aspect of the Soil Management CRSP Global Plan is a global alliance that will facilitate the communication and use of knowledge and tools developed across all subprojects in the CRSP. To achieve a truly functional global alliance, subprojects must simultaneously work to achieve their own objectives and cooperate with each other, ensuring that their products are integrated and made available for widespread access and use. One strategy that the CRSP will use to make this Global Alliance truly functional is the development of an interactive Internet site, which will:

- Communicate project outcomes and impacts to a global audience
- Facilitate response capabilities and greater cooperation with missions
- Provide a marketing strategy for CRSP products
- Support internal working group cooperation (exchange data, develop educational materials, write reports and papers)
- Help harmonize data structures and access methods
- Match requests with expertise from the Global Alliance for effective responses . Improve clients' understanding of tools (experts systems, models) via on-line access of tools and tutorial information

This web site will have an interactive home page that allow users to access information, to communicate with each other for general purposes and for cooperative activities, and to provide information and tools for access by the global network. It will have the following features:

- On-line educational material on soil management technology, soils, expert systems, models
- On-line capabilities for operating software for educational purposes, including nutrient management expert systems, soil carbon sequestration models, economic tradeoff models
- On-line access to data, tools, reports, papers (Download capabilities)
    - Site and spatial- from project
    - Information on other sources of data (metadata base)
    - Respect for property rights, user access privileges
- Password access to working group activities, for development of educational materials, etc.
- Links to other sites as appropriate, particularly partner organizations in developing world, missions, etc.
- Other, including images (pictures, remote sensing), etc.

The Internet site will be developed by a network educational specialist with experience in Information Technologies and web-based information systems, hired at the management entity site. This person will be responsible for the overall design and implementation of the site, coordinating with each CRSP subproject. This strategy will ensure that all CRSPs will contribute to the development of the network while providing a person with the responsibility needed to ensure access. The network specialist will also be responsible for integrating all training material, providing tools for software access, training in the use of authoring tools, and initiating activities that will ensure that the network meets the goals of the Global Alliance.

MANAGEMENT ENTITY

The University of Hawaii serves as the Management Entity for the Soil Management CRSP. Dr. Goro Uehara serves as director and Dr. Gordon Y. Tsuji serves as deputy director. As Management Entity, the University of Hawaii administers grant funds received from USAID and is responsible for the overall implementation of the research program, and for coordination of project activities among participating institutions through sub-contractual agreements.

The Management Entity reports on the overall progress of program activities and represents the SM CRSP in negotiations with AID and in meetings and teleconferencing of the CRSP Council. Additionally, the Management Entity represents the interest of the SM CRSP in responding to requests for technical support and/or participation in forums received from the Office of Agriculture and Food Security and from USAID missions.

Operationally, the office of the Management Entity is in the Department of Tropical Plant and Soil Sciences in the College of Tropical Agriculture and Human Resources at the University of Hawaii.

Administratively, the Management Entity utilizes the services of the Research Corporation of the University of Hawaii (RCUH) to implement and manage its sub agreements with participating institutions. The RCUH is a non-profit organization established by the Hawaii State Legislature in 1965 to support "off-shore" research and training programs of the University of Hawaii. The University of Hawaii has oversight responsibilities of the RCUH.

The CRSP Guidelines established in 1975 and revised in 2001 by the Board for International Food and Agricultural Development (BIFAD) for USAID and federal regulations serves as a guide to manage the SM CRSP by the Management Entity. Those guidelines direct CRSP programs to establish a Technical Committee, a Board of Directors, and an External Evaluation Panel. The office of the Management Entity is responsible for administrative and logistical support to members of these "bodies."

Budget

The following tables are the estimated five-year budget for the office of the management entity at the University of Hawaii and the estimated 5 year budgets for each of the projects listed. The first project is on the nutrient management decision support system, NuMass, and includes the Universities for Florida and Hawaii and North Carolina State University. This will be followed by the Tradeoff Analysis project at Montana State Univeristy, the Rice-Wheat Project at Cornell University, and the project on Carbon Sequestration involving Cornell and the Universities of Florida and Hawaii.

Management Entity

	PY1	PY2	PY3	PY4	PY5	Totals
Salaries/Wages	221,672	228,322	235,172	243,403	250,705	1,179,274
Fringe Benefits @27%	59,851	61,647	63,496	65,719	67,690	318,4033
Contracts	21,000	21,000	23,000	20,000	20,000	105,0000
Supplies	10,000	11,000	12,000	11,000	10,000	54,0000
Equipment	-	-	-	-	-	-
Rental	6,000	6,000	7,000	6,000	6,000	31,0000
Other	27,500	27,500	27,500	27,500	27,500	137,5000
Travel						
Domestic	45,110	38,832	45,110	45,110	45,110	219,2722
International	19,246	11,562	35,946	15,836	12,594	95,1844
Total Direct	410,379	405,863	449,224	434,568	439,599	2,139,633
Indirect Costs						
On-campus @36.3%	73,736	74,290	79,332	77,942	79,528	384,8288
Off-campus @20.6%	42,693	41,449	47,520	45,290	45,426	222,3788
Total Costs	526,808	521,602	576,076	557,800	564,553	2,746,839

A. NuMaSS Project

University of Hawaii - NuMaSS

	PY1	PY2	PY3	PY4	PY5	Totals
Salaries/Wages	90,000	91,560	94,310	95,965	97,670	469,505
Fringe Benefits	20,984	21,408	22,051	22,502	22,965	109,910
(27.2% Reg, 18% Grad, 1% Student)						
Consultants	10,000	10,000	10,000	10,000	10,000	50,000
Subcontracts	146,000	220,000	225,000	222,000	220,000	1,033,000
Supplies/Services	3,662	7,049	7,048	9,273	9,573	36,605
Equipment	56,000	6,000	-	-	-	62,000
Travel						
Domestic	2,000	2,000	2,000	3,000	3,000	12,000
International	34,000	27,000	31,000	30,000	29,000	151,000
Total Direct	362,646	385,017	391,409	392,740	392,208	1,924,020
Modified Total Direct Costs	240,646	179,017	161,409	157,740	159,208	898,020
Indirect Costs						
On-campus@36.3%	87,354	64,983	58,591	57,260	57,793	325,981
Off-campus @20.6%						
Total Costs	450,000	450,000	450,000	450,000	450,001	2,250,001
Cost sharing @25% MTDC	64,790	46,290	45,040	45,790	46,290	248,200

North Carolina State University - NuMaSS

	PY1	PY2	PY3	PY4	PY5	Totals
Salaries/Wages	42,902	43,987	45,102	46,247	47,424	225,662
Fringe Benefits (23% Reg, 8.3% Student)	8,755	9,001	9,254	9,515	9,783	46,308
Consultants	-	-	-	-	-	-
Subcontracts	31,500	31,000	30,000	30,000	29,500	152,000
Supplies/Services	9,000	4,500	4,500	4,500	4,150	26,650
Equipment	-	-	-	-	-	-
Other	133,930	142,698	143,213	140,207	140,504	700,552
Travel						
Domestic	5,050	5,050	5,050	5,050	5,050	25,250
International	15,175	15,375	14,275	15,875	14,875	75,575
Total Direct	246,312	251,611	251,394	251,394	251,286	1,251,997
Indirect Costs	66,188	60,889	61,106	61,106	61,214	310,503
Total Costs	312,500	312,500	312,500	312,500	312,500	1,562,500
Cost sharing @25% MTDC	80,278	81,350	83,852	87,111	90,498	423,089

MTDC: modified total direct costs

B. Tradeoff Analysis Project

Montana State University – Tradeoff Analysis

	PY1	PY2	PY3	PY4	PY5	Totals
Salaries/Wages	143,000	162,735	169,970	178,566	187,074	841,345
Fringe Benefits (@ 30% exc. Grad)	40,200	43,421	45,291	47,870	50,122	226,904
Consultants	46,150	46,950	37,750	38,450	45,850	215,150
Subcontracts	288,863	297,216	297,864	279,792	256,714	1,420,449
Supplies/Services	2,000	2,000	2,000	2,000	2,000	10,000
Equipment	-	-	-	-	-	-
Other	133,930	142,698	143,213	140,207	140,504	700,552
Travel						
Domestic	6,000	6,000	6,100	6,400	6,500	31,000
International	24,300	24,700	23,200	19,400	15,800	107,400
Total Direct	550,513	583,022	582,175	572,478	564,060	2,852,248
Indirect Costs @41.5% (Applied to first 25,000 of subs/cons)	120,558	99,125	102,447	105,508	105,178	532,816
Total Costs	671,071	682,147	684,622	677,986	669,238	3,385,064
Cost sharing (25% of total on-campus costs)	51,625	55,214	56,965	58,809	58,361	280,974

C. Rice-Wheat Project

Cornell University – Rice Wheat

	PY1	PY2	PY3	PY4	PY5	Totals
Salaries/Wages	94,000	98,700	103,365	108,533	113,960	518,558
Fringe Benefits @32.91%	13,262	13,925	14,621	15,353	16,120	73,281
Consultants	-	-	-	-	-	-
Subcontracts	72,300	87,300	87,300	87,300	87,300	421,500
Supplies/Services	20,000	20,000	20,000	20,000	20,000	100,000
Equipment	-	-	-	-	-	-
Other	91,225	75,000	70,000	65,000	60,000	361,225
Travel						
Domestic	4,520	4,520	3,000	3,000	3,000	18,040
International	27,000	27,000	27,000	27,000	27,000	135,000
Total Direct	322,307	326,445	325,286	326,186	327,380	1,627,604
Indirect Costs						
On-campus @59%	38,282	40,196	42,206	44,316	46,532	211,532
Off-campus @26%	52,103	44,575	44,575	41,475	38,337	221,065
Total Costs	412,692	411,216	412,067	411,977	412,249	2,060,201
Cost Sharing @25%	103,173	102,804	103,017	102,994	103,062	515,050

D. Carbon Sequestration Project

Cornell University – Carbon Sequestration

	PY1	PY2	PY3	PY4	PY5	Totals
Salaries/Wages	99,450	104,423	109,644	115,126	120,882	549,525
Fringe Benefits @32.91%	20,947	19,697	20,681	21,715	21,721	104,761
Consultants	-	-	-	-	-	-
Subcontracts	32,300	30,000	30,000	30,000	30,000	152,300
Supplies/Services	16,000	25,000	25,000	20,000	15,000	101,000
Equipment	-	-	-	-	-	-
Other	69,110	57,000	46,000	40,000	33,000	245,110
Travel						
Domestic	3,000	3,000	3,000	3,000	3,000	15,000
International	17,000	20,000	20,000	20,000	20,000	97,000
Total Direct	257,807	259,120	254,325	249,841	243,603	1,264,696
Indirect Costs						
On-campus @59%	78,098	70,914	74,459	78,182	82,753	384,406
Off-campus @26%	18,207	24,004	25,204	26,464	27,787	121,666
Total Costs	354,112	354,038	353,988	354,487	354,143	1,770,768
Cost Sharing @25%	88,528	88,510	88,497	88,622	88,536	442,693

University of Florida – Carbon Sequestration

	PY1	PY2	PY3	PY4	PY5	Totals
Salaries/Wages	134,000	137,120	140,334	143,644	147,054	702,152
Fringe Benefits (@8.3% exc Grad)	8,632	8,891	9,158	9,432	9,715	45,828
Consultants	-	-	-	-	-	-
Subcontracts	50,200	74,000	74,000	66,000	66,000	330,200
Supplies/Services	10,500	5,300	10,500	5,300	10,500	42,100
Equipment	7,500	5,000	2,500	-	-	15,000
Other	6,136	6,760	7,436	8,180	8,998	37,510
Travel						
Domestic	7,000	7,000	7,000	7,000	7,000	35,000
International	20,000	12,000	14,000	12,000	14,000	72,000
Total Direct	243,968	256,071	264,928	251,556	263,267	1,279,790
Indirect Costs (@44.5% of MTDC)	102,498	86,824	80,541	78,932	83,780	432,575
Total Costs	346,466	342,895	345,469	330,488	347,047	1,712,365
Cost Sharing (@25% of MTDC)	74,067	67,224	67,867	66,122	70,262	345,542

University of Hawaii – Carbon Sequestration

	PY1	PY2	PY3	PY4	PY5	Totals
Salaries/Wages	96,000	96,000	98,000	98,000	98,000	486,000
Fringe Benefits (@27% Reg, 18% Gra, 1% Stu)	21,044	21,044	21,064	21,064	21,064	105,280
Consultants	-	-	-	-	-	-
Subcontracts	90,000	120,000	120,000	120,000	120,000	570,000
Supplies/Services	11,157	10,453	15,096	14,096	15,096	65,898
Equipment	-	-	-	-	-	-
Other	-	-	-	-	-	-
Travel						
Domestic	-	-	-	-	-	-
International	34,000	34,000	30,000	31,000	30,000	159,000
Total Direct	252,201	281,497	284,160	284,160	284,160	1,386,178
Indirect Costs (@36.3% of MTDC)	91,549	62,253	59,590	59,590	59,590	332,572
Total Costs	343,750	343,750	343,750	343,750	343,750	1,718,750
Cost Sharing (@25% of MTDC)	31,050	30,874	31,540	31,540	31,540	156,544

BUDGET SUMMARY

The following is a summary of annual budgets for each of the project proposals in volume 2 of this grant extension proposal.

	Yr1	Yr2	Yr3	Yr4	Yr5	Totals
Rice Wheat - CU	412,692	411,216	412,067	411,977	412,249	2,060,201
Trade-Off Analysis - MSU	671,071	682,147	684,622	677,986	669,238	3,385,064
NuMass						
NCSU	312,500	312,500	312,500	312,500	312,500	1,562,500
UH	450,000	450,000	450,000	450,000	450,000	2,250,000
Subtotal	875,000	875,000	875,000	874,998	875,002	4,375,000
Carbon						
CU	354,112	354,038	353,988	354,487	354,143	1,770,768
UF	346,466	342,895	345,469	330,488	347,047	1,712,365
UH	343,750	343,750	343,750	343,750	343,750	1,718,750
Subtotal	1,044,328	1,040,683	1,043,207	1,028,725	1,044,940	5,201,883
Bio-Tech	200,000	200,000	200,000	200,000	200,000	1,000,000
Management Entity	588,525	523,294	584,090	543,475	568,643	2,788,027
Subtotal	3,678,740	3,619,839	3,686,786	3,624,662	3,649,516	18,259,543
Cost Sharing	-	-	-	-	-	-
Total	-	-	-	-	-	-